

Energy Consumption of the Russian Road Transportation Sector: Prospects for Inter-Fuel Competition in Terms of Technological Innovation

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Abstract

The development of production and consumption technologies for the road transport has led to large scale introduction of alternative energy in this sector. These alternatives to the conventional petroleum fuels include biofuels, electricity, natural gas and synthetic fuels produced from coal and natural gas. However, it is very important to point out, that inter-fuel competition is determined not only by the development of technologies, but also by such parameters as availability, fuel cost, consumer preferences and government legislations, all of which vary greatly across the globe. In other words, the very same technologies can be capable of radically altering the fuel mix in some countries while having little to none impact in the others. The topic of the inter-fuel competition development in the transportation sector holds much importance for Russia, as the country's fuels mix is almost totally dominated by the petroleum products. The diversification of energy sources

for transport may positively influence energy security and domestic fuels market stability; reduce the strain on ecology, especially in major cities; all the while increasing Russian oil and petroleum products export potential.

The article presents results of the research for prospects of the developments in Russian transport sector fuel mix. The research was carried out using the tools of economic and mathematical modeling under various scenario assumptions. The analysis has shown that natural gas and, to a lesser extent, electricity hold the best prospects as petroleum products substitutes in the long-term. Their cumulative share in the total energy consumption of the road transport sector has the potential of reaching as high as 26% by 2040. Yet, the extent of substitution largely depends on the government actions for infrastructure development and tax incentives for alternative vehicle owners.

Keywords: inter-fuel competition; road transportation; technological innovations; alternative fuels; energy consumption; scenario planning

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The diversification of the road transport sector's fuel mix is a new global trend. In 1990-2013, the global share of petroleum products (which have historically dominated this sector) decreased, from 99% to 95% [IEA, 2014], despite the significant growth of total energy consumption in the sector. This is due to the growing demand for electricity, natural gas, biofuels, and synthetic motor fuels derived from natural gas and coal. Furthermore, the sector's interest in new energy types is growing all the time, among consumers and vehicle manufacturers alike.

It should be noted that this diversification can be observed not only in developed countries that have traditionally been major oil and petroleum product importers (for them it is mainly prompted by the desire to reduce imports of these energy resources), but also for major oil producers. For example, in Iran, natural gas accounted for 14% of the total energy consumption in the road transport sector already in 2013, while in Brazil, the share of biofuels and natural gas amounted to about 19% of the sector's total energy consumption [IEA, 2014].

For oil exporters, the diversification of the fuel mix provides an opportunity to increase the exports of petroleum fuels. In addition, it serves as an environmental policy tool for all countries since all alternative transportation modes allow one to significantly reduce vehicles' direct emissions (not counting the emissions made during the production of energy resources).

So far, in terms of the diversification of the road transportation sector's fuel mix, Russia lags behind most other countries: petroleum products amount to 99% of the sector's energy balance, while the consumption of gas motor fuel and electricity remains negligible (at 1.4 million tonnes of oil equivalent). At the same time, the sector's demand for petroleum products amounts to up to 90% of total domestic consumption [IEA 2014]. Despite the road transportation sector's importance to the national economy (along with that of demand for oil as such), the number of studies forecasting the sector's fuel mix prospects remains rather small. Some works [e.g. *Bobylev et al.*, 2006; *Braginskiy*, 2012; *Milovidov et al.*, 2006] do describe certain methodological approaches to forecasting demand, but they cannot be considered detailed, integrated studies of future energy demand in the road transportation sector. The authors of this paper have developed a unique tool for forecasting demand for motor fuel. For a detailed description of the forecasting tool's theoretical and methodological basis see [Mitrova et al., 2015; Grushevenko et al., 2015].

The current study has the following objectives: to identify the key incentives for diversifying the fuel mix; assess the current state of inter-fuel competition in the Russian road transport sector; using the state-of-the-art economic and mathematical modeling tool, determine whether Russia has the potential for a large-scale switch to alternative energy resources in the road transportation sector; and, finally, assess the potential for the growth of demand for energy in the sector and the prospects for meeting it.

The Structure of Energy Demand in the Transportation Sector: Incentives for Diversification

In 2015, energy consumption in the Russian transportation sector amounted to about 65 million tonnes of oil equivalent; 99% of that was accounted for by petroleum fuels (liquefied hydrocarbon gases, gasoline, and diesel). The share of gasoline amounted to 60% [IEA, 2014]. The remaining one percent of consumption came in the form of natural gas, in condensed (compressed) form.

At first glance, this structure of energy consumption in the road transportation sector of one of the world's largest exporters and producers of oil appears quite natural, especially considering that domestic retail prices of petroleum products are practically 50% lower than in Europe. However, there are several reasons to believe this structure is not optimal for the country.

The first one is that Russia regularly experiences problems with supplying the domestic market with high-quality, high-octane petrol (which dominates energy demand for personal road transportation). Particularly acute shortages were experienced in 2011, when the Omsk Refinery and the Angarsk Petrochemical Works had to conduct unplanned repair and maintenance, in 2012, after the accident at the Moscow Refinery, and in 2014, when an accident at the Achinsk Refinery coincided with the delayed completion of maintenance work at the Yaroslavl Refinery.

