European Proceedings of
Multidisciplinary Sciences
EpMS

www.europeanproceedings.com
e-ISSN: 2421-826X

DOI: 10.15405/epms.2024.09.5

MTMSD 2022
I International Conference «Modern Trends in Governance and Sustainable Development of Socio-economic Systems: from Regional Development to Global Economic Growth»

THE USE OF DIGITAL TWINS IN THE OIL AND GAS INDUSTRY

Azieva Raisa Husainovna (a)*, Taymaskhanov Hasan Elimsultanovich
*Corresponding author

(a) Grozny State Oil Technical University named after named after M.D. Millionshchikov, Grozny, Russia, raisaazieva@list.ru
(b) Grozny State Oil Technical University named after named after M.D. Millionshchikov, Grozny, Russia

Abstract

Digital twins are a virtual model in which the virtual and physical worlds are interfaced. The virtual model allows oil and gas companies to perform system monitoring and data analysis in such a way as to increase the efficiency of operations, reduce maintenance costs, accelerate production processes, reduce operating costs, prevent equipment downtime, increase the life cycle of assets and ensure faster decision-making. It is shown that in Russia the technology of digital twins is at the evaluation stage: the concept is used by individual companies, and its use is fragmentally limited to some key projects. However, the positive economic effects achieved, as well as solving the problems of integrating new technology into existing information systems, may in the future create the necessary conditions for the widespread introduction of digital twins into the Russian oil and gas industry. Digital twin technology will allow Russian oil and gas companies to remain competitive in conditions of reduced demand and lower energy prices. The problems of introducing digital twins are largely related to unresolved problems of integration with existing information systems. According to the author, in order to spread the technology, it is necessary to provide opportunities for disclosure and exchange of information between players in the oil and gas sector, as well as the need for joint work to create a digital infrastructure of twins.

Keywords: Digital technologies, digital twin, digital field, oil and gas sector, virtual model

https://doi.org/10.15405/epms.2024.09.5
Corresponding Author: Azieva Raisa Husainovna
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2421-826X

1. Introduction

Currently, most companies rely on digital technologies, and the oil and gas industry is no exception here. The oil and gas industry is increasingly using digital twins to maintain the operability of assets, reduce downtime, and reduce capital and operating costs. So, as of the end of 2019, about 65% of companies in the United States invested in digital twin technologies in the oil and gas market (Transparency Market Research).

Digital twins are a virtual copy of a complex technical object, for example, an oil well. The formal definition of the concept of digital twins is as follows: virtual representation of physical assets using data and simulators for real-time forecasting, optimization, monitoring, control and improvement of the decision-making process (Perno et al., 2022).

Digital twins combine physical objects and their virtual representation, reliably reproduce all the processes taking place on the object, which allows you to control all processes in real time, as well as choose optimal loading levels, do experiments, make predictions, etc. (Bykova et al., 2020). Working with digital twins improves the quality of decisions made, as well as expands management capabilities, since it allows you to see the final results.

The use of digital twins is becoming particularly relevant at the present time, since the oil and gas industry is facing such problems as the complication of supply chains, increased transportation costs, an increase in the cost of production and a simultaneous reduction in the cost of energy carriers. The difficulties faced by the oil and gas industry, since 2020, force top managers of companies to make a choice about which specific digital technologies to direct the investments available to companies. Achieving the goal of rational use of assets and realizing the innovative potential of the industry through the introduction of digital technologies requires an in-depth analysis of the technology's capabilities, which determines the relevance of the chosen study of the use of digital twins in the oil and gas industry.

2. Literature Review

Content analysis shows that interest in the use of digital twins in Russian scientific publications and materials of scientific conferences is growing, but the concept is still blurred. However, as shown in Figure 1, there is currently a relatively low number of publications with keywords such as "digital twins" and "digital alter ego". The scientific electronic library Elibrary has 347 publications published in the period from 2017 to 2021. It can be concluded that the use of digital twins in the oil and gas industry requires appropriate scientific justification in the academic literature. It is worth noting that no articles with these keywords were published until 2017.

https://doi.org/10.15405/epms.2024.09.5
Corresponding Author: Azieva Raisa Husainovna
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2421-826X

