Development of the gas supply system in the Eastern part of the RF

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Abstract.

The paper substantiates the necessity for developing the gas supply system in the Eastern part of the RF. The current and potential natural gas demand as well as the state-of-the-art and prospects for development of the resource base are shown. The calculation results of staged development of the gas supply system up to 2030 are given.

Keywords: **gas demand, gas resources, Eastern part of the RF, stages of development**

The current and potential natural gas demands in both Western Europe and Russia and also the state-of-the-art and prospects for development of the resource base in Siberia necessitate studies on the gas supply system (GSS) in Russia with detailed consideration of its Eastern part.

The forecast of gas demand was made for the period till 2030.

The priority potential consumer of natural gas in East Siberia is a chemical complex, including enterprises of chemical, petrochemical, microbiological industries and enterprises for production of fertilizers. By the year 2030 the total natural gas demand of the chemical complex in Irkutsk region is estimated at 4.1 billion m^3, in Krasnoyarsk territory – at 930 million m^3. By authors' estimates in 2030 the gas demand of East Siberia as a whole will increase and reach 8.7 billion m^3.

The second direction of natural gas utilization is replacement of traditional kinds of fuel (fuel oil and coal) at boiler and power plants. On the whole, in terms of economic conditions gasification of power and boiler plants in East Siberia will require from 6.1 to 7.7 billion m^3 of natural gas.

Together with agricultural and unaccounted potential consumers the total demand in all the directions of effective gas utilization here will amount to the values presented in Table 1.

TABLE 1. AGGREGATE RATIONAL LEVELS OF NATURAL GAS DEMAND IN EAST SIBERIA (TRANSIT AND EXPORT) IN 2007-2030 (BILLION M^3 PER YEAR)[1]

No.	Industrial (administrative) consumption nodes	Directions of gas utilization	2010	2015	2020	2025	2030
		Irkutsk region					
1	Angarsk	Chemical complex	1.7	2.0	2.5	2.8	3.1
		Boiler plants		0.1	0.1	0.3	0.3
		Total	1.7	2.1	2.6	3.1	3.4
2	Irkutsk	Technological needs, etc.		0.03	0.03	0.03	0.03
		Boiler plants		0.67	0.67	0.67	0.67
		Total		0.7	0.7	0.7	0.7
3	Usolie-Sibirskoye	Chemical complex	0.3	0.4	0.5	0.6	0.7
		Boiler plants		0.1	0.1	0.1	0.1
		Total	0.3	0.5	0.6	0.7	0.8
...	…	…	…	…	…	…	…
15	Gas transit to West Siberia				6.9	13.8	27.6
16.	Gas export to APR countries				5.0	10.0	20.0
	Total		2.4	10.5	26.0	40.4	66.2

Hence, in 2030 the total gas demand is estimated at about 66.2 billion m^3, considering gas transit to West Siberia and export to APR countries.

Table 2 illustrates the state-of-the-art and prospects for development of the resource base in East Siberia and Sakha Republic (Yakutia) [1].

TABLE 2. NATURAL GAS RESOURCES AND RESERVES IN EAST SIBERIA AND SAKHA REPUBLIC (YAKUTIA), BILLION M^3

Entities	Initial potential resources	Reserves of category $A+B+C^1+C^2$	Extent of territory exploration, %
East Siberia (Siberian platform)			
Total, of which:	43790	3640	8.3
Irkutsk region	8420	1100	13.2
Krasnoyarsk territory	24940	1200	4.8
Sakha Republic (Yakutia)	10430	1340	12.8

On the whole, in Irkutsk region, Krasnoyarsk territory and Sakha Republic (Yakutia) 53 hydrocarbon fields have been registered in the State balance, of which 51 fields contain natural gas, 18 fields contain different quantities of oil, 23 fields include gas condensate reserves. The fields are at different stages of commercial development.

The current known gas reserves of the main fields on the Siberian platform are presented in Table 3 [2].

TABLE 3. NATURAL GAS RESERVES OF THE MAIN FIELDS ON THE SIBERIAN PLATFORM
(AS OF 2000)

Fields	Natural gas, billion m^3	
	$A+B+C_1$	C_2
Irkutsk region (10 fields in total)		
Kovyktinskoye	296.7	1100.7
Verkhnechonskoye	11.7	83.8
Krasnoyarsk territory (18 fields in total)		
Sobinskoye	138.7	19.6
Yurubcheno-Takhomskoye	93.7	321.2
Sakha Republic (25 fields in total)		
Chayandinskoye	164.8	44.7
Srednebotuobinskoye	152.3	18.6
Srednevilyuiskoye	160.0	-
Srednetyungskoye	156.2	9.2
Talakanskoye	35.5	18.6

The system estimation of gas supply development in the Eastern part of the RF was fulfilled on the network flow-oriented model [3]. The detailed model includes 30 nodes (see Figure), consisting of 17 gas consumption nodes, 9 gas production nodes from the fields, 2 gas processing nodes.

At the node "Proskokovo" gas is transported to the West and at the node "Irkutsk" gas is supplied for export to Mongolia and China. Quasi-dynamics of gas supply system development in the Eastern part was calculated for 2010, 2015, 2020, 2025 and 2030.

Potential gas production and capital investment were determined based on the gas reserves of the Eastern part and the analysis of existing projects on exploitation of natural gas fields (Table 4).