The reason such crises keep occurring is quite simple: the lack of petrol refining capacities. For example, as of 2016, the combined maximum technological capacity of all Russian refineries to produce high-octane Euro-5 standard petrol (the usage of fuel types with lower environmental standards has been banned in Russia since July 2016), with full utilization of all secondary production processes (i.e. no downtime, no repair, or maintenance during the year) amounts to about 40 million tonnes per year. Meanwhile demand has already reached 39 million tonnes (for more about Russian refineries' production capacities, their current state, and development prospects see [Kapustin, Grushevenko, 2016; Kapustin, Grushevenko, 2018]).

If demand for petrol keeps growing (as it does, despite the difficult economic situation in the country), the extension and modernization of required production capacities and supporting infrastructure of the oil refinery sector will require significant investments. About \$20 billion will be needed [Kapustin, Grushevenko, 2018] in the next five to ten years, which is comparable with investments in building gas filling infrastructure (the investments required to convert Russian petrol stations for use of gas fuel are estimated at \$12.6-\$31.5 billion [Promexpertisa, 2016]). It is also important to keep in mind that Russian refineries are quite dependent on imported equipment and consumables (e.g., 50%-100% of catalysts applied to produce commercial petrol are imported [Kulagin et al., 2015]). The weak ruble makes these costs heavier, especially combined with reduced oil export revenues. The high dependence on imported supplies also negatively affects the country's energy security. Launching the domestic production of the aforementioned catalysts

would require major investments, but more importantly, it would not be possible to fully substitute imports even by 2020 [Kapustin, Grushevenko, 2018]. Accordingly, a valid question arises: should we invest in oil refining, almost exclusively to meet the growing domestic demand for petrol (and the sole source of these investments would be oil companies), or spread the risks between numerous market players and invest in reducing demand for petrol, among other things by diversifying the fuel mix?

The second factor that raises doubts about the structure of the Russian road transportation sector's fuel mix is that several Russian cities with over a million residents face severe environmental challenges and the petroleum products dominating the road transportation sector are relatively "dirty" energy resources. For example, on average, CO₂ emissions from gas-powered cars are 20%–25% lower than those of petrol cars of the same class, while the emissions of very toxic nitric oxides are 90% lower compared with diesel cars [Curran et al., 2014]. Switching to electric cars can also significantly reduce the emissions of hothouse gases, if we do not take into account the emissions made over the course of electricity generation.

Third, oil and petroleum products are the key sources of the Russian Federation's currency revenues. According to the Russian State Statistics Service (Rosstat), these products' share in the exports' value structure exceeded 45% even in the crisis-hit 2015¹. The more active use of alternative fuel types by the road transportation sector would allow Russia to export more oil and petroleum products, which would help to step up the country's export potential following Iran's example.

Note also that there is a huge surplus of previously installed gas production capacities in the European part of the country, whose output is only limited by the limited markets. Russia has significant potential to step up gas production, which could be used to generate electricity or directly in vehicle engines. This industry's development would also allow Russia to increase the exports of oil and petroleum products (which are more expensive). This is particularly relevant in a situation when the niche for domestic consumption and export of gas is limited, while the potential for stepping up production is much higher for gas than oil [Mitrova, 2016].

All of the above reasons can be seen as incentives for the government to encourage the substitution of petroleum products in the road transportation sector with alternative energy sources. However, the extent of such shift would largely depend upon consumer preferences, namely how much more attractive the available alternatives would look in terms of costs, convenience, and environmental characteristics.

To assess the future prospects for the emergence of a new energy mix in the road transportation sector, we will need to analyze various aspects of inter-fuel competition, taking into account consumer preferences and expected government regulatory measures.

Inter-fuel Competition in the Russian Road Transportation Sector

Inter-fuel competition is becoming increasingly active in the present-day transport sector. Conventional oil-based fuel types (such as petrol, diesel fuel, and to a lesser extent, liquefied hydrocarbon gases (LHG)) compete with alternative energy sources which can be divided into direct and indirect substitutes (for a more detailed classification see a study previously published in *Foresight and STI Governance* [Mitrova et al., 2015]):

1. Direct substitutes that do not require motorists to radically modify their car engines, such as:
 - biofuels made from plant materials: bioethanol and biodiesel [Mussatto, 2016];
 - coal-to-liquids and gas-to-liquids fuels [Höök, Aleklett, 2010; Glebova, 2013].
2. Indirect substitutes which do require a radical modification of vehicles and consumer infrastructure, such as:
 - Electricity to power electric or hybrid cars;
 - Fuel cells converting hydrogen energy into electricity [Sorensen, 2012].
 - Gas motor fuel (GMF) made from natural gas or biomethane.