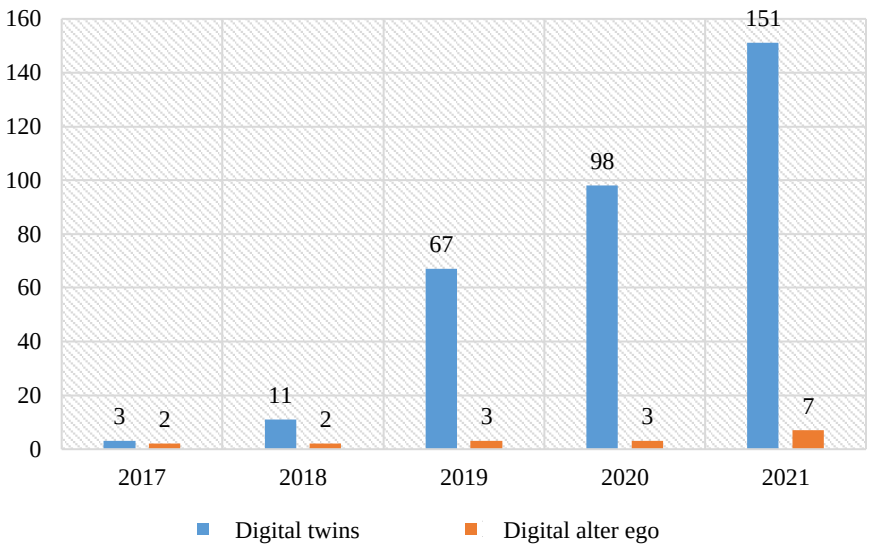

Figure 1. Publication activity of scientific articles with the keywords "digital twins", "digital alter ego"

As shown by the authors Perno, Hvam and Haug, the concept of digital twins was formed back in 2002, but still remains relatively little studied in academic sources. Digital twins began to attract the attention of researchers only in 2016, when the research and consulting firm Gartner included them among the top 10 strategic technological trends for 2017 (Perno et al., 2022).

Thus, Perno, Hvam and Haug come to the conclusion that the technology of digital twins has not yet gained wide popularity, since companies face serious problems when deciding on implementation due to the novelty of the concept itself. In addition, relatively few scientific studies have been conducted in the field of digital twins for the needs of the processing industry, which can be explained by the high complexity of accurate representation and modeling of the physics underlying production processes (Perno et al., 2022).

Researchers Thumeera, Wroblewski and co-authors consider the problems of introducing digital twins for the needs of the oil and gas industry. The authors show that the positive effects of technology implementation are achieved by increasing productivity, efficiency and safety of operations while minimizing capital and operating costs, health and environmental risks. However, despite these advantages, the oil and gas industry is still at an early stage, when implementation is limited to isolated and selective applications, rather than industry-wide implementation, which limits the benefits of implementing digital twins technology (Thumeera et al., 2020).

Sircar, Nair and co-authors point out the following problems of implementing digital twins technology, namely: accessibility, security, privacy, integration, maintenance, etc. These problems must be overcome, which will allow obtaining the digital infrastructure necessary for the introduction of technology in all sectors related to the hydrocarbon industry (Sircar et al., 2023).

Russian researchers Eremin and Eremin analyze the economic effects of the introduction of digital twins in the oil and gas industry. The authors have concluded that the technology significantly increases the efficiency of managing oil and gas infrastructure facilities, allows predicting efficiency, tracking individual parameters of the operation process, and planning. The concept of digital twins can

https://doi.org/10.15405/epms.2024.09.5
Corresponding Author: Azieva Raisa Husainovna
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2421-826X

significantly reduce the operating costs of the industry, equipment downtime, prevent the occurrence of emergencies, and improve the safety of operation of oil and gas facilities (Eremin & Eremin, 2018).

In addition, Bykova, Kim and others analyze the use of technology in the segments of oil production, processing and transportation. Researchers show that the use of technology can increase productivity by 10% and expect that in the next few years more than half of the oil and gas companies in the world will switch to digital twins. However, the limiting factor slowing down the implementation is the need to attract significant investment in the creation of an information system and a data collection system (Azieva & Taimaskhanov, 2020; Bykova et al., 2020).

However, Kochetov, Mashrapov, Alekseyenko examine examples of the use of digital twins technology in Russian oil and gas companies. According to researchers, the potential for the introduction of promising technologies in the industry is not fully realized, which is due to a lack of funding, sanctions imposed on the acquisition of advanced technologies, and the risk of cyber threats (Kochetov et al., 2021).

From the presented literature review, it can be concluded that asset integrity monitoring, project planning and life-cycle management are areas of application of the digital twin in the oil and gas industry. The analysis showed that factors such as cybersecurity, lack of standardization, high cost, complexity of modeling and uncertainty cause a low degree of technology implementation.

3. Materials and Methods

The research materials are scientific publications of Russian and foreign authors devoted to the possibilities of using digital twins in the oil and gas industry, as well as reports of the British Petroleum (BP) oil and gas company, which is one of the leaders in the field of digital twins implementation. The research methods are: system analysis, analogy method, content analysis, synthesis. The systematization of the information obtained allows us to increase scientific knowledge regarding the use of digital twins for the Russian oil and gas industry.

