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Innovative Development of the Gas Industry of Siberia and the Far East in Order to Increase the Social and Economic Level of the Regions

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Abstract— **The paper considers the problem of forecasting of hydrocarbon production in regions with a low degree of exploration. A forecast algorithm allowing for simulation of production dynamics at oilfields is proposed. The algorithm is part of a comprehensive methodological approach to the geological and economic assessment of promising petroleum territories - IPGG-Estimator, developed at IPGG SB RAS. The developed software allows for forecasting key parameters of the development of various oil and gas facilities. Approbation of the algorithm was performed on the Eastern Siberia and the Far East. The region is characterized by the presence of significant oil and gas resources and a low degree of their exploration, which creates the conditions for the start of large-scale production. Currently large-scale natural gas production in Eastern Siberia is constrained by the lack of a gas transportation infrastructure, however PAO Gazprom completes the construction of the Siberia Power pipeline in late 2019. Structure and quality of the region's resource base have a significant influence on the dynamics of gas production. The natural gas of Eastern Siberia has complex composition and contains a large number of homologs of methane (ethane, propane, butane, helium, etc.). Development of processing facilities will result in high added value products, that will allow for realization of the economic and geopolitical interests of the country, increase in the socio-economic level of the development of the regions. Recommendations for state regulation of the gas industry in Siberia were proposed.**

Keywords— production forecast, the Eastern Siberia, the Far East, Gazprom, natural gas, innovative development.

1. INTRODUCTION

The long-term interests of the Russian Federation consist in creating an innovation type of economy that is optimally integrated into the world technological and economic sphere [9, 16]. A special role in increasing the production levels and ensuring the growth of the country's mineral resource base is allocated to Eastern Siberia and the Far East [6, 8]. The region is characterized by the presence of significant energy resources and proximity to the dynamically developing and capacious markets of the Asia-Pacific region [13, 19].

The oil and gas complex of Eastern Siberia and the Far East is the most dynamically developing center of the Russian oil and gas industry. Since the late 2000's the main increase in oil production in Russia was carried out by the Eastern Russian regions [7, 17]. The regions are also strategically important for the Russian oil industry in the long term [5, 10].

A distinctive feature of the hydrocarbon resource base of the Eastern regions of Russia is the presence multi-component natural gas containing a significant amount of methane homologues, including ethane, propane, butane, condensate, and helium with high share of condensate [2, 11]. In this regard, the issues of production forecasting, taking into account the effective use of all associated components are of great interest.

The involvement of multi-component gas in industrial development will boost the development of petrochemical, gas chemical and helium industries in the region; create additional jobs and accelerate the social and economic development of the regions in the country's East. [14, 18]

2. DATA

More than 60 trillion cubic meters or 24% of the initial total gas resources of the country are concentrated in Eastern Siberia and the Far East. Explored and previously estimated natural gas reserves in the region exceed 11 trillion cubic meters or 16.1% of the total reserves of Russia. The degree of exploration is 10%, while the all-Russian level is 25% [4, 15]. The main recourse user of the largest gas fields in Eastern Siberia is PAO Gazprom.

Currently, large-scale production of natural gas in the territory of Eastern Siberia is constrained by the lack of a main gas transportation infrastructure and is conducted mainly within the local gas supply centers. Associated petroleum gas is produced in the region as well [3, 12].

In 2017, gas production in Eastern Siberia and the Far East was 42.0 billion cubic meters, of which 25.3 billion cubic meters were produced in Sakhalin, and 16.2 billion cubic meters in the Krasnoyarsk Territory, the Republic of Sakha (Yakutia) and the Irkutsk Region (Table 1). Most of the produced gas is transported to consumers in the region and for export, while more than 20% of the produced gas is injected back into the reservoir or burned in flares [1, 20].

Table 1. Production of natural gas in the Eastern Siberia and the Far East

1.Regions	**2.**2000	**3.**2005	**4.**2010	**5.**2015	**6.**2016	**7.**2017
8.Irkutsk region	9.0	10.361	11.5432	12.3818	13.2578	14.1360
15. Krasnoyarsk region	16.4269	17.3463	18.6827	19.13036	20.12652	21.11935
22. Republic of Sakha (Yakutia)	23.1826	24.1572	25.2249	26.2722	27.2856	28.2897
29. Far East	30.1897	31.2370	32.23949	33.27322	34.26720	35.25847
36.Total of the Eastern Siberia and the Far East	**37.7992**	**38.7766**	**39.38458**	**40.46899**	**41.44806**	**42.42040**
43. Russia	44.581548	45.641015	46.665462	47.645941	48.652570	49.704107
50.*Share of Eastern Siberia and the Far East in all-Russian*	*51.1.4%*	*52.1.2%*	*53.5.8%*	*54.7.3%*	*55.6.9%*	*56.6.0%*

3. METHODS

The integrated methodical approach to the geological and economic assessment of the prospective oil and gas areas - IPGG-Estimator, has been developed at IPGG SB RAS. This approach is implemented in the form of software that allows for forecasting key parameters of the development of various oil and gas objects (reservoir, deposit, resources, license area, petroleum region, etc.). One of the key stages at the initial stage of modeling of the process of developing the oil and gas object is the stage of forecasting the recovery potential. The methodology for forecasting of hydrocarbon production in the prospective territory includes three stages (Table 2).

Table 2. Scheme of the methodology for forecasting hydrocarbon production in the oil and gas region (IPGG-Estimator, IPGG SB RAS).

