SYNTHETIC FUEL VS. LNG

DEVELOPMENT OF HIGH-VISCOSITY OIL DEPOSITS

FOR WELL LOW-RATE FUND

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BIG PLANS FOR RUSSIAN LNG

Yamalo-Nenets Autonomous Okrug

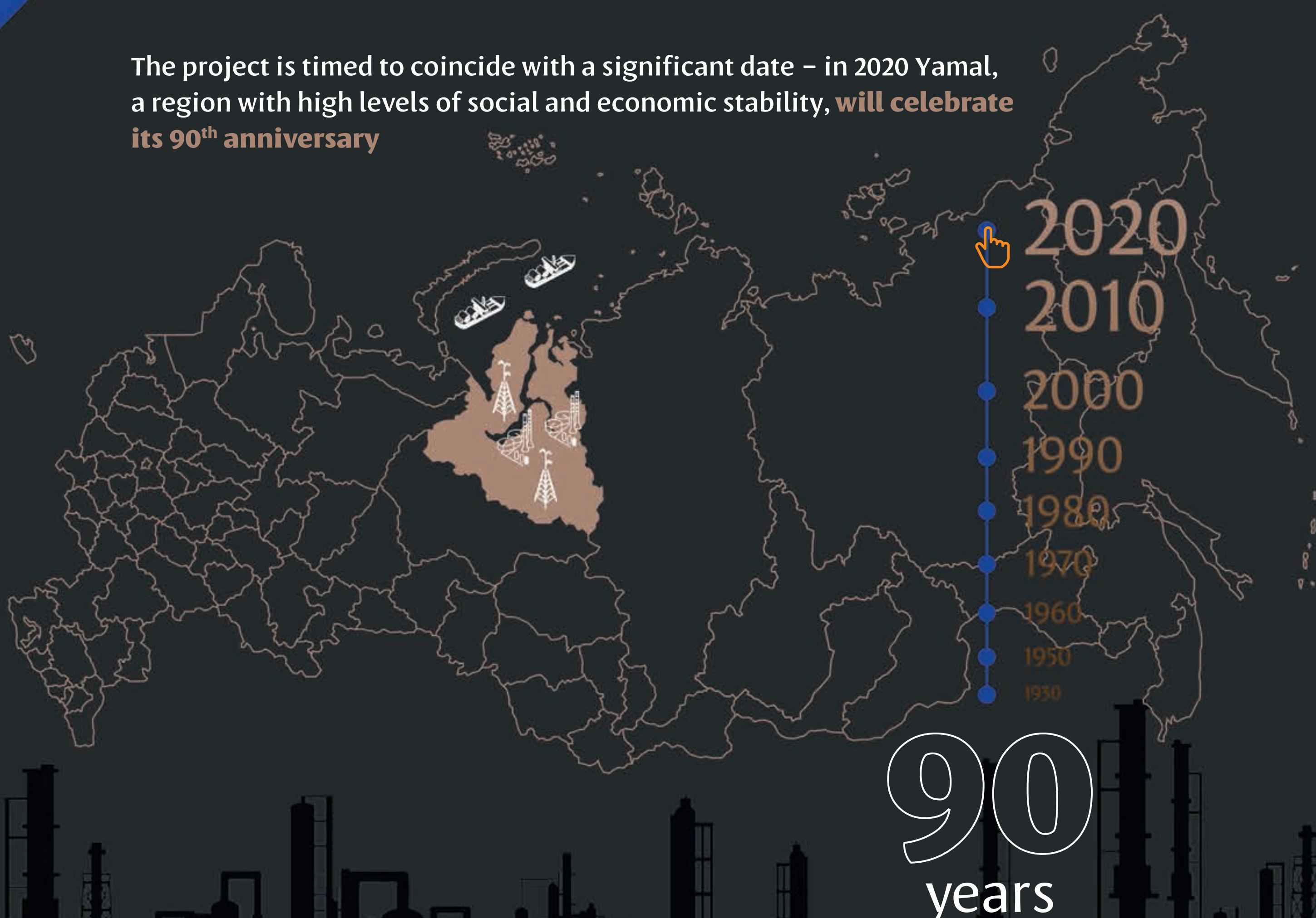
Neftegaz.RU

Yamal – at the heart of the oil and gas industry is a modern, interactive online platform demonstrating the phase-by-phase development of the oil and gas industry in the region

The information agency Neftegaz.RU, in conjunction with the government of the Yamalo-Nenets Autonomous Okrug and with support from the Ministry of Energy of the Russian Federation, launched an interactive federal media project:

Yamal – at the heart of the oil and gas industry in Russia

The project is timed to coincide with a significant date – in 2020 Yamal, a region with high levels of social and economic stability, **will celebrate its 90th anniversary**



The media project will consist of several parts:

Interactive map

displaying the main oil and gas companies, energy units and related industry enterprises operating in the region.
Using the format of a single information window, it will be possible to look into the past, present and future of oil and gas production in Yamal

Enterprises

engaged in field development in the Yamalo-Nenets Autonomous Okrug, offering design, communication, drilling services, etc. will present their field operations and development plans, plus other major players contributing to the social and economic development of the region

Transportation

Enterprises, providing transportation services in the Arctic, including the Northern Sea Route (NSR)

Comments from experts

and interviews from the head of the region's administration, ministers and competent specialists of the Russian oil and gas industry

Investment Projects of YaNAO

It will be possible to get acquainted with government programmes for developing oil and gas production in YaNAO

Sites of minority peoples of the North

In February 2020, the media project will already be available to the public www.yanao.neftegaz.ru

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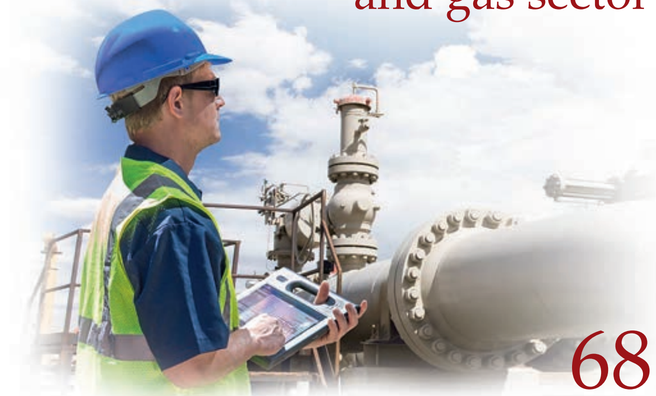

68

OIL AND GAS INDUSTRY EPOCHS

182 years ago

In 1837 an oil refinery was built in Azerbaijan and in order to produce illuminating kerosene in iron cubes, the distillation of oil was launched.

156 years ago

In 1863, a German gas specialist Heinrich Hirzel received a patent for a lighting gas recovery unit from oil and oil residues.

132 years ago

In 1887, natural gas was discovered while drilling a water well in the Berdyansk district.

126 years ago

In 1893, work began on the Staro-Grozny oil field. The first oil well was drilled using the rod tool percussion method.

122 years ago

In 1897, the compressor method of oil production was tested. The technology for extracting hydrocarbon from the reservoir through the supply of compressed air to the well (airlift) was proposed by the engineer V.G. Shukhov.

112 years ago

In 1907, strong gas manifestations were observed in the first well of the Timano-Pechora province.

98 years ago

In 1921, the General Directorate of Fuel was established in Russia. Its functions included the management of the oil and shale industry.

89 years ago

In 1930, the scheduled regulatory work in the exploration, research and exploitation of gas fields was entrusted to the Charred Coal and Gas Chemical Department of Vsekhimprom.

73 years ago

In 1946, the Bavlinskoye field was discovered (Tatar ASSR).

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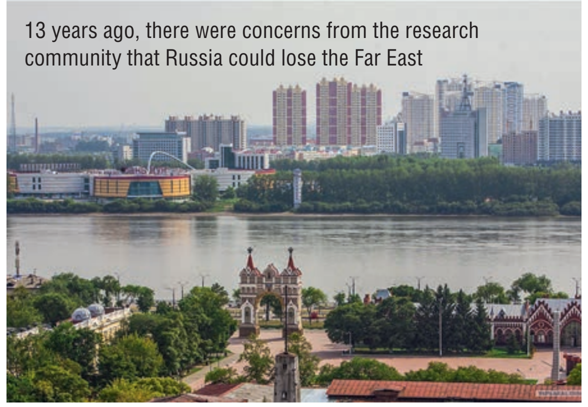


13 years ago, there were concerns from the research community that Russia could lose the Far East

The 5th Eastern Economic Forum was held in Vladivostok

The Far East has 20 Priority Social and Economic Development Areas

14 major investment agreements were concluded during the Forum

EEF 2019

Anna Pavlikhina

In 2006 Blagoveshchensk (Amur Oblast) hosted a conference where participants set out to answer the question: will Russia lose the Far East. Back then, 13 years ago, this was a valid concern due to the influx of residents from the neighboring Heilongjiang province and the constant outflow of the Russian population, whose ancestors were brought to these lands by the tsarist resettlement policy, promising references. Afterwards, not much attention was given to the region – it seemed the state had forgotten all about the 5.5% share of the population, separated from Moscow by 11 time zones.

It is difficult to say exactly when the country's leadership decided to begin the revival of the Far East. Perhaps, it was when construction of the Russky Bridge began in 2008, or when Rosneft announced plans to set up the Far Eastern Petroleum Company (FEPCO) in 2015. Maybe even earlier in 2007 when the President signed a decree on the construction of the Vostochny Cosmodrome. Whichever of these triggered the interest into the Far East, the fact remains that for the past 10 years the government has been proactively developing the region and it has every chance to transform itself from a subsidized territory into an independent one.

Even though the Russky Bridge makes one doubt its feasibility and the Vostochny Cosmodrome, involved in financial fraud right before launching its first satellite, is still partly under construction (based on the Svobodny Cosmodrome successfully operating before), and even though the FEPCO project was abandoned at the project stage, the Far East is no longer a far-flung, forgotten area. Decisions made and agreements signed during the economic forums held over the past five years in Vladivostok are proof of this.

The Far East has 20 Priority Social and Economic Development Areas; since 2015 investors have put up 612 billion rubles into the region's economy; 242 new production facilities have been built, while industrial production growth (as President Vladimir Putin announced in his speech) within the past 5 years has amounted to almost 23%.

In September, the 5th EEF was held aimed at contributing to the economic development of the Far East. All the leading media outlets, including foreign ones, reported on the agreements reached at the forum. An article on The Wall Street Journal stood out in particular, giving an assessment as follows: no major deals were concluded, the outflow of the region's population is hindering growth, while foreign investors are losing interest. To compensate for this, the Russian government promised to spend 10 billion dollars for the expansion of roads, but these funds, according to the journalist's forecasts, even if they are allotted, will take time and may not reach the full amount.

This information does not overlap with other sources and assessments. 270 agreements worth over 3.4 trillion rubles were concluded, shouldn't this count? Or is the article by the American journalist a story worthy to be published in the tabloid press?

During the forum 14 major investment agreements were signed, including agreements on developing chemical industries, pharmaceuticals, livestock, shipbuilding and other projects with several companies involved. If we look closer, the participation of foreign investors becomes more obvious.

A landmark agreement envisaging the construction of a methanol and ammonia production plant was signed by the Far East Development Corporation and the Nakhodka Mineral Fertilizer Plant (investments amounting to 200.7 billion rubles). Furthermore, the Far East Development Fund and the Russian Copper Company signed an agreement on implementing an investment project to construct a mining and refining complex (142.5 billion rubles)

The Far East Investment and Export Agency concluded several agreements: with Technoleasing JSC and the Japanese company Marubeni Corporation on methanol supply, the investment amount is unknown; with Mengniu Dairy Group Ltd. and Zhongding Dairy Farming Co. (eight-party agreement) on the construction of a livestock complex (45 billion rubles); with Arctic Ocean Holding Group LLC on cooperation in creating a tourism cluster (57.2 billion rubles); with Harbin Pharmaceutical Group Holding Co. on the relocation of the Hayao pharmaceutical plant in the Far East (10 billion rubles); with Antey LLC and Nakhodka Shipbuilding Company PJSC for the construction of a series of fishing vessels (10 billion rubles). FINR LLC and the Far East Development Corporation signed an agreement on the development of the Krutogorovskoye coal deposit (11 billion rubles). Financial Corporation Otkritie reached an agreement with Far East cities on the development of a network of industrial parks (442.5 billion rubles). Polymetal JSC and the Far East Development Fund concluded an agreement on cooperation for implementing projects in the Far East. Finally, four agreements of intent in the sphere of promising information technology projects were signed by Russian Helicopters JSC, MTS PJSC, Russian Railways JSC and Element LLC with the participation of the Ministry for the Development of the Russian Far East and Arctic, the Ministry of Communications of the Russian Federation and the Far Eastern Federal University.

Adding up the total investment in projects involving foreign companies, it turns out that their share is 1.6%.

Russian companies are interested in expanding projects in the Far Eastern Federal District. Finally, the region is receiving the incentives it needs for further development. The bad news is that foreign investors, even amongst friendly countries, do not see Russia as a reliable partner, due to the risks associated with conducting business in our country. It seems this factor outweighs the unique advantages provided by the country's riches and vast potential.

$21.3 BILLION SET ASIDE FOR ARCTIC LNG 2

Elena Alifirova

The final investment decision for the Arctic LNG 2 project has been approved. Capital investments for launching the Arctic LNG 2 project at full capacity will amount to $21.3 billion. L. Michelson is content with the coordinated work of investors.

In a short period of time, several companies approved the final investment decision (FID), meaning that the project will be in demand. And although East Asian countries are supposed to be the main consumers of LNG from the project, L. Mikhelson is ready to supply LNG to any part of the world. The Arctic LNG 2 project envisages the development of the Utrenneye Field and the construction of an LNG plant on the Gydan Peninsula.

The oil-and-gas condensate field is located on the territory of the Tazovsky district of the Yamalo-Nenets Autonomous District in the Gulf of Ob. Proved and prospective reserves according to PRMS standards amounted to 1.138 billion m^3 of natural gas and 57 million tons of liquid hydrocarbons.

Based on Russian classification, the reserves of the field amounted to 1.978 trillion m^3 of natural gas and 105 million tons of liquid hydrocarbons.

Arctic LNG 2 will become NOVATEK's second large-capacity LNG plant, after Yamal LNG launched in 2017.

Having approved the project's FID, NOVATEK has taken another step towards its goal of becoming one of the world's largest LNG producers.

Project participants include NOVATEK (60%), Total (10%), CNPC (10%), CNOOC Limited (10%) and a Mitsui-JOGMEC consortium, Japan Arctic LNG (10%).

If NOVATEK decides to lower its stake below 60%, for instance to 50.1%, as was the case with Yamal LNG, then Total, in accordance with previously announced plans, will exercise its right to increase its stake up to 15%.

Speaking at EEF 2019, A. Novak estimated Russia's potential share in the global LNG market at 15–20%.

Neftegaz.RU ratings

Russia's revenues from LNG exports within the first 7 months of 2019 increased by 75% amounting to $69.28 billion, while oil revenues decreased by 2.9% compared to January-July 2018. At the same time, the volume of oil exports increased by 1.4% equaling 149.56 million tons. Revenues from the export of natural gas decreased by 5.3% and amounted to $25.74 billion. Are traditional fuels losing ground?

Which fuel export will generate the highest budget revenues in the near future?

48%
Oil. The temporary drop in revenues from sale in the first half of 2019 was due to the incident with the Druzhba pipeline

35%
Natural gas. By the end of the year, gas will be delivered to the Near East through MGP Power of Siberia. When the Nord Stream 2 project commissioning, most of Europe will be covered, while the Turkish Stream pipeline will meet Turkish demands

17%
LNG. Revenues from LNG have increased by 75% since the beginning of the year, in part due to Yamal LNG reaching full capacity. When several planned LNG projects are fully implemented, liquefied natural gas will conquer the fuel market

The fuel and energy complex is the main drive of the economy, accounting for 25% of GDP and more than half of the budget revenue. The state plays a crucial role in raising the competitive level of national industries and attracting investments. What segment of the budget-forming industry should it support first?

Where should investments go?

15%
Over the past 10 years, production costs have markedly increased, while the flow rate of wells has fallen, which is the reason why traditional production must be supported

5%
The largest hydrocarbon reserves are concentrated in the Arctic – on the shelf of the northern seas. Production in this region needs incentives most of all

16%
With the right approach, it is possible to raise LNG production from today's 30 million tons to 120–140 million tons and occupy 20% in the global market

49%
Oil and natural gas production will always be profitable, but oil refining must be supported

15%
Rosneft and Gazprom are recognized as the richest companies in the world, as these two companies, along with their subsidiaries, own the main oil fields and refining facilities. They are free to expand without any preferences

Oil prices
Duty abolition
Presidential elections
Gas wars
Increase in production capacity
Nord Stream
The new head of "Rosneft"
Stock market crash
Launch of new production

Joint efforts in expanding Russia's LNG Fleet

Russia is ramping up efforts to expand its LNG fleet and the LNG bunkering market. During EEF 2019, Gazprom Neft, Gazprom Gas-Engine Fuel and the United Shipbuilding Corporation (USC) agreed on

further developing the LNG fleet. The agreement envisages research and engineering cooperation between the companies aimed at increasing production capacities for creating and constructing LNG carriers, as well as boosting the LNG infrastructure.

The companies plan to interact with shipping companies – potential customers of LNG fuel carriers.

Another area of cooperation is joint participation in creating and improving the regulatory framework for the use of LNG fuel in Russia.

It was also agreed to implement a mutual roadmap aimed at developing the LNG fuel bunker market.

USC will analyze the existing technical capabilities for developing, constructing and certifying LNG carriers.

Gazpromneft Marine Bunker specialists will conduct a comprehensive analysis of the projects for creating LNG bunkering infrastructure based on the ship-to-ship and shore-to-ship methods.

Gazprom Neft set to develop a unique field

Gazprom Neft began drilling wells at the Chayandinskoye oil-and-gas condensate field. The full-scale development of the oil rim is scheduled for the fourth quarter of 2021.

In terms of recoverable reserves (B1+B2), the field belongs to a unique category – 1.2 trillion m^3 of natural gas and 61.6 million tons of oil-and-gas condensate.

The field is also used as a resource base for MGP Power of Siberia-1.

Gazprom owns the license for the Chayandinsky subsoil block, while Gazprom Dobycha Noyabrsk has been assigned to develop and operate the field. However, the field's oil rim is being developed by Gazprom Neft, as part of an operator agreement with Gazprom Dobycha Noyabrsk.

The first oil production well, built by Gazprom Neft, will be used for coring and in-depth sampling, as well as for the performance of a series of geophysical studies. The design length of the well will be over 4 km, while the length of the horizontal section will be about 1.5 km.

During preparations for the active phase of the pilot unit, Gazprom Neft is operating several gas wells. The gas produced will be directed to a 17.5 MW field power station that will supply power to equipment units, production facilities and a residential town. Currently, preparations are underway for launching the power plant.

Smart technologies for production

As part of a project, scientists from KFU managed to apply machine-learning methods in order to solve troubleshooting tasks in integrated circuits. Scientists can evaluate the properties of an oil-bearing reservoir located at a depth of several kilometers only by indirect measurements, which entails the need for analyzing information obtained during oil field development, modeling and mathematical experiments.

For effective production, specialists need to make numerous calculations. Furthermore, each field is a complex system consisting of reservoirs, wells, surface facilities and infrastructure units. The field has so many parameters that can be used to control efficiency and the only possible way to find the global extremum is to use artificial intelligence.

KFU scientists have proposed new ways to select the essential characteristics that can increase the accuracy of predictions and improve the quality of fault diagnosis.

NGL: to be or not to be
Nord Stream built
Reached his hands up in the Arctic
Stock market crash
Gas prices
The second wave of crisis
Boguchany HPP launched
Russia has joined the WTO

Gazprom partners with KOGAS to develop LNG projects...

Gazprom is ready to expand cooperation with South Korea's KOGAS in the area of LNG.

As part of EEF 2019, a working meeting was held between Gazprom's head Alexey Miller and KOGAS president and CEO Hee-Bong Chae.

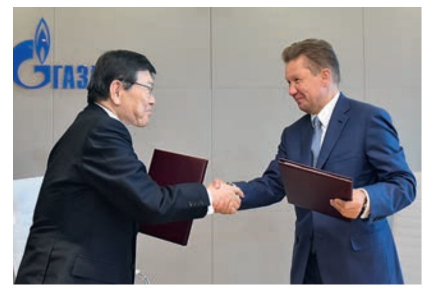
Back in September 2018, as part of EEF 2018, the head of Gazprom discussed forming a partnership with the former president and CEO Seung-Il Cheong,

At the time, the main focus was on developing cooperation in the LNG sphere, however, it was cautiously implied that Gazprom and KOGAS were ready to discuss pipeline gas technologies. Suffice to say, the project was never further developed, and during EEF 2019 Gazprom and KOGAS mainly discussed the dynamics and prospects for interaction in the area of LNG.

Stable LNG supplies under a contract between Sakhalin Energy Investment Company Ltd. and KOGAS were highlighted and praised. Alexey Miller and Hee-Bong Chae expressed interest in further boosting cooperation in the LNG sector and maintaining interaction in the scientific and technical sphere.

...and Mitsui

Alexey Miller held another meeting, this time with Chairman of the Board of Directors of Mitsui & Co. Masami Iijima. During negotiations, the Sakhalin-2 project was given a high assessment. A. Miller and M. Iijima specifically focused on issues of cooperation in the field of small and medium tonnage LNG plants. Mitsui is engaged in the development, purchase, sale, distribution and processing of all types of energy products in Japan and abroad, and also provides financial services.



Gazprom and Mitsui remain partners in the Sakhalin-2 project, which had its first operating LNG plant in Russia turn 10 in February 2019.

Today, the share of Sakhalin LNG in the Asia-Pacific region (APR) is 4.8 % and 3.6 % in the world market.

Mitsui is participating in LNG projects not only with Gazprom, but also with NOVATEK.

In 2014 the company, along with Sovcomflot (SCF) and Teekay LNG, was included in the list of company partners for the Yamal LNG project. Furthermore, in June 2019, Mitsui and JOGMEC acquired a ten percent stake in NOVATEK's Arctic LNG 2 project, slated to commence operations in 2021 – 2022.

Rosatom and the Ministry of Natural Resources solve Arctic problems

Rosatom CEO A. Likhachev and Minister of Natural Resources and the Environment D. Kobylkin have signed an agreement on cooperation.

According to D. Kobylkin, this agreement defines the basis for cooperation in implementing state programmes and the national project "Ecology".

Additionally, the agreement provides for developing joint proposals in order to implement the state policy in the Arctic zone of the Russian Federation.

This implies identifying promising areas of research in terms of development and resource exploration, environmental safety, as well as the study and conservation of unique natural ecosystems.

In 2019, Rosatom is due to begin developing the state information system and the federal roadmap necessary for implementing the Federal Project "Creation of Infrastructure for Safe Handling of Class I and II Hazardous Waste".

In the near future the Russian government is set to determine the federal operator for the handling and treatment of industrial waste.

BIG PLANS FOR RUSSIAN LNG

Irina Gerasimova

AS OF TODAY, RUSSIA HAS TWO LARGE-CAPACITY GAS LIQUEFACTION PLANTS, WITH A TOTAL DESIGN CAPACITY OF APPROXIMATELY 26 MILLION TONS OF LNG PER YEAR. BUT BY 2025, THIS FIGURE SHOULD EXCEED 40 MILLION TONS, ACCORDING TO GOVERNMENT ESTIMATES. PLANS FOR THE SUBSEQUENT YEARS ARE EVEN MORE AMBITIOUS – TO BECOME ONE OF THE TOP THREE LEADERS IN GLOBAL LNG PRODUCTION

Russia eyes greater dominance in LNG production

2018 was a breakthrough year for Russian LNG production: Yamal LNG reached its full capacity ahead of schedule. This is the second largest gas liquefaction plant in the country. The first plant has been operating since 2009 as part of the Sakhalin-2 project.

Last year, LNG production in Russia sharply increased by 70% – up to 20 million tons from 11.8 million tons in 2017. According to the Analytical Center under the Government of the Russian Federation, 19.8 million tons went to foreign markets, which is 69% more than in 2017. Countries of the Asia-Pacific region accounted for 70% of exports, Europe accounted for 24%, while America and the Middle East accounted for 6%.

During 2017–2018 Russia increased its participation in the global LNG market from 4% to about 8%, according to estimates by Russian Minister of Energy Alexander Novak. And the government intends to increase this figure. By 2025, the total capacity of gas liquefaction plants in Russia should augment to 41.2 million tons, and the share of Russian LNG – up to 15%, according to information presented by Alexander Novak during a Cabinet meeting in October 2018.

By 2035, it is planned to increase LNG production in Russia up to 120–140 million tons per year, and Russian LNG plants will account for up to 20% of LNG plants in the world, cited Alexander Novak in June. At the same time, Russia should enter the top three global leaders in terms of LNG export. The government is counting on the increase of global LNG demand (up to 600 million tons by 2035), on the one hand, and also on the country's vast resource base and its advantageous geographical position, on the other. However, it is imperative that companies comply with previously announced plans to create new gas liquefaction facilities.

FACTS

41.2 million tons

Total capacity of gas liquefaction plants in Russia by 2025

Several projects for liquefying natural gas are being prepared for implementation. Many of them were announced at the beginning of the decade and were due to start operations by 2020. However, a considerable part of the plans and projects were revised due to unforeseen circumstances – after 2014 energy prices tumbled and due to sanctions against Russia, it was difficult to attract financing from the West.

It is worth noting that competing countries at that time also delayed the commissioning of new gas liquefaction facilities. Nonetheless, according to Vygon Consulting, at year-end 2018, 16 projects with a total capacity of 93 million tons (over half of them in the USA) were under construction around the world, and facilities producing 87 million tons are planned to be commissioned until the end of 2025.

Upcoming projects

According to the report of Alexander Novak, by 2025 Russia will have launched the projects Arctic LNG 2 and Baltic LNG, additionally, expanding LNG production as part of Sakhalin 2.

TABLE. Existing Russian large-scale LNG projects

No.	Project	Operator and shareholders	Estimated capacity, mln tons of LNG per annum	Commissioning deadline	Resource base
1.	LNG plant on Sakhalin (Sakhalin-2)	Sakhalin Energy (Gazprom – 50% plus one share, Shell – 27.5% minus one share, Mitsui – 12.5%, Mitsubishi – 10%)	1 train – 4.8 2 train – 4.8	2009 2010	Piltun-Astokhskoye and Lunskoye (total gas reserves of 633.6 billion m^3)
2.	Yamal LNG	Yamal LNG (NOVATEK – 50.1%, Total – 20%, CNPC – 20%, Silk Road Fund – 9.9%)	1 train – 5.5 2 train– 5.5 3 train– 5.5 4 train (planned) – 0.9	2017 2018 2018 2019	South Tambey field (proven and projected gas reserves according to PRMS standards – 1.002 trillion m^3)

Source: *company data*

The largest of these projects is the Arctic LNG 2 project of NOVATEK. Foreign partners have been engaged, FEED documentation has been prepared, EPC-contracts have been signed and most of the equipment has been contracted.

Three LNG trains are envisaged (each producing 6.6 million tons of LNG per year): the first LNG train is planned to be launched within four years, the last one should be implemented within six years. According to several experts, the enterprise may begin operations ahead of the announced schedule – as has already happened with Yamal LNG. Analysts predict that the future plant may become one of the most competitive in the world.

NOVATEK did not ask for subsidies for Arctic LNG 2, as was the case with Yamal LNG, so as not to expose the project to the risk of sanctions. However, the project will be able to enjoy tax benefits. Furthermore, the government is investing in the infrastructure of the Northern Sea Route, which is necessary for the transportation of Yamal LNG. The government will also provide subsidies for the construction of a tanker fleet for transporting LNG from Arctic LNG 2.

Another important project for Russia is expanding the capacity of Sakhalin's LNG plant owned by Sakhalin Energy (controlling stake belongs to Gazprom). Today, the plant operates with an excess of the design capacity (9.6 million tons of LNG per year) and in 2018 production amounted to around 11 million tons.

There are plans to construct a third LNG train with a capacity of 5.4 million tons of LNG per year. Gazprom and Shell signed the corresponding memorandum in 2015, and by now FEED documentation is ready. However, construction has not begun.

There are several reasons for the delay, but experts claim the main one is uncertainty in regard to the resource base. At first it was planned to use gas from the Sakhalin-3 project of Gazprom, but its largest field – Yuzhno-Kirinskoye – fell under American sanctions. It became impossible to develop the oil deposits of Yuzhno-Kirinskoye field, and this postponed the start of gas production to 2023.

There were also negotiations with Exxon Neftegas Limited on the purchase of gas from the Sakhalin-1 project, but the parties did not reach agreement. Rosneft and Exxon want either an advantageous offer or independently liquefy Sakhalin-1 gas by building their own refinery.

However, the expansion of the Sakhalin-2 LNG plant remains on the agenda. What is more, the topic was discussed in July during President Vladimir Putin's meeting with Shell President Ben van Beurden.

The third major project to be launched by the middle of the next decade is Baltic LNG in Ust-Luga. Gazprom initially planned to build a plant with its long-standing partner Shell. Potential participants include the Japanese companies Mitsui and Itochu Corporation.

However, in March it was announced that Gazprom would build a complex near Ust-Luga in partnership

FACTS

93

million tons

Total capacity of 16 projects worldwide under construction at the end of last year

with RusGazDobycha JSC (owned by Artem Obolensky). The complex will combine ethane-containing gas processing (45 billion m^3 of gas per year) and LNG production (13 million tons per year) on one site. Moreover, the complex will produce ethane and LPG.

The commissioning of the first phase of the complex is scheduled for the second half of 2023, the second phase is due to begin operations by the end of 2024. The total project cost is estimated to be at least 700 billion rubles. In August, it emerged that Gazprom asked the government to support the construction of the new facility, in particular, offering to finance the initial stage of the project through a contribution to VEB Capital.

Possible projects

In addition to the above-mentioned projects, during the period 2025-2035, several more gas liquefaction projects could be implemented.

By 2025, Rosneft, with its partners, could still build Far East LNG in order to liquefy gas from the Sakhalin-1 project. Production will be based in the village of De-Kastri in Khabarovsk Krai, where the oil-loading terminal of Exxon Neftegas Limited operates.

NOVATEK is preparing to further advance its experience in setting up production facilities as part of the Arctic LNG 3 project. Now NOVATEK is conducting geological exploration in the Severo-Ob area in the Ob Bay area, where a field with reserves of at least 320 billion m^3 was discovered last year. In the future, there are plans to construct a large-scale LNG production plant in this area. In any case, NOVATEK intends to expand its activities: the company's strategy provides for the production of 57 million tons of LNG by 2030. Within the next two years, the company promised to revise its strategy and increase the target to 70 million tons per year.

Another project that can be expected in the next decade is Pechora LNG, implemented by the company ALLTECH (Dmitry Bosov). In 2015, Rosneft bought 50.1% of Pechora LNG. However, last year the state-owned company deemed the project unpromising and reduced the package value to 1%.

The project has a small resource base, with no possibility of expansion. Moreover, the state denied Pechora LNG the opportunity to export products. One of the reasons was that the project potentially created excessive competition in regard to Gazprom in Europe, according to Pavel Zavalny, Chairman of the State Duma Committee on Energy, in his interview to Vedomosti in February. Thus, the prospects for Pechora LNG are not yet clear.

The future of a possible Gazprom LNG project on the basis of the Shtokman field is also unclear. As of today, the development of the field has ceased.

Low and medium tonnage production

In the coming years, NOVATEK plans to build another plant near Sabetta – the relatively small Ob LNG, which includes three trains each with a capacity of about 1.6 million tons per year. An investment solution is expected next year and the launching of the first stage is set for the end of 2022. This plant will be different in that it will operate based on a Russian technology of gas liquefaction.

Medium-tonnage plants also include Gazprom's Vladivostok LNG. Seven years ago, Gazprom planned to launch a plant with a capacity of 10 million tons per year near Vladivostok. There were plans to take raw materials from the Chayandinskoye field (this gas is now supplied to China), or from Sakhalin-3 (but development of the Yuzhno-Kirinskoye field had to be postponed). Vladivostok LNG now envisages a plant with an output of 1.5 million tons per year and the LNG produced will be used for the bunkering of ships. This will be the first such facility in the region. Construction may begin in 2020.

