Eder, Leonty Viktorovich; Filimonova, Irina Jur′evna; Nemov, Vasiliy et al.

Article

Forecasting sustainable development of transport sectors of Russia and EU : energy consumption and efficiency

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2018, 8(2), 74-80.

Forecasting Sustainable Development of Transport Sectors of Russia and EU: Energy Consumption and Efficiency

Leonty Viktorovich Eder[1,2,3]*, Irina Filimonova[4,5], Vasiliy Nemov[6,7], Irina Provornaya[8,9]

[1]Economic Faculty, Novosibirsk State University, Novosibirsk, Russia, [2]Institute of petroleum Geology and Geophysics SB RAS, Novosibirsk, Russia, [3]Institute of Economics and Industrial Engineering, Novosibirsk, Russia, [4]Economic Faculty, Novosibirsk State University, Novosibirsk, Russia, [5]Institute of petroleum Geology and Geophysics SB RAS, Novosibirsk, Russia, [6]Economic Faculty, Novosibirsk State University, Novosibirsk, Russia, [7]Institute of petroleum Geology and Geophysics SB RAS, Novosibirsk, Russia, [8]Economic Faculty, Novosibirsk State University, Novosibirsk, Russia, [9]Institute of petroleum Geology and Geophysics SB RAS, Novosibirsk, Russia. *Email: EdreLV@yandex.ru

ABSTRACT

The paper analyzes energy efficiency for the road transport of Russia and its regions against the backdrop of the ongoing processes in the EU countries. The emphasis is laid on mathematical modeling of energy consumption forecasts for the transport sector. The results show that despite the fact that economy of Russia as a whole has a relatively low level of energy efficiency however in road transport the situation is different. Total consumption of energy in Russia's transport sector is expected to decrease by 15% by 2040, despite a significant increase in the number of vehicles. However, unlike in the EU, the share of renewable sources of energy will be relatively low in the structure of energy consumption in Russia.

Keywords: Energy Consumption, Energy Efficiency, Road Transport
JEL Classifications: Q35, Q42, Q47

1. INTRODUCTION

Analysis of the current status of and forecasting in the energy sector is a key component in the formation of long-term policies for sustainable development of the economy (Kontorovich et al., 2016; Korzhubaev et al., 2015). An important aspect is the relationship between the economy and its major industries, energy and environment. Transport is one of the largest and strategically important industries. Given that transport is the main consumer of petroleum products, the transport sector accounts for about 30% of total energy consumption.

In order to reduce the emission of greenhouse gases, European countries have set targets for efficiency of energy consumption and widespread use of renewable energy sources, which they have achieved and become world leaders in using them.

By 2020, the goal is for at least 20% of energy consumption to be from renewable sources (Directive 2009/28/EC) and for this amount to reach 27% by 2030 (2030 Energy Strategy). Forecast of energy consumption by vehicles in Europe and in Russia and its regions is needed to determine the long-term guidelines for the development of energy markets, development of transport infrastructure, petrochemical and related industries, ecology and environment.

At the same time, Russia's economy as a whole has a relatively low level of efficiency of energy consumption. This is due to the relatively large number of factors. For Russia, it is necessary to change the paradigm of energy policy aimed at integrated and maximum effective use of fossil energy and reduce energy intensity of the economy and greenhouse gas emissions (Kontorovich et al., 2013; Kontorovich et al., 2016). However, in road transport the situation is different. The basic amount of vehicles Russia imports from the EU and Japan. This is technology transfer in goods intended for final consumption. So there is a similar dynamics is efficiency of energy resources consumption in Russia and Europe.

The object of the study is road transport of Russia and European countries, with the methodological approaches to forecasting energy consumption by road transport being its subject.

The purpose of the study is to establish long-term trends and forecasts for the energy consumption by road transport in Russia and EU countries.

The objectives of the study include: (1) Identifying sustainable trends in the dynamics of motorization and structures of energy use in the transport sector; (2) development of methodological approaches to forecasting the energy consumption by road transport; and (3) forecasting energy and oil consumption by transport for regions of the Russian Federation.

