JAES | JOURNAL OF APPLIED ENGINEERING SCIENCE | www.engineeringscience.rs

ISTRAŽIVANJA I PROJEKTOVANJA ZA PRIVREDU

Indexed by

COST ESTIMATE FOR FILLING WITH DIFFERENT MOTOR FUELS IN FREIGHTING BY LIGHT-DUTY VEHICLES

Mikhail Banket
Siberian State Automobile and Highway University (SibADI)

Dmitry Shapoval
Siberian State Automobile and Highway University (SibADI)

Ivan Eychler
Siberian State Automobile and Highway University (SibADI)

Irina Pogulyaeva
Siberian State Automobile and Highway University (SibADI)

Denis Aleshkov
Siberian State Automobile and Highway University (SibADI)

Key words: *motor fuel, filling station, fueling costs, light-duty vehicles*
doi:10.5937/jaes0-36647

Cite article:

Banket M., Shapoval D., Eychler I., Pogulyaeva I., Aleshkov D. (2022) COST ESTIMATE FOR FILLING WITH DIFFERENT MOTOR FUELS IN FREIGHTING BY LIGHT-DUTY VEHICLES, *Journal of Applied Engineering Science*, 20(2), 537 - 545, DOI:10.5937/ jaes0-36647

Online aceess *of full paper is available at: www.engineeringscience.rs/browse-issues*

Istraživanja i projektovanja za privredu
Journal of Applied Engineering Science

Original Scientific Paper

doi:10.5937/jaes0-36647

Paper number: 20(2022)2, 959, 537-545

COST ESTIMATE FOR FILLING WITH DIFFERENT MOTOR FUELS IN FREIGHTING BY LIGHT-DUTY VEHICLES

Mikhail Banket, Dmitry Shapoval, Ivan Eychler, Irina Pogulyaeva, Denis Aleshkov*
Siberian State Automobile and Highway University (SibADI)

The use of natural gas as a motor fuel in road transport can significantly reduce fuel costs and the adverse environmental impact of motor vehicles. However, an insufficiently developed infrastructure for compressed natural gas (CNG) constrains the growth in the number of natural gas-powered road transport enterprises. The limited number of automobile gas-filling compressor stations (AGFCS) increases the mileage of motor vehicles, which reduces the efficiency of natural gas use in road transport. This study aims to assess the costs of filling with different types of motor fuel regarding the overall costs of road freight. The scientific novelty of the work lies in establishing the dependence of costs for filling with motor fuel on the operational performance of vehicles and the development of fueling infrastructure of specific motor fuel types. For the first time, the authors evaluated the share of fueling costs for light-duty vehicles (LDVs) for different hydrocarbon fuels regarding the costs associated with the transportation process. It was found that the share of fueling costs varies depending on the type of hydrocarbon fuel used and can range from 1.5 to 15%, depending on the fueling infrastructure development. The results obtained can be used in decision-making on choosing the fuel type in the transportation process by LDVs to minimize overall costs.

