# Study of the Digital Transformation of the Russian Oil Industry: Applied Technologies and Effects

L.V. Silakova[1][a] and A. Andronik[2][b]
[1]*Ph.D, ITMO University, St.Petersburg, Russia*
[2]*student,, ITMO University, St.Petersburg, Russia*
*silakovalv@itmo.ru, anastasia-andronic@mail.ru*

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Abstract: These days, in conditions of uncertainty, oil and gas industry enterprises need to develop digital transformation strategies to optimise business processes. At the same time, the issues of assessing the impact and planning the implementation of digital tools at each stage of the oil industry value chain become relevant. This paper provides an overview of implemented projects for the introduction of digital technologies and identifies the effects of their implementation. In addition, the work presents the problems that oil producing enterprises face when implementing digital transformation. The combination of the identified effects from digital technologies, considering the cost creation chain of either a production cycle or a process, allows us to substantiate the effectiveness of digital transformations in the oil and gas complex and will serve as the basis of digital transformation strategies for oil industry companies.

## 1 INTRODUCTION

The mineral resource base is the foundation of the Russian economy and is a set of different-ranked subsoil fund objects (deposits, mineral occurrences, wells, water bodies, mine workings), which are characterised by explored and assessed reserves and/or tested sources of minerals. Russia is one of the world leaders in the production of various minerals, such as oil, natural gas, coal, iron ores, nickel, and copper. In 2022, the share of the oil and gas sector in GDP was 21.7%, and the index of physical volume of gross value added in this industry accounted for 120.4% (Ostrik, Balko, 2019).

Despite sustainable development programs that include reductions in the production and use of hydrocarbon resources, the International Energy Agency forecasts that global oil consumption will reach a record level of 101.9 million barrels in 2023, while the demand will reach 104.1 million barrels in a day by 2026 (The IEA Oil Market Report). Fig.1 shows global oil demand over the past five years.

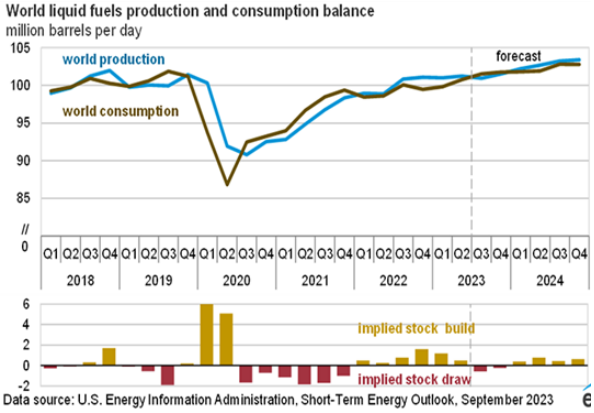


Figure 1: Global oil demand, million barrels/day (Ostrik, Balko, 2019).

Despite the increased demand for oil, currently there is a low price for hydrocarbons worldwide (see Fig. 2), which leads to the revision of strategic policy for the oil production development and the digital transformations necessity.

[a] https://orcid.org/0000-0003-2836-1281
[b] https://orcid.org/0009-0008-9303-2840

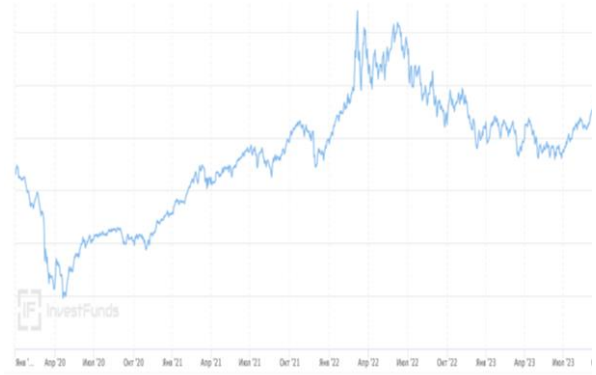

Figure 2: Oil price chart, Brent oil prices over the last three years (Shlykov, 2023).

Due to the above-mentioned fact, oil and gas enterprises need to improve the efficiency of their business processes by applying innovative and digital technologies at different stages of the value chain. Thus, the issues of performing global transformations in the oil industry are being currently revised.