4. Results and Discussion

Digital twins provide oil and gas companies with tools to improve planning and operational standards, using big data to obtain new information about oil fields. In foreign practice, the capabilities of digital twins are used by the oil and gas company British Petroleum, which invested in this technology and developed a complex APEX modeling and observation system developed by APEX SYSTEMS. The APEX modeling system creates virtual twins of all production systems (Shabalina & Ajavenko, 2019).

According to the company's press releases, in 2017, the APEX system increased production by 30,000 barrels. With the help of APEX, time-consuming modeling, which previously took several hours, is performed in a few minutes, and the consequences of potentially dangerous operations can be assessed in a secure environment of the virtual world. The capabilities of digital twins allow you to safely test "what if?" scenarios. By comparing the model with the actual data, deviations can be detected hourly, and the impact of procedures can be simulated to show engineers how they can adjust flow, pressure and other parameters to safely optimize production. The system, which was first tested on some of BP's most

https://doi.org/10.15405/epms.2024.09.5
Corresponding Author: Azieva Raisa Husainovna
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2421-826X

complex assets in the North Sea, very quickly demonstrated tangible operational efficiency (Shabalina & Ajavenko, 2019).

Table 1 shows examples of the implementation of digital twins technology by foreign oil companies. It can be seen that large oil companies use promising technology to achieve higher performance indicators.

Table 1. Use of digital twins by foreign oil companies (RBC trends, 2021; Environmental Defense Fund)

Company	Using a digital twin
British Petroleum	The APEX process modeling and monitoring system, which creates a virtual copy of all production systems. The system allows you to speed up the data processing process, improve the safety of activities, ensure the stability of systems, and increase oil production indicators.
Equinor	The use of digital twins to create virtual versions of wells that are in difficult operating conditions in order to simulate the consequences of decisions made in a safe environment. The company also uses digital twins to simulate traversing real objects, real-time reproduction of real field activities and advanced safety training.
Shell	The use of digital twins in order to provide integration, visualization and analytics capabilities for its global asset portfolio. Digital twins increase efficiency, allowing you to perform remote operations, automate and significantly improve the economic performance of the company.
Eni	The use of digital twins to create virtual versions of their wells in difficult operating conditions and simulate the consequences of decisions made in a safe environment. The company also uses digital twins to simulate traversing real objects, real-time reproduction of real field activities and advanced safety training.

Thus, the use of digital twins can significantly improve the efficiency of the production process, increase the productivity of oil and gas sector workers, improve the efficiency of geodata management, as well as provide communications in a single digital workspace, which ultimately leads to significant reductions in operating costs, an increase in production volumes, an increase in the return of deposits, achieving the stability of production systems, acceleration of the production process. The potential of digital twins technology is really very high, since the technology can be used in different segments of the oil and gas industry: in production, transportation and processing (Bykova et al., 2020).

The relatively low degree of technology dissemination is due to the fact that the creation of digital twins requires a systematic approach, which includes simultaneous work in the four directions indicated in Figure 2. This approach provides for parallel work on the development of digital tools, systematization of databases, creation and development of an IT platform, as well as work with personnel, namely: staff training, adaptation, equipping with the necessary digital devices.

https://doi.org/10.15405/epms.2024.09.5
Corresponding Author: Azieva Raisa Husainovna
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2421-826X

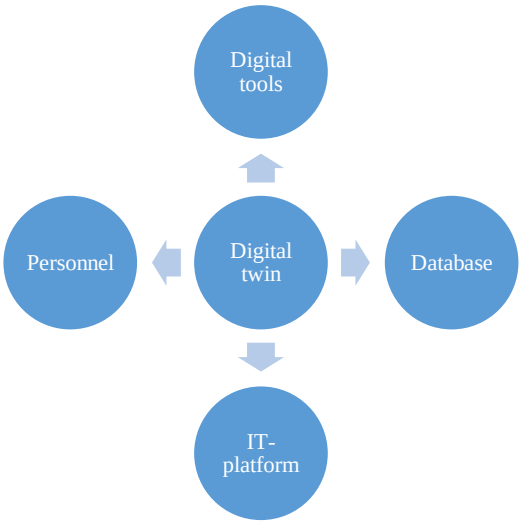

Figure 2. Implementation of a systematic approach for creating digital twins (Holmas & Rogov, 2021)

To achieve a successful result, these processes must be carried out in parallel, and the final tasks must be of equal importance, because otherwise it is possible to significantly slow down the development processes in the implementation of digital twins. For example, an attempt to thoroughly systematize the database can significantly delay the start of the project and push back the planning horizon of the business process. And insufficient attention to the personnel component can lead to the fact that the operation of a digital twin will be difficult due to the lack of necessary digital competencies among employees of an oil and gas company (Holmas & Rogov, 2021).