Key words: motor fuel, filling station, fueling costs, light-duty vehicles

INTRODUCTION

When transporting goods and passengers, carriers try to reduce the cost of these services as much as possible. The study [1] presents the analysis of uncertainty in road transportation, affecting the overall costs of the enterprise and the region under conditions of economic instability [2]. An assessment of the efficiency of trucks in urban transportation is presented in (Putra et al., 2020). However, these costs considered by road transport enterprises in the Russian Federation do not take into account the costs associated with fueling. Currently, the most common are five types of fuel, which cost ranges from 20 rubles per m^3 of CNG to 53 rubles per liter of diesel fuel [3]; the cost to charge an electric car is 10 rubles per kilowatt [4]. A detailed literary analysis of using different types of alternative fuels for road transport is presented in [5, 6]. The work [7] presents the review on performances of motor fuel production, which, certainly, is the aspect of strategic planning of infrastructure development of one or another alternative type of motor fuel. Although the replacement of fossil fuel vehicles with lighter electric vehicles has the greatest potential to reduce CO2 emissions [8], the widespread use of electric power on freight and passenger transport (excluding trolleybuses and streetcars) in the Russian Federation is currently impossible due to the lack of infrastructure for charging [9], maintenance and repair of such vehicles. In Europe [6, 10-12], North America [13], China [14-16], India [17, 18], and other countries, the use of electric transport is a priority for the transport industry. The use of CNG, as the cheapest [19] and economical by more than 15% [20] among hydrocarbon motor fuels, does not always provide the maximum economic effect of the transportation process [19, 20] that caused by the insufficiently developed AGFCS infrastructure [19, 21-23]. In [15], an evolutionary analysis of the impact of a three-dimensional model of technology, market, and policy on the development of the automobile industry on new energy sources in China is conducted. The comparison study [24] substantiates that the emission reduction of hydrocarbon fuel products is most effectively achieved with a reasonable investment in road transport and transport infrastructure. Based on the game model, it was shown that a certain state policy, for example, in taxi services, determines a winning strategy for motor vehicles based on CNG [23]. Five aspects of strategic management of road infrastructure are described in [25], but they are general and do not make it possible to specifically assess the effectiveness of using a particular type of fuel in the transportation process. An overview of studies conducted on the environmentally friendly vehicle routing problem and its classification, given all types and variants of environmentally friendly vehicle problems, is presented [26]. Keeping the number of gas-filling stations and gas-fueled vehicles in line is necessary. For example, there are two AGFCS in Omsk with 186 registered vehicles using CNG as fuel (Form 1 – Traffic Safety). At the same time, in existing international practice, it is considered optimal to have 1 AGFCS per 1,000 gas-powered vehicles to balance the infrastructure economic efficiency and its capacity. Simultaneously, [27] proposes a methodology for ensuring high accuracy in forecasting CNG demand. Choosing the fuel type and the corresponding vehicle has been studied quite extensively. There are also many publications devoted to the impact

*mikhail.banket@mail.ru

on urban planning, forming supply routes [28], distribution networking [14], and design changes in the vehicles themselves [19]. A methodology for multi-criteria choice of vehicles depending on the available infrastructure of the transport network is presented in [29]. In [30], using China as an example, the issue of choosing the vehicle type in terms of reducing CO2 emissions based on the Theory of Planned Behavior is studied, offering some reasonable suggestions for the government and corporate service providers of electric vehicles toward increasing the distribution only of electric vehicles. The study [31] considers the relationship between symbolic meanings and the choice of electric vehicles in China, which can be an effective expression of consumer identity. An algorithm for selecting a rolling stock for freight transportation based on the specific conditions of a motor transport enterprise was developed and proposed in [32]. The research [5] presents the design requirements for the rolling stock to effectively manage road transportation, considering the assessment of the vehicle dimensions. The impact of technological innovations on emissions in transport is considered by the case of China [33]. Scientific research [34] considered the issue of improving the efficiency of road freight transport in cities through the development of a two-factor analysis of vehicles, but without considering the choice of rolling stock. Improving the transport system efficiency is described by [16]. However, this work does not consider the influence of fuel. The work [35] presents a new way to collect data on freight traffic to ensure efficient urban planning, but it does not consider fueling infrastructure. The authors of [14] proposed optimizing distribution routes in terms of time and costs, but this study does not consider fueling costs. The work [28] studies the logistics of freight and passenger transportation in the existing layout of the city. Based on a microscopic model, [36] assesses the environmental impact of transport, including gas fuel, given the configuration of the road network, characteristics, and modes of its operation, but also without considering fueling infrastructure. The role of fueling infrastructure in road transport efficiency regarding electric transport is shown by [37], establishing that the following postulate is crucial for optimization – large fleet size and high charging infrastructure capacity can reduce the minimum required battery capacity. A universal model based on which the driver can choose a filling station should consider the fueling network development, road conditions, and exactly the required amount of fuel in intercity and international transportation. According to [38-40], each truck can have different average daily mileage, depending on the assigned city districts. A detailed simulation of the transportation process was built to determine the impact of the transported cargo weight and transportation conditions, but only relating to electric transport with the efficiency criterion of the battery discharge [41]. In the case of motor fuel, the range depends on a certain consumption of motor fuel and the volume of motor fuel in the fuel tank (cylinder). Determining the consumption of the certain fuel type per 100 km is presented in the methodology [42], and assessing the costs of fueling the rolling stock is described in [43], but there is no comparative assessment of costs depending on fuel and its share in the total costs of the transportation process. Of some interest are studies [44], which compare the energy efficiency of road freight transportation by the example of timber transportation, based on which the payload for the maximum environmental effect is ensured. These studies consider the characteristics of the transported cargo in detail, but the impact of the fueling number is not considered. However, almost all publications study the problem of choosing the type of fuel and the factors influencing this choice concerning passenger transport and determining the waiting time at the filling station. As for freight and passenger transportation, they focus on assessing the efficiency of the process: optimization of traffic routes and rolling stock selection but do not consider the costs of travel to the filling station and the cost of time for fueling. Thus, on the one hand, the strategic solution for increasing the economic efficiency of alternative fuels is described; on the other hand, the recommendations for increasing the economic efficiency of the transportation process, considering fueling and fuel type at the level of a particular driver are substantiated in detail. However, the tactical task of increasing the efficiency of intracity transportation by choosing alternative fuel types for companies and owners of the transportation fleet has not been fully solved. The study hypothesis is that the lack of cost accounting for fueling with motor fuel makes it impossible to assess the total cost objectively. The study aims to assess the share of costs for fueling with different types of motor fuel relative to the total cost of freighting by road transport.