For sustainable growth of oil producing companies, it is necessary to adjust the following areas:

- extraction of hard-to-reach reserves. According to the reports, tight oil production in 2022 increased by 3.8% up to 166 million tons (Ostrik, Balko, 2019);
- modern technology improvement in the production process. In particular, to use the latest approaches to reservoir modelling and development;
- implementation of innovative solutions in the management process. For example, to use machine learning methods to predict oil production, malfunctions and equipment failures;
- digitalization of all business processes. For example, Gazprom Neft PJSC has transformed 20% of the company's business processes, which, according to the experts, will reduce costs by 30% by 2030 (Independent data source for a private investor in Russia).

Digital transformation is the process of changing socio-economic relations at all levels of an enterprise through the use of digital technologies and the transfer of all types of resources into digital format, thereby providing the company with the most competitive advantages (Kuklina, Semkova, 2020).

As a result of digital transformation, business models change or new trends occur; information products and services become a priority; an information network structure is being formed, which requires new approaches to management; Investments in intangible assets such as software and R&D continue.

Digitalization, such as an element of digital transformation, plays a crucial role in ensuring competitiveness. As a result, company profit increases due to the use of digital technologies in the production processes. For example, McKinsey research has shown that digitalization of the chemical industry leads to profit growth of 8.5-16.0% (End-to-end digital transformations for chemical companies).

Thus, the purpose of this paper is to determine the digital transformation of the oil industry, as well as to identify the effects of digital transformation.

It is possible to identify the individual elements of digital transformation as the following:

- **Automation** is the process of using technical, mathematical or digital tools and methods to eliminate direct human participation in the production management process. As an example, let us consider the information system "Capital" of the company PJSC Gazprom Neft. This system is designed to manage logistics in the Arctic. Based on the data received about daily oil production volumes, oil accumulation volumes in oil storage tanks, the location and characteristics of the vessel's movement, and the ice situation, the system independently generates the optimal route and schedule for the movement of tankers and vessels (Suloeva, Martynatov, 2019).
- **Informatization** is the application of information and communication technologies to ensure coherence between production processes. As an informatization, we can implement the ERP system of Gazprom Neft PJSC, which integrates tools for managing internal markets and business movements (Yurak, Polyanskaya, Malyshev, 2023).
- **Digitalization** is the introduction of digital technologies into various areas of organisational, production and service processes. One example of digitalization is the implementation of a project on the use of IT and concepts in the field of logistics companies Gazprom Neft PJSC and Gazpromneft Supply LLC (Independent data source for a private investor in Russia). Radio frequency identification (RFID) tags and satellite position sensors (GPS) were installed as a part of the project**.** Using these sensors, it was possible to track the cargo movement to the final point, as well as to control the speed of its movement and the number of stops along the way. It is important to note that the complete history of logistics operations on a global scale is preserved,

since all data on transported goods was collected in a single information space, which does not require centralised storage at a distance. As a result of home display technology, there has been established a continuous communication between physical delivery and related processes. The entire document flow chain was clearly presented, providing participants with access to encrypted, reliable information.

Thus, digital transformation is moving towards opening up business models using new opportunities provided by digital technologies.

The works of modern authors examine various aspects of the digital transformation of the oil industry. Zhang Dali concludes that the increase in the production cost of hydrocarbon raw materials is affected by the increase in costs of searching for a field, production and transportation of hydrocarbons and the decrease in the extracted raw materials quality (Khasanov, Rakhmatullina, Shakirov, 2020). Digital transformation is recognized by R.H. Azieva as an important direction for the development of the oil industry, as it affects all business processes of the organisational and production activities of the company. A study conducted by I.A. Gorbova and E.S. Gavrilyuk, ensuring the need to change the strategies and approaches of the oil industry in a world of growing competition with alternative energy sources. In this regard, companies engaged in oil and gas production look for ways to increase their competitive ability by increasing efficiency and implementing an innovative development strategy (Automation of technological processes in the oil and gas sector NEFTEGAZ.RU).

In modern conditions, oil producing companies are considering the possibility of moving from traditional business models to solutions that correspond to digital innovations. D.V. Shvechikhin, M.A. Sheikin, O.E. Malykh, Yu.V. Khodkovskaya, A.M. Molchanov and other authors have already characterised the effects of digital transformation in the oil industry. These researchers use digital technologies to optimise manufacturing processes in factories, reduce costs, as well as minimise errors and uncertainties.

