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A Simplified Model of the Russian Gas Industry

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A Simplified Model of the Russian Gas Industry

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Abstract. Russia feels confident in the group of leading countries in the production and export of natural gas (natural and associated) due to the largest proven reserves. The unique ecological properties of natural gas in comparison with other types of fossil fuels, according to analysts of the largest international energy companies and leading world energy agencies, will allow it to maintain an ever-increasing demand in the future until 2040, despite the massive introduction of renewable energy sources (RES) around the world. There is no consensus among the forecasters about the levels achieved at the end of the forecast period and the growth rates. According to forecasts, the main drivers of gas demand growth will be the third world countries, which will be led by India and China. According to forecasts, the European gas market will stagnate due to the widespread introduction of energy-saving technologies, global climate change and the massive construction of renewable energy sources in the large and small electric power industry, due to significant legislative and significant economic preferences. The COVID 19 pandemic has significantly reduced the demand for gas, which, together with low prices in all world markets, calls into question the implementation of not only the most capital-intensive projects, but also projects with medium capital intensity. In this regard, the creation of a simplified model of the gas industry in Russia is becoming more urgent.

1. Introduction

For many years, Russia has been confidently in the group of leading countries in the production and export of natural (natural and associated) gas due to the world's largest proven reserves [1]. The unique ecological properties of natural gas compared to other types of fossil fuels, the low cost of production and ease of delivery to the end consumer, according to analysts of the largest international energy companies and leading world energy agencies, will allow it to maintain the ever-increasing demand in the future until 2040, despite the massive introduction of renewable energy sources (RES) around the world [2] - [7]. There is no consensus among the forecasters about the levels achieved at the end of the forecast period and the growth rates. According to forecasts, the main drivers of gas demand growth will be the third world countries, which will be led by India and China. According to forecasts, the European gas market will stagnate due to the widespread introduction of energy-saving technologies, global climate change and the massive construction of renewable energy sources in the large and small electric power industry, due to significant legislative and significant economic preferences. The COVID-19 pandemic has significantly reduced the demand for gas everywhere, which, together with low prices in all world markets, calls into question the implementation of not only the most capital-intensive Russian projects, but also projects with medium capital intensity in the Russian gas industry. The recovery in gas demand is currently very uncertain - due to the second wave of the COVID 19 pandemic in European countries and attempts by large multinational corporations to reduce the risks of international supply chains disrupted by the pandemic. Large international corporations have now come to the conclusion that the location of production in countries with cheap labor is not worth the possible risks and are starting to return production to the country where the corporation is located in a robotic form. Lower interest rates on loans, which central banks are trying to compensate for the pandemic, will also help bring production capacity home in a robotic form. In the Russian gas industry, investments in medium-term projects have already been made, and the conservation of unfinished facilities may even cost more than their completion. The introduction of a tax on the so-called carbon footprint by European countries is very likely, since the WTO rules currently do not directly prohibit this. In such conditions of high uncertainty of the international gas markets of this connection, the creation of a simplified model of the gas industry in Russia is becoming most urgent.

2. Optimization model of the Russian gas industry

The innovative development of the Russian gas industry and its fulfillment of its obligations to supply gas to domestic and foreign markets will primarily depend on the reliability of funding sources. Reliable financing, in turn, depends on the state of the world gas markets, the dynamics of the internal gas market, changes in taxation - both in the field of subsurface use and in the field of greenhouse gas emissions and the possibility of reducing costs through the widespread introduction of innovative technologies along the entire technological chain from production to supply gas to the end consumer. Maintaining the efficient operation of the Russian gas industry requires very significant investments, taking into account the significant depletion of gas reserves at existing giant fields and the significant aging of the gas transmission system created during the existence of the Soviet Union. To select innovative options for the development of the gas industry in Russia, ERI RAS developed an optimization model of OMO "Gas", which is an integral part of the Scaner model and information complex created at ERI RAS, described in [8] - [10].

The production and financial linear optimization model of OMO "Gas" takes into account both the production and technological processes of the gas industry companies, as well as financial and economic transactions both within companies and between companies, banks and the state in the future until 2050. This model takes into account all possible technological, financial and economic ties of enterprises in the gas industry in the form of structured constraints that set the limit values for all financial, economic and production operations of enterprises in the gas industry of the Russian Federation. The decision models obtained as a result of the work cover a prospect of up to 40 years, of which the first 10 years - annual decisions, the next years - five-year decisions. The last 10 years of the forecast were made to exclude the so-called "edge effect". OMO "Gas" allows you to select effective investment programs of companies in the gas industry only in the gas business, since the activities of companies in the following areas are modeled:

- Geological exploration.
- Production of natural gas.
- Gas processing.
- Transportation of pipeline gas
- Gas liquefaction.
- Transportation of liquefied gas.
- Gas sales on the domestic market.
- Gas sales on foreign markets.
- Purchase of associated and imported gas.
- Financial and economic support of production activities of companies in the gas business

The related and non-core activities of gas companies are not considered in the OMO Gas model.

Functionally, the model of OMO "Gas" consists of three blocks - production and technology, financial and economic and rating. In the production and technological block, resource and technological parameters and restrictions in gas production for deposits of fields, gas processing plants, transportation of pipeline gas to domestic and foreign markets, liquefied natural gas (LNG) plants and LNG transportation are laid down. The financial and economic block includes cash flows of gas industry enterprises, restrictions and structural relationships in settlements between gas companies, banks and the state. The rating block forms indicators of financial stability, investment attractiveness and capitalization of gas companies. The model of OMO "Gas" adequately reflects the functioning of the gas industry in Russia for the long term due to the joint calculation and optimization in one model of the production, technological and financial and economic capabilities of the companies in the industry. At the same time, it is necessary to note the great complexity of this model due to the increased detail and relatively high time costs in the calculations. It is rather difficult to obtain with the help of OMO "Gas" solutions that lie outside the optimal ones, such as investments made with a view to large volumes of markets, but the volumes of gas sales are several times lower. In this regard, there is an urgent need to assess the position of companies in the gas industry and the creation of a simplified model of the gas industry in Russia is becoming most urgent.

