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Assessment of The Impact of Services and Digitalization Level on The Infrastructure Development in Oil and Gas Regions

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Abstract. The relevance and feasibility of studying the problem lie in increasing the investment attractiveness of oil and gas enterprises by activating regional services in mineral resource specialization based on the extensive infrastructure being created. The purpose of this study is to establish a typology for infrastructure services catering to oil and gas enterprises by enhancing the service component and implementing digitalization programs in the regions specializing in mineral resources in Russia. The work substantiates the conceptual foundations of an integrated approach to the formation of infrastructure for economic systems of mineral resource specialization and related services in the form of a synthesis of concepts of reproductive, structural-functional, and systemic approaches. An analysis of the current state of the methodologyfor implementing a typology of infrastructure services for oil and gas enterprises in the Russian Federation and abroad was carried out. The formation of innovative infrastructure facilities was substantiated through economic modelling of the influence of oilfield services and the level of development of the territory's digitalization on the development of infrastructure facilities in oil and gas regions.

Keywords: Infrastructure; Oil and gas complex enterprise; Region of mineral resources specialization; Service; Typology

1. Introduction

The innovative scenario for sustainable long-term socio-economic development is characterized by strengthening the investment focus of economic growth and the country's position in the world economy. Sustainable development is directed towards establishing a modern, innovative infrastructure foundation for both the national economy and regional economies. It seeks to foster the self-development of territorial economic systems by cultivating a competitive sector of high-tech industries.

In the process of markets formation of markets, a transformation of infrastructure schemes took place towards the complication of the infrastructure component of the economy due to a certain transformation of relations in the "producer-consumer" system, leading to the need for differentiation and customization of products, which was

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emphasized in the work of (Vasilenko *et al.,* 2020).

Following the direction of global trends, the process of infrastructure formation in Russia developed progressively, reflecting the nature of the development of productive forces and relations at each stage of economic development, which was clearly presented in the works of (Babkin *et al.,* 2021). In modern conditions, resulting from the emergence of an innovative economy, a systematic idea of infrastructure is being formed, which was substantiated in the works of (Varnavskii, 2021), (Konoplyanik, 2017), (Tatarkin, 2016), (Van-Van, 2011), and others. The presented idea is conditioned by the reproductive nature of the infrastructure, thepresentation of its structural composition, and the broad interpenetrating nature of functions.

The specialization deepening contributed to the use of concepts of the system methodology in the sectoral aspect, primarily in the process of forming the infrastructure of territorial systems of mineral resources specialization, which was emphasized in the works of foreign scientists (Mahmood *et al.*, 2023), (Diez, Marangé, and Levrat, 2017) and Russian researchers (Litvinenko *et al.*, 2023), (Matrokhina, Makhovikov, and Khaikin, 2023), (Litvinenko and Sergeev, 2019), and others. In this regard, increasing the investment attractiveness of oil and gas enterprises by activating services based on the infrastructure being created contributes to the sustainable development of territories.

2. Methods

Progressive economic development, reflecting at each stage the characteristics of productive forces and relationships, predetermined the transformation of infrastructure schemes and service components towards their complexity, which was reflected in the evolution of approaches, starting with reproductive and taking shape in a systemic approach.

Based on the studies of the classics of economic thought, who first outlined the role of infrastructure in the social division of labor, as well as the works of K. Marx, who emphasized the need for the development of infrastructure as “general conditions of production”, a reproduction approach was formed.

The expansion of the infrastructure component contributed to the emergence of a structural approach, the main principles of which were laid down in the works of scientists of the neoclassical direction, who were at the origins of the concept revealed infrastructure as a large-scale sector of the economy with a complex structure with moving boundaries. Further changes are associated with the introduction of institutional tools into the modeling of economic processes within system boundaries, which was clearly presented in the works of scientists of the institutional.

The expansion of positions and the structural complexity of services helped attract the attention of scientists to the analysis of ongoing processes within the framework of a systemic orientation in the second half of the twentieth century. In this regard, the following works are important: (Tatarkin, 2016), who raises issues of optimal location of production within the boundaries of territorial systems (Burström *et al.*, 2021; Babkin *et al.*, 2021; Byankin *et al.*, 2021; Berawi, 2020), emphasizing the importance of management in the formation of complex economic systems; (Kleiner, 2023), substantiating restrictions affecting the regional development within the boundaries of territorial systems.