Certainly not all these alternatives are finding wide application in the world. For example, due to the high production costs, synthetic GTL and CTL fuels turned out to be non-competitive in terms of price on the world market. According to [Höök, Aleklett, 2010], the production costs of coal- and gas-based liquefied fuels are between \$48–\$75 per barrel, not counting the raw material costs and the producers' tax burden. Meanwhile, the average international production cost of oil-based fuel is between \$5–\$15 per barrel. This ratio of oil- and non-oil-based fuel production costs is expected to remain in place in the long term.

Technologies for the large-scale application of fuel cells in transport vehicles are still seen as an issue for the future. For example, the hydrogen-powered Toyota Mirai car was sold for \$55,000, which is comparable with luxury car prices. According to experts, the company makes not a profit, but a loss selling these cars, to the tune of up to \$100,000 per vehicle [Voelcker, 2014]. For Russia, that kind of price and the lack of fuelling station infrastructure for the time being make forecasting demand for hydrogen-powered cars irrelevant.

For biofuels, the key limitation is the high cost. According to Russian legislation², biofuel is classified not as an energy source but as an ethyl alcohol, and is subject to an excise duty of 102 rubles (\$1.6.) per liter, while

¹ Calculated by the authors using data of the Central Bank of Russia. Access mode: <http://www.cbr.ru/statistics/?PrId=svs>, last accessed on 23.12.2017.

² Federal law No. 171-FZ of 22.11.1995 "On government regulation of the production and turnover of ethyl alcohol, alcohol- and spirits-containing products, and limiting consumption (drinking) of alcohol products"

the retail price of petroleum-based fuel as of 2016 was around 40 rubles (\$0.6.) per liter, which of course makes biofuel non-competitive.

The position of electricity as an alternative energy source for the Russian road transportation sector is also quite shaky unlike, for example, on the European market where, as the authors' calculations show, electricity as a motor fuel can not only pressure conventional petroleum products, but also limit the growth of demand for compressed natural gas (CNG) [Grushevenko *et al.*, 2016]. In Russia, large-capacity public transportation vehicles (trolleybuses and trams) account for almost 100% of all electricity consumption in the road transportation sector. It should be noted that according to the Russian Ministry of Transport, the number of passengers carried by such vehicles has been declining since the early 2000s [AC, 2015]. Many large cities already display a trend toward gradually dismantling these types of transportation: for example, in St. Petersburg the fleet of trolleybuses decreased by 12% between 2005 and 2014 and the fleet of trams by 30%. The recent years' decision by the Moscow authorities to reduce the trolleybus fleet in favor of diesel buses leads to the expansion of consumption of petroleum products in this segment, however, it is worth noting that in parallel, there are significant plans to purchase electric buses. If this trend continues, demand for electricity in the large-capacity road transportation segment would be bound to a decrease in the medium term, however, there are grounds for its future growth owing to the extensive use of electric buses.

As to increasing the number of electric cars (which would lead to increased demand for electricity in that segment), there are again several limiting factors affecting the Russian market. For example, up to 90% of new car sales in Russia take place in the budget segment (up to \$13,000) [Autostat, 2016], while the available electric cars (six models altogether) and even hybrid ones (seven models) belong to the medium and premium segments (with prices starting from \$16,000³), so they remain simply unaffordable for the average consumer. Another problem is the extremely low level of service infrastructure. For example, only official dealers can service electric and hybrid cars available on the market, other service stations simply do not have the equipment and skilled personnel to repair such vehicles.

Also, Russia almost completely lacks charging infrastructure for electric cars, which significantly reduces their consumer appeal compared with petroleum-powered models, even with the lower fuel costs (on average 67%-83% cheaper than petrol). Given the almost total absence of public charging stations (about 60 altogether in the country), the only choice consumers have is to charge their cars at home, which is a very difficult task for residents of large city buildings with no parking facilities (as a rule, apartment buildings in Russia do not have a sufficiently powerful energy supply). It should be noted that Russian Grids (Rosseti) plans to build 1,000 electric car charging stations by 2018 [Voronov *et al.*, 2016], but these overly optimistic plans raise doubts: in just two years' time, the company would have to build 16 times more charging stations than their current total number (60).

Inadequate government policy to promote electric car purchases is also worthy of note. Relevant initiatives include zero customs duties for importing such vehicles into the Eurasian Economic Union (EAEU) until September 2017 [Interfax, 2016], free parking in paid parking zones in Moscow, and the free issue of parking permits for residents of such areas, and free charging until the end of 2016 [Moscow 24, 2016]. There were also plans to equip petrol stations with electric car charging outlets starting from November 1, 2016.⁴

However, the key factor limiting the widespread use of electric cars at the current stage is their high prices: on average an electric car costs 25%–50% more than a petrol- or diesel-powered one of a similar class (the world over). The same is also true for the truck segment (with practically no medium-capacity electric vehicles available at all). According to our estimates, the average annual cost of owning an electric car in 2016 was two times higher than for internal combustion vehicles. As to Russia, the situation is further aggravated by the very limited range of available electric cars: the options are either super-compact vehicles that are relatively unpopular among Russian consumers or luxury cars unaffordable to the average buyer.