The North-East of Russia already has medium and low tonnage LNG plants. For instance, Kriogaz-Vysotsk operates in the Baltic (51% – NOVATEK, 49% – Gazprombank) and the first LNG train with a capacity of 660 thousand tons per year has been launched. The second train (1.1 million tons) will be completed in 2020. Kriogaz-Vysotsk produces bunker fuel and LNG for export and the domestic market.

Technologies and equipment

Western sanctions have steered clear of LNG technologies, but experts do not exclude that for now. The possible increase of pressure from the US and the EU is seen as one of the key risks in the industry.

In Russia, there is no proprietary technology for large-scale liquefaction methods. Shell's dual mixed refrigerant (DMR) technology is used for Sakhalin-2, while American Air Products' C3MR technology is used for Yamal LNG. Arctic LNG 2 plans to use the German Linde technology. In the meantime, Baltic LNG is negotiating with both Shell and Linde.

We have our own developments, but so far they are applied in a limited extent. NOVATEK has developed the Arctic Cascade gas liquefaction technology, which uses the natural cold of the environment. The technology is

FACTS

2-

fold increase

of Russia's participation in the global LNG market during 2017–2018

more cost-efficient than the C3MR technology, and better suited for use in the northern latitude. Furthermore, it paves the way for using domestic equipment. The fourth LNG train of Yamal LNG will be launched based on the Arctic Cascade technology; it will also be used at NOVATEK's Ob LNG.

In 2017, Gazprom signed a contract with the company Cryogenmash (OMZ Group) in order to develop a production technology for up to 100 tons of LNG per hour (0.87 million tons per year). Project participators also include Giprokislorod (OMZ Group), Gazprom VNIIGaz and HMS Group. It was reported that the pilot and industrial operation of the first installation would begin in 2020. Looking forward to the future, large enterprises could be created on the basis of such installations.

It is worth noting that a year ago, the government approved a roadmap for localizing crucial equipment for medium and large capacity LNG facilities and the construction of gas carrier vessels. Several domestic enterprises are already working on the necessary machines and materials. Severstal, working for Gazprom, is manufacturing design elements of LNG storage tanks from innovative cryogenic low-carbon steel. The joint venture of Power Machines and Linde in St. Petersburg produces heat exchange equipment for gas liquefaction plants, which will be purchased by Gazprom and NOVATEK. Products of the HMS Group are used by NOVATEK to liquefy gas using the Arctic Cascade technology.

Shipbuilding for LNG projects is also being conducted in Russia. For instance, the fleet of Arc7 ice-class gas carriers for Arctic LNG 2 will be built at the Zvezda shipyard.

Up to 80% of bulk equipment and materials could be provided by Russian enterprises in the near future, and for critical positions within the next five to seven years, announced Alexander Novak last year. According to the Minister of Energy, this will almost completely eliminate dependence on imports.

THE STATE OF THE MINERAL RESOURCE BASE OF HYDROCARBONS IN RUSSIA

ASSESSING THE STATE OF THE MINERAL RESOURCE BASE OF CRUDE OIL AND GAS FOR RUSSIA IS OF PARAMOUNT IMPORTANCE. SINCE THE MIDDLE OF THE TWENTIETH CENTURY, THE SOVIET UNION, AND AFTERWARDS RUSSIA, OCCUPIED THE LEADING POSITION IN THE WORLD IN TERMS OF HYDROCARBON RESERVES. WHAT IS THE CURRENT STATE OF THE MINERAL RESOURCE BASE IN RUSSIA?

UDC 558.981

KEYWORDS: *mineral resource base, crude oil, gas, hydrocarbon reserves, growth of reserves.*

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During the past decade our country has given up its positions in terms of oil and gas reserves and currently, according to the International Energy Agency, Russia ranks second in terms of gas reserves and sixth in terms of oil reserves.

The assessment of the hydrocarbon resource base rests upon the oil and gas geological zoning of the territory, where prospective zones of oil and gas accumulation are determined at intervals of 5–10 years according to the results of geological exploration.

TABLE 1. State of the resource base of crude oil of the Russian Federation (land and sea areas) as of 01.01.2018

Prospective resources (recoverable)	Prepared (D_0)	Prospective + projected (D_1+D_2)
OIL		
Volume, billion tons	13.9	43.9
change in relation to resources on 01.01.2009 billion tons	1.9	-9.4
share of distributed Fund, %	52.6	33.8
CONDENSATE		
Quantity, billion tons	1.9	11.3
change in relation to resources on 01.01.2009 billion tons	-0.4	-0.3
share of distributed Fund, %	61.3	19.8
Reserves (recoverable)	**AB_1C_1**	**B_2C_2**
OIL		
Volume, billion tons	18.5	11.3
change in relation to resources on 01.01.2009 billion tons	1.3	1.8
share of distributed Fund, %	96.6	92.2
CONDENSATE		
Quantity, billion tons	2.3	1.7
change in relation to resources on 01.01.2009 billion tons	0.4	0.2
share of distributed Fund, %	98.4	94.6

ТАБЛИЦА 2. State of the resource base for free gas and gas caps of the Russian Federation (land and sea areas) as of 01.01.2018

Prospective resources	Prepared (D_0)	Prospective + projected (D_1 + D_2)
GAS		
Volume, billion tons	34.1	157.2
change in relation to resources on 01.01.2009 billion tons	1.2	-12.0
share of distributed Fund, %	66.5	11.4
Reserves	**AB_1C_1**	**B_2C_2**
GAS		
Volume, billion tons	49.5	23.8
change in relation to resources on 01.01.2009 billion tons	1.3	3,9
share of distributed Fund, %	97.4	93.7

The state of the resource base for oil and condensate in the Russian Federation (land and sea areas) as of 01.01.2018 is presented in Table 1, and for gas in Table 2.

The total initial resources (TIR) for each quantitative assessment continuously increase by 5–7%, however, the incremental resources predicted in the previously unaddressed oil and gas prospective zones and oil and gas complexes at the regional stage of geological exploration are practically not involved in reconnaissance surveys.

This is because companies are not interested in investing in geological exploration activities in new directions and in areas with undeveloped infrastructure, while the demand-supply situation and the price of hydrocarbons in the foreign market remain high, and while the state is not engaged in exploration works.

Much greater success in the production of reserves can be achieved with the direct participation of the state when conducting exploration operations as well as monitoring companies in this direction.

According to the results of a quantitative assessment of the resources of oil, gas and condensate of the Russian Federation, as of 01.01.2009, the total initial resources of the Russian Federation were: oil – 111,415.1 million tons, extracted. (including sea areas – 94,024.5 million tons); free gas – 287460.2 billion m^3 (including sea areas – 106690.6 billion m^3); condensate – 17813.1 million tons, extracted (including sea areas – 5064.3 million tons).

In the TIR structure of land oil of the Russian Federation, as of 01.01.2018, the cumulative production is 35%, reserves of category A+B_1+B_2+C_1+C_2 – 30%, resources of category D_0 – 10%, resources of category D – 25%.

In the TIR structure of shelf oil of the Russian Federation, as of 01.01.2018, the cumulative production is 1%, reserves of category A+B_1+B_2+C_1+C_2 – 8%, resources of category D_0 – 26%, resources of category D – 65% (Fig. 1, 2).

As of 01.01.2018, the TIR structure of oil in the oil and gas provinces is presented in Figure 3.

During the period 2009–2017 Russia experienced an increase in oil reserves (exploration and reappraisal) which amounted to 5,751 million tons. During the same period, 4,475 million tons was produced. Thus, the increase in reserves compensates for production by a ratio of 1.3:1 (Fig. 4).

From Figure 5, it can be seen that the increase of oil due to exploration and reappraisal during this period was carried out mainly at the

FIGURE 1. TIR structure of oil in the Russian Federation (land)

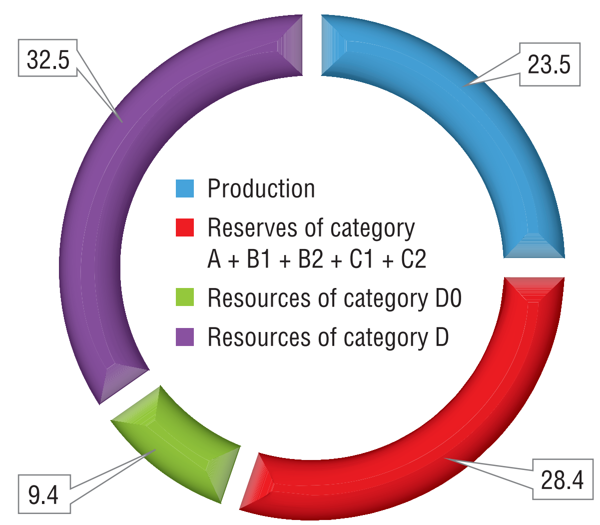


FIGURE 2. TIR structure of oil in the Russian Federation (shelf)

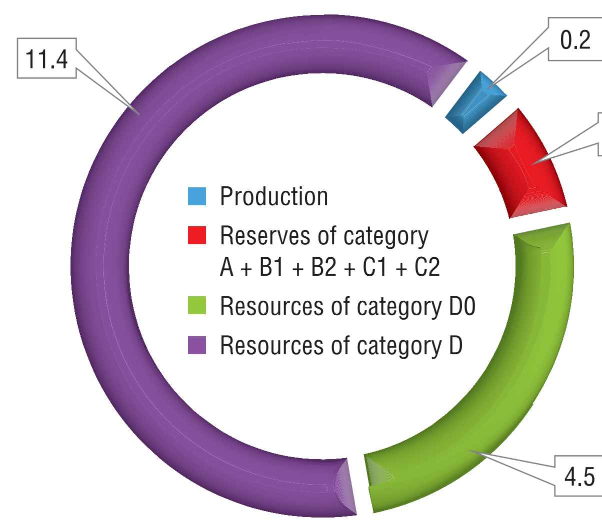


FIGURE 3. TIR structure of oil in the oil and gas geological zoning of the Russian Federation (land)

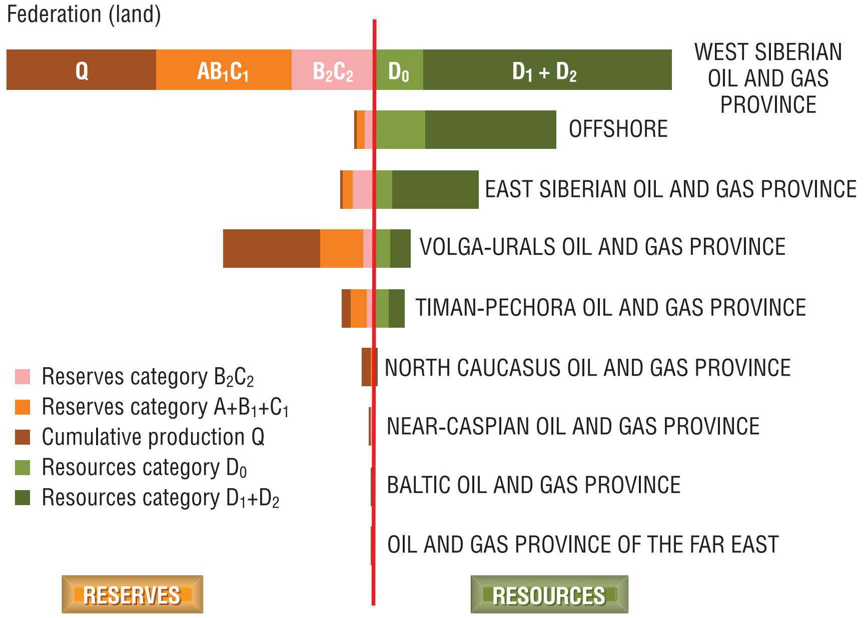


FIGURE 4. Dynamics of annual production and the increase of extractable oil reserves due to exploration and reappraisal

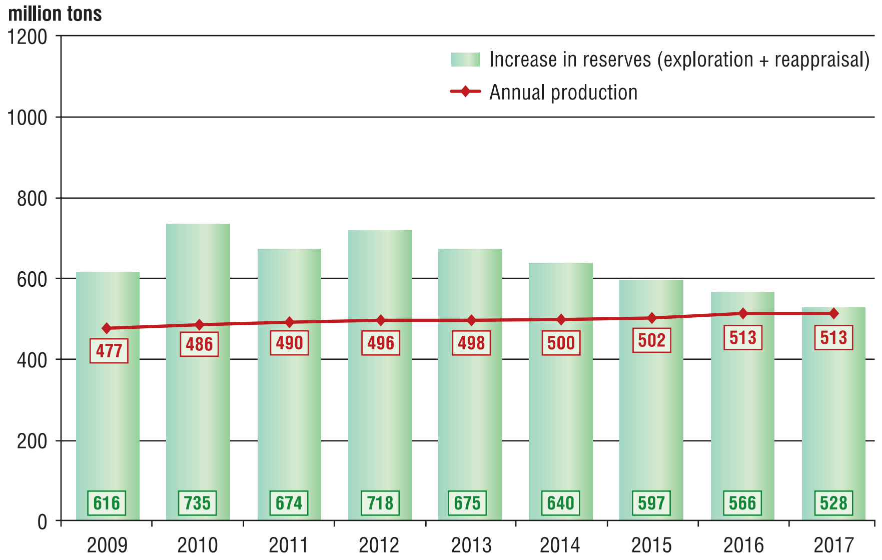
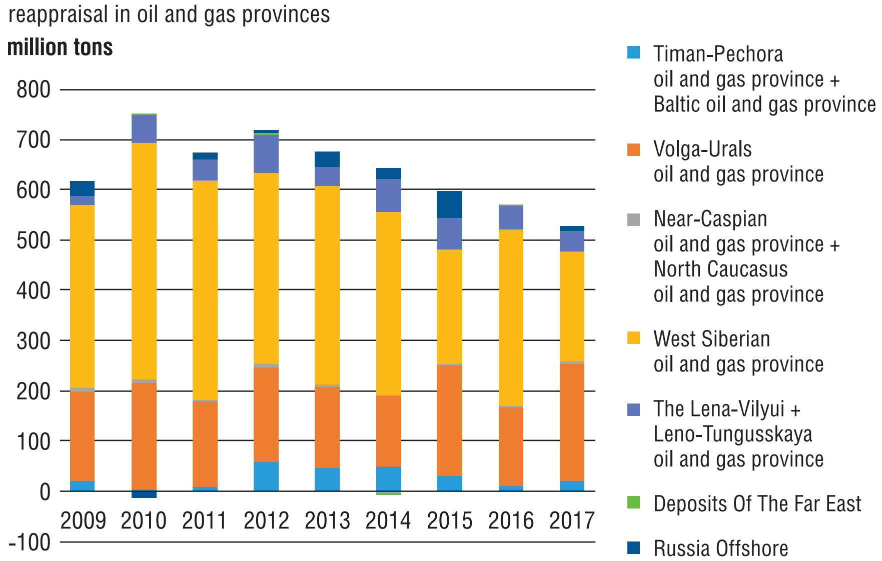


FIGURE 5. Distribution of the increase in extractable oil reserves due to exploration and reappraisal in oil and gas provinces



expense of the West Siberian and Volga-Ural oil and gas provinces (OGP). Moreover, for almost the entire period, the West Siberian OGP experienced the most growth. The Volga-Ural OGP exceeded the growth in reserves of the West Siberian OGP only in 2017.

In the structure of TIR in terms of free gas (land) in the Russian Federation, as of 01.01.2018, the cumulative production accounts for 12 %, reserves of category $A + B_1 + B_2 + C_1 + C_2$ – 33 %, resources of category D_0 – 12 %, resources of category D – 43 % (Fig. 6).

In the TIR structure of free gas (shelf) of the Russian Federation, based on data as of 01.01.2018, cumulative production is 0.5 %, reserves of category $A + B_1 + B_2 + C_1 + C_2$ – 12 %, resources of category D_0 – 12 %, resources of category D – 75.5 % (Fig. 7).

As of 01.01.2018, the TIR structure of gas in terms of oil and gas provinces is presented in Figure 8.

During the period 2009 – 2017, the Russian Federation experienced an increase in free gas reserves (exploration + reappraisal) and this amounted to 6,833 billion m^3. During the same period, 5,520 billion m^3 was produced. Thus, the increase in reserves compensates for gas production in the ratio of 1.2 : 1 (Fig. 9).

From Figure 10 it can be seen that gas growth due to exploration and reappraisal during this period was mainly carried out at the expense of the marine environment of Russia and the West Siberian OGP. Moreover, for almost the entire period, gas growth in the West-Siberian OGP was the highest. However, large debookings of reserves – 483,804 billion m^3 – were carried out in the in the West Siberian OGP in 2017. Large debookings were also made in 2017 in the East-Siberian megaprovince, in the Far East and insignificant ones in the Timan-Pechora OGP.

According to the proposals of the All-Russian Geological Research and Development Oil Institute, the All-Russia Petroleum Research Exploration Institute, the Siberian Research Institute of Geology, Geophysics and Mineral Resources,

FIGURE 6. The TIR structure of free gas in the Russian Federation (land)

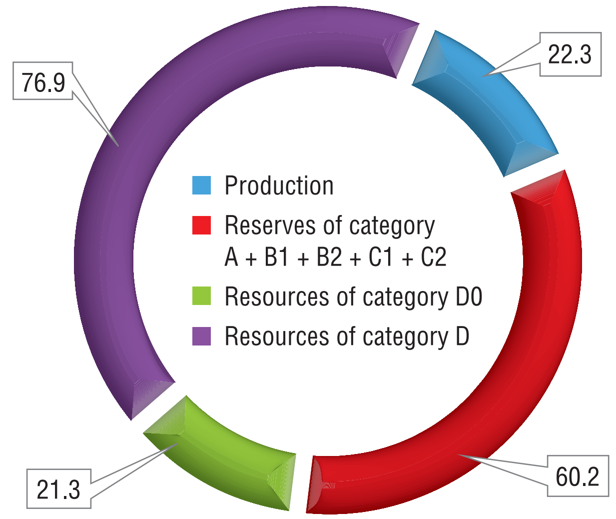
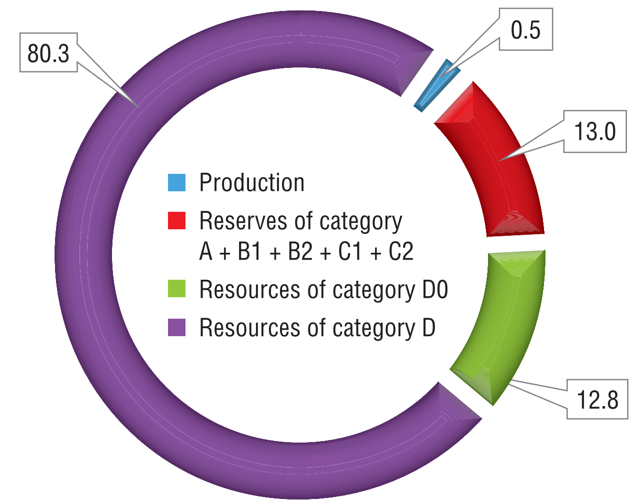


FIGURE 7. The TIR structure of free gas in the Russian Federation (shelf)



the Lower Volga Research Institute of Geology and Geophysics, the West-Siberian Research Institute of Geology and Geophysics, the Shpilman Research-Analytical Centre and ZAO SibNRC, 26 zones have been distinguished, 5 of which are priority areas for regional work. They are the Ozinsk-Almatinsk, Karabash, Yugansk-Koltogorsk, Argishk-Chunsk and Gydano-Khatanga zones (Fig. 11).

According to the results of the regional work in 2013 – 2017. 83 new subsoil licenses have been issued in these zones. The most successful licensing is found in the Karabash, Yugansk-Koltogorsk and Gydan-Khatanga zones. The total one-time payment amounted to 35.6 billion rubles. As of 01.01.2018, eight oil fields have been opened with total extractable deposits in the category $C_1 + C_2$ – 72.7 million tons. Six of them have production licenses, and their one-time payment amounted to 31.7 billion rubles, which is 3 times higher than the total cost of regional work (12 billion rubles) spent from the Federal budget.

As a result of the new geological information and reappraisal of resource potentials, it became necessary to adjust the list of priority areas. Based on the degree of geological knowledge and prospects, the following list is proposed:

1. Gydano-Khatanga (Anabaro-Khatanga)
2. Argishsk-Chunsk

FIGURE 8. The TIR structure of free gas in terms of the oil and gas geological zoning in the Russian Federation

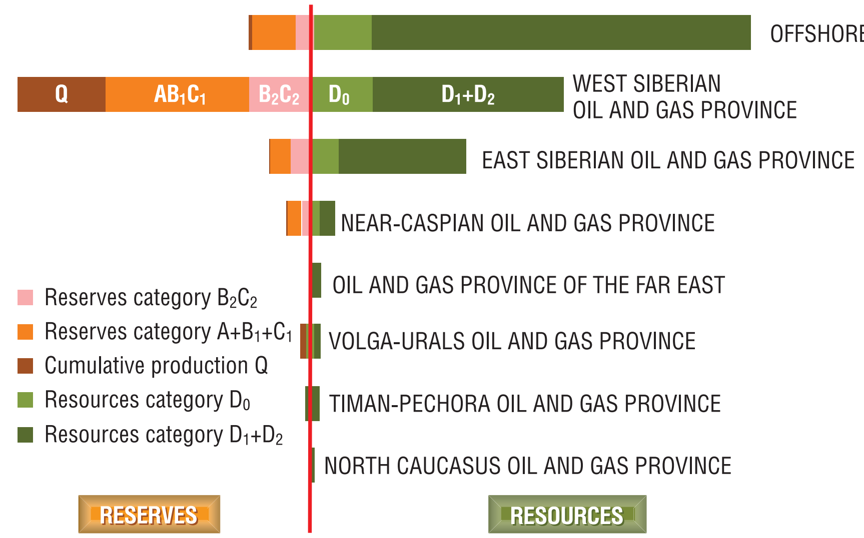


FIGURE 9. Dynamics of annual production and growth of extractable reserves of free gas and gas caps due to exploration and reappraisal

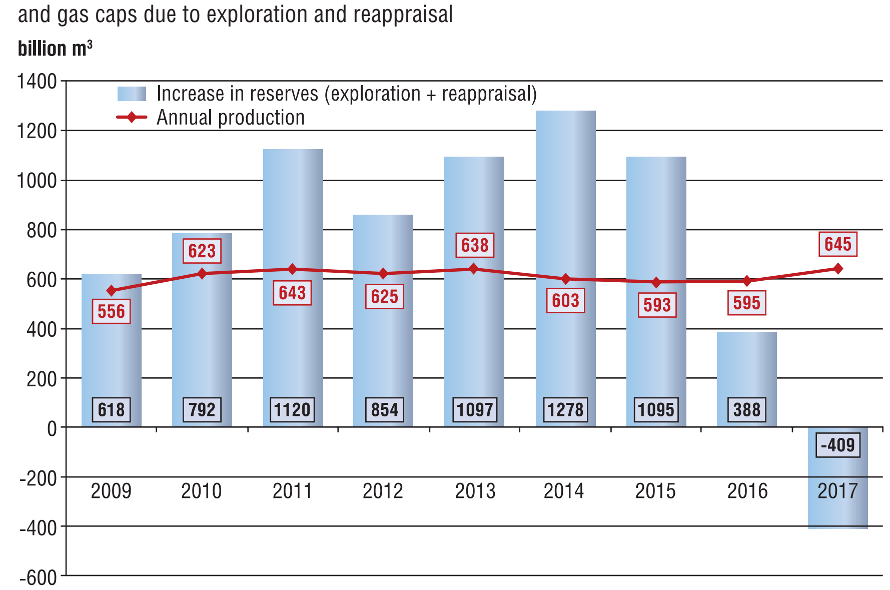


FIGURE 10. Distribution of augmentation in extractable reserves of free gas due to exploration and reappraisal in oil and gas provinces

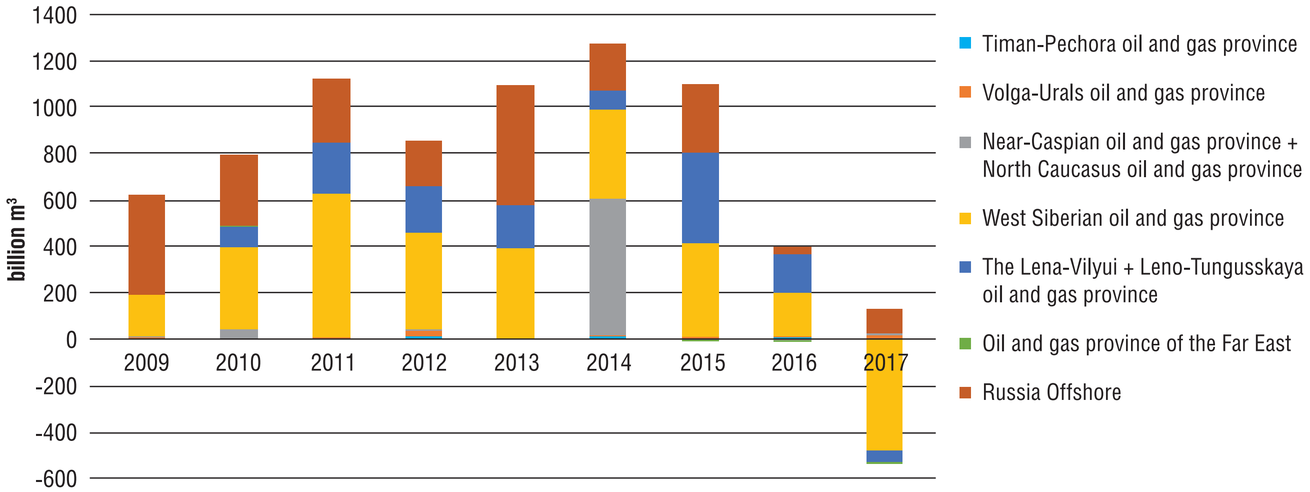
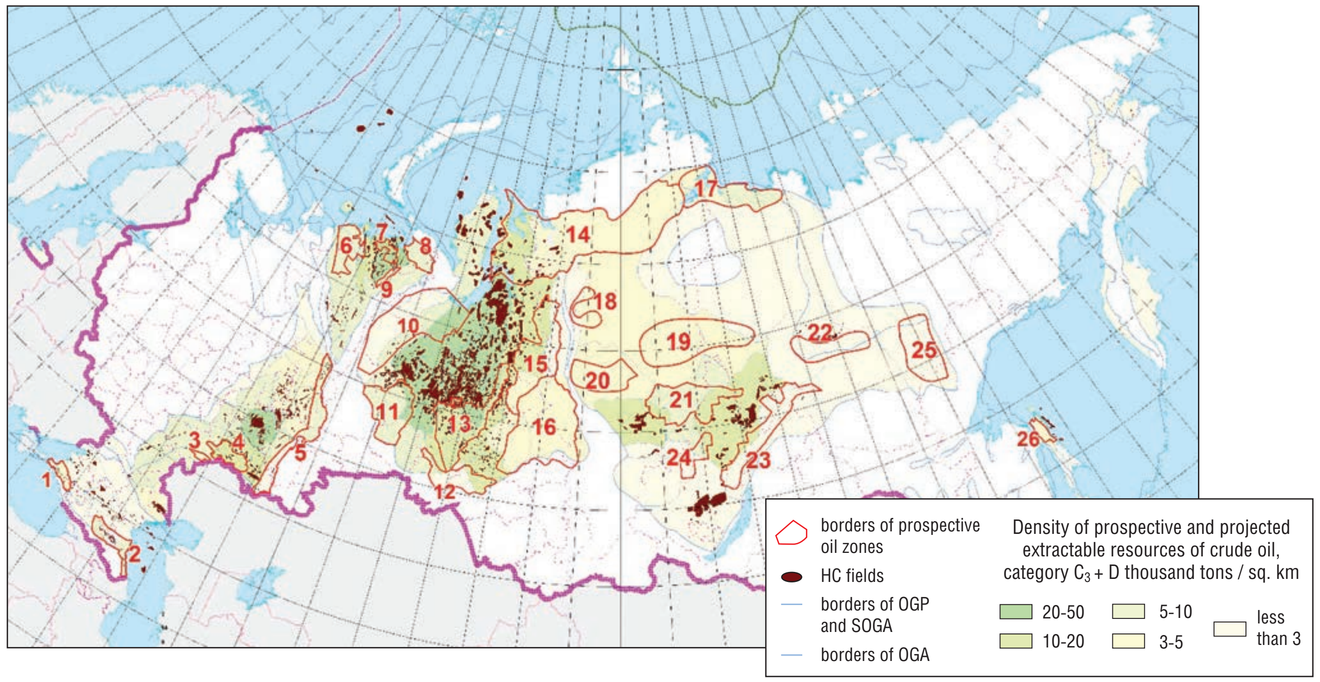


FIGURE 11. Overview map of prospective oil and gas zones in the Russian Federation



3. Kochechumsk-Markhinsk (Cambrian Reef development zone)

4. Predverhoyansk (Predverhodyansk-Maysk)

5. Preduralsk (Yuzhno-Preduralsk, Mid-Preduralsk).

It should be noted that budget allocations for regional work increased compared to 2009 (in 2009, Federal budget expenditures on exploration amounted to 8.9 billion rubles, and in 2017 – 12 billion rubles), but physical volumes of geological exploration remain at about the same level. This is due to the fact that currently there is a rapid increase in prices for materials and equipment used in the exploration process. According to expert estimates, the costs of geological exploration have increased 2–4 times over the past five years.

Despite the difficulties, Russia has had a steady average global trend in the development of the mineral resource base of hydrocarbons. Moreover, unlike most countries, Russia has not lost the potential for extensive development in building up oil and gas reserves. ●

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NEW GENERATION LINES FOR DIAGNOSTICS AND REPAIR OF TUBING AND SUCKER RODS

TMC Group presents TMC-Hightech and TMC-SRLine of in-house production

UDC 622

MAINTENANCE SERVICE AND REPAIR OF DEEP-WELL PUMPING EQUIPMENT – TUBING, SUCKER ROD PUMPS AND SUCKER RODS – FROM THE START OF MECHANIZED OIL PRODUCTION ARE EXTREMELY IMPORTANT TASKS FOR ANY OIL AND GAS PRODUCING COMPANY AND OIL SERVICE CORPORATION. ALONG WITH THE CONSTRUCTION OF FACILITIES AT NEW OIL AND GAS FIELDS, COMPANIES PAY SPECIAL ATTENTION TO THE SERVICE BLOCK AND THE TECHNOLOGIES AND EQUIPMENT USED IN IT. IT IS NO SECRET THAT THE INCOMING INSPECTION CONTROL OF NEW OR REPEATED INVOLVEMENT AND DESCENT OF REPAIRED DEEP-WELL PUMPING EQUIPMENT (DPE) INTO AN OIL WELL ALLOWS ENTERPRISES TO SIGNIFICANTLY SAVE MONEY, SOMETIMES UP TO 80 %. THE FIRST SCENARIO IS TO ELIMINATE THE RISK OF LOWERING POOR-QUALITY UNITS INTO WELLS, THEREBY EXCLUDING REPEATED WORKS; THE SECOND SCENARIO IS WHEN THE WELLS ARE EQUIPPED WITH REPAIRED EQUIPMENT, WHICH EQUALS NEW EQUIPMENT IN QUALITY AND RUN LIFE

KEYWORDS: *service, deep-well pumping equipment, sucker rods, compressor pipes, diagnostics.*

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In order to comply with the latest conditions, the diagnostics and repair of DPE must be carried out on specialized lines equipped with modern equipment with the necessary performance and level of automation, and meet the requirements of GOST (state standard) and lean manufacturing in terms of the quantitative and qualitative components of operations. Another key factor is the low cost of diagnostics and repair of one equipment unit, which is achieved by way of high productivity of lines, a competent planning solution for arranging equipment and organizing jobs, as well as minimizing non-production losses. All of the above conditions are met by the new generation lines for the diagnostics and repair of tubing TMC-Hightech and sucker rods TMC-SRLine manufactured by TMC Group.

DPE repair experience taken into account in designing new generation lines

In 2019, TMC Group celebrates its 14th anniversary of successful operations. The company confidently moved from the stage of a young developing enterprise to the status of an experienced player in the oilfield services market, providing customers with a full range of services and a wide variety of equipment.

