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Scenario Analysis of the Prospects for the Use of Alternative Fuels for Road Transport in Russia

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ABSTRACT

The article examines the economic and environmental consequences for the Russian Federation that may be caused by the transition of road transport to natural gas fuel and electricity. According to strategic planning documents, public authorities are pursuing the policy aimed at converting a significant share of road transport to natural gas fuel. As singled out, this policy is mainly motivated by the issues of limiting emissions of harmful substances into the atmosphere from the combustion of oil products. In addition to a positive impact on the environment, this transformation should have a positive impact on the economy, since the use of alternative energy sources reduces transport costs, and construction of the necessary related infrastructure will create additional growth points for the economy.

The objective of the study described in the article is to investigate the economic and environmental effects for the Russian Federation from the transfer of road transport to natural gas fuel. Main economic indicators analysed comprise subsidies that are necessary to create conditions for development of the relevant market, changes in budget revenues from the mineral extraction tax and excise duty on oil products, as well as additional gross value added due to multiplier effects in the economy. The study of environmental effects consists in assessing the reduction of emissions of greenhouse gases and particulate matter into the atmosphere.

The analysis of the effects for the Russian economy from the transfer of road transport to alternative energy sources has shown that due to the multiplier effect, for the period up to 2035, gross value added will increase by 3,6 trillion rubles, and investments in the necessary infrastructure will amount to about 2,7 trillion rubles, which is about 13 % of the projected investment in the road sector. Due to the use of gas motor fuel and electric vehicles, by 2035 CO2 (carbon dioxide) emissions will be reduced by 11 million tons annually, which represents only 0,5 % of nationwide emissions. This means that the transfer of road transport to alternative energy sources is not effective enough from the point of view of the existing motivation, and the motivation must be changed in favour of positive economic effects.

Keywords: road transport, gas motor fuel, electric vehicles, infrastructure investment, ecology.

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INTRODUCTION

In most developed and developing countries of the world, there is a trend aimed at replacing oil products in the motor transport sector in favour of alternative energy sources. Currently, the most popular alternative energy sources are electricity, natural and associated petroleum gas. The transport sector is one of the largest consumers of energy in Russia, because of which this trend may lead also to a significant transformation of the energy sector of the economy. Due to the operation of road transport, significant budget revenues are formed due to such tax components as the mineral extraction tax (MET) on oil and excise duty on oil products. Given the high tax burden on energy resources, following the transformation of the energy structure of consumption by road transport, budget revenues will also be subject to significant changes. An early analysis of the consequences for the budget and the entire economy will minimise potential risks from a reduction in budget revenues from oil and gas revenues in the future.

At the same time, the growth in the number of vehicles powered by alternative energy sources will also require development of related infrastructure, such as electric charging stations and gas fuelling stations. Without their development, consumers will not use electric vehicles and gas motor fuel since their charging or refuelling will be associated with significant time and value costs. The creation of the minimum required amount of associated fuelling and charging infrastructure is a critical condition for development of road transport using alternative energy sources. Best international practices show that at the initial stage of development, most of the costs are borne by the state.

The *objective* of the study is to analyse economic and environmental effects for the Russian Federation of the transfer of road transport to gas motor fuel.

This paper assesses the investment required to provide the minimum amount of required infrastructure, multiplier effects for the economy based on input-output tables, as well as budget losses from lost revenues from MET and excise duty on oil products.

Additionally, the paper assesses the environmental consequences of the transition of road transport to alternative energy sources.

