Special Aspects of Modelling the Russian Federation Gas Industry in the Context of Market Transformation

Special Aspects of Modelling the Russian Federation Gas Industry in the Context of Market Transformation

A E Tarasov[1]

[1]Russia and world energy complex research department, The Energy Research Institute of the Russian Academy of Sciences (ERI RAS), Nagornaya st., 31, k.2, Moscow, 117186, Russia

E-mail: aet98@mail.ru

Abstract. Currently, the most environmentally friendly fossil fuel is gas. Russia occupies one of the first places in the world for gas production and reserves. A significant part of the gas produced is being exported as piped or liquefied. Lately, the gas markets conventional for Russia have undergone some rather major changes. Ukraine has almost left the CIS market and settled for reverse gas supplies from Eastern Europe. Nowadays, independent gas producers have access to the liquefied gas export channels. From this year on a number of the Eurasian Economic Union (EAEU) states got access to this platform besides the Russian buyers. Independent gas producers are now allowed to sell gas on the commodity exchange to the EAEU states, thus also including piped gas into the exports. The European countries aspiration to diversify gas supply sources and the raging growth of renewable power result in the essential periodicity of supplies and demand growth at the gas spot markets. The article reviews the special aspects of the gas industry modelling under the conditions of market transformation.

1. Introduction

In terms of discovered and produced gas reserves, the Russian Federation firmly ranks among the world's leaders falling back a bit for Iran and the USA (in terms of reserves and production, respectively) [1]. Russia is one of the leading gas exporters in the world. Recently, the traditional for Russia gas markets in Europe and the CIS have undergone rather major changes.

Successful development of shale gas recovery technology in the US led to major changes in several markets at once. In the US domestic market, cheap shale gas due to the specific production technology and associated condensate replaced domestic coal. This coal was instead exported to the foreign markets including Europe. Up until recently, the majority of the newly commissioned generating capacities in the European energy market were coal due to its low prices compared to relatively expensive gas along with the growing price of oil and initially overestimated emission quotas as per the Kyoto Protocol. As a result, the traditional for the RF European gas market, stagnating until the recent times, has been narrowed down both due to the increased coal production share and imports of liquefied gas from Qatar, originally intended for the United States. Meanwhile, the US has turned from an LNG importer to its exporter. The major part of American liquefied gas supplies is exported to the countries of the Asia-Pacific region and the American continent [1]. As for the European gas market, due to the norms of the Third Energy Package it has been impossible for a long time to load the Nord Stream gas pipeline fully. Currently, this problem is partially resolved by allowing PJSC Gazprom to auction 30-40% of the Opal gas pipeline capacity in addition to the existing 50% stake, and partially -

by moving gas delivery points of PJSC Gazprom's European partners in terms of their share in gas production at the jointly developed fields (Yuzhno-Russkoye, deposits of the Achimov Formation, Urengoiskoye field). The EU countries aspiration to diversify the sources of gas supplies due to the European Union's political ambitions and the unrestrained growth of subsidized RES lead to highly periodical supply and an increased demand on the spot gas markets. The European countries domestic production will decline because of the depletion of the existing deposits (in the North Sea, on the Norwegian shelf) or because of a significant decrease in production due to man-induced threats (earthquakes near the Groningen field), and the newly implemented Norwegian fields would be unable to compensate for the production drop. The newly concluded long-term contracts for the piped gas supply to the EU countries include binding to the gas hubs prices [2] and electricity instead of oil and exclude "take or pay" conditions and prohibitions for contracted gas re-export.

The LNG market that has recently become relatively global is characterized by a high degree of uncertainty in regard to demand and supply, thus resulting in high price volatility. This is all due to a change in the participant roles in this market - the US began to export gas, Egypt and Malaysia - to import it due to the completion of the industrial development of the deposits. In the new LNG contracts, there is an increasingly frequent link to mixed pricing in place of oil and the terms "destination clause" and prohibitions on re-export of supplied gas are excluded. One of the new trends in the LNG market development is the use of liquefied gas to bunker sea vessels in accordance with the decision of the International Maritime Organization to limit sulphur emissions. For the Russian Arctic projects, Yamal LNG and the Arctic LNG, it is necessary to build transshipment facilities in Murmansk and Kamchatka to shorten the route of LNG delivery with reinforced ice-class tankers in the ice-free water zone.