The development of the company takes place not only domestically – in the Republic of Tatarstan and Russia, but also outside the country on a global scale. Today, TMC Group, by studying the experience of domestic and foreign companies, as well as applying its own unique methods and knowledge base, is creating new techniques/methods and technologies. These new developments allow customers to save funds, including in the area of import substitution and resource conservation. Examples of such products are: the production line for diagnostics and repair of tubing TMC-Hightech and sucker rods TMC-SRLine.

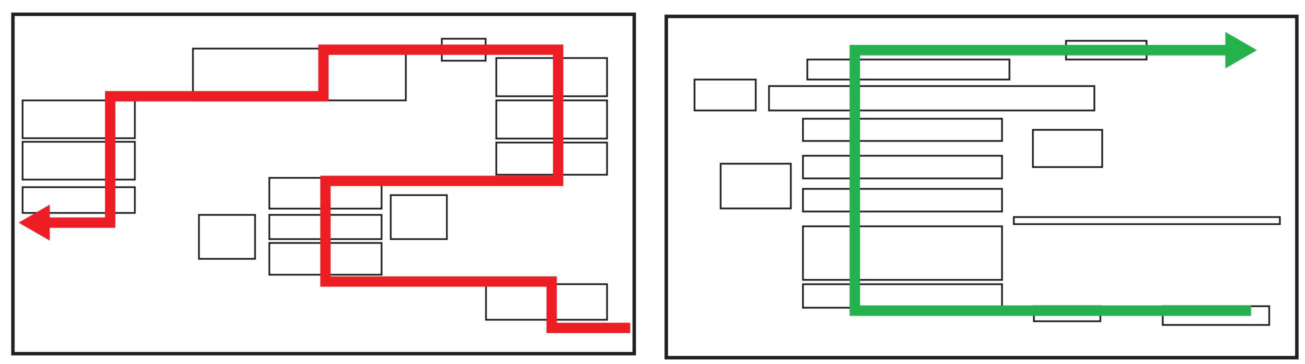
FOTO 1. Tubing line

TMC Group, being one of the main service providers in the field of tubing and sucker rod services in Russia, has gained serious professional experience in operating the relevant lines. As a result, today we are able to offer our customers turnkey solutions for the construction of production lines and their subsequent maintenance.

Thus, with the help of our company, more than 15 lines for the diagnostics and repair of tubing and sucker rods have been developed, built and upgraded in total. Large oil companies such as PAO Surgutneftegaz and PAO Rosneft already use our new methods to repair equipment and also we have our in-house bases that provide DPE services to numerous Russian oil companies.

Today, technical specialists and designers of TMC Group create unique technological processes taking into consideration current trends and lean manufacturing tools, which provide a new lease of life to equipment under repair. In order to create the lines, based on existing or planned production facilities and customer requirements, the scope of work includes individual design, manufacture and installation of metallic structures for the transportation system, technological equipment, automation and electrification systems, as well as the modernization of existing technologies. The lines use only modern high-tech equipment, mechanisms and components of domestic and foreign production.

TMC Group is actively implementing and using lean manufacturing tools in its operations: 5C, TPM, TWI, etc. In view of this, the planning solution for repair lines is developed with the maximum reduction in the path of the equipment from



		Before	After
1	Area of facilities, occupied by the line, m²	2 592	540
2	Pipe's route from the repair entrance to the warehouse of finished products, meters	376	84
3	Coefficient of beneficial use of the facilities, tubing/1m²	0.14	0.83
4	Productivity of the complex, pipes per day	380	850
5	Product cycle, pipes per hour	18	40
6	Unfinished products, pipes per shift	219	40
7	Line operators, person/shift	8	5

the loading point to the finished goods warehouse. This eliminates counter flows, congestion in areas and streamlines the movement of DPE. The control system of the conveying line allows to organize flow line production and eliminate the human factor, directing the equipment under repair strictly as intended, from process to process. The control and monitoring systems allow to receive online reports on the state of the DPE located on the production line.

These are not all the advantages of TMC Group and its new products TMC-Hightech and TMC-SRLine.

Tubing Line TMC-Hightech

Today, oil companies and oil service corporations – owners of workshops on tubing diagnostics and repair – are faced with several problems. The first issue is the low quality of repaired pipes resulting in warranty claims for repeated works in wells. Secondly, there is a high percentage of tubing rejection during the repair process amounting to 70% of the total number of pipes delivered to workshops. Thirdly, it is impossible to repair tubing due to hard-to-remove deposits (paraffin, salt, gypsum) owing to the lack of highly efficient washing and cleaning units in companies.

The latter problem does not allow to involve visually suitable tubing to be in re-operations – such pipes are stored "until better times", occupying storage units and workshop areas.

In addition, frequent equipment breakdowns lead to the downtime of lines, reduced productivity and/or to a limited number of operations leading to poor repair levels. Consequently, companies reduce the quality of service provided, lose a significant part of their income and, ultimately, fall short of customers.

The above-mentioned problems arise due to obsolescence and physical deterioration, incompleteness of lines, imperfection of the technological

FOTO 2. Tubing line

process, low qualification of operators, and also owing to lack of working standards.

This is caused by the fact that the main period of construction of the lines occurred in the 2000s and given their average service life of 15–17 years, this has resulted in such dire consequences. In those times, the construction of lines involved several design companies having no in-house experience in tubing diagnostics or repair, and most importantly, no operation lines. Technological lines were developed with high metal consumption, a large number of equipment units, including duplicate ones in order to increase productivity, and complex intricate circuits for moving tubing during repair. There was also the practice of using additional, but not worthwhile processes, for example, ultrasonic treatment of tubing nipples and couplings, etc. Because of this, the transportation system and equipment of the line had to be placed on two or sometimes even three workshop floors, with the area being more than 2,500 m^2. Naturally, this limited oil and oil service companies in terms of the beneficial use of production and storage facilities.

In order to solve the above-mentioned issues, TMC Group specialists have implemented several projects for the technical re-equipment of tubing service lines. As a result, six new lines for diagnostics and repair – TMC-Hightech tubing – were developed and built in Almetyevsk (2 units), Leninogorsk, Aznakaevo and Djalil workshops, while three lines were reconstructed in Bavly, Elkhovo and Leninogorsk workshops. Today the lines operate successfully, providing tubing services to customers throughout Russia.

The new lines made it possible to build two lines, each occupying no more than 540 m^2, on existing production facilities, instead of one line, located on an area of 2,592 m^2, while the rest of the workshop's space is used as a warehouse for storing goods and materials, and also organizing additional manufacturing. The path of tubing movement during repair was reduced 4.5 times from 376 m to 84 m, the quantity of non-finished products between shifts was reduced 5.5 times from 219 to 40 pipes, productivity was increased 2.2 times from 380 to 850 tubing per day and the number of operators was reduced from 8 to 5 persons per shift.

This experience allowed TMC Group to enter the production line supply market.

The TMC-Hightech production line is designed to inspect and repair used tubing in order to determine suitability for further operation in wells and to inspect new incoming pipes. A necessary and sufficient

FOTO 3. Sucker rod pump line

set of operations is performed on the line for effective diagnostics and repair of pipes, taking into account the current requirement standards. The site allows to make tubing services of all sizes, including technological pipes with wear-resistant locks and with an internal polymer anti-corrosion coating.

The TMC-Hightech line is capable of producing new tubing, as it has the necessary control and diagnostics equipment and facilities for mechanical operation and assembly.

The TMC-Hightech line is recommended for oil and oil service companies owning a tubing fleet or planning activities in the field of pipe service.

TMC-SRLine sucker rods

The TMC-SRLine production line was developed the same way as TMC-Hightech, aiming to solve similar problems. It is intended for comprehensive diagnostics and repair of used sucker rods, as well as for inspection of new sucker rods in accordance with GOST 31825-2012 using modern technologies on high-performance equipment.

Specialists of TMC Group and customers who already use the line in their production noted the high productivity of TMC-SRLine – 1,000 rods per day, a rational layout of the technological equipment and, in general, its compactness – 16×32 m (512 m^2). The excellent quality diagnostics of the threaded parts of the rods is achieved due to the mechanization of the stripping process and tool control. It is possible to conduct defectoscopy of rods with centralizing scrapers; production efficiency of the line is increased due to the flow organization of single products.

Positive customer reviews and operating experience of the TMC-SRLine line show that the implemented units and improvements in the diagnostics and repair technology provide companies with high-quality sucker rod service and allow them to achieve the best performance indicators.

* * *

Today, for the successful day-to-day business in conditions of fierce competition, it is necessary to conduct operations in order to reduce production costs by eliminating losses. Efficiency can be improved either by introducing new expensive technologies, making significant investments in updating fixed assets, or improving production flows by reducing losses utilizing lean manufacturing tools, products, and new equipment. TMC Group company has extensive experience in this area and is ready to share it with prospective partners. ●

EXTRACTION OF METHANE FROM HYDRATE-SATURATED PERMAFROST ROCKS BY FLUE GAS INJECTION:

results of experimental modeling

UDC 551.345

AT PRESENT, THE RUSSIAN ARCTIC IS THE MOST PROMISING AND ACTIVELY EXPLORED REGION. THIS IS DUE TO THE DISCOVERY, EXPLORATION AND COMMISSIONING OF NEW OIL AND GAS FIELDS IN THIS REGION. HOWEVER, THEIR DEVELOPMENT IS COMPLICATED DUE TO NUMEROUS FACTORS AND, ABOVE ALL, THE DIFFICULT PERMAFROST-GEOLOGICAL SITUATION ASSOCIATED WITH THE PRESENCE OF A THICK STRATUM OF PERMAFROST, AS WELL AS HYDRATE-BEARING HORIZONS IN THE PERMAFROST ZONE. FURTHERMORE, THE PRESENCE OF HYDRATE ACCUMULATIONS IN THE STRATA OF PERMAFROST ROCKS CAN POSE SERIOUS GEOLOGICAL HAZARDS DURING EXTRACTION OF TRADITIONAL HYDROCARBONS IN THE ARCTIC. IN THIS REGARD, THE AUTHORS PROPOSE A METHOD OF PRELIMINARY DECOMPOSITION OF INTRAPERMAFROST HYDRATES NEAR THE DEVELOPED PRODUCTION WELLS

KEYWORDS: *Arctic deposits, permafrost-geological conditions, hydrate-containing horizons, method for decomposing intrapermafrost hydrates, experimental modeling.*

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Gas hydrates are ice-like crystalline compounds consisting of water and gas molecules. The crystal structure of a gas hydrate is a three-dimensional openwork frame constructed of water molecules in such a way that a large number of cavities are formed in it, partially or completely occupied by gas molecules. One volume of gas hydrate binds about 164 volumes of gas into the gas hydrate state (Istomin and Yakushev, 1992).

Gas hydrates are formed by the interaction of water (or ice) and gas under certain thermobaric conditions (low temperatures and high pressures). In natural conditions, gas hydrates (mainly methane hydrates) are formed both in the bottom sediments of the seas and oceans, and in areas of perennial permafrost. In the permafrost zone, gas hydrates can exist in permafrost horizons, as well as in the stratum of permafrost with a permafrost thickness of more than 300 m. Moreover, relict (metastable) gas hydrate formations may exist in the upper horizons of frozen rocks at depths of up to 150 m. These hydrates were formed in the past under favorable thermobaric conditions and have survived to this day due to the effect of self-preservation of gas hydrates at low temperatures (Chuvilin et al., 2018) and are often observed during drilling shows.

The effect of self-preservation of gas hydrates is that if the conditions for stable existence (pressure reduction) are violated, the hydrate begins to decompose into gas and water, which freezes at a minus temperature, forming a gas-tight ice crust around the hydrate accumulation, thereby preserving the gas hydrate from further decomposition.

Figure 1 shows a contour map layout of the permafrost zone to the north of Western Siberia based on the conditions of the existence of gas hydrate formations in frozen rocks (Fig. 1).

The map shows the existence areas of subpermafrost and intrapermafrost gas hydrate formations, including those under metastable conditions, as well as areas of active gas showings from the upper horizons of the permafrost zone that were recorded during the drilling of engineering, parametric, and production wells. The map shows that the distribution area of stable gas hydrate formations in rocks in the permafrost zone covers a significant part of the considered area above the 64th degree of the northern latitude, with the exception of the southwestern part of the Yamal Peninsula where, in the upper part of the cross section (up to 150 m), relict hydrates may be found. Furthermore, several regions are characterised by the large thickness of frozen strata (more than 300 m), the roof (upper boundary) of the hydrate stability zone will be located inside the frozen stratum, thereby creating favourable conditions for the formation and existence of stable intrapermafrost hydration clusters (Fig. 2). For instance, in the cross section of the permafrost zone in the area of Gydansky Peninsula, the thickness of the zone of possible existence of intrapermafrost gas hydrate clusters is about 150 m.

The experimental and field data accumulated to date have shown that natural gas hydrates are extremely sensitive to various technogenic influences (temperature increase, decrease in formation pressure, interaction with saline solutions and drilling fluids), which bring about their decomposition, accompanied by active gaseous release, changes in thermal and filtration properties, and also loss of mechanical reliability. Ultimately, all this will create additional complications in the process of drilling and well operation during the development of oil and gas fields in the Arctic. These complications include: intense gas flows, release of gas, soil and drilling instruments, cavern formation, gasification around the wellhead and formation of gas craters, erosion of the

FIGURE 1. Contour map layout of the permafrost zone to the north of Western Siberia based on conditions for the existence of gas hydrates in the strata of perennial permafrost rocks

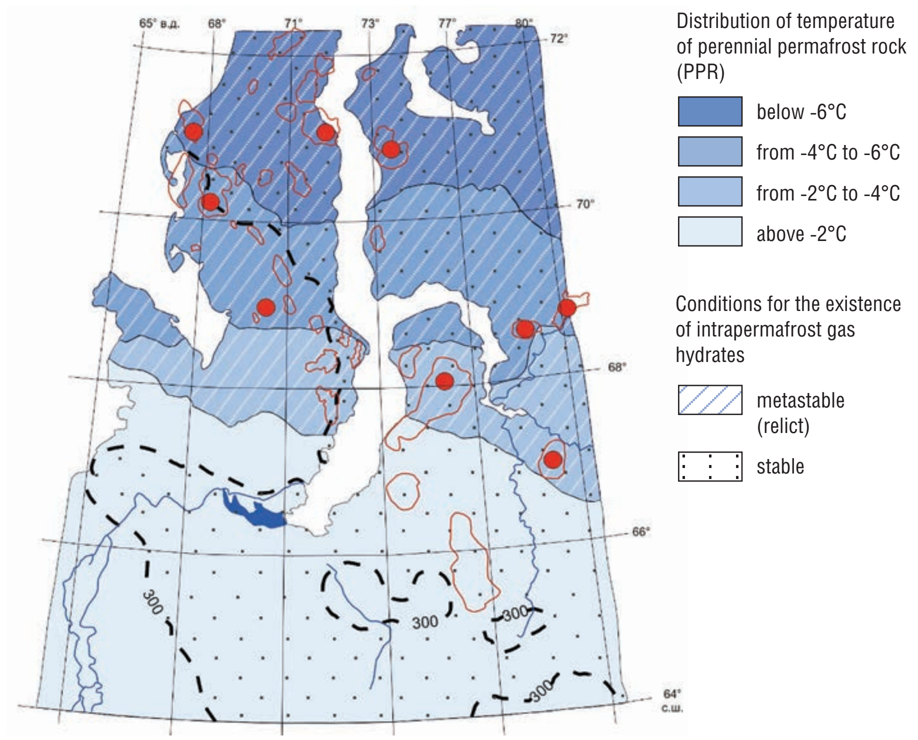


FIGURE 2. Cross section showing the thickness of perennial permafrost rocks and stability zones of gas hydrates in the area of the Gydansky Peninsula (created based on research by S.E. Agalakov and A.R. Kurchikov, 2004)

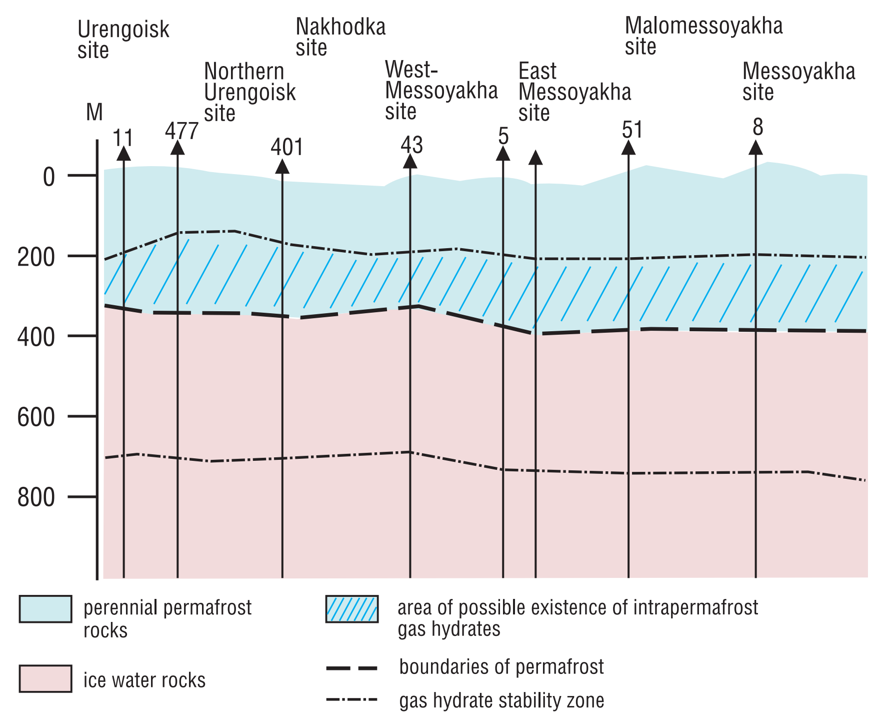
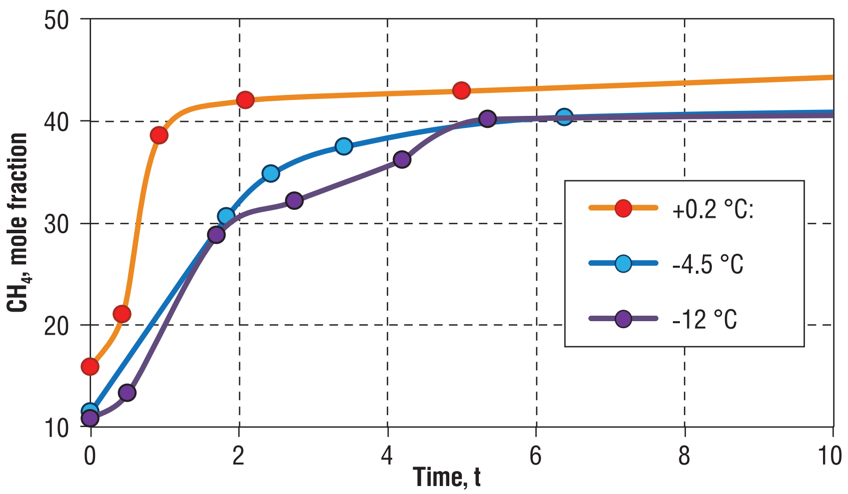


TABLE 1. Main parameters of the experiment and the physical characteristics of the tested sand samples

№	Pressure P, МПа	Temperature T, °C	Moisture content W, %	Density ρ, g/cm³	Porousness n, %	Degree of hydrate saturation S_h,%	Degree of hydrate methane extraction (%)
1	4,2	+0,2	14,4	1,8	38	60	25
2	5,64	-4,5	14,4	1,8	38	66	23
3	4,35	-12	14,4	1,8	41	67	21

FIGURE 3. Dependence on temperature of the degree of methane extraction from hydrate-saturated sand soil during the injection of flue gas



wellhead, collapse and deformation of individual intervals of the wellbore, etc. (Chuvilin et al., 2019).

In this regard, there is the need to reduce the above-mentioned risks beforehand by forcibly dissociating intrapermafrost gas-hydrate interlayers, located in the immediate vicinity of the planned production well before drilling and well operation. The solution to this problem can be based on the use of existing approaches to the decomposition of gas hydrates, proposed for the production of natural gas in the development of hydrate-bearing reservoirs in subaqueous and subpermafrost conditions. Furthermore, apart from solving the main problem, associated with the reduction of geological risks during decomposition of intrapermafrost gas hydrate accumulations, an additional benefit can be obtained in the form of collecting hydrate gas for local energy supply. To date, the main technological approaches for the extraction of hydrated methane from the reservoir are based on thermal exposure, injection of various inhibitors (including pure CO_2), as well as the reduction of formation pressure (Moridis and Collett, 2003; Max and Johnson, 2018).

However, it is worth noting that their implementation is fraught with several technological problems, especially when used in the Arctic (thawing of perennial permafrost sediment, loss of stability of the developed reservoir, secondary hydrate formation in the bottomhole zone, low permeability of frozen hydrate-saturated rocks) (Moridis et al., 2010) . Therefore, in the past few years, other options for the extraction of hydrated gas have been actively considered, the most promising of which is the injection of flue gases (a mixture of nitrogen and CO_2), which has a high potential in relation to frozen hydrate-containing horizons (Chuvilin et al., 2018). When implementing the proposed approach, flue gas can be obtained as a result of the operation of thermal power plants and other industrial enterprises on the territory of a hydrocarbon field. The implementation of this approach involves the replacement of methane hydrate with CO_2 hydrate with the release of free methane. Therefore, the proposed method can also be used for the disposal of CO_2 in hydrated form and for reduction of greenhouse gas emissions into the atmosphere from infrastructure facilities at the field. Upon implementation of this approach for the injection of flue gases into the hydrate-containing horizons of the permafrost zone, three tasks can be solved at once: the reduction of potential geological risks associated with destabilization of hydrate-saturated deposits during field development and exploitation; the extraction of additional hydrated methane; and the reduction of greenhouse gas (CO_2) emissions into the atmosphere due to its disposal in hydrated form.

In order to evaluate the effectiveness of this approach at low plus and minus temperatures, an experimental simulation of methane extraction from hydrate-saturated rocks was conducted by injection of flue gas (mixture of 15% CO_2 and 85% N_2). The tests were carried out on a special installation developed in conjunction with a team from Heriot-Watt University (UK). Fine-grained quartz sand was used as the object for study and it was selected from the bottom sediments of the North Sea shelf.

Experimental studies have shown that the injection of flue gases into the hydrate-containing formation shifts the hydrate stability zone to a zone of lower pressures and higher temperatures. This process leads to the decomposition of methane hydrates, which becomes available for extraction, as well as for the formation of CO_2 hydrates according to the substitution procedure. In order to determine the best conditions for the extraction of methane from cooled and perennial permafrost hydrated saturated sand reservoirs, experimental modeling was carried out in the temperature range from +0.2°C to -12°C with gas pressure approximately 5 MPa.

The experiments lasted about 10 hours until the studied parameters stabilised. The conditions of each experiment, the physical parameters of the samples, and the results (percentage of methane extraction) are shown in Table 1. It was found that in the sand reservoir under study, during the decrease of formation temperature, the efficiency of extracting methane hydrate at the initial stage decreases; by the end of the experiment, the degree of extracting methane hydrate varies slightly (Fig. 3, Table 1).

Thus, if 30 minutes after the start of the experiment at a temperature of +0.2 °C, the methane content in the gas phase was about 21% (at an initial content of about 16 %), then at a temperature of -12 °C this value was close to 13% (at an initial content of 11%), i.e. almost twice as less.

Subsequently (after 1.5 hours), the intensity of methane extraction from the hydrated phase at a plus temperature (+ 0.2°C) sharply decreased, while at a temperature of -12°C this decrease was observed only 5 hours after the start of the experiment. As a result, at the end of the experiment, the methane content in the gas phase was almost the same at the above-mentioned temperatures (Fig. 3).

Therefore, the total extraction of methane from the hydrate phase is comparable at low plus and minus temperatures. It amounted to 25 % at a temperature of +0.2 °C, and 21% at a temperature of -12°C. Consequently, in spite of the decrease in the intensity of methane extraction from the hydrate phase with decreasing temperatures to minus values, the total methane extraction remains quite high. This allows us to consider the flue gas injection method as a promising method for the dissociation of gas hydrate formations located in the strata of frozen rocks.

Conclusion

During experimental modeling on the effect of temperature on methane extraction from hydrate-saturated rocks during flue gas injection, it was revealed that in the range of minus temperatures, when the gas hydrate reservoir is in permafrost condition, the methane extraction efficiency remains high and differs slightly from conditions in plus temperatures. The obtained experimental results show that the flue gas injection method can be successfully used to extract methane from hydrate-saturated formations located in the perennial permafrost zone. Consequently, this method can be used both to reduce the methane hazard associated with the destabilisation of hydrate-containing horizons in the strata of permafrost rocks during the production of traditional hydrocarbons in the Arctic, and also for the production of gas hydrates from frozen hydrate reservoirs. Moreover, the application of this method will reduce carbon dioxide emissions into the atmosphere due to its disposal in hydrate form. ●

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GOLDEN ALLOY: EXPERIENCE AND YOUTH

Siberian Service Company summed up the results of the annual professional skills competition

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ON THE EVE OF OIL AND GAS INDUSTRY WORKERS DAY A PROFESSIONAL SKILLS COMPETITION WAS HELD AT SSC JSC

Keywords: *oil service, competition, Siberian Service Company, drilling, workover.*

Oil and gas production drilling crews and exploratory drilling crews, workover crews and cementing unit machine operators competed for the title Best in Profession.

“The best workers from all the divisions of Siberian Service Company have gathered here. They have already won in company branches at the qualifying stages,” announced **Vladimir Shesterikov, General Director of SSC JSC**, in his welcoming address. – Everyone knows their job perfectly well and knows how to perform the relevant tasks at the highest level. The main thing is to tune in, cope with excitement, prove oneself and demonstrate what workers do every day.

The competition consisted of theoretical and practical tasks. First, a test of knowledge on industrial, environmental safety and labor protection was given. The second part was the demonstration of practical skills. The competition was held at two sites: drilling crews competed near the city of Raduzhny, at the Tagrinskoye field, while cementing unit machine operators and workover crews competed in the city of Nefteyugansk.

“The work of the driller has always been and remains difficult,” noted **Viktor Nazarevsky, Chairman of the Tender Committee and Deputy General Director of SSC JSC for the construction and repair of wells**. – Our team employs persistent, reliable and dedicated personnel. For every meter driftage and for every high financial result, there is tremendous work and professionalism involved, which I have seen once again today.

Employees of the Tomsk, Krasnoyarsk, Yamal and Nefteyugansk branches of SSC competed for the title “Best team for production and exploratory drilling of oil and gas wells". Moreover, the latter branch was represented by two teams. During practical tests, the participants took over and relinquished the tour, conducted hoisting operations of the drilling assembly, and also performed mock drilling processes. Particular attention was given to industrial safety issues.

“It is important to follow all instructions for labor protection and safety, carefully analyze the work at hand and possible risks of injury, as well as avoid mistakes,” said **Yury Korobkov, Chief specialist on labor protection, industrial safety and the environment of SSC JSC**. – We want all employees to get home from work in a healthy state. This is very important. Safety is the first and foremost issue in this company.

Customers also note the level of work and the attention to issues of industrial safety in the Siberian Service Company. In particular, this was noted by representatives of Varyoganneft JSC where the professional skills competition was held.

FACTS

Crew No. 38 of the Workover branch became the best among workover teams

Machine operators of the cementing unit of the Nefteyugansk regional division of the TC branch received the title "Best Squad for Cementing Wells"

“During our cooperation with the Siberian Service Company, there were no complaints about the work of the drilling crews – they are professionals: they strictly observe and follow the terms and requirements for safety,” said **Shamil Bikbulatov, Head of the oil and gas production department of the Tagrinskoye field of Varyoganneft JSC**. – That is precisely why our company plans to continue its partnership with SSC JSC.

Many drilling crews consist of workers with many years of experience and very young employees as well: an alloy of experience and youth. Annually, senior specialists and beginners take part in competitions. This approach is welcomed in SSC as it is an opportunity to transfer experience and skills to the younger generation.

“Our company has all the necessary modern technical equipment, thanks to the constant updating of equipment in the workshops, what is more, improved units, assemblies, and installations are appearing on the rigs,” said one of the dedicated employees of SSC JSC, with almost 35 years of experience, **Vladimir Serdyukov, Head of the SBR Krasnoyarsk branch**. – However, the most important component is personnel. In our team, mutual assistance and a sense of team spirit are especially appreciated. Without confidence that reliable comrades are there for you, it is impossible to work in the drilling sector. The mentor system is actively developing in all branches of the company.

One of the youngest drilling members of SSC is a representative of the Tomsk branch. His team employs workers under the age of thirty. The drilling foreman confirmed that everyone who came

here to defend the honor of their branch was a real professional in drilling, meaning that opponents in the competition were worthy ones.

In addition to the drilling competition held at the site of the Well cementing department, another competition was held among cementing units. Three teams from Nefteyugansk, Krasnoyarsk and Orenburg gathered there. After completing the theoretical part, the competitors went on to the site to complete practical tasks.

"The participants are to perform simulation operations of cementing work. They will arrange the necessary equipment and set up the high pressure lines," said **Valery Fedyaev, Chairman of the jury and Deputy General Director for technological support of SSC JSC.** – During the practical part, I hope to see the coordinated actions of the crews and the absence of last year's drawbacks. They must constantly improve their skills. I expect a higher level from all participants.

The Best in Profession competition at the Siberian Service Company is not just a competition, it is a tribute to traditions and a real festive holiday. Employees of different branches have attended the competition for several years. The company appreciates the desire to be the best and to be a professional. The competition provides an opportunity to earn respect in the team, demonstrate skills and share experience with colleagues.

"We value the success of our employees and try to stimulate them to new industrial victories," said **Vinera Sultanova, Deputy Director for Human Resources of the Yamal branch of SSC JSC.** – For almost 20 years, our company has managed to create favorable conditions for those who work on the field – the most remote deposits have been equipped and power supply has been organized. In addition, our collective agreement provides for several benefits that are not included in the labor code, such as payment for holidays, vouchers for children and much more.

This time, the challenge cup and the title "Best Squad for Cementing Wells" were received by the cementing unit machine operators of the Nefteyugansk regional unit of the TC branch. The best team for production and exploratory drilling of oil and gas wells was the team of the Nefteyugansk branch. The best among the workover crews was team No. 38 of the Workover branch. It is worth noting that SSC employees were nominated as well. The Yamal branch "For vigilance in the field of labor protection", the Nefteyugansk branch "For promoting company policy" and the Krasnoyarsk branch "For coordinated work". The 2019 Competition has ended. Employees of all branches look forward to continue operations and the daily effective and safe work for the benefit of the company. This is the best proof of their professional skills.

FACTS

Crew

of the Nefteyugansk branch became the best crew for production and exploratory drilling of oil and gas wells

DEVELOPMENT OF HIGH-VISCOSITY OIL DEPOSITS

Comparison of the forecasting approaches of technological indicators

UDC 622.276.55

AS THE RESERVES OF LIGHT OIL ARE DEVELOPED MORE AND MORE AHEAD OF TIME, IT IS BECOMING INCREASINGLY URGENT EACH YEAR TO ACTIVELY DEVELOP THE VAST RESERVES OF ABNORMALLY VISCOUS OILS AND BITUMENS. ANOTHER URGENT PROBLEM IS THE DEVELOPMENT OF EFFICIENT TECHNOLOGIES FOR THE EXTRACTION OF SUCH HYDROCARBONS, SINCE TRADITIONAL, WIDELY-USED METHODS OF OIL PRODUCTION CANNOT BE USED TO EXTRACT HIGHLY-VISCOUS OILS, SINCE THEY DO NOT ALLOW AN INCREASE IN OIL RECOVERY OF MORE THAN 15%. AS OF NOW, THE ACCUMULATED EXPERIENCE OF LABORATORY AND FIELD RESEARCH SHOWS THAT THE MOST EFFECTIVE AND INDUSTRIALLY DEVELOPED TECHNOLOGIES FOR DEVELOPING SUCH RESOURCES ARE THERMAL METHODS OF OIL EXTRACTION. ONE OF THE MOST IMPORTANT TASKS IN THE DESIGN OF FIELDS IS TO PREDICT THE VOLUME OF OIL PRODUCTION. THE CRUCIAL TASK FOR THE MANAGEMENT OF LEADING OIL COMPANIES IS TO DETERMINE THE PAYBACK PERIOD OF INVESTMENTS BASED ON THE FORECAST OF EXTRACTABLE PRODUCTS. IN THIS RESEARCH WORK, THE CALCULATION OF THE TECHNOLOGICAL INDICATORS OF THERMAL-MINING DEVELOPMENT FOR SECTOR B OF THE 2T-4 MINE BLOCK IS CONDUCTED, WHICH WILL BE DEVELOPED USING THE MODERNIZED ONE-HORIZON THERMAL-MINING SYSTEM. FORECASTING OF PRODUCTIVE CHARACTERISTICS WAS PERFORMED BY USING NUMERICAL MODELING IN THE CMG HYDRODYNAMIC SIMULATOR, BY BUILDING A SINGLE-FACTOR STATISTICAL REGRESSION MODEL BASED ON ACTUAL DATA FROM THE PILOT PROJECT SITES OPU-2 BIS, OPU-3 BIS (OM-2) OF THE YAREGSKOYE FIELD AND BY USING THE ANALYTICAL METHOD FOR CALCULATING TECHNOLOGICAL INDICATORS OF THERMAL-MINING DEVELOPMENT

KEYWORDS: *mine block, modernized one-horizon thermal-mining development system, single-factor statistical regression model, numerical modeling.*

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Object for study

The Yaregskoye petroleum-titanium field (Figure 1) consists of the following areas: Yaregskaya, Lyaelskaya and Vezhavozhskaya areas. At the moment, only the Yaregskaya and Lyaelskaya areas are in industrial development.

