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# Digital Transformation of the Russian Oil and Gas Industry: Main Directions and Expected Results

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**ABSTRACT**
The transition to a new technological order, being observed in the last decade, actualized the processes of innovative development of oil and gas companies. The key factor in ensuring effective innovative development is digital technologies, aimed at increasing business profitability and developing fields with hard-to-recover reserves. The article justifies the need for the implementation and use of digital technologies. The article provides statistical data on digital oil fields in Russia, identifies strategic benchmarks for the development of oil and gas companies in the field of digitalization. The expected forecast estimates of the effeciency of the implementation of digital technologies in the oil and gas industry are presented. The conclusion is drawn about ensuring an increase in oil extraction due to digitalization, due to an increase in the design oil recovery factor and hard-to-recover reserves.
***Keywords:*** *digital technologies, digital transformation, digital oil field, hard-to-recover reserves*

## 1. INTRODUCTION

The current stage of development of the world and Russian economies is characterized by a change in the technological order or a long cycle of the economic environment of N.D. Kondratyev. The formation of a new upward wave of the cycle is based on innovative developments, based on biotechnology, nanotechnology, global information networks, artificial intelligence systems, etc. [1]. The role of innovative technologies is to ensure a significant increase in production efficiency, reduce costs, reduce energy and capital capacity at enterprises, using them, and ensure the economic growth of the country as a whole.

For the Russian economy, the transition to an innovative type of development is of particular importance, since investment in the outgoing technological order does not allow providing effective efficiency, but only amplifies inflationary processes [2]. The implementation and use of innovative projects is due to the need to modernize and ensure the diversification of the Russian economy, reduce dependence on raw materials, as well as create competitive advantages in international markets.

The growth stage of the new technological order is accompanied by a change in the technological structure of the economy, the emergence of new leaders and outsiders among enterprises. In this regard, the stimulation of innovative activity and the use of innovation is a priority task not only for the state, but also for the enterprises themselves [3].

Currently, in the oil extracting industry there is an intensive implementaion of digital technologies at all stages of production, from exploration to the sale of final products. This is contributed by the need to increase the profitability of the business and its competitiveness, caused by a number of factors, among which experts note the depletion of easy-to-recover oil and fossil natural gas deposits on land, the need to master recovery technologies in difficult conditions: shale oil production, arctic, offshore and deep-sea drilling. Initially, the development of such deposits was carried out only in the presence of significant proven reserves. However, the use of new technologies actualized the opportunities of their effective development.

The main factors, stimulating the need for digitalization of the oil and gas industry, include:

– reduction in the volume of reserves in conventional deposits with the simultaneous absence of an increase in recovery factors [4];
– significant depreciation of Russian software technologies in the areas of study and assessment of the involvement of mineral reserves;
– the impossibility of using modern Western technologies for mineral extraction due to the sanctions of the United States and Western Europe;
– the need to recover hard-to-recover reserves, located in the sea shelf zone, as well as in the arctic zone [5].

Currently, all large Russian oil and gas companies are carrying out digitalization processes, the expected economic effect of which is a reduction in costs and an increase in volumes due to the involvement of new and more complete depletion of existing reserves.

## 2. MATERIALS AND METHODS

In the course of the study, the author used general scientific methods of cognition, as well as abstract and logical methods and a set of methods of economic and statistical analysis. The sources of information were statistical data on the oil and gas industry of the Russian

Federation, published in the abstracts of the State Statistics Committee, as well as reports on the activities of oil and gas companies PJSC "Rosneft", PJSC "Gazprom Neft" and PJSC "LUKOIL".

## 3. BACKGROUND

### *3.1. Directions of digitalization in the oil and gas sphere*

At the present stage, the ongoing global changes, associated with the transition to a new technological order, affected all society living environment. The digital transformation of the economy is based on the automation of equipment operation and minimal human participation. As a result of this division of labor, productivity increases and the efficiency of the enterprise activity increases. A Dell survey results showed, that implementation of digital innovation can provide the following benefits to industrial enterprises [6]:

- improvement of indicators of production and economic activity (53% of managers agreed with this statement);
- improvement of competitive positions (50% of managers);
- reduction in total cost of ownership (50% of surveyed executives).