Scientific novelty of research consists in:

- Offered directions for improvement of the methodological approach to forecasting energy consumption in the transport sector, taking into account specific characteristics of the countries and regions and prerequisites for stable trends in improving the efficiency of energy consumption by road transport;
- Multi-factor model built on the basis of established and systematized indicators, allowing to calculate the transport saturation level for the economy in the medium and long term perspective, depending on a number of selected factors;
- Formalized dynamic model for predicting the effectiveness of energy consumption per unit of vehicle in Russia, with detailiations for the federal districts in the medium and long-term perspective. The model specificity consists in nonlinearly reducing transportation energy consumption, with the rate of reduction of energy consumption depending on its initial level.

The paper is organized into following sections: (1) Is an introduction to the study; (2) is a literature review; (3) presents the data and methodology; (4) is devoted to results discussion; and (5) provides the conclusions.

2. LITERATURE REVIEW

Both global and Russia's economy show persistent trends that influence differently energy consumption and structure of the road transport sector, among them are: (1) Increased number of vehicles; (2) higher engine efficiency; (3) appreciable shifts in the structure of energy consumption.

In order to determine the long-term targets of energy consumption in the transport sector of Russia it is necessary to consider global trends, especially in the EU and to determine the possibilities of their application with the specificity of Russian regions taken into account.

2.1. Vehicle Quantity Dynamics

In most developed countries the optimal vehicle saturation level per 1,000 populations has been achieved. Given that energy consumption dynamics in the transport sector is most affected by increasing engine efficiency, this results in gradual reduction of energy consumption (Arslangulov, 2009). However, in most countries with developing economies, the current level of vehicle ownership is far from saturation, while the transport fleet growth rate is consistently high. As a result, despite the developing energy-saving technologies, energy consumption in transport sector is generally increasing (Eder and Nemov, 2017; Paravantis and Georgakellos, 2007).

The relationship between the number of cars per capita and gross domestic product (GDP) is not linear. The specific number of vehicles is growing relatively slow at low levels of this indicator, which is followed by about two-fold increase in an average level (from \$ 3,000 to \$ 13,000 per capita) (Liddle and Lung, 2013). With further increase in GDP per capita, there is a slowdown in growth in the number of vehicles as long as the number of cars per capita reaches a certain level, which is interpreted to be vehicle saturation level in the economy (Dargay et al., 2007). This dependence is shown in Figure 1. Notably, we used the data from countries with different income levels during the period of 1991-2013.

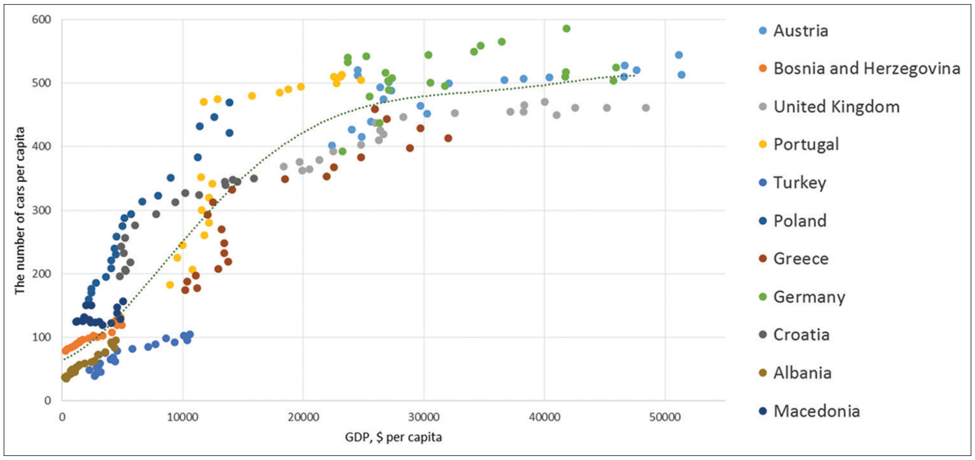
As a result, the relationship between the number of vehicles and the GDP per capita can be represented by an S-shaped curve. There are a lot of different functional forms that can describe such process, for example, logistics, logistics logarithmic, normal storage. Gompertz function shows the most accurate description of the level variation that is connected with motorization of population depending on the level of GDP. The function parameters allow to change the intensity of growth at different stages and the time of reaching the level of vehicle saturation, depending on the level of GDP per capita.

