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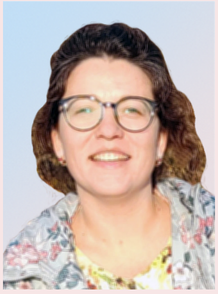
Digitalization Experience in the Oil and Gas Sector and Its Implementation in the Russian Arctic Zone



Natalia S. AVDONINA
Northern (Arctic) Federal University named after M.V. Lomonosov
Arkhangelsk, Russian Federation
e-mail: n.avdonina@narfu.ru
ORCID: 0000-0001-9871-3452

Nikolay A. KONDRATOV
Northern (Arctic) Federal University named after M.V. Lomonosov
Arkhangelsk, Russian Federation
e-mail: n.kondratov@narfu.ru
ORCID: 0000-0002-7763-1797

Nikita M. KUPRIKOV
Moscow Aviation Institute (National Research University)
Moscow, Russian Federation
e-mail: nkuprikov@mail.ru
ORCID: 0000-0003-3152-0941; ResearcherID: O-6851-2017

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Mikhail Yu. KUPRIKOV
Moscow Aviation Institute (National Research University)
Moscow, Russian Federation
e-mail: kuprikov@mail.ru
ORCID: 0000-0002-5296-7630; ResearcherID: AAB-7336-2020

Fedor D. LARICHKIN
G.P. Luzin Institute of Economic Problems of the Kola Science Centre of the Russian Academy of Sciences
Apatity, Russian Federation
e-mail: larichkinfedor@yandex.ru
ORCID: 0000-0002-6378-9198; ResearcherID: AAQ-2126-2020

Natalia V. ROMASHEVA
Empress Catherine II Saint Petersburg Mining University
Saint Petersburg, Russian Federation
e-mail: natasmir84@mail.ru
ORCID: 0000-0003-3074-5137; ResearcherID: N-2419-2016

Alexey M. FADEEV
G.P. Luzin Institute of Economic Problems of the Kola Science Centre of the Russian Academy of Sciences
Apatity, Russian Federation
Peter the Great St. Petersburg Polytechnic University
Saint Petersburg, Russian Federation
e-mail: alexfadeev79@gmail.com
ORCID: 0000-0002-3833-3316; ResearcherID: AAR-2969-2020

Abstract. The relevance of this study stems from the fact that globalization – accompanied by the penetration of information and communication technologies and the internet into production and social processes, the opening up of new pioneer regions, and the COVID-19 pandemic – has triggered a catalytic reaction that is turning digital technologies into the main driving force of scientific and technological progress. One of the sectors affected by digitalization is the fuel and energy complex, particularly oil and natural gas extraction enterprises. In the Russian Arctic, digitalization has become a strategic priority for development. Hence the aim of this study: to characterize digitalization as a strategic direction for the development of oil and gas companies operating in the Russian Arctic. To achieve this aim, the following methods were employed: analytical method, content analysis of digitalization strategies and practices, expert interviews, and a comparative descriptive analysis of the authors' own experience. The scientific novelty of the study lies in providing a more detailed characterization of the drivers of, and barriers to, the development of digital technologies in the Russian Arctic; in revealing how these drivers and barriers influence one another; and in firmly establishing digitalization as a strategic development path for oil and natural gas companies active in the region. The objective facts and subjective assessments presented in the paper highlight the need to deploy and refine digital technologies in the interests of effective and safe resource management in the Arctic. From a practical standpoint, the article's materials will be useful to strategic planning specialists and to experts working on import substitution and on ensuring Russia's technological sovereignty. A promising avenue for further research could be to systematize and classify the experience of digitalization in Russian and foreign energy companies, quantifying the effects of introducing such technologies under Arctic conditions and identifying the infrastructure requirements this entails.

Key words: Arctic zone of the Russian Federation, mineral resources, digitalization, import substitution.

Introduction

The subject of this study is digitalization[1] at oil and gas enterprises in the Arctic Zone of the Russian Federation (hereinafter – AZRF).

Digitalization in a broad sense is understood as the process of developing and implementing digital technologies into product manufacturing and enterprise management. Digitalization is facilitated by the development of information and communication technology (hereinafter – ICT) networks, the Internet, mobile applications, artificial intelligence (hereinafter –AI), the construction of high-speed fiber-optic communication lines (hereinafter – FOCL), data processing service centers (hereinafter – DPSCs).

In Russia, considerable effort is devoted to the development of digitalization by both the state and business. Given the size of the Russian Federation, the use of digital technologies is vital for some regions, for example, the Northern and Arctic Zone of the Russian Federation. The drivers and barriers of the digital economy differ there from those in any other part of the country.

The use and development of ICT are enshrined in the Strategy for the Development of the AZRF and Ensuring National Security for the period up to 2035. Considering the geographic and economic factors of the region's development, digitalization in the AZRF is a mega-project. Its implementation will improve the quality of life of the local population and will contribute to safety of environmental management and sustainable development of the region. Extraction of minerals, primarily hydrocarbons, is the predominant economic activity in the Arctic in the long term, and the key element of socio-economic development of the AZRF constituent entities.

The authors set out to determine what makes the drivers and barriers of digitalization unique in the AZRF constituent entities and the oil and gas industry, what digitalization means for the oil and gas industry, and whether successful examples of digitalization can be found at oil and natural gas enterprises in the AZRF over the past 10 years. The limited length of the article does not allow

[1] The concepts of "digitalization", "digital economy", "digital solutions", "digital technologies" are used as synonyms in this article.

an exhaustive examination of the features of digitalization in the Russian Arctic, but it provides a necessary foundation for future researchers of digitalization in remote resource regions.