METHODS

The current filling network infrastructure is not evenly developed. The fuel filling stations for petrol and diesel fuel are quite well developed. The network of automobile gas filling stations (AGFS) in most regions of Russia is almost as developed as the network of fuel stations [45]. Fig. 1 shows the percentage ratio of the number of filling/charging stations located in Russia [46, 47] and the average relative cost of 1 fuel liter (kW) relative to the most expensive fuel in rubles [3, 4]. Development trends of filling/charging stations for different fuel types for the last two years are shown in Fig. 2 [48]. The figure shows that AGFCSs have a significant potential for their development which, against the background of economic costs of fuel purchase, looks quite promising for all vehicle owners. Thus, the key consumers of CNG are currently large enterprises. At the same time, 62% of all LDVs in the Russian Federation are mainly GAZ Gazelle of different modifications [49]. LDVs in intracity transportation are used for various goods and passengers. As the average daily mileage increases, the fueling number increases proportionally. However, depending on the type of fuel used, the enterprise location, and the vehicle's route, the

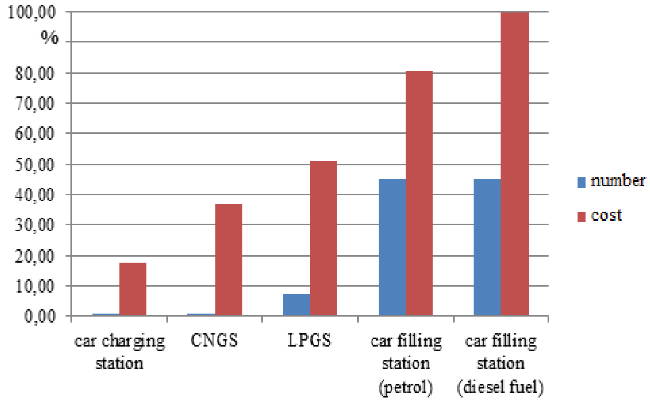


Figure 1: Percentage ratio of the number of filling/charging stations located in Russia and the average relative cost of 1 fuel liter (kW) relative to the most expensive fuel

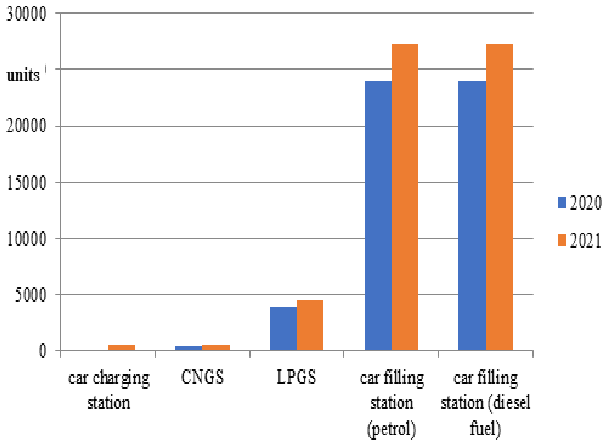


Figure 2: Development trends of filling/charging stations for different fuel types for the last two years

mileage to the fueling place will vary because the infrastructure of filling stations is not evenly developed.

Costs were determined based on the following assumptions:

- The driver's tariff rate is constant and does not depend on the fuel type;
- Only intracity transportation is considered.

