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Study of the Outlook for the Development of the Gas Industry in Russia and Analysis of Risk Associated with this Process

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Abstract—The gas industry in Russia will develop under conditions of the persistence of existing risks and emergence of the new ones caused by the world financial crisis, increased uncertainty in estimating world prices for natural gas, together with disturbed balance between interests of gas producers and consumers, and threat of loss of the competitiveness of Russian natural gas on foreign markets. In this context, in choosing a strategy of the development of the gas industry and its production-and-financial program, it is necessary to carry out a risk analysis of optimum decisions. Specific features of carrying out a risk analysis and results of the risk analysis of strategic decisions that would provide enhanced steadiness and the effectiveness of the development of the gas industry under conditions of the uncertainty of both external and internal factors are presented.

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INTRODUCTION

The Energy Strategy of Russia for the period up to 2030 (ES-30) approved by the Government of the Russian Federation on August 27, 2009 determines the following strategic targets of the development of the gas industry:

—meeting domestic and international gas market demand in sustainable, uninterruptible, and economically viable ways;

—development of the unified system of gas supply and its expansion to the east of Russia, strengthening of integration of regions on this basis;

—improvement of the institutional framework of the gas industry for the purposes to improve economic results of its activity and formation of the liberalized gas market;

assurance of stable money receipts to the revenue side of the consolidated budget of the country according to the significent contribution of the energy sector in the formation of the gross domestic product (GDP) and export at the given stage of the government energy policy.

With these objectives in mind, the volume of natural gas resources in Russia should be increased from 698 billion m^3 in 2008 to 871–905 billion m^3 by the end of the second stage of the future period up to 2020 and to 954–1009 billion m^3 by 2030. In this case natural gas production should be increased from 664 billion m^3 to 803–837 billion m^3 and 885–940 billion m^3, respectively, in other words, by a factor of 1.4-1.5 as compared to the 2008 level

In the future, territorial distribution of gas extraction should change. Since depletion of gas fields takes place comparatively fast (25–35 years over an initial area), gas fields that are the main ones for today: Medvezhye, Yubileynoye, Yamsoveyskoye, may, in fact, cease to exist as productive formations by the year 2030; production in the Urengoy field will drop to a minimum; production in the Zapolyarnoye gas field will be reduced by a factor of 2; while in the Yamburg gas field, by 70%.

It might be possible to compensate for the decline of production from depleting gas fields and ensure the planned increase in the output in the gas industry as a whole only in case if the package of measures on putting new natural gas fields into production, construction of a gas pipeline system, storage, and processing of natural gas, will be implemented.

Tasks of securing the supply of natural gas to the Russian economy just recovering from the recession, and of natural gas export, would involve considerable efforts aimed at developing the gas industry and implementing huge investments. Over 2004–2030, cumulative investments for the gas sector are assessed under ES-30 at US$ 565–590 billion.

In this connection, the development of effective gas production and financing programme justifying the sector's key strategic targets is viewed now as one of the key national projects.

Taking account of the risks associated with the development of the gas industry, when drawing up a production-and-financial program for the development. In 2009 the world financial crisis broke the upward trend in the development of the Russian gas industry. Reduction in demand for natural gas on domestic and international markets and decline in prices make it

necessary to amend outlined plans for the development of the gas industry. Reorganization of the entire Russian economy is under way, and the scope and many-sided character of the crisis make quantitative assessments of indicators of the development of the gas industry for the future difficult. The uncertainty in assessing the future development of the gas industry and gas companies increases.

Former risks associated with the development of the gas industry not only persist but are becoming aggravated, and new ones have emerged, namely:

—decline in production from unique fields being developed in the Tuymen and Orenburg regions calls for utilization of more expensive natural gas resources located far from the developed gas infrastructure and occur at a great depth;

—risk of deterioration of the resource base in respect of high rate of depletion of large reserves of methane gas in Western Siberia and an increase in the share of "rich" gas with high content of ethane, propane, butanes, carbon dioxide, and other components including helium in recoverable reserves. This calls for the development of gas processing and an appropriate infrastructure;

—high degree of uncertainty in assessments of world prices for fuel-and-energy resources for the future. Assessments of the level of prices for crude oil and natural gas and of demand for fuel-and-energy resources made by leading world agencies (International Energy Agency, Cambridge Energy Research Associates, US Department of Energy, etc.) differ manyfold: from the expectation of a decline in prices for oil down to 23 US dollars/bbl to their soaring up to 200 US dollars/bbl. The corresponding spread is also seen in assessments of the level of prices for gas because of their indexation according to the changes in prices for oil;

—the process of liberalization of the domestic market for natural gas slows down; the development of the competitive segment of the gas market (even low-volume commodity exchange biddings for natural gas were not held during 2009), as well as switch over to the principle of formation of domestic prices that would bring in the same revenue as prices on the European market, that has been enunciated by the Russian government, are delayed;

—upsetting the balance between interests of gas producers and those of gas consumers in respect of lagging of demand for natural gas behind the planned rate of its growth on the domestic market and abroad down to shortage in natural gas volumes stipulated by contracts;

—occurrence of surplus productive capacities and the investment idleness caused by the non-approved prediction of demand for natural gas and unplanned decline in production from existing gas fields resulting in underutilization of gas transport capacities. This type of risk stems from the previous one;

—occurrence of a natural gas shortage on the domestic market because of increased demand for gas as compared with planned levels, as well as because of insufficient introduction of energy-saving measures and technologies and substitution of other energy resources for natural gas. High inertia of the gas industry precludes drastic increase of, and changes in the structure of production capacities in a short time;

—prolonged period of low prices for natural gas reduces investment opportunities available to the gas industry and makes the outlook for implementation of highly capital-intensive gas projects worse;

—because of the world crisis, reduction in opportunities for attracting borrowed funds needed for investing in the Russian gas industry puts implementation of new capital-intensive projects in jeopardy;

—low effectiveness of geological surveying and prospecting in new regions;

—the development of new projects for production of cheaper natural gas and its supply to the markets of Western Europe from Northern Europe, Africa, Near East, Caucasus, and Central Asia creates conditions for excess of supply over demand, decline in prices for natural gas, and a threat of loss of competitiveness of Russian natural gas on foreign markets occurs.