In terms of combined consumer, operational, and environmental properties, gas-powered cars seem to offer the most attractive alternative in all market segments. In addition to significant savings on fuel (according to our calculations, such cars are 60% cheaper to run than petroleum-powered ones, per 100 km) and a moderate price difference (compared with similar class vehicles in various market segments), using natural gas prolongs the service life of the internal combustion engine, significantly increases the mileage between repairs, and reduces explosion and fire hazards compared with petrol and LPG (gas is lighter than air and in case of leakage, it immediately evaporates, which significantly reduces the risk of fire). Also, natural gas has a much higher self-ignition temperature and a lower explosiveness limit than, for example, petrol, which in case of a leak flows under the car and creates a pool of an explosive mixture on the ground.

In addition, installing a gas bottle and other necessary equipment does not imply a total rejection of conventional fuel types. Even mass-produced gas-powered cars have fuel tanks and can operate using gas and petrol/diesel in turn, which significantly increases their mileage and makes them much more convenient to use. Still, as of 2015, the share of gas motor fuel in Russia was just about 0.5% of the road transportation sector's total energy consumption (or less than 0.4 million tonnes of oil equivalent) [IEA, 2014].

A key reason for this low gasification rate in the sector is inadequate infrastructure. About 280 gas filling stations operate in Russia altogether [NGA, 2016], compared with 24,000 conventional filling stations. Plus, most of the existing gas stations need upgrading because they were built in the late 1980s – early 1990s. The

³ The price of Mitsubishi i-MiEV.

⁴ Russian Government Regulation No. 890 of 27.08.2015 "On amendments to certain Russian Government acts regarding the use of charging outlets for electric vehicles at filling stations".

Table 1. Recommended use of CNG-powered vehicles for public transportation in cities

Population (thousand)	Share of CNG-powered vehicles (%)
1,000+	Up to 50
300+	Up to 30
100+	Up to 10

Source: composed by the authors on the basis of the Russian Government Regulation of 13.05.2013 No. 767-r “On regulating the use of gas motor fuel”.

design capacity of the filling stations exceeds 2 billion square meters of CNG, but their average utilization rate is just 20% due to the small number of gas-powered vehicles in the country, only 110,000 altogether, or about 2% of the total motor vehicle fleet. In effect it is a classic infrastructure paradox: “consumers do not buy cars due to lack of filling stations, and companies do not invest in building filling stations due to low consumer demand” [Mitrova, Galkina, 2013].

The second reason for the slow growth of the gas-powered vehicles’ fleet is problems with supply of such vehicles. As of 2016, practically no factory-made gas-powered cars and commercial minivans were available on the market, while the supply of such trucks and buses was very limited. To switch to using natural gas, most consumers have to resort to the relatively expensive custom conversion, which in most cases voids the manufacturer’s warranty.

The third reason is the uncertain future prospects for CNG prices. After changes were made to Russian legislation,⁵ the price of methane is no longer linked to the price of A-76 petrol (due to the absence of A-76 on the market, A-80, and then AI-92 prices were used instead). Currently no official documents regulate the upper limit of CNG prices. Accordingly, owners of gas-powered cars have no guarantees that this fuel will remain attractively priced in the future, while producers already have reservations about the economic advisability of selling gas at gas filling stations, again, due to the lack of an official price ceiling.

The government pays significant attention to promoting the use of gas motor fuel and dealing with the existing adverse situation (the infrastructural paradox). The Russian Energy Strategy Until 2030 [Ministry of Energy, 2009, and draft Energy Strategy Until 2035 [AC, 2014] mention the increased use of natural gas as motor fuel and increasing the share of gas-powered vehicles to 7% of the total motor vehicle fleet by 2035 as a promising area of developing the country’s energy sector.

To promote the growth of the CNG market, the Russian government introduced norms regulating the use of this fuel type in cities (Table 1). A specialized company called Gazprom Gas Motor Fuel OJSC was established in 2012, whose mission was to promote the integrated development of the gas motor fuel market in the Russian Federation. To this end Gazprom PLC signs cooperation agreements with regional authorities, according to which the company undertakes the task of building and launching gas filling infrastructure facilities and organizing the conversion of vehicles. The regional authorities provide subsidies for creating fleets of gas-powered vehicles for public and municipal use, helping organizations put in place the necessary maintenance facilities and train staff. As of September 2016, such agreements were signed with 38 regions. Out of them, 10 were selected for priority development: St. Petersburg and the Leningrad Region, Moscow and the Moscow Region, the Krasnodar, Stavropol, Rostov, and Sverdlovsk Regions, and the Republics of Tatarstan and Bashkortostan. Already in 2016, investments were made to build 35 gas filling stations. By the end of 2018, Gazprom planned to extend the federal network of gas filling stations to 488 [Gazprom, 2016].

To promote the use of gas-powered vehicles, Gazprom Gas Motor Fuel OJSC signed cooperation agreements with numerous Russian and international vehicle manufacturers.