Despite the prospects for digital transformation, oil and gas enterprises face challenges that lead to changes in business models. We characterise the dependence of the oil industry on international technologies and the problems of equipment in the main oil industry. The most serious problem concerns Arctic shelf projects, which have been stopped after the American company ExxonMobil and the British BP, which supplied equipment for mining, left the projects (Wang, Liu, Shen, Huang, Van Den Hengel, Shen, 2017).

There is another problem, existing throughout the raw materials complex, related to the lack of qualified specialists. The industry requires specialists with knowledge and understanding of modern digital technologies, as well as with competencies and familiarity concerning new professions that have arisen as a result of digitalization.

# 2 MATERIALS AND METHODS

The study uses materials from scientific papers and analytical reports from oil and gas companies. We applied the methods of analysis, synthesis, generalisation, analogy, and comparison. The result of the research and analysis is to determine the features of the digital transformation of the oil and gas industry. The object of the study is Russian oil producing companies, including PJSC Gazprom Neft, PJSC Rosneft, and PJSC Lukoil.

# 3 RESULTS

When analysing the value chain in oil producing companies, the key business processes can be identified, among which the oil production process is one of the most important. To successfully implement this process, it is necessary to study the rational development of the field and the entire oil reservoir in accordance with the project, as well as to use various types of energy, transport, repair work, various materials, as well as tools and devices.

The oil production business process consists of the following stages:

geological exploration;
field development;
mining;
logistics, transportation and sales.

The more detailed description of the processes is presented in Fig. 3.

Figure 3 shows the sequence of the main technological operations performed on oil, from its production to sale to the consumers. Despite the fact that this process is quite labour-intensive and time-consuming, upstream is considered the most knowledge-intensive process, which includes field exploration work and production processes. Geological exploration and development of the field are considered to be the key stages.

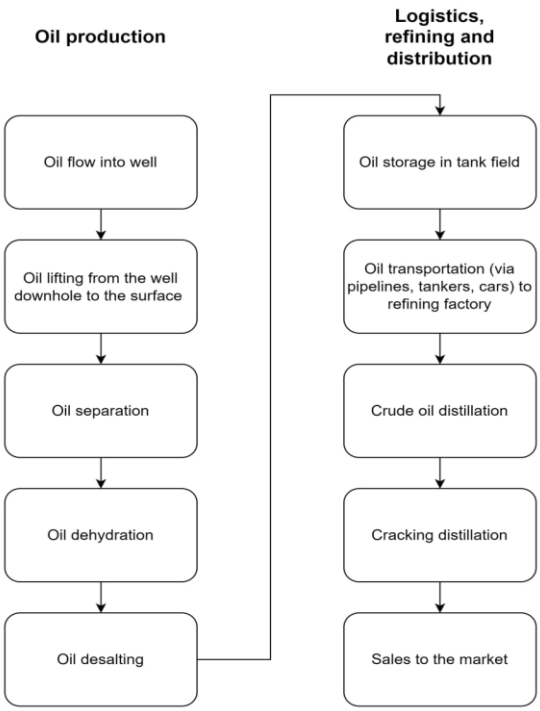


Figure 3: Sequence of the main technological operations with oil, from production to marketing.
Source: compiled by the authors.

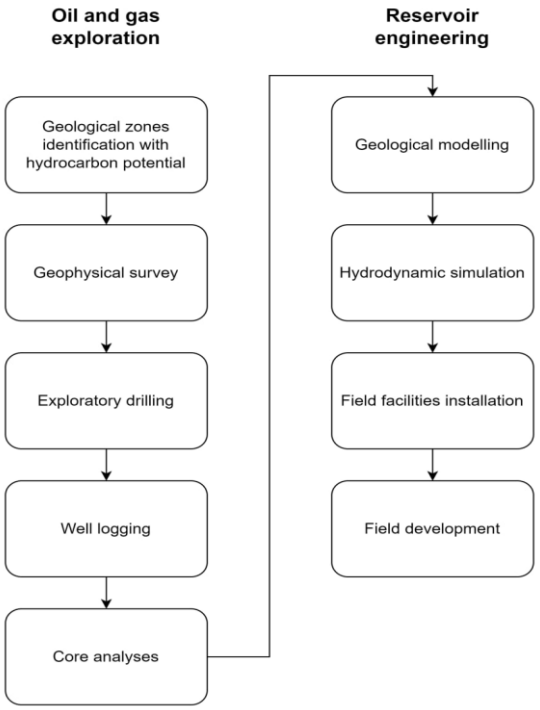


Figure 4: The main stages of prospecting, measurement and development of the field.
Source: compiled by the authors.