As a result, high risks associated with the development of the gas industry, especially in the context of crisis and consequent recession of the economy, a numerical assessment of development indicators given in the ES-30 by now does not adequately reflect possible parameters of the development of the gas industry at the above-mentioned stages of the future period (although the objectives of the development of the gas industry indicated in the ES-30 remain the same).

In the Energy Research Institute attached to the Russian Academy of Sciences (INEI RAN) a mathematical apparatus has been developed and is used that, in case of change in external factors of the development (a level of demand and prices natural gas), makes it possible to promptly select an investment strategy for the gas industry or individual gas-producing companies, and to form the dynamics of gas production and the development of a gas transport network, at which:

—demand on the domestic market will be met, and gas export commitments will be fulfilled;

—all financial obligations of the gas industry (companies) to creditors, the state, and shareholders will be fulfilled;

—financial stability and investment attractiveness of the gas industry (companies) will persist.

Setting the task of drawing up an optimum production-and-financial program for the development of the gas industry maximizes, at preassigned demand and prices for natural gas over 26 regions of Russia and its exportation to European and Asian markets, net discounted income of the gas industry over the entire period considered, on condition that all production-and-technological constraints, as well as preassigned criterion, constraints are adhered to.

Instruments applied for the drawing up the production-and-financial program for the development of the gas industry. The optimization linear dynamic model that describes the development of the gas industry, the OAO "Gazprom," and independent gas producers up to the year 2030 (hereinafter referred to as Omo "Gaz") tackles the problems related to assessing the comparative effectiveness of various investment programs drawn up by the gas industry (companies) and strategic decisions about the development of the gas industry. Model calculations rather adequately reflect specific production and financial features of the OAO "Gazprom" and independent companies, trends in their development, and conditions of their interaction during the long future period, conditions of operation on foreign and domestic gas markets, with due regard for natural gas import and providing transportation services.

Structurally, the Omo "Gaz" comprises:

—the production module that describes technological and resource constraints, dynamic and technological interaction in the course of core activities of companies engaged in the gas industry;

—the finance module in which cash flows are simulated, as well as dynamics of incomes, expenditures, the financial balance, assets belonging to the gas industry and companies, and own and borrowed capital, is reflected. All components of the financial balance are variables of the model and are recalculated automatically when production figures and prices for pipeline and liquefied natural gas vary;

—the ranking module which reflects the effect of solutions related to production and financing on such indicators as the profitableness of assets, internal funds, investments, indicators of financial soundness, quantitative assessments of capitalized value, and investment attractiveness of companies. Critical values of ranking indicators, beyond which bankruptcy is in store for companies of the gas industry, serve as constraints in this unit. The latter plays the role of criterion requirements.

The content of the model is constantly becoming more and more complex, thereby reflecting changes that take place in the development of the gas industry and in the gas business [1, 2]. Thus, for analyzing prospects for the development of production of liquefied natural gas (LNG), the module of its production, while for analysis of prospects for gas processing, the gas processing module were incorporated into the model. By means of appropriate assessment the finance module was expanded.

At present, in the Omo "Gaz" the following spheres of activity of gas companies are taken into account: preparing of gas reserves; natural gas and condensate extraction; LNG prodaction; transportation of pipeline gas and LNG, as well as condensate and gas processing; sale of LNG, condensate, and products of gas processing on the domestic and foreign markets; purchases of natural gas on the domestic and foreign markets; and financial support of production activities of gas companies. The scheme of the model and the results obtained are shown in Fig. 1.

The Omo "Gaz," as a modern economical and mathematical instrument used for drawing up and assessing the effectiveness of optimum production-and-investment programs for the long-term development of the gas industry, meets the following requirements:

—The OAO "Gazprom" and independent gas producers (IGP) are the subjects of simulation, with reflection of conditions of their interaction.

—The structural basis of the model is a combination of the following balances:

(i) of total gas reserves and with their breakdown by fields, regions, and producing companies;

(ii) of production, import, processing, liquefaction, transportation, and delivery of natural gas to consumers, including export and transit deliveries, total and by no less than 20 hubs of the main gas transportation network;

(iii) of extraction and production of condensate and products of gas processing;

(iv) of financial balances with consideration for their own and borrowed funds and their allocation between investment-related and current needs, including dividend policy and tax payments—total in the industry and by companies.

Into the set of goal-oriented (criteria) constraints are included ultimate (critical) values of ranking indices and indicators reflecting financial soundness and investment attractiveness of gas companies.

Optimum solutions are formed within the framework of the linear programming problem, with invoking any one from a preassigned set of dynamic criteria (constraints), among them, total investments made in the gas industry for a given period, growth rate of average prices on the domestic gas market for the given period, as well as a level of capitalization of gas companies averaged over the industry for the forecast