These steps were intended to create “guaranteed demand” for gas motor fuel by municipal motor transportation organizations, but they do not promote the use of gas-powered vehicles in the private sector: for the latter, the critical factor of switching to an alternative fuel type, in addition to infrastructural limitations, is vehicle conversion costs.

A system of subsidies for converting vehicles to run on CNG should be designed and put in place. These measures should include import duties for components and parts required to build gas-filling stations and ensure that methane-powered motor vehicles are reduced or eliminated altogether. The Russian public authorities should reduce transportation tax rates for owners of gas-powered vehicles⁶.

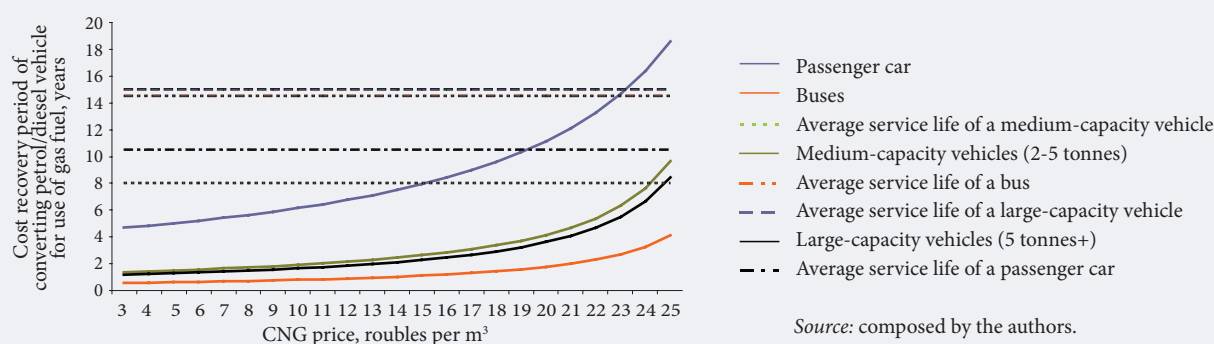
Still, even these measures to promote the use of gas motor fuel will not be enough to attract private consumers, given the uncertainty regarding the future prospects for gas prices, first of all, compressed methane.

An analysis of gas-powered vehicles’ cost recovery shows that passenger cars (which dominate the private sector) are particularly sensitive to changes in CNG prices due to the low purchase prices and low mileage. The gas price ceiling (if the average price of petrol/diesel fuel remains at about 40 rubles per liter) is estimated at about 19–20 rubles per square meter; after that using a gas-powered car becomes unprofitable for the whole period of its service life (Figure 1).

⁵ Russian Government Regulation of 10.04.2015 No. 338 “On invalidation of the RF Government Regulation of January 15, 1993 No.31”.

⁶ Russian Government Regulation of 13.05.2013 No. 767-r “On regulating the use of gas motor fuel”.

Figure 1. Cost recovery period of gas-powered motor vehicles depending on the average CNG price (with an average petrol price of 40 roubles per litre)



Source: composed by the authors.

At the same time, it is important to keep in mind that there is also a price floor and selling gas motor fuel below this level becomes unprofitable for filling station owners. This floor is close to 19 roubles per square meter as well (at this level, the cost recovery period for a Russian gas filling station, given the current rate of wholesale gas prices and with full utilization, would be about two and a half years, or roughly the same as for petrol stations).

Interestingly, although gas motor fuel prices are not officially linked to the prices of petrol products, 19 roubles per litre is just about 50% of the average petrol price. We will be using this figure as a reference in our subsequent calculations and to outline the prospects for inter-fuel competition in Russia.

An integrated long-term analysis of inter-fuel competition also requires taking into account electricity as another substitute of petroleum products with good prospects in the road transportation sector in Russia.

The competitiveness estimates and subsequent calculations are based upon the following key characteristics (scenario prerequisites): fuel costs, basic car costs, the availability of infrastructure, and environmental characteristics. The current values of these parameters for various motor vehicle types are presented in Table 2.

Scenario Building

Demand for energy in the road transportation sector was forecasted using two scenarios: “Basic” and “Promoting alternative fuel types”. Both scenarios are based upon the same prerequisites and macroeconomic indicators (GDP, population, prices of oil, petroleum products, electricity, and natural gas), but differ in terms of how successful government policies promoting and supporting use of alternative motor fuels in Russia are going to be. The main macro-parameters of the study are presented in Table 3.