Prospective directions for the implementation of digital innovations in the oil and gas sphere are shown in fig. 1 [7].

1) Big Data technology.

The snowballing growth of data volumes for analysis and effective management decisions made it necessary to use unique data processing technologies. The opportunity to collect information from sensors, RFID tags and oil and gas equipment allows to optimizes production operations and improves planning efficiency. Arrangement of information processes of collecting, storing, processing and transmitting data is a tool for regulation and controlling to achieve the economic goals of an enterprise [8].

2) Industrial Internet of Things (IoT).

The use of wireless networks in the oil and gas industry allows to organize monitoring of technological parameters and the condition of equipment in order to increase the efficiency and safety of the production process, as well as reduce capital investments and operating costs [9]. The effect of using IoT technology is as follows:

- providing remote monitoring and management of assets, thanks to the connection of various systems to a unified network and the prompt transfer of information, notifications of emerging malfunctions;
- increasing the level of cybersecurity and reducing the risks of hacker attacks on automated processes in the enterprise;
- real-time asset management, hazard identification and prompt decision-making;
- formation of a sustainable environment through preventing environmental hazards and minimizing potential damage to the environment;
- Implementation of equipment inspection and preventive maintenance by providing information, collected by sensors.

As a result, equipment downtime is reduced, operating costs are reduced, risks are minimized, and business profitability increases.

3) Robots and drones.

Automation of processes using robots can provide profit in the form of increased productivity, efficiency and safety of production. The greatest effect will be achieved with the full integration of robotic systems with automated systems, providing the operator with relevant data [10].

