Prospects for the Development of the Gas Motor Fuel Market in Russia

I.V. Provornaya[1], I.V. Filimonova[1,*], V.A. Vakhnova[2], A.A. Dolganov[1,2]

[1] Trofimuk Institute of Petroleum Geology and Geophysics of the Siberian Branch of the Russian Academy of Sciences, Novosibirsk, Russia
[2] Novosibirsk State University, Novosibirsk, Russia

***Abstract* — The study focuses on a gas motor fuel market, assessing its level of expansion across Russia's federal districts in the context of their specific economic situation and infrastructure capabilities. A unique set of key factors influencing the expansion of the vehicle fleet that uses natural gas as fuel is identified for each federal district. The current availability of the necessary compressed natural gas refueling infrastructure across different regions is analyzed in detail. The effectiveness of government support measures aimed at stimulating both demand and supply in the gas motor fuel market is evaluated. The paper also reviews forward-looking projects intended to further expand the market both in individual constituent entities of the Russian Federation and nationwide. The findings suggest that for the market to thrive, it is vital to enhance the regulatory and legal framework that governs interaction between the federal center and the regions, expand the network of refueling stations, promote innovative projects through private investment, and cultivate a positive public image of gas motor fuel.**

***Index Terms* — Natural gas, alternative fuel, gas motor fuel, GMF infrastructure, government support.**

* Corresponding author.
E-mail: filimonovaiv@list.ru

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I. INTRODUCTION

There is a persistent global trend toward the adoption of alternative fuels in many countries. Gas motor fuel (GMF), which is based on natural gas rather than petroleum products, offers a number of significant advantages: it is economically beneficial, environmentally clean, and features a high level of safety. The most common types of gas motor fuel are liquefied natural gas (LNG), compressed natural gas (CNG), and liquefied petroleum gas (LPG).

Each of these fuel types is characterized by specific physical properties, transportation methods, and areas of application. LPG, a mixture of propane and butane, while relatively inexpensive and environmentally friendly, it nevertheless remains mostly a petroleum-refining product and poses explosion risks at certain atmospheric concentrations. Since government support programs for the development of gas-powered transport do not include this type of fuel, its impact on the market will not be considered in this study.

Possessing the world's largest natural gas reserves, Russia has substantial prospects for the development of the market for natural gas as a motor fuel [1]. This position underpins energy security and independence, while stimulating the production of gas equipment and the creation of new jobs in servicing and operating gas-powered transport. The shift to methane will likewise help reduce fuel costs, i.e., provide more affordable fuel for the public and businesses [2]. Consequently, the state policy is aimed at increasing domestic consumption of natural gas through the advancement of GMF infrastructure [3].

In 2021, the Government of the Russian Federation approved the "Transport Strategy of the Russian Federation to 2030 with a Forecast up to 2035," which envisions an increase in natural gas consumption by a factor of 15–19 by 2035 relative to 2021. According to the

Strategy, the key prerequisites for introducing new types of transport fuels encompass the development of fuel production, fuel cells, and engines; the establishment of a distribution system for new fuels, and the build-out of infrastructure. In addition, the state program for Energy Development 2024 was aimed at stimulating the adoption of natural gas-powered vehicles and increasing domestic consumption. Similar objectives were set out in the “Energy Strategy of the Russian Federation until 2050,” published on April 12, 2025, which envisions a tenfold increase in methane consumption compared to 2023 levels.

The uneven development of the gas motor fuel (GMF) market across Russia’s regions is heavily influenced by economic conditions, regional policy, and the suspension of government support programs, which limits the availability of statistics. This study aims to assess the level of natural gas development as a motor fuel in various regions of Russia.

II. Literature Review

The development of the gas-motor fuel market is relevant due to the strategic importance of converting transport to natural gas. The analysis of literature reveals a wide range of studies conducted to assess the gas motor fuel market. Methodological approaches utilized by researchers can be grouped into several most common areas: econometric modeling, economic efficiency assessment methods, life cycle assessment methods, and rating analysis.