Both scenarios also share the same vehicle efficiency prerequisites (they assume that efficiency of vehicles powered by liquid and gas fuels would grow by 20%-25% in the next 25 years, due to the increased efficiency of the internal combustion engine among other things achieved through the application of hybrid technologies and the use of more advanced body and tire materials⁷). The efficiency of electric cars during

Table 2. Key consumer properties of motor vehicles powered by various alternative fuel types in Russia (2015 data)

Parameter	Fuel type			
	Petroleum products	Gas motor fuel	Electricity	Biofuels
Fuel costs (roubles per 100 km)	300–400	130–160	70–150	800–1000
Price of a motor vehicle powered specific fuel type (% of the cheapest car in the main consumer class)	100	120	150–350	100
Availability of infrastructure	24000 petrol stations	250 gas filling stations	40 charging stations*	24000 petrol stations**
CO ₂ emissions in the atmosphere (g/km)	290–320	200–250	0***	95–114

Notes:

* “Fast charger” public stations without taking into account opportunities to charge cars at private homes or public parking lots

** Assuming each filling station has additional biofuel storage capacity or that biofuel is mixed with petroleum products

*** CO₂ emissions of electric cars do not take into account emissions made while electricity is generated

The color coding (from green to red) indicates which fuel type is better than others in terms of the relevant parameter

Source: composed by the authors.

⁷ For more on prerequisites of increasing motor vehicles’ fuel efficiency see [Makarov et al., 2014].

the same period is expected to increase by 5% (only the use of better body and tire materials was taken into account, with the electric motor's efficiency factor remaining unchanged at about 90%).

Also, neither scenario envisages major changes in the conditions for inter-fuel competition between petroleum products, electricity, and natural gas on the one hand, and gas-, coal-, and biomass-based synthetic fuels on the other. In particular, such fuel types are not expected to become competitive with the alternatives in the foreseeable future in terms of production costs. That is, no large-scale production of such fuel types is expected to be launched, so there will be no supply and consumers will not have an opportunity to switch to them.

Commercialization or the large-scale use of fuel cell-powered motor vehicles is not expected either. Individual consumers can certainly buy various concept or prototype cars or luxury vehicles, but this will not significantly affect the transportation sector's energy balance during the period until 2040.

The key difference between the scenarios is the prerequisites for changing conditions for inter-fuel competition between petroleum products and their indirect substitutes, natural gas and electricity.

The basic scenario implies that key government decisions on the gasification of public transport will be carried out. The mass production of large-capacity gas-powered motor vehicles will be launched, but no subsidies will be provided for the conversion of passenger cars and medium-capacity vehicles and no mass production of gas-powered motor vehicles is expected to begin at Russian facilities. Regarding electric transport, no support will be provided for the construction of public charging stations. The existing government initiatives such as zero transport tax, permission to drive in dedicated lanes, and zero import duties will retain their current status (i.e., they will not become laws). Meanwhile electricity is gradually becoming more available, individual charging stations will appear at various parking lots and in public areas, making charging an electric car more convenient than it currently is.

The "Promoting alternative fuel types" scenario implies extending the gas filling stations' network by 2030 (following the introduction of the requirement to provide such services at all existing and new petrol stations) to a level where the infrastructure factor stops hindering people from switching to this vehicle type. Also, this scenario implies providing subsidies to convert passenger cars and medium-capacity vehicles for use of CNG (either full compensation of consumers' costs to convert their cars or launching large-scale mass production of gas-powered motor vehicles at Russian automobile factories), which would allow Russia to fully level the difference in basic prices of petrol/diesel and gas-powered vehicles by 2025.

Regarding the development of electric transport after 2025, the "Promoting alternative fuel types" scenario envisages the construction of a public "quick charging" infrastructure and creating better conditions for charging cars at home (installing charging outlets at underground parking lots and in private buildings). Generally, the charging infrastructure is expected to become comparable with the network of petrol stations by 2040. Electric car prices will be brought down by reducing import duties (from 25% of the car price to 0% after 2025) and by promoting domestic production. Cars powered by alternative fuels will be made more attractive to customers through active promotion and advertising and by allowing them to be driven in dedicated lanes in large cities.

Modeling Results

Our calculations show that under both scenarios, the total number of cars in Russia is expected to more than double from 43 to 97 million. However, this will not double the demand for energy, due to the increased efficiency that the scenarios take into account. Total energy demand in the road transportation sector is estimated to reach 109 million tonnes of oil equivalent by 2040, compared with 64 million tonnes in 2015 (Figure 2).

Our calculations show that even if the current situation with the promotion of alternative fuel types remains unchanged, inter-fuel competition in the Russian road transportation sector is still going to increase, up to a point. Note that compressed natural gas is the key alternative to petroleum products. For example, even under the relatively pessimistic "Basic" scenario, its share of the total motor fuel consumption is going to reach 11% by 2040, or 11.5 million tonnes of oil equivalent, which is comparable to the amount of petrol consumed in 2014 in the Central and North-Western Federal Districts combined. It should also be noted

Table 3. Dynamics of major macro-parameters between 2014–2040

Parameter	2014	2040
Average growth rate of the Russian GDP	2.4% annual growth	
Russian population	0.4% decrease, in line with the UN forecast [UN 2015].	
Domestic Russian petroleum product prices (<i>rouble/l</i>)*	40	60
Prices of natural gas sold at filling stations (<i>rouble/m³</i>)	20	40
Electricity prices (<i>rouble/KWH</i>)	4.5	7.7
* It is particularly important to measure prices in the national currency, since a majority of the population make their economic decisions (which are imitated in the course of modelling) based upon the national currency's purchasing power.		
Source: composed by the authors.		