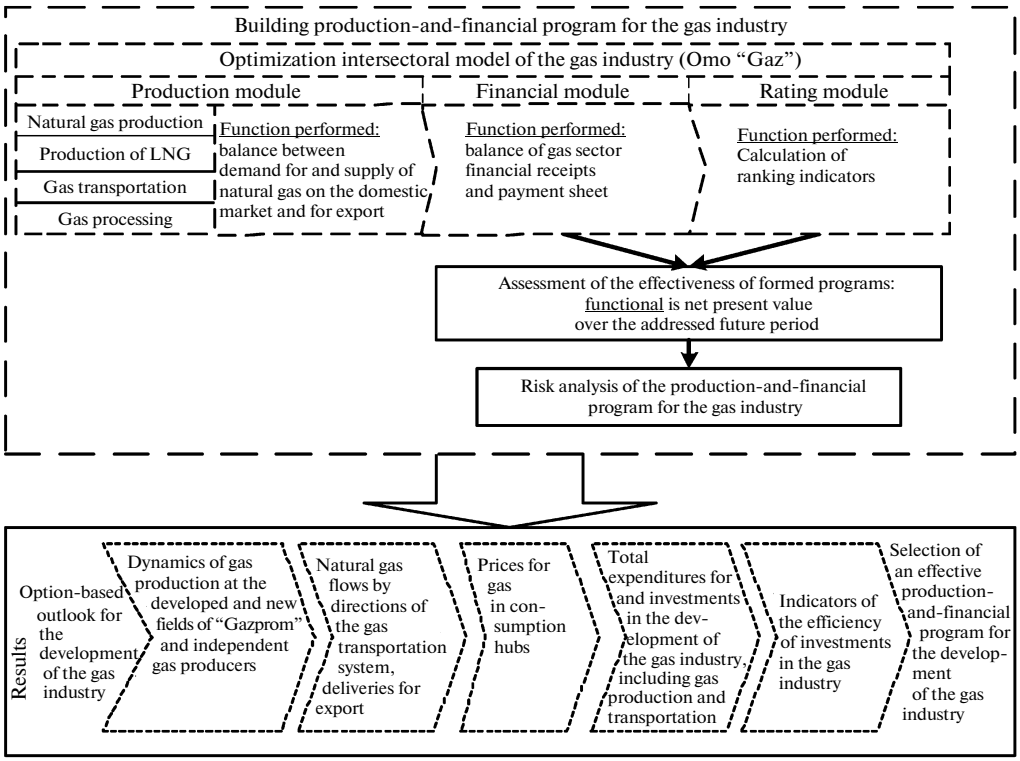


Fig. 1. The scheme of formation and assessment of the effectiveness of the production-and-financial program for the Russian gas industry.

period in question. Content of this list is made more precise in the course of studies.

Combined (in one model) consideration of all production-related proposals submitted by gas companies and financial capabilities of these companies, as well as factors (both internal and external) which affect the effectiveness of their implementation, provide complex optimization of production and financial programs for the gas industry and companies that make it up, with choosing technologically feasible and economically justified scenarios of development of extraction, liquefaction, processing, and transportation of pipeline and liquefied natural gas, together with calculation of the financial state of the gas industry and gas companies.

The key specific features of the model that makes it possible to use it as a basic instrument in problems for optimization of the most promising directions of the development of the gas industry, are the following:

—the model is a dynamic one and it is oriented towards the long-term future. The model provides, owing to description (by years up to 2020, and by five-year periods, up to 2030) of production-and-financial development of the OAO "Gazprom" and independent gas producers, informational and conceptual succession of strategic decisions for the long-term future (up to 2020–2030), with detailed program of the development for the nearest period;

—the model can be adapted to the change in a scenario, introduction of programs and governing decisions, inclusion and exclusion of constraints, and change in a modification of the model, by means of adding new constraints, new commands, and new units.

A set of source information (a model modification) varies depending on the goal of investigation: the gas industry as a whole, an individual gas company, part of the gas industry within the limits of the unified gas supply system, or the development that takes place in the east of Russia, can be considered.

All operations done on the model are carried out in the Excel environment of the Microsoft Office package, with the use of the entire arsenal of tools available in this program. Only solving of the linear programming problems is carried out by means of a special-purpose package of programs. Communication between Excel and this package of programs for linear programming is implemented through files, and it is automated as well.

The Omo "Gaz" allows"

1. To determine efficient, by criteria of economic (national economy) and commercial (corporative)

efficiency, volumes of gas production in Russia as a whole, by companies, and by oil-and-gas producing regions. In so doing the following factors should be taken into account: condition and preassigned dynamics of volumes and production-and-economic indicators of the development of explored natural gas reserves; possibilities for scientific and technological progress in opening-up gas reserves and development of gas fields.

2. To estimate volumes of natural gas exports and imports at preassigned price parameters and the capacity of foreign markets.

3. To evaluate amounts of investment by key production spheres of the gas industry with breakdown by individual projects and companies.

4. To prepare financial balances of the gas industry of Russia and leading gas companies depending on external (regulation, taxation, and price level) factors, as well as production, investment, and borrowing activities of companies.

5. To assess the risk related to an investment program drawn by both an individual gas company and the gas industry as a whole and methods of risk management.

6. To determine the stability of a strategy selected for the development of both individual companies and the gas industry as a whole.

7. To determine optimum variants of developing a network of trunk gas pipelines.

8. To determine optimum variants of constructing plants for natural gas processing and liquefaction.

Brief characteristics of production-and-financial programs formed by means of the Omo "Gaz." The use of the Omo "Gaz" made it possible to adjust forecasts of the development of the Russian gas industry on the basis of assessing external factors of development—rates of overcoming of the crisis, including the levels of world prices for crude oil and natural gas on foreign and domestic markets.

Calculations were carried out for both conservative and innovative scenarios of the socioeconomic development of Russia, adjusted with due regard for the crisis. A more precise innovative scenario presupposes overcoming of recession and obtaining of the growing rate of the gross domestic product (GDP) already in 2010, with reaching by 2015 growth rates (but not levels) of the economy that will correspond to those envisaged in "The Concept of Long-Term Socioeconomic Development of the Russian Federation" approved by the Government of the Russian Federation in November, 2008. The conservative scenario presupposes that the Russian economy will reach the dynamics of the innovative development only by the year 2020.

Because of high uncertainty inherent in prices for crude oil, evaluation and the dynamic of prices for main fuels have changed. Thus, the Ministry of Economic Development of Russia (MED) in its scenarios of the predicted socioeconomic development of Russia for the period 2009–2011 increased Urals crude oil price predicted for the year 2009 from 47 to US$ 54 per barrel, but in fact it turned out to be about 70 dollars [3, 4].