2.2. Energy Consumption Per Unit of Vehicle

The second important factor is to identify the laws of energy consumption dynamics per unit of a motor vehicle or specific energy consumption. The research made by the authors has shown that the dynamic trend models allow a high degree of certainty to describe the patterns of change in the share of energy consumption in developed countries, showing relatively long downward trend of this indicator (over 20 years). At this, specific energy consumption per unit of GDP is described by an exponential dependence (Eder, 2013). This means that with time, the growth of energy intensity tends to be decreasing evenly.

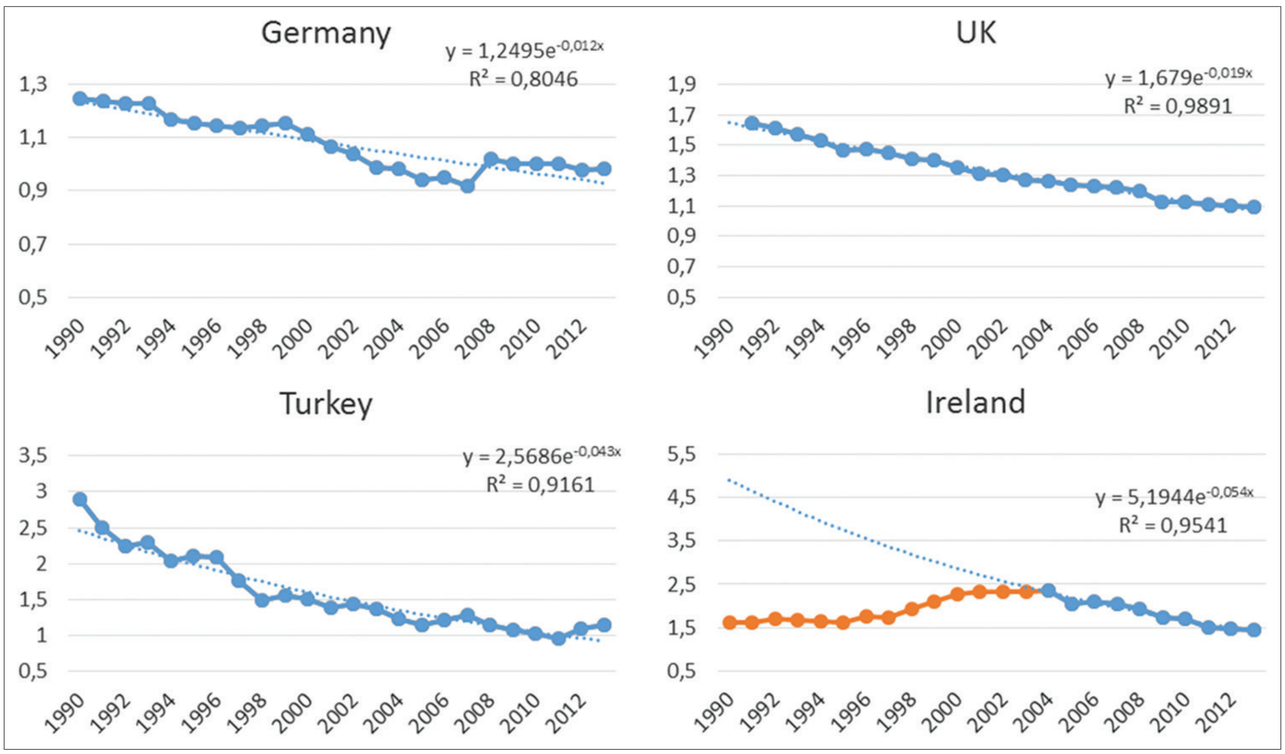
The duration of the energy consumption reduction dynamics in the transport sector is not as long as in economy on the whole. As a result, in addition to the exponential, energy consumption in the transport sector can be described by a number of other trends, in particular by a linear trend (Figure 2). This is because the nonlinearity can be documented for a sufficiently long period of time. Therefore, when predicting specific energy consumption in the transport sector, the dynamics of energy consumption by a vehicle unit is assumed to be described by the same laws as changes in the energy intensity for the whole economy. The basic principles of open economy and participation in international trade allow us to extend these laws to the regions of the Russian Federation (Mazurova, 2010). Most of motor vehicles are imported by Russia from Europe and Japan, which results in similarity of the energy consumption reducing processes in the transport sector, as well as European countries.