The importance of developing the industrial infrastructure of the oil and gas sector can be found in the works of foreign scientists (Mahmood *et al.*, 2023), emphasizing the connection betweenthe formation of infrastructure facilities and sustainable development of regions; (Lindholt and Glomsrod, 2022), focusing on features of the territorial

development of the oil and gas sector. The focus on a sustainable factor in the development of oil and gas production is also confirmed in the works of domestic scientists (Cherepovitsyn and Rutenko, 2022; Il'inskii and Tan-Syuivei, 2017), analyzing the fundamental concepts and methods of strategic planning, as well as (Zemtsov *et al.*, 2020), emphasizes the sustainability of the development of the territory and the national economy as a whole, (Ponomarenko, Galevski, and Marin, 2022; Kryukov and Tokarev, 2022; Tereshko and Rudskaya, 2021), indicating the complexity of the development of production in the regions.

Activation of the service component within the boundaries of the development of economic structures, contributing to the complexity of the development of the territory, is presented in works of (Matrokhina, Makhovikov, and Khaikin, 2023; Vasilenko *et al.*, 2020; Krainova, 2018). The authors note that as the digital economy develops, there is a gradual change in relations in the assessment of the impact of services and digitalization level on the infrastructure development in oil and gas regions "producer-consumer" system, which affects the development of economic systems. The use of economic and mathematical approaches in forecasting the formation of infrastructure facilities within the boundaries of territorial development is noted in the works of (Matrokhina, Makhovikov, and Khaikin, 2023; Zipir and Chernova, 2020; Nedosekin and Reishakhrit, 2019; Kozlov, Teslya, and Chernogorskii, 2018). For the purpose of innovative formation of infrastructure and related services, digital transformation is necessary, leading to the creation of objects that correspond to the new way of life, as noted by (Ilyushin, 2022; Zaytsev *et al.*, 2021; Zagloel *et al.*, 2021; Kuklina, 2021; Razmanova and Andrukhova, 2020; Abukova, Dmitrievskii, and Eremin, 2017). Thus, in conditions of an innovative economy formation, the presentation of infrastructure from a systemic perspective allows us to talk about the formation of integrated economic structures. The presented idea is due to the features of infrastructure and related services within the boundaries of economic structures, the composition of the infrastructure, and industry characteristics.

3. Results

The theoretical results of the study on the formation of the infrastructure of economic systems indicate the evolutionary nature of its expansion. This nature is associated with the reproductive approach to the development of infrastructure and emerging services within economic systems. At the same time, depending on the characteristics of the reproduction process, several directions of schemes for the formation of infrastructure facilities and serviceobjects created on this basis have been identified. One direction is associated with the activation of infrastructure-service relations at stages of the reproduction process as capital is transformed in the circulation (Figure 1). A more complex form (Figure 2) is associated with the self-increasing nature of the movement of various forms of infrastructure and the service formed on this basis, and assumes a cyclical representation of various forms of infrastructure.

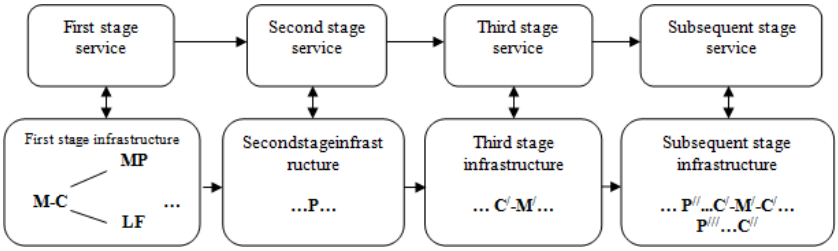

Figure 1 The formation of the infrastructure and service connections from the standpoint ofthe reproduction approach (first approach)