Let us determine the number of days, D, prior to full fueling:

$$D = \frac{l_r}{l_{ad}} \tag{1}$$

where l_{ad} – average daily mileage (excluding the mileage for fueling), km; l_r – range, km. Range l_r for GAZ Gazelle depending on the hydrocarbon fuel type is presented in Table 1. Let us assume a linear law of the fueling duration at the filling station and its independence from the fuel type, and then the time of fuel filling into the vehicle's tank will be as follows:

$$t_f = \frac{W}{Q} \tag{2}$$

where W – free volume in the tank (amount of consumed motor fuel), l; Q – performance of the dispenser according to the data in Table 1 [50]. The amount of fuel consumed over the average daily mileage lad is determined by the formula:

$$\mathrm{W} = l_{ad} \cdot H_m \tag{3}$$

where H_m – motor fuel consumption, l/km. Then the fueling time for one work shift after substituting (3) in (2) will be:

$$t_f = \frac{l_d \cdot \acute{I}_{\grave{o}}}{Q}$$

The fueling time of a full tank for several working days without fuel top-up will look like (1):

$$t_f = \frac{D \cdot l_d \cdot \acute{I}_{\grave{o}}}{Q} = \frac{l_r \cdot \acute{I}_{\grave{o}}}{Q}$$

Now let us consider the time to get to the filling station, assuming that there is no queue:

$$t_f = \frac{D \cdot l_d \cdot \acute{I}_{\grave{o}}}{Q} + \frac{l_{p}}{V_{tech}}$$

where l_{rp} – distance from the truck parking to the filling station and from the filling station to the first discharge point, km; V_{tech} – average technical speed, km/h. Then the fueling cost C_f will be:

$$C_f = C_{rh}\left(\frac{D \cdot l_{ad} \cdot H_m}{Q} + \frac{l_{rp}}{V_{tech}}\right) + l_{rp} \cdot H_m C_{mf} \tag{4}$$

where C_{rh} – driver's tariff rate per hour, rub./h. Expression (4) does not explicitly account for the costs of filling with a particular fuel. The cost of a particular fuel will be accounted for by determining the operating costs directly related to the transportation process as another summand in equation (4) and replacing the average daily mileage with the product of the average technical speed by the work shift duration:

$$C_f = C_{rh}\left(\frac{T \cdot D \cdot V_{tech} \cdot H_m}{Q} + \frac{l_{rp}}{V_{tech}}\right) + l_{rp} \cdot H_m C_{mf} \tag{5}$$

where $H_т$ – motor fuel consumption, l(m^3)/km; C_{mf} – the cost of motor fuel, rubles. Presenting the average daily mileage as the product of the average technical speed by the work shift duration, we finally get the total costs, excluding the costs associated with fueling (5):

$$C = T \cdot C_{rh} + T \cdot D \cdot V_{tech} \cdot H_m \cdot C_{mf} \quad (6)$$

where T – duration of the driver's work shift, T = 8 hours. Thus, given the accepted assumptions, the obtained expression is a function of the two varying parameters of the average technical speed Vtech and the distance to the filling station, lrp. In order to obtain a solution by equation (6), it is necessary to determine the possible number of shifts of the vehicle operation without fuel top-up by formula (1). The calculation results by formula (1) for values of average technical speed V_{tech}, which varied from 20 km/h to 55 km/h in increments of 5 km/h, are presented in Fig. 3.

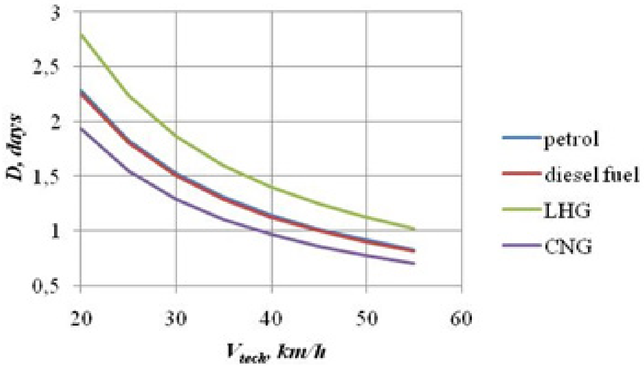
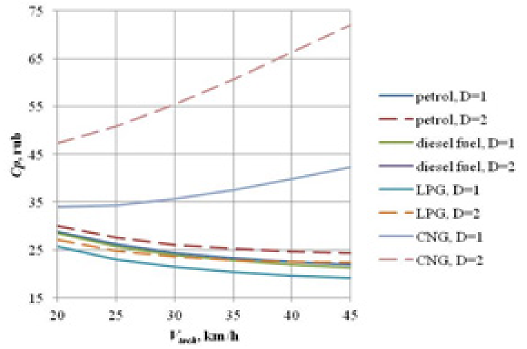