Stage	Name of the Stage	Объект оценки	Формула
1.	Forecast of production from distributed and undistributed reserves		$Q^{reserves}(t) = Q^{all}(t) + Q^{unall}(t)$
1.1.	Forecast of hydrocarbon production from distributed reserves	Explored and estimated reserves	$Q^{all}(t)$
1.2.	Forecast of hydrocarbon production from undistributed reserves	Explored and estimated reserves	$Q^{unall}(t)$
2.	Forecast of production of hydrocarbons expected to be discovered	Inferred and prospective recourses	$Q^{resources}(t)$
3.	Forecast of production of oil and gas region		$Q(t) = Q^{reserves}(t) + Q^{resources}(t)$

Stage 1.1. Forecast of hydrocarbon production from distributed reserves is determined by strategic and target indicators of development of resource users, as well as by the terms of license agreements, which indicate the terms of commissioning, the time to reach the designed capacity and the maximum production level.

Stage 1.2. For the hydrocarbon fields of the undistributed reserves, a methodology to predict the dynamics of hydrocarbon production based on the idea of its phased nature is used. This method is aggregated and applied due to the limited information about the object of forecasting as a result of the low exploration of the region and the lack of sufficient sampling of analogous objects.

Mathematical model is used to build the forecast for the production of hydrocarbon fields. The hydrocarbon production curve has the so-called π-shape.

$$Q^{unall}(t) = \begin{cases} A \cdot t^{\alpha} \cdot \exp(-\vartheta \cdot t), 0 \le t \le t_1 \\ Q^{const}(t), t_1 < t \le t_2 \\ A \cdot t^{\alpha} \cdot \exp(-\vartheta * (t - t_2 + t_1)), t_2 < t \le T \end{cases} \quad (1)$$

where – time to reach the designed production capacity,, – time of production completion at the design capacity, – time of production completion, – production at maximum capacity, $Q^{const}(t) = A \cdot t_1^{\alpha}$, – scaling coefficient, – empirical coefficients.

Cumulative production can not exceed the recoverable reserves of industrial categories. Hypothetically, the value of these reserves corresponds to the expected accumulated production at the field for the entire period of its development.

Stage 2. For forecasting the production of hydrocarbon fields expected to be discovered, it is necessary (1) to estimate the number of fields expected for discovery and the amount of geological reserves, (2) to determine the sequence of discovery of these deposits and (3) to convert geological reserves to recoverable reserves.

The forecast of hydrocarbon production in the fields expected to be discovered, reflects the dynamics of production at the deposits of the undistributed fund of mineral resources, where the limitation is the resource base.

Stage 3. The forecast of hydrocarbon production in the prospective oil and gas bearing area includes a forecast for hydrocarbon production at the fields of a distributed, undistributed reserves, as well as deposits expected to be discovered.

4. RESULT AND DISCUSSION

With application of the production forecasting algorithm, it was calculated that the oil production in the east of the country can reach 70 million tons by 2025 and almost 100 million tons by 2040 (Table 3). The development of the gas resources of the Leno-Tunguska province within the framework of the "Siberia Power" project will begin with the priority commissioning of the Chayandinskoye field at the end of 2019 and Kovykta in 2023. The projects has the plan of the maximum gas production in the Chayandinskoye field of 25 billion cubic meters, and in Kovykta up to 35 billion cubic meters. The gas will be supplied to the Asia-Pacific region, primarily to China. It was decided that the "Siberia Power" gas pipeline will be laid in the close proximity of the route of the Eastern Siberia-Pacific Ocean oil pipeline.

Table 3. Forecast of natural gas production in the Eastern Siberia and the Republic of Sakha (Yakutia).

Field	2019	2020	2025	2030	2035	2040	2045	2050
Chayandinskoye	5,0	10,0	25,0	25,0	25,0	25,0	15,0	10,0
Kovykta	0,0	0,0	23,0	25,0	25,0	25,0	35,0	35,0
Verhnevilyuchanskoye	0,0	0,0	5,5	5,5	5,5	4,4	3,3	2,2
Srednebotuobinskoye	0,3	0,3	3,0	3,0	3,0	2,4	1,8	1,2
Tas-Yuryakhskoye	0,0	0,0	3,0	3,0	3,0	2,4	1,8	1,2
Yurubcheno-Tokhomskoye	0,7	1,0	2,1	2,2	1,8	1,4	1,0	0,7
Verkhnechonskoye	1,2	1,2	1,0	0,7	0,4	0,3	0,1	0,1
Kuyumbinskoye	0,3	0,5	1,3	1,3	1,1	0,9	0,5	0,2
Talakan	0,8	0,8	0,6	0,4	0,2	0,2	0,1	0,0
Dulisminskoye	0,5	0,5	0,4	0,2	0,1	0,0	0,0	0,0
Sobinskoye	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Other and projected for the opening	24,0	26,0	20,0	29,1	31,0	35,0	50,3	58,7
Eastern Siberia and the Republic of Sakha (Yakutia)	32,7	40,2	84,9	95,4	96,1	97,0	108,9	109,2

The start of the full-scale production of natural gas in the east of the country and development of gas processing facilities will allow for increasing the impact on the socio-economic development of individual regions of the Eastern Siberia and the Far East. The implementation of the project "The Power of Siberia" will provide a powerful impetus to the socio-economic development of the territory. The implementation of projects in the fuel and energy sector has the national economic importance for the regions of the Eastern Siberia and the Far East.

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