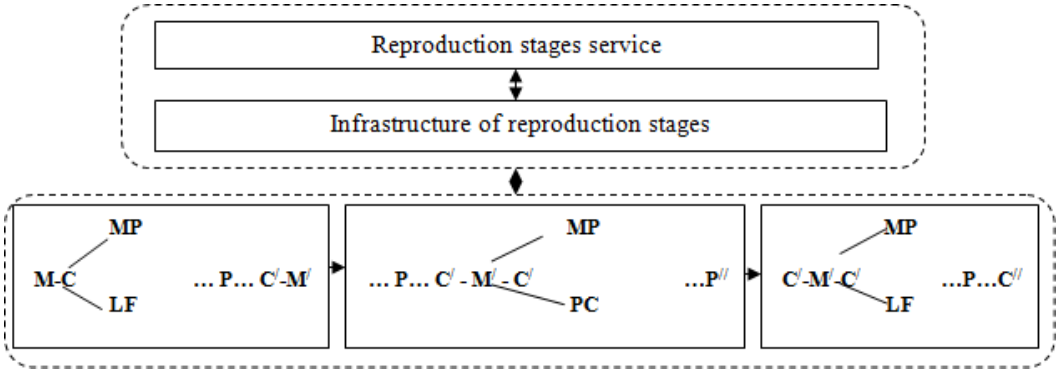

Figure 2 The formation of the infrastructure and service connections from the standpoint ofthe reproduction approach (the first extended approach). (In figures: M, C, P - money, commodity, production capital, MP - means of production, LF - labor force

The second direction of the formation of infrastructure and service facilities is associated with phases of the reproduction process as social value is created. At the same time, an infrastructure of the phases of the reproduction process will be formed at each level, supplemented by service enterprises (Figure 3).

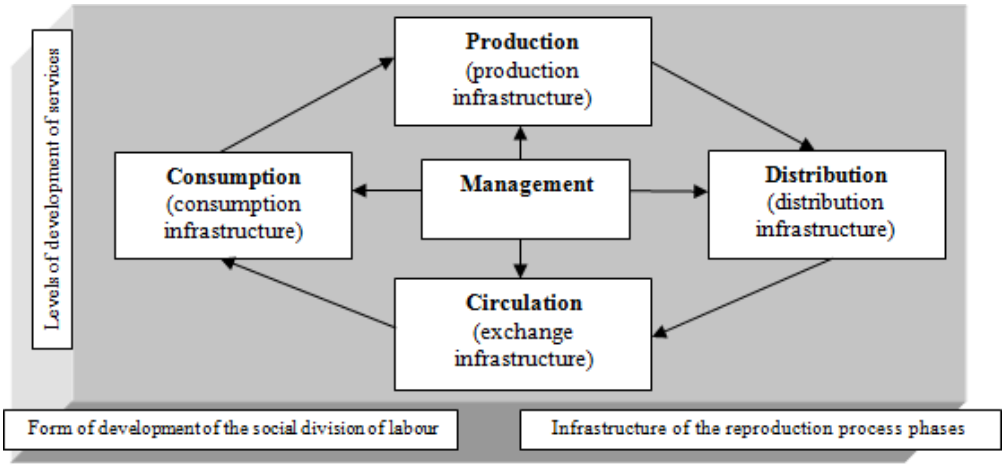

Figure 3 Formation of infrastructure from the perspective of a service cube (second approach)

In modern conditions associated with the innovative orientation of economic growth, a systematic direction in infrastructure development is being formalized. Analyzing infrastructure from the standpoint of the presented approach requires consideration of the features of the evolutionary development of the system, the specifics of the formation of industrial agglomerations within the boundaries of systems, the level of innovative activity of enterprises, the availability of service programs, and the use of digital technologies. To evaluate the impact of the aforementioned factors on the formation of an innovation-active infrastructure within the development boundaries of economic systems specializing in mineral resources, refer to the provided diagram (Figure 4).

Each group of factors presented above is evaluated using integral characteristics. The monitoring indicators are based on a method for determining the integral indicator in each group based on the integration of partial analysis indicators. Thus, rating characteristics are formed for various options for investment processes in the region.