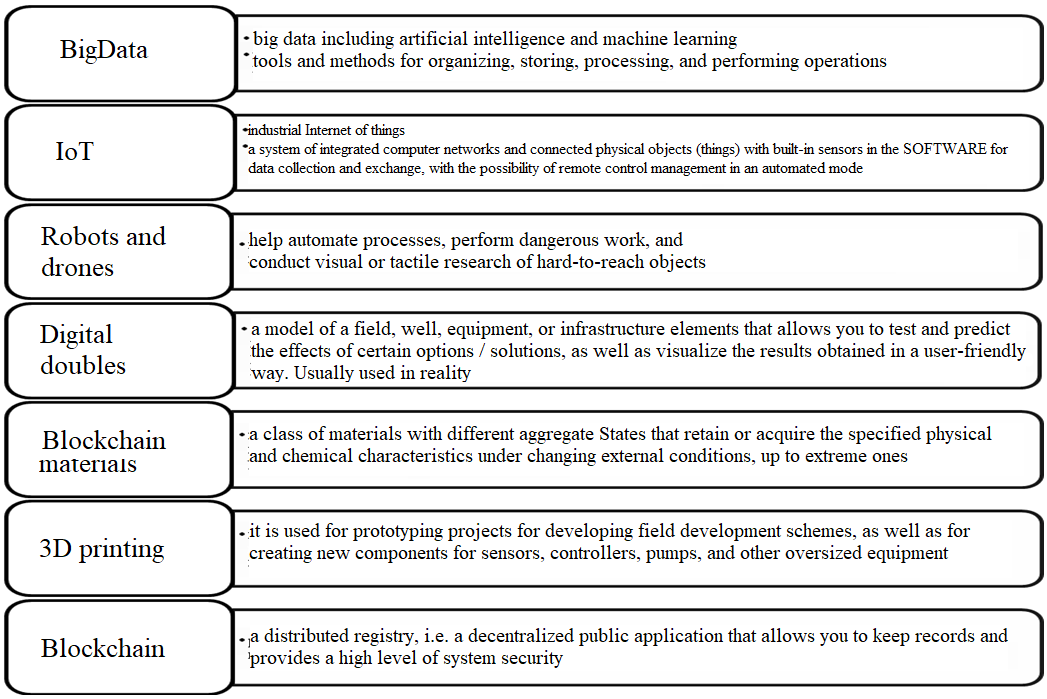


**Figure 1** Directions for implementing digital innovations in the oil and gas sphere

The use of unmanned aerial vehicles (UAVs, drones) in the oil and gas industry provides significant advantages. For example, in the field of exploration, this is a preliminary analysis of prospecting sites, as well as geodetic surveyings for the design and preparation of seismic surveys. In the field of oil and gas transportation, it is the identification of damages of the integrity of the pipeline, minimization of the risks of accidents, etc. The advantages of using drones are distinguished as [11]:

– increased safety;
– good scalability and easy adaptation to other devices;
– reducing of labor costs;
– high productivity;
– the accuracy of the received data;
– high mobility;
– the opportunity to use in hard-to-reach places.

4) Digital twins allow simulating the behavior of a physical object and become the basis for the design and operation of objects. Combining 3D models with real-time field data allows to get the following advantages:

– ensure operationability in the development of assets;
– simulate the behavior of an asset under different operating conditions;
– determine the most effective operating modes;
– improve the efficiency of the decision-making process;
– identify potential risks;
– increase the safety and productivity of operations throughout the operational life of the asset.

According to experts, the use of automated design systems, that create 3D models of objects, can reduce the number of errors in the design and operation process of various installations by 2-3 times [12].

5) Intelligent materials are materials, whose properties can vary significantly under the influence of any external factors (mechanical stress, electric or magnetic field, temperature, light, humidity, chemical properties of the environment, etc.), and also capable of converting one type of energy in another. Moreover, the change in properties is reversible and can be repeated many times [13].

6) 3D printing allows to make products of any geometry and complexity, which allows to reduce production costs, to make a part at the production site, thereby allowing not to stop the process.

7) Blockchain implies the use of technologies and protocols of a distributed ledger, the result of which is actually a reliable and resistant to hacking and substitution of a distributed database. The database does not need a central repository and is transparent to all participants.

Oil and gas companies appreciate the opportunities of using blockchain very highly. Thus, specialists from BP, Shell and Statoil calculated a 30% saving on the time of transactions, "Gazprom Neft" determined an increase in the company's efficiency by 10-15%, and a decrease in administrative and commercial costs in the company by 5-10% will allow large oil companies to obtain savings in the amount of $ 0.4-0.7 billion [14].

Globally, according to the World Economic Forum, the tokenization of the oil industry will increase market liquidity by $ 1.6 trillion, market volume by $ 2.5 trillion, will bring companies an additional $ 1 trillion and society

as a whole additional $ 640 billion. The volume of CO2 emissions into the atmosphere will decrease by 13 trillion tons, the volume of oil spills will decrease by 230 thousand barrels, and the water savings will amount to 800 million gallons of water [15].

Thus, the implementation of digital technologies in the activities of enterprises in the oil and gas industry has significant advantages (fig. 2) [16].

| | Exploration | Development | Extraction |
|---|---|---|---|
| Goal | Choosing the optimal size of the existing resource base | Solving the problem of data fragmentation and determining the level of investment profitability in digital technologies, which makes it possible to ensure the stability of a set direction and pace of innovation implementation | Solving the problem of an endless cycle of modernization and retrofitting of equipment at existing fields without unnecessary costs |
| Current condition | Data standardization, the use of advanced algorithms and high-performance computers made it possible to move to the stages of analysis and visualization | The presence of different goals, own tools, as well as the lack of data standardization formats cause problems with integration | Low level of sensor equipment is associated with the used outdated equipment and the need to ensure the continuity of extraction |
| Offered digital technologies | Supplementing of the visual perception of geophysicists by using machine training technology to obtain data about geographic features | Conduction of integration and analysis by carefully overlaying integration and analytics systems on a variety of drilling data, using an open systems architecture | Installation of sensors using a layer-by-layer data formation strategy and expansion of the analysis to tank level |
| Potential advantage | Higher probability of recovery and higher profitability of probable 2P category reserves, accounting for 50% of all proved 1P category reserves | Total annual drilling cost reduction of over $ 30 billion for enterprises in the exploration and extraction sector | Additional cash flows of over $ 20 billion, excluding cost reductions due to equipment failures and repairs |