RESULTS

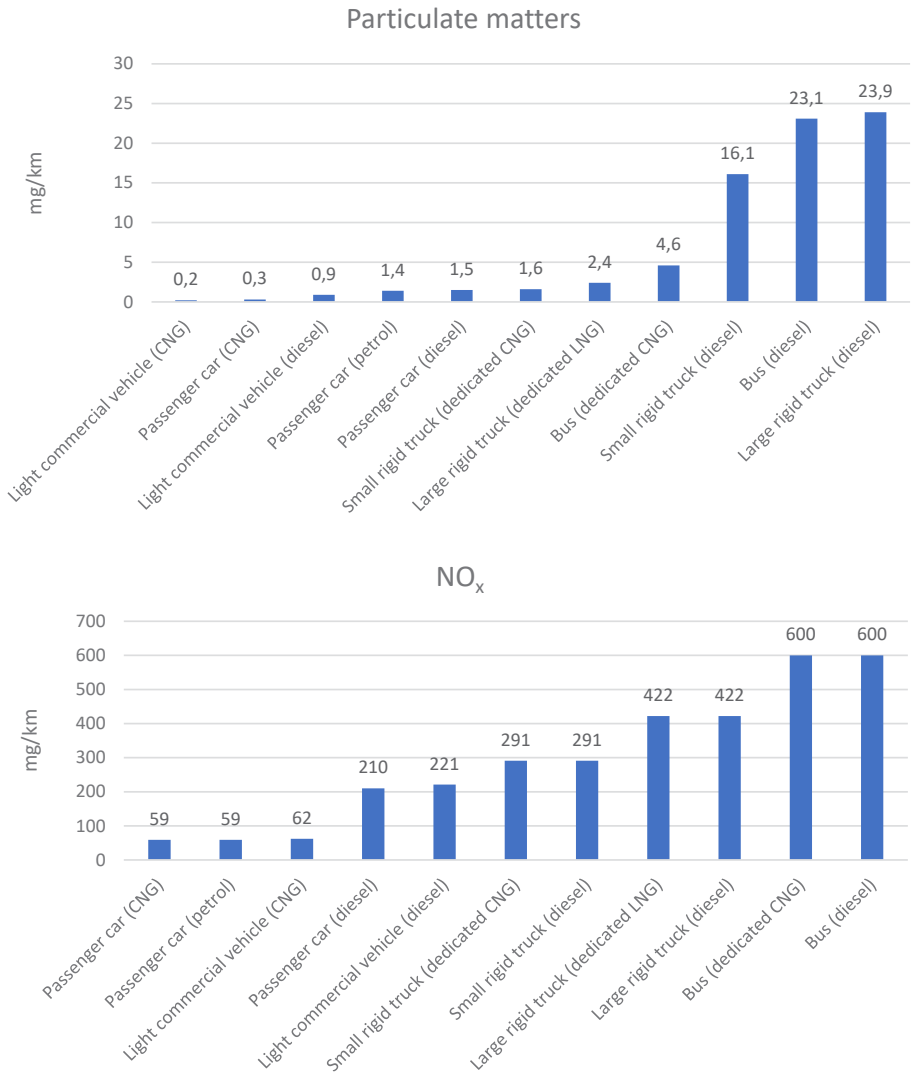
Overview of the Current State of the Automotive Market in the Russian Federation

In Russia, main types of fuel for road transport are refined oil products. Mainly, petrol is used as fuel for passenger cars, while diesel fuel is used for road freight vehicles, passenger cars and specialised vehicles. The carbon intensity of refined products is almost one and a half times higher than that of natural gas. This means that to obtain the same amount of energy, burning diesel or petrol releases one and a half times more carbon dioxide than burning natural gas. According to measurements, to obtain 1 Mbtu (1BTU = 1055–1059 J) of energy from burning natural gas, 52,9 kg of CO_2 will be released into the atmosphere, and when burning petrol, 70,7 kg of CO_2[1] will be released into the atmosphere. Besides carbon dioxide, the combustion of oil products also releases other harmful substances into the atmosphere, of which the greatest harm to health is caused by particulate matter that provokes cancer [1; 2].

It has been measured that the use of natural gas fuel allows emitting five times less particulate matter per 100 km [3] than when using diesel fuel, which is especially important in megacities (Pic. 1). If replacement of refined fossil fuels with natural gas motor fuel will for sure guarantees reduction of specific emissions of harmful substances into the atmosphere per 1 km of the distance travelled, then for electric vehicles, not everything is as simple as it is commonly believed. Indeed, when consuming electricity, an electric vehicle almost does not emit harmful substances into the atmosphere. However, it is necessary to consider emissions into the atmosphere during production of electricity at power plants, as well as losses occurring during transportation of electricity to the consumer. However, the main environmental impact of electric vehicles is the use of heavy metals in production of batteries [4; 5]. Large amounts of heavy metals in the composition of batteries and the difficulties of their disposal [6; 7] imply that the overall negative effect on the environment over the life cycle of an electric vehicle is even more than of vehicles with internal combustion engines.