Figure 1: The relationship between number of vehicles and gross domestic product per capita in some countries, according 1991-2013



Source: European Commission: Eurostat. Transport statistic; World Bank Open Data: Free and open access

Figure 2: Dynamics of energy consumption of one vehicle in road transport in Europe, tonnes of oil equivalent per vehicle per year



Source: European Commission: Eurostat. Transport statistic; World Bank Open Data: Free and open access

2.3. Changing Structure of the Energy Balance for Road Transport

The role of alternative sources of energy (biofuels, natural gas, electricity) has been recently notably increasing in the transport sector, which is a limiting factor for an increase in demand for conventional fuels in the road sector – gasoline and diesel fuel (Andreev and Karpel, 2012).

For example, over the last three decades, the share of petroleum products was characterized by a continuous decline in the energy balance of Europe in the transport sector (Petrov, 2009). In the period from 1990 to 2005, the share of oil products in the region decreased from 98.7 to 97.2%. The period of high oil prices and the economic crisis of 2008-2009 acted as incentive to switch to more economical alternative energy sources (Ivanov, 2011). As a result, over 5 years – from 2005 to 2010– the share of oil products fell from 97.2% to 93.5%. By 2013, the consumption of gasoline and diesel fuel accounted for 92.9% (Table 1).

The world development in the last decade is characterized by the rapidly growing consumption of biofuels in the transport sector. So, in the period of 2005-2013, the share of biofuels in the structure of energy consumption in Europe has increased from 1.1% to 4.6%. The total transportation consumption of alternative energy sources such as natural gas, biofuels, electricity in 2013 was 7.1%, whereas in 2000 their share was not >1.7%.

Table 1. The structure of fuel consumption in road transport in Europe, %

The type of energy	1990	1995	2000	2005	2010	2011	2012	2013
Gasoline	57.8	53.7	47.2	38.1	30.5	29.5	28.5	27.7
Diesel fuel	40.9	44.9	51.2	59.0	63.0	63.6	64.1	65.2
Natural gas	1.2	1.2	1.4	1.7	2.1	2.2	2.3	2.5
Biofuels	0.0	0.1	0.2	1.1	4.4	4.6	5.0	4.6
Electricity	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.03

Source: European Commission: Eurostat. Transport statistic

The share of diesel fuel tends to increase in the structure of energy consumption by transport is increasing rapidly. Diesel fuel is more economical in terms of fuel consumption (lower by 30-35% versus gasoline). In addition, diesel fuel is cheaper in European countries due to lower tax rate. As a result, the use of diesel fuel as an energy carrier in the transport sector grew from 40.9% to 65.2% in the period 1990-2013.

3. METHODOLOGY

3.1. Data

The pattern of energy consumption dynamics for road transport in Europe was analyzed on the basis of the Eurostat data presented for 32 countries for the period 1990-2013.