Digital technologies can be applied at every stage of oil production.

The first stage of oil production is geological exploration. The main effect of digital transformation in geological exploration is the ability to accumulate, save and quickly process large volumes of data, which leads to the reduction in time losses and work costs, as well as to the efficiency of decision-making management. This stage includes artificial intelligence, machine learning methods, robotics, Internet of things, and cloud technologies.

Thus, the company PJSC Gazprom Neft implements a digital project “Cognitive Geologist” based on artificial intelligence. The information system builds detailed digital models of fields, processes seismic data, geophysical well surveys, and core studies. The effect of this project is a shortened cycle of geological analysis from six months to one-two weeks. According to the financial and economic model, the project of introducing technologies at the geological exploration stage will bring additional profit in the amount of 6 billion roubles starting from 2025 (Independent data source for a private investor in Russia).

Despite this, the most important problem in the era of digital transformation of geological exploration is the lack of personnel with competencies in geology and digital technologies since universities currently provide no necessary studying programs.

The second stage is field development, where Internet of Things (IoT), home theatre, robotics, 3D models, virtual reality, and digital twins are used. The main effect of digital transformation of this stage is to increase production efficiency, reduce production costs, and increase the speed of decision-making management.

Thus, the company PJSC Rosneft has introduced artificial intelligence (AI) to calculate reserves and intensify oil production. The system allows us to more accurately and correctly determine the hydrocarbon content in the formation and to select the highest quality types of production.

The main problem of performing the stages of digital transformation is the adherence to traditional mining.

The next stage is oil production. For this stage, AI, IoT, robotics, and virtual reality were used. The main effect of the digital transformation of these stages is to increase productivity, minimise downtime, and make management decisions promptly and timely.

Thus, the company PJSC Gazprom Neft implemented an information system based on machine learning (ML) to predict any equipment failures during oil production. Thus, based on historical data, the system predicts future equipment breakdowns, thereby preventing the down times of wells as a result of ordering of equipment parts on time.

The main problem in performing the stages of digital transformation of oil production is the lack of historical information to use as input data for digital technologies.

The final stage is logistics, transportation and sales. For this stage, the measures of AI and IoT are used. The main effect of digital transformation of this stage is to increase operational efficiency, improve control and management methods, and raise the quality of hydrocarbon raw materials.

Thus, oil producing companies such as PJSC Rosneft, PJSC Gazprom Neft, and PJSC Lukoil have begun to use unmanned ground vessels for pipeline systems. These vessels were custom-made by the Kalashnikov concern. The drones are equipped with thermal imagers and a navigation system. This allows assessing the possibility of displacement and damage to the pipe, as well as identifying illegal tappings.

The main challenge in driving digital transformation is lack of infrastructure.

As a result, assessing the impact of digital technologies remains important at different stages of digital transformation, as the impact of these technologies has a delayed nature, which can last for three-ten years, depending on the scale.

Digital transformation management and its consequences are analysed based on the report by the consulting company Deloitte (From bytes to barrels. The digital transformation in upstream oil and gas). A. Cunha believes that the highest potential for creating value is associated with seismic exploration. These days, seismic exploration uses standardised data, algorithms and high-performance computers to analyse geological data.

The goal of implementing seismic exploration is to increase the efficiency of using available data and increase company revenues. Seismic surveys allow us to identify not only commercially significant reserves, but also hidden, underdeveloped resources.

Due to offshore exploration, it becomes possible to determine the economic benefits of field development more accurately. As a result, oil producers can optimise their resource portfolio, which helps to improve company efficiency and profitability.

Achieving digital transformation in seismic exploration requires the introduction of innovative technologies that increase the efficiency, accuracy and speed of seismic research. R.H. Azieva concludes that data interpretation is a promising area for digitalization. ML techniques can be used to obtain relevant data. In practice, the use of ML when processing seismograms leads to acceleration of similar data by 10-100 times (Burkov, 2019). This reduces the cost of re-examining data. In addition, the data obtained can be used in petrophysical studies, namely, to predict the characteristics of well zones, the distribution of permeability, and fluid in the formation. With the traditional approach, this process requires from several months to several years. However, neural networks allow speeding up this process by 1000 times.