There are different levels of detail, visualization, functionality and depth of analytics of digital twins. The most optimal strategy is aimed at gradually deepening these parameters of the digital twin model, accompanied by active involvement of personnel in the development process. In other words, digital twins should be gradually improved during operation, which will allow for the best possible consideration of the features of the modeling object and bring the information system into the best compliance with the needs of the business unit.

It can be concluded that, in accordance with the theory of diffusion of innovations of E. Rogers, the concept of digital twins is at the evaluation stage (Figure 3). Currently, there are isolated examples of the use of technology on the Russian market. Innovative companies apply the technology on individual projects, but after universal information solutions are developed and convincing efficiency results are obtained, the technology will be adopted by most companies in the oil and gas industry.

Figure 3. Stages of the innovation diffusion process

Analysis of the stage of the process of diffusion of innovations will allow us to draw correct conclusions about the prevalence of technology and make a forecast of future development. To solve this problem, it is necessary to analyze the application of digital twins technology in Russian practice. Table 2

https://doi.org/10.15405/epms.2024.09.5
Corresponding Author: Azieva Raisa Husainovna
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2421-826X

shows some examples of the implementation of digital twinning projects in the Russian oil and gas sector. These tables indicate that the technology application projects are isolated and fragmentary. However, an analysis of the effects of implementation shows that digital twins can ensure the stability of systems, prevent failures, reduce costs and increase the efficiency of oil and gas companies.

Table 2. Digital twins in the Russian oil and gas sector (Kochetov et al., 2021)

Company	Project	Effect
Rosneft	Digital deposit in Bashkiria	Real-time tracking of mining, transportation, employee actions, transport movement. The growth of production capacity and production by 5%, increased energy efficiency, reduced logistics costs by 60%.
Gazpromneft-Khantos	Digital twin of the process of lifting fluid from wells	Selection of optimal operating modes of the production system, prevention of emergency situations, timely warning of personnel about equipment breakdowns and system failures.
Messoyakhaneftegaz	Digital twin of the Vostochno-Messoyakhskoye field	Improvement of facility management efficiency, forecasting of efficiency growth, control of operation parameters. Reduction of operating costs, reduction of equipment downtime

According to expert data, the use of digital twin models can increase the productivity of the facility by 3-4%, reduce downtime by 25%, reduce the cost of inspection and re-maintenance by 50%, and reduce the energy consumption of the facility by 20% (RBC trends, 2021).

Returning to the theory of diffusion of innovations, it should be noted that the most effective strategy for the development of innovation potential and the introduction of innovations for individual states and other economic entities is precisely the borrowing of technologies. However, for Russia, the problem of the presence of existing economic sanctions by Western countries is urgent, which hinders the process of spreading promising technologies. Thus, the development of digital twins in Russia is hampered by the lack of full access to foreign developments. However, combining the efforts of innovative companies to create their own projects will allow them to quickly pass all the stages of spreading innovation to introduce technology at most facilities in the industry.

The unstable external environment, as well as the high volatility of energy prices, creates a demand for innovative solutions that will contribute to increasing the sustainability of the oil and gas sector. According to the forecast of Transparency Market Research, in the long term until 2030, the digital twin market will double largely due to increased demand for technology from oil and gas companies (Transparency Market Research).

According to analysts of Transparency Market Research, one of the most significant problems of implementing digital twins is the complexity of integrating software with existing information systems. Also, another obstacle to the spread and widespread adoption of the technology is ignorance about the actual profitability indicators of the introduction of digital twins in the oil and gas industry (Transparency Market Research).

Thus, the problem of disclosing data on the amount of costs, the duration of the development process and the availability of data on the quantitative measurement of the beneficial effect are factors

https://doi.org/10.15405/epms.2024.09.5
Corresponding Author: Azieva Raisa Husainovna
Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2421-826X

hindering the development of promising technology. In our opinion, in order to solve these problems, it is necessary:

i. To provide opportunities for disclosure and exchange of information between players in the oil and gas sector.
ii. To provide opportunities for joint work on the creation of digital infrastructure of twins in the oil and gas sector.
iii. To promote the development of uniform standards that ensure the integration of digital twins with existing information solutions.
iv. To create conditions for the development of the information technology industry, since the creation of technically complex software products requires the participation of professional IT industry companies.
v. To create favorable conditions for placing long-term investments in digitalization projects of the oil and gas industry.