In our calculations, forecast of oil prices that was prepared by MED in July, 2009 and approved by the Government of the Russian Federation is assumed as a basis; according to this forecast, an increase in the average annual price for one barrel of Ural crude oil by 2010 will be up to US$ 55 in the conservative and US$ 60 (in constant 2007 dollars) in the innovative scenarios. In the more long-term future rise in prices for crude oil is presupposed as well, but at different growth rates—by a factor of 1.2–1.3 towards 2010 (up to US$ 66–75 bbl) and by a factor of 1.4–1.5, as compared with the 2010 level (up to US$ 73–86 bbl) towards 2030. In this case, on the basis of established parity of prices, rise of the accounting price for 1000 m^3 of the Russian pipeline natural gas on the border with countries—members of the European Union is predicted to be at the level from 215 to US$ 255 per 1000 m^3 in 2010 and from 300 to US$ 342 per 1000 m^3 in 2030.

When forming prices for natural gas in Russia, a problem had to be solved that consisted in providing the self-sufficiency of the domestic market for natural gas by way of transition to equal profitability of its delivery to the domestic market and for exporting. Internal prices for natural gas will tend to conformity with (but not to parity of) prices on wholesale markets of Central Europe, minus specific payments (including customs charges) for transportation of exported natural gas from one or another region of Russia. Time of introduction of prices ensuring equal profits that was adopted by the Government of the Russian Federation in 2007 are postponed, in view of the crisis, until 2014 [5]. Towards 2020 internal price for gas on the domestic market will increase, as compared with the level of controlled prices in 2010, by a factor of 2, and towards 2030, by a factor of 2.5–2.6 (up to US$ 190–205 per 1000 m^3) (Fig. 2).

The outlook for the development of sectors of the Russian economy, in accordance with the scenarios of the development of the national economy, as well as predicted levels of prices for fuel-and-energy resources, made it possible, as a result of multivariance simulation of market equilibrium between demand for and supply of main types of fuel-and-energy resources on domestic and foreign markets of energy resources, to determine rational volumes of production and consumption of fuels by type, including natural gas. Rational levels of natural gas production for the year

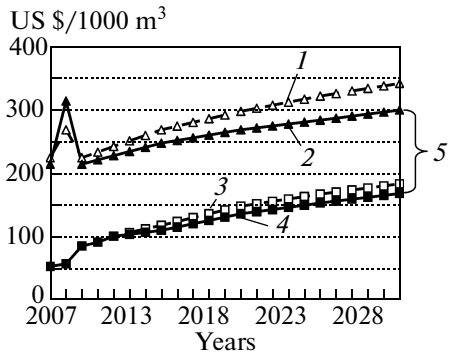


Fig. 2. Forecast of prices for natural gas on the domestic and foreign markets, dollars/1000 m^3; *1*—price for gas on the border with the European Union, the innovative scenario; *2*—the same, under the conservative scenario; *3*—prices for gas in the Russian Federation, under the innovative scenario; *4*—the same, under the conservative scenario; *5*—area of expenditures for gas transportation and customs duties.

2030 were estimated at 840 billion m^3 for the conservative scenario of development and 884 billion m^3 for the innovative one. Thus, levels of natural gas production according to the innovative scenario that were outlined in the ES-30 seem to be overestimated for the entire time period.

The calculated production-and-investment program for the development of the gas industry takes into account the complex financial situation that has emerged and will persist in the current crisis and the nearest post-crisis years (2009–2011), when opportunities to attract additional funds are (and will be) limited, prices for natural gas on the domestic market are (and will be) controlled by the state, and rates of their growth do not (and will not) provide a rise in the profitability of gas companies. Because of a lack of sources of finance, putting of the Bovanenkovo gas field located in the Yamal Peninsula into production has to be postponed: in the conservative scenario, until 2015, in the innovative one, until 2014. Respectively, construction of the gas pipeline from the Yamal Peninsula to the city of Ukhta is delayed as well. Putting of gas fields located in another new region of development—in the water area of Ob' and Taz bays—in production is postponed until 2015. As for large projects in the Tyumen Region, for the period up to 2015, the following events are predicted: reaching the planned level of production from the Yuzhno-Russkoye field, putting of new blocks in the Yurkharov field belonging to the NOVATEC company on operation, as well as an increase in production of associated petroleum gas owing to enhanced utilization of its resources up to 95%.

In the European part of Russia, according to the innovative scenario, the following is predicted: placing of the Stockman field on production not before 2015, while, according to the conservative scenario, this would be advisable to do after 2015. It is expected that the LUKOIL company will begin to implement its new gas project on the Caspian Sea continental shelf, with priority placed on the field named after Yu. Korchagin on production, and as soon as the year 2015, development of other gas fields prepared for production, with the capacity level of 14–20 billion m^3, is anticipated.

In the Far East, for the period until 2015, the only thing predicted is an increase of gas production from the existing Sakhalin projects and reaching the design output of 9.6 million tons (which corresponds to 13.6 billion m^3 of input feedstock) at the natural gas liquefaction plant located in the Sakhalin-2 field.

After 2015 intensive development of all new projects is predicted; otherwise, it would be impossible to compensate for the decline in levels of gas production from fields being under operation and increase volumes of gas production over the country as a whole. In the Yamal Peninsula, it is necessary to bring production from the Bovanenkovo gas field to 140 billion m^3, to place the Kharasovey field (up to 32 billion m^3), and in the innovative scenario, the Kruzenstern field, into production; to form the new gas-producing region in the water area of the Ob' and Taz bays; to place into production new fields belonging to the OAO LUKOIL in the Bolshekhet depression (the Yamalo-Nenets National District) and on the Caspian Sea continental shelf; to implement the Stockman project with construction of a natural gas liquefaction plant (taking into account the changed time of placing this field into production).