Thus, the use of digital technologies in seismic development can be considered as:

optimization the modelling process through the use of neural networks for simple data (Gorbov, Gavrilyuk, 2022);

improving the data quality by applying deep learning algorithms;

analysing the historical data using neural networks in order to reduce the time for creating a geological model.

Moreover, according to R.Kh. Azieva, the goal of digital transformation of production processes is to optimise the operation of assets. Thus, the use of digital technologies in production processes will improve the reliability and safety of processes, prevent failures and failures of equipment, as well as improve the quality and control of the operating condition of wells and fields.

Thus, analysis of research and practical experience in this area allows us to highlight the following features of digital transformations in the oil industry:

1. Due to the dependence on foreign technologies and equipment, as well as the external geopolitical situation, oil producing companies gradually switch to domestic developments and technologies. The share of Russian participation in production increased from 43% to 62%, and by the end of 2023 it is planned to exceed the level of 65% (Official website. Federal State Statistics Service).

2. In conditions of traditional hydrocarbon resources depletion, oil producing enterprises create oil fields with hard-to-recover reserves.

3. It is required to revise the strategic plans of oil producing enterprises in connection with the near-

term price of hydrocarbon resources (Official website. Federal State Statistics Service).

During the mid-term analysis of the practice of using digital technologies in the oil industry, the following effects were identified:

1. The dual field expansion technology was applied at the Yuzhno-Priobskoye field by Gazpromneft-Khantos LLC. The resources of this field are classified as hard-to-recover, and the volume of geological oil reserves is 1.6 billion tons, with an average daily production of 41.5 thousand tons of oil. The introduction of technologies reduces operating costs for the field development by 15% (Linnik, Kiryukhin, 2019).

2. Employees of the Gazprom Neft Science and Technology Center, Gazpromneft-GEO and Gazpromneft-Razvitiya developed a digital algorithm for technological planning to attract new company assets. The algorithm has learned to simulate the placement of objects in fields, marginal restrictions and terrain parameters, resulting in reduced construction costs and resources by up to 10%. This technology is used at the planning stage of oil production projects for the purpose of financing (Ivlev, Eremin, 2018).

3. Machine learning algorithms implemented at General Electric Oil & Gas have optimised oil and gas equipment diagnostic schedules, resulting in a 10% reduction in downtime. By continuously analysing the data obtained from mechanical sensors, machine learning algorithms automatically identify and investigate where unusual problems occur (Dali, 2022).

The experts conclude that the optimal criteria are based on the use of modern methods and technologies of real-time management, scenario analysis and decision support under risk and uncertainty conditions. In such conditions, digital technologies become significant tools for increasing the company efficiency.

Research on this topic has identified the technologies implemented and their consequences. The impact of these technologies is reflected in Table 1.

Table 1: Digital technologies used in the oil industry and the effects of their production.

| Name | Effect of implementation |
|---|---|
| Big Data and predictive analytics | Analyse seismic and microseismic data, improve the quality of field analysis, reduce the time of production operations, optimise equipment operation, and improve occupational safety (Suthaharan, 2014). |
| Internet of things | Timely identify malfunctions and failures through control and monitoring the equipment condition in real time (Official website. Federal State Statistics Service). |
| Artificial intelligence | Identify the patterns and development trends to predict the performance indicators of equipment, wells, and fields. |
| Robotization (drones and robots) | Provide convenient access to large and hard-to-reach objects for performing geodetic geological work, monitoring and control the equipment work. |

Thus, we can conclude that the benefits of digital transformation for oil producing companies include increased competitiveness through productivity gain, reduced costs and business processes optimization.

As a result of the study, we can conclude that the digital transformation of the oil industry is inevitable, especially in conditions of flexible prices for hydrocarbons and growing investments in oil and petroleum products. The introduction of digital technologies accelerates oil production from difficult-to-permeate sources and extends the life of fields, as well as reduces costs and risks.

In modern conditions, the digital transformation of the oil production sector becomes especially relevant. The need is due to the wide range of possibilities for using digital technologies in the oil industry such as:

1. Development of interdisciplinary processes and democratisation of internal corporate information.

2. Development of human resources specialising in digital technologies.

3. Use of digital calculations for current assets.

4. The opportunity to move on to testing scientific developments and production methods.

5. Transition from increasing profits by oil producing enterprises to the digital strategy for optimising the production of hydrocarbons.