In recent years, production at the Yaregskoye field, made up of a terrigenous type of reservoir, has been increasing at an accelerated rate. The field is unique not only by its rheological characteristics (oil viscosity above 12000 mPas), but also by the development method. Since 1939, the field has been developed by a unique mining method, and starting from 1972 up to the present moment, the process of injecting thermal fluid into the producing formation is carried out in order to reduce viscosity and increase oil production.

In general, three oil mines are operated on the Yaregskoye high-viscosity field in the Yaregskaya area of the Yaregskoye field.

Geological and physical characteristics of the field are presented in Table 1.

Mine block 2T-4 is confined to oil mine No.3 and has the following location (Figure 2).

Figure 3 shows the design location of the wells of mine block 2T-4 (OM-3). Depending on the length, the production and injection wells were ranked and divided into three sectors:

FIGURE 1. Map of the Yaregskoye field

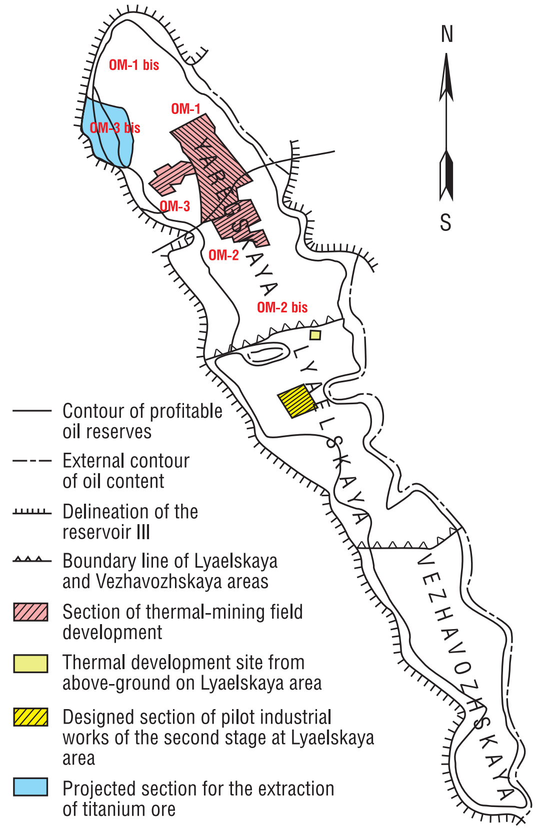


TABLE 1. Geological and physical characteristics of the Yaregskaya area

Indicator	Units of measurement	Value
Type of reservoir	–	terrigenous, fractured and porous
Average coefficient of porosity	unit fraction	0.26
Average coefficient of absolute permeability	mkm²	2.5–3.0
Average coefficient of oil saturation of the maximum saturation zone	unit fraction	0.87
Average coefficient of oil saturation of the "transition zone"	unit fraction	0.48
Average effective thickness	m	44.8
Average effective oil saturated thickness	m	35.8
Average level of OWC	m	-55...-65
Average reservoir temperature	°C	9
Reservoir pressure	МПа	0.1–0.2
Viscosity of oil under reservoir conditions	mPas	12 000–15 000
Density of oil under reservoir conditions	kg/m³	933

FIGURE 2. Main diagram of the location of mine block 2T-4 on the map (highlighted in red)

FIGURE 3. Layout of wells of mine block 2T-4 (OM-3)

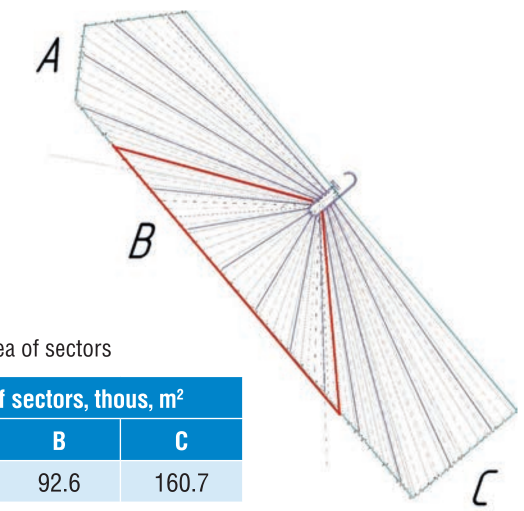


TABLE 2. Area of sectors

Area of sectors, thous, m²		
A	B	C
150	92.6	160.7

- sector A (well length – from 450 m to 690 m);
- sector B (well length – from 270 m to 400 m);
- sector C (well length – from 460 m to 700 m).

The area of the sectors is presented in Table 2.

Due to the fact that the construction of a statistical regression model will be carried out using actual data from the pilot project sites OPU-2 bis, OPU-3 bis (OM-2), the average well length of which is 250 m, sector B of mine block 2T-4 was chosen as the site for calculating technological indicators (see Figure 3, highlighted in red).

The mine block 2T-4 will be developed by a modernized one-horizon thermal-mining development system using thermally insulated tubing strings in order to minimize heat losses along the wellbore and in order to maintain steam quality and the maintenance of a normal temperature in the mine gallery. The advantages of a one-horizon thermal-mining development system are presented below.

Advantages of one-horizon thermal-mining development system are as follows:

- the use of thermally insulated strings ensures high rates of injection by increasing the discharge pressure of the thermal fluid;

- capital costs for drilling and development of above-ground injection wells are excluded;
- steam injection from the mine gallery allows for more flexibility when controlling the development process of the block;
- low steam-oil ratio due to high thermal efficiency of the development process.

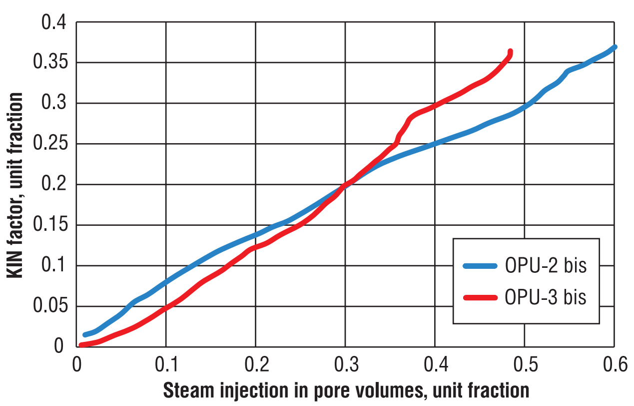
Regression model

Development of oil fields using thermal methods is a complex process in oil production. Therefore, statistical approaches for determining relationships and forecasting technological development indicators are the most simple research methods. The extrapolation of the dependence based on actual data makes it possible to predict oil recovery in the reservoir for a subsequent period with a higher degree of accuracy.

The use of a single-factor regression model in this research work is due to the lack of actual data of the mine blocks being developed by the modernized one-horizon thermal-mining development system.

As noted above, in order to build a statistical single-factor regression model, we used actual data from pilot sites OPU-2 bis, OPU-3 bis (OM-2), developed by a modernized one-horizon thermal-mining system [4]. Figure 4 shows the actual behavior of the curves of the oil recovery factor (KIN) by way of steam injection in pore volumes of the reservoir.

FIGURE 4. Actual curves of the dynamics of KIN (oil recovery factor) due to steam injection in pore volumes of sections OPU-2 bis, OPU-3 bis (OM-2)



Next, the dependence of the oil recovery increment on the steam injection rate, expressed in pore volumes of the reservoir for the above-mentioned sections was outlined (Figure 5).

From the presented figure, it can be seen that in the dynamics of oil production, there are characteristic stages of thermal-mining development. Stage 1 – increasing production of oil. By the end of this stage, the steam injection volume is 0.4 of the pore volume of the reservoir. Stage 2 – decreasing production.

Thereafter, regressions were constructed separately for each of the pilot sites OPU-2 bis, OPU-3 bis for each stage of development (Figure 6).

FIGURE 5. Dynamics of the increment change in oil recovery due to steam injection in pore volumes

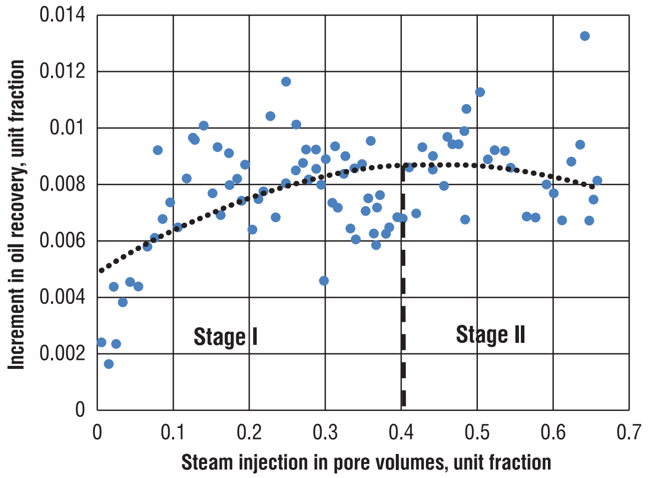
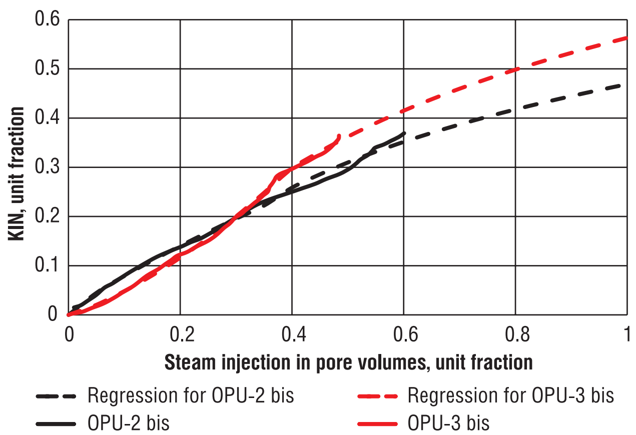


FIGURE 6. Statistical regressions for the first and second stages of development



The regression equation was chosen in such a way that the coefficient of determination (R^2) during Stage 1 was at maximum level. In Stage 2 of thermal-mining development, a logarithmic dependence was applied based on the fact that the actual curves of the change of the oil recovery factor due to the injection of steam in pore volumes for the mine areas of the Yaregskoye field experience logarithmic changes.

OPU-2 bis:

Stage 1: KIN = $0.5272 \cdot V_{I.S.}^{0.8235}$;

Stage 2: KIN = $0.2294 \cdot ln(V_{I.S.}) + 0.4687$.

OPU-3 bis:

Stage 1: KIN = $0.9009 \cdot V_{I.S.}^{1.263}$;

Stage 2: KIN = $0.2898 \cdot ln(V_{I.S.}) + 0.5631$,

where $V_{I.S.}$ – volume of Injection of Steam in reservoir pore volumes, unit fraction.

Analytical model

In order to predict the technological indicators of thermal-mining development for sector B of the 2T-4 mine block (OM-3), an analytical technique was chosen [4] for the reason that this technique has already been tested for the mining areas of the Yaregskoye field, which is characterized by a fractured porous reservoir.

EXTRACTION

Presented below is a procedure for calculating oil recovery during drainage of the fractured reservoir by a system of horizontal wells. The oil recovery calculation is performed according to the following algorithm:

1) initial data: $T_п$, T_0 – temperature of the injected steam and the initial temperature of the reservoir; $s_н$, $s_в$ – initial oil and water saturation of the reservoir; m – effective porosity, κ – absolute permeability; V – reservoir volume;

2) a time interval is selected Δt_1 during which the temperature of the reservoir is considered equal to the half-sum of the initial temperature T_0 and the temperature at the end of this interval;

3) using the formula (1) the temperature of the reservoir is determined at the end of the interval Δt_1 and the average temperature for this period is calculated:

$$\overline{\theta}(t)=\frac{1}{L}\int_0^L\theta(x,t)\,dx=\frac{\tilde{h}}{L\cdot\sqrt{Bi}}\cdot th\left(\sqrt{Bi}\cdot\frac{L}{\tilde{h}}\right)-$$
$$-\sum_{n=1}^{\infty}(-1)^{n+1}\cdot\frac{2}{\mu_n^2+Bi\cdot\left(\frac{L}{\tilde{h}}\right)^2}\cdot\sin\mu_n\cdot\exp\left(-\left(\mu_n^2+Bi\cdot\left(\frac{L}{\tilde{h}}\right)^2\right)\cdot Fo\right). \quad (1)$$

where $Bi=\frac{\alpha\cdot\tilde{h}}{\lambda}$ – Bio modulus;

$Fo=\frac{a\cdot t}{L^2}$ – Fourier modulus; $\mu_n=(2n-1)\cdot\frac{\pi}{2}$;

α – coefficient of reservoir heat transfer with surrounding rocks, *W*/(*m*²K);

λ – coefficient of thermal conductivity, *W*/*m*K;

a – coefficient of thermal diffusivity, *m*²/*s*;

$\tilde{h}$ – ratio of the section area to the section perimeter, m;

h – thickness of reservoir, m;

t – time, s;

L – distance between fractures, m;

4) next we determine the viscosity of oil based on (2):

$$\mu(T)=\exp\left(0{,}000411\cdot T^2-0{,}108\cdot T+10{,}167\right), \quad (2)$$

where $T = T_0 + \theta \cdot (T_п - T_0)$, °C;

T_0 – – initial temperature of reservoir, °C;

$T_п$ – temperature of injected thermal fluid.

The dynamics of the average temperature of the reservoir is presented in Appendix E;

5) next we determine the relative phases based on (3) and phase permeability based on (4):

$$\kappa_в(s)=\begin{cases}0 & \text{при } 0\le s\le 0{,}2,\\ \left((s-0{,}2)/0{,}8\right)^{3{,}5} & \text{при } 0{,}2\le s\le 1;\end{cases}$$
$$\kappa_н(s)=\begin{cases}\left((0{,}85-s)/0{,}85\right)^{2{,}8}\cdot(1+2{,}4\cdot s) & \text{при } 0\le s\le 0{,}85,\\ 0 & \text{при } 0{,}85\le s\le 1,\end{cases} \quad (3)$$

$$\kappa_н^*=\kappa_н(s)\cdot\kappa\ \kappa_в^*=\kappa_в(s)\cdot\kappa, \quad (4)$$

where s – water saturation;

κ – absolute permeability, m²;

6) next we calculate the inflow of oil from the porous part of the productive formation based on Borisov's formula (5):

$$q=\frac{2\pi\cdot\kappa\cdot h\left(P_к-P_c\right)}{\mu\left(\ln\frac{F(n)\cdot R_к}{\ell\cdot\sin\alpha}+\frac{h}{n\cdot\ell}\cdot\ln\frac{h\cdot\sin\alpha}{2\pi\cdot r_c}\right)}, \quad (5)$$

where $P_к$ – pressure on external reservoir boundary, Pa;

P_c – oil well pressure, Pa;

α – deviation angle of well from the vertical line, degrees;

ℓ – average oil well length, m;

$R_к$ – radius of circuit, m;

r_c – radius of oil well, m;

μ – viscosity of oil, cP;

7) next we determine oil recovery factor of the reservoir for the period Δt_1 as the ratio of oil produced during this period to the geological reserves of the developed element;

8) next we calculate the volume of water in the reservoir as the sum of the initial volume of water and the volume of oil produced during the period Δt_1;

9) next we determine the water saturation level of the reservoir at the end of the period Δt_1.

The next cycle of oil recovery calculations over a period of time must be started from point Δt_2 of this algorithm.

Table 3 presents the initial data for the calculation of indicators of the thermal-mining development of sector B of the 2T-4 mine block.

TABLE 3. Initial data for calculations

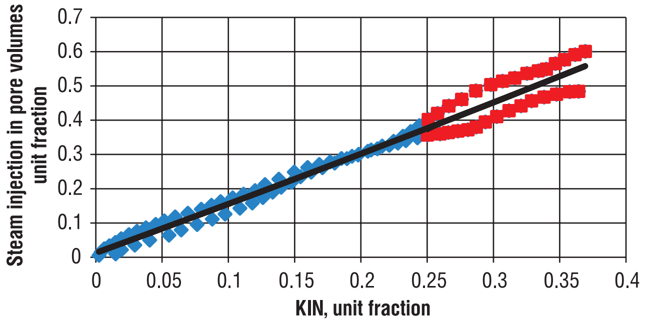
Coefficient of reservoir heat transfer, W/m²·K	0.35
Coefficient of heat conductivity, W/m·K	2.8
Distance between fractures, m	25
Average reservoir thickness, m	24
Coefficient of thermal diffusity, m³/day	0.0816
Initial temperature of reservoir, °C	10
Temperature of injected steam, °C	150
Number of production wells	13
Absolute permeability, D	2.5
Initial oil saturation, unit fraction	0.86
Pore volume, m³	797 000
Volume of water in reservoir, m³	111 580

The disadvantage of this or any other analytical method to predict productive characteristics is the fact that the injection of thermal fluid must be set as a constant value at the initial moment of time, thereby the final curve of the dynamics of KIN (oil recoverability factor) from steam injection in pore volumes becomes linear, which is not entirely correct. This conclusion was made during the analysis of field (actual) data.

This research paper proposes a method for determining the injected thermal fluid in pore volumes by way of constructing a statistical regression based on the actual data of the pilot project sites OPU-2 bis, OPU-3 bis.

Figure 7 shows the statistical regression based on the actual data of the pilot project sites OPU-2 bis, OPU-3 bis (OM-2).

FIGURE 7. Statistical regression based on the actual data of the pilot project sites OPU-2 bis, OPU-3 bis (*blue – stage 1, red – stage 2*)



This type of regression is used to calculate the injection in reservoir pore volumes in order to obtain the oil recovery factor (KIN), calculated according to the analytical method described above for each stage of the thermal-mining development:

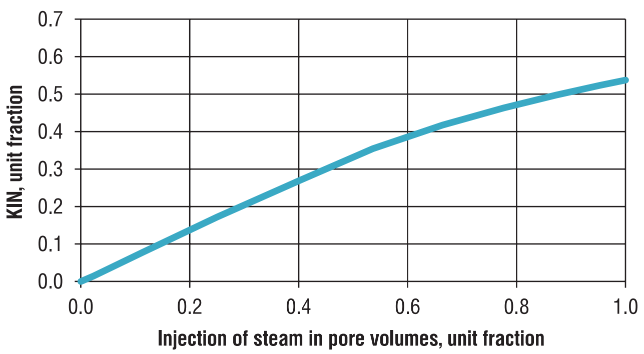
Stage 1: $V_{I.S.} = 0{,}1826 \cdot KIN^2 + 1{,}4089 \cdot KIN + 0{,}0128$;

Stage 2: $V_{I.S.} = 0{,}1606 \cdot exp^{3{,}4021 \cdot KIN}$,

where $V_{I.S.}$ – injection of steam in reservoir pore volumes, unit fraction.

Figure 8 shows the calculated curve of the oil recovery factor (KIN) from the injection of steam into the pore volumes of the reservoir.

FIGURE 8. Dynamics of KIN due to injection of steam in pore volumes (calculated by the analytical method)



Numerical model

Construction of a three-dimensional geological model of the 2T-4 mine block of the Yaregskoye field was performed using the IRAP RMS software of ROXAR company.

Creating a detailed geological model includes several stages:

- preparation, quality control and loading of the initial data;
- structural modeling;
- construction of a three-dimensional geological grid;
- averaging (smoothing) of oil well data;
- building a lithological model;
- building a petrophysical model;
- assessing the geological reserves of oil.

Initial information for constructing a geological model is presented below:

- wellhead coordinates;
- data on well inclinometry;
- results of quantitative interpretation of GIS (stratigraphic boundaries of reservoirs, boundaries of permeable layers, nature of reservoir saturation, values of porosity and oil saturation of reservoirs);
- structural maps of the upper boundary and the lower boundary of the productive formation;
- graphic data in digital format, taken from the estimated plans of the latest recalculation of reserves ("Operational Estimation of Oil Resources of the Yaregskoye Field", 2012);
- adopted position of OWC;
- lower ultimate values of porosity for reservoir rocks and petrophysical dependencies;
- statistical data of petrophysical parameters (porosity, permeability) based on the results of core sample research.

After constructing the geological model, it was updated. In order to update the geological model of the 2T-4 mine block, sections of exploratory wells from the 1940s and 1950s, drilled within the specified area, were digitized. A total of 35 wells were digitized. Using the obtained data, las-files of exploration wells were compiled, which were loaded into the IRAP RMS software package in order to create a digital model.

As underground wells were drilled with the help from the obtained gamma-well log data and its analysis based on the formula and criteria (6), the intervals of the wells were sampled based on the lithology parameter, and also las-files were created for loading into the IRAP RMS software package, the averaging and rebuilding of the lithology cube of the 2T-4 mine block model also took place:

$$i = \frac{J - J_{min}}{J_{max} - J_{min}}, \qquad (6)$$

if $i \geq 0{,}5$, it means that there is no productive formation in this interval.

i – relative value of gamma-well log data;

J – value of gamma-well log data in the current interval;

J_{min}, J_{max} – minimum and maximum values of gamma-well log data respectively in the well interval.

Afterwards, in the software product IRAP RMS, sector B of the 2T-4 Mine block was singled out and exported to the hydrodynamic CMG simulator for further calculations of technological development indicators.

FIGURE 9. Geological filtration model of sector B

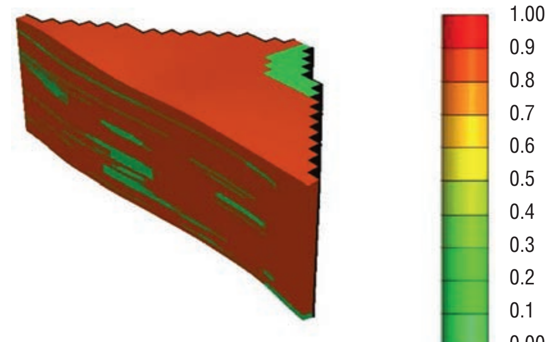


TABLE 4. Parameters of the model

	X	Y	Z	
Cell size, m	10	10	0.5	
Number of cells	60	41	59	Total number of cells: **145140**

Figure 9 shows the geological filtration model of sector B of the 2T-4 mine block.

Table 4 shows the main parameters of the geological filter model.

Number of wells in the B sector is 26. Of these, 13 are production wells, the other 13 are injection wells. Injection pressure was 5 atm, the temperature of the injected agent – 150 °C, the degree of steam dryness – 0.7. Calculation time is ten years.

FIGURE 10. Current technological indicators of the development of sector B

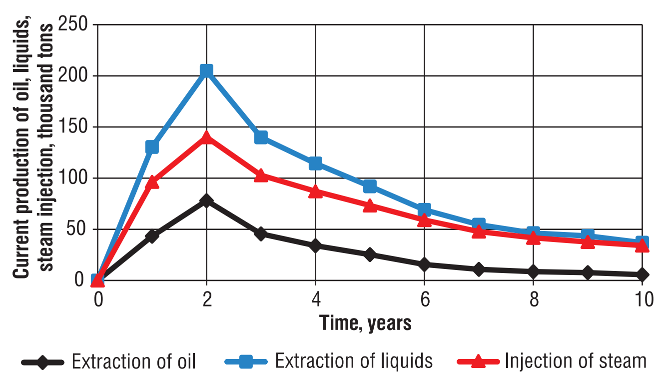
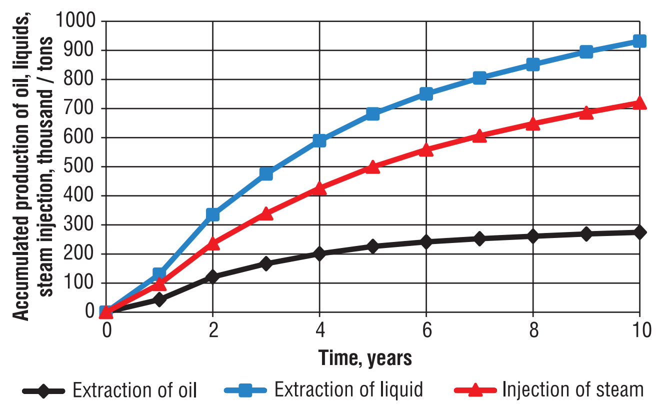


FIGURE 11. Accumulated technological indicators of the development of sector B

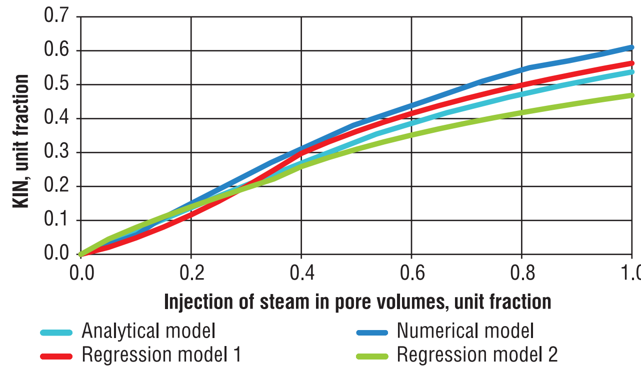


The main technological indicators of the development are presented in Figures 10–11.

Comparison

Figure 12 shows a comparison of the analytical, numerical and regression models.

FIGURE 12. Comparison of the results of the calculation models



As can be seen from this graph, there is a good convergence between the presented methods, which indicates the need to apply the presented models when predicting the technological indicators of thermal-mining development, regardless of the assumptions made.

Conclusions and recommendations

We managed to calculate the technological indicators of thermal-mining development for a section of the 2T-4 (OM-3) mine block by way of the numerical modeling, the statistical regression model and the analytical model (Borisov's model).

Analysis of the results showed a good convergence between the applied approaches to the prediction of technological indicators for fractured, porous reservoirs. In this regard, at the initial stage (steam injection in reservoir pore volumes is less than 0.4, unit fraction), it is recommended to use the regression statistical model or the proposed analytical method in order to optimize the cost of working time for the calculation of technological development indicators.

In the course of collecting field data, obtained during the operation of the mine block, it is recommended to use numerical model in order to further predict the technological development indicators due to the broader consideration of numerous factors when using hydrodynamic modeling. ●

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FOR WELL LOW-RATE FUND

FIELDS OPERATED TODAY BY OIL PRODUCING COMPANIES ARE INCREASINGLY EXHAUSTING THEIR PERFORMANCE POTENTIAL, AND THE MOST OF NEW FIELDS ARE LOW-RATE. THIS TREND MAKES OIL PRODUCTION MORE AND MORE EXPENSIVE AND TIME CONSUMING THAT FORCES COMPANIES TO CONSTANTLY SEEK SOLUTIONS TO REDUCE PRODUCTION COSTS THROUGH THE USE OF NEW TECHNOLOGIES AND MODERN EQUIPMENT. THE HEAD OF THE CENTRAL MAINTENANCE SERVICE OF ELECTRIC CENTRIFUGAL PUMP UNITS OPERATION AT THE SURGUT CSB OF ESUS, VLADISLAV KIRICHENKO, TELLS HOW SURGUTNEFTEGAZ PJSC SOLVES THE PROBLEMS OF LOW-RATE WELL STOCK OPERATION

UDC 622.276

KEYWORDS: *low-rate fund, electric centrifugal pumps, efficient operation, structural reliability of equipment, submersible equipment.*

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To date, in Surgutneftegaz PJSC the well stock equipped with electric centrifugal pump units (ECPUs) amounts to more than 21 thousand. The annual increase in the operating well stock is 4%, while the growth of the low-rate fund is 2 times higher than in the fund as a whole and is 8%. The share of low-rate well fund at the beginning of 2019 is 53.6%.

The low-rate fund is the same trouble as the high temperature of the formation liquid, scaling on the working attachments of ECPs, the high content of mechanical impurities. Its operating time is lower than the average-rate fund and the high-rate fund, due to the fact that the ECP operates near the limits of the left head and rate zone with a low efficiency rate value, which results in heating of the liquid over the pump intake and reduction of the useful life of the electrical component of the submersible unit. In addition, when the ECP is operating with low production rate, the impeller is pressed with greater force to the guide vane, which results in more intensive wear of the impeller support washers and the useful life of the ECP is reduced.

To increase the efficiency of operating the low-rate fund, Surgutneftegaz PJSC is working in the following areas:

- increase the structural reliability of the submersible equipment;
- introduction of organizational decisions;
- search for alternative ECPU equipment.

Until 2015, the company's specialists on their own developed, tested and launched into serial production the following equipment of increased reliability:

1. High temperature:

- line of compounded and heat-loaded electric motors;
- a system for selecting the lengths of thermal inserts for cable lines is developed.

2. Wear-resistant equipment for wells with a high content of solid mechanical impurities (more than 1,000 mg/l):

- input module filter with a size of MFV5 and 5A;
- bypass input module with a size of MVPV 5 and 5A that enables to continue operation of ECPUs in the event of complete clogging of the filter;
- wear-resistant ECPs with packet assembly scheme of working steps.

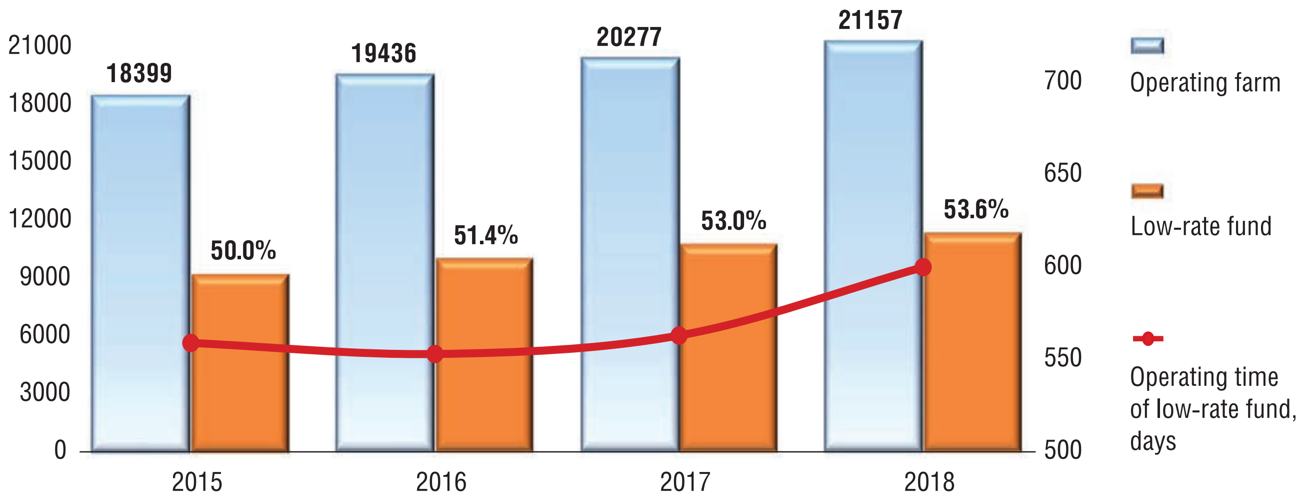
For more than 10 years, the development of complicated fields of the Oktyabrsky District has been conducted. Complicating factors of which are high formation temperature (up to 120 °C), inhomogeneity of reservoir properties of formations, weak inflow characteristics.