Figure 3: Maximum number of days D without fuel top-up depending on vehicle average technical speed V_{tech}

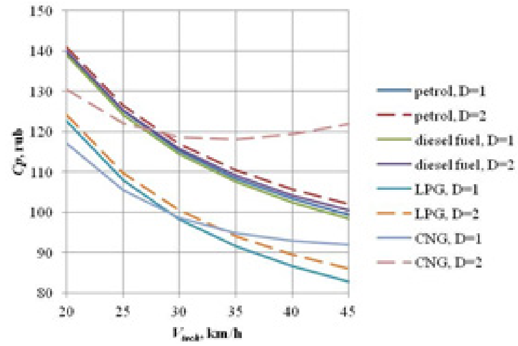
Table 1: Initial data for different hydrocarbon fuels

	Petrol	Diesel fuel	LPG	CNG
Range l_r, km	365	360	447	309
Motor fuel consumption H_T, l/km	0,14	0,112	0,161	0,138
Motor fuel cost C_{mf}, rubles	45,41	56,29	28,67	20,88
Performance of the dispenser, l (m^3)/h	3000	3000	2700	250

The dependences of fueling costs Cf for daily fueling and fueling every other day when the filling station is 2 and 10 km away from the route are shown in Fig. 4 and 5. Fig. 6 shows, as an example, a general view of fueling costs in fueling with CNG motor fuel every other day, depending on the average technical speed Vtech and the distance of the filling station from the route. The total cost of fueling associated with the average technical speed Vtech and the distance of the filling station from the route is well approximated by a polynomial function of the form of standard functions in MATLAB environment, and the regression analysis gave R^2 = 0.9999. The polynomial function has the form:

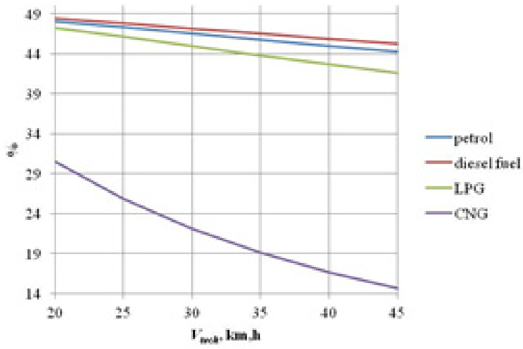


(a)

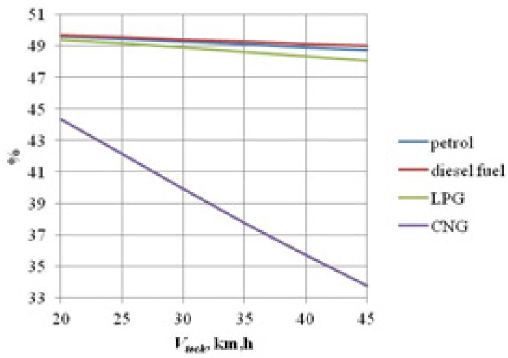


(b)

Figure 4: Dependences of fueling costs Cf for daily fueling and fueling every other day when the filling station is 2 (a) and 10 km (b) away from the route



(a)



(b)

Figure 5: Share of the difference in fueling costs Cf for daily fueling and fueling every other day when the filling station is 2 (a) and 10 km (b) away from the route

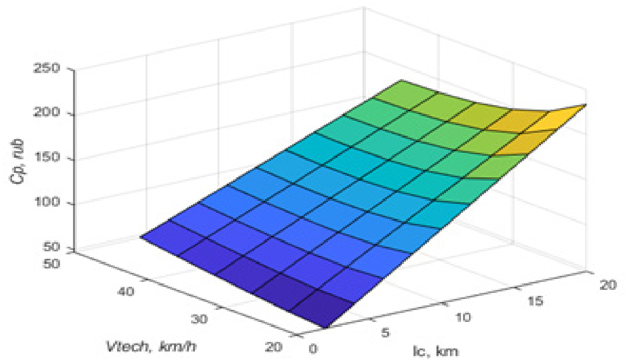


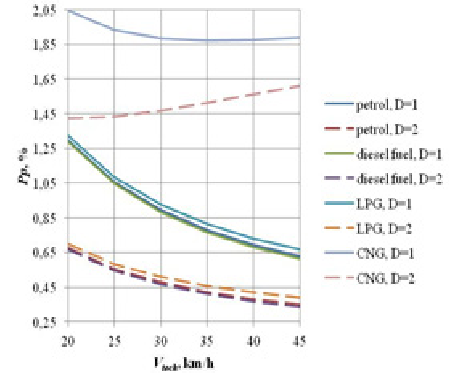
Figure 6: General view of the dependence of fueling costs Cf in the case of fueling with CNG motor fuel every other day, on the average technical speed and the distance of the filling station from the route