It is the reduction of greenhouse gas emissions and particulate matter that is the

[1] Carbon Dioxide Emissions Coefficients, EIA. [Electronic resource]: https://www.eia.gov/environment/emissions/co2_vol_mass.php. Last accessed 11.07.2023.



Pic. 1. Emissions of harmful substances into the atmosphere by some types of road vehicles. Charts built by the authors based on the data retrieved from [3, pp. 30–31].

main motivation for replacing oil refinement products in road vehicles with alternative energy sources in developed countries. The environmental agenda is also relevant in the Russian Federation and certain steps are being taken to reduce greenhouse gas emissions by road transport. However, in addition to the environmental aspect, for the Russian Federation, the transfer of road transport to alternative energy also promises direct economic benefits. The use of gas engine fuel and electricity can significantly reduce the costs associated with transportation. According to the authors' calculations, at the current levels of fuel prices, for a trip over the same distance the cost of gas motor fuel will be 2–2,5 times lower than when using oil products, and 3–10 times lower for electricity, depending on the chosen tariff (Table 1).

Depending on the type of road vehicle, the payback period may vary. Table 2 shows the calculations of the payback period for the transfer of a vehicle to gas motor fuel. As can be seen from this table, the payback period for all types of vehicles is less than 200 days. It should be noted that for passenger cars, a small maximum mileage with a full tank of gas motor fuel is a significant barrier, since with a run of 100 km per day, it will be necessary to refuel once every three days. For city buses and freight vehicles, the limited range is not so critical, since buses can be refuelled at the end stations, and the range

Table 1

Fuel costs for passenger vehicles per 100 km [authors' calculations]

Fuel type	Measurement unit	Price, rub. per unit	Energy cost per 100 km***, rub.
Petrol AI-92	l	47,6	476
Petrol AI-95	l	54.1	541
Petrol AI-98	l	59,83	599
Diesel fuel	l	54	432
Compressed natural gas (CNG)	m^3	22,50	202,5
Electricity* (day tariff)	kWh	5,92	148
Electricity* (night tariff)	kWh	1,74	43,5
Charging stations **	kWh	0–9	0–225

* Charging from the mains supply of an apartment building, day and night tariffs, as for consumption of 25 kWh per 100 km.
** Charging from a specially equipped charging station.
*** With an average petrol consumption of 10 litres per 100 km, natural gas consumption of 9 m^3 per 100 km.

of freight road vehicles will be limited not by fuel reserves, but by the need of the driver to rest. The quick payback of vehicles running on gas engine fuel already makes vehicle owners install gas equipment on their own.

According to statistics of «Gazprom gas motor fuel», over the past ten years, the gas-fuelled fleet in Russia has quadrupled and amounted to 259000 vehicles[2], or 0,4 % of the total vehicle fleet. Liquefied petroleum gas (LPG) is predominantly used in passenger cars (it accounts for 73 % of gas consumption in passenger cars and for 89 % in light commercial vehicles)[3], while the share of CNG for gas-fuelled passenger cars is only 9 %. This statistic confirms that the use of CNG in passenger cars is in low demand due to the short range on a full tank.

The number of LPG and CNG fuelling stations (NGFS) that provide services for refuelling vehicles with natural gas in 2022 was equal to 711 units, of which 393 belonged to Gazprom[3]. Of course, such a small number of gas fuelling stations is a significant barrier to the start of mass use of gas motor fuel, since the costs of finding consumers will be very high. In

[2] Gazprom – gas motor fuel. [Electronic resource]: https://gmt.gazprom.ru/press/news/2022/09/188/. Last accessed 11.07.2023.

[3] Using natural traction. Kommersant newspaper. [Electronic resource]: https://www.kommersant.ru/doc/5017206. Last accessed 11.07.2023.