Econometric analysis was conducted to identify factors influencing the number of vehicles per capita and the saturation level (optimal, desired number of vehicles). More than 400 indicators for 85 regions of the Russian Federation was considered in the formation of the database. Statistics taken from the "Regions of Russia. Socio-economic indicators. 2016" statistical collection and the "FEC of Russia" magazine for the period of 2012-2016 (Dargay et al., 2007; Khrustalev and Ratner, 2015).

The analysis was conducted on the basis of several factors that affect most the level of motorization in the regions of the Russian Federation. These factors are divided into the following groups: Environmental, climatic, infrastructure; institutional, technological; social; and economic. Forecasting the level of transportation energy consumption in Russia was carried out according to the federal districts.

3.2. Empirical Analysis

As was shown in the paper by Eder and Nemov (2017), the cumulative forecast for energy consumption of road transport per capita was calculated as multiplying of the total number of vehicles by energy consumption of a vehicle unit (1). In addition, the population projections were used to calculate the absolute number of vehicles in the regions. They are based on the optimistic scenario of population dynamics in Russia according to the UN.

$$E_{tr\,it} = \left(V_{it}^{a} + V_{it}^{b} + V_{it}^{t}\right) * P_{it} * Y_{it} \tag{1}$$

$E_{tr\,it}$ – energy consumption of vehicles in region i at time t; V_{it}^{a} – the number of passenger vehicles per 1000 people in region i at time t (calculated by authors); V_{it}^{b} – number of buses per 1000 people in region i at time t (calculated by author); – the number of freight vehicles per 1000 people in region i at time t (calculated by author); Y it – energy consumption for one vehicle in region i at time t (calculated by authors); Pit – predicted number of population in region i at time t (based on the forecast of the Department of economic and social Affairs of the United Nations).

3.2.1. A Model for Predicting the Number of Vehicles

A model for predicting the number of vehicles is based on the patterns of change in the number of vehicles per person depending on the dynamics of GDP per person. Gompertz function best describes this functionality:

$$V_t = V_{max} e^{-\alpha e^{-\beta GDP_t}} \tag{2}$$

Vt – the number of motor vehicles per 1000 people at time t; Vmax – "saturation level", desired equilibrium number of motor vehicles per 1000 people; GDPt – GDP per capita in time t; α, β >0 – parameters.

The parameters of the model (2) are estimated on the basis of the analysis which reflects the dynamics of the level of motorization and GDP per capita in the regions of the Russian Federation in the period 2000-2013. The coefficients β and the saturation level V_{max} i was estimated individually for each region.

In accordance with the proposed methodological approaches, the calculation of the parameter V_{max} is based on factors characterizing the individual characteristics of the regions of the Russian Federation. The set of factors for cars derived from multivariate econometric analysis: The share of urban population (U), an institutional factor - the number of organisations using electronic document flow (H), consumer expenditure per capita per month, RUB. (D) the share of hard-surface roads (R). The highly important for Europe environmental and carbon dioxide emission indicators appeared not significant in the econometric model for Russia's regions.

The regression equation has the form:

$$V=57.22+0.61*U+1.92*H+0.003*D+0.48*R \tag{3}$$

Similar calculations are carried out for trucks and buses. The results of estimation model (2) (the number of motor vehicles per 1000 people) and an estimate of the "saturation level" for the regions of Russia are presented in Table 2.

3.3. The Model of Energy Consumption by Unit of the Vehicle

The model of energy consumption by a vehicle unit was based on time series analysis, with subsequent plotting the for dynamic trend model.