**Figure 2** Advantages of using digital technologies in different sectors of the oil and gas industry

Studies, carried out to assess the effeciency of using digital technologies, indicate, that, from the standpoint of potential economic benefits for the oil extracting industry, the most promising technologies are big data, the Internet of things and digital twins. The combination of such solutions makes it possible to form an “digital” oil field.

Currently, there are various products, required to create such digital fields, the implementation of which allows to increase the recovery factor by 5-10% and reduce costs (Figure 3) [17].

| Developer | Technology | Impact on reserves or production | Influence on economy |
|---|---|---|---|
| • Shell | • Smart Field | • KIN up to +10%, KIG up to +5% | • Downtime up to-10%, costs up to -20% |
| • Chevron | • i-field | • KIN +6% production +8% | • - |
| • BP | • Field of the future | • Production +1-2% | • - |
| • Petoro | • Smart Operation | • - | • Capex -50% |
| • Statoil | • Integrated Operation | • Production +20% | • - |
| • Halliburton | • Real Time Operation | • - | • Capex -20% |

**Figure 3** Efficiency of various digital oil field technologies

The implementation of the Internet of Things and Big Data is very important for optimizing the operation of the existing well stock or supporting new drilling. The stage of exploration and data interpretation requires the active use of digital technologies, since it is at this stage, where the greatest risks emerge. Consequently, increasing the efficiency of search and assessment will provide a positive effect for extraction, as well as lead to a revision of the level of risk and an acceptable rate of return.

### *3.2. Use of digital technologies in Russian oil and gas companies*

The implementation of digital technologies in Russian oil and gas companies began after Shell and BP entered the market. The first project for the implementation of remote monitoring and control systems "Digital fields" was implemented in 2008 at the Salym group of fields. By 2018, the number of such fields increased to 43, of which 5 are projects in the gas industry (Table 1). The leader in the implementation of digital technologies is PJSC Rosneft [18]. Cumulated extraction from all fields is 27% of the total oil extraction in Russia. All offshore projects, the largest new fields (Vankorskoye, Novoportovskoye), and large traditional fields (Romashkinskoye, Samotlorskoye, Priobskoye, etc.) are digital oil fields.

**Table 1** Data on digital fields in Russia for 2018

| Development company of the field | Number of digital fields, units | Share in extraction, % | Share in reserves, % |
|---|---|---|---|
| PJSC "Rosneft" | 16 | 36 | 33 |
| PJSC "Lukoil" | 13 | 16 | 10 |
| PJSC "Gazprom Neft" | 8 | 45 | 32 |
| PJSC "Tatneft" | 1 | 53 | 28 |
| Total | 43 | 27 | 21 |

In comparison with the largest international oil and gas companies, the level of implementation of digital technologies in the Russian industry is significantly lower. However, understanding the importance and perspectives of their use, companies develop and implement strategic development plans. In the "Rosneft 2022" strategy, PJSC "Rosneft" identified digitalization as one of the key development directions, which, according to experts, will allow to reduce specific operating costs by 2-3%, reduce well drilling time by 5%, and increase the efficiency of well workovers by 20%. PJSC "Gazpromneft" added a digital solutions implementation program to its technological strategy, which covers the entire oil sector from exploration to oil field construction. Since 2012, about 30 projects of the program have been implemented, the productivity of which at the Romashkinskoye field was expressed in an annual increase in extraction by 0.5-2%, even in conditions of a high degree of depletion. Since 2015, the "Tatneft" company has been operating a Business Service Center, that provides support and technical support for production processes. Well modeling allows predicting extraction economics, identifying residual oil reserves and calculating options for optimizing the operating mode of wells. In 2020, the company plans to calculate similar models for all existing wells. The assessment of the economic effect of digital pilot projects at the fields in LUKOIL amounted to more than 3.5 billion rubles. for two years. IT strategy “Digital LUKOIL 4.0” was identified as a promising direction of development for the company.