Table 2

Payback period for the transition of the vehicle to gas motor fuel [authors' calculations]

Model variables	Measurement unit	Passenger car	Bus	Freight road vehicle
Retrofitment cost	rub.	50 000	212 500	700 000
Type of base fuel	–	AI-92	Diesel fuel	Diesel fuel
Base fuel price per litre	rub.	51	54	54
Base fuel consumption per 100 km	l	9,3	25	40
Methane consumption per 100 km	m^3	8,1	27,3	43,6
Volume of CNG tank	l	90	250	1420
Mileage per day	km	100	250	300
CNG compression ratio	times	222	222	222
CNG price per 1 m^3	rub.	22,5	22,5	22,5
Range available with one CNG filling	km	246,9	203,7	723,1
Savings from the use of CNG relative to the use of the base type of fuel per 1 km of run	rub.	2,9	7,4	11,8
Mileage corresponding to the return on investment in the re-equipment of the vehicle	km	17 241	28 612	59 322
Payback period	days	172	114	197

Source: authors' calculations using GOST [State Standard] 27577-2000-CNG, GOST R 52087-2018-LPG.

works devoted to assessing the optimal number of NGFS, researchers agreed that the optimum is achieved in the range from 1000 to 1500 vehicles per one NGFS [8; 9]. For example, in countries such as Iran, China, Pakistan, India, Brazil and Italy, with a significant proportion of road vehicles that use gas motor fuel, this figure varies from 850 to 1800[4]. A higher value of the index will lead to an increase in the cost of searching for gas fuelling stations, and a lower value of this index is a barrier to infrastructure development, as there may be insufficient demand for gas fuelling station services. One of the exceptions is Sweden, where the specific indicator of the number of gas-fuelled vehicles per fuelling station is about 200 units [10]. Researchers note that development of the gas fuelling station network and the transition of cars to gas motor fuel must be carried out simultaneously, otherwise either the payback period for creation of gas fuelling stations will be very long due to insufficient demand for services, or the cost of searching for gas fuelling stations by motorists will be a barrier to market development [11–13].

The development of electric vehicles in Russia is also associated with certain barriers. In those countries where electric vehicles have now become widespread, a significant number of owners live in their own homes, which makes it possible to easily charge an electric car in the garage or on the site. According to studies, 88 % of electric vehicle owners charge their electric vehicles at home, most often at night[5]. If an owner of an electric vehicle lives in an apartment building, then this becomes a significant obstacle to recharging the vehicle.

Another significant barrier to development of electric vehicles in the Russian Federation is associated with climatic conditions. Low ambient temperatures will significantly limit the range of trip with a single charge due to decrease in battery capacity and the need for heating in the vehicle. On the contrary, when the air temperature is high, it will be necessary to use the air conditioner, which will also quickly discharge the battery.

The development of a network of electric charging stations will require significant investments. Private companies are not interested in developing a network of electric charging stations, since this market is a low-margin one[6]. This means that development of the electric charging network will either be carried out at the expense of the public authorities, or it will be necessary to provide various measures of public support to private companies, which will increase the return on investment.

Despite insufficient development of the electric charging network in Russia, the number of electric vehicles is gradually increasing. According to the statistics of the Avtostat analytical agency, as of July 1, 2022, 18,7 thousand electric vehicles were registered in Russia, which amounted to 0,04 % of the total number of passenger cars in the country[7]. To enhance the market for electric vehicles, the government approved a Concept for development of production and use of electric vehicles in the Russian Federation for the period up to 2030. The concept considers three main scenarios for development of the electric vehicle market in Russia: inertial, balanced, and the scenario of accelerated development. Each of them predicts an increase in production and use of electric vehicles, as well as development of refuelling infrastructure.

Various programs[8] are currently in place in Russia to support the conversion of vehicles to natural gas fuel or the use of electric vehicles. Thus, the law adopted in 2012[9] set the goal of stimulating the use of gas motor fuel in transport as an alternative fuel, as well as increasing the fleet of electric vehicles. In July 2020, the Government approved a program to subsidise

[4] Natural Gas Vehicles Journal. [Electronic resource]: http://www.ngvjournal.com. Last accessed 11.07.2023.