Materials and methods

To fully study the opportunities and risks of digitalization development at oil and gas enterprises, the methodology was based on the results of research into the factors determining the processes in question and their interrelationships. Accordingly, not only theoretical and methodological provisions are valuable, but also a focus on applied management tasks and examples, as well as the authors' personal experience.

Thus, the research tools included the analytical method, content analysis of digitalization strategies and practices, interviews with experts, and comparative-descriptive analysis of the authors' experience.

In our problem field, the research topics are extremely broad. A search for "Arctic" in the Russian Science Citation Index (RSCI) yielded nearly 95 thousand publications. Many experts have compiled detailed descriptions of the geographical and economic features of the global and Russian Arctic (Tatarkin, 2014).

A search for "Digitalization" in the RSCI yielded more than 95 thousand publications. They focus on general issues of the digital economy development, including service industries, tourism, social services, education, and public administration.

A search for "Digitalization of the Arctic Zone of the Russian Federation" yielded 323 publications in the RSCI. The role of digital technologies in regional development is studied by scientists M.G. Treiman, A.V. Kupryakova, D.Yu. Ignatova. Their article provides a comparative description of the level of digitalization in the AZRF constituent entities and compares it with national averages, offering recommendations for improving digitalization (Treiman et al., 2025). D.B. Iakhiaev, I.A. Ivanova, L.V. Voronina, and A.V. Grigorishchin state the positive effect of digitalization on the economy and social issues of the Russian Arctic. The authors propose for discussion a classification of digitalization problems to be considered when making plans and programs for the development of Arctic regions (Iakhiaev et al., 2023). P.V. Smirnova and D.A. Stepanenko conclude that there is an imbalance between the natural resource potential of the Arctic macro-region and the approaches to its development since the industrial model. To solve the problem, they propose a digital consortium model with a justification of the legal framework for its functioning (Smirnova, Stepanenko, 2025). Yu.S. Vasil'ev, N.I. Didenko, V.I. Cherenkov believe that "innovative high-tech solutions, such as a digital cyberspace for the AZRF developed using unmanned aerial vehicles (UAVs), can contribute to solving problems and responding to challenges of sustainable development of the Russian Arctic" (Vasil'ev et al., 2019).

Dozens of articles in the RSCI are devoted to digitalization of the fuel and energy complex. For example, S.S. Vopilovskii notes that "the active development of the energy market contributes to Russian energy sector diversification" (Vopilovskii, 2022). His study presents key directions of energy development in the context of new trends and challenges. It is emphasized that the AZRF is becoming a growth driver and opens "new windows" for Russia's development. It is established that "the current situation of global technological breakthroughs, geopolitical challenges, and climate changes contributes to a transition from vertical integration to distributed generation and decentralization, making maximum use of the opportunities of Russia's northern territories". A.G. Kazanin concludes that the use of domestically produced equipment and software systems in hydrocarbon development can ensure Russia's technological sovereignty (Kazanin, 2024). This is possible on the basis of "a holistic concept of coordinated sectoral and corporate strategies with established methodological approaches". The article (Skotarenko, Khatsenko, 2022) substantiates the need to use digitalization instead of the traditional contractual form in communicative interactions between energy resource suppliers and client markets, using the example of a company operating in the AZRF. The authors emphasize that digitalization is vital for high-tech business management, including ESG transformation processes management both at the industry level and at the level of an individual enterprise.

The sources used in our study indicate that the energy industry generally remains conservative in terms of innovation. A number of scientists note that for oil and gas companies that generate up to 90% of the GRP of the Arctic constituent entities of Russia – Khanty-Mansi, Yamal-Nenets and Nenets autonomous areas – digital transformation is an important area of modernization (Dmitrieva et al., 2022). O.V. Skotarenko and co-authors in their collective research provide a comparative assessment of the digital maturity of companies authorized to operate in remote areas of the Russian Arctic (Skotarenko et al., 2012). Their approach is based on an analysis of sustainable supply chain management techniques in the oil and gas industry. The study identifies the limits for reducing hydrocarbon production costs through digital transformation of Arctic projects. The growing technological lag of oilfield service companies is identified as the main factor limiting the digitalization of shelf projects in the AZRF. N.A. Polyakov and P.E. Zherebchikova consider technological innovation as a factor in the competitiveness of oil and gas companies. An important role is played by the use of AI, augmented and virtual reality technologies, "smart field" and other approaches that ensure an increase in reserves and oil recovery, improve the safety of technological processes and personnel at all stages of the field life cycle (Polyakov, Zherebchikova, 2025).

Promising directions for digitalization of the oil and gas industry include modeling and visualization systems (especially for areas with hard-to-recover reserves), well construction and predictive maintenance, industrial robotization, remote field data management, "unmanned warehouses". UAVs, 2D and 3D seismic survey vessels are used everywhere (Pitukhina, Belykh, 2023; Zaikov et al., 2021; Dmitrieva et al., 2022; Filippov et al., 2022; Ponomarenko et al., 2022; Zemenkova et al., 2022; Romashev et al., 2022; Samylovskaya et al., 2022; Vasileva et al., 2023; Buzmakov et al., 2023; Zhukovskiy et al., 2023; Beloshitskiy et al., 2024). At the Sobolev Institute of Mathematics of the Siberian Branch of RAS, scientists are engaged in numerical modeling of the structure of reservoirs and collectors of oil and gas fields based on seismic surveys. They found that only about 30% of oil can be extracted from a well without additional efforts[2].