Econometric modeling provides an important tool for analyzing and forecasting the gas motor fuel market. “Motor fuel choice: An econometric analysis” is a classic study that uses econometric models of multiple logistic regression to analyze consumer behavior when choosing motor fuels, including GMF [4]. The authors provide a quantitative framework for assessing the demand elasticity and consumer preferences for fuel. The study [5] uses Bayesian VAR models to estimate the elasticity of demand for automotive fuels and thoroughly examines the demand sensitivity to prices and external factors for the Italian market. Some papers forecast natural gas consumption in the transportation sector. A multi-hybrid model used in [6] combines statistical and deep learning models to predict natural gas consumption in the transport sector. A similar problem is solved in [7] for Pakistan’s market. The advantages of econometric modeling include the ability to quantify the demand elasticity, while taking account of consumer behavior, the impact of competition and political factors. At the same time, there are disadvantages such as the need for extensive and reliable data, the models’ sensitivity to the selection of variables and assumptions, challenges in interpreting the results under multidimensional influences, and limited data on the GMF market.

The methodology for assessing the economic efficiency of GMF is an important tool for making informed decisions on the introduction and development of the GMF market. In [8], an investment project for the creation of a network of compressed natural gas (CNG) filling stations in Romania is analyzed based on the cost-benefit analysis methodology. Some studies analyze the transition of freight transportation from diesel fuel to LNG [9, 10]. The greenhouse gas emissions from various types of motor fuels are assessed in [11, 12]. The disadvantages of methodological approaches to assessing the economic effectiveness of using GMF include the difficulty of adapting models to regional conditions; complexity of integrating technical, economic, and environmental parameters; and a high dependence on the quality and completeness of data.

The Well-to-Wheel (WTW) method is often used as a life cycle assessment approach for both fuels and vehicles. It is also employed to assess the energy efficiency and greenhouse gas emissions of vehicles throughout the entire lifecycle of fuel or energy. This approach is considered both for individual vehicles [13–15] and for the entire fleet [16–18]. Nevertheless, the Well-to-Wheel (WTW) method has a number of significant drawbacks that are important to consider when conducting analysis and making decisions. It offers limited life cycle coverage, ignores some environmental impacts, exhibits strong dependence on generalized and averaged data, and leaves out of consideration economic and social aspects.

The methods of rating the development of the gas motor fuel market are based on a variety of factors. The study [19] proposes a methodology for ranking vehicles using different types of fuels, including renewable and non-renewable. Data on the territorial ranking of the GMF market are often found in specialized industry reports and market research, which are difficult to analyze in detail.

Despite the variety of existing approaches to analyzing the gas motor fuel market, there are some disadvantages associated with the inaccessibility of the methodological approach and the statistical database, which does not allow us to thoroughly analyze the research results.

III. METHODOLOGY

The selection of factors plays an important role in constructing a regression model. According to the published research, the model's factors must satisfy certain requirements: they should be quantitatively measurable and independent of one another, since high correlation among factors may lead to inconsistent estimates. In theory, the model can include an unlimited number of factors that meet these conditions; in practice, however, a large number of explanatory variables does not yield the desired results. The introduction of superfluous indicators into the model will neither increase the coefficient of determination nor reduce the residual variance.

Accordingly, after selecting variables based on the research problem, a correlation analysis is needed to exclude redundant factors. A correlation matrix is employed to identify relationships between factors and a dependent variable, while examining pairwise correlations between independent variables. Correlation coefficients above 0.6 indicate interdependence of factors. In this case, one of the factors, the one demonstrating lower correlation with the dependent variable, should be excluded, as they duplicate each other.

There are also cases where two or more factors influence each other. This phenomenon is referred to as multicollinearity, which prevents assessing the effect of each factor separately. Multicollinearity leads to a loss of economic meaning for the regression parameters and their unreliable estimates. Testing for multicollinearity is carried out using the determinant of the factors' correlation matrix: if the determinant is zero or close to zero, the factors are highly dependent. The solution to multicollinearity reduces to excluding factors or incorporating their interaction terms into the model. In the latter case, the statistical significance of the interaction is verified using Fisher's F-test.

In the literature, the regression equation is commonly constructed using one of the following factor-selection procedures: backward elimination, forward selection, and stepwise regression analysis. The first method removes factors from the full set; the second adds factors to an empty model one by one; and the third combines the previous two, checking at each step the significance of the factors included in the model and removing those that are not significant.