The implementation of programs for the digitalization of oil extraction in the conditions of depletion of reserves of the largest operating fields in traditional oil extraction regions will allow Russia to maintain its leading position in the world oil market, and companies to increase the profitability of their activities. The use of digital technologies allows to improve the accuracy of forecasting and modeling for explored fields. For already developed

fields, the effect of digitalization is manifested by reducing costs and equipment downtime. According to expert assesment, the implementation of digital technologies reduces oil extraction losses by 2.5%, and increases the well flow rate by 2% [19]. This makes it possible to put into operation part of the deposits of the existing fields, which are currently recognized as economically unsound. The results of using digital technologies depend on many factors of the external and internal environment, including the availability of financial resources in companies, the development of infrastructure projects, support from the state, developed regulatory legal acts, demand from oil-consuming countries, etc.

## 4. CONCLUSION

One of the key problems of digitalization of the oil and gas sector is the lack of qualified personnel, since the needs of the economy are changing faster, than the curricula in universities. In this regard, oil and gas companies are forced to launch their own training programs, closely interact with universities, lobby for state funding for new educational programs [20] to eliminate the shortage of personnel.

The anti-Russian sanctions, introduced in 2014, had an extremely negative impact on the intensification of the implementation of digital technologies in the oil sector. In this regard, one of the key problems of digital transformation is the need for import substitution of foreign technologies.

Based on the current trends in the external economic environment, credit risks and limitations on the reduction of oil extraction, including the agreement with OPEC+, the advanced capabilities of companies to maintain oil extraction will depend on their ability to implement modern techniques and technologies for increasing oil recovery, software tools for drilling and extraction, from the implementation of import substitution projects in related industries, as well as the timely putting into operation of new fields, located in remote regions with difficult development conditions.

According to expert assesments, the implementation of digital technologies allows companies to increase the oil recovery factor. On a state scale, an increase in oil recovery factor by 1% in general will increase extraction by 20 million tons of oil per year.

The digital transformation of the oil and gas industry will bring a significant multiplier effect for the entire economy, the preliminary assessment of which is over 700 billion rubles per year by 2035.

Thus, the digital revolution in the oil and gas industry is a natural process of its development. The main principle of digitalization is the transition from fragmented automation of individual stages or productions to fully automated digital production, controlled by intelligent systems in real time mode. Currently, the digitalization of the industry is a priority direction for development both at the state level and of individual companies. The results of the active use of new technologies in the oil and gas industry are expressed in the optimization of extraction by increasing oil recovery, reducing the number of equipment failures, reducing operating and capital costs, putting into operation part of the deposits of existing fields, that are currently economically unsound, as well as developing new hard-to-reach fields.

At the same time, the most significant problems in the development of the oil and gas sector are due to the formation and active use of innovations. Among these problems should be distinguished:

– insufficient interest of oil companies in long-term investments in digital technologies and financing of R&D, due to weak incentives from the state;
– lack of specification of measures to support the implementation of digital technologies in industry in the state program for digitalization of the economy;
– the impossibility to attract investments at the most risky stages of R&D, due to the presence of unsolved issues in the legislation on intellectual property and the poor development of the financial market;
– lack of qualified personnel, that meet modern requirements;
– insufficient presence of substitute software of domestic production.

The solution to these problems in the oil and gas sector should be carried out on the principles of equality between customers and contractors, active development and implementation of digital technologies, on improving the quality of cooperation and active interaction with educational institutions and the state.

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