Up-to-date information on the regulatory framework and development trends of the fuel and energy complex (hereinafter – FEC) and AZRF, as well as on digitalization projects in the oil and gas industry of Russia and abroad, was borrowed

[2] Black twins. Available at: https://www.kommersant.ru/doc/8399652 (accessed: 12.02.2026).

from specialized media resources whose audience includes experts, economists, and managers[3].

In modern conditions, access to foreign literature on the research topic is greatly limited. The discovered sources examine general issues of digitalization of the Arctic and its major industries, contain geographical examples of Arctic oil and natural gas endowment, and analyze problems of their development[4].

The “Arctic way” of digitalization in foreign publications is considered through the development of ICT and broadband Internet. These studies are in line with the ideas of sustainable development of northern regions and their local communities (Moulton, 2000; Kukul, Coşkun, 2011; Palviaa et al., 2017). We can take Northern Canada as an example (here the word “Northern” means not only Arctic territories): “...over 99 percent of Canadian households currently have access to broadband with speeds of at least 1.5 Mbit/s. However, only 27 percent of households in the rural Nunavut region have access to broadband”[5]. In articles by Russian scientists published abroad, attention is paid to cases of digitalization of the economy and logistics services in the context of the Northern Sea Route (hereinafter – NSR) development and data transmission via FOCL (Levina et al., 2025; Pichkov et al., 2022).

Given the limited length of the article, the presented literature review on the research topic does not claim to be comprehensive. Acquaintance with sources not included in the references showed that in Russia and abroad, digitalization is understood as the process of introducing digital (or ICT) technologies into various areas of activity to convert analog data, processes, and interaction models into a digital form. According to experts, the goal of digitalization is to increase the efficiency of enterprises, optimize business processes, and improve the accessibility and quality of products. We share such concepts and goals of digitalization in a broad sense.

A common “weak point” of publications on digitalization in the AZRF is the general topics and research objectives, which almost never contribute to developing digital solutions in the real economy sector, and even less so at oil and gas enterprises, despite its strategic importance for the Arctic region. Our article contributes to filling this gap.

In recent years, Russia has developed strategies and adopted state programs in the field of digitalization[6]. The Government of the Russian Federation will allocate more than 1.5 trillion rubles

[3] Barriers to digital transformation. Available at: https://companies.rbc.ru/news/CcvFFaFWLx/bareryi-na-puti-tsifrovoj-transformatsii (accessed: 15.01.2026); Digital transformation of the Arctic. Available at: https://goarctic.ru/news/tsifrovaya-transformatsiya-arktiki-napravlenie-diversifikatsii-rossiyskogo-tek (accessed: 12.12.2025) How the oil and gas industry is digitizing. Available at: https://www.kommersant.ru/doc/7026080 (accessed: 10.01.2026); IT technologies for the Arctic. Available at: https://www.kommersant.ru/doc/6666173 (accessed: 12.12.2025).

[4] Arctic oil and natural gas resources. Resource basin in the Arctic region. Available at: https://www.eia.gov/todayinenergy/detail.php?id=4650 (accessed: 12.05.2026); The Development of Arctic Offshore Oil and Gas Resources in Russia: Energy Policy Updates and New Activities by Companies. Available at: https://arcticyearbook.com (accessed: 12.05.2026); Developing Oil and Gas Resources in Arctic waters. Available at: https://www.academia.edu/8345201/DEVELOPING_OIL_AND_GAS_RESOURCES_IN_ARCTIC_WATERS (accessed: 12.05.2026).

[5] Improving digital infrastructure in the Arctic. Available at: https://jsis.washington.edu/news/improving-digital-infrastructure-in-the-arctic (accessed: 12.05.2026).

[6] Strategy for the Development of the Information Society in the Russian Federation for 2017–2030. Available at: https://tass.ru/politika/3869202. (accessed: 12.12.2025); Strategic directions in the field of digital transformation of public administration. Available at: http://government.ru/docs/all/152609/ (accessed: 12.12.2025); Digital Economy of the Russian Federation: state program. Available at: https://digital.gov.ru/target/naczionalnaya-programma-czifrovaya-ekonomika-rossijskoj-federaczii (accessed: 12.12.2025); Strategic direction in the field of digital transformation of the fuel and energy complex until 2030. Available at: http://government.ru/docs/51101 (accessed: 12.12.2025).

for the implementation of the national project "Data Economy and Digital Transformation of the State" in 2025–2035[7]. The Strategy for the Development of the Mineral Resource Base covers the questions of the development of algorithms for analyzing data generated by the mineral resource base monitoring, as well as ways, means and technologies for data exchange between participants in the geological exploration process, and the development of remote sensing technologies for the subsurface[8].

The article contains an analysis of strategies and examples of digitalization at PAO "Gazprom" and PAO "Rosneft"[9]. The choice of companies was not accidental. In 2020–2024, PAO "Gazprom" accounted for about 16% of world and over 70% of Russian natural gas reserves, and 12% and 68% of gas production in the world and in Russia, respectively. PAO "Rosneft" is also a leader of the Russian oil industry. Rosneft's share in world oil production is about 6%.

Gazprom and Rosneft are corporations that, in accordance with federal legislation, are authorized to work on the continental shelf of the Arctic Ocean. They have the necessary (more than 5 years) experience and technologies adapted to areas with extreme climatic conditions, and a state participation share of over 50%. Gazprom and Rosneft are public companies whose reports are published on the Internet.

The strategies of Gazprom and Rosneft in the Arctic differ. The former is primarily focused on the development of gas and oil fields onshore, in the Yamal-Nenets Autonomous Area and on the shelf of the Barents Sea. The latter operates on small, poorly studied areas in remote parts of the AZRF, such as the eastern Kara Sea, Siberia, and the Far East.