Table 2: The number of motor vehicles per 1000 people and «saturation level»

Federal district	2015	2020	2025	2030	2035	2040	V_{max} Variation (For other provinces)
Central Federal district	360.0	371.3	388.8	407.0	425.4	443.6	422-514
North-Western Federal district	369.2	380.9	399.3	418.7	438.6	458.5	402-529
Southern Federal district	305.0	315.2	330.5	345.7	360.3	373.6	378-475
North Caucasian Federal district	259.2	266.0	277.0	289.3	302.7	317.2	274-475
Volga Federal district	342.9	353.3	370.0	387.9	406.6	425.8	456-515
Urals Federal district	381.1	393.7	413.2	433.2	453.3	472.6	424-502
Siberian Federal district	339.8	350.6	367.6	385.7	404.5	423.3	363-496
Far Eastern Federal district	385.7	395.3	408.9	421.7	433.5	444.3	382-540
Russian Federation. total	344.8	355.5	372.2	389.6	407.4	425.0	274-540

As shown in the previous section, the forecast values of consumption of energy in transport will be calculated on the basis of the exponential dependence:

$$Y_t=\beta*e^{-\gamma t} \tag{4}$$

Yt – energy consumption of one vehicle in year t, o.e.; β – energy consumption of one vehicle in the initial period (period t=0); γ – coefficient of the intensity reduction of energy consumption.

Calculation of parameters of the exponential function for Russian's regions was carried out on the basis of obtained regularities of the effect of consumption convergence of across regions. The authors have shown the existence of the effect of beta-convergence, showing the relationship of initial level and subsequent decline in energy consumption per unit vehicle. The effect of beta-convergence allows to assess the dependence of the rate of decline of energy consumption in the region i(γ_i) from its initial value (β_i):

$$\gamma_{i=}0.219*\beta_i-0.126 \tag{5}$$

As the result, the higher is energy consumption per unit of a motor vehicle, the higher is the rate of its decline. However, when energy consumption by a motor vehicle approaches the average level of developed European countries, the rate of its decline becomes slower. To evaluate the effect of beta-convergence enables the use of trend models to predict energy consumption by road transport with a limited observation period for this indicator.

4. RESULTS AND DISCUSSIONS

Forecasting the number of vehicles in the regions of the Russian Federation was carried out based on the scenario population projections published by the Department of economic and social Affairs of the United Nations. The Gross Regional Product estimates were calculated on the basis of the «Long-term forecast for the socio- economic development of the Russian Federation up to 2030» issued by the Ministry of Economic Development of the Russian Federation.

4.1. Forecast of the Number of Vehicles

A forecast made by author shows the number of motor vehicles per capita allows to draw a conclusion about the high potential for growth of motorization level and a decline in differentiation by the number of vehicles across the regions. According to the forecast, the number of passenger cars in Russia will grow by 20% by 2040, specifically, from 43.3 million in 2015 to 52.1 million in 2040. The largest increase in vehicles will is projected for the Siberian Federal district 21.4% by 2040 (Table 2). In absolute terms, by 2040 the greatest increase in the number of passenger cars is expected in the Central Federal district and Moscow – by 876 thousand pcs.

In the Russian Federation, an increase in road transport is expected on 10.1 million units from 50.4 to 60.5 million over the period 2015-2040. The highest growth rates are predicted for the Central regions of Russia and Siberia (Table 3).

4.2. Forecast of Energy Consumption Per Unit of a Motor Vehicle

The forecast for energy consumption per unit of a motor vehicle showed a decrease in differentiation according to the Federal districts by 2040. At the same time, differentiation of Federal districts would remain, depending on economic and climatic conditions. So by 2040 the highest level of energy consumption per vehicle will remain in the North-Western and Urals Federal districts – about 1.1 tons of oil equivalent to one vehicle per year (Table 4).

4.3. Forecast of Change of Structure of Consumption of Energy in Transport

Analysis of tendencies of changes in the structure of energy consumption in transport has allowed to execute the forecast for the medium term. The share of alternative sources energy (LPG, natural gas, biofuels, electricity) in road transport in 2020 will increase to 9.7%, in 2040 - 24%. In the structure of energy consumption will be a significant reduction share of gasoline to 11.4% by 2040. The share of diesel fuel will increase up to 2027 to the level of 69.1%. However, an increase in the consumption of alternative energy sources will lead to stabilization and further reduction of the share of diesel fuel to the level of 64.6% by 2040 (Table 5).

