Modern Technological Priorities of the Gas Industry
Innovative Development

S B Baurina¹, V Y Garnova², L A Tchaikovskaya³
¹Academic Department of Industrial Economics, Plekhanov Russian University of Economics, Stremyanny, 36, Moscow 117997, Russia
²Academic Department of Management Theory and Business Technology, Plekhanov Russian University of Economics, Stremyanny, 36, Moscow 117997, Russia
³Academic Department of Accounting and Taxation, Plekhanov Russian University of Economics, Stremyanny, 36, Moscow 117997, Russia

E-mail: baurinaaa@yandex.ru

Abstract. This article is devoted to modern technological priorities of the innovative development of the gas industry. It presents the pattern of capital investments in the global oil and gas industry. Technological priorities for the innovative development of the gas industry are identified. Basic trends in R&D are identified in the context of technological priorities of the gas industry. Target performance indicators and the period of effect are specified. The latest technological innovations in the gas exploration and production sector are reviewed. High-demand technologies and innovative developments of the Russian gas complex are presented in the following areas: geology, prospecting and exploration, field production, transportation and underground gas storage; hydrocarbon processing, ecology. Inactivity of the Russian gas industry in the field of innovation is noted

1. Introduction
In today's world, innovative development, the ability to innovate is one of the main factors for long-term business success in any high-tech company or industry. The development of the gas industry as a reliable supplier of energy resources is associated with the ongoing solution of strategic, technological, economic and other tasks that require searching, obtaining and applying new knowledge, continuously increasing the activity and efficiency of innovations [1].

Over the past few decades, the global gas industry in developed countries has become one of the most technologically advanced industries. The introduction of high technologies has transformed the industry and made it one of the technological leaders of the world economy.

2. Priority innovative technologies of the gas industry
Being one of the cleanest and most common types of fossil fuels in the world, natural gas is increasingly used for energy production. This results in an ever-increasing demand for this type of energy source (Figure 1). At the same time a number of experts expect that the consumption of natural gas will continue to increase. In particular, the International Energy Agency (IEA) predicts the onset of the “golden era” of natural gas in the coming years. It will increasingly replace other energy sources
and its share in the global energy sector will grow by 2035 to 25% or more [2]. New external conditions, the rapid progress of technology in all fields, the economic situation in the country necessitate the need to ensure the effectiveness of innovation in the gas industry [4-6].

![Figure 1. Capital investment in the global oil and gas industry, USD Million. The source: compiled by the authors based on the data [3].](image)

To identify the most relevant areas of innovation development for the gas industry, an assessment was made of the potential economic effect from the introduction of innovative technologies within each business line. Thus, the sensitivity of various indicators of activities to the technological progress is determined.

The calculations were made taking into account the influence of geological conditions on the projected specific capital and operating costs in course of implementation of technologies. Based on the calculations, key areas for technology improvement and technological priorities are identified, investing in which will yield a positive economic effect for the gas industry (Figure 2).

![Figure 2. The list of technological priorities of the gas industry and their effectiveness, billion rubles.](image)

NPV – Net Present Value; TP1 - the technologies for increasing the efficiency of gas transportation via main pipelines, and diversification of the methods of gas delivery to consumers; TP2 - new field development technologies; NG3 - the technologies for hydrocarbon resources development on the continental shelf; TP4 - the technologies for increasing the efficiency of gas and gas condensate processing; TP5 - the technologies for increasing gas storage efficiency; TP6 - the technologies for the sale and use of gas; TP7 - the Technologies permitting to improve the efficiency of new field development; TP8 - the technologies for prospecting and exploration of hydrocarbon deposits, including the development of unconventional resources; TP9 - the technologies of liquefied natural gas production.
Of the presented R&D areas (Table 1), a special place belongs to the research aimed at developing technologies and technical solutions that will allow for cost-effective development of remote regions, the production of new readily marketable product, and liquefied natural gas using domestic technologies. The vast majority of the developed innovative technologies and activities will be used in several lines of business, both at the existing and future production facilities, which will provide a synergistic effect. For example, technological innovations in the exploration and production sector permitted to open up new opportunities for the industry in order to increase the volume of natural gas production and meet the growing demand for it [8-10]. It is important that these technologies at the same time allowed to make the exploration and production of natural gas more efficient, safe and environmentally friendly.