Figure. Calculated scheme of gas supply of the Siberian Federal District for 2030

TABLE 4. POTENTIAL PRODUCTION (Q_f, BILLION M^3) FROM AND INVESTMENT (K_f, MILLION DOLLARS) IN THE MAIN FIELDS OF EAST SIBERIA[*)]

Fields	2010		2015		2020		2025		2030	
	Q_f	K_f	Q_f	K_f	Q_f	K_f	Q_f	K_f	Q_f	K_f
Kovyktinskoye	2.5	582	4.9	1140	18.7	4351	25.0	5817	30.0	6981
Yaraktinskoye and others			0.9	209	1.0	233	9.0	2094	15.0	3490
Verkhnechonskoye									13.0	3025
Bratskoye			0.6	140	0.8	186	1.0	233	1.0	233
Sobinskoye			4.5	1047	7.0	1629	8.0	1862	10.0	2327
Total	2.5	582	10.9	2536	27.5	6399	43	10006	69	16056

*) Capital investment is given with regard for investment in the previous years.

Self-financing prices for the fields of East Siberia were calculated based on a simplified business plan by year of the calculated period on the basis of gas production program. The fixed assets, current costs (depreciation, other expenses, taxes, interest on credit, etc.) were determined. In addition the flow of cash assets, the state of running account, etc. were obtained. Gas production profitability was set equal to 15%. Table 5 presents the calculated weighted average self-financing prices of gas production from the fields for the 30-year period of their exploitation.

TABLE 5. WEIGHTED AVERAGE SELF-FINANCING PRICES OF GAS PRODUCTION FROM THE MAIN FIELDS OF EAST SIBERIA (DOL./1000 M^3)

Fields	C_f
Kovyktinskoye	42
Yaraktinskoye and others	45
Verkhnechonskoye	45
Bratskoye	46
Sobinskoye	45

The aggregated calculated scheme of the gas supply system in the Eastern part of Russia includes 23 main gas pipelines. Maximum capacities (the upper model constraints), investment, self-financing prices and coefficients of decrease in gas flow because of gas consumption for auxiliaries and losses were calculated for these pipeline systems by stage of their development. Maximum capacities of and capital investment in the main gas pipelines of the Eastern part by stage of their construction are shown in Table 6.

TABLE 6. MAXIMUM CAPACITIES (Q_g, BILLION M^3) AND CAPITAL INVESTMENT (K_g, BILLION DOL.) FOR THE MAIN GAS PIPELINES IN EAST SIBERIA[*)]

Gas pipelines	2010		2015		2020		2025		2030	
	Q_g	K_g	Q_g	K_g	Q_g	K_g	Q_g	K_g	Q_g	K_g
Kovyktin-skoye GCF-Angarsk GPP	2.4	300	4.9	607	18.7	1919	322	3231	56.5	4690
Angarsk GPP-Angarsk city	1.7	30	2.8	60	9.2	90	148	120	25.1	120
Angarsk city-Irkutsk node			0.7	185	6.6	185	11.7	185	21.7	185
…	…	…								
Total invest-ment		364.1		5332.2		12021.2		5963.2		22442

*) Capital investment is given with regard for investment in the previous years

Note. GCF – gas condensate field, GPP – gas processing plant.

The self-financing prices for the mentioned gas transportation systems were determined as weighted average values for the 30-year period of service life (similarly to the gas fields). These indices are presented in Table 7.

TABLE 7. WEIGHTED AVERAGE SELF-FINANCING PRICES (C_g) FOR THE MAIN GAS PIPELINES OF EAST SIBERIA

Gas pipelines	C_g, dol./1000 m^3
Kovyktinskoye GCF - Angarsk GPP	10.5
Angarsk GPP – Angarsk city	0.3
…	…
Sobinskoye GCF - Yeniseisk-Lesosibirsk node – Kansk city	13.5

Comprehensive studies on Russia's gas industry with more detailed analysis of the Eastern part made it possible to simulate the gas supply system development of the region in five stages.

The first stage comprises development of the Kovyktinskoye GCF with gas production of 2.5 billion m^3 a year, construction of the Angarsk GPP and expansion of the gas pipeline system to supply gas to enterprises of the chemical industry.

The second stage implies expansion of the gas supply system in Irkutsk region to the Taishet-Biryusinsk industrial node. In parallel, gas is supplied to consumers in the north of Irkutsk region.

At this period the Sobinskoye GCF under development starts to deliver natural gas to consumers in the south of Krasnoyarsk territory.

At the third stage the gas supply system will further develop in East Siberia. Based on the available gas reserves it is possible to arrange transit of 6.9 billion m^3 of gas to the West and export of 5.0 billion m^3 to China.

The fourth stage shows that a higher gas demand of consumers in East Siberia and an increase in gas transportation to the West and its export to China can be provided based on the

Table 8 presents the weighted average self-financing prices at the nodes of the calculated scheme for the 30-year period.

CONCLUSION

The paper substantiates the stages in formation of the gas supply system in the Eastern part of the RF up to 2030 and presents the self-financing prices calculated on the model.

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TABLE 8. WEIGHTED AVERAGE VALUES OF SELF-FINANCING PRICES AT THE NODES OF THE CALCULATED SCHEME

Nodes of calculated scheme	Prices, dol./1000 m^3
Ust-Ilimsk	43.8
Mama-Bodaibo industrial node (including "Sukhoi Log" field)	48.8
Bratsk	37.0
…	…
Proskokovo	74.0

Kovyktinskoye GCF in combination with the northern fields of Irkutsk region.

The fifth stage indicates that further increase in gas transit to the West and its export to China is possible only at the full utilization of reserves from the gas fields in the north of Irkutsk region and partially the gas reserves in the fields of Sakha Republic (Yakutia).

No. 3. P. 25-29. (in Russian)

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