5. Conclusions

Digital technologies in the oil and gas industry is a concept that can change the way this industry works. If this concept is fully adopted and implemented, it will be able to change the basic principles of the industry in the near future. Digital twin technology can effectively combine big data analysis and accumulated knowledge in the oil and gas industry to solve problems in the design, operation management, optimization and other aspects, including the entire life cycle of an oil field from the initial design of the field to the process of delivering refined products to the final consumer. Digital twin technology increases the efficiency of oil and gas assets and allows for competitiveness in the face of declining oil prices.

The advantages of using digital twins technology are to reduce the workload on operators, the possibility of testing various designs, working out "what if?" scenarios without the risk of damage to equipment, as well as the ability to reuse the knowledge gained in future projects. Production processes in the oil and gas industry, built on the basis of the use of digital twins, are able to ensure high productivity and efficient production of oil wells.

The existing problems related to the disclosure of data on the introduction of technology, as well as the difficulties of borrowing solutions by Russian companies are serious obstacles to the introduction of technology. The development of digital twins and their implementation in the Russian oil and gas sector largely depends on the results of the projects implemented, as well as on solving the problems of standardization, integration and universalization. The successful solution of these problems will expand the use of technology, increase the efficiency and competitiveness of Russian oil and gas companies in the world market.

Acknowledgments

The research was carried out with the financial support of the RFBR within the framework of the scientific project "Digital transformation of the oil and gas industry using intelligent technologies: necessity and opportunities" No. 20-010-00583.

References

Azieva, R. H., & Taimaskhanov, H. E. (2020). Digital investment direction for oil and gas companies of the Russian Federation. *Bulletin of the Buryat State University. Economics and Management, 4*, 3-9. https://doi.org/10.2991/aebmr.k.201205.086

Bykova, V. N., Kim, E., Gadzhialiev, M. R., Musienko, V. O., Orujev, A. O., & Turovskaya, E. A. (2020). Application of the digital twin in the oil and gas industry. *Actual problems of oil and gas*, *28*(1), 1-11. https://doi.org/10.29222/ipng.2078-5712.2020-28.art8

Environmental Defense Fund. (2019). *Fueling the Digital Methane Future*. https://www.edf.org/sites/default/files/documents/Fueling%20a%20Digital%20Methane%20Future_FINAL.pdf

Eremin, N. A., & Eremin, A. N. (2018). Digital twin in oil and gas production. *Oil. Gas. Innovations, 12*, 14–17. https://www.researchgate.net/publication/330533772_Digital_twin_in_the_oil_and_gas_production

Holmas, H., & Rogov, V. (2021). The use of digital twins in the oil industry. *National industry journal Oil and Gas Vertical, 5*.

Kochetov, D. A., Mashrapov, A. B., & Alekseenko, N. V. (2021). Digital twins in the Russian oil and gas industry. *Regional scientific and practical conference "Youth and scientific and technological progress"* (pp. 28-31) . Far Eastern Federal University.

Perno, M., Hvam, L., & Haug, A. (2022). Implementation of digital twins in the process industry: A systematic literature review of enablers and barriers. *Computers in Industry*, *134*, 103558. https://doi.org/10.1016/j.compind.2021.103558

RBC trends. (2021). How digital twins help to extract oil and gas. https://trends.rbc.ru/trends/industry/613895d29a79477154fec314

Shabalina, L. V., & Ajavenko, I. N. (2019). Digitalization as a way to increase the competitiveness of oil and gas companies of the Russian Federation. *Trends in the development of the Internet and the digital economy: II All-Russian scientific and practical conference with the participation* (pp. 69-72). Individual entrepreneur Zueva T. V.

Sircar, A., Nair, A., Bist, N., & Yadav, K. (2023). Digital twin in hydrocarbon industry. *Petroleum Research, 8*(2), 270-278. https://doi.org/10.1016/j.ptlrs.2022.04.001

Thumeera, W., Wroblewski, L., Petersen, B., Gosine, R., Lesley, J., De Silva, O., Mann, G., & Warrian, P. (2020). Digital Twin for the Oil and Gas Industry: Overview, Research Trends, Opportunities, and Challenges. *IEE Access, 8*, 175–198. https://doi.org/10.1109/ACCESS.2020.2998723

Transparency Market Research. (2020). Digital Twin in Oil & Gas Market – Global Industry Analysis, Size, Share, Growth, Trends, and Forecast, 2020–2030. https://www.transparencymarketresearch.com/digital-twin-in-oil-gas-market.html