**Table 1.** Basic trends in R & D in the context of technological priorities of the gas industry.

| R & D directions in terms of technological priorities | Performance indicators                                                                 | Target value | The year the effect begins |
|-----------------------------------------------------|---------------------------------------------------------------------------------------|--------------|---------------------------|
| 1. The technologies for prospecting and exploration of hydrocarbon deposits, including the development of unconventional resources; | Reduction of predicted unit costs in prospecting and exploration for deposits in the Russian Federation | 10 %         | 2023                      |
| 2. The technologies to improve the efficiency of the existing fields development | reduction of unit capital costs for production growth in the Nadym-Pur-Taz region; reduction of predicted unit operating costs during production; reduction of predicted unit capital costs for gas production in the shelf zone of the Russian Federation | 5 %          | 2019                      |
| 3. The technologies for hydrocarbon resources development on the continental shelf | reduction of predicted unit operating costs for gas production in the shelf zone of the Russian Federation | 5 %          | 2017                      |
| 4. New field development technologies | reduction of predicted unit operating costs during gas production; reduction of predicted unit operating costs during gas production | 2 %          | 2016                      |
| 5. The technologies for increasing the efficiency of gas transportation via main pipelines, and diversification of the methods of gas delivery to consumers; | reduction of capital investment in the construction of the line section; reduction of capital investment in the construction of PPS | 2 %          | 2019                      |
| 6. Gas storage efficiency technologies; | reduction of operating costs; reduction of reconstruction costs; reduction of capital investment in underground gas storage; reduction of operating costs for underground gas storage; reduction of capital investment in hydrocarbon processing; reduction of operating costs in the | 1 %          | 2012                      |
| 7. The technologies for increasing the efficiency of gas and gas condensate processing; |                                                                      | 10 %         | 2018                      |
processing of hydrocarbons  
production and sales of new products  1 %  2020

reduction of the estimated specific capital and operating costs of large-scale LNG production  1 %  2017

increase in gas sales in Russia  1 %  2020
increase in gas sales in foreign markets  1 %  2020

The source: compiled by the authors based on the data [7].

3-D and 4-D seismic exploration - the development of seismic exploration which permits to obtain and analyze the data on the density of rocks in three dimensions, has greatly changed the method of natural gas production.

3-D seismic allows to combine traditional seismic imaging methods with the capabilities of powerful computers, as a result of which three-dimensional models of underground layers are created [11].

4-D seismic complements them and permits to observe performance variation over time. Thanks to 3-D and 4-D seismic it became easier to identify promising fields, improve the efficiency of their development, reduce the number of dry wells, reduce drilling costs, and reduce the time of exploration. All of this yields economic and environmental benefits.

Fracking technology (CO₂ – Sand – Fracking) involves using a mixture of sand proppants and liquid CO₂ which leads to the formation and expansion of cracks through which oil and natural gas can flow more freely. CO₂ then evaporates, leaving only sand in the body with no other residues from the fracking process that must be removed [12; 13]. This technology allows to increase the extraction of natural gas and at the same time does not damage the environment, because it create no waste underground, and also protects groundwater resources.

Coiled tubing - one of the most dynamically developing areas in the production of gas and oil field equipment in the world. Coiled tubing method of well operation is based on the use of coiled flexible pipes for drilling and operation of wells. Coiled tubing technology significantly reduces the cost of drilling, as well as the likelihood of emergencies and oil spills, cuts the amount of waste, and also the time to complete the work by 3-4 times compared with traditional methods. Coiled tubing can be used in conjunction with complex drilling operations to increase drilling efficiency, achieve higher hydrocarbon recovery rates and a lower environmental impact [14].