Ukraine has almost dropped from the CIS market, now satisfied with the reverse gas supplies purchased in the Eastern Europe. Up until recently, PJSC Gazprom had exclusive rights to export Russian gas. Now independent gas producers have access to the export channel for the liquefied gas supply. From this year on, the trading volumes on the gas exchange in Saint Petersburg increased to 35 bcm for both Gazprom and independent gas producers. Also, the Saint Petersburg Gas Exchange became available to buyers from the European Economic Union countries. Therefore, Gazprom can now sell its share of gas at any contract price, which was not possible earlier due to legislatively fixed minimum price level for Gazprom's regional domestic gas supplies. Independent gas producers can sell gas to the exchange to buyers from the EAEU countries, thus also exporting piped gas. The upcoming commissioning of a nuclear power plant in Belarus and the vague prospect of the former Soviet Union unified energy system BRELL will raise the issue of the volumes and cyclical nature of the purchases of Russian gas, since for the nuclear power plant's normal operation it is necessary to have backup generating capacities that would replace the nuclear power plant blocks shut down at planned intervals for maintenance.

The analysis of long-term forecasts by the leading world energy agencies - the International Energy Agency (IEA), the US Department of Energy (EIA) and the largest oil and gas corporations (BP, ExxonMobil, Shell, and Statoil) - demonstrates the growing energy demand in the world by 2035-2040. [3] - [8]. The growth of world energy consumption is on the one hand determined by population and GDP growth and is at the same time constrained by increasing energy efficiency. According to the forecasts, the increase in energy consumption will mostly occur in the developing countries, and the largest contribution will be made by India and China.

The comparison of the world energy development forecasts [3] - [8] revealed major differences in the production and consumption levels of various types of energy along with significant differences in the rates of change and levels depending on the groups of countries.

2. Modelling of the energy industry development in Russia and the world

To model the energy development in Russia and the world, the SCANER modelling and information complex [9] is used in the Energy Research Institute of the Russian Academy of Sciences (ERI RAS).

It is a system of optimization and simulation models developed at ERI RAS, interconnected by cross production and financial and economic links (Figure 1).
The Scaner complex includes the following models with the corresponding databases:

- module for global energy forecasts;
- module for forecasting the Russian Federation development;
- module for the development of scenarios of external conditions;
- module for forecasting energy consumption;
- electric power sector module; gas and gas processing industry module;
- oil and oil refining industry module;
- coal industry module.