[5] Level Up: Electric Vehicle Owners with Permanently Installed Level 2 Chargers Reap Benefits from Their Investment, J. D. Power Finds, 2021. [Electronic resource]: https:// www.businesswire.com/news/home/20210203005223/en/ Level-Up-Electric-Vehicle-Owners-with-PermanentlyInstalled-Level-2-Chargers-Reap-Benefits-from-TheirInvestment--J.D.-Power-Finds. Last accessed 01.03.2023.

[6] Electric Car-Charging Business Is Doing Everything But Making Money. Bloomberg. [Electronic resource]: https://www.bloomberg.com/news/articles/2021–04–30/ev-charging-industry-is-doing-everything-except-showing-a-profit. Last accessed 11.07.2023.

[7] Avtostat analytical agency. «There are almost 19000 electric vehicles in Russia». [Electronic resource]: https://www.autostat.ru/news/52361. Last accessed 11.07.2023.

[8] Subsidising the conversion of vehicles for the use of gas equipment, as well as financial assistance to plants producing hybrid vehicles.

[9] Decree of the Ministry of Transport of the Russian Federation dated July 30, 2012, No. NA-96-r, «On approval of the Guidelines for installation of gas equipment on wheeled vehicles in operation in the Russian Federation». [Electronic resource]: www.garant.ru/products/ip. Last accessed11.07.2023.

the conversion of vehicles to natural gas fuel[10]. According to the decree, 60 % of the cost of re-equipment will be compensated by the state, and 30 % by «Gazprom gas motor fuel» company. As a result, the total subsidy for vehicle retrofitting amounted to 90 %. Currently, discussions are underway on the allocation of budget subsidies by the Government for development of natural gas fuelling infrastructure. According to the draft decree, it is planned to allocate for the period 2023–2025 5,9 billion rubles[11]. According to the draft General Scheme for Development of the Gas Industry of the Ministry of Energy of the Russian Federation, by 2035 the consumption of gas motor fuel in the Russian Federation should reach 13 billion m^3.

To develop electric vehicles, the public authorities also apply several incentive programs. For electric vehicles in some regions, the transport tax has been cancelled[12], and from May 2020 to January 2022, a zero rate[13] of import duty on electric vehicles was in effect. In some regions, owners of electric vehicles are entitled to free parking[14] in the city. At the same time, starting from January 2022, in the Russian Federation, the import duty on electric vehicles amounted to 15 % of the cost, which also creates certain obstacles for development of the electric vehicle market but is aimed at supporting national manufacturers.

Russia's strategy for development of the electric vehicle market currently implies a gradual but steady increase in their share in the structure of motor transport fleet. Thus, production of electric vehicles in Russia, in accordance with the Concept for development of production and use of electric vehicles, should increase to 44000 units in 2025 and to 217000 units in 2030. Moreover, by 2030, production of electric vehicles in Russia should reach 10 % of the total volume of car production in the country. Also in Russia, a policy is being pursued aimed at developing the infrastructure of electric charging stations, and by 2030 it is planned to build at least 72000 electric charging stations (as compared to 529 electric charging stations in 2021)[15].

A Scenario Analysis of the Prospects for the Use of Alternative Fuels for Road Transport

For modelling, at the first stage of the study, a forecast is made for consumption of diesel fuel and petrol until 2035. The forecast for consumption of these types of fuel by road vehicles is based on scenarios for the growth of cargo and passenger road transport. It is assumed that cargo transportation is carried out using diesel fuel, but without the use of petrol, and passenger vehicles use petrol as fuel, since the share of diesel passenger cars in the Russian Federation is less than 6 %[16].

The study uses the hypothesis that, over time, electric vehicles will increasingly replace petrol passenger cars, and freight vehicles using natural gas fuel will partially replace diesel trucks. This hypothesis is a consequence of existing technological barriers to the mass use of natural gas motor fuel in passenger cars and of electric vehicles for transportation of goods (nevertheless, it should be born in mind that rapid technological developments can update those scenarios).