Energy efficiency in transport and the active introduction of alternative motor fuels, primarily methane, will reduce the consumption of gasoline and diesel fuel by motor transport (Kontorovich et al., 2008). Therefore, by 2040 the consumption of petroleum products by road will be reduced from 63.2 million tons of oil equivalent to 44.1 million tons of oil equivalent (Table 6). The share of oil products in the structure of energy consumption in the road sector at the end of the forecast period will be reduced to 80%.

Table 3: Forecast the number of vehicles in the 2015-2040 in the Russian Federation, thousand

Federal district	2015	2020	2025	2030	2035	2040	2040/2015,%
Central Federal district	14022	14451	15034	15578	16154	16803	119.8
North-Western Federal district	5111	5269	5488	5695	5919	6173	120.8
Southern Federal district	4971	5133	5347	5537	5724	5922	119.1
North Caucasian Federal district	2503	2567	2656	2746	2850	2980	119.0
Volga Federal district	10189	10492	10915	11326	11779	12306	120.8
Urals Federal district	4678	4829	5035	5226	5424	5642	120.6
Siberian Federal district	6563	6767	7049	7321	7615	7950	121.1
Far Eastern Federal district	2395	2453	2522	2574	2625	2684	112.0
Russian Federation, total	50433	51961	54047	56004	58090	60459	119,9

Table 4: Forecast of energy consumption per unit of a motor vehicle, toe/vehicle

Federal district	2015	2020	2025	2030	2035	2040
Central Federal district	1.23	1.15	1.07	1.00	0.93	0.87
North-Western Federal district	1.50	1.40	1.31	1.22	1.14	1.06
Southern Federal district	1.43	1.34	1.25	1.16	1.08	1.01
North Caucasian Federal district	0.60	0.56	0.52	0.49	0.45	0.42
Volga Federal district	1.36	1.27	1.18	1.10	1.03	0.96
Urals Federal district	1.51	1.41	1.31	1.22	1.14	1.06
Siberian Federal district	1.44	1.34	1.25	1.17	1.09	1.02
Far Eastern Federal district	1.36	1.27	1.18	1.10	1.03	0.96
Russian Federation. total	1.33	1.24	1.16	1.08	1.01	0.94

Table 5: Forecast of the structure of energy consumption in the road sector of Russia,%

The type of energy	2015	2020	2025	2030	2035	2040
Petroleum products (gasoline, diesel fuel, LPG)	94.2	92.7	90.5	87.6	84.1	80.0
Other (biofuels, natural gas, electricity)	5.8	7.3	9.5	12.4	15.9	20.0

Table 6: Forecast demand for gasoline and diesel fuel by motor transport of the Russian Federation, differentiated by Federal districts, mln ton

Federal district	2015	2020	2025	2030	2035	2040	2040/2015,%
Central Federal district	17.2	16.2	15.3	14.2	13.1	12.0	69.7
North-Western Federal district	7.1	6.7	6.3	5.9	5.4	5.0	70.2
Southern Federal district	6.6	6.2	5.8	5.4	5.0	4.5	69.3
North Caucasian Federal district	1.4	1.3	1.2	1.1	1.0	1.0	69.2
Volga Federal district	12.8	12.0	11.3	10.5	9.8	9.0	70.2
Urals Federal district	6.5	6.1	5.8	5.4	5.0	4.6	70.1
Siberian Federal district	8.7	8.2	7.8	7.2	6.7	6.1	70.4
Far Eastern Federal district	3.0	2.8	2.6	2.4	2.2	2.0	65.1
Russian Federation, total	63.2	59.5	56.1	52.2	48.2	44.1	69.7

5. CONCLUSION

The transport sector is one of the largest areas of energy consumption in the economy. Transport is the main sector that consumes oil. The main factors which influence energy consumption in transport are: (1) Quantity of vehicles, (2) energy consumption per a unit of motor vehicle, (3) the structure of energy consumption in transport.