The Russian government has been discussing for several years the idea of allowing private companies to work on the Arctic shelf, which would correspond to global trends. However, at present, the main role is still played by state-owned corporations. Nevertheless, PAO "Lukoil" has been operating in the Yamal-Nenets Autonomous Area for more than 30 years, its activity reports are published on the company's official website.

Results and discussion

The Arctic is the last promising area on Earth for the development of hydrocarbon deposits. "...The Arctic Zone of the Russian Federation provides more than 80% of natural gas and 17% of oil (including gas condensate) in Russia ... The Russian continental shelf in the Arctic contains more than 85 trillion m^3 of natural gas, 17.2 billion tons of oil (including gas condensate)"[10].

To develop oil and gas resources, Russia continues to implement investment projects with international participation for exploration and extraction of minerals and fuel onshore and on the continental shelf of the Arctic Ocean, as well as for the development of transport infrastructure (mega-projects) "Arctic LNG", "Yamal LNG", "Yamal LNG 2", "Vostok Oil". "The volume of state investment in these projects exceeds 1.3 trillion rubles, and their result will be the creation of more

[7] Data Economy and Digital Transformation of the State: National Project. Available at: http://government.ru/rugovclassifier/923/about (accessed: 12.12.2025).

[8] Strategy for the Development of the Mineral Resource Base of the Russian Federation until 2050. Available at: http://static.government.ru/media/files/TNB3oQkPRJTmDE3AMaxuTn2KRSHG9X0S.pdf (accessed: 05.03.2025).

[9] Digital Transformation Strategy of PAO "Gazprom" for 2022–2026. Available at: https://www.gazprom.ru/press/news/2021/december/article545124 (accessed: 12.12.2025); Digitalization of PAO "Rosneft". Available at: https://www.rosneft.ru/Development/Tehnologicheskij_klaster/Cifrovizacija (accessed: 12.12.2025).

[10] Strategy for the Development of the AZRF and Ensuring National Security for the period up to 2035. Available at: http://publication.pravo.gov.ru/Document/View/0001202010260033 (accessed: 10.06.2024).

than 30 thousand jobs and an increase in average wages... By 2030, the number of state-supported projects should be at least 1300, the volume of private investment – at least 730 billion rubles, and the total planned investment – almost 5 trillion rubles”[11].

The Russian Arctic is a macro-region with non-standard environmental and socio-economic conditions. It has special options for the development of the digital economy that other regions lack.

The economy of Arctic regions is highly dependent on the extractive industries. The resource-based nature of the economy means that if extractive industries show slower growth, the same processes affect other sectors. The narrow economic base leads to amplification of boom and bust cycles. This creates problems for intensive environmental management development in areas beyond the Arctic Circle and hinders sustainable socio-economic development of territories and preservation of the environment.

In this regard, the experience of Arctic countries, such as the USA, Denmark, Norway, and Canada, shows that many companies and government agencies are investing in expanding broadband (Nuvitik Communications, the Innovation, Science and Economic Development (ISED) agency under the Greenland Connect initiative, the Quintillion project to reduce the digital divide in Alaska, a submarine cable system near the Norwegian Svalbard archipelago). Obstacles to the implementation of these projects include the size and cost of investments, their payback period, coordination with governments and indigenous organizations, settlement of the land issues with natives, environmental constraints, logistics development, and confidentiality. Solving these problems and challenges can take years, so time is also a constraint here. Finally, the Arctic is sparsely populated: only about 4 million people live there, of which about 2.4 million are in the AZRF. When assessing investments and the final cost of digital infrastructure projects in the Arctic, it is necessary to consider factors such as specific photoperiodicity, the presence of permafrost, the short construction season, poor road conditions, the need to create reserves and warehouses with spare parts and equipment for long periods of impassability, etc.[12]

In the Russian Arctic, these constraining factors for the development of the digital economy are exacerbated. Geographic barriers include a huge (more than 9 million km^2) and sparsely populated territory, more severe climatic conditions than anywhere else in the Arctic, peripherality, remoteness of industrial facilities on the Arctic Ocean shelf from coastal supply and assistance centers. Northern and Arctic regions of Russia are characterized by poor and uneven development of the land transport network. Significant distances between production facilities lead to a lack of reference stations. Many settlements and municipalities are virtually cut off from the Internet and mobile communications.

The unique environment in areas beyond the Arctic Circle is extremely vulnerable and requires special approaches to environmental management. At the same time, over the past 30 years, natural conditions in the global Arctic have been changing,

[11] Sanctions will not melt the Arctic. Available at: https://www.kommersant.ru/doc/5407059 (accessed: 05.01.2026).

[12] Improving digital infrastructure in the Arctic. Available at: https://jsis.washington.edu/news/improving-digital-infrastructure-in-the-arctic (accessed: 12.05.2026).

with "Arctic amplification of global warming" taking place. This may facilitate access to resources on the Arctic Ocean shelf and simplify the development of ICT and other digital infrastructure[13].

New technologies and means of production, and the constant outflow of population from the AZRF, are changing approaches to production organization. Overcoming the personnel barrier of digitalization requires continuous recruitment, targeted training of specialists, cooperation with educational organizations in order to develop sector-specific educational standards in the field of ICT with an emphasis on practical training. Mentoring in secondary vocational and higher education, provision of professional education services are effective tools for solving the problem of personnel shortage (Zaikov, 2021).