Since 2015, only machines of enhanced reliability are used at these fields, with 100 % high-temperature and wear-resistant equipment. This made it possible to ensure an annual increase in equipment operating time by 20 %.

Since 2017, equipment of enhanced reliability, depending on availability of complicating factors, has been applied at all fields of the Company and in 2018 reached 5480 units or 12.5 % of the annual volume of installations.

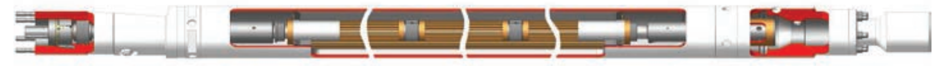
Simultaneously with the expansion of the implementation volumes of ECPU equipment of enhanced reliability, a qualitative change occurred in relations

Dynamics of well fund with ECPU



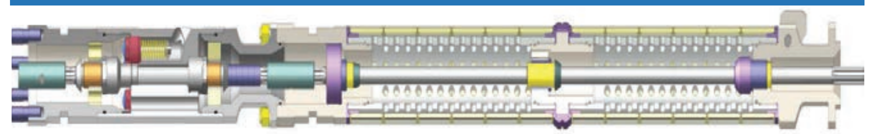
Compounded SM

Thermally loaded SM

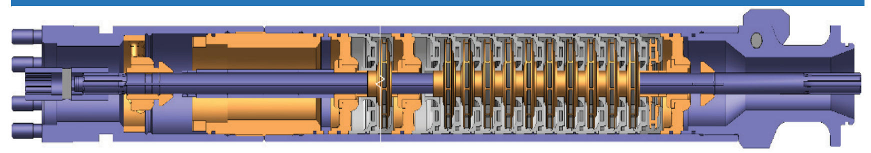


Envelope filter module 5 or 5A

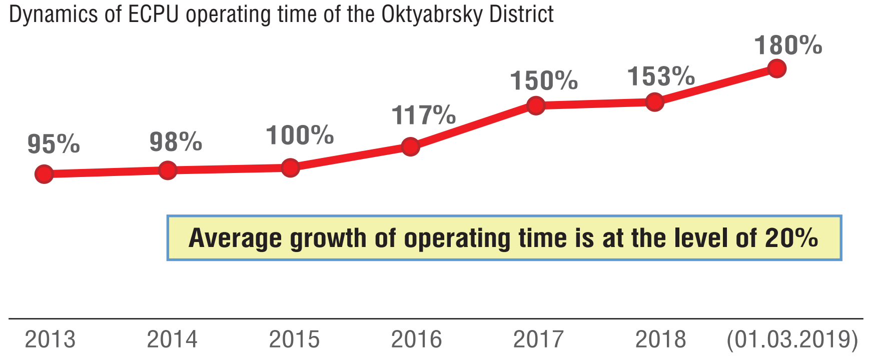
Since 2016, it is used only in conjunction with the input bypass module MVPV 5-SS



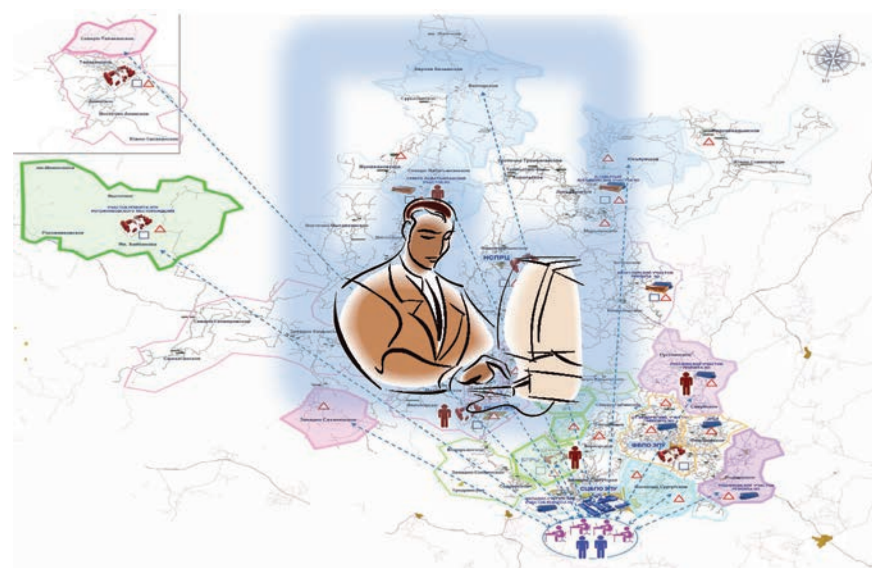
ESP packet diagram of stages Assembly



Dynamics of ECPU operating time of the Oktyabrsky District



The organization of a support service operation at of EPU



with the oil-and-gas production department on closing requests in the installation of submersible equipment.

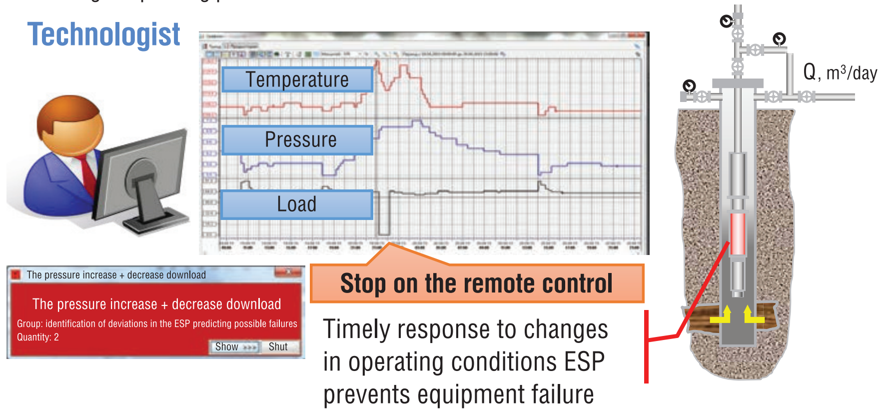
Now, the CSB of ESUs for the wells of the special-purpose fund, from the moment of the ECP system's refusal until the installation, analyzes the causes of the failure of the previous equipment in these wells, analyzes the preliminary causes of the fresh failure and, in accordance with the line of serial equipment, equipment of enhanced reliability, gives recommendations of the oil-and-gas production department for the application of a particular type and the use of primary devices.

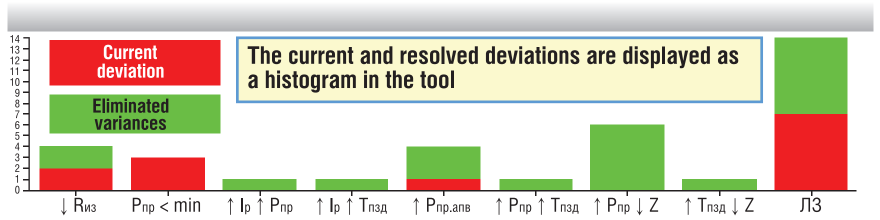
For this purpose, from 2019, the maintenance service of ECPU operation was established as part of the CSB of ESUs. Among other things, the duties of the specialists of this service include: analysis of the ECPU operation, prompt detection of troubles and the timely taking of remedial actions.

The idea of timely detection of troubles, the so-called ALARMS, is not new,Western oil service companies are pioneers here.

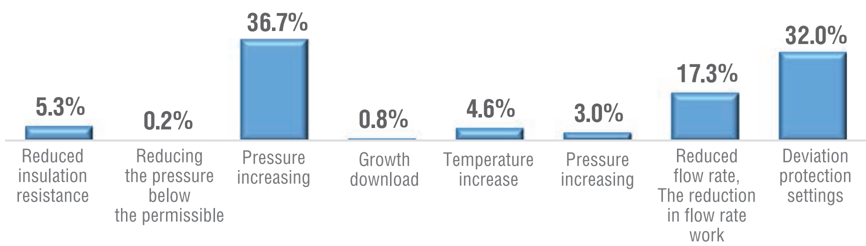
Having great experience in ECPU operation, as well as programmers represented by the specialized division SurgutASUneft, Surgutneftegaz PJSC developed and put into commercial operation in 2017 the software "Detection of deviations in the operation of the ECPUs and forecasting possible failures". This program can, by

Monitoring of operating parameters of ESP





Distribution of alarming events by types of deviations



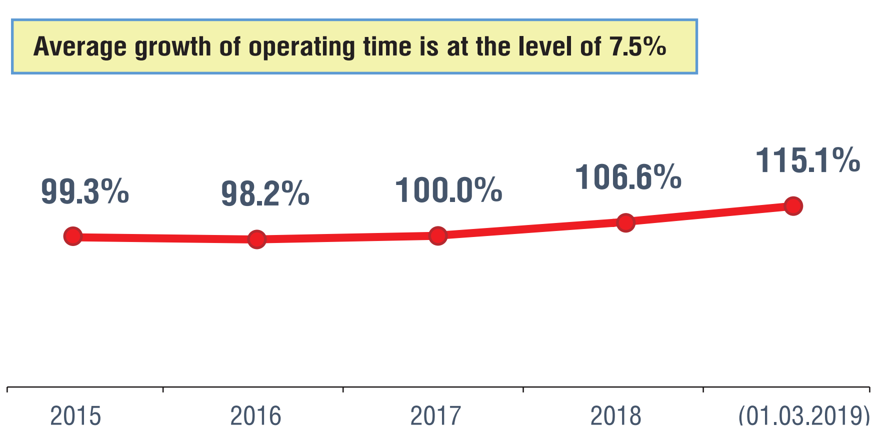
assessing the rate of change of one or another operational parameter, forecast the occurrence of a critical operating mode of the unit and to alarm the user about it. For 2018, through the automated system "Detection of deviations in the operation of the ECPUs and forecasting possible failures", in the special-purpose fund of more than 6,000 wells more than 900 deviations were identified and eliminated that create the risk of equipment failure.

Thus, today Surgutneftegaz PJSC has an effective tool for monitoring the operating mode of the ECPUs, which allows timely detection of unacceptable conditions for equipment operation and promptly taking of remedial actions.

In recent years, a systematic approach to operation of the low-rate problem well stock has allowed forming a stable positive growth trend in the ECPU operating time and, from the time of distribution of introducing equipment of enhanced reliability to all fields of the Company, as well as arranging systematic work for quickly detection of troubles and timely respond to them, annual increase in operating time of the low-rate fund at the level of 7.5%.

Based on the materials of the 16th International scientific and practical conference "Mechanized oil production-2019»

Dynamics of ECPU operating time on well low-rate fund



BULK PROPERTIES OF NATURAL GAS

found in reservoirs at high temperatures and pressures

IN THIS PAPER THE AUTHORS PRESENT THE METHOD OF A BALLASTLESS PIEZOMETER OF CONSTANT VOLUME, WITH THE HELP OF WHICH THE INTERDEPENDENCIES OF PRESSURE, MOLAR VOLUME AND TEMPERATURE (p, V_M, T) OF A NATURAL GAS MODEL (METHANE-WATER SYSTEM) WERE OBTAINED USING ISOTHERMS 523.15; 573.15; 623.15; 653.15K AT PRESSURES UP TO 60 MPA AND MOLAR FRACTIONS OF WATER IN THE RANGE OF 0.15...0.95. THE VALUES OF THE FOLLOWING QUANTITIES WERE DETERMINED: DIMENSIONLESS COMPRESSIBILITY FACTOR $Z = pV_M/RT$ (WHERE R IS THE UNIVERSAL GAS CONSTANT), EXCESS MOLAR VOLUMES OF MIXTURES, THE APPARENT MOLAR VOLUME OF WATER VAPOUR IN METHANE AND THE APPARENT SPECIFIC VOLUME OF METHANE IN WATER. ASSESSMENTS ARE GIVEN OF THE CHANGE IN THE VOLUME OF NATURAL GAS CAUSED BY DISSOLUTION OF WATER IN IT AT HIGH TEMPERATURES AND PRESSURES

UDC 622.276.654

KEYWORDS: *vapour-saturated natural gas, reservoir conditions of high temperatures and pressures, determining gas reserves using the volumetric method, p,V,T-measurement system "methane–water".*

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The main component of natural gas is methane (over 90%), whose bulk properties have been studied in detail by many researchers in a wide range of state parameters (refer to [1–4]). The gas in deposits is usually in contact with the marginal (bottom) and buried water, that is why it is saturated with water vapour. At reservoir temperatures exceeding 473.15 K and medium pressures, the water vapour content in the gas becomes very large, and at high pressures the solubility of gas augments exponentially in buried water. Consequently, water vapour contained in natural gas can significantly change the bulk properties of natural gas, which must be taken into account when calculating reserves and developing deep gas fields.

The method of determining gas reserves by means of pressure drops at high temperatures in reservoirs is complicated by the fact that when pressure drops, water should noticeably evaporate into the gas phase and gas release should occur, having been dissolved in buried water. A more acceptable method for determining the reserves of natural gas occurring at high temperatures and pressures is the volumetric method. The volumetric method for calculating reserves takes into account part of the deposit volume, occupied by the gas phase per vapour percent of water dissolved in the gas, as well as the increase in the volume of buried water due to the dissolution of gas in it.

Consequently, the volumetric method for calculating natural gas reserves occurring at great depths is based on knowledge of the bulk properties of its mixture with water. This requires data on the bulk properties of the mixture of the main component of natural gas – methane – with water in a wide range of state parameters for various compositions of this mixture. Such information can be obtained by calculation from known data on the bulk properties of pure components [1–5]. More reliable are the experimental data obtained by measuring pressure (p), molar volume of the mixture (V_m) and temperature (T) in the methane–water system in a wide range of state parameters. The calculated and experimental data on the bulk properties of this system for various values of temperature and pressure and compositions have been published [6–14].

FIG. 1. Dependence of $V_м$ on p and the water–methane mixture for T = 653.15 K

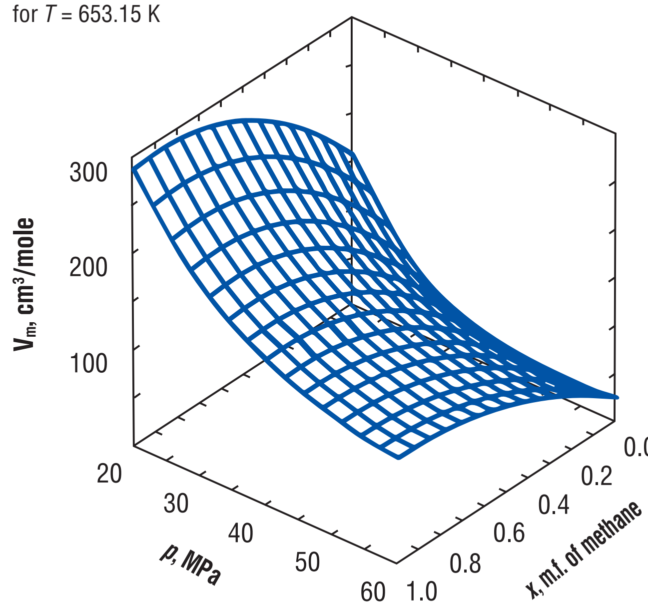
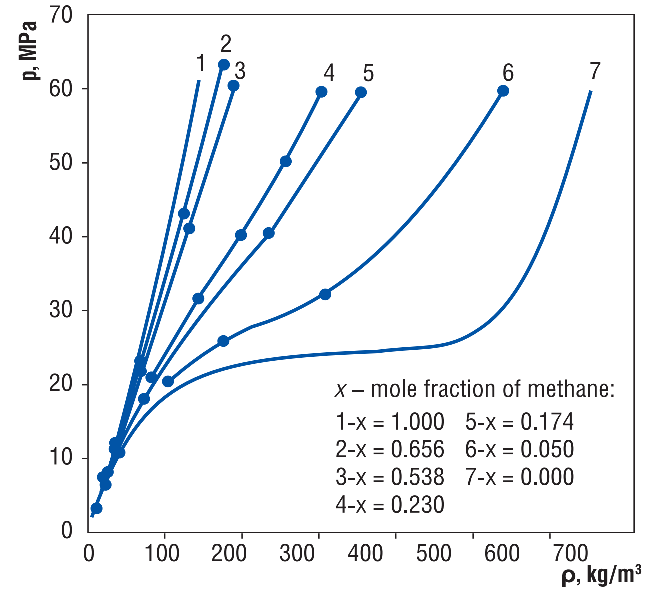


FIG. 2. Dependence of p on the density (ρ) of the water–methane mixture for T = 653.15 K



Based on the experimental p, V_m, T-dependences (Table 1, Fig. 1, 2) for a natural gas model (methane-water system) obtained by the method of a constant volume piezometer using isotherms 523.15; 573.15; 623.15; 653.15 K at pressures up to 60 MPa for various mixture compositions in the range of the molar fraction (x) of water x_{H_2O} = 0,15…0,95 [7–10], the authors assess the change in the volume of natural gas due to the dissolution of water in it under conditions of high temperatures and pressures. The experimental data on p, V_m, T, and x-dependences in the methane-water system, calculated were the values of the dimensionless compressibility factor $Z = pV_m/RT$, where R = 8.314 J/(mol·K) being the universal (molar) gas constant. At the investigated temperatures 523.15; 573.15; 623.15 and 653.15 K, the Z factor of vapour mixtures of water with methane decreases with increasing water concentration. At water vapour concentrations ≈ 0.23; 0.15...0.37 and 0.34...0.46 (Fig. 3) the value of Z is close to 1.0, i.e. the methane-water mixture behaves like an ideal gas. This important result greatly simplifies the calculation of the bulk properties of natural gas containing water vapour at pressures exceeding the vapour pressure of water at given temperatures.

Excessive molar volumes of mixtures, $V_м^И$, determined by the formula

$$V_м^И(T,p,x) = V_м(T,p,x) - \left[(1-x)V_м^1(T,p) + xV_м^2(T,p)\right],$$

where 1 and 2 – components of the mixture, x – molar fraction of the second component, are given in Table 2 and Fig. 4. The values of ($V_м^И$) are positive in the entire studied area of variation of T, p and x, i.e. the intermixture of components is accompanied by an increase in volume. The relative increase in volume when pure components are mixed for temperatures far from the critical temperature of water (647.1 K) does not exceed 10%. For temperatures close to the critical

FIG. 3. Dependence of the mixture compressibility factor on pressure for T = 653.15 K

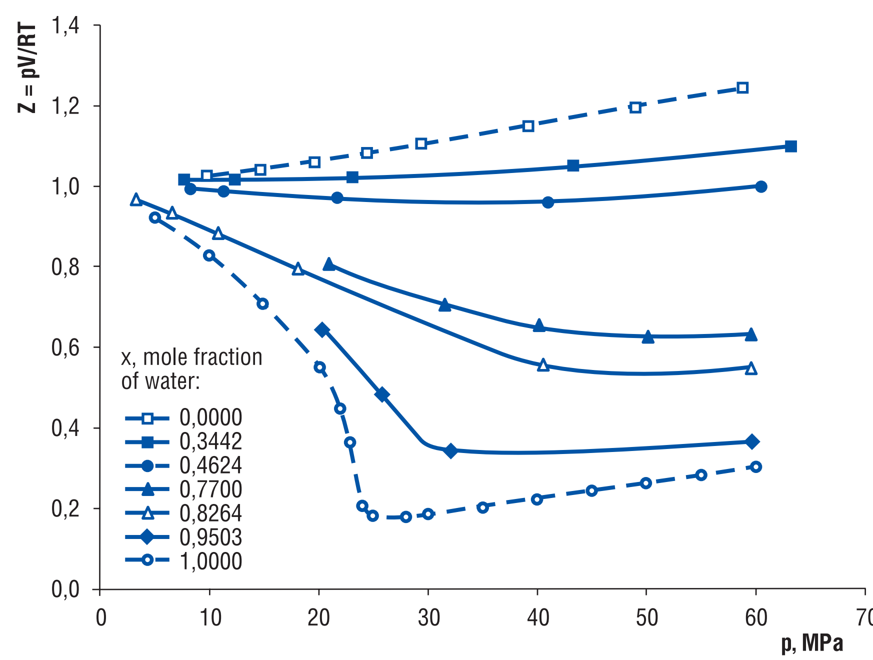
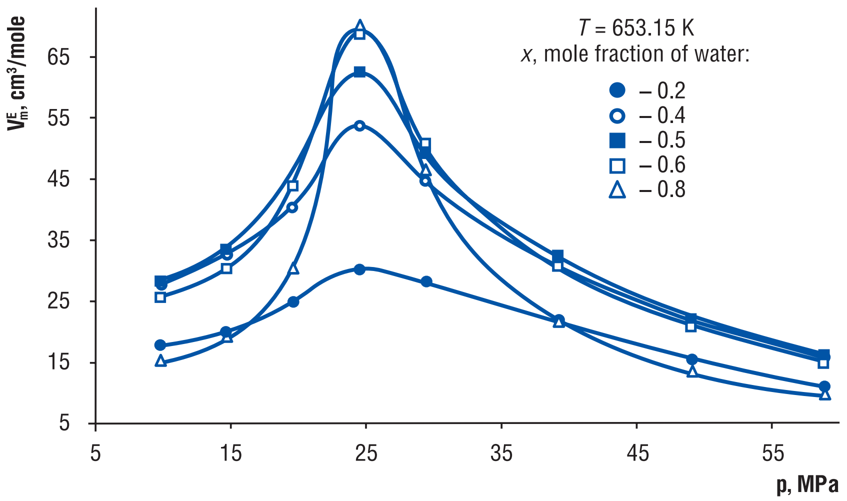


TABLE 1. Experimental dependences of the state parameters of the methane – water mixture

T, K	*p*, MPa	Molar volume, m³/mole		$V_м$, cm³/mole, for x^{H_2O}					%
		Methane $V_м^{CH_4}$	Water $V_м^{H_2O}$	0.2	0.4	0.5	0.6	0.8	
523.15	3.9	1114.2	917.0	1108.8	1043.4	1064.4	1080.5	1104.5	4.8
573.15	3.9	1224.7	1084.2	1214.8	1179.1	1194.0	1205.5	1221.6	3.4
	5.9	822.7	667.9	809.9	765.8	683.4	797.6	813.7	5.1
	7.8	617.0	450.0	607.4	566.8	588.5	605.4	613.0	10.3
623.15	5.9	896.3	778.1	880.5	855.6	871.8	885.2	890.4	4.1
	7.8	697.8	552.7	660.4	637.6	654.9	669.6	683.0	4.8
	9.8	542.0	414.7	528.3	502.4	519.7	532.9	537.9	8.6
	11.8	454.5	319.4	440.3	414.0	432.1	450.2	450.7	11.7
	13.7	390.3	247.2	377.4	349.0	367.6	358.7	388.7	15.3
653.15	9.8	566.9	460.1	553.7	528.4	541.2	552.2	564.2	5.5
	14.7	383.8	265.2	369.2	343.0	358.0	376.3	380.1	10.3
	19.6	292.3	156.3	328.5	234.6	267.4	288.1	290.1	19.6
	24.5	239.4	42.0	221.5	189.6	203.2	214.2	230.2	44.4
	29.4	203.1	34.1	184.6	152.4	177.6	179.2	197.6	49.8
	39.2	157.3	30.5	138.4	112.0	126.3	138.2	153.9	34.5
	49.0	132.6	28.8	110.8	81.3	102.7	113.1	127.3	26.0
	58.8	114.6	27.6	92.3	71.3	87.1	95.8	113.2	22.5

% – relative excess volume of the mixture (0.5 molar fractions).

FIG. 4. Dependence of the excess molar volume of the methane – water mixture on pressure for *T* = 653.15 K



temperature of water and pressures of 20...30 MPa, the relative increase in volume upon mixing reaches 40...50 % (see Fig. 4).

Values of the apparent molar volume of water vapour $\left(V_м^{H_2O}\right)^*$, determined by the equation

$$\left(V_м^{H_2O}\right)^* = \frac{V_м - \left(1 - x^{H_2O}\right)V_м^{CH_4}}{x^{H_2O}},$$

are shown in Table 3. It can be seen that the apparent molar volumes of water vapour at low concentrations in methane in the temperature range 523.15 ... 553.15 K are close to the volumes of an ideal gas. This result is unusual in terms of the phenomena observed when methane is mixed with vapours of liquid hydrocarbons. The apparent molar volume of liquid hydrocarbons vapourised into methane is usually less than the volume of pure liquid hydrocarbon and may even be negative (water-n-octane) [14]. The apparent volume of water vapour in methane gas is much larger than the volume of liquid water and is approximately equal to the volume of an ideal gas. Thus, the apparent molar volumes of water vapour mixed with methane can approximately be taken equal to the molar volume of an ideal gas $V_м^{иг}$.

It should be noted that within gas reservoirs in contact with water (both marginal and buried), the gas is in the conditions of the dew point (relative to water). The experimental studies described in this paper were conducted in a homogeneous gas area, and therefore their results cannot be directly transferred to the conditions of the gas reservoir. The pressure in gas reservoirs is always significantly higher than the vapour pressure of water at reservoir temperature. Table 4 shows data on the apparent molar volumes of water vapour for *T* = 573.15 K under condition of pressures significantly exceeding the vapour pressure of water at such temperature. In this case, with augmenting pressure, the apparent molar volumes of water vapour become slightly less than the volumes of an ideal gas, but continue to exceed volumes of liquid water.

TABLE 2. Excessive molar volumes of methane – water mixtures

T, K	*p*, MPa	$V_м^{CH_4}$, cm³/mole	$V_м^{H_2O}$, cm³/mole	$V_м^{И}$, cm³/mole, for x^{CH_4}					%
				0.2	0.4	0.5	0.6	0.8	
523.15	3.9	1114.2	917.0	29.7	47.4	48.6	45.0	28.5	4.8
573.15	3.9	1224.7	1084.2	19.4	31.7	33.4	32.4	22.7	3.4
	5.9	822.7	667.9	22.0	36.0	38.0	36.8	25.8	5.1
	7.8	617.0	450.0	29.4	50.0	55.0	55.2	39.6	10.3
623.15	5.9	896.3	778.1	12.5	18.5	21.0	21.5	15.0	4.1
	7.8	697.8	552.7	16.0	26.9	29.6	29.8	21.2	4.8
	9.8	542.0	414.7	21.3	36.8	41.3	41.8	30.0	8.6
	11.8	454.5	319.4	23.2	40.6	45.1	45.5	33.0	11.7
	13.7	390.3	247.2	27.0	44.0	48.8	49.7	37.2	15.3
653.15	9.8	566.9	460.1	17.7	28.0	28.3	25.6	15.3	5.5
	14.7	383.8	265.2	20.0	32.9	33.5	30.4	19.2	10.3
	19.6	292.3	156.3	25.0	40.2	43.9	43.9	30.4	19.6
	24.5	239.4	42.0	30.3	53.8	62.5	68.7	69.7	44.4
	29.4	203.1	34.1	28.2	44.7	49.0	50.7	46.4	49.8
	39.2	157.3	30.5	22.0	31.6	32.4	30.8	22.0	34.5
	49.0	132.6	28.8	15.5	22.0	22.0	21.0	13.5	26.0
	58.8	114.6	27.6	11.0	16.0	16.0	14.9	10.0	22.5

The research performed makes it possible to evaluate changes in the volume of gas caused by the evaporation of water into gas. For example, according to experimental data [6], at p = 25 MPa, the water vapour content in the gas phase of the methane-water system is 14.5%. This water vapour content in gas should increase the gas volume by about 10%. A rough estimate of the change in the volume of natural gas during the evaporation of water in it can be obtained for other values of temperature and pressure as well.

A change in the volume of methane due to its mixing with water vapour can play a role in the injection of natural gas into a reservoir preheated beforehand with water vapour [15].

For deep gas deposits, it is of interest to change the volume of water (marginal and buried) due to the dissolution of methane in it [9]. Having data on the solubility of methane in water and the apparent molar volume of methane dissolved in water $\left(V_м^{CH_4}\right)^*$ (Fig. 5), we can determine the change in the volume of such water. Table 5 shows the values of the apparent molar volume of methane dissolved in water, and the ratio of the volume of water saturated with methane to the volume of pure water at the same temperature and pressure variables.

TABLE 3. molar volumes of water vapour in methane for the mixture composition x^{H_2O} = 0.2

T, K	p, MPa	$V_м^{CH_4}$, cm³/mole	$V_м^{H_2O}$, cm³/mole	$V_м^{иг}$, cm³/mole	$(V_м^{H_2O})^*$, cm³/mole
523.15	3.9	917.4	1114.1	1108.8	1065.8
573.15	3.9	1084.2	1224.7	1214.8	1201.2
	5.9	667.9	882.7	809.9	777.9
	7.8	450.0	617.0	607.4	597.0
623.15	5.9	778.1	896.3	880.5	866.9
	7.8	552.7	697.8	660.4	623.8
	9.8	414.7	542.0	528.3	521.6
	11.8	319.4	454.5	440.3	435.4
	13.7	247.2	390.3	377.4	382.5
653.15	9.8	460.1	566.9	553.7	559.6
	14.7	265.2	383.8	369.2	365.2
	19.6	156.3	292.3	328.5	281.5
	24.5	42.0	239.4	221.5	193.5
	29.4	34.1	203.1	184.6	175.6
	39.2	30.5	157.3	138.4	140.5
	49.0	28.8	132.6	110.8	106.3
	58.8	27.6	114.6	92.3	82.6

Judging by the data in Figure 4 and Table 5, at high temperatures and pressure, the volume of water increases markedly when methane is dissolved in it. Consequently, when gas is released from water, shrinkage should be observed.

The obtained research results can be used to introduce amendments into the methods for calculating the reserves of natural gas deposits located at high temperatures and pressures.

TABLE 4. Experimental values $V_{\text{м.эксп}}$ of the molar volume of the methane-water mixture at pressures exceeding the vapour pressure of water, T = 573.15 K, T = 573.15 K, x^{H_2O} = 0.4325

p, MPa	$V_{\text{м}}^{CH_4}$, cm³/mole	$V_{\text{м}}^{H_2O}$, cm³/mole	$V_{\text{м}}^{\text{иг}}$, cm³/mole	$V_{\text{м.эксп}}$, cm³/mole	$(V_{\text{м}}^{H_2O})^*$, cm³/mole
2.0	2439.00	2307.85	2429.66	2400.00	2348.83
3.9	1222.49	1084.20	1214.83	1200.00	1170.50
5.9	818.33	667.85	809.89	788.00	739.00
7.8	614.63	450.04	607.42	594.00	566.94
9.8	436.68	25.20	485.93	477.30	530.59
12.3	396.83	25.01	388.75	384.01	367.19
14.7	333.33	24.84	323.95	310.60	280.79
17.2	288.18	24.68	277.68	264.84	234.22
19.6	254.45	24.53	242.97	231.14	200.55
22.1	228.31	24.39	215.97	205.05	174.52
24.5	207.47	24.26	194.37	182.66	150.10
27.0	190.48	24.14	176.70	163.76	128.62
29.4	176.68	24.02	161.42	146.42	106.01

FIG. 5. Dependence of apparent specific molar volume of methane dissolved in water $\left(V_{\text{м}}^{CH_4}\right)^*_{\text{уд}} = V_{\text{м.уд}} - \frac{G_2 V_{\text{м.уд}}^{H_2O}}{G_1}$, where $V_{\text{м.уд}}$ – specific molar volume of the mixture, $V_{\text{м.уд}}^{H_2O}$ – specific molar volume of water in the mixture, G_1, G_2 – weight fractions of methane and water respectively, on temperature for p = 39.2 MPa

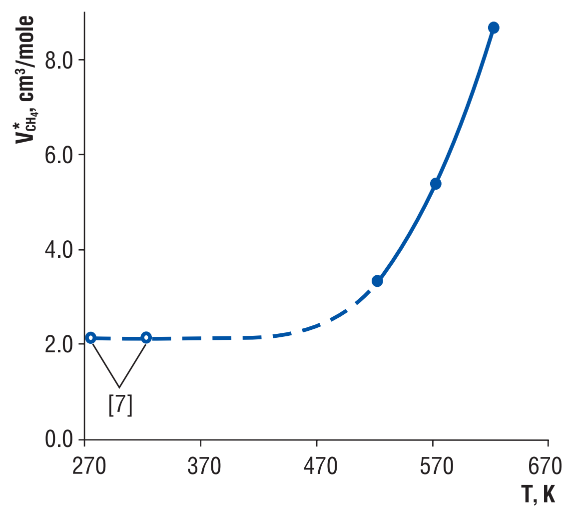


TABLE 5. Apparent specific volumes of methane dissolved in water

T, K	p, MPa	Weight fraction CH_4	$V_{\text{м}}$, cm³/mole	$V_{\text{м}}^{CH_4}$, cm³/mole	$V_{\text{м}}^{H_2O}$, cm³/mole	$V_{\text{м}}/V_{\text{м}}^{H_2O}$, cm³/mole	$(V_{\text{м}}^{CH_4})^*$, cm³/mole
523.15	39.2	0.018	1.229	7.792	1.199	1.025	3.335
573.15	39.2	0.023	1.416	8.598	1.309	1.082	5.399
623.15	39.2	0.045	1.861	10.054	1.494	1.246	8.664

In the volumetric method of calculating reserves, it should be noted, firstly, that part of the volume of the deposit occupied by the gas phase corresponds to the water vapour fraction dissolved in the gas; secondly, that the volume of buried water in gas deposits should increase due to the dissolution of gas in it.