This study involves examining the correlation matrix of the regressors, which allows for the removal of highly correlated variables at the first step. All remaining regressors are selected using a stepwise elimination procedure.

TABLE 1. Factors and Their Conventional Designations Used in the Model

Factor	Conventional Designation
Fixed Capital Investment	*Inv*
Gross Regional Product	*GRP*
Per Capita Income	*PCI*
Population	*Pop*
Number of Natural Gas station (automobile gas-filling compressor stations and cryogenic refueling stations)	*NGst*
Paved Road Density	*PRD*
Average Annual Methane Price	*AMP*
Harmful (Pollutant) Emission into Atmospheric from Motor Vehicles	*HEA*

To carry out the panel-data analysis, we formed a balanced panel dataset based on the databases of the websites of federal state statistical services (EMISS, Rosstat) and the State Traffic Safety Inspectorate (GIBDD), as well as the annual reports of Gazprom Gas Motor Fuel LLC. The analysis covered 66 regions selected by the volume of methane consumption in transport sector. Regions with zero values for this indicator were excluded from the analysis. In light of the lack of official statistics beyond 2022, particularly regarding the critical indicator of "the number of gas stations on highways," the data is confined to the period from 2015 to 2022. For convenience, all candidate factors considered for inclusion in the model were assigned designations, as shown in Table 1.

The panel datasets are compiled for each federal district. These panel data are used to build the regression models, including a pooled regression:

$$Ngt_{it} = \alpha + \beta_1 NGst_{it} + \beta_2 Inv_{it} + \beta_3 GRP_{it} + \beta_4 PCI_{it} + \beta_5 PRD_{it} + \beta_6 AMP_{it} + \beta_7 HEA_{it} + \beta_8 Pop_{it} + \varepsilon_{it}, \quad (1)$$

where α and β_n are the model coefficients, i is the region index, t is the year (time) index, and ε_{it} is the error term;

a fixed-effects model:

$$Ngt_{it} = i\mu_i + \beta_1 NGst_{it} + \beta_2 Inv_{it} + \beta_3 GRP_{it} + \beta_4 PCI_{it} + \beta_5 PRD_{it} + \beta_6 AMP_{it} + \beta_7 HEA_{it} + \beta_8 Pop_{it} + \vartheta_{it}, \quad (2)$$

where i is the region index, t is the year (time) index, β is the vector of regression coefficients, μ_i is the regional effects (fixed unknown parameters), ϑ_{it} is the error term, normally distributed with parameters $(0, \sigma_\vartheta^2)$; and a random-effects model:

$$Ngt_{it} = \alpha + \delta_i + \beta_1 NGst_{it} + \beta_2 Inv_{it} + \beta_3 GRP_{it} + \beta_4 PCI_{it} + \beta_5 PRD_{it} + \beta_6 AMP_{it} + \beta_7 HEA_{it} + \beta_8 Pop_{it} + \lambda_{it}, \quad (3)$$

TABLE 2. Sample of Regions by Federal District

Federal District	Regions
Central	Regions: Belgorod, Bryansk, Vladimir, Voronezh, Ivanovo, Kaluga, Kostroma, Kursk, Lipetsk, Moscow, Oryol, Ryazan, Smolensk, Tambov, Tver, Tula, Yaroslavl; City of Moscow
Southern	Regions: Astrakhan, Volgograd, Rostov; Republics: Adygea, Crimea; Krasnodar Territory; City of Sevastopol
Northwestern	Regions: Arkhangelsk, Vologda, Kaliningrad, Leningrad, Novgorod, Pskov; Republic of Komi; City of Saint Petersburg
Siberian	Regions: Irkutsk, Kemerovo, Novosibirsk, Omsk, Tomsk; Altai Republic; Altai Territory
Ural	Regions: Kurgan, Sverdlovsk, Tyumen, Chelyabinsk; Khanty-Mansi Autonomous Area-Yugra; Yamalo-Nenets Autonomous Area
Volga	Regions: Kirov, Nizhny Novgorod, Orenburg, Penza, Samara, Saratov, Ulyanovsk; Republics: Bashkortostan, Tatarstan, Udmurt Republic, Chuvash Republic; Perm Territory
North Caucasian	Republics: Dagestan, Ingushetia, Kabardino-Balkaria, Karachay-Cherkessia, North Ossetia–Alania; Stavropol Territory
Far Eastern	Republic of Sakha (Yakutia), Sakhalin region

where i is the region index, t is the year (time) index, β is the vector of regression coefficients, δ_i is the regional effects, normally distributed with parameters $(0, \sigma_{\vartheta}^2)$, α is the intercept, λ_{it} is error term, normally distributed with parameters $(0, \sigma_{\lambda}^2)$.