Compared to economically developed states, Russia's lag in digitalization can be explained by gaps in the regulatory framework[14]. Despite the adopted laws and programs in the field of digitalization, the Arctic strategy describes the AZRF territories as having "a poorly developed communication environment and noncompetitive telecommunications sector," as well as "... a low share of high-tech and knowledge-intensive sectors' added value in the Arctic zone's GDP, underdeveloped R&D, insufficient rates of innovation development ..."[15].

The digital transformation of the oil and gas industry in Russia in the last decade has been significantly influenced by changes in the global environment. Sanctions imposed by Western states (in excess of 32 thousand as of 2026)[16] are, in the long term, exacerbating the technological barriers to digitalization.

Global experience in implementing energy projects in the Arctic region testifies to their high complexity and the fact that the development of resources onshore and on the Arctic Ocean's shelf requires any northern country to involve foreign partners. Globalization brought dozens of companies from the USA, Canada, Norway, Sweden, Finland, and Western European countries to the Russian Arctic. Their withdrawal from joint Arctic projects with Russia in 2012–2024 was all the more painful.

The energy industry, as an indicator, has demonstrated the failure of the theory of the international division of labor (with "unfriendly" countries). Russia is relying on its own resources in its development. However, many IT products introduced into domestic production processes belong to foreign companies. The Russian government is stimulating the transition to domestic products, but also allows parallel imports of technologies and equipment.

The Russian Federation's course toward integration into the global economy in the 1990s contributed to dependence not only on industrial equipment, but also on standards used in its manufacture and parameters it takes into account. API (American Petroleum Institute) and IFP (French Institute of Petroleum) have either suspended the issuance of conformity certificates to Russian enterprises or are revoking them. Foreign manufacturers from friendly Eastern countries,

[13] Climate Change 2022: Impacts, Adaptation and Vulnerability. Available at: https://report.ipcc.ch/ar6/wg2/IPCC_AR6_WGII_FullReport.pdf (accessed: 10.12.2023).

[14] Global information technologies. 2024: report. Available at: https://gtmarket.ru/ratings/networked-readiness-index (accessed: 12.01.2025).

[15] Strategy for the Development of the AZRF and Ensuring National Security for the period up to 2035. Available at: http://publication.pravo.gov.ru/Document/View/0001202010260033 (accessed: 10.06.2024).

[16] Total number of list-based sanctions imposed on Russia by territories and organizations worldwide from February 22, 2022 to January 11, 2026, by target. Available at: https://www.statista.com/statistics/1293531/western-sanctions-imposed-on-russia-by-target/ (accessed: 12.02.2025).

fearing illegal secondary sanctions, are forced to cease their activities in Russian projects.

Drivers of digitalization in the oil and gas industry of the AZRF, as in the FEC as a whole, are associated with technological, organizational, regulatory, and socio-economic factors. They include:

– development of high-tech breakthrough technologies and software used at all stages of the production process;

– development of import substitution (systems of standardization and certification in the energy sector as a tool for technological sovereignty);

– strategic planning of digital transformation of the Russian economy, the FEC and its industries;

– use of experimental legal regimes (proposed "... special regulatory measures for the development, testing, and implementation of digital and technological innovations")[17];

– state support measures (development and adoption of industry strategies, AZRF development programs, activities of the Coordination Council for Import Substitution of Oil and Gas Equipment under the Government Commission on Import Substitution);

– development of land, sea, and digital infrastructure;

– personnel training and development of educational programs in the field of ICT, creation of science and technology parks and centers based at universities (for example, the "Digital Arctic" IT Park operates at Northern (Arctic) Federal University named after M.V. Lomonosov).

In the AZRF territories, the greatest success in digitalization has been achieved by PAO "Gazprom", PAO "Rosneft", and PAO "Lukoil". At the same time, we do not aim to compare their overlapping approaches to the development and use of digital solutions in environmental management, limiting ourselves to demonstrating successful cases.

The architecture of Gazprom's digital strategy is based on a Unified Data Model, which consists of digital platforms – specialized IT services. On their basis, digital ecosystems of the gas and oil business operate. "Digital twins" are virtual copies of existing production facilities that contain complete digital characteristics of the original to predict its operation under various conditions.

The "Captain" system (Complex for Automatic Planning of Interactive Transportation of Arctic Oil) of "Gazpromneft" company is designed for planning and developing predictive analytics. The system contributes to increased safety, reduced logistics costs (up to 10–12%), and reduced time for calculation and approval of shipment operations. "Captain" is part of a comprehensive plan for the modernization of trunk infrastructure to increase cargo traffic along the NSR.

"Gazpromneft-Khantos" (Khanty-Mansi Autonomous Area) introduces video analytics into drilling and well stock management. In 2024, more than 2 thousand vehicles moving both within fields and on public roads were equipped with smart cameras.

The digitalization of "Rosneft" is based on a Technological Digital Platform. It consists of several databases and applications developed for a specific field. The platform's activity is based on neural network technologies, computer vision, and mathematical models for remote field management. The information technology system "Sfera 3D" contains more than 3 thousand models, allowing decisions to be made during exploration and oil production, and reservoir pressure maintenance.

[17] On experimental legal regimes in the field of digital innovations in the Russian Federation: Federal Law 258-FZ, dated July 31, 2020. Available at: http://www.kremlin.ru/acts/bank/45796 (accessed: 13.05.2026).

Table 1 presents the main characteristics of digitalization identified by analyzing the digitalization strategies of companies engaged in oil and natural gas production in the AZRF.

The data in Table 1 show that the approaches to digitalization in oil and gas companies in the AZRF are similar in goals, objectives, and developments. Differences are, in particular, in the geography of activities and application of digital developments, as we have already mentioned above.