The method of determining gas reserves from pressure drops at high temperatures in the deposit is complicated by the fact that when pressure drops, water should noticeably evaporate into the gas phase and gas release should take place in the buried water.

The data obtained are also important for the theoretical analysis of the solubility of methane in water and its mixtures with other gases in conditions of high temperatures. ●

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OIL AND GAS POTENTIAL OF MORPHOSTRUCTURES OF THE CENTRAL TYPE IN EASTERN SIBERIA

IN THIS ARTICLE THE AUTHOR TRIES TO SHOW THE EXISTENCE OF A CERTAIN LINK BETWEEN THE ARRANGEMENT OF HYDROCARBON DEPOSITS IN THE EAST SIBERIAN PLATFORM AND THE ARRANGEMENT OF PLUME-TECTONIC STRUCTURES PRESENT ON THE EARTH'S SURFACE, BASED ON INTERPRETATION AND ANALYSIS OF SATELLITE IMAGES, IN THE FORM OF CIRCULAR (SOMETIMES SPIRAL-SHAPED) MORPHOSTRUCTURES OF THE CENTRAL TYPE. THIS HAS RESULTED IN A DISPERSION IN THE LOCATION OF OIL AND GAS FIELDS RELATIVE TO THE POSITION OF THE SURFACE MARGINAL PART (SURFACE TOPOGRAPHY OF THE EARTH) OF SOME PLUME-TECTONIC STRUCTURES OF THE EAST SIBERIAN PLATFORM

UDC 553.042

KEYWORDS: *morphostructures of the central type, deep geologic and geophysical sections, East Siberian Platform, potential presence of oil-and-gas content.*

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The President of the Russian Federation Vladimir Putin set before the fuel and energy complex of Russia the task of advancing the economic development of the regions of Eastern Siberia and the Far East. In accordance with the task, Russian research, based on the identified correlational connection between the spatial location of oil and gas fields and morphostructures of the central type (MSCT) [1, 2], is trying to present to Russian oil and gas companies possible prospects in the search for new oil and gas fields on the territory of the East Siberian Platform which, in turn, will contribute to the accelerated economic development of various regions of Siberia and the Far East of the Russian Federation.

Research methods

In order to identify morphostructures of the central type on the territory of the East Siberian Platform, in addition to geological and geophysical (magnetic, gravitational, geothermal) data, the author used satellite image interpretation materials. Various authors [1, 3–5, 7, 8] have noted that with a decrease in the resolution of space images, that is, the generalisation of space images, information on the structure of the earth's crust of deeper horizons can be extracted and analysed. Furthermore, it emerged that a more reliable correlational connection exists between the results of space images, geophysical fields, and geological materials depicted on regional geological maps. That is, the ideas of academician A.L. Yanshin on the importance of studying the sounding of deep geological structures based on space images [5] also point to the relevance of studying the deep structure of morphostructures of the central type.

Initial data

On the territory of the East Siberian Platform (ESP), various authors [3–8] have identified many morphostructures of the central type in various shapes (circular, ellipsoid, spiral) and spatial size (with diameters from several hundred metres to several thousand kilometres) based on the use of decryption satellite images of the Earth's surface topography (Fig. 1).

We can distinguish various surface morphological features of MSCT

FIG. 1. Fragment of the map of morphostructures of the central type on the territory of the East Siberian Platform (ESP) [4]

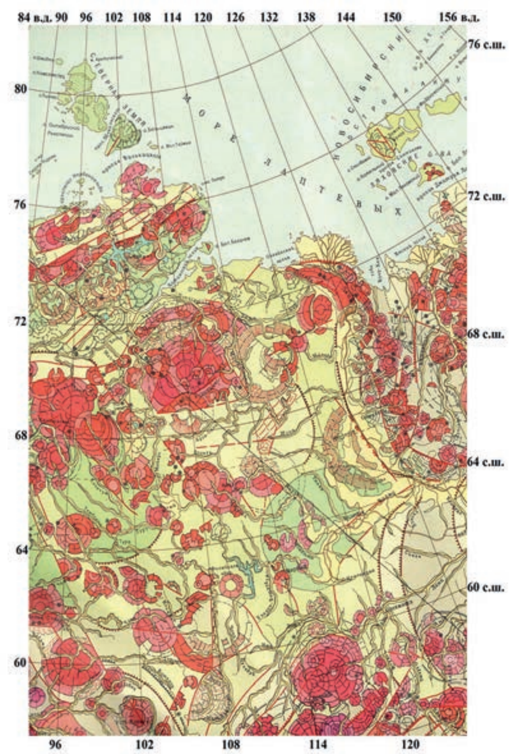


FIG. 2. Cross section diagram of deep plume-tectonic structures along the territory of the East Siberian Platform (East Siberian Astenokon) [4]

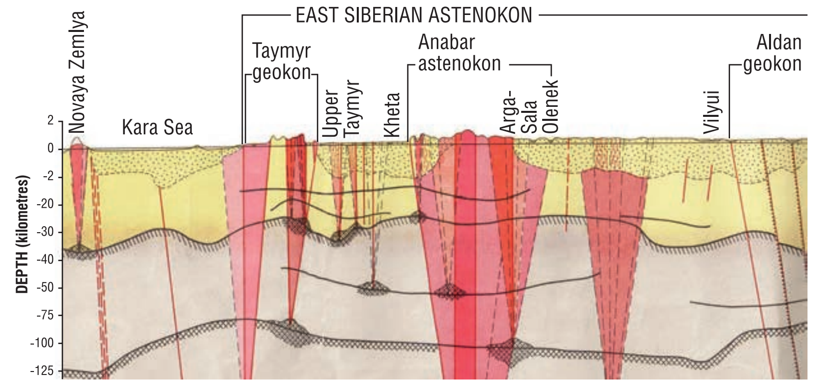
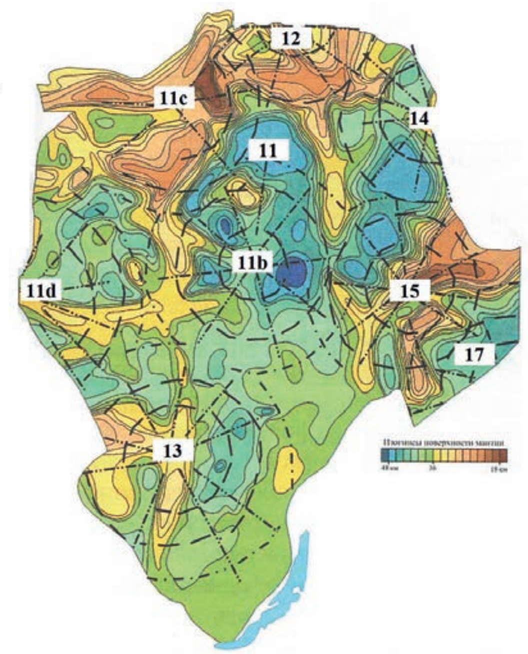


FIG. 3. Morphostructures of the central type on the territory of Eastern Siberia, depicted against the backdrop of the surface topography of the upper mantle [9]



Anabar (11a)
East Tunguska (11b)
Khatanga (11c)
Sredneyeniseisk (11d)
Laptev (12)
Sayano-Yenisei (13)
Yansk (14)
Vilyui (15)
Aldan (17)

The colour scale of the symbols below the figure shows the depth of the isohypse of the upper mantle's surface (in kilometres)

on the territory of the East Siberian Platform: circular, shaft-like, spiral-shaped, cone-shaped surface structures (Fig. 1). The spatial dimensions of the main identified MSCT observed on the territory of the East Siberian Platform range from ten to one thousand kilometres in diameter. Most of these morphostructures of the central type were formed during various geological periods of time during the geological evolution of the Earth.

The morphological structures of the central type of the 3rd and 4th order on the territory of the East Siberian Platform (East Siberian Astenokon – MSCT of the 2nd order) include Anabar (11a), East Tunguska (11b), Khatanga (11c), Laptev (12), Sayano-Yenisei (13), Yansk (14), Vilyui (15), Aldan (17), Nepa-Botubinsk (18) and some others (Fig. 1). Additionally, on the territory of the East Siberian Platform there are also morphostructures of the central type of a lower order (5th–7th orders) [9], such as the Taymyr, Kamovsk, Bakhtinssk, Nizhneyansk, Sredneyansk, Olondinsk, Aldano-Amginsk, Uchursk structures and some others.

Morphostructures of the central type of the East Siberian Platform have different ages and different types of physical mechanisms in terms of formation, which determine the depth of their "roots" and horizontal spatial dimensions (Fig. 2).

The actual location of the morphostructures of the central type (MSCT) on the territory of the East Siberian Platform (East Siberian Astenokon), identified by the interpretation of satellite images is confirmed by independent geological and geophysical data in regard to the location of these morphostructures at the depths of the Mohorovičić discontinuity, presented in Fig. 3, based on research work [9].

The deep morphological features of plume-tectonic morphostructures of the central type identified on the territory of the East Siberian Platform can be summarised as follows (Fig. 4).

In the innermost parts of the Earth, due to magmatic and hydrothermal formations moving from the depths of the earth to its surface [7],

FIG. 4. Schematic cross section of the deep structure of the central (astenokon) and derived (geokons) plume-tectonic morphostructures of the central type (MSCT)

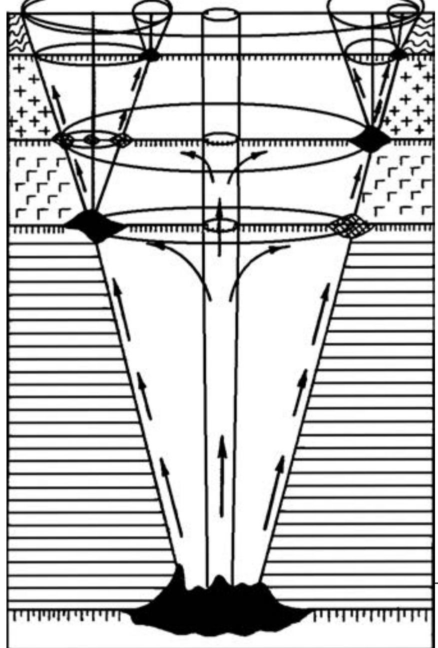
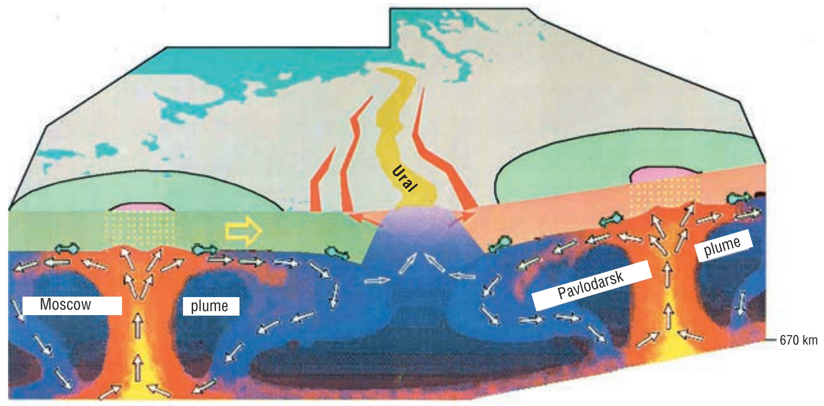
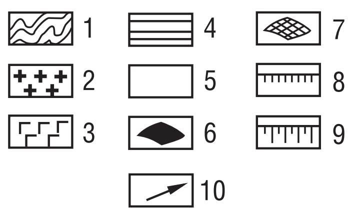


FIG. 5. Circulation pattern of hydrocarbon fluids within the Moscow and Pavlodarsk plume-tectonic structures (astenokons) [7]



Eastern European plate
West Siberian plate
Lithosphere enriched with mantle substance
Flow direction of the fluid
Warmed-up areas
Thermal lines of Urals
Direction of mantle convection
Forces, acting on the lithosphere from the mantle
General direction of motion of the lithosphere plate



1 – rocks of the sedimentary layer of the earth's crust; 2 – weathering crust of the granite layer of the earth's crust; 3 – rocks of the basalt layer of the earth's crust; 4 – rocks of the lithospheric layer of the Earth; 5 – rocks of the asthenospheric layer of the Earth; 6 – accumulations of liquid hydrocarbon fluids at the intersection of subhorizontal boundaries of the physical layers of the Earth and the subvertical boundaries of MSCT; 7 – accumulation of gaseous hydrocarbon fluids at the intersection of subhorizontal boundaries of the physical layers of the Earth and the subvertical boundaries of MSCT; 8 – boundaries dividing the physical layers of the Earth's crust; 9 – boundaries dividing the physical layers of the Earth's mantle; 10 – direction of the heat and mass transfer of the substance and the flow of hydrocarbon fluids from lower layers to the Earth's surface

a truncated cone-shaped deep structure is formed, and along the boundary zones of this structure, gas-thermal and hydrothermal fluid currents advance spirally to the surface (Fig. 5).

Similar morphostructures of the central type formed by the currently active thermal plume-tectonic structures were also analysed in detail in several papers [1, 2, 7].

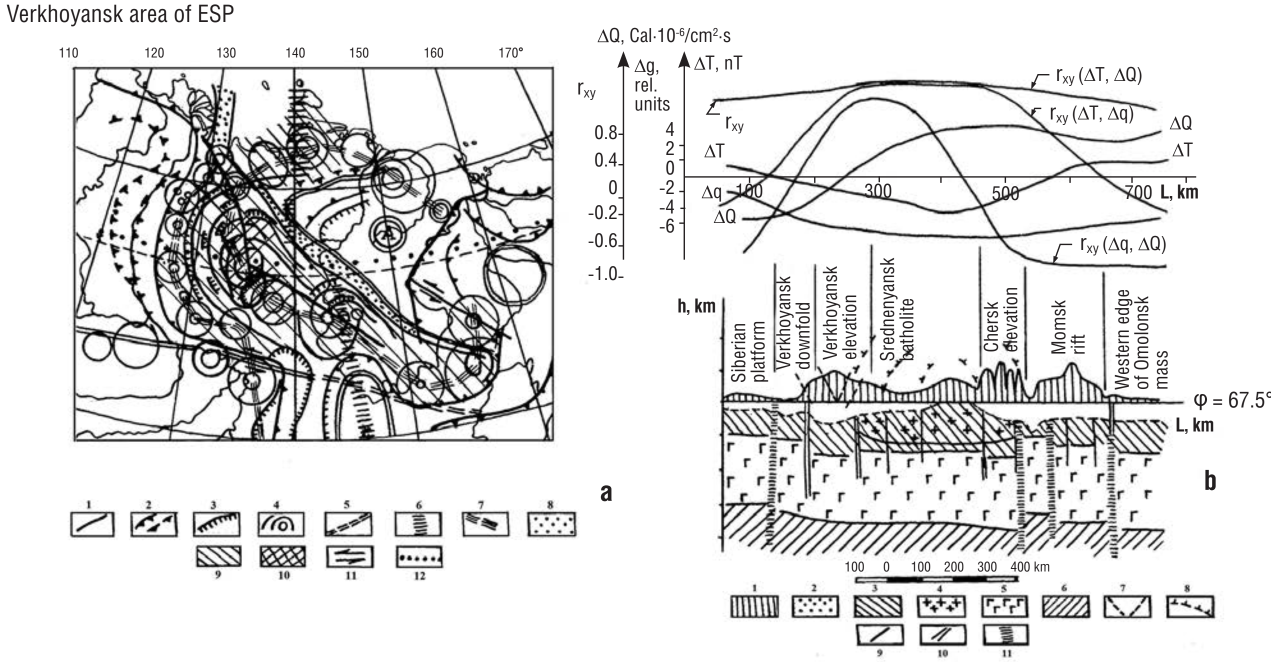
Geological and geophysical interpretation of MSCT data located within the East Siberian Platform

Let us consider the results of the geological and geophysical interpretation of some morphostructures of the central type of the 3rd–7th orders located on the territory of the East Siberian Platform (East Siberian Astenokon), identified by a range of geological and geophysical data and the interpretation of satellite image data. Based on the results of geological and geophysical analysis of various physical fields (Fig. 6b) and the interpretation satellite image data (Fig. 6a), a schematic deep cross section of the earth's crust was created (Fig. 6c), intersecting the Yansk and smaller morphostructures of the central type (MSCT) along the 67.5 degree of the northern latitude. The results of this geological and geophysical analysis are shown in Fig. 6.

Morphological structures of the central type of the 3rd order in the eastern part of Siberia include Ob, Anabar, Yansk, Aldan and others. On the territory of the Verkhoyansk region of the ESP there are numerous lower-order MSCT shown in Fig. 6a, which are formed in the flank zones of Yansk MSCT of the 3rd order.

Clearly distinguished on the satellite image decryption diagram are annular MSCT, located along the marginal suture of the Verkhoyansk ridge, and also along the coastline of the Arctic Ocean. These annular MSCT are caused by formations in the basal complex, apparently related to the Yansk plume-tectonic system, which includes the Momsk plume. On the territory of the Verkhoyansk region, near the upper part of the Lena-Yansk interfluve, clearly distinguished are annular MSCT of the 4th–7th orders, thereby

FIG. 6. Complex geological and geophysical layout of some morphostructures of the central type (MSCT) on the territory of the East Siberian Platform (ESP), tectonic disturbances, isolines of anomalous magnetic and gravitational fields within the territory of the Verkhoyansk area of ESP



1 – deep tectonic faults of the core-mantle level, 2 – collision zones between the Siberian platform and the Verkhoyansk geoblock based on geophysical data and remote sounding of the Earth, 3 – overlap faults and mass overthrusts, 4 – the "core" of the Yansk morphostructure of the central type (MSCT), 5 – suture zone, bounding the Kolymsk microcontinent 6 – transregional faults of the transversal type, 7 – axial zones of increased magma permeability, 8 – rift-induced Neogene-quaternary formations, 9 – sphere of increased values of the geothermal field, 10 – sphere of high values of the geothermal field, coinciding with the sphere of Late Mesozoic granitisation, 11 – displacement of faults, 12 – section for research, A – Alazeisk MSCT, formed during two geodynamic regimes (initial and island-arc); b) Results of the correlation analysis of a complex of various physical fields along the latitudinal section crossing the territory of the Yansk MSCT and its eastern margin along the 67.5 degree of the northern latitude

1 – mountain ranges located above sea level, 2 – unconsolidated sedimentary rocks, 3 – consolidated sedimentary rocks, 4 – granitoid rocks, 5 – basaltic rocks, 6 – mantle rocks of the Earth, 7–8 – direction of the course of blocks of the earth's crust, 9 – deep location of tectonic faults, 10 – topography of folded areas on the Earth's surface, h – height of the Earth's surface topography (in kilometres) along the section; d – depth (in kilometres) of the lower boundary of the sedimentary cover, folded base of the basal complex, Mohorovičić discontinuity (in kilometres); dQ – anomalous values of the heat flux from the innermost parts of the Earth; dg – anomalous values of the Earth's gravitational field (in relative units) [9]

complicating the spiral Yansk MSCT of the 3rd order (Fig. 6a).

From the constructed geological and geophysical cross section that intersects MSCT of the Verkhoyansk region (Sredneyansk batholith), it can be seen that on the Mohorovičić discontinuity there is a depression, which is the basis of this MSCT in the earth's crust, and in the sedimentary cover layer granitoid formations are observed. Spiral branches contouring (on the surface of the Earth) the Yansk MSCT, together with similar structures deep in the earth's crust, allow us to outline the subvertical deep boundaries of this MSCT.

Also, based on the results of complex geological and geophysical studies (aeromagnetic, gravimetric studies), deep aeromagnetic

FIG. 7. Deep aeromagnetic section of the earth's crust through the territory of the Olondinsk MSCT [10, 11]

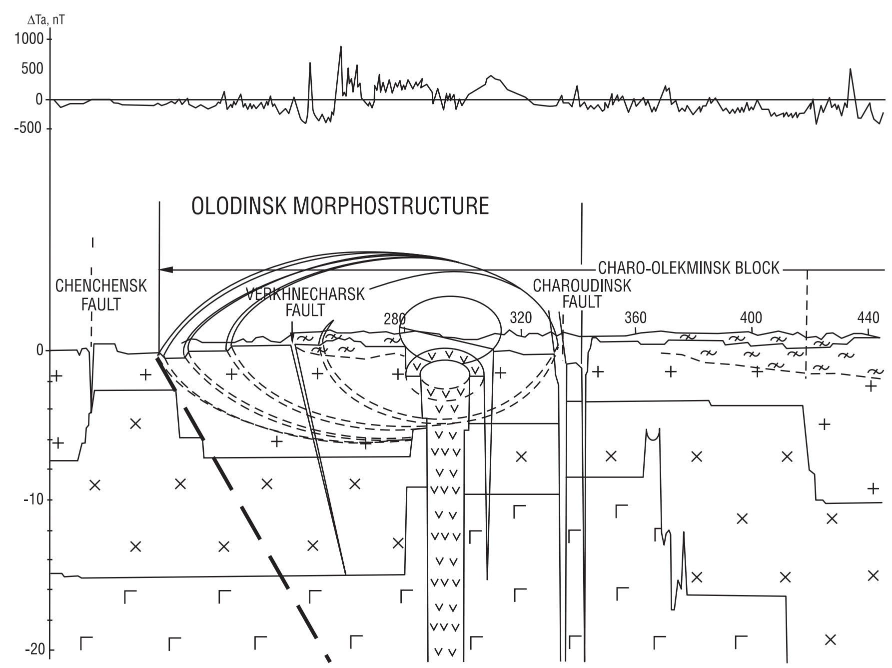
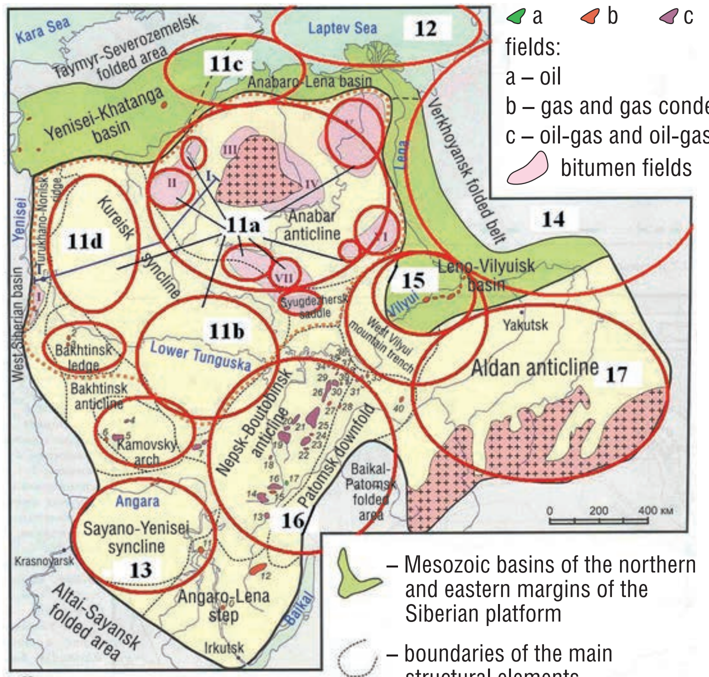


FIG. 8. Diagram for comparing selected morphological structures of the central type of the 3rd and 4th orders in Eastern Siberia with the location of oil and gas fields within known geological structures presented on the map [12]



a b c
fields:
a – oil
b – gas and gas condensate
c – oil-gas and oil-gas-condensate
bitumen fields

– Mesozoic basins of the northern and eastern margins of the Siberian platform
– boundaries of the main structural elements
– line of profile
– contours of studied region
– Leno-Tunguska basin
– ledges of the foundation of the Siberian platform

Morphostructures of the central type:

11a – Anabar, 11b – Tunguska, 11c – Khatanga, 11d – Sredneyeniseisk, 12 – Laptev, 13 – Sayano-Yenisei, 14 – Yansk, 15 – Vilyui, 16 – Nepo-Botubinsk, 17 – Aldan

sections of the earth's crust were constructed that intersect the Olondinsk, Aldan-Amginsk, Uchursk MSCT of the 5th order and others (within the Aldan MSCT of the 3rd order) [10, 11]. Fig. 7. shows one of the aeromagnetic sections of the earth's crust.

From the constructed geological and geophysical section that intersects the Olondinsk morphostructure of the central type (Fig. 7), it can be seen that the deep boundaries of the earth's crust have recesses of the basal complex, limiting the deep asymmetric funnel-shaped depression (plume-tectonic structure), which is the basis (roots) of this MSCT in the earth's crust. Figure 7 shows that in the centre of the Olondinsk plume-tectonic structure there is the so-called "degassing track" along which hydrocarbons can migrate to surface "traps" of hydrocarbons in rocks of the sedimentary cover.

As a result, based upon data from research [6], it can be seen that the Noyabrsk MSCT, located on the territory of Western Siberia, the Yansk MSCT (14 a, b, c) and the Vilyui MSCT (15), located on the territory of Eastern Siberia, are connected with currently active thermal plumes, which by analogy with the Noyabrsk MSCT, allows to predict numerous rich oil and gas fields within them. Similar highly promising oil and gas deposits can be adjacent MSCT of the East Siberian Astenokon: the Sayano-Yenisei MSCT, the Kamov MSCT, the Bakhtinsk MSCT and the eastern bitumen fields of the Anabar MSCT formed by active thermal plume-tectonic structures.

On the territory of the East Siberian Platform, geological and geophysical (aeromagnetic) sections of the earth's crust have been formed. Based on the use of complex data of decoding satellite images and analysis of anomalous magnetic and gravitational fields on the territory of the East Siberian Platform and the results of studies of complex geological and geophysical sections of the earth's crust, we have identified the main structures of the central type of the 3rd–7th orders, which can be associated with deposits of various types of hydrocarbons (gas, oil, coal methane).

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TROJAN ATOM

POLSKA.

Wojciech Jakubik

Despite the favorable conditions offered by Rosatom, Poland will most likely choose another partner for the construction of nuclear power plants. It turns out that Russian nuclear power plants, with thousands of employees from Russia, problems with access and the limited control given to countries where they are built, turn electric power station into extraterritorial Russian bases.

According to government documents, Poland intends to launch its first nuclear reactor in 2033 and commission new ones every two years, meaning that by 2043 there will be six nuclear power plants in total.

The Czech Republic and Ukraine, together with the Americans, are looking for a replacement for Russian nuclear fuel, even though this will require the technical re-equipment of reactors and costly investments. These countries are interested in avoiding Russian suppliers, since cooperation will translate into political consequences, like any other economic dependence on Russia.

PUTIN'S APPEAL TO JAPAN AND INDIA TO INVEST INTO THE RUSSIAN FAR EAST REMAINS UNANSWERED

THE WALL STREET JOURNAL.

Thomas Grove

The three-day investment forum held in Vladivostok, aimed at highlighting the opportunities of the Russian Far East, ended without any clear victories for Moscow or the mostly underdeveloped region which the Kremlin wants to build up and position as a gateway to Asia.

The complete absence of significant deals at this forum reflects the Kremlin's difficulties in an attempt to integrate this remote region and bring it closer to Moscow. The most significant participants of the forum – Narendra Modi, Prime Minister of India and Shinzo Abe, Prime Minister of Japan – left without concluding any major agreements, aside from India's line of credit amounting to $1 billion for the development of the Russian Far East. Mr. Abe left for Japan without signing a single major agreement.

"The problem is that the government does not have enough funds, and so far no one is ready to invest in this region," said A. Lukin, an expert on the Far East. "Businesses do not see an opportunity for profit here."

The lack of jobs and high prices for consumer goods trigger the constant outflow of the population.

"It is wonderful that the economic forum is taking place here and agreements are being signed. But what do we get from this?" asked Alexander Shkirsky, an unemployed resident of Vladivostok. And then answered: "Nothing".

BERLIN WALL IN THE ENERGY SECTOR

POLSKA.

Andrzej Schensnyak

The intention of the Baltic states to unplug from Russia's power grid network echoes the construction of the Berlin Wall, this time in the energy sector between the Russian Federation and the European Union. Connecting the Baltic states to the EU's grid is politically motivated and is bound to cause problems. Europe and Russia are isolating their power resources from each other. Moscow is bolstering and fortifying its only exclave on the Baltic Sea, while Brussels is connecting the Baltic states to Europe's own power system. The floating storage and regasification unit, Marshal Vasilevsky, has already appeared and commenced operations in the Kaliningrad region. It can navigate in ice with a thickness of up to 0.9 meters and withstand temperatures of up to -30 °C, with an annual capacity of 2.7 billion m^3 (50 % more than the LNG terminal in Swinoujscie). The project's cost amounted to $90 billion and the new installation will fully meet the region's gas demands.

Meanwhile, as Kaliningrad turns into an energy stronghold, the Baltic states remain part of Russia's IPS/UPS system. Not for long it seems, since Brussels has decided to connect them to the European power system. The first stage is synchronization with the European Union's UCTE, which will be preceded by desynchronization from Russian networks.

The refusal to accept power supplies from Russia, thereby creating a barrier, is reminiscent of the Berlin Wall, this time, however, in the energy sector.

SYNTHETIC FUEL VS. LNG

Comparative analysis of using synthetic fuel and LNG as motor fuels

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AT PRESENT, THE MAIN SOURCE OF MOTOR FUEL IS OIL. THE INCREASE OF ENVIRONMENTAL REQUIREMENTS FOR MOTOR FUELS AUGMENTS THEIR COST; MOTOR FUELS FROM NATURAL GAS ARE BECOMING MORE WIDESPREAD. THIS PAPER PRESENTS A COMPARATIVE ANALYSIS OF THE USE OF FUEL PRODUCED BY GAS-TO-LIQUID (GTL) TECHNOLOGY AND THE PRODUCTION OF LNG FOR UTILISATION AS A GAS MOTOR FUEL

KEYWORDS: *alternative fuel, LNG, GTL, comparative analysis, natural gas.*

Over the past hundred years, oil has been an important source for energy production and is widely used in the transportation, industrial and domestic sectors. Currently, approximately 80% of global demand for transportation fuels (automotive, rail, air and marine) is met by derivatives of fossil fuels – oil.

However, over the past few decades natural gas has overtaken oil and has acquired the role of the major fuel source. This is largely due to the growth of LNG production, which has globalised gas markets. Furthermore, a growing awareness that cleaner technologies are vital to the future of the planet makes natural gas the primary source of fuel. Due to a combination of environmental issues, high oil prices and peak oil production, the development of cleaner alternative fuels and advanced power systems for vehicles has become a priority for many governments and vehicle manufacturers around the world.

The main alternatives to fossil fuels are:

- liquefied hydrocarbon gases (LHG)
- liquefied and compressed natural gas (LNG and CNG)
- synthetic fuel derived from natural gas or coal – methanol, dimethyl ether (DME), synthetic liquid hydrocarbons (SLH)
- ethanol
- hydrogen.

Environmental concerns about fossil fuels are driving the search for suitable alternatives. The use of hydrocarbon gas is widespread. When it is used, according to some estimates, greenhouse gas emissions are about 15% lower than use of petrol in vehicles. Additives or other agents are not required to increase the octane rating. A comparison of the levels of harmful gases emitted by vehicles operating on LHG and petrol is inconclusive, with test results indicating both higher and lower emission levels from vehicles.