Figure 2. Number of motor vehicles by type, and total energy consumption in the road transport sector

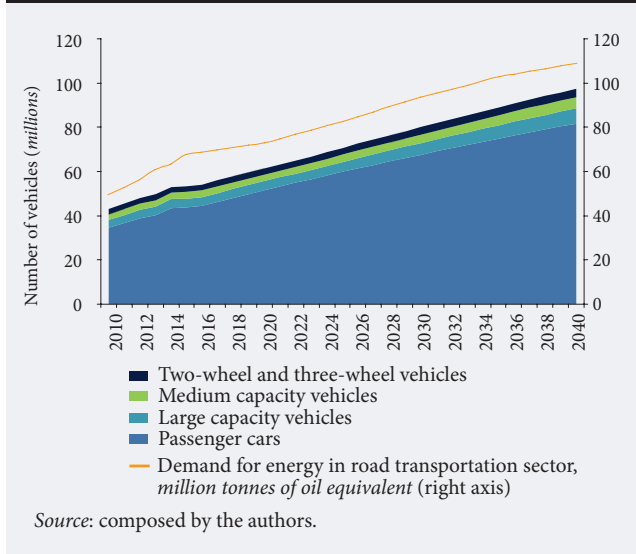
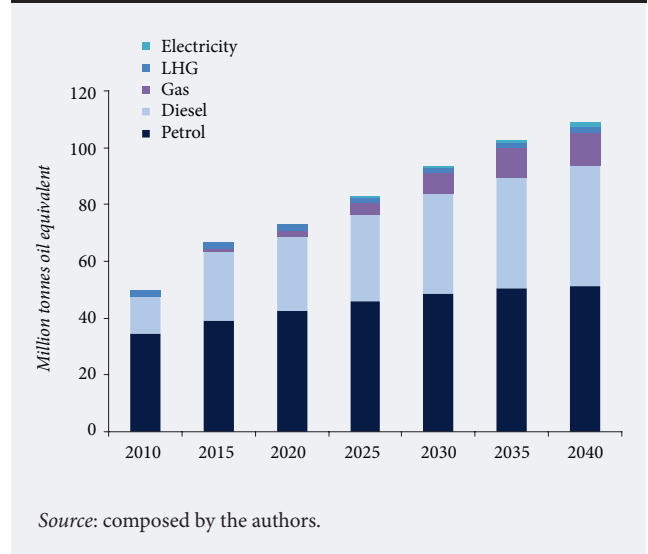


Figure 3. Demand for energy by fuel type under the “Basic” scenario



that about 35% of this amount is expected to be consumed by large-capacity vehicles which make the highest emissions, so it would lead to a significantly reduced environmental impact (compared with the situation where this substitution does not happen).

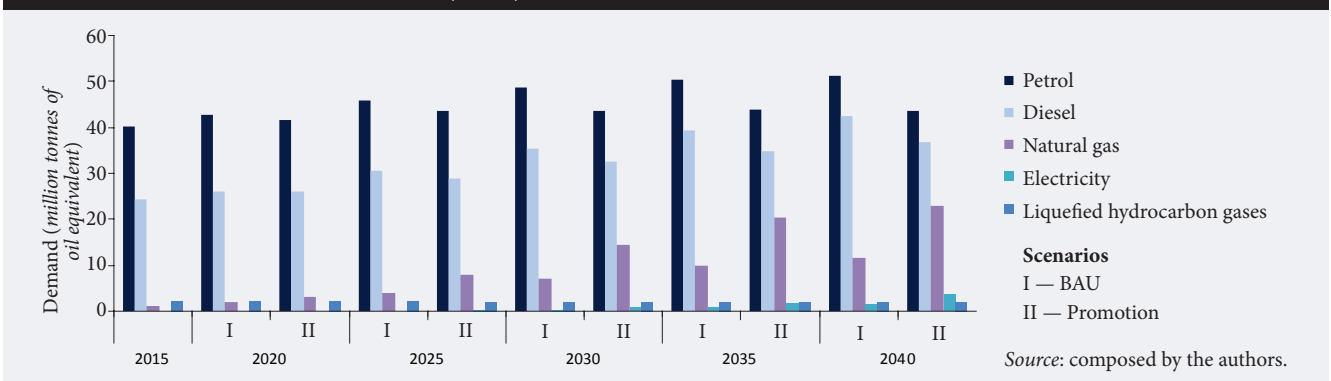
If no additional effort is made to promote the use of electric vehicles, electricity’s potential to substitute petroleum-based fuels seems to be much lower. Under the “Basic” scenario, its share of the total energy consumption in the road transportation sector is not going to exceed 1% by 2040, or just over 1 million tonnes of oil equivalent. Still, it would be enough to fully meet demand for petrol in 2014 in the Far Eastern Federal District, which commonly experiences shortages of petroleum products.