All models were estimated by ordinary least squares (OLS) and subsequently tested for autocorrelation and heteroskedasticity of the errors. Where necessary, the OLS estimator was replaced with a generalized least squares (GLS) estimator. The most appropriate model was chosen using the Wald, Wooldridge, and Hausman tests. Based on the test results, the significant factors for each federal district were then identified.

IV. RESULTS AND DISCUSSION

The level of development of natural gas as a motor fuel for vehicles was analyzed separately for each federal district (Table 2 shows the regions considered).

The Far Eastern federal district includes only two regions, as only they demonstrate a positive value for the indicator of the “number of gas stations along highways.” However, according to the statistical information available after 2022 on other factors, the market for natural gas as a motor fuel is burgeoning in the Far Eastern federal district, as well as throughout the country. The escalation of the geopolitical situation significantly affected the gas motor fuel market in Russia after 2022, resulting in the stimulation of import substitution policy, improvement in energy security, and adaptation to the instability of global energy markets. In the face of sanctions and limited access to international petroleum market, Russia has intensified the development of its domestic natural gas market as an alternative to traditional fuels. As a result, the Government of the Russian Federation has approved a Concept for the development of the gas motor fuel market in the Russian Federation until 2035, considering external geopolitical challenges.

The dependent variable is the number of motor vehicles running on natural gas. This indicator is chosen because it reflects consumer demand (i.e. it is more mass-market in nature than trucks and buses), demonstrating infrastructure accessibility for the population. Based on the findings in paper [7] along with the reports of Gazprom Gas Motor Fuel [20, 21], we identified the factors presented in Table 3.

The results of the regression analysis of the natural gas market in the Central federal district enable tests to determine whether individual effects are present (Table 4).

The first two tests confirmed the presence of individual effects, while the Hausman test helped select a model with random effects. Next, the residuals obtained in the selected model were checked for autocorrelation and

TABLE 3. Model Factors

Socio-economic	Industry-specific	Environmental
Fixed capital investment per capita (thousand rubles)	Number of refueling stations (units)	Emissions of harmful (pollutant) substances from transport (thousand tonnes)
Gross regional product per capita (thousand rubles)	Density of paved public roads (km per 1 000 km² of territory)	
Average per capita monetary income (rubles per month)	Average annual methane price (rubles)	
Population (thousand people)		

TABLE 4. Statistical Tests for Choosing the Best Model for the Central Federal District

Test	Calculated statistics	P-value	Output
Wald test	16.948	<2.2e-16	Reject the null hypothesis
Breusch-Pagan test	2.422	0.015	Reject the null hypothesis
Hausman test	8.017	0.155	Accept the null hypothesis

TABLE 5. FGLS Model with Fixed Effects for the Central Federal District

Indicator	Value	Standard deviation	P-value
Number of gas stations	-0.129	0.116	0.261
Investments in fixed assets per capita	-0.005	0.303	0.987
Average annual methane cost	-0.271	0.547	0.62
Paved-road density	6.503	2.297	0.004
Emissions into the atmosphere	-0.07	0.107	0.512
Multiple R^2		0.708	

heteroscedasticity. The Breusch-Godfrey test was used to test the hypothesis about the absence of first-order autocorrelation, since the p-value took the value 5.322e-08, it was rejected. The Breusch-Pagan test for heteroscedasticity was also performed, we obtained a p-value equal to 0.001, therefore, the null hypothesis about the absence of heteroscedasticity was rejected.

The next step is to eliminate the consequences of heteroscedasticity. A feasible generalized least squares (FGLS) model was built for both fixed and random effect regression, and then the best of the two models was selected using the Hausman test (Table 5).