Table 2 presents the effects of digitalization at fields in the Russian Arctic.

Table 1. Features of digitalization in Russian companies developing oil and gas fields in the AZRF

No.	Company name	Digitalization features
1	PAO "Gazprom"	Digital Transformation Strategy up to 2035 developed; digitalization covers all types of the company's activities; digitalization uses AI and DPSCs; digitalization covers all stages of the field life cycle; more than 150 digitalization projects are being implemented, including in the social sphere
2	PAO "Rosneft"	Digital Transformation Strategy up to 2030 developed; digitalization covers all types of the company's activities; digitalization is part of the corporate strategy, including projects such as "digital filling station", "digital supply chain", "digital plant", "digital field"; uses its own software, AI, and DPSCs; digitalization covers all stages of the field life cycle
3	PAO "Lukoil"	Company Informatization Development Strategy up to 2030 developed, including projects: robotization, "digital twins", "digital personnel", "digital field"
Source: own compilation.		

Table 2. Classification of digitalization effects by life cycle stages of oil and gas fields in the AZRF

Stage No.	Stage	Digitalization effects
1	Exploration	Increased amount of data, improved accuracy of seismic surveys; development of visualization and modeling technologies; increased probability of new discoveries; development of new approaches to standardization of exploration processes
2	Drilling	Remote drilling (hundreds of kilometers from the facility); remote control of the technological process; development of predictive analytics algorithms; development of new approaches to standardization of drilling processes: operating parameters, required equipment
3	Field operation	Introduction of telemetry at the field; automation of technological processes; remote control of technological processes and modeling ("digital twins", emergency situation modeling); monitoring of personnel actions and infrastructure at the field
Source: own compilation.		

Based on the analysis of open data, the use of digital technologies at oil and gas enterprises has been systematized, requirements for infrastructure and some effects of innovations have been summarized. The data are presented in *Table 3.*

"Gazprom" and "Rosneft" cooperate with PAO "Sberbank" ("SBER"). A digital service created by "SBER" and OOO "Arktik Katering Servis" is designed to support the daily life of shift workers in the Far North. The mobile application can be used to solve urgent problems in a "one-stop" mode, or as an electronic key for entering the enterprise and production facility. Biometric terminals have been installed at the fields to use all functions. More than 15 thousand workers can use them, with a potential coverage exceeding 750 thousand users.

Despite difficulties, PAO "MTS", PAO "Megafon", and PAO "Rostelecom" continue projects to build FOCL along the Arctic Ocean coast. The new communication lines will be used for hydrocarbon production and transportation, and will contribute to the development of port infrastructure[18].

The introduction of digital technologies in the development of remote fields in the Arctic is also taking place in foreign companies (*Tab. 4*).

Table 3. Examples of digital solutions and qualitative effects of their implementation at oil and gas enterprises in the AZRF

Digital solutions	Implementation effects	Required infrastructure
AI for geological exploration and well construction	Fast processing of big data with proposals for optimal field development schemes	1. DPSCs 2. Specialized software 3. Professional education services to maintain and develop the production base
Monitoring of remote production facilities	Improved industrial and environmental safety through the use of UAVs and machine vision technologies (control of oil and gas leaks, other emergency situations)	1. UAVs and technical means for remote monitoring and control 2. Specialized software
Additive technologies and their application in production automation	Reduction of logistics costs and uninterrupted operation through 3D printing	Equipment and consumables (powder, cartridges) for 3D printing
Source: own compilation.		

Table 4. Technologies and effects of digitalization in the development of oil and gas fields by foreign companies

Developer	Technology name	Impact on reserves/production	Impact on enterprise economics
Shell	Smart Field	Increase in gas recovery factor up to 5%	Reduction of capital costs by 20%
Chevron	I-field	Gas production increase up to 30%	-
Petoro	Smart Operations	–	Reduction of capital costs by 50%
Equinor	Integrated Operations	Production increase by 20%	–
Halliburton	Real Time Operations	–	Reduction of capital costs by 20%
Compiled based on: (Cherepovitsyn, Tretyakov, 2023; Ponomarenko et al., 2022).			

[18] Arctic internet cable projects are being scrapped one after another. Available at: https://servernews.ru/1119745 (accessed: 12.02.2026).

A comparative analysis of Tables 1, 3, and 4 shows that while the focus of digitalization of Russian companies in the Arctic is shifted toward creating digital ecosystems and developing application tools, foreign companies target specific operational KPIs, such as increase in reserves and production, as well as reduction in costs and payback period of investments.

One of the first states to start using digital technologies in the development of offshore fields in the Arctic was Norway (state-owned company Statoil-Equinor). However, it must be considered that climatic conditions in Norway and on its shelf in the Barents Sea and Norwegian Sea are the mildest in the Arctic. Innovative technical solutions were used in 2006 at the Kirkinesskoe gas condensate field (hereinafter – GCF), and then planned for the Shtokmanovskoe GCF.

With respect to quantitative effects from the introduction of digital solutions, the following data can be considered.

According to estimates by the Government of the Russian Federation, the share of imported equipment and technologies (including software) in various sectors of the Russian FEC in 2023 ranged from 25% to 90%[19]. The reduction in import dependence of the Russian oil and gas industry from 2014 to the active phase of anti-Russian sanctions in 2022 was 20% (from 60% to 40%). According to McKinsey, the use of cloud technologies can accelerate data processing by 30%. Oil and gas companies that use digital technologies show productivity growth of up to 8%. The introduction of currently available digital developments will increase the probability of discovering new fields in the Arctic by 48–50%, reduce costs in exploration drilling and production by 10–15%, up to 150 billion rubles, and reduce emergency shutdowns by up to 20%[20].