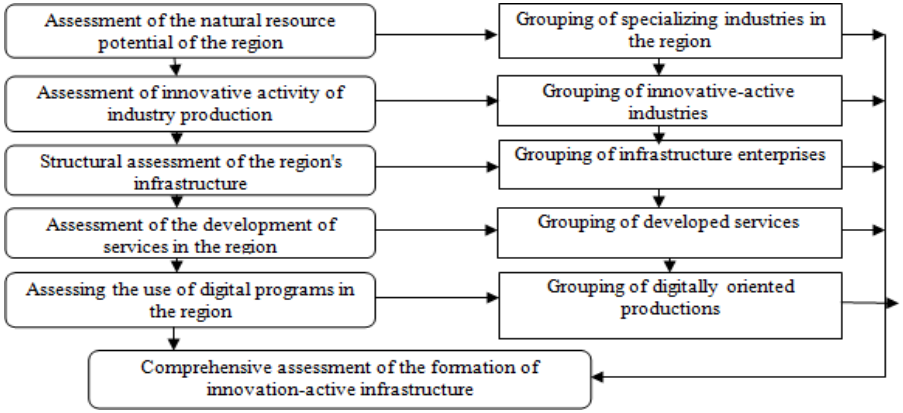

Figure 4 Comprehensive assessment of the formation of the innovation-active infrastructure.

To do this, this research presents an assessment of the influence of the factors listed above on the formation of infrastructure within the boundaries of economic systems of oil and gas specialization in Russia (Table 1).

Table 1 Analysis of the natural resource potential of the territorial-economic system of Russia*)

Federal District	Coal	Gas	Oil	ron ores	Manganese ores	Chromium ores	Titanium	Copper	Lead	Zinc	Bauxite	Gold	Silver	Phosphori teores	Drinking and industrial groundwat ĩ	Water resources (annual flow)	Hydropow er resources	Timber reserves Land resources (agricultural land)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Central	1.7	-	-	58.9	-	-	2.6	0.1	-	-	14.0	-	-	27.1	31.7	2.6	0.7	4.8	14.9
North-western	3.5	1.3	7.1	4.3	1.1	70.1	56.0	1.8	3.0	3.2	51.6	0.7	0.9	6.6	5.0	13.5	3.7	12.5	3.2
Southern	3.5	7.0	2.0	1.5	-	-	-	3.0	2.0	2.0	-	2.0	2.0	3.7	10.3	6.1	4.5	0.6	15.3
North Caucasian	0.00 5	0.2	0.5	-	-	-	0.2	2.4	2.1	1.9	-	0.1	0.8	-	5.8	0.5	0.8	0.3	5.4
Privolzhsky	0.6	2.0	20.4	0.4	0.7	17.0	0.06	12.8	1.7	17.5	-	10.0	17.7	46.5	18.7	6.2	5.4	6.9	24.8
Ural	0.5	75.6	57.4	15.8	30.3	12.9	7.7	7.8	1.8	4.4	34.4	8.0	6.0	5.2	6.2	12.1	3.8	9.6	7.2
Siberian	77.5	6.7	8.8	10.0	61.0	-	3.8	40.7	37.1	15.6	-	36.8	20.1	7	15.8	23.8	46.4	40.5	20.7
Far Eastern	12.7	7.2	3.8	9.1	6.9	-	29.7	31.4	52.3	55.4	-	42.4	52.5	3.9	6.5	35.2	34.7	24.8	8.5

*) as a percentage of the total for the Russian Federation. The calculation was carried out based on the materials of the State report "On the State and use of mineral resources of the Russian Federation in 2020

The analysis of data in Table 1 indicates that the sustainability of economic systems specializing in oil and gas in Russia, particularly in the territories of Siberia, the Far East, and part of the European zone (the Northern region), is primarily influenced by substantial natural resource potential. Consequently, in regions characterized by a high concentration of extractive industries and an insufficient level of infrastructure development (Tables 2-3), enterprises tend to merge through horizontal integration, with a predominant focus on the fuel and energy sector.

The sustainable development of regions of oil and gas specialization, including the Volga, Ural, and Siberian districts, is largely determinedby the high level of production diversification and increased innovative activity of industry production (Table 2). The results of the analysis indicate that the active use of digital technologies occurs in the economic systems of the Volga and Ural Federal Districts, which have significant oil and gas potential and are characterized by a high level of infrastructure development (20.4 and 23.4, respectively), increased innovative activity of organizations (15.5 and 10.2) and a high level of civilization (at level 30).

In addition, the analysis shows that the activities of domestic oil service companies are carried out in a narrow range of services provided (mainly of a drilling nature) in a limited area, in the regions of Siberia and the Far East. Meanwhile, infrastructure facilities of an innovative nature are concentrated in the regions of the Central and Northwestern districts (Table 3).