The rational version of the balance of natural gas suggests creation after 2020 of a large gas-producing base using natural gas resources of the Irkutsk Region, development of gas production using resources of the Yurubcheno-Takhom oil-and-gas bearing zone in the Krasnoyarsk region, beginning of commercial production of coal-bed methane in the Kuznetsk coal basin (Kuzbass). This will make it possible to bring gas production in Eastern Siberia to the level of 34 and 47 billion m^3 towards the year 2030, according to the conservative and innovative scenarios, respectively.

In the Far East development of the Sakhalin gas-producing base will continue by means of increasing production from existing fields and developing new projects on the Okhotsk Sea continental shelf and creation of new capacities for production of liquefied natural gas. Fundamentally a new gas base will be organized in the Republic of Sakha (Yakutia) where placing of the Chayandino gas field in production after 2015 will become effective only after creation of production capacities for helium utilization. If issues related to export of Far Eastern natural gas to China

are solved, volumes of gas production may increase by 2030 up to 76–84 billion m^3/year.

As a result of implementation of planned changes, the share of the Tyumen Region in the total gas production in Russia will decrease from 90.4% in 2008 to 70%, of which 20% will be provided from new gas-producing areas of the region, and the share of eastern areas will increase from 2% in 2008 to 14–15% in 2030 (Fig. 3).

Changes in the resource base of the gas industry will lead to a new stage in developing natural gas production: the share of reserves of purely methane gas will decrease, and it will become necessary to develop gas reserves with multicomponent composition of reservoir mixture and to develop fields with high content of hydrocarbons C_{2-4}, helium, and carbon dioxide. Creation of capacities for the processing of liquid hydrocarbons, separation of hydrocarbons C_{2-4} from gas and their transportation that would take place simultaneously with the development of gas fields, should become a determining factor in putting these reserves into production (this is particularly true for fields located in the East of Russia, with a unique content of helium). Organization of gas processing will not only prevent losses of valuable hydrocarbon material, but also make the development of gas fields more effective.

The production program of the gas industry involves considerable amount of gas transportation construction. The largest project—construction of the multiline system from the Bovanenkovo field in the direction of Ukhta, with consequent distribution of Yamal gas through the existing transportation system and new gas pipelines in the direction of Gryazovets, Torzhok, and Cheboksary, in order to provide for the demand for natural gas in central regions of Russia and deliver natural gas for export.

For diversification of gas export to Europe, it is planned to construct during the future period in question:

—the North-European trunk gas pipeline (Nord Stream). The first line of this facility is scheduled for commissioning in 2011, with volumes of delivery equal to 27 billion m^3/year. After placing this pipeline in full operation its total capacity will be 55 billion m^3/year.

—The Southern trunk gas pipeline (Southern Stream) in the direction of countries of Southern Europe, with capacity of up to 30 billion m^3/year. In optimization calculations concerning the development of the gas industry, according to the conservative scenario, a program-related decision was obtained when scheduled commissioning of the first line of the "Nord Stream" was postponed in the program until 2015, and commissioning of the "Southern Stream", until 2025, with capacity of 30 billion m^3/year. In the program drawn up according to the innovative scenario of the development, in which external factors are more favorable, the scheduled commissioning of the first line of the Nord Stream remains the same. As for the Southern Stream gas pipeline, it will be possible to put this facility into operation in 2020.

For delivering natural gas from the Shtockman field, it is planned to construct in the Unified Gas transportation system the gas pipeline from the Murman Coast (settlement of Teriberka) to the city of Volkhov.

In eastern regions, the priority project is the gas pipeline Sakhalin—Khabarovsk—Vladivostok for delivering natural gas to the domestic market (the first stage is scheduled to start operation in 2011) and for export (from 2013). Construction of the gas transportation system from the Chayandino field in the Republic of Sakha (Yakutia) to Vladivostok is scheduled for 2016–2020. Later on it is intended to supply gas produced from the Kovyktia field to this system, in order to deliver gas for export to countries of the Asia-Pacific Region. Reasoning from the calculated balance of natural gas, the capacity of the gas transportation system created in the direction of the border with China should be 50–60 m^3/year, for which it will be necessary to lay either two pipes 1490 mm in diameter each, or three pipes 1020–1220 mm in diameter each.

As for the gas industry altogether, in the European part of Russia alone volumes of construction of new trunk gas pipelines should be around 9500 km, in the East of Russia, 7000 km, while in case if it is decided to connect the eastern gas transportation system to the existing one, 11000 km. Large volumes of work on upgrading the existing gas transportation system, both on replacement of its linear part and on construction of additional shops in the existing pumping stations, will become necessary.

Implementation of the forecasted program for natural gas production, construction of the gas transportation system, the development of allied subsectors will be possible provided that capital investment in the gas industry will increase from 666 billion rubles in 2008 to 772–872 billion rubles in 2015. During the subsequent period 13.7–13.9 trillion rubles (US$ 537–545 billion) should be invested in the gas industry. Almost half of the investments should be earmarked for the development of the gas transportation system—51% and 55%.

It should be noted that, according to the conservative scenario, lack of funds in 2010–2015 determines the delay in projects and investments for further years. In accordance with the innovative scenario, amount of investments in 2011–2015 exceeds investments mentioned in the conservative scenario by almost 30%, i.e., funds of the industry make it possible to implement new projects sooner.