High oil prices in the period 1999-2008 stimulated improvement of the energy efficiency in the transport sector. At the result of introduction of energy-saving technologies and production of more fuel-efficient vehicles the consumption of energy is reducing in the transport sector of countries with relatively low growth of number of vehicles. In addition, changes in the structure of energy in the road transport sector have become more intensive over the past 15 years. These processes actively influence energy consumption in transport in Russia too. By 2040, in Russia, despite the significant increase in vehicles, the total consumption of energy in transport is expected to decrease by 15% compared to 2015.

Since the 2000s, the processes of energy sources diversification have been observed against the backdrop of stricter environmental requirements for vehicles and high petrol prices. However, in Russia's structure of energy balance in the transport sector dominance of the traditional automotive fuels (gasoline and diesel) is expected by 2040. Despite the high rate of increase in the share of other energy sources such as natural gas, electricity, their wide distribution is limited by the low level of infrastructure development and insufficient incentives to their use by the government. As a result of improved efficiency of vehicles and diversification of energy sources, the demand for traditional automobile fuel by 2030 will be reduced by 16% to 52.2 million tons per year.

6. ACKNOWLEDGMENTS

The authors would like to thank the Russian Foundation for basic research 17-06-00537; Grant of the President МД-6476.2018.6 for their financial support.

REFERENCES

Andreev, A.F., Karpel, E.M. (2012), Strategy of natural gas as a motor fuel in road transport. Problems of Economics and Management of Oil and Gas Complex, 3, 11-16.

Arslangulov, U.Y. (2009), Perspectives the Global Transport Sector. “Energy” M.: Publishing House. p52.

Dargay, J., Gately, D., Sommer, M. (2007), Vehicle ownership and income growth, worldwide: 1960-2030. Energy Journal, 28, 143-170.

Eder, L.V., Nemov, V.Y. (2017), Forecast of energy consumption of vehicles. Studies on Russian Economic Development, 28(4), 423-430.

Eder, L.V. (2013), Forecast of world energy consumption: Methodological approaches, comparative evaluation. Mineral resources of Russia. Economics and Management, 6, 15-26.

Ivanov, A.V. (2011), Current state and trends of the world’s use of natural gas as an alternative fuel on vehicles. Oil, Gas and Business, 5, 3-8.

Khrustalev, E.Y., Ratner, P.D. (2015), Advances in technology and energy efficiency in industry and transport. The Economic Analysis: Theory and Practice, 2, 36-44.

Kontorovich, A.E., Eder, L.V., Nemov, V.Y. (2013), Oil and gas in the Russian economics. Oil Industry, 1, 4-8.

Kontorovich, A.E., Eder, L.V., Filimonova, I.V., Mishenin, M.V. Nemov, V.Y. (2016), Oil industry of major historical centers of the volga-ural petroleum province: Past, current state, and long-run prospects. Russian Geology and Geophysics, 57(12), 1653-1667.

Kontorovich, A.E., Korzhubaev, A.G., Filimonova, I.V., Eder, L.V. (2008), Development of hydrocarbon raw material deep processing in Russia. Oil Industry, 5, 24-27.

Korzhubaev, A.G., Filimonova, I.V., Eder, L.V., Sokolova, I.A. (2015), Strategy of development of an oil-and-gas complex Siberia. Oil Industry, 3, 14-17.

Liddle, B., Lung, S. (2013), The long-run causal relationship between transport energy consumption and GDP: Evidence from heterogeneous panel methods robust to cross-sectional dependence. Economics Letters, 121, 524-527.

Mazurova, O.V. (2010), Power consumption of the Russian transport on the background of global trends. Energy Policy, 3, 62-66.

Paravantis, J.A., Georgakellos, D.A. (2007), Trends in energy consumption and carbon dioxide emissions of passenger cars and buses. Technological Forecasting and Social Change, 74(5), 682-707.

Petrov, V.Y. (2009), Passenger transport of the future: electric cars, hydrogen cars or traditional? Automotive Industry, 5, 7-11.