Table 2 Infrastructure development indicators by regions of Russia *)

Federal District	Infrastructure development	Developmentof transport infrastructure	Development of energy infrastructure	Development of social infrastructure	Development of utility infrastructure	Developmentof telecommunications infrastructure
1. Central	7.77	8.54	6.90	7.49	7.83	9.87
2. North-western	6.91	7.01	5.87	6.38	8.25	8.40
3. South	5.72	3.98	5.48	5.85	7.37	6.89
4. North Caucasian	5.48	3.49	4.73	5.06	8.07	6.15
5. Privolzhsky	6.05	3.23	5.68	7.05	7.65	7.44
6. Ural	6.55	4.34	8.78	6.55	7.62	6.97
7. Siberian	6.25	4.64	8.49	6.15	7.24	7.81
8. Far Eastern	5.96	3.60	5.71	7.14	7.30	7.48

Note: *) – the index of development of infrastructure services by type is presented (Russian Infrastructure Development Index – 2020 (Indeks Razvitiya Infrastruktury Rossii, 2020).

Table 3 Indicators of innovative development by regions of Russia

Federal District	Infrastructure Services Development Index*)	Drilling Services Development Index**)	Digitalization Development Index***)	Innovation Activity Index****)
1. Central	7.77	1	31	12.5
2. North-western	6.91	5	30	10.8
3. South	5.72	4	29	8.0
4. North Caucasian	5.48	2	23	3.5
5. Privolzhsky	6.05	31	30	15.5
6. Ural	6.55	38	30	10.2
7. Siberian	6.25	18	28	9.8
8. Far Eastern	5.96	6	27	6.9

Note. Compiled by the author based on sources: *) - Russian Infrastructure Development Index -2020. **) - Review of the Russian oilfield services market - 2020. ***) - Indicators of the digital economy - 2020. ****) - Indicators of innovation activity - 2020.

The obtained results of the analysis make it possible to form a typology of infrastructure services in the region of oil and gas specialization (production, social and

everyday infrastructure, market infrastructure, infrastructure for supporting the development of systems, institutional infrastructure of the regions) and related services, directed along the vector of innovative development (depending on the form of social division of labor development), taking into account the innovation of developments in the system and the level of digitalization of activities, participating in the creation of an infrastructure and service cube (Figure 5). Additionally, based on the results of the analysis, an economic and statistical model was presented, reflecting the influence of oilfield services and the level of development of the territory's digitalization on the development of infrastructure facilities in regions of oil and gas specialization (Figure 6).

The presented model was carried out based on regression analysis and the establishment of correlation dependencies of the main indicators characterizing the influence of factor characteristics (the level of digitalization and innovative activity, the level of development of services) (Table 3) on the functional one - infrastructure development in the regions of Russia. Among many research options, model y = -2.006-0.043×x1+0.151×x2, which is a linear multiple regression of the dependence of the infrastructure factor on digitalization and the level of service development, showed qualitative results (based on the coefficient of determination R^2 = 0.78, p -statistics, shares of the residual sum of squares in the total sum of squares and comparison of F-score according to the table data).

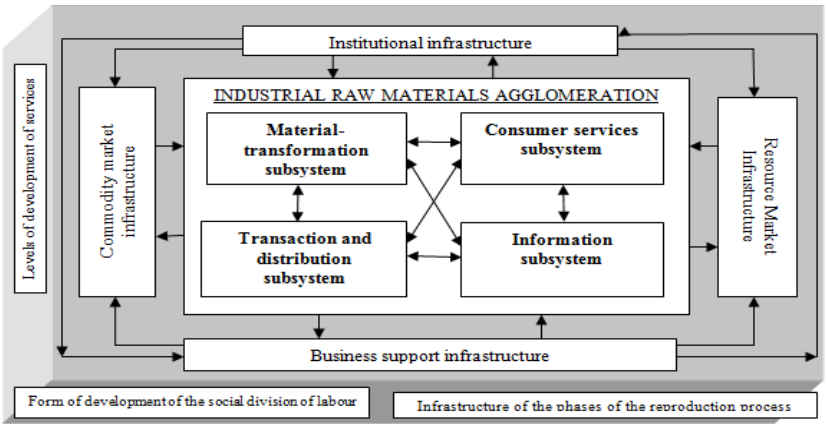

Figure 5 Formation of the infrastructure of industrial agglomerations within the boundaries of the development of economic systems