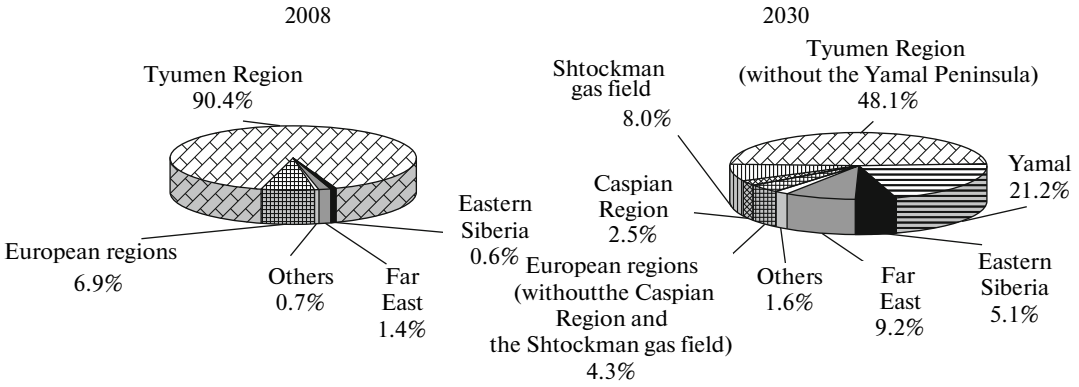


Fig. 3. Dynamics of volumes and the regional structure of natural gas production in Russia.

Risk analysis of drawn-up programs. The drawn-up production-and-financial program for the development of the gas industry is the sequence of financing and commissioning of projects that is tied to concrete dates; in this case, implementation of these projects has already been approved, and in the course of a certain time, it cannot be discontinued without considerable losses irrespective of information that might become available in the course of further development of the gas industry. Possible deviation of actual factors of the development of the gas industry from values included in calculations involves certain risks that should be identified and assessed by both participants of concrete projects (the state and private companies) and investing organizations that take part in financial backing of these projects.

The peculiar feature of risk analysis of production-and-investment programs for the development of industries and companies lies in the basic approach. The purpose of risk analysis of an individual investment project is to determine the probability of suffering losses at the time of its completion in case of an unfavorable situation. Such an approach is unacceptable for assessing a program for the development of the gas industry and a large company in what really matters: both of them do not have a priori determined "lifetime," after which it would be possible to sum up. The curve of the "life cycle" of the gas industry (combination of dynamics characterizing financial position of the industry) should be the subject of risk analysis as a whole, over a long-term interval of the future development that exceeds the typical lifetime of a particular investment project. In managing the development of companies an absolute value of profit is one of the conditions of the sustainable development. Assessment of a risk of decrease in the market value of a company, decrease in its ratings, and, finally, a risk of its bankruptcy is brought to the forefront.

The gas industry cannot confine itself to the risk analysis of individual projects, since its projects are highly inertial, highly capital-intense, and related by common technological processes (exploration—production—transportation—sale). The distinction of risk analysis carried out in the gas industry is that it is impossible to abandon the implementation of any program whatsoever in the same way as this can be decided with respect to an investment project.

The INEI RAN has been developed and is used as a technique of risk analysis of production-and-financial programs for the gas industry over the entire period of their implementation; the general scheme of risk analysis is shown in Fig. 4.

The key concept of the risk analysis is the use of simulation experiments. This means calculation of many simulations of the process of implementing the investment program under study. Forecasts of external conditions of the development of the gas industry differ radically and are considered as development scenarios, while accidental variations of internal and external conditions of development, as simulations within the framework of one scenario.

In the simulation experiment the system checks compliance with key criteria of financial soundness for each scenario of development of events and for an analyzed version of the program-related solutions. Calculations performed in the simulation system are organized according to the Monte-Carlo method [6, 7]. Initial data for each simulation in the scenario are formed by means of the random-number generator within the limits of ranges for risk factors preassumed by experts. Simulation is considered to be successful, if for each year of the time period in question, simulated interconnections and criteria conditions of the investment program under study are fulfilled.

The totality of simulations describes the diversity of possible implementation of an investment program that corresponds to the description made by experts. Conclusions should be drawn on the basis of statistical processing of simulations.

The next step of the method of simulation modeling is calculations, made by means of the simulation procedure, of consequences of realization of one or other values of primary risk factors. For this purpose calculation of the financial position of the gas industry is carried out in the simplest case (when there are no governing actions) making it possible to change the course of the implementation of the program depending on the availability of new, presently unknown information according to the determinate scheme.

Optimum solutions, with their characteristics of the effectiveness of the program for the gas industry, obtained for each random combination of risk factors, are to be treated statistically: from each characteristic range of possible values, assessments of the average value of magnitude, etc., are determined. On the basis of the quantitative analysis of characteristics describing performance of gas companies over the time interval in question, preferable strategies are selected and assessment of their risk is made.

In case, when in some simulation, if only one of the prescribed criteria for investment programs had not been met only in one year, this simulation should be considered unsuccessful. Risk assessment is calculated from results of the simulation modeling as a ratio between the number of unsuccessful simulations and the number of all simulations performed. The number of simulations is determined from required accuracy of assessment.

Since it is not known what combination of conditions occurs in reality, it is necessary to elaborate an assessment of risk associated with program-related decisions that would be the same for the entire totality of these conditions, for example, by the minimax method.

It should be noted that analysis of scenarios is the most crucial stage of drawing up program-related decisions, and this stage can be formalazed to the least extent. The state of the gas industry is assessed in each of the scenarios, and on this basis, ranking of the scenarios analyzed is carried out. In this case it is important not so much to distinguish especially attractive scenarios as to point to the most dangerous ones that do not ensure sustainable existence of the gas industry.

Programs with increased (not justified) risk should be rejected; however, it is not necessary that a program with minimum risk should be preferred. Thus, if lessening of risk involves production curtailing, it is possible to give preference to a program for the gas industry with somewhat higher risk, but not involving a decrease in production. The final decision should be made after weighing up the effectiveness of a program vs. its riskiness.

An important advantage of the method of simulation modeling is that risk assessment is made not in some conventional units but in the dimensions of probability, i.e., a ratio between the number of cases of suffering losses as a result of the implementation of a program and the total number of cases.