In 2020–2023, "Rosneft" received a patent for 63 inventions, and the total number of patents used approached 1 thousand. The use of its own ICT led to the discovery of seven fields and hundreds of hydrocarbon deposits. The introduction of digital technologies allowed reducing well downtime by 56% and oil losses by 63%. Production process efficiency increased by 10%. The economic effect from the implementation of the production efficiency improvement program in 2023 exceeded 3.5 billion rubles, and over 5 years amounted to 15 billion rubles[21].

Digitalization of the oil and gas industry makes an important contribution to ensuring the technological sovereignty of the Russian Federation. Let us consider the activities of the Institute of Oil and Gas Technological Initiatives (hereinafter – INTI) as an example[22]. It was established in 2020 to modernize outdated domestic (from the Soviet period) and inaccessible Western (2014–2022) standards for equipment and technologies used in the oil and gas industry, and their certification. INTI's founders include such Russian FEC companies as "Gazprom", "Gazpromneft", "SIBUR", "NOVATEK", "Lukoil", "Tatneft", "Transneft", "Rosneft" (joined in 2023)[23], as well as foreign companies "Uzbekneftegaz" (Uzbekistan),

[19] The share of imported equipment in different segments of the fuel and energy complex varies from 25% to 90%. Available at: https://oilcapital.ru/news/2023-09-20/dolya-importnogo-oborudovaniya-v-raznyh-segmentah-tek-variruetsya-ot-25-do-90-novak-3047190 (accessed: 12.11.2025).

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[21] How the oil and gas industry is digitizing. Available at: https://www.kommersant.ru/doc/7026080 (accessed: 10.01.2026).

[22] INTI – Institute of Oil and Gas Technological Initiatives. Available at: https://inti.expert (accessed: 30.12.2025).

[23] "Rosneft" became one of the founders of INTI. Available at: https://www.interfax.ru/russia/1065652 (accessed: 12.05.2026).

"KazMunayGas" (Kazakhstan), "Kyrgyzneftegaz" (Kyrgyzstan), "Belorusneft" (Belarus).

INTI is a platform designed to discuss challenges facing the oil and gas industry, promote local manufacturers of equipment and technologies in the oil and gas industry, test innovative products and pilot standards, exchange information on suppliers of equipment and technologies, organize interaction between them and raw material producers, and unify the requirements of energy and engineering companies for equipment and technologies through the development of industry regulations (standards).

A foreign analogue of INTI is API, established in the USA in 1919. API's tasks include developing cooperation with the government, stimulating trade in oil and natural gas in external and domestic markets, attracting investment, and increasing interest in the activities of the US oil and gas industry. API remains one of the most authoritative structures in the field of standardization and certification of oil and gas equipment.

The presence of foreign partners, including from OPEC+ countries: "ADNOC" (UAE), "Sonangol" (Angola), "Sonatrach" (Algeria), "KPC" (Kuwait), is not just an indication of interest in Russian developments; it means that a manufacturer that receives conformity assessment according to standards developed by INTI (more than 500 in 2025) has the opportunity to work not only in the Russian market but also in the countries of the Middle East and Africa. Analyzing the interest of foreign partners in INTI's activities, we believe that the number of firms wishing to replace American and European standardization models will increase. INTI contributes to the development of Russian import-substituting standards in the field of application of polymer reinforced pipes at oil and gas fields, technologies of surface hardening of metal products by ion chemical-thermal treatment, and other technologies[24].

INTI is developing a certification system – verification of compliance of standards with the requests of the manufacturer company. A network of testing centers has been created on the territory of Russia (including in the constituent entities of the AZRF) for proving equipment and technologies, and testing is not required to be carried out at each oil and gas company; it is now sufficient to confirm product quality at a single testing ground.

INTI is a modern digital standard in the oil and gas industry, which exists in several interconnected applications: INTI.DOC serves for storing standards, INTI.QUALITY is intended for expert evaluations and tests, INTI.INSIGHTS contains information about equipment, products, services, standards certified in INTI.

Among the effects of INTI's activities, the following can be distinguished:

– elimination of barriers to the application of foreign standards and certification systems by creating an alternative conformity assessment system;

– accelerated implementation of technologies and equipment into production activities;

– reduction of manufacturers' costs for passing technical qualification and competence assessment;

– optimization of the technological chain through uniform standards from customers;

– expansion of product sales geography;

– simplification of processes for implementing and scaling innovative developments.

– The effects for oil and gas companies can be as follows:

– reduction of sanctions risks to economic activity;

[24] Aleksei Fadeev on standardization measures in INTI. Available at: https://lng.expert/2025/11/mnenie-eksperta-aleksej-fadeev-o-merah-standartizatsii-v-inti (accessed: 12.05.2026).

– expansion of the pool of equipment and technology suppliers;

– supply security and technical independence;

– optimization of capital and operating costs during project implementation;

– reduction of time and financial costs for the application and testing of innovative and import-substituted products;

– reduction of time and financial costs for technical assessment of product quality, as well as assessment of manufacturers' competencies.

Conclusion

Despite the development of alternative energy sources, international energy agencies forecast an increase in demand for traditional energy sources by 2030. Meeting this demand entails the need to bring new reserves into operation, as well as to improve the efficiency of existing equipment. This determines the relevance of using modern digital technologies at all stages of oil and gas field development.