Results								
Regression statistics								
Plural R	0.883417406							
R-square	0.780426313							
Normalized R-squared	0.670639469							
Standard error	0.415840942							
Observations	7							
Analysis of variance								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	2	2.458476673	1.229238336	7.108559528	0.048212604			
Remainder	4	0.691694756	0.172923689					
Total	6	3.150171429						
	Odds	*Standard error*	*t-statistic*	*P-Value*	*Lower 95%*	*Upper levels 95%*	*Lower 95%*	*Upper levels 95%*
Y-intersection	-2.005946749	2.339084082	-0.857577872	0.439469763	-8.500285299	4.4883918	-8.500285299	4.4883918
Development of services	-0.042697364	0.014657778	-2.912949405	0.043549421	-0.083393879	-0.00200085	-0.083393879	-0.00200085
Level of digitalization	0.151282209	0.041032693	3.686870096	0.021076498	0.037357189	0.265207228	0.037357189	0.265207228
y=-2.006-0.043×x1+0.151×x2								

Figure 6 Regression analysis results

The results of the study indicate that the development of digitalization and oil services in regions of oil and gas specialization, the Urals, Siberia and the Far East have a significant impact on the formation of the infrastructure. Thus, the presented model will make it possible to manage the formation of innovative infrastructure facilities in the regions of the Urals and Siberia and will also allow planning the development of the infrastructure in promising regions of hydrocarbon production, in particular in the Far East, Eastern Siberia, in the North-West region, and on the continental shelf of Russia.

4. Discussion

As the innovative scenario for the development of the national economy is implemented, a new institutional environment is being formed in the country, whichmakes changes to the organizational chart of relations between the state and private structures when developing projects related to the formation of the infrastructure and service facilities. What is presented is especially important for economic systems of oil and gas specialization, for which strategic development is determined by:

- geological features: deterioration of the structure of oil reserves due to an increase in the share of hard-to-recover reserves (Il'inskii and Tan, 2017);
- technological features: the use of import substitution and parallel import procedures (Babkin *et al.*, 2021);
- production features: the concentration of a significant volume of oil production in highly productive fields while leaving small and medium-sized fields, as written by (Kryukov and Tokarev, 2022) and etc.;
- economic features: increased wear and tear of fixed assets associated with oil and gas production during the strategic sustainable development of enterprises, as noted by (Mahmood *et al.*, 2023; Cherepovitsyn and Rutenko, 2022);
- financial features: changes in the structure of financial resources and planned project financing schemes (Ponomarenko, Galevski, and Marin, 2022).

The highlighted features underscore the necessity of predicting the development of economic systems and infrastructure facilities, particularly in the territories of the Urals, Siberia, and the Far East, as emphasized by the authors in this work. In addition, to increase the efficiency of geological exploration and oil and gas production, the importance of using digital technologies is increasing, making it possible to increase the level of investment attractiveness of oil and gas facilities in economic systems and to include these components in forecast dependencies. Moreover, the "Digital Economy of the Russian Federation" program being implemented at the country level is focused on the active use of end-to-end technologies and digital control platforms.

5. Conclusions

The study of the process of activation of services based on the formation of the infrastructure of economic systems of oil and gas specialization in Russia in conditions of using innovative tools of a systemic orientation allows concluding. The infrastructure of economic systems of oil and gas specialization formed as a result of evolutionary development is presented as an integral economic system that ensures market interaction of business units both within the system and with external agents and takes into account the specifics of the formation of oil and gas agglomerations within the boundaries of sustainable development. Sustainable development of economic systems of oil and gas specialization is largely determined by significant natural resource potential, as well as the formation of industrial agglomerations of an innovative type, characterized by the innovative infrastructure and high-tech oil services, the attractiveness of which is

explained by the high level of diversification of production, increased innovative activity of industry production, high level of digitalization in the regions. Managing the formation of innovative infrastructure facilities in the economic systems of the Urals and Siberia, as well as planning the development of infrastructure facilities in promising hydrocarbon production territories, is possible through economic modeling of the impact of oilfield services and the level of development of digitalization on the development of infrastructure facilities in regions of oil and gas specialization, which contributes to the complexity of development. The presented model will make it possible to plan the development of infrastructure and services within the boundaries of economic systems. This will also be important for the strategic development of economic systems specializing in mineral resources. To make the study more detailed, additional factors can be used within individual economic systems, which can be done in the following studies.

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