The use of CNG due to the high octane rating of methane is an excellent option for spark ignition engines. The use of CNG significantly reduces particulate emissions, at the same time CNG for transport is being used more and more in the urban bus fleet sector. The main problem of CNG is its storage – due to its low boiling point, the natural gas must be stored at high pressure. In order to do this, metallic or metallic-composite cylinders are used, which reduce the imposed load and space in moderate vehicles.

FACTS

80 %

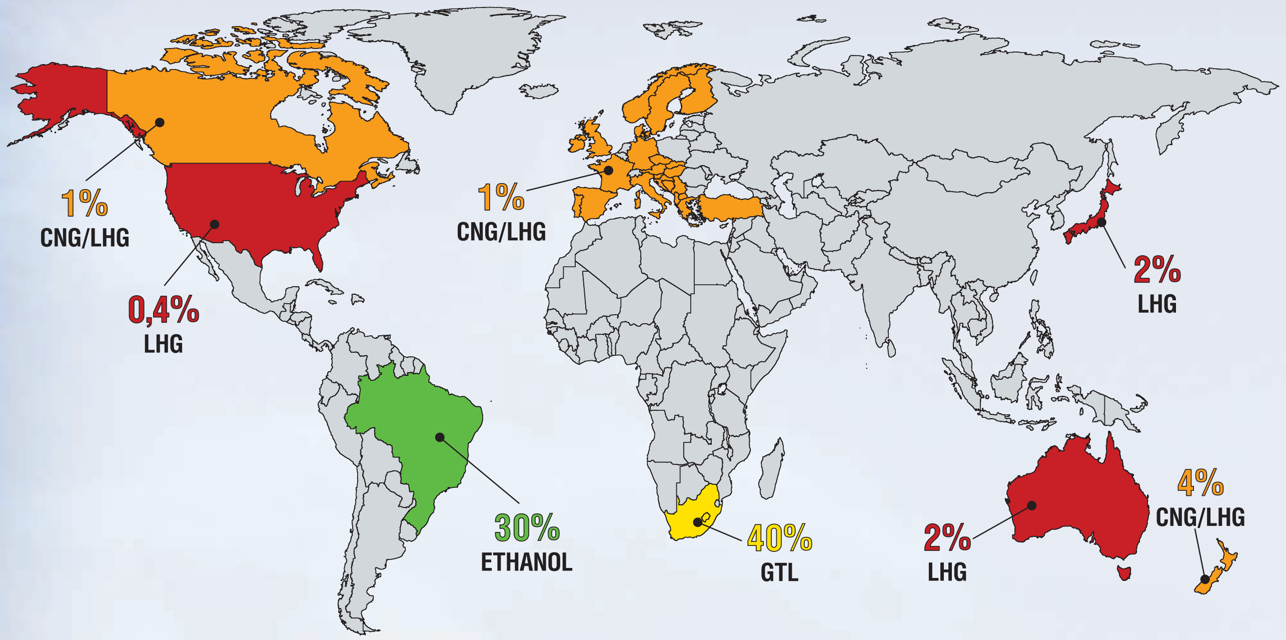
of global demand for transportation fuels met by oil

An alternative way to store natural gas is to liquefy it. In a liquid state, natural gas is 3 times denser than compressed CNG. Unlike CNG, which is stored at high pressure (200–250 atm.), and then reduced to lower pressure that the engine can handle, LNG is stored at low pressure (3–12 atm.) and simply evaporates in the heat exchanger in front of the fuel engine dispenser. Consequently, the mileage of a vehicle using LNG (without refueling) is three times more than that of a vehicle using CNG.

Ethanol is currently the most widely used alternative biofuel in the world. It is mainly obtained from crops containing sugar (for instance, sugarcane or sugar beets), or by pre-treatment of starch crops (maize or wheat). The positive environmental aspect is that, unlike oil, gas or coal, ethanol is a renewable resource. However, there are drawbacks: solubility in water which makes ethanol more difficult to separate, its production requires large areas of land, and also while reducing CO emissions, the emission of aldehydes increases. At present, ethanol production is 2–3 times more expensive than petrol production, making this type of fuel absolutely unprofitable.

A hydrogen vehicle is a vehicle that uses hydrogen as its primary source of energy for transportation. These cars usually use hydrogen in one of two ways: combustion or conversion in fuel cells. During combustion, hydrogen burns in engines in the same way as traditional petrol or methane. Upon conversion in a fuel cell, hydrogen is converted into electricity, which powers the electric motor. In both methods, the only by-product of the spent hydrogen is water, but

FIGURE 1. Main consumer countries of alternative fuels



nitrogen oxides can form during combustion with air. As of now, hydrogen is used as fuel only in space rockets. However, some car manufacturers are developing hydrogen engines, and the main technical difficulty is hydrogen storage and safety – hydrogen is extremely flammable in a wide range of air-fuel ratios.

Synthetic fuels constitute another group of alternative fuels. These include derivatives of natural gas or coal, namely methanol, DME and SLH. Currently, pure methanol is used in specially designed engines for racing cars, because its high octane rating allows the use of high compression, which gives significantly more power than traditional petrol engines. Although emissions of CO, hydrocarbons, and nitrogen oxides are lower, car-based methanol exhaust fumes contain more formaldehyde, which is carcinogenic. Methanol can also lead to more unburned fuel emissions of methanol and methane. Moreover, it is extremely toxic and therefore dangerous to handle. Another negative feature is its increased corrosion, which requires the modification of the fuel system of a conventional vehicle.

Dimethyl ether is a promising fuel in diesel engines and gas turbines due to its high cetane number. The simplicity of this compound with a short carbon chain results, upon combustion, in very low emissions of particulate matter, NO and CO. For these reasons, and also due to the absence of sulfur, DME meets the most stringent environmental requirements.

Another class of synthetic fuels that has received considerable attention recently is gas-to-liquid (GTL) fuel. GTL diesel fuel is produced from natural gas using the Fischer– Tropsch process.

GTL diesel consists exclusively of paraffin oils, with virtually no aromatic hydrocarbons or olefins.

FACTS

15 %

reduction of carbon dioxide emissions when hydrocarbon gas is used as fuel

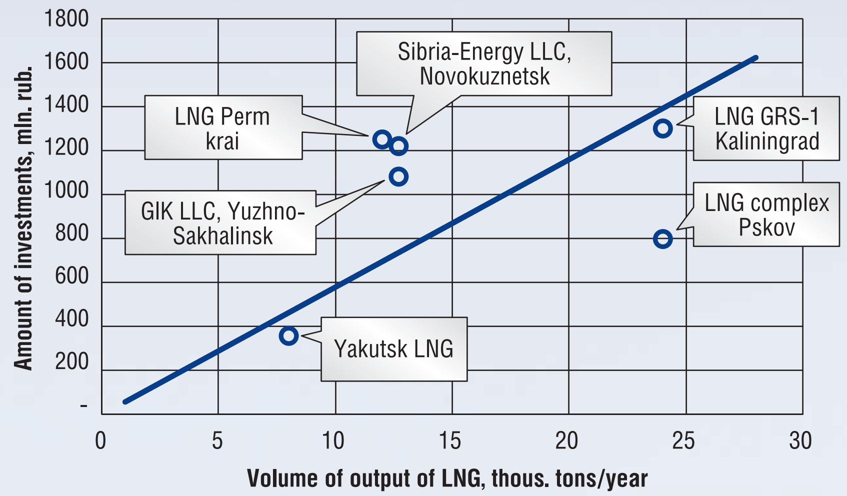
Additionally, GTL diesel fuel is almost sulfur and nitrogen free. The cetane number of GTL diesel fuel is significantly higher than that of petroleum diesel fuel – typically in the range of 70 to 75. GTL diesel fuel has poor lubricity and lubricating additives are required for commercial use. What is more, GTL fuel has poor low-temperature characteristics, which limits its potential use in cold climates. At the same time, a GTL diesel engine with a set of additives is fully compatible with existing diesel engines and can be used both as a replacement for conventional diesel fuel or as a mixture with it.

GTL diesel fuel leads to lower emissions of hydrocarbons, carbon monoxide, nitric oxide and particulate matter compared to conventional diesel. It is also worth noting that GTL diesel has no advantages in terms of CO_2 emissions.

Alternative motor fuels are currently widespread only in individual countries (Figure 1).

Other types of alternative fuels (ammonia, biodiesel, formic acid, etc.) will not be examined due to insufficient technological maturity and the impossibility of commercial use.

FIGURE 2. Volume of investments into low-tonnage LNG plants (measured in 2018 prices)



From the options considered above, two of the most promising and accessible in terms of application in the technological and economic sphere are LNG motor fuels and GTL diesel fuels.

The use of gas-based motor fuels is relevant for low-yield natural gas fields, as well as for the involvement of associated petroleum gas for refining

Monetization of gas using LNG is limited by its chemical composition and has narrow commercial applications in the regasified state, which distinguishes it from synthetic hydrocarbons.

LNG production is a key link in building the infrastructure for the production, storage, distribution and consumption of liquefied natural gas [1].

In modern installations for liquefying natural gas, technological plans are used based on the following main cycles:

- cooling cycles with throttling
- expander cooling cycles
- cascading cooling cycles with clean cooling agents
- single-threaded cascade cycles with the cooling agent being a multicomponent mixture

Often, various combinations are used in liquefaction methods, including elements of the above-mentioned cycles.

Currently, low-tonnage LNG technologies are the most effective – they are implemented in a compact modular design, located on an open area, not requiring significant construction and installation works, which leads to a decrease in investment.

Accurate data on the costs of LNG production is difficult to identify, since it can vary significantly depending on the location, LNG production volumes and logistics features. Data on the volume of investments in some Russian low-tonnage LNG plants is shown in Figure 2.

Liquefaction of natural gas is carried out for its transportation, and at the place of consumption, LNG

FACTS

3

times denser

liquefied natural gas (LNG) is 3 times denser than CNG

is regasified, and currently the bulk of natural gas is used to generate energy. When using LNG as a motor fuel, regasification occurs in the vehicle's fuel system.

Today, in world practice, LNG is actively used, for the bunkering of sea vessels, and also for freight transportation as a motor fuel. The undisputed world leader in the use of LNG in transport is China, which has about 6 million units of gas engine vehicles and over 3 thousand LNG filling stations, making this country the largest gas motor market in the world (by comparison, the figure in Europe is 212 [2], in Russia – 2). The utilisation of natural gas in the transportation sector of China in 2018 amounted to about 36 billion cubic metres and according to forecasts, this value will have increased to 55 billion cubic metres by 2020 [3].

The main volume of consumption is accounted for by heavy LNG-powered freight trucks, whose number has already exceeded 240 thousand units in China. [4].

In Russia, the network of LNG fuel stations is virtually absent. Now LNG can only be refueled at two stations (Table 1).

Modern factory-made LNG-powered trucks have the same power and torque as diesel engines.

During the operation of Euro-V and Euro-VI ecological class trucks with 330 and 400 hp engines, it was found that the average LNG consumption is 25.9 kg/100 km. For gas vehicles, fuel consumption is about 15% lower than for diesel cars. Fuel consumption, among other things, is also affected by the type and weight of the cargo, route profile, refueling infrastructure, terrain and climate.

An important indicator for trucks is the driving range with one fill-up. Currently, the LNG supply aboard provides quite acceptable autonomy:

- KAMAZ – 1600 km;
- Ural – 1000 km;
- Scania – 1000 km;

TABLE 1. LNG fuel stations

LNG filling station	Location	Quantity	Stage	Year of commissioning
LNG GDS-1 Kaliningrad	Bolshoye Isakovo settl., Kaliningrad Oblast	1	Commissioned	2018
Moscow GPP	Razvilka settl., Moscow Oblast	1	Commissioned	2019
LNG fuel station project	Tyubuk settl., Chelyabinsk Oblast	4	CIW	2020
Multi-fuel filling station project	Kondratyevo, Leningrad Oblast	2	CIW	n.a.
LNG fuel station project	Bukharino village, Chelyabinsk Oblast	4	Project phase	n.a.
LNG fuel station project	Okulovsky area, Novgorod Oblast	2	Project phase	n.a.
LNG complex project	Petergrof, Leningrad Oblast	1	Project phase	n.a.
LNG fuel station project	Solnechnogorsk area, Moscow Oblast	n.a.	Pre-project phase	n.a.

- Iveco – 1500 km;
- Volvo – 1000 km.

Another important issue is the storage of LNG aboard the vehicle.

Natural gas must be supplied to the engine at the appropriate temperature, pressure and flow rate. In the simplest variant, in order to overcome hydraulic losses in heat exchangers and pipelines and to supply a sufficient amount of fuel to the engine, the supply system uses pressure in the tank.

In order to improve the flow characteristics, especially in the case of operating highly efficient spark ignition engines, the so-called warm LNG is used. Other, more sophisticated fuel systems are capable of using cold LNG.

Cold LNG is used at temperatures below -142 °C and 3–6 atm., while warm LNG is used at temperatures from -125 to -135 °C and 6–12 atm. Cold LNG has a higher density than warm LNG, and as a result more fuel with a longer drainage-free storage time can be aboard the vehicle. However, such an unsaturated fuel has low pressure, and auxiliary equipment is required for increase to take place before being supplied into the engine.

Refueling a vehicle with cold LNG compared with warm LNG increases mileage by 12 % and the time of drainless storage from 5 to 10 days (Figure 3).

The choice of the type of LNG filling station depends on traffic and the type of fueling machine. For example, in Europe, both cold-filling stations and warm-filling stations are used, and in particular, warm-type stations are common in Germany.

LNG vehicle operating experience shows reduced engine oil consumption. Gas, unlike diesel fuel, does not wash off oil from cylinder walls, and also it lasts longer. In practice, there is an increase in service life by about 30 % [6].

FACTS

200-250 atm

Pressure at which CNG is stored

Thus, as already noted, the only serious obstacle to the active widespread use of LNG is the small number of filling stations.

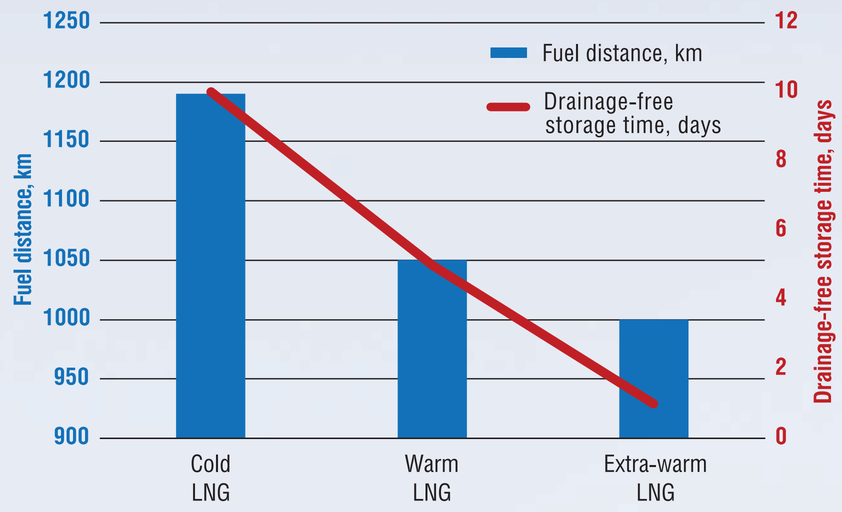
The chemical method of monetising natural gas for use as a motor fuel is to convert it to liquid hydrocarbons by means of the Fischer–Tropsch process. This process produces a wide range of products: fuels, base oils, LPG, naphtha and hard paraffins. Such a product line opens up more markets for sale, but it requires significant capital expenditures.

The technology for producing synthetic liquid fuels has existed since the 1920s. In 1923, German scientists Franz Fischer and Hans Tropsch developed the process of forming long-chain hydrocarbons by the chemical reaction of carbon monoxide and hydrogen based on a catalyst.

The development of this process was supported by the German government after the First World War to ensure energy independence. Subsequently, this technology allowed Germany during World War II to provide military equipment with fuel, thereby weakening the effectiveness of Nazi Germany's blockade.

The synthesis gas for this process was produced by gasification of the country's rich coal resources. Germany had 9 plants operating,

FIGURE 3. Effect of the type of LNG fill-up on vehicle distance and drainage-free storage time (based on data [5])



which produced approximately 0.6 million tons of SLH per year.

After World War II, international conventions imposed obligations to dismantle SLH production. Plant equipment was either broken down into scrap metal, or exported from the country to the UK or the USSR.

Further on, the development of GTL technology was constrained by low oil prices. The total production of SLH in the world by 2010 amounted to less than 100 thousand barrels per day, which is comparable to one medium-sized refinery.

However, an increase in the service life of the catalysts used to produce liquid hydrocarbons from natural gas, an increase in the efficiency of the Fischer-Tropsch process, independence of natural gas markets from oil prices and a subsequent drop in natural gas prices, as well as global trends in the transition to low-impact fuels on the environment paved the way for the development of the SLH industry.

FACTS

3-12 atm

Pressure at which LNG is stored

World capacities for the production of SLH are presented in Table 2.

The largest of the existing plants is the Pearl GTL in Qatar, with a total capacity of 140 thousand barrels per day. Initially, the cost of the plant was estimated at 5 billion US dollars, but the final costs were more than 3 times higher and amounted to 19 billion US dollars.

LNG production at the plant is based on Shell Middle Distillate Synthesis (SMDS) technology. The main products in this case are kerosene and diesel fuel, and additionally, ethane, LHG, naphtha, paraffins and base oils are produced.

The process of producing synthesis gas occurs due to the partial oxidation of purified natural gas with oxygen. The resulting synthesis gas, after cooling, is sent to the tubular reactors for the synthesis of fats. In total, the plant has 24 reactors, each containing tens of thousands of tubes having a cobalt catalyst. At the third stage, fractionation and hydrocracking of heavy paraffins takes place to increase the yield and quality of the obtained diesel fraction.

Products made from natural gas do not contain aromatic compounds, sulfur compounds or metals. This leads to a significantly smaller number of harmful carcinogenic compounds formed during the combustion

TABLE 2. Large plants for the production of SLH

Name of plant	Country	Licensor	Year of commissioning	Power based on SLH, barrel/day
Mossel Bay GTL	South Africa	PetroSA	1992	30,000
Bintulu GTL	Malaysia	Shell	1993	14,700
Mossel Bay GTL Expansion	South Africa	PetroSA	2005	15,000
ORYX GTL Phase 1	Qatar	Sasol	2006	32,400
Pearl GTL Phase 1	Qatar	Shell	2011	70,000
Pearl GTL Phase 2	Qatar	Shell	2011	70,000
GTL-plant in Ovadandepe settl.	Turkmenistan	Haldor Topsoe	2019	15,000
Total				**247,100**

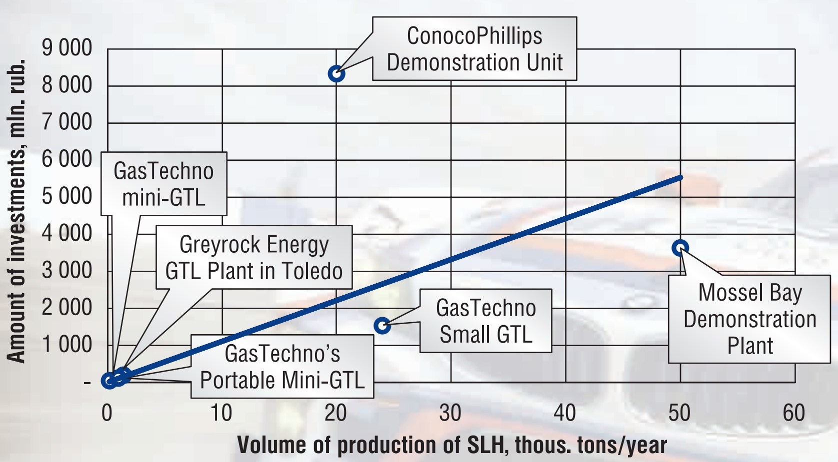
TABLE 3. Comparison of quality indicators

Indicators	Euro-5	Synthetic diesel fuel
Cetane number	>51	>70
Sulphur content, mg/kg	<10	n/a
Density at 15 °C	0,82-0,84	0,77
Polyaromatic hydrocarbons,% vol.	<11	<0,1
Temperature limit of filterability, °C	-20..-38	-27
Boiling temperature 95% vol., °C	<360	340
Lubrication capability, μm	<460	457

TABLE 4. Examples of low-tonnage GTL-plants [7–10]

Plant	Country	Year of commissioning	Output by SLH, ton/year
ConocoPhillips Demonstration Unit	USA	2003	20 000
Mossel Bay Demonstration Plant	South Africa	2011	50 000
Greyrock Energy GTL Plant in Toledo	USA	2011	1 400
GasTechno's Portable Mini-GTL	USA	2013	190
GasTechno mini-GTL	project		950
GasTechno Small GTL	project		24 000

FIGURE 4. Volume of investments into low-tonnage GTL-plants (2018 price range)



of fuel in the car engine than when using fuel obtained through oil refining.

Daily, such a plant produces 50 thousand barrels of diesel fuel, as well as 30 thousand barrels of high-quality base engine oils of the 3rd group.

A comparison of synthetic diesel fuel quality indicators with the requirements of GOST 32511-2013 (EN 590:2009) for 5th grade diesel fuels is presented in Table 3.

The next large liquid hydrocarbon production plant was launched only in July 2019 in the village of Ovadandepe in Turkmenistan. Unlike the plant built in Qatar, the main product of this plant is petrol, the production of which is 600 thousand tons/year (diesel fuel capacity – 12 thousand tons/year). The total yield of liquid hydrocarbons is approximately 15 thousand barrels per day, and the capital costs for the construction of the plant amounted to 1.7 billion US dollars, which correlates with the specific capital costs for the plant in Qatar.

However, such installations require a large amount of natural gas and are not suitable for monetization of small fields. For this purpose, low-tonnage plants for the production of synthetic hydrocarbons have become widespread, presented in Table 4.

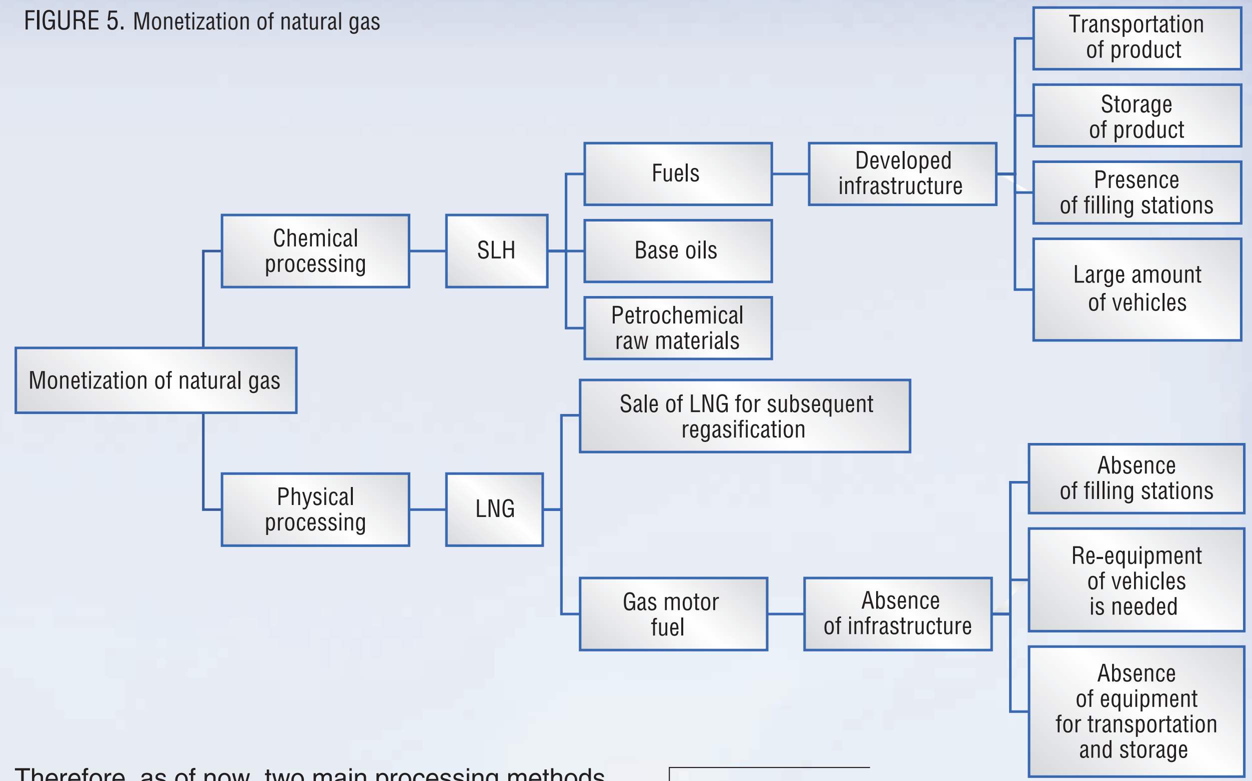
GTL low-tonnage plants have higher specific capital costs, however, their use can be advantageous in the presence of cheap raw materials. Data on investments at prices from 2018 are presented in Figure 4.

Due to the high capital investments, the feasibility of constructing a GTL plant is only possible at a low cost of natural gas, which is why global oil and gas companies currently prefer to invest into traditional methods for producing liquid fuels.

For example, the planned cost of the Amur Refinery, the construction of which was postponed for an indefinite period in 2019 due to lack of raw materials [11], amounted to approximately 120 billion rubles, which is slightly less than 2 billion US dollars. These investments are commensurate with the costs of the GTL plant in Turkmenistan.

The planned capacity of the refinery for raw materials is 6 million tons per year. Thus, with the same capital costs for the construction of a refinery and a GTL plant, the capacity of the former will be several times greater, ensuring lower production costs and quicker payback.

FIGURE 5. Monetization of natural gas



Therefore, as of now, two main processing methods can be distinguished as options for monetising natural gas reserves for utilisation as motor fuels: the physical method – production of liquefied natural gas (LNG) and the chemical method – production of synthetic liquid hydrocarbons (SLH) based on the Fischer-Tropsch method (Figure 5).

Both methods, undoubtedly, have advantages, but they are not without drawbacks. In terms of LNG, this means the need to re-equip automobiles and the underdeveloped sales infrastructure; in terms of GTL, this implies large investments into production.

By way of comparison, let us consider these two options as an example of a small company having a natural gas field with a production cost of 2 thousand rubles/thousand m^3 and its own fleet of 20 truck tractors, having a mileage of 1000 km, due to minimum fuel distance of modern LNG vehicles.

FACTS

2-3

times higher

ethanol production is 2–3 times more expensive than petrol production

TABLE 5. Capital costs for transition of equipment and construction of installation

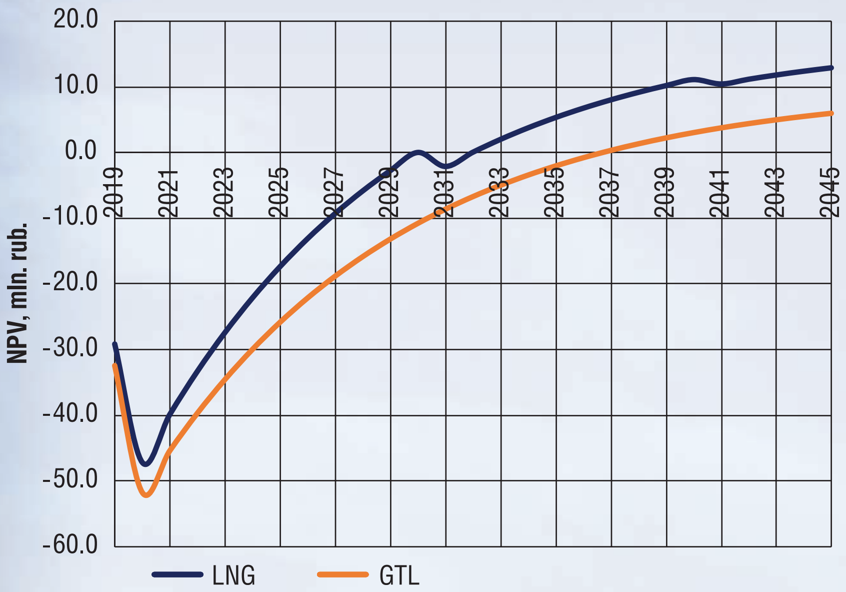
Unit	Characteristics	Volume of investments, mln./rub.
LNG unit	32,5 kg/h	15
LNG filling station	1	11
Re-equipment of trucks	20	13
Semitrailer-cistern for LNG transportation	1	5
TOTAL		**44**

If the company selects an investment project for converting transport to LNG, the following costs will be required (Table 5).

For subsequent calculations, it was assumed that the annual mileage of each truck will be 50 thousand km. Based on these initial data, the unit capacity per year was calculated and capital expenditures were determined based on Figure 2. Furthermore, in order to switch to gas engine fuel, apart from converting equipment, it is necessary to provide fueling for the vehicle. And since at present the LNG filling-station infrastructure is poorly developed in Russia, the company will have to inject additional investments for the construction of a filling station and a semi-trailer cistern for LNG transpaortation from the plant to the filling station. The service life of the relevant trucks was assumed to be 10 years (after this period, collateral costs for re-equipment of trucks were taken into account).

Conversely, in order to implement the GTL project under the same conditions, only investments into a sy nthetic fuel production unit with a capacity of 425 tons will be required.

FIGURE 6. Comparison of NPV dynamics



A comparison of the dynamics of net present value (NPV) during implementation of these investment projects is presented in Figure 6.

During 25 years of operation, both options have a positive NPV. However, in the case of the LNG project, the net present value is more than twice as high and the discounted payback period is 5 years less.

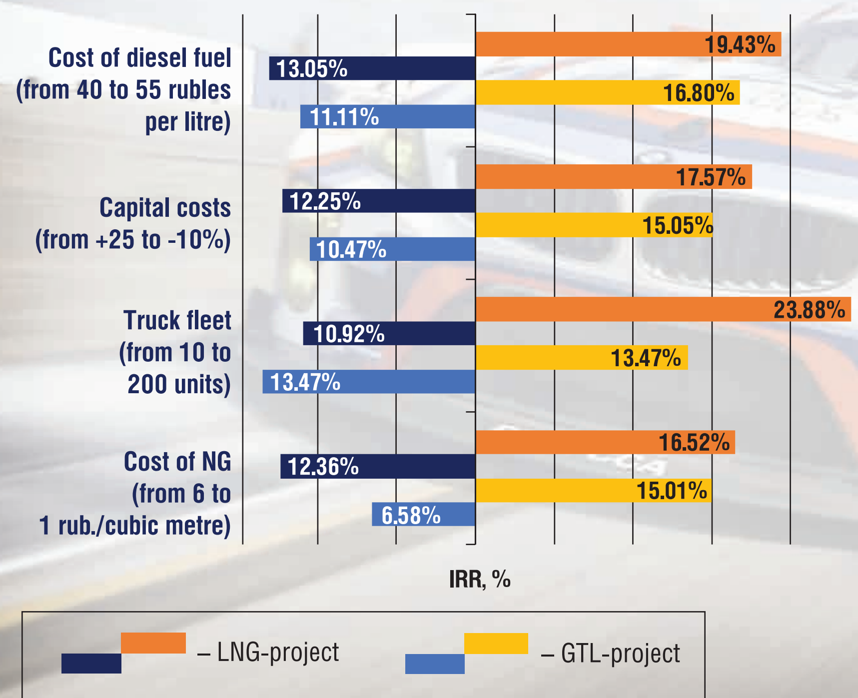
Figure 7 shows the sensitivity analysis of the internal rate of return (IRR) depending on changes in various parameters.

FACTS

Cetane number

of GTL diesel fuel is significantly higher than petroleum diesel fuel – ranging from 70 to 75

FIGURE 7. Sensitivity analysis of investment projects



As can be seen from these diagrams, the project which is more resistant to external factor changes is the method of using LNG as a gas engine fuel. The only exception is the truck fleet factor (fuel consumption), which is less sensitive to change, even in regard to increasing payback during augmented productivity.