The coefficient of determination in this model shows that the selected factors describe the dependent variable by 70%, which indicates the high quality of the model. At the same time, the p-value for each individual factor does not meet the accepted significance level of 0.1. The factors are eliminated step by step, starting with the regressor showing the largest p-value (Table 6).

Thus, the number of passenger vehicles that can run on methane in the Central Federal District is affected by the number of gas filling stations and the paved-road density. Both factors belong to the group of industrial factors, indicating that infrastructure plays a crucial role in the expansion of the market for natural gas as a fuel in the Central federal district. The negative coefficient for the number of CNG stations is attributed to the presence of multi-fuel filling stations in the regions of the Central federal district. Consequently, in the regions with a larger fleet, it may be more profitable to deploy these facilities.

In all districts, the “population size” factor is strongly correlated with other variables, therefore we exclude it from the analysis at the selection stage. GRP and fixed asset investments are strongly correlated, which is explained by Keynesian theory suggesting that investments are integral to aggregate demand, which fosters the growth of GRP. In each federal district, only one of these factors is included in the model. In most districts, the average monthly per capita income strongly correlates with other regressors, but it has a lesser effect on the number of methane-fueled vehicles. Consequently, we opted to exclude it at the selection stage in five out of eight districts.

Analysis of the models using the R software enabled us to identify the most significant factors for each federal district from those initially selected (Table 7).

TABLE 6. Total Coefficients for the Central Federal District

Regressors	Value	P-value
The number of gas stations	-0.169	0.069
Paved-road density	3.758	0.013

TABLE 7. Significant Factors by Federal District

Federal district	The number of CNG/LNG stations	Methane price	Fixed capital investment	Paved-road density	Pollutant emissions	Model
Central	1			1		GLS “within”
Southern	1	1	1	1		GLS “within”
Northwestern	1	1	1			GLS “within”
Siberian	1	1	1		1	GLS “within”
Ural	1		1		1	GLS “within”
Volga	1	1				GLS “random”
North Caucasian		1	1	1	1	GLS “within”
Far Eastern	1		1			GLS “within
All regions		1	1	1		GLS “random”

Moreover, the same factors entered the models with different signs across districts, indicating regional specificities in the development level of the gas motor fuel (GMF) market. The sets of significant factors also differ; therefore, to generalize the results at the national level, four of the most frequently occurring factors were highlighted: the number of CNG stations, paved-road density, the average annual methane price, and fixed capital investment per capita.

The number of vehicles running on GMF is strongly influenced by infrastructure, i.e., by the number of refueling stations. Accordingly, developing the infrastructure will drive the expansion of the vehicle fleet, which will positively affect methane consumption. Another important factor for Russia’s GMF market is the price of methane itself. It is therefore important to take measures to support both vehicle owners and entrepreneurs in this market for the equilibrium price to be acceptable for both the demand and supply sides. The last significant factor – fixed capital investment – underscores the need to attract investors to the developing natural gas market.

Note that in three districts –Siberian, Ural, and North Caucasian – there is a negative relationship between the number of methane-fueled vehicles and atmospheric pollutant emissions, which points to the environmental effect of this fuel type.

Table 7 also presents the final models selected. All of them take account for unobserved effects. These effects include government support measures at both the federal and regional levels. Essential measures to foster the growth of the methane market encompass providing subsidies for converting vehicles to methane; funding the construction of gas refueling infrastructure; reducing transport tax on methane-powered vehicles; and granting access to land for CNG stations without competitive bidding.

The calculations indicate that the level of GMF market development is influenced by different factors across the federal districts. This is due to the historically established spatial distribution of production, population, and infrastructure. In this context, federal GMF development policy should be differentiated for each district, aiming at addressing its specific barriers (for example, supporting LNG projects in the Siberian and Far Eastern federal districts, expanding the CNG network in the Central and Volga federal districts).

Since 2022, the gas motor fuel market has experienced the dynamic growth despite the current economic challenges and instability in global markets. The growth is ensured by an active government policy (in 2025, the Government of the Russian Federation approved the Concept for the development of the gas motor fuel market in the Russian Federation until 2035). This policy is driven by the economic benefits of using GMF compared to petroleum products, striving to bolster energy security and reduce the environmental burden. The share of GMF in the total fuel balance is currently modest, yet it holds a potential for a substantial growth in the future.