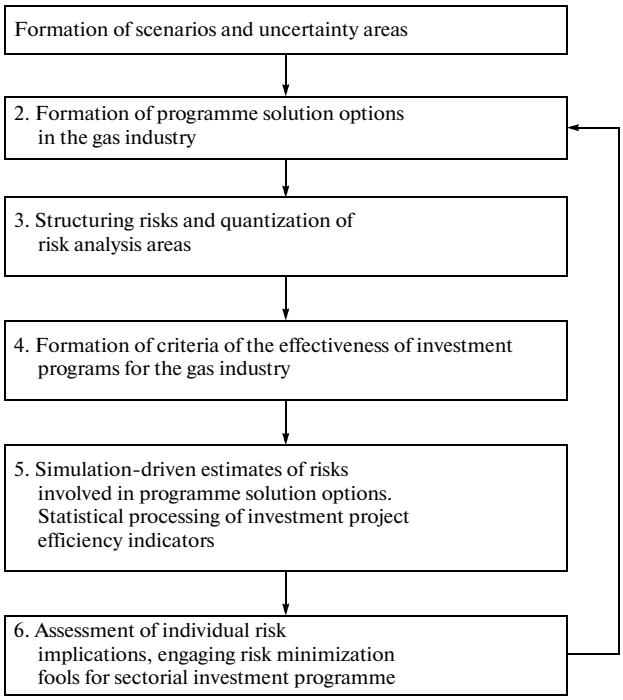


Fig. 4. The stages of risk analysis of investment programs.

Calculation of risk assessment can be supplemented with:

—analysis of the impact of individual risk factors upon the risk of the project as a whole;

—analysis of various methods of risk management.

In our calculations, in the process of statistical simulation, each scenario of an investment program was adapted to 1000 random realizations of external and internal conditions of the development of the gas industry. These realizations are constructed in accordance with the special program using the Monte-Carlo method, on the basis of ranges and/or functions of distribution of the probability of values of all risk factors in question. The following risk factors and interrelations between them were taken into account: world prices for oil; price for natural gas in Europe, the Asia-Pacific Region and the CIS; price for natural gas and demand for it on the domestic market; maximum volume of gas export to Europe and the Asia-Pacific Region; tariffs for gas transportation through the territory of Europe and the CIS; price for imported gas and possibilities for import; price for LNG; price for butane-propane gas, ethane, condensate, and volumes of their production; and investment and expenditures by key types of activity. Figure 5 shows ranges of prices

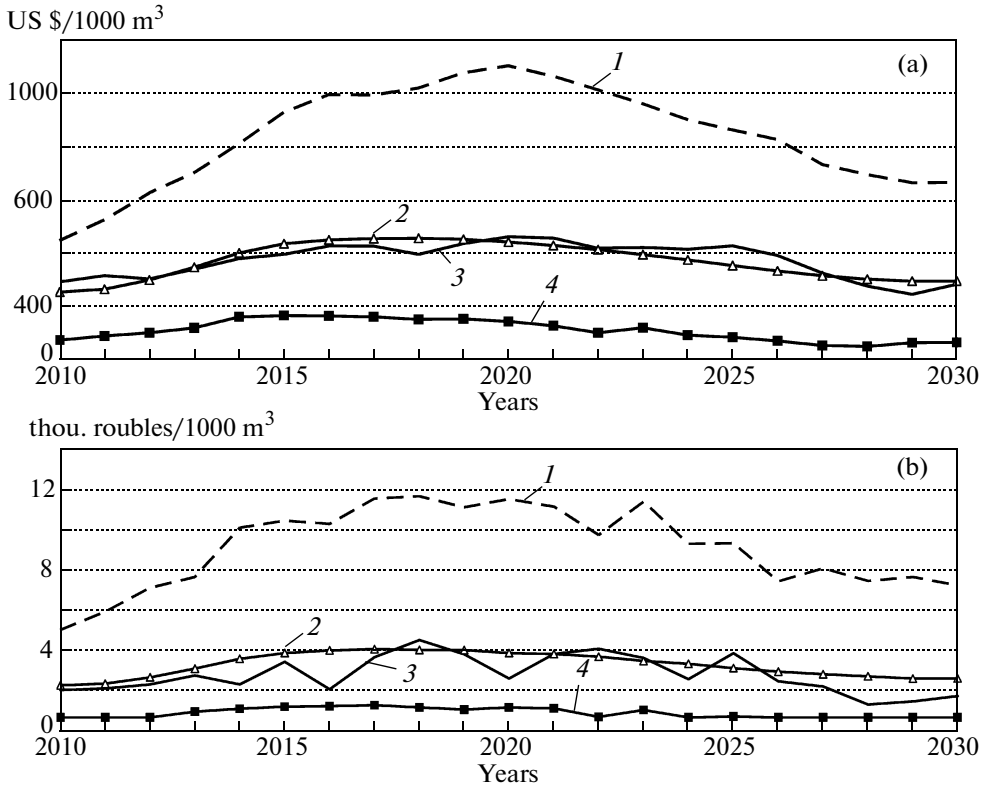


Fig. 5. Prices for gas in Europe (a) and Russia (b): *1*—maximum; *2*—average; *3*—one of simulations of price; *4*—minimum.

and random intermediate dynamics of external (on the European market) and domestic prices for natural gas formed for the purpose of calculations (they were calculated as being brought in equilibrium with prices on the European gas market).

The method of statistical studies makes it possible to determine two criteria parameters that characterize, under conditions of uncertainty, the effectiveness of scenarios of the investment program for the gas industry which are under examination, and that cannot be determined by means of other methods of study.

The first of these parameters is a risk of total failure in the activities of the gas industry or a company calculated for each scenario of the investment program as the share in the total number of random realization of those conditions under which either minimum external or the total domestic demand cannot be met (balance of gas is disrupted), or the gas industry (a gas company) becomes financially bankrupt.