To build a forecast for consumption of diesel fuel and petrol, the forecast of cargo and passenger traffic until 2035 of the Ministry of Transport of the Russian Federation, contained in the Transport Strategy of the Russian Federation, was assumed as a basic guideline[17]. As part of the study, it is assumed that the growth rate of petrol and diesel fuel consumption will correspond to the growth rate of transportation

[10] Decree of the Government of the Russian Federation dated June 19, 2020m No. 886. [Electronic resource]: http://government.ru/news/39909/. Last accessed 11.07.2023.

[11] The government proposed to allocate 6 billion rubles for gas fuelling stations in 2023–2025. IA Interfax. [Electronic resource]: https://www.interfax.ru/russia/873155/. Last accessed 11.07.2023.

[12] Transport tax-2020. Who and why may avoid payment. IA «AUTONEWS». [Electronic resource]: https://www.autonews.ru/news/5e745ec39a794727d794d4c5. Last accessed 11.07.2023.

[13] Import duty on electric vehicles will be zeroed for the entire EAEU, except for Russia. Vedomosti [Electronic resource]: https://www.vedomosti.ru/auto/news/2022/03/18/914205-poshlinu-na-elektromobili-obnulyat. Last accessed 11.07.2023.

[14] Official website of the Mayor and the Government of Moscow. [Electronic resource]: https://parking.mos.ru/news/2770/. Last accessed 11.07.2023.

[15] In Russia, the number of stations for charging electric vehicles has increased by 68 %. Komsomolskaya Pravda. [Electronic resource]: https://www.kp.ru/online/news/4522921. Last accessed 11.07.2023.

[16] 15 % of all SUV in Russia are those with a diesel engine. IA Avtostat. [Electronic resource]: https://www.autostat.ru/news/49657/. Last accessed 11.07.2023.

[17] Federal Road Agency. Transport Strategy of the Russian Federation for the period up to 2030 with a forecast for the period up to 2035. [Electronic resource]: https://rosavtodor.gov.ru/docs/transportnaya-strategiya-rf-na-period-do-2030-goda-s-prognozom-na-period-do-2035-goda. Last accessed 11.07.2023.

Table 3

Key indicators used in modelling [compiled by the authors]

Variable name	Year			
	2021	2024	2030	2035
Freight road transportation, million tons	5488	5906	6117	6300
Transport mobility by road, km per person per year	5345	9000	13200	14200
Diesel fuel consumption without substitution, thousand tons	40101	39598	38612	37819
Petrol consumption without substitution, thousand tons	36437	59531	78693	77366
Gas engine fuel consumption in diesel equivalent, thousand tons	1005	2834	6491	9539
Number of passenger electric vehicles, thousand	18	76	1397	2089
Electricity consumption in petrol equivalent, thousand tons	20	93	1723	2577
The cost of gas fuelling stations, including connection works, million rubles	160			
Sales of NGV fuel at fuelling stations per year, thousand m^3	7200			
The cost of a slow-charging station, including connection works, million rubles	0.6			
The cost of a fast-charging station, including connection, million rubles	3,15			
Number of electric vehicles per 1 electric charging station	10.0			
Share of slow electric charging stations		0,691	0,69	0,548

volumes, considering changes in the level of energy efficiency of cars. It is assumed that the growth rates of energy efficiency are the same in all the regions of the Russian Federation, and during the considered time period this growth will be smooth and amount to 1 % per year.

The forecast is based on actual data from Rosstat [Federal State Statistics Service] on supply of petrol and diesel fuel (petrol shipments/diesel shipments) and supposes that these fuels are not stored in tanks but are completely consumed during the corresponding time periods.

Next, a forecast is made for consumption of gas motor fuel based on the scenario of the gas motor fuel market of the Ministry of Energy of the Russian Federation. According to the latter, by 2035 the level of natural gas consumption by road transport will reach 12,5 billion cubic meters [18]. The authors of the study assume that from the current level to the indicated value in 2035, consumption volumes will grow linearly.

A forecast for the growth in the number of electric vehicles and the energy they consumed was made in the similar manner. The concept approved by the Government of the Russian Federation for development of production and use of electric vehicles was used as a basis, which was extended in the forecast until 2035, considering the average annual increase. Next, based on the predicted number of electric vehicles, a forecast was made of the energy consumption of electric vehicles. For this purpose, the average electricity consumption of electric vehicles in the United States was used [19]. At the next step, the forecast volumes of consumption of gas motor fuel and electricity were expressed in diesel and petrol equivalents, which made it possible to estimate substitution of their consumption in the Russian Federation.