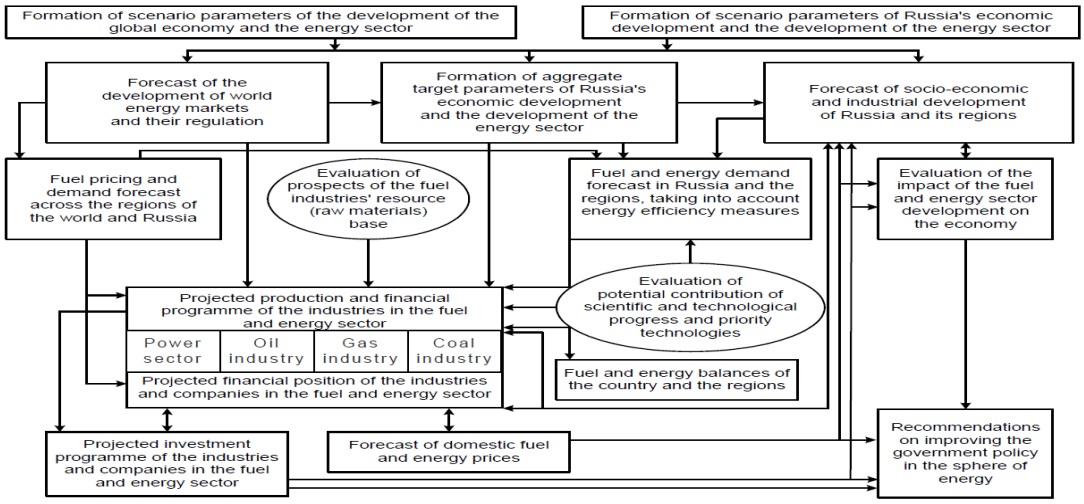

Figure 1. The structure of the Scaner.

Due to the extensive volume of verified technical, power and economic information available in the system, SCANER makes it possible to develop mutually agreed scenarios for the development of energy in Russia and the world in terms of the main stages of energy conversion - from production (for 20 types of primary energy resources) to consumer use (for 10 main energy sources) in a long term perspective.

SCANER enables forecasting world energy in the world's main macroregions and 62 major countries, the economy and the fuel and energy sector of Russia - for all basic foreign trade activities in 83 constituent entities of the Russian Federation and for modelling the development of the country's big energy companies. A high degree of final detail allows to consider different compositions and number of regions of the world and Russia [9].

Generation of scenario parameters of the country's social and economic development and the development of the Russian energy industry in relation to selected global trends, as well as possible scenarios for the transformation and modernization of the Russian economy and the state's internal energy policy (tax, price, structural, etc.) is carried out using a simulation Coordinating System. This model allows to calculate the forthcoming dynamics of the economy and the population's incomes, the corresponding domestic consumption, basic energy resource production and exports, wholesale prices in the countries' regions, as well as to estimate the country's total greenhouse gas emissions and required capital investments for the fuel and energy industry development, the level of energy conservation and the development of distributed energy.

Forecasting the development of the world's energy markets is based on the evaluation of demography, development of the world economy, technological development pace, energy and environmental policies accepted in various countries all over the world. The results of the calculations

include: scenario forecasts of primary energy consumption in the world as a whole, main regions and major countries; forecasts of demand for oil, basic petroleum products, natural gas, coal, nuclear energy and renewable energy sources globally, in macroregions, countries and consumption sectors; the volume of gas production and consumption with a breakdown by the world states, spot and contract gas prices by countries and regions, as well as volumes of piped gas and LNG supplies in relation to the sectors.

The module for forecasting social and economic development of Russia and its regions ensures the coordination of the parameters of investment, pricing, taxation and export policies in the energy sector with the dynamics of economic development, capabilities of the state budget, consumer industries and households. Besides, this module performs an evaluation of the macro-economic consequences and feasibility of investment programs in the energy sector and the options for reforming fuel and energy markets. Also, in this module the macro-economic analysis of the suggestions regarding the improvements to the taxation, pricing and investment policies of the state applying to the industrial production, transportation and energy resource sales is carried out.

The module for forecasting energy consumption and the development of fuel and energy balances is intended to assess the demand for the main types of fuel, electricity and centralized heat for the country, federal districts and constituent entities of the Federation for up to 20-25 years on the basis of external forecasts (demographic, socioeconomic, technical progress, etc.) and various state programs (housing construction and improvement, energy conservation, etc.), thus forming up an interrelated system of reporting and estimated federal and regional energy balance plans in an international format.

The electric power sector module allows to obtain electric power and capacity balances with an estimation of rational development of generating capacities and electric power production with a breakdown by regions, technologies and energy resources; balances of centralized heat use by constituent entities of the Russian Federation, the structure of generating capacity commissioning, necessary volumes and targets of investments in the electric power industry, their economic and commercial efficiency, a forecast of organic fuel demand and the volumes of involved non-fuel resources.

The oil industry module is intended to deliver on the following tasks: long-term forecast of oil industry development agreed with the interests of oil companies under various scenarios of external and internal prices and tax and customs regimes; optimization and risk analysis of options for oil production, transportation and refining ensuring sustainable oil industry development under given forecasts of world prices; selection of technologically feasible and economically viable options for the development of production, processing, transportation and export of oil and petroleum products and assessment of the financial condition of major gas and oil companies.