Measurement while drilling (MWD): – the systems designed to measure drilling parameters and transfer information to the surface. The information received and processed with the help of modern MWD technology allows workers in the field to monitor the drilling process, which reduces the likelihood of errors and accidents [15]. In addition, the use of MWD systems can also be useful for geologists, providing information on the properties of the rock being drilled.

Slimhole drilling can significantly improve the efficiency of drilling operations, as well as reduce the environmental impact. It is a cost-efficient method for drilling exploratory wells in new areas, deep wells in existing fields, as well as for extracting natural gas from undepleted fields.

Deep-water drilling enables safe and efficient development of deposits in waters at a depth of more than 3 km. Currently the main directions of further development of these technologies are the improvement of offshore drilling rigs, the development of dynamic positioning devices, the creation of sophisticated navigation systems.

The gas industry needs to keep up with growing demand and produce more natural gas, including through qualitative growth, that is, through the introduction of technological innovations. The development of unconventional sources of natural gas has considerable potential for further growth of the gas industry. Thus in the past few years, shale gas production in the United States has been developing at a rapid pace. On the other hand, the technologies for extraction of methane from coal...
seams are currently important for Russia. In particular, people in the Russian "Gazprom" consider this direction as one of the main focus areas in the strategy for expanding the resource base of the gas concern.[16; 17]. The implementation of projects for extraction of natural gas on the sea shelf, including in the Arctic, is essential to expanding the resource base for domestic and foreign oil and gas companies.

Today, the investments of the Russian Gas Complex in new technologies and innovative developments can be divided into the following areas: geology, prospecting and exploration; field production; transportation and underground gas storage; hydrocarbon processing; ecology

A special attention in the field of geology, prospecting and exploration is paid to the creation of technologies that ensure a qualitative increase in the progress of geologic exploration and the effective construction of exploration wells as well as the development of new and improvement of the existing methods for assessing resources and hydrocarbon reserves.

The development of deposits is accompanied by the following innovative solutions:
- the development of technologies and equipment for efficient production of natural gas, liquid hydrocarbons and high-molecular raw materials;
- the development of new cost-effective technologies for the production and use of "low-pressure" gas;
- creation of new patterns and methods of field development using directional, horizontal and multilateral “intelligent” wells with big vertical deviations;
- elaboration of the methods, equipment and technologies for development of hard-to-recover and unconventional gas resources in low-pressure reservoirs, gas hydrate deposits and methane of coal basins.

In the field of hydrocarbon processing, the development of energy-saving technologies for deep processing of hydrocarbon raw materials, technical solutions for creating new and improving existing gas processing and gas chemical plants. In addition, there is a demand for development of equipment and technologies aimed at improving the efficiency of processing sulfur gases, obtaining readily marketable products based on gas sulfur. Also new technologies are needed for the production of synthetic liquid fuels from natural gas and new efficient reagents (selective absorbents, multifunctional adsorbents, catalysts) for use in the processing of hydrocarbons into marketable products.

Innovations are also important for environmental impact mitigation [18]. The investments of the gas complex in innovative developments in this respect can be divided into the following areas:
- the development and implementation of methods and technologies for construction of commercial facilities that ensure the preservation of natural landscapes;
- the development of methods for reducing the man-made impact of the industry enterprises;
- creation of a geodynamic monitoring system for field development;
- the development and implementation of technologies and equipment to reduce greenhouse gas emissions.

3. Conclusions
The identified technological innovations represent only a part of complex technologies that are gradually introduced in exploration and production of natural gas. These technologies allow the gas industry to achieve higher economic results and develop the fields previously considered unprofitable.

However, despite the apparent successes, the level of innovation in the Russian gas industry, is not high enough versus the best practice. In almost all key areas, foreigners are technologically superior to domestic companies. In particular, they are much better able to work on the shelf, they widely apply ultramodern methods of enhanced oil recovery, advanced drilling technologies.

Russian companies are rather reluctant to invest in their own technological developments that do not guarantee commercial benefits and require many years of investment in pilot production. In turn,
research institutes operating with oil and gas companies or performing under their orders are often simply not ready to solve long-term tasks that require large investments and involve high risk.