To calculate the demand for fuelling stations, namely, CNG fuelling compressor stations, the average volume of gas motor fuel shipped by one of them per year was taken into account. The predicted consumption of natural gas motor fuel was divided by this value. The resulting predicted number of gas fuelling stations was multiplied by the average cost of gas fuelling stations. Similarly, the predicted number of electric vehicles was multiplied by the appropriate factor to obtain the predicted number of fast and slow charging stations. Then the number of slow and fast charging stations was multiplied by the cost of the first and second ones.

[18] In Russia, consumption of natural gas motor fuel will grow to 12 billion m^3 by 2035 // IA TASS. [Electronic resource]: https://tass.ru/ekonomika/17567893. Last accessed 11.07.2023.

[19] Drive U. S. Summary Report on EVs at Scale and the US Electric Power System, 2019. [Electronic resource]: https://www.energy.gov/eere/vehicles/articles/summary-report-evs-scale-and-us-electric-power-system-2019. Last accessed 11.07.2023.

Table 4

Simulation results [performed by the authors]

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
NGV fuel consumption (in units of diesel equivalent), thousand tons	1615	2224	2834	3444	4053	4663	5272	5882	6491	7101	7710	8320	8930	9539
Consumption of electricity by road vehicles (in units of petrol equivalent), thousand tons	20	57	93	152	247	401	652	1059	1723	1894	2064	2235	2406	2577
Amount of total investment in infrastructure, million rubles	29430	60650	58662	91896	96420	135009	157109	216736	281768	269298	326579	321084	372088	372242
Amount of state subsidies, million rubles	5759	10442	10144	15167	15846	21634	24949	33893	43648	41834	50426	49601	57252	57275
Reduction in the amount of received excise duty payments, million rubles	15712	22929	30684	37855	45570	54172	64214	76599	92793	101643	110493	119343	128194	137044
Additional GVA due to the multiplier effect, million rubles	38259	78845	76261	119465	125346	175512	204241	281757	366299	350087	424553	417409	483714	483915
Reduction of CO_2 emissions, thousand tons	965	1388	1809	2275	2815	3473	4325	5493	7173	7865	8557	9249	9941	10633
Reduction of particulate emissions, kg	109767	152127	194451	237483	281666	327722	376823	430874	492975	539557	586138	632719	679300	725882

The study also calculated tax implications of switching to natural gas motor fuel by freight road vehicles. For this purpose, the predicted volumes of diesel fuel, which are expected to not be used due to the transition of trucks to natural gas fuel, were multiplied by the excise duty rate. This made it possible to determine the amount of excise duties that will not be received as a result of this transition. To calculate the shortfall in MET funds, the volumes of diesel fuel that, according to the forecast, will not be consumed, were multiplied by a factor reflecting the volume of diesel fuel received from a unit volume of oil. Further, the received volume of oil was multiplied by the MET tax rate. Similarly, the amount that is supposedly expected to be lost by the state in the form of MET and excise duty, because of the partial transition of cars from using petrol to electricity, was calculated in a similar way.

Table 3 shows the main indicators used in the simulation.

Table 4 shows the main simulation results. According to the estimates, by 2035 the share of gas motor fuel consumption by freight and specialised vehicles will be about 34 %. To provide the required fuelling infrastructure by 2035, it will be necessary to build about 2000 fuelling stations. By 2035, the total accumulated investments for construction of fuelling stations will amount to about 1,5 trillion rubles. As for passenger cars, by 2035, the number of electric vehicles will reach 2,1 million units, and electricity consumption will be about 2,6 million tons of petrol equivalent, or about 9 % of the projected energy consumption by passenger cars. To ensure the possibility of recharging electric vehicles, it will be necessary to build 260000 slow- and fast-charging stations, and the total accumulated investment will amount to about 1,2 trillion rubles.