The gas industry module ensures long-term forecasts for the gas industry's production base development, gas exports and supplies for the domestic market based on Russia's energy needs and the conditions for the financial stability of gas companies under different world price scenarios, as well as different options for gas pricing and tax and customs regulations in Russia. Among the unique features of the module is the original dynamic model of the development of the gas industry “OMO Gas” ensuring optimization and risk analysis of options for the development of gas companies, their work at the domestic market, exports, imports and transportation services - over the years for the current decade and five-year periods up to 2050. Along with the development of production, processing, liquefaction and transportation of piped gas, liquefied gas and gas condensate, it describes the financial flows of PJSC Gazprom and other gas producers taking into account their interactions at the domestic and foreign markets.

3. Modelling of the Russian Federation gas industry

The linear optimization production and financial model of the gas industry (fig.2) in dynamics includes the following interconnected modules:

- The production module describing dynamic and technological interrelationships of industrial processes of production, processing, liquefaction and transportation of piped gas, LNG and

condensate to the domestic and foreign markets as a system of balance constraints. The text should be set to single line spacing.

- The financial module reflecting the terms of the financial balance of Gazprom and independent gas producers, and also assessing the dynamics of revenues, expenses, dividends, assets, own and borrowed capital. Paragraphs should be justified.
- The ranking module, determining the conditions (ratings) of financial stability and the growth of companies' capitalization during the implementation of their production and financial decisions. The first paragraph after a section or subsection heading should not be indented; subsequent paragraphs should be indented by 5 mm.

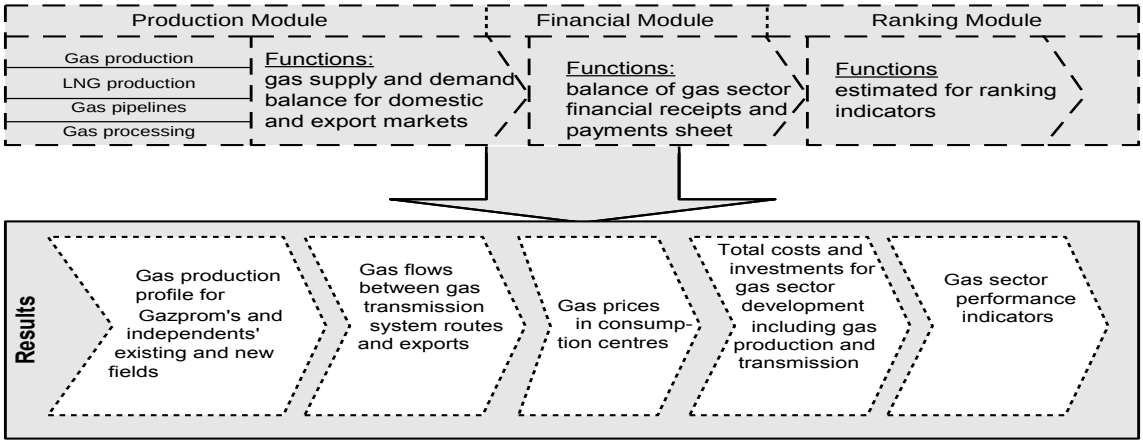

Figure 2. The structure of the gas industry model "OMO Gas".

In the model, the predicted period is divided into T time intervals $t = 1, ..., T$ (possibly of different durations h_t).