Table 1. Main criteria parameters used in the scenarios of an investment program for the gas industry

Scenarios of the program	Conservative	Innovative
Mathematical expectation of net discounted income, US $ billion	199.2	178.1
Risk of failure (bankruptcy), %	21.1	24.0

The second criterion is the function of distribution of values of a main integral indicator of the effectiveness of a company's activity—net discounted income over the period in question—with customary statistical characteristics of distribution: mathematical expectation and dispersion.

Figure 6 shows histograms: the function of distribution of values of a main integral indicator of the effectiveness of the gas industry's activity—net discounted income over the period in question, and mathematical expectation of this function, for two scenarios of the development of the gas industry.

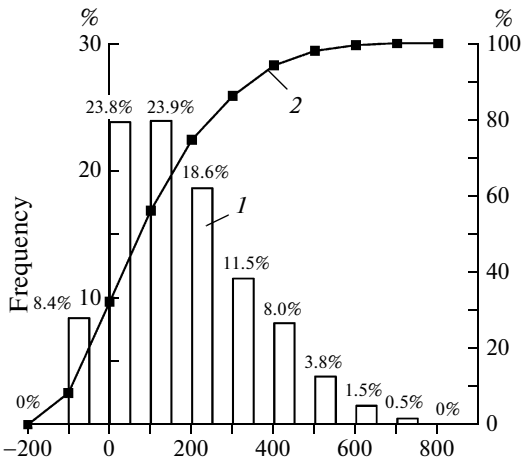
For the conservative scenario of the calculated program, the risk of failure in the activities of the gas industry is assessed at 21.1%, i.e., in 211 out of 1000 cases, solution of a problem that could meet both the preassigned demand for natural gas and financial constraints has not been found. Table 1 gues the values of the above criteria parameters for the conservative and innovative scenarios of the investment programme.

In the process of risk analysis of strategies of the development of the gas industry, apart from the value

(a)

from –200 to –100	0%	0%
from –100 to 0	8.4%	8.4%
from 0 to 100	23.8%	32.2%
from 100 to 200	23.9%	56.1%
from 200 to 300	18.6%	74.7%
from 300 to 400	11.5%	86.2%
from 400 to 500	8.0%	94.2%
from 500 to 600	3.8%	98.0%
from 600 to 700	1.5%	99.5%
from 700 to 800	0.5%	100.0%
Above	0%	100.0%

Mathematical expectation US $ 199.17 billion
Mathematical expectation at successful simulations US $ 250.55 billion
Risk assessment based on net discounted income 8.4%
Total risk 21.1%



(b)

from –200 to –100	0%	0%
from –100 to 0	8.4%	8.4%
from 0 to 100	30.1%	38.5%
from 100 to 200	23.4%	61.9%
from 200 to 300	17.2%	79.1%
from 300 to 400	10.9%	90.0%
from 400 to 500	6.5%	96.5%
from 500 to 600	2.5%	99.0%
from 600 to 700	0.9%	99.9%
from 700 to 800	0.1%	100.0%
Above	0%	100.0%

Mathematical expectation US $ 178.13 billion
Mathematical expectation at successful simulations US $ 230.65 billion
Risk assessment based on net discounted income 8.4%
Total risk 24.0%

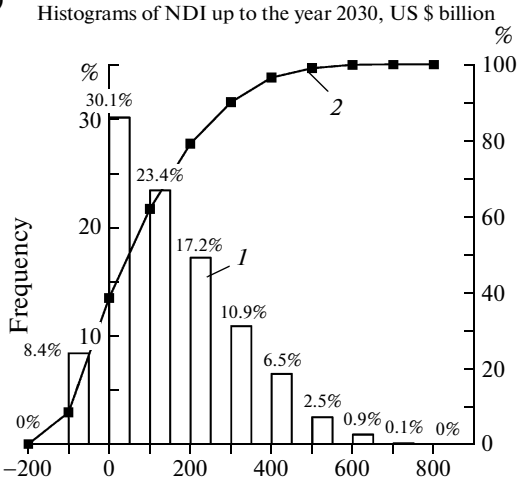


Fig. 6. Distribution of net discounted income of the gas industry for an investment program: (a) conservative scenario; (b) innovative scenario; *1*—frequency; *2*—integral distribution, %.

of net discounted income, the following indicators are also determined: free cash flow, balance of money, net profit, both annual dividends and those discounted over the entire period, borrowed funds, gearing, and annual credits. Results of calculation are given in Table 2. Analysis shows that the innovative scenario is less risky than the conservative, with respect to net profit and discounted dividends, equally risky with respect to net discounted income, and considerably worse with respect to annual credits, and, hence, to the total risk.

The average value of borrowed funds for the year 2030 obtained as a result of successful simulations was 70 billion rubles in the conservative scenario and 130 billion rubles in the innovative one, which, presumably, can be attributed to the innovative nature of these scenarios.

The risk analysis of production-and-financial programs for the development of the gas industry up to the year 2030 makes it possible to quantitatively assess for the industry the consequences of development strategies being selected and to make the following conclusions:

(a) under conditions of high uncertainty in internal and, especially, external conditions of the develop-

Table 2. Risks associated with the strategy for the gas industry, by individual criteria

Risks	Scenarios of the programme	
	Conservative	Innovative
With respect to net discounted income, %	8.4	8.4
With respect to discounted dividends, %	4.3	3.8
With respect to net income, %	14.6	13.8
With respect to gearing, %	10.5	11.4
With respect to credits, %	20.9	24
Total, %	21.1	24

ment of the gas industry, the most effective strategy (ensuring minimum risk at maximum expected value of net discounted income of the gas industry) is the strategy of moderate investment during the nearest future period (2010–2015) in large new projects, with delay in their development;

(b) under this strategy that corresponds to the principle of "postponed development," it is advisable to prepare, both during the current years and in the coming five-year period, new projects organizationally and technologically, rather than speed up their putting into production. It would be more advisable to put off intensive investments in large efficient projects until external conditions required for the developmental change.

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