Thus, when comparing the alternative motor fuels GTL diesel and LNG, the most promising option is that of liquefied natural gas (LNG) used as a motor fuel. The results obtained during research show that, if there is a source of inexpensive natural gas, both options can be used. Nonetheless, despite the costs of creating built-in infrastructure for refueling trucks with liquefied natural gas, the option with LNG utilisation not only supersedes synthetic diesel fuels, but also allows to save a significant amount of money. ●

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EVENT CALENDAR

5–8.11
1st International Scientific and Practical Conference
ProGREss 2019: Exploration as a Business
Sochi

12–15.11
25th International Industrial Exhibition
Metal-Expo
Moscow

13–14.11
Interregional Specialized Exhibition
NIZHNEVARTOVSK. OIL. GAS - 2019
Nizhnevartovsk

14–15.11
14th Technical Conference and Exhibition
Oil Terminal
St. Petersburg

NOVEMBER

S		3	10	17	24
M		4	11	18	25
T		5	12	19	26
W		6	13	20	27
T		7	14	21	28
F	1	8	15	22	29
S	2	9	16	23	30

14.11
5th International Conference
Petrochemicals in Russia 2020: Prices, Markets, Forecasts
Moscow

16–21.11
Transport Week 2019
Moscow

18–21.11
XI International Youth Scientific and Practical Congress
Oil and Gas Horizons
Moscow

21–22.11
International Forum
Key Trends in Composites: Science and Technology
Moscow

27–28.11
International Forum and Exhibition
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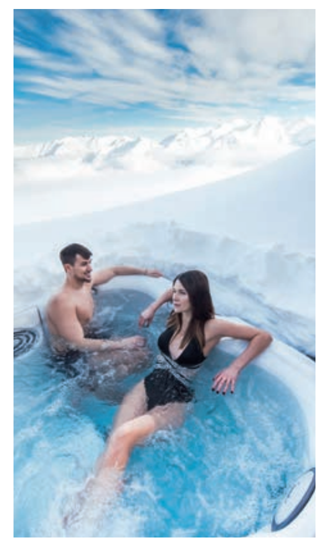

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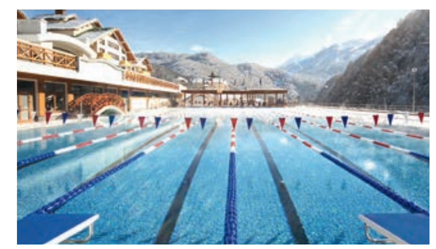

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GAZPROM MOUNTAIN RESORT

CORPORATE SECURITY IN THE OIL AND GAS SECTOR

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THIS ARTICLE TOUCHES UPON ASPECTS OF THE PROCESS ENSURING CORPORATE SECURITY IN THE MODERN ERA. BY TAKING INTO ACCOUNT INDUSTRY SPECIFICS OF OIL AND GAS COMPANIES, THE MAIN ELEMENTS OF THE STRATEGY FOR BUILDING AN INTEGRATED CORPORATE SECURITY SYSTEM FOR COMPANIES ARE FORMULATED AND ANALYZED

KEYWORDS: *digital economy, corporate security, information support, cybersecurity, cyber threats, Internet of things, oil and gas sector.*

UDC 004

In the midst of turbulent times in the oil and gas industry, it is becoming increasingly difficult for companies to predict their business plans and, as a result, they have to look for ways to increase operational efficiency and reduce costs. At the same time, however, organizations introduce vulnerabilities in areas such as process safety, HSSE, equipment reliability, and the smooth operation of production.

In situations where the development of information and communication technologies, as well as the announced transition of world leaders to the digital economy, exert a significant impact on the process of ensuring corporate security, it is paramount for employees of security companies to possess the necessary professional knowledge in regard to the relevant processes. For instance, in the oil and gas sector, elements of the so-called Internet of Things (IoT) occupy a strong place.

IoT technologies allow the monitoring and analysis of constantly changing data, serving as the basis for making decisions. Within the framework of existing technologies, oil and gas companies are forced to process large amounts of data relating to all stages of production; this data must be generated, transmitted, stored and processed. With the development of IoT strategies, oil and gas companies have benefited from the digital transformation.

Despite the fact that many companies are aware of the benefits of introducing ideas and approaches of the digital economy, which can take the rapidly developing process of integrating the information technology environment of companies and their branches to a totally new level, thereby making data processing and analysis more accessible, there is an alarming trend of increasing cyber threats.

In these conditions, one of the tasks of the corporate security service is the selection of security solutions. It is crucial to develop security systems that provide support for the closure of the cycle of an oil and gas enterprise, involving all stages.

According to estimates, by 2018, oil and gas companies amounted to $1.87 billion in cybersecurity spending, as production continues to accelerate in the most frequently attacked industries. It appears that in addition to the financial consequences of a security breach, there are also critical risks in oil and gas organizations that emerge due to increased convergence between enterprise business applications and operational technology (OT) applications in areas such as process safety, equipment reliability, as well as production continuity, HSE, company reputation, and oil market fraud.

This increase in spending is primarily due to a rise in the number of cybersecurity incidents. According to Symantec Corporation, one of the largest cybersecurity companies, 43% of the world's mining, oil and gas companies experience security incidents annually. According to a study by Trend Micro Incorporated, 47% of companies in the energy sector reported instances of attacks, which is the highest among any other sector of the economy. Furthermore, according to the Global Information Security Survey conducted by PricewaterhouseCoopers (PwC) in 2016, 42 % of oil and gas companies experienced phishing attacks. These studies very clearly demonstrate the targeted activity of offenders in the oil and gas industry.

In particular, the following were attacked: an alarm and communication system for the Baku-Tbilisi-Ceyhan pipeline in Turkey (the result was a spill of more than 30,000 barrels of oil), a failure in the monitoring system in Bayamon, Puerto Rico led to a fuel tank overflow, leading to an explosion and a three-day fire (2009), the STUXNET virus was used to capture industrial control systems (ICS) around the world, including computers used to operate refineries, pipelines and power plants (2010). Another cyberattack was directed at the Saudi national oil company Saudi Aramco, which resulted in damages to 30,000 computers (in 2012).

The aim of the attack was to stop the extraction of oil and gas in Saudi Arabia in order to prevent the influx of resources into international markets. In 2012, Telvent, a supplier of remote administration and monitoring tools in the energy sector, was the victim of a threat due to a violation of its internal security system. According to Telvent, each Fortune 100 energy company uses its own systems, managing more than 60 % of the total hydrocarbon traffic in Northern and Latin American pipelines. Attackers were able to steal project files associated with the Oasys Supervisory Control and Data Acquisition (SCADA) project[1], a remote administration tool that allows companies to combine old IT equipment with Smart Grid technologies. The purpose of the hacker attack was probably to analyze the source code and search for vulnerabilities in the software in order to ultimately attack energy companies directly.

Companies spend $ 1.87 billion on cybersecurity

Also in 2012, computer systems at Rasgas, Qatar's largest LNG exporter, were infected by an unknown virus, Flame, a distributed malware program, which was used to spy on a Middle Eastern energy company. In 2014, hackers attacked about 300 different companies in the Norwegian oil and gas industry, including Statoil. The attack was carried out by sending emails with attachments. When opening attachments, software was activated to search for vulnerabilities in the information security system of companies. In 2015, attackers gained control over the automatic tank gauge (ATG) system used to monitor fuel levels throughout the United States.

The main objectives of hacker activity in the oil and gas sector can be distinguished as follows:

Economic (preventing the influx of resources into international markets, such as the incident with Saudi Aramco in 2012, the possibility of obtaining confidential data in order to provide investment advantages, fraud in the oil market by distorting reporting data used and submitted by oil and gas companies);

Political (for example, seizing control of an oil and gas company's technical equipment can lead to a violation of the environmental situation or create a threat to security of the environment and the population, which has the possibility of provoking protest activity).

Causing material and physical damage to individual companies (aimed at reducing company resources, which ensure smooth operation, as well as committing actions that could potentially harm the health and interests of employees).

Regardless of the intentions of the attackers, the constant threat of increasing cyberattacks has a huge impact on the oil and gas industry, as the boundaries between company information systems and operating technology systems continue to blur.

At the same time, companies' security structures are characterized by the absence of clear regulation, also absent is the distinction between information work and analytical work. In the security divisions, measures are taken to collect and accumulate information files (databases) strictly within a certain direction, however, work is not conducted in order to identify and analyze possible chains of interrelated factors or to authenticate accumulated information from different databases, as well as direct and indirect links of the studied elements with other risk factors.

The purpose of informational and analytical work is the preparation and substantiation of decision options at different levels of the management hierarchy. Information Analytics as an integral part of managerial activity implies information-intensive operations. It cannot be conducted optionally and it inevitably requires its own selection, organizational design and specialization in the scope of collecting, accumulating, processing, issuing, analyzing and implementing information for the purpose of preparing options for decision-making at various levels.

All informational and analytical work is limited to the use of simple comparative tables of indicators for different periods of time. The interaction between a company's security departments is carried out in the form of submitting information bulletins, while the accumulation and analysis of the information received is not done.

An important aspect is resolving the issue of ensuring interaction between the security divisions in company branches where information databases are developed and operate, and where information

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[1] *https://theaviationist.com/tag/supervisory-control-and-data-acquisition/.*

systems are introduced, mainly as tools for information support for the performance of the security divisions when conducting work within their jurisdiction. It is worth noting that existing databases are not governed by regulatory documents; they exist on an initiative basis and function on different software platforms.

The lack of a unified integration platform designed to combine information components of the security unit into a single informational space, and automation based on principles of managing end-to-end business processes of all significant and critical information systems that affect its business processes, could complicate the control of the activities of the security units of a group of companies and does not allow to effectively adopt measures in order to establish a cause-and-effect link between ongoing events, a multiple-factor analysis of the impact of these events, prevention and localization of risks, as well as the accumulation of incoming information for verification in a company's knowledge database.

The lack of an integrated security system for a corporation can lead to:

- the inability to effectively manage and coordinate the activities of a company's security departments or to obtain a general idea of the level of corporate security for a company as a whole;
- excessive labor costs for solving specific tasks within individual enterprises and divisions;
- difficulty in setting corporate security goals when developing a functional integrated security development strategy;
- incomplete achievement of strategic goals in the field of corporate security, and also insufficient implementation of a company's development strategy.

The functioning of the security system of companies should be prescribed by regulatory and methodological documents and design documents (regulations, concepts, terms of reference, technical projects, etc.) that determine the functional and technical requirements for the implementation of information and analytical processes in the field of security.

which are used to prepare single or periodic information materials.

An information support system structured in this way will allow corporate security managers to analyze reporting documents and identify problems that need to be addressed at the level of company management, as well as concentrate on issues that can be referred to the competence of company departments. One of the important tasks of the corporate security department is to build a reliable

Security structures are characterized by the absence of clear regulation, also absent is the distinction between information work and analytical work

It is obvious that there exists the objective need for collecting, processing and providing information, as well as securing analytical functions for the security departments of companies. An important task is to organize the regular influx of information flows from subordinate security divisions to higher ones. These documents (for instance, quarterly and annual reports) should contain estimated, prognostic information, which should be taken into account by companies when planning activities. Furthermore, it is necessary to ensure the timely delivery of the results of a comprehensive analysis of risks and threats to a company's security to subordinate security units. Another form of information sent to the security divisions of company branches could be information tasks prepared in the form of instructions from the management of corporate security divisions or verbal instructions from the heads of security centers,

and sound system for assessing and forecasting potential threats to a company's existence; this also implies the analytical processing of reporting materials.

Preconditions for the integrated security of a corporation are as follows: the application of a systematic approach to the implementation of information and analytical activities in the security sector; the presence of qualitative regulatory documents, well-established mechanisms and methods for ensuring security; security units must have all the necessary information resources based on modern technologies that can effectively resolve the issue of integrated security management of a company.

Attention should be paid to the following:

- as a rule, companies already have internal information flows between departments, which can be used as channels for obtaining information on ensuring the functioning of the corporate security service;
- users of corporate security services in companies (for example, company management) should be interested in presenting information services and analytical materials.

In addition to publicly available sources of information (mass media, social media, websites of corporations and companies, official websites of government agencies, databases of legislative

and regulatory acts, etc.), some information on ways to conduct and organize business intelligence could be obtained from the community of competitive intelligence professionals, as well as competitive intelligence experts.

Traditional channels for obtaining official information about companies include: official websites of government departments, information databases and registers of government organizations.

Information analysis methods used by corporate security services involve traditional approaches and methods, as well as modern ones that take into account external factors that affect the status quo of the industry domestically and at the international level.

In general, information retrieval in order to ensure a company's security includes: collecting and processing registration data on potential partners, company structure, the founders and shareholders, information in regard to partners and competitors; relations within the enterprise; affiliation with government agencies; information on the stability of the financial situation.

Ensuring corporate security at the present stage involves the active use of competitive intelligence methods and does not exclude the necessary impact on the strategy of competing companies. For example[2], the acquisition of information of commercial value about competitors is complemented by the study of the criminal, political situation, legislation, personnel movements of people whose activities can affect companies and new technologies. Moreover, modern conditions dictate to use an integrated approach to creating a corporate security system, which includes a wide range of technical security equipment: video surveillance systems, fire and burglar alarms, access control and warning systems that allow you to identify and respond quickly to emergency situations. The way large corporations view the control of elements of integrated security systems[3] should be conducted on the basis of a single situational center with direct prompt communication with the departmental standby units of the Ministry of Internal Affairs, the Federal Security Service, and the Emergencies Ministry. The creation of situational centers built on the basis of modern smart security systems, together with the deployment of prompt response groups organized on a territorial basis, will make it possible to raise the level of protection of company assets to a higher level, significantly reducing costs for physical security.

In respect to the aspect of ensuring corporate security, an important problem is the need to create a system for the early detection of threats and the pre-emptive formation of a resource base to neutralize them. This means a comprehensive set of measures utilizing all possible tools in order to neutralize threats.

In order to build a security system in a company that corresponds to the growth and development of emerging threats, information and analytical support for the activities of corporate security departments should be forward-looking nature and must include enhancement methods for information and analytical work, as well as analytical and forecasting work related to issues within the competence of the corporate security service.

Strategic management, as a function of the corporate security mechanism, is one of the most crucial functions pertaining to the organizational and economic mechanism of corporate security.

As applied to the corporate security system, this means that corporate governing boards should implement the following set of measures:

- monitoring factors, serving as threats to corporate security. The most important elements of the corporate security mechanism are monitoring and predicting factors determining corporate security. Monitoring is an operational information-analytical system for observing the dynamics of corporate security indicators. One of the main tasks of monitoring is the implementation of quantitative and qualitative registering and analysis of the state and dynamics of indicators characterizing internal and external threats to corporate security, as well as their trends for making timely decisions on ensuring the effective functioning of corporations in the long term;
- developing a system of criteria and parameters (threshold values) of corporate security. A mandatory element of the strategy leading to corporate security is the combination of quantitative and qualitative parameters (threshold values) in regard to the functioning and the development of corporations, the violation of which pose a threat to corporate security. The following indicators should be included in the system of such parameters: indicators of business activity; liquidity indicators; solvency indicators; indicators of financial stability; indicators of innovation; occupational safety and health indicators; personnel safety indicators; environmental safety indicators; information security indicators;
- identifying cases of deviation of actual or forecasted parameters of a corporation's development from corporate security thresholds, development and implementation of a set of measures aimed at preventing or overcoming security threats;
- examining decisions made on production, technical, financial and economic issues from the viewpoint of corporate security.

Corporate security should be based on a strategy that includes[4]:

- defining corporate interests;
- characterizing the most probable external and internal threats to corporate security as a combination of conditions and factors creating danger that could hinder implementing the vital interests of corporations;
- identifying and monitoring factors affecting the sustainability of the effective functioning of corporations in the short and medium term;
- creating corporate policy, institutional transformations and the necessary mechanisms to mitigate the impact of factors that destabilize

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[2] https://www.audit-it.ru/articles/finance/a106/189897.html.

[3] https://ria.ru/interview/20111125/497505663.html.

[4] http://group-global.org/ru/publication/21258-strategiya-korporativnoy-bezopasnosti.

the functioning and development of corporations;

- goals and objectives of the corporate security system;
- determining criteria and parameters of a company's economy state that meet the requirements of corporate security and protect the vital interests of a corporation and its stakeholders;
- the functioning mechanism of the corporate security system based on the use of legal, economic and administrative measures of influence by a company's security service.

The corporate security strategy should be based on various forecasts of company development and it should be adjusted depending on the specific sequence of events in terms of company development. A multiple-option strategy allows you to switch from one option to another depending on the particular development of a given situation without making urgent, insufficiently developed and interconnected decisions. Additionally, a system of management actions in regard to a corporation's economy should be formed, allowing regulation of changes in the structure of production and capable of supporting the functioning and development of corporations on a safe level.

In order to ensure corporate security, its management should[5]:

- conduct institutional transformations that facilitate the coordination of actions and bring together strategies of various departments for implementing the corporate security strategy;
- develop general principles of economic and social behavior for all participants of the business process at the expense of their maximum unification;
- monitor compliance with these rules and regulations by all entities of corporate security;
- create a mechanism for resolving disputes and conflicting situations arising during the day-to-day functioning of corporations;
- ensure the training of personnel in terms of modern methods of analyzing economic activity and evaluating investment projects from the standpoint of corporate security;
- ensure the harmonious development of economic relations with external interested parties.

Equipping businesses with special equipment, information devices, etc. It should be carried out with the participation of specialists in the corresponding relevant areas, this aspect also includes using materials prepared by reputable analytical agencies. Corporate security service specialists are required to monitor the activities of counterparties when equipping company facilities with technical security systems (CCTV systems, anti-theft frames, viewing mirrors, walkie-talkies, fire alarms, burglar alarms, etc.), and monitor the performance of technical equipment.

An integrated security system should generally consist of the following elements:

- video surveillance system;
- access control and management system;
- security system for company premises and alarm system;
- fire alarm system;
- alarm system;
- hardware module ensuring the corporate security technological process;
- system for controlling the engineering communications of buildings and other structures;
- system for ensuring the functioning of facilities.

In the context of creating a modern security system, planning is one of the most important conditions for organizing the effective work of corporate security services.

Planning should cover all the main components of company defense: physical security, technological tools, organizational measures; this also encompasses areas of security: economic, informational, psychological, physical, etc.

It should be noted that developed plans smoothly combine the interaction of these security components and organize their interconnection and interaction. Corporate security service activity planning relies on the competent identification of threats and the prediction of corporate security risks. Furthermore, when planning the development of a security system, it is advisable to analyze and evaluate the resources at its disposal and the prospects for its development. This implies the need to link security service plans with the main technological cycles of a company that it protects, and also organizing constant monitoring, in order to promptly adjust the activities of the security service due to possible changes in regard to risks and threats.

Thus, an important factor when organizing protection is economic feasibility and the availability (allocation) of necessary financial resources. Protection should be organized only for those objects and subjects whose protection costs are less than losses from possible threats to these entities. In this respect, the following should also be taken into account – the financial capabilities of companies to implement a system of measures aimed at ensuring corporate security.

In order to develop an effective strategy for ensuring an organization's security, it is important to minimize the risk of future uncertainties and take into account the largest possible number of scenarios. Scenario analysis and scenario planning allow companies to simulate various options for possible future events, and provide an opportunity to prepare an optimal action plan for each situation.

Periodically arising crisis situations and events affecting corporate security highlight the incompetence of many companies in the face of uncertainty and deteriorating conditions. The effectiveness of the corporate security model and the sustainability of the organization immediately become clear.

In order to improve the activities of the corporate security service it is imperative to study the foreign and domestic experience of business entities in the field of corporate security and the market for services in this area. Based on the analysis and generalization of foreign corporate security units, recommendations can be developed for improving

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[5] http://group-global.org/ru/publication/21258-strategiya-korporativnoy-bezopasnosti.

approaches and methods in order to ensure the functioning of a company's security system.

The duties of the corporate security service include the search for personnel recruitment, the selection and verification of candidates for work in company departments; the scope of activities of security units also includes the categorization and classification of requirements for candidates. The importance of a company's security service in providing company staff is due to the growing importance of potential threats posed by company employees. In this regard, the responsibility of the security unit is high when inspecting potential employees during the hiring process, and also when preventing illegal actions by personnel that can cause significant damage to companies. Methods adopted by corporate security services to resolve this are as follows: the use of a polygraph when selecting candidates for employment and conducting internal corporate investigations, the development of "predictability cards" of employee behavior from the standpoint of security, etc. As for the specific, private aspects of the work of security units, for example[6], in the field of employee control, this is deemed as internal operational work, which is carried out by employing various methods. Also important is work with sources within a company to identify information of a warning (dangerous) nature, as well as the set-up of specific tasks for security officers to monitor the implementation of certain routine measures, approved by a special order for organizational procedures, technical methods and control methods.

In summary, personnel safety in companies is primarily achieved by:

- verifying activities during the selection of employees;
- coordinating measures to protect companies from illegal actions by employees, including preventive measures and internal investigations;
- enacting measures for the dismissal of employees.

Preventive work is also very important when dealing with employees, examples are: checks during hiring, preventive conversations that warn employees against actions that are unlawful and/or dangerous for companies, and also regular trainings with company employees. The corporate security service should conduct timely training for company employees, which also involves training test grounds, designed not only to demonstrate possible threats to company security, but also to display measures by the corporate security service (in conjunction with representatives of special services) aimed at neutralizing threats. Such programs should result in raising awareness and skills of security specialists of company and government agencies in matters of corporate security.

In modern conditions, a necessary requirement for security personnel is to constantly increase the level of training and qualifications for unit employees, conduct trainings and exercises, including joint ones with representatives of the Ministry of Internal Affairs, the Federal Security Service, the Emergencies Ministry, the Russian Guard, etc. For instance, upon cooperation with divisions of the Ministry of Internal Affairs, the Federal Security Service and the Emergencies Ministry of Russia on countering terrorism, security personnel on company facilities should conduct training and joint exercises with the Ministry of Internal Affairs, the Federal Security Service, the Emergencies Ministry and the Russian Guard on the anti-terrorist protection of facilities.

In conclusion, corporate security specialists should be able to comprehensively analyze and verify all available information, predict the occurrence of possible security threats to companies, assess the opportunities and risks of business relations with third parties – suppliers and contractors, customers and business partners, investment entities and potential employees.

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[6] *http://www.psj.ru/saver_people/detail.php?ID=19792.*

WHAT Neftegaz.RU WROTE ABOUT 10 YEARS AGO…

Polish Prime Minister hopes to sign gas contract this autumn

On September 1, 2009, a meeting of Russian Prime Minister Vladimir Putin and Polish Prime Minister Donald Tusk took place, paving the way for negotiations on gas supply. A contract could already be signed in autumn. According to Donald Tusk, during his talks with Vladimir

Putin, it was highlighted once again that gas has no place in politics and cannot be used as a political weapon. This factor is crucial in terms of the time limit for the contract to be signed.

• Comment

Neftegaz.RU

Ten years later, the Poles, who were once quite content with Russian gas contracts, are directing their efforts to fight against Nord Stream 2, comparing it with the Molotov-Ribbentrop Pact.

The gas pipeline bypasses Poland and the Baltic states. Polish Deputy Foreign Minister Szymon Szynkowski vel Sęk has claimed that this agreement between Russia and Germany is a threat not only to the two countries, but also to Europe as a whole.

He is losing hope that the US has the power to prevent the implementation of the Nord Stream 2 project.

Venezuela may be forced to buy oil

Venezuela, an OPEC member, may have to import fuel due to the shutdown of oil production at three oil refineries, it emerged in September 2009 from sources in the oil industry. "Based on estimates, owing to these stoppages, Venezuela will require at least six deliveries from foreign countries."

• Comment

Neftegaz.RU

Venezuela had to import fuel 10 years ago due to the stoppage of the cracking unit. Today, the country continues to buy fuel due to economic hardships.

Over the years, no reforms were carried out, as a result, the country's economy did not develop. For some time the economy was kept adrift only thanks to high oil prices, however, the refining industry eventually fell into decline. Six months ago, Venezuela had no problems with fuel suppliers, but sanctions imposed by America against the country reduced the entire pool of exporters to zero and today Russia's Rosneft is the last fuel supplier to Venezuela.

OPEC does not believe in high oil prices

Oil prices may fall again, as fundamental market indicators are still weak. This statement was made in September 2009 by OPEC Research Director H. Qabazard. He was quoted as saying: "the current price increase is due to investors, not fundamental indicators." The prices of oil futures on the stock exchange rose by an average of 3.6 % on June 1, 2009 and reached record peaks within the last seven months.

• Comment

Neftegaz.RU

H. Qabazard's prediction came true only five years later. Before 2014, oil prices were soaring high and were around $100 per barrel. But then a rapid decline began. In 2016, the price per barrel barely reached $30, which became the lowest point within 12 years. Only in 2017 did the situation with oil prices begin to gradually change. The reason for this, in part, was due to a decrease in production by OPEC countries, with Russia playing a significant role. Even though the situation improved, the price of oil did not reach 2014 levels.


Employees at Gazprom Pererabotka Blagoveshchensk LLC


E. Dmitrieva


Participants of the Contracting Organizations and Suppliers Forum


Participants of the seminar Energy-efficient oil and gas production and processing

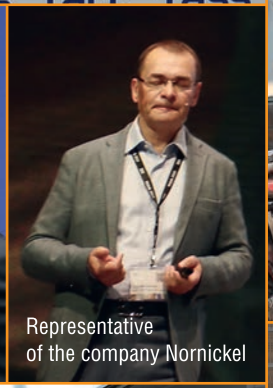

A. Kozlov, A. Moore, I. Alexandrova


R. Sharafutdinov


R. Shakirov


A. Radchenko, M. Ksenofontov


P. Pouyanné, R. Dudley


Representative of the company Nornickel


Employees of Gazprom Bureniye LLC at the drilling rig of the Kovyktinskoye field


Yu. Shcherbanin


Operator of the Uralmash 6000400 EK-BMCH drilling rig at the Kovyktinskoye field


Activities as part of launching the Eastern blocks of the Srednebotuobinskoye field


N. Ryabkov, V. Shchipkov


A. Khomchenko


SPIEF 2019


Student interns at the construction site of the Amur GPP


At the industrial site of the Amur GPP under construction


Participants of the conference Transport Networks Russia & CIS

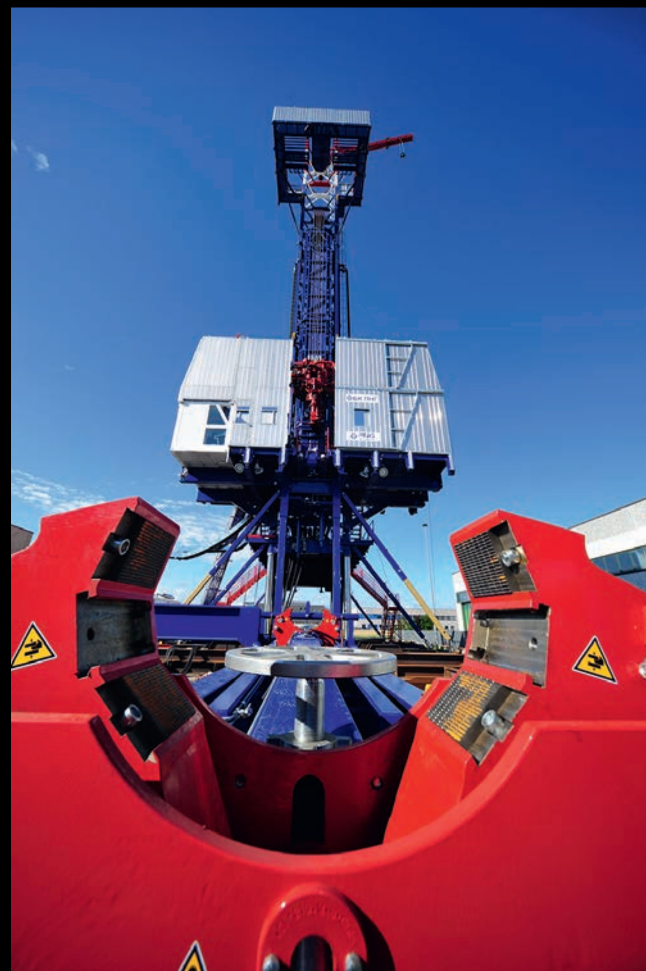
MOBILE DRILLING RIG «VIKING 6000 WEI D340-32»

1 *Drilling equipment and instruments*

1.1 *Equipment for oil and gas production*

1.1.1 *Drilling equipment and tools*

1.1.1.2 *Drilling rigs and their components*



A unique rig unrivaled in terms of its performance and mobility.

Mobile (semitrailer, 5 axles), hydraulically operated diesel drilling rig:

- Two diesel «Caterpillar C 32» engines, total power is 2 250 h.p. (1678 kW);
- Maximum hook load capacity is 340 MT;
- Maximum top drive torque is 53000 Nm, power is 700 h.p;
- Adjustable weight on the bit is 0–30 MT;
- Clearance for BOP is 7,2 m (18 ft);
- Conventional drilling depth with HWDP 127 mm (5") is 6000 m;
- Mobile rig is equipped with:
  - a) semi-automated pipe handling system (pipe handler);
  - b) hydraulically operated torqueing and breakout power tong (rough-neck type);
- Drilling with three-pipe or two-pipe joints (RII of RIII length class) with maximum joint length of 28 m;
- Mobile rig is equipped with 2 mud pumps «WEI» (Italy) type F-1600 (2 x 1600 h.p. «Caterpillar C-32» engines);
- 4 cleaning steps, circulation system volume is 450 cu m;
- «Shaffer» type BOP, 350 x 700 (13 5/8" x 10,000 psi);
- Primary coupled and standby Kammenz DDG;
- Winterization in accordance with project requirements for work in cold-weather conditions in Russia. ●

MOBILE DRILLING RIG «PATRIOT 4500 WEI DS 250–23 LT HP»

1 *Drilling equipment and instruments*

1.1 *Equipment for oil and gas production*

1.1.1 *Drilling equipment and tools*

1.1.1.2 *Drilling rigs and their components*

Mobile, semitrailer mounted, draw-works and derrickman free drilling rig:

- Drilling with Doubles DP Range 2, maximum length of DP stacks – 19 meters;
- Option – skidding system for cluster wells drilling;
- Type of drive – diesel-hydraulic (HPU), 2 x «Caterpillar C 18» curve «C» with total power of 1500 h.p. (1103 kW);
- Type of the mast – two sections, hydraulic, telescopic, sliding upper section;
- Mast height is 33.2 m;
- Maximum hook-load capacity is 250 metric tons/ 550,000 lbs;
- Power of the top drive is 600 h.p. (447 kW);
- Maximum top drive torque is 53 000 Nm;
- Adjustable weight on the bit is 0–25 MT;
- Conventional drilling depth is 4,000 m with DP 5" and 4,500 m with DP 4 1/2";
- Clearance for BOP is 5,5 m (18 ft);
- Mobile rig is equipped with:
  - a) telescopic pipe handler (Power Catwalk) for doubles DP R2;
  - b) automatic pipe rack with second layer to have more DP stocked;
  - c) overshot-elevators special kit for DP tripping and casing tripping with circulation and rotation;
- Mobile rig is equipped with 2 mud pumps WEI RS QF-1600 HL (Italy), 7,500 psi WP Diesel «Caterpillar C 32» engine;
- 5 cleaning steps, circulation system volume is 350 cu m;
- Unit for mud preparation and weighing; unit for mud chemical treatment;
- «Shaffer» type BOP, 350 x 350 (set) complete with testing stand and PC (13 5/8" x 5 000 psi);
- Primary coupled DDG «Cummins» and one standby DDG (2 X 550 kW +1 X 350 kW);
- Winterization in accordance with project requirements for work in cold-weather conditions in Russia. ●

“The situation with oil revenues in our budget is not catastrophic; there is a positive trend in moving away from dependence on raw materials”

S. Gafurov

“We are ready to maintain the competition level, we have been doing this for the past 50 years in the European gas market”

A. Novak

“The development of tertiary oil recovery enhancement methods is hindered by lack of competitive domestic technologies, chemicals, and government incentives”

N. Komarova

“The modern economy does not only depend on oil and gas production”

D. Medvedev

“Transit risks always exist. Especially in a situation where Russian gas is delivered through the territory of a NATO member state”

A. Miller

“Usually, our oil and gas revenues are much higher in comparison to non-oil and non-gas revenues that are quite small. This time round, the situation has changed”

A. Siluanov

“The Saudis and the Russians have swapped places in the oil market: they need $70 per barrel, while we are quite content with $40”

M. Oreshkin

“We need to set goals and achieve results each day. This is the most important Concept. Results, only results, can measure the level of development”

Yu. Shafranik

“In most fields, we see the trend of declining production, and not only in Russia, but around the world”

D. Kobylkin