Thus, to achieve the target indicators laid down in the Transport Strategy and the General Scheme for development of the gas industry, the total investments for the period 2023–2035 into refuelling and charging infrastructure will amount to about 2,7 trillion rubles, which is about 13 % of the projected investments in the road sector, presented in the Transport Strategy. Due to the multiplier effect in the economy, the additional value added for the Russian economy from construction of refuelling and charging infrastructure for the period 2023–2035 will amount to 3,6 trillion rubles, which will have a positive impact on the economy. With current rates of excise duty payments on petrol and diesel fuel and preservation of gas motor fuel as an excise-free product, the budget of the Russian Federation, starting from 2030, will annually lose about 100 billion rubles. From an environmental point of view, switching to natural gas by 2035 will reduce greenhouse gas emissions by 5,5 million tons annually. Cumulative reduction of greenhouse gas emissions for the period 2023–2035 will amount to 44,7 million tons of carbon dioxide (CO_2). The use of electric vehicles will further reduce carbon dioxide (CO_2) emissions in 2035 by 5,2 million tons, considering emissions from electricity generation if we take the current fuel balance for the basis.

Cumulative reduction in particulate matter emissions from switching to natural gas and electric vehicles over the period 2023–2035 will amount to 5,7 thousand tons.

CONCLUSION

The study simulated the consequences for the economy and the environment from replacement of oil refined products for road transport with alternative energy sources.

Simulation results have shown that to achieve the targets set in the Transport Strategy and the General Scheme for development of the gas industry, significant investments in gas fuelling and electric charging infrastructure will be required. Systematisation of the experience of countries in which gas-powered vehicles and electric vehicles are actively used has shown that the state policy to stimulate the use of vehicles powered by alternative energy sources should be carried out simultaneously with large-scale development of the refuelling and charging infrastructure network. To ensure the level required for the trouble-free use of gas-powered vehicles and electric vehicles, by 2035 it will be necessary to invest about 2,5–3 trillion rubles in fuelling infrastructure, which is about 13 % of the projected investments in the road sector presented in the Transport Strategy. Foreign experience recommends distributing construction of related infrastructure between the state and private investors. At the initial stage, the optimal strategy involves construction of the necessary infrastructure by the state to form the foundations of the market. After creating the foundations for functioning of the market, the inflow of private capital is stimulated by providing various types of state support, among which tax incentives are most often used in world practice. This mechanism will guarantee the necessary minimum level of

profitability to private investors at the initial stage of market formation when the demand for services may be insufficient. At the same time, the regulatory framework for this market should be fixed for a long period, which will reduce the risks for private investors associated with possible changes in legislation that may have a significant impact on the market (for example, legally approve zero excise duty on gas motor fuel for the next ten years). Investments in related infrastructure due to the multiplier effect will increase the gross value added by 3,6 trillion rubles, which will have a positive impact on the economy and will partly compensate for provision of tax incentives to private companies and shortfall in budget revenues from reduction in excise duties on oil products and the mineral extraction tax on oil.

From an environmental point of view, the transition of road transport to alternative energy sources will not significantly reduce greenhouse gas emissions. On a national scale, the annual reduction in emissions by 2035 will be about 0,5 % of all greenhouse gas emissions, excluding agriculture and farming. From a point of view of healthcare, the positive effect will result in reduced emissions of particulate matter into the atmosphere, which is especially important in large cities, as particulate matter provokes cancer.

Taking into account the foregoing, we can conclude that the transfer of road transport to alternative energy sources will not have a significant impact on reduction of greenhouse gas emissions and, given the high toxicity to humans of heavy metals used in batteries, it can also cause even negative consequences. The positive effects of switching to alternative forms of energy will not be in environmental aspects, but in economic ones.

First, the transfer of road transport to alternative energy sources, subject to creation of refuelling and charging infrastructure, will reduce transport costs, since the cost of gas motor fuel and electricity per 100 km of run is much lower.

Secondly, due to the multiplier effect, additional growth points for the economy will be created through construction of related infrastructure and introduction of new technologies.

Thirdly, maximising the use of natural gas motor fuel will contribute to the growth of gas consumption which will also have a positive impact on the economy, since underused volumes of oil products can be exported to foreign markets.

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