Based on the study, we identified the features of the digital transformation of the oil industry. According to the sources studied, the current priority is to develop tools and methods for in-depth analysis and analysis of the data obtained from geophysical research fields. In production drilling, the key factor

is the integration of data from various information systems, which allows improving production processes and operational monitoring. In the field of manufacturing operations, an important aspect is the increased use of digital technologies.

Due to the analysis of the oil and gas enterprises' capabilities, it is necessary to change the implementation of digital transformations. In this regard, a key aspect is the use of digital technologies at every technological chain stage (from geological exploration and oil production to the sale of products to end consumers).

To develop this strategy, it is necessary to agree on a common approach and understanding of it, as well as to identify the main obstacles and opportunities. The basis of digital transformation lies in the implementation strategy that covers the entire value chain, thereby increasing the efficiency of all business processes in the technological chain.

## REFERENCES


Burkov, A., 2019. The Hundred-Page Machine Learning Book, 1st ed.; Publishing Kindle Direct: Seattle, WA, USA.

End-to-end digital transformations for chemical companies. URL: https://www.mckinsey.com/industries/chemicals/our-insights/end-to-end digitaltransformations-for-chemical-companies.

From bytes to barrels. The digital transformation in upstream oil and gas. URL: https://www.deloitte.com/content/dam/assetsshared/legacy/docs/industry/energy-resources-industrials/2022/gx-online-frombytes-to-barrels.pdf.

Linnik, Yu.N., Kiryukhin, M.A., 2019. Digital technologies in the oil and gas industry. *Vestnik universiteta*, I. 7, pp. 37–40.

Suthaharan, S., 2014. Big Data classification: problems and challenges in network intrusion prediction with machine learning. *ACM SIG- METRICS Performance Evaluation Review*, Vol. 41. No 4. P. 70—73.

The IEA Oil Market Report. URL: https://www.iea.org/reports/oilmarket-report-april-2023.

https://www.cdu.ru/tek_russia/articles/1/1145/.

Wang, P., Liu, L., Shen, C., Huang, Z., Van Den Hengel, A., Shen, H.T., 2017. Multi- attention network for one shot learning.

Yurak, V.V., Polyanskaya, I.G., Malyshev, A.N., 2023. The assessment of the level of digitalization and digital transformation of oil and gas industry of the Russian Federation. *Mining Science and Technology* (*Russia*). 2023;8(1):87–110.

Automation of technological processes in the oil and gas sector NEFTEGAZ.RU . Moscow, 2015. http://neftegaz.ru/analisis/view/8362-Avtomatizatsiya-tehnologicheskih-protsessov-v - neftegazovoy-sfere 10.

Gorbov, I.A., Gavrilyuk, E.S., 2022. Research of drivers of digital transformation of the oil and gas industry. *Scientific journal of ITMO Research Institute. Series: Economics and Environmental Management*, No. 2. pp. 49-62.

Ivlev, A., Eremin, N., 2018. Petrorobotics: robotic drilling complexes. *Drilling and oil*, No2.

Kuklina, E. A., Semkova, D. N., 2020. Characteristic risks of a merger and acquisition transaction. *Managerial consulting*, No. 4. pp. 53-65.

Ostrik, V.Yu., Balko, S.V., 2019. Digital transformations of modern personnel management systems. *Innovative development of economics Founders: Scientific and Consulting Center.* No. 4. pp. 23-33.

Official website. Federal State Statistics Service: https://rosstat.gov.ru/.

Suloeva, S.B., Martynatov, V.S., 2019. Features of digital transformation of oil and gas complex enterprises. *Production organizer*, Vol.27. No 2. pp. 27-36.

Khasanov, I.I., Rakhmatullina, Yu.A., Shakirov, R.A., 2020. Introduction of digital technologies in the oil and gas industry of Russia.*Transport and storage of petroleum products and hydrocarbon raw materials*, No. 4. pp. 24-28

Dali, Zh., 2022. Problems and prospects of development of the oil and gas industry. *Progressive economy*, No. 11. pp. 18-29.

Shlykov, S.V., 2023. Application of machine learning methods for automation of processes in the oil and gas industry. *Transport and storage of petroleum products and hydrocarbon raw materials*, No. 2. pp. 46-53.

Independent data source for a private investor in Russia URL: https://investfunds.ru/indexes/624 /.

Official website. PJSC Gazprom Neft: https://www.gazprom-neft.ru/.