Among the enterprises of the fuel and energy complex operating in the Russian Arctic, practical success in digitalizing economic activities has been achieved by PAO "Gazprom", PAO "Rosneft", and PAO "Lukoil". At the same time, one of the difficulties of our study was the search for up-to-date information. The lack of data in official statistics and closed corporate reports did not allow us to fully quantify the interim results of digitalization at oil and gas enterprises in the AZRF.

Nevertheless, one of the outcomes of the study is the recognition that digitalization at oil and gas facilities is a comprehensive concept. It includes the processes of developing and implementing high-tech equipment, software, and ICT into the technological process, as well as improving enterprise management systems, including remote management. The goal of digitalization at fuel and energy enterprises in the Arctic is to increase the return on investment, profitability of enterprises, personnel safety, and preserve the quality of the fragile environment. Digitalization also increases the probability of discovering new fields.

One of the authors' contributions to the study of digitalization issues was the examination of its drivers and constraints in the AZRF. The research showed that they are paradoxically interrelated. On the one hand, a large number of documents and industry strategies on the transition to a digital economy have been adopted at the state and corporate levels in Russia. On the other hand, according to international experts, imperfections in legislation still hinder digitalization. On the one hand, the extreme natural conditions in the AZRF make the development of land transport impossible and create prerequisites for the provision of digital communication services. On the other hand, climatic features, remoteness of facilities, and deserted spaces increase the costs of developing and implementing digital solutions. On the one hand, sanctions have a negative impact on the implementation of Arctic mega-projects and shift timelines. On the other hand, successful examples of overcoming external constraints indicate import substitution processes in Russia. On the one hand, the digital economy faces the problem of personnel shortage. On the other hand, the Russian government's decisions in the areas of recruitment, targeted training of specialists, joint development with educational organizations of industry educational standards in the field of ICT with an emphasis on practical training, mentoring, and the development of a professional education system contribute to overcoming the personnel shortage and the emergence of breakthrough scientific and technological developments.

One of the obstacles to digitalization in the Arctic fuel and energy complex is the high cost of projects. Though the goals are recognized as important and the funds allocated from the budget are significant, they are insufficient. It seems appropriate to continue the practice of creating public-private partnerships, applying concession agreements and the status of "resident of the Arctic zone", which implies credit, tax, customs, and organizational privileges. It appears that interaction between the state, business, scientific and educational organizations contributes to the development and connectivity of territories, and allows accumulating knowledge and valuable experience of environmental management.

The activities of INTI are presented in the article as an absolute management innovation. This digitalization tool has proven itself well in terms of import substitution: oil and gas companies agree on uniform requirements for equipment, technologies, and software to replace foreign analogues. Also, the instrument helps to specify industry demand, identify anchor manufacturers, and test samples. This positive experience of recent years certainly needs to be replicated and gain international recognition.

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Author Contributions

Natalia S. Avdonina: investigation; data curation; visualization; writing – original draft.

Nikolay A. Kondratov: conceptualization; methodology; writing – review and editing.

Nikita M. Kuprikov: methodology; software; validation; writing – review and editing.

Mikhail Yu. Kuprikov: methodology; writing – original draft; writing – review and editing.

Fedor D. Larichkin: formal analysis; project administration; visualization.

Natalia V. Romasheva: investigation; data curation; validation; writing – original draft.

Alexey M. Fadeev: conceptualization; supervision; formal analysis; resources; writing – review and editing.

Information about the Authors

Natalia S. Avdonina – Candidate of Sciences (Political Science), Associate Professor, associate professor of department, Northern (Arctic) Federal University named after M.V. Lomonosov (17, Northern Dvina Embankment, Arkhangelsk, 163002, Russian Federation; e-mail: n.avdonina@narfu.ru)

Nikolay A. Kondratov – Candidate of Sciences (Geography), Associate Professor, associate professor of department, Northern (Arctic) Federal University named after M.V. Lomonosov (17, Northern Dvina Embankment, Arkhangelsk, 163002, Russian Federation; e-mail: n.kondratov@narfu.ru)

Nikita M. Kuprikov – Doctor of Sciences (Economics), Associate Professor, associate professor of department, Moscow Aviation Institute (National Research University) (4, Volokolamskoe Highway, Moscow, 125993, Russian Federation; e-mail: nkuprikov@mail.ru)

Mikhail Yu. Kuprikov – Doctor of Sciences (Engineering), Professor, head of department, Moscow Aviation Institute (National Research University) (4, Volokolamskoe Highway, Moscow, 125993, Russian Federation; e-mail: kuprikov@mail.ru)

Fedor D. Larichkin – Doctor of Sciences (Economics), Professor, chief expert, G.P. Luzin Institute of Economic Problems of the the Kola Science Centre of the Russian Academy of Sciences (24A, Fersman Street, Apatity, 184209, Russian Federation; e-mail: larichkinfedor@yandex.ru)

Natalia V. Romasheva – Candidate of Sciences (Economics), Associate Professor, associate professor of department, Empress Catherine II Saint Petersburg Mining University (2, 21st Line, Vasilyevsky Island, Saint Petersburg, 199106, Russian Federation; e-mail: natasmir84@mail.ru)

Alexey M. Fadeev – Doctor of Sciences (Economics), Associate Professor, Chief Researcher, G.P. Luzin Institute of Economic Problems of the Kola Science Centre of the Russian Academy of Sciences (24A, Fersman Street, Apatity, 184209, Russian Federation); professor of department, Peter the Great St. Petersburg Polytechnic University (29, Politekhnicheskaya Street, Saint Petersburg, 195251, Russian Federation; e-mail: alexfadeev79@gmail.com)

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