Gas sales from the LNG terminal $x_{мi}^{LNG}(t)$ at the network node i in the last year of the time interval t,

$$x_i^{LNG}(t) = \left(1 - a_i^{LNG}(t)\right) \cdot u_i^{LNG}(t)$$

The capacity of the LNG terminal $x_{мi}^{LNG}(t)$ at the network node i in the last year of the time interval t,

$$x_{мi}^{LNG}(t) = x_{мi}^{LNG}(t-1) + u_{npi}^{LNG}(t)$$

OPEX of the LNG terminal $x_{зi}^{LNG}(t)$ at the network node i in the last year of the time interval t,

$$x_{зi}^{LNG}(t) = C_i^{LNG}(t) \cdot u_i^{LNG}(t)$$

Capital investments in the LNG plant $x_{кi}^{LNG}(t)$ at the network node i over the period t,

$$x_{кi}^{LNG}(t) = k_i^{LNG}(t) \cdot u_{npi}^{LNG}(t)$$

LNG flow $x_{ir}^{LNG}(t)$ directed from the network node i to the LNG market r

$$x_i^{LNG}(t) = \sum_r^i x_{ir}^{LNG}(t)$$

Tanker freight and regasification costs for the delivery of LNG $x_{ir}^{LNG}(t)$ sent from the network node i to the LNG market r

$$C_{ir}^{LNG}(t) = \left(\sum_{r}^{i} c_{ir\,fr}^{LNG}(t) + \sum_{r}^{i} c_{ir\,reg}^{LNG}(t) \right) * x_{ir}^{LNG}(t)$$

When delivering LNG on the "destination clause" terms and sea with vessel bunkering, the cost of tanker freight and regasification

$$c_{i\,fr}^{LNG}(t) = c_{i\,reg}^{LNG}(t) = 0$$

Terminals for LNG loading are located in the transport and logistics chain nodes and are characterized by the following values:

‘ $c_i^{LNG}(t)$ – specific OPEX, including depreciation, over a time interval *t*',

‘ $k_i^{LNG}(t)$ – specific capital costs',

‘ $a_i^{LNG}(t)$ – specific loss of gas for the terminal's own needs, where *i* is the number of the network node’,

‘ $u_i^{LNG}(t)$ – gas delivery to the terminal at the network node *i* in the last year of the time interval *t*'.

‘ $u_{npi}^{LNG}(t)$ – increase in the LNG terminal capacity over the time interval *t*'.

‘ $c_{ir\,fr}^{LNG}(t)$ – specific costs for tanker freight from node *i* to market *r'*,

‘ $c_{ir\,reg}^{LNG}(t)$ –specific costs for regasification at the market *r*.

Revenue from gas sales in all markets of the domestic market for Gazprom $R_{sum}^{rec}(t)$, consists of revenues from gas sales on the exchange $R_{ste}^{rec}(t)$, gas sales to industrial consumers $R_{ind}^{rec}(t)$, to the population $R_{h}^{rec}(t)$ over the period t:

$$R_{sum}^{rec}(t) = \sum_{j=1}^{3} R_{j}^{rec}(t)$$

In the financial balance of Gazprom introduced retroactive payments $P^{ra}(t)$. Gazprom's participation in the projects Turkish Stream and Nord Stream 2 is reflected in the financial balance in the form of long-term financial investments $L^{TS}(t)$ and $L^{NS2}(t)$, respectively.

The changes made in the "OMO Gas" model allow us to obtain the greatest number of optimal solutions in the area of forecasting the development of the Russian gas industry and its constituent companies for the period up to 2040. By maximizing the approximated production and financial processes of the Russian gas industry and its constituent companies, accuracy of calculations increases significantly.

4. References

[1] *BP Statistical Review of World Energy* June 2017
[2] P Heather *Development of gas hubs and their role in benchmarking for physical natural gas supply contracts* https://energy.skolkovo.ru/downloads/documents/SEneC/research01.pdf reference date 20.05.2018
[3] *Annual Energy Outlook 2018* U.S. Energy Information Administration (EIA)
[4] *World Energy Outlook 2018* International Energy Agency (IEA)
[5] *BP Energy Outlook – 2018 edition*
[6] Exxon Mobil *Outlook for Energy: A View to 2040*
[7] *Sky Scenario* Shell 2018
[8] *Energy Perspectives2017* Statoil

[9] *Modelling and information complex SCANER* https://www.eriras.ru/data/92/eng reference date 20.05.2018