If the regulatory parameters remain unchanged, petroleum products will retain their dominating position. The combined demand for such products by the road transportation sector by 2040 will reach 95.8 million tonnes of oil equivalent (Figure 3). Note that under the “Basic” scenario, demand for petrol by 2040 is expected to grow almost by 12.3 million tonnes of oil equivalent (compared with the current level), which would require the Russian oil industry to make a significant technological and investment efforts to upgrade and possibly extend its production capacities.

Additional steps to promote the use of alternative fuels described in the “Promoting alternative fuel types” scenario would lead to significant changes in the structure of energy demand by the road transportation sector. The share of gas motor fuel in total energy consumption increases by 2040 to 21% or in absolute terms to 23 million tonnes of oil equivalent, displacing petroleum products and the more expensive petrol types.

The share of electricity in total energy consumption is expected to reach 3% by 2040 or, in absolute terms, 3.5 million tonnes of oil equivalent compared with 1 million tonnes under the “Basic” scenario (Figure 4).

Figure 4. Demand for energy by fuel type in the Russian road transport sector under the “Basic” (BAU) and “Fuel mix diversification” scenarios



Note that under the “Promoting alternative fuel types” scenario, demand for petrol essentially remains at the level of the Russian refineries’ current production capacity due to the substitution of alternative fuel types.

Conclusion

This study showed that Russia does have objective reasons to diversify the fuel mix of the country’s road transportation sector, namely:

1. *Structural factor*: as of 2015, imports of petrol (which dominates the Russian road transportation sector’s energy consumption) remained at a very low level, but Russian refineries have reached the ceiling of their production capacity. The potential to further increase the production of petrol is limited due to the lack of investment resources and domestic technologies. Stepping up production capacities would require significant investments (at about \$20 billion according to [Kapustin, 2011]), which is comparable with the investments in, for example, developing gas motor fuel infrastructure, which, provided that all Russian petrol stations are equipped with gas motor fuel facilities, is estimated at \$12.6–\$31.5 billion [Promexpertisa, 2016]. If demand for this energy resource grows and no new refinery capacities are built, Russia, despite being one of the world’s largest producers of oil and petroleum products, would have to import fuel.
2. *Environmental factor*: petroleum products are the least environmentally friendly fuel among the alternatives under consideration. Using CNG instead of conventional diesel and petrol would reduce harmful emissions of urban traffic into the atmosphere by 25%, while switching to electric cars would reduce vehicles’ direct emissions.
3. *Export factor*: reduced demand for petroleum products on the domestic market would help Russia step up relevant exports. This has already been successfully accomplished by Iran, which has managed to convert a significant proportion of its motor vehicle fleet to the use of gas fuel by launching the domestic production of such vehicles.
4. *Gas factor*: the growth of the domestic gas market may help Russian gas producers to create an additional niche for selling their products internally, which is particularly relevant given the currently limited demand at home and on key European export markets combined with significant gas production capacities [Kulagin, Mitrova, 2015].

All these incentives provide good reason to consider where public support should be concentrated to promote the diversification of the fuel mix and increase the consumer appeal of specific fuel types. After all, it is the consumer preferences that ultimately determine whether customers decide to switch from petroleum products to alternatives.

The analysis shows that theoretically, on the basis of its operational characteristics, gas motor fuel can already compete with petroleum-based fuels on the Russian market. However, the degree of oil substitution would largely depend upon the regulation and promotion prospects regarding the pricing of gas motor fuel, the development of infrastructure, and subsidies for the conversion of conventional motor vehicles to use gas fuel.

Among other things, the scenario analysis indicates that electric cars, which are actively conquering the developed countries’ markets, in particular in Europe, still have rather limited potential in Russia due to their very high basic prices compared with other car types. Accordingly, if gas motor fuel’s success can be supported by regulatory measures, the promotion of electric cars would require further technological development in order to cut their production costs.

The Russian government has already introduced a number of measures aimed at encouraging the diversification of the fuel mix, but this is done exclusively by promoting the use of gas motor fuel by large-capacity public transportation vehicles. Plus, our calculations show that these measures will not be sufficient to achieve a significant substitution of petroleum products in the passenger car and medium-capacity vehicle segments.

Fully realizing Russia’s potential to diversify the transportation sector’s fuel mix and limiting the growth of demand for petroleum products requires taking an integrated approach to significantly extend consumer infrastructure (a network of gas filling stations) combined with reducing the prices of vehicles powered by alternative fuels (in the case of gas-powered ones, by launching domestic assembly line production or through the provision of tax breaks).

Implementing such measures would help save up to 13 million tonnes of oil equivalent of petroleum products by 2040 (compared with the “Basic” scenario), which can be exported. Of course, making these changes may turn out to be very expensive and require major investments which are hard to attract, especially during a recession. However, the costs are comparable with those of a major upgrading of refineries and, in the case that an integrated government policy is implemented, they would be borne not just by oil producers but shared by gas and electricity generation companies, cities, municipal authorities, consumers, and automobile manufacturers. Further, the diversification of the fuel mix would make a major contribution to improving the environmental situation in large cities and in the country as a whole.

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