3. Simplified model of the gas industry

The simplified model of the gas industry in Russia UMO Gas uses as a basis the optimized scenarios for the development of the gas industry in the Russian Federation, obtained as a result of the operation of the UMO Gas model and contains three similar blocks in its structure - production and technology, financial and economic, and rating. UIO "Gas" should make it possible to determine:

- Amounts of required financial borrowings by companies in the industry, depending on the dynamics of the volumes of external markets for network gas specified by the user.
- Amounts of required financial borrowings from companies in the industry, depending on the price dynamics set by the user in the external markets of network gas.
- Amounts of required financial borrowings by industry companies, depending on the dynamics of the volumes of external liquefied gas markets specified by the user.
- Amounts of required financial borrowings by companies in the industry, depending on user-specified price dynamics in external markets for liquefied gas.
- Dynamics of prices on the domestic gas market for the chosen scenario of the gas industry development.
- The production, technological, financial and economic state of the companies in the gas industry with delays in the commissioning of facilities (Nord Stream 2).

Each *i*-th project in gas production is represented by three vectors characterizing the design levels of gas production, operating costs and capital investments:

$$P_i = (d^i, c^i, k^i),\ i \in I_l, \tag{1}$$

There are different options for implementing the *i*-th project:

$$\left(d_t^i(\tau), c_t^i(\tau), k_t^i(\tau)\right) = \begin{cases} \left(d_{t-\tau+1}^i, c_{t-\tau+1}^i, k_{t-\tau+1}^i\right), & for\ t \ge \tau \\ (0, 0, 0), & for\ t < \tau \end{cases} \tag{2}$$

The total production volume will be determined as:

$$x_l^{\partial}(t) = u_l^p(t) + \sum_{i \in I_l} \sum_{\tau=1}^{t} d_t^i(\tau) u^i(\tau) \tag{3}$$

The total operating costs for production will be determined as:

$$x_c^p(t) = \sum_l c_l^p(t) u_l^p(t) + \sum_l \sum_{i \in I_l} \sum_{\tau=1}^{t} c_t^i(\tau) u^i(\tau) \tag{4}$$

The total capital investment in production will be determined as:

$$x_к^p(t) = \sum_l k_l^p(t) u_l^p(t) + \sum_l \sum_{i \in I_l} \sum_{\tau=1}^{t} k_t^i(\tau) u^i(\tau) \tag{5}$$

The gas flow from node *i* to node *j* in the last year of period *t* will be defined as:

$$x_{ij}^{tr}(t) = u_{ij}^{0}(t) + u_{ij}^{н}(t) \tag{6}$$

The total operating costs for the main transport of network gas will be determined as:

$$x_c^{tr}(t) = \sum_i \sum_j (c_{ij}^o(t) u_{ij}^o(t) + c_{ij}^н(t) u_{ij}^н(t)) \tag{7}$$

The total capital investments in the main transport of network gas will be determined as:

$$x_l^{tr}(t) = u_l^p(t) + \sum_{i \in I_l} \sum_{\tau=1}^{t} d_t^i(\tau) u^i(\tau) \tag{8}$$

Fixed restrictions on transport on existing gas pipelines at t = 0 (taking into account the dynamics of their disposal) will be determined as:

$$u_{ij}^o(t) \le q_{ij}^*(t) \tag{9}$$

Transport restrictions on new gas pipelines will be determined as:

$$u_{ij}^н(t) \le x_{ij}^{np}(t) \tag{10}$$

The capacity of the LNG plant will be determined as:

$$x_{м\,i}^{LNG}(t) = x_{м\,i}^{LNG}(t-1) + u_{np\,i}^{LNG}(t) \tag{11}$$

The total operating costs of the LNG plant will be determined as:

$$x_{c\,i}^{LNG}(t) = C_i^{LNG}(t) \cdot u_i^{LNG}(t) \tag{12}$$

The total capital investment in the LNG plant will be determined as:

$$x_{к\,i}^{LNG}(t) = k_i^{LNG}(t) \cdot u_{np\,i}^{LNG}(t) \tag{13}$$

The costs of transit of pipeline gas through the territory outside Russia will be determined as:

$$x_{tr}^{tr}(t) = h_t \sum_{i=1}^{M} \sum_{r=1}^{F} x_{П\,r\,i}(t) \cdot S_{r\,i}^{T}(t) \cdot R_{r\,i}^{T} / 100 \tag{14}$$

Gas consumption for its own technological needs by the Russian gas transmission system will be determined as:

$$x_{on}(t) = \sum_{ij}(1 - a_{ij}^{+}) \cdot x_{ij}^{tr}(t) \quad (15)$$

Gas consumption for own technological needs of the i-th LNG plant will be determined as:

$$x_{on}^{LNG}(t) = \sum_{i}(1 - a_{i}^{+}) \cdot x_{i}^{LNG}(t) \quad (16)$$

4. Conclusions

UMO "Gas" is a dynamic model with the presence of uncertain factors, such as sales volumes in the domestic and foreign markets of network and liquefied gas, the dynamics of prices for them, the tax burden on industry companies.

With fixed values of uncertain factors, the model takes on a linear character and makes it possible to assess the effectiveness of innovations with any given functionalities - from determining the minimum prices and volumes of gas sales in various markets to minimizing the credit and tax burden on the industry.

UMO Gas could be modified to add new restrictions and controls - such as carbon footprint fees.

5. References

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