In view of this, the domestic Gas Complex for the most part invests in the purchase of high-tech equipment. As a result, today the gas industry has become very dependent on the transfer of innovations from abroad. This, in particular, occurs through the involvement of Western contractors in joint projects for drilling in Russia. In addition, domestic companies are actively borrowing the engineering bank owned by the leaders of the gas business and adapting their progressive technologies to their own subsoil objects.

4. References
[1] Lebedev R V, Shenkarenko S V 2018 The development of innovation in the gas industry Fundamental and applied developments in the field of technical, physics and mathematical sciences: collection of scientific articles summarizing the results of the fourth international round table Kazan: "Konvert" LLC 13-18
[2] World Energy Outlook 2018 https://www.iea.org/weo2018/
[3] Trends in the development of the oil and gas industry in 2018-2019 The strategy formed in the conditions of market volatility https://www.strategyand.pwc.com/media/file/Oil-Gas-Trends-2018-19_RU.pdf
[4] Baurina S B 2014 Innovative potential of the enterprise Innovations: prospects, problems, achievements: the materials of II international scientific and practical conference M.: Publishing house of REU named after G V Plekhanov 267-272
[5] Garnov A P, Garnova V Yu 2016 Innovative potential of Russia: the problems and prospects of implementation RISK:Resources, information, supply, competition 1 92-97
[6] Doronin E S 2014 Management of innovation activity of international companies in the oil and gas sector Modern scientific research and innovation 6 Part 2 http://web.snauka.ru/issues/2014/06/36061
[7] The Innovation Development Program of PJSC Gazprom until 2025 http://www.gazprom.ru/f/posts/76/904731/prir-passport-2016-11.pdf
[8] Analytic Innovations Address New Challenges in the Oil and Gas Industry https://www.sas.com/content/dam/SAS/en_us/doc/whitepaper1/analytic-innovations-address-new-challenges-oil-gas-industry-105974.pdf
[9] Volkov V A, Razmanova S R 2016 Technological modernization of the oil and gas industry: the current state and prospects of development St. Petersburg State Politechnical University Journal of Economics 5(251) https://cyberleninka.ru/article/n/technological-modernization-of-the-oil-and-gas-industry-the-current-state-and-prospects-of-development
[10] Malinovsky D A 2018 Economic efficiency of innovative activity at oil and gas enterprises Economics, management, finance: the materials of VIII International scientific conference(Krasnodar, February 2018) 144-146 https://moluch.ru/conf/econ/archive/264/13710/
[11] Shraer A V 2011 The economic and innovative factors in the development of the fuel and energy complex of Russia European Social Science Journal 4
[12] Tchaikovskaya L A 2017 The role of accounting in the involvement of public funds in R & D Accounting. Analysis.Audit 5 40-47
[13] Eder L N, Filimonova I V 2014 The main problems of the innovative development of the oil and gas industry in the field of oil and gas Drilling and oil 4 165 – 184
[14] Burger A Digital Innovation in Oil and Gas Industry https://www.eniday.com/en/technology_en/digital-innovation-oil-gas-industry/
[15] Pinchbeck D Research and technological innovation in the gas sector: the views of the european gas research group http://gerg.eu/public/uploads/files
[16] Website of PJSC Gazprom http://www.gazprom.ru/press-cente/archive/2015june/1108291/
[17] The Accounting policy of PJSC GazpromNeft for 2018 http://ir.gazprom-neft.com/fileadmin/user_upload/documents/adhoc_releases/new/new_04.03.16/qrep/1q2018/pril 4.pdf
[18] Nakhle C Technological Innovation Creates New Opportunities in Oil & Gas https://www.aspentech.com/en/blog/blog/Technological_Innovation_Creates_New_Opportunities_in_Oil_and_Gas

Acknowledgments
The publication was prepared in the framework of the "Development of accounting and analytical support of innovative processes in the gas industry" research funded by the FSBEI of Higher Education, REU named after G. V. Plekhanov in 201.