V. CONCLUSION

The development of the gas motor fuel (GMF) market in Russia varies significantly by region, which is associated with the differences in the level of government support, the political and economic landscape, and the availability of infrastructure.

Econometric analysis reveals that the significant factors for most federal districts are the number of CNG stations, paved-road density, the average annual methane price, and fixed capital investment per capita. The models selected based on statistical tests that feature fixed or random effects underscore the individual differences among regions within each federal district. Many models contain negative coefficients for certain factors, which can be explained by specific characteristics of the district or region. The primary apparent contradictions in the findings are a negative relationship between the number of vehicles and the infrastructure serving them, as well as a positive relationship between the price of methane and the number of vehicles using it as fuel.

For example, in the Northwestern federal district, a 1% expansion of infrastructure for methane-fueled vehicles leads to a 0.05% decrease in the number of such vehicles. In Saint Petersburg, methane sales per CNG station exceed the level observed in other constituent entities of the Russian Federation. Therefore, in this case, construction of new refueling stations is required solely to meet the demand of the existing vehicle fleet. The expansion of infrastructure is not the cause for the decrease in the number of vehicles, but rather an ineffective attempt to stimulate them, leading to the opposite result due to a complex imbalance in the market. Addressing this contradiction requires simultaneous stimulation of both supply (infrastructure) and demand (vehicles).

Furthermore, the Northwestern federal district can be used as an example of an individual region to explain the evident violation of the law of demand. In the Vologda region, growth in per capita income is proportional to growth in methane prices, therefore when consumers choose a vehicle, the cost of fuel has little influence on the purchase decision, while other characteristics, such as environmental performance, become more important. Thus, one of the individual unobserved effects may be vehicle owners' preferences. The positive relationship between the cost of methane and the number of vehicles using it as fuel may reflect a situation where the price of methane is in a favorable range for attracting investors and users, justifying the improvement in infrastructure, and providing environmental benefits.

The further dynamic development of the GMF market in Russia requires continuous refinement of the regulatory and legal frameworks, expansion of the refueling-station infrastructure, and support of innovative projects, while incentivizing demand for GMF vehicles. The following recommendations can be applied to ensure the successful advancement of the natural gas fuel market:

1. Adopt a comprehensive approach: ensuring active coordination between the federal center and the regions, incorporating tax incentives, subsidies for vehicle conversion to methane, and other incentives.

2. Attract investment: supporting domestic manufacturers of equipment and technologies, creating appealing conditions for private investors.

3. Enhance infrastructure: expanding the network of gas refueling stations and improving the quality of service for gas-fueled vehicles.

4. Cultivate a positive image: raising awareness about the benefits and environmental advantages of gas motor fuel through the mass media and social campaigns.

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Irina V. Provornaya, Ph.D. in Economics, is a Senior Researcher at the Trofimuk Institute of Petroleum Geology and Geophysics of the Siberian Branch of the Russian Academy of Sciences, Novosibirsk, Russia. She is also an Associate professor in Novosibirsk National Research State University. Her scientific interests include analysis of the current state and forecast of the oil and gas market expansion in Russia and the world.

Irina V. Filimonova, D. Sc. in Economics, Professor, currently holds the position of Head of Laboratory at the Trofimuk Institute of Petroleum Geology and Geophysics of the Siberian Branch of the Russian Academy of Sciences, Novosibirsk, Russia. She also leads the Political Economy Chair in Novosibirsk National Research State University. Her scientific interests include strategic planning of the oil and gas industry development in Russia and the regions of Eastern Siberia and the Far East.

Victoria A. Vakhnova is a student at Novosibirsk National Research State University, Novosibirsk, Russia. Her scientific interests include forecasting the development of the gas market in Russia and globally.

Alexey A. Dolganov is a Master's student at Novosibirsk National Research State University, Novosibirsk, Russia. He also serves as an engineer at the Trofimuk Institute of Petroleum Geology and Geophysics of the Siberian Branch of the Russian Academy of Sciences, Novosibirsk, Russia. His scientific interests include forecasting the development of the oil and gas market in Russia and across the globe.