$$C_f = P_{00} + P_{10} \cdot l_{rp} + P_{01} \cdot V_{tech} + P_{11} \cdot l_{rp} \cdot V_{tech} + P_{02} \cdot V_{tech}^{\ 2} + P_{12} \cdot l_{rp} \cdot V_{tech}^{\ 2} + P_{03} \cdot V_{tech}^{\ 3} \quad (7)$$

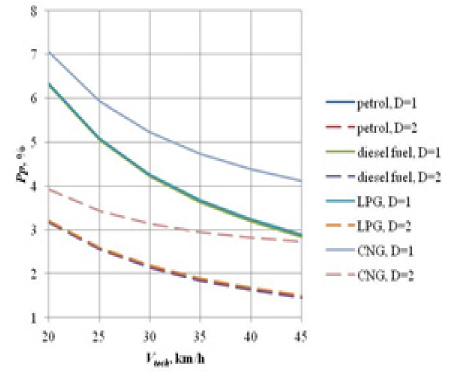
where P_{ij} are polynomial coefficients for different types of hydrocarbon fuels whose numerical values are presented in Table 2. Let us compare the total costs, including fueling, and the costs incurred directly for fueling. For comparison, let us use the ratio of costs related to fueling to the cargo delivery costs expressed as a percentage:

$$P_f = \frac{C_{rh}\left(\frac{T \cdot D \cdot V_{tech} \cdot H_m}{Q} + \frac{l_{rp}}{V_{tech}}\right) + l_{rp} \cdot H_m C_{mf}}{T \cdot C_{rh} + T \cdot D \cdot V_{tech} H_m C_{mf}} 100\% \quad (8)$$

The lower this value, the more correct the choice of fuel is. Fig. 7 shows dependencies of the ratio of costs connected with fueling to the cargo delivery costs at daily fueling and every other day on the average technical speed Vtech for various hydrocarbon fuels at a distance of 2 and 10 km to the filling station from the route.



(a)



(b)

Figure 7: The ratio of costs connected with fueling to the cargo delivery costs at daily fueling and every other day at a distance of 2 and 10 km to the filling station from the route

Table 2: Polynomial coefficients for different types of hydrocarbon fuels

	P_{00}	P_{10}	P_{01}	P_{11}	P_{02}	P_{12}	P_{03}
Petrol	124.2	63.47	-12.38	-8.066	4.238	2.232	-1.158
Diesel fuel	122.9	63.17	-12.57				
LHG	106	53.38	-12.11				
CNG	125.3	43.34	-1.937				

RESULTS

The graphs in Fig. 4 show that the cost in the case of fueling every other day is higher than at daily fueling, but Fig. 5 shows that the increase is not proportional, and thus the savings in the case of fueling every other day are between 40% and 50%, and the further away the filling station is, the less pronounced the savings. As distance and the average technical speed Vtech increase, costs monotonically decrease. When using CNG, there is an inverse pattern of change in costs depending on the average technical speed Vtech: with its increase at short distances to the filling station, costs for fueling increase monotonically, and at distances over 7 km, there is a minimum of costs depending on the average technical speed Vtech both in the case of daily fueling and every other day. When CNG fueling takes place every other day at short distances to the filling station, savings vary from 14 to 30% and at distances over 7 km – from 30 to 45%. It should also be noted that the growth of fueling costs is non-linear primarily due to the strong impact of the average technical speed Vtech. Based on the above, it can be clearly stated that the practice of fueling with petrol and CNG at the end of the shift on the way to the enterprise and LHG fueling at the start of the shift on the way to the first discharge point used by several enterprises, is irrational in terms of optimizing the fueling costs. The average technical speed Vtech has to be considered for long distances to CNG filling stations. In all cases considered, except CNG fueling, when the average technical speed Vtech is less than 20 km/h, the difference in savings becomes almost invisible, regardless of the fueling strategy chosen. As a result of formula (5) approximation, expressions (7) were obtained, based on which we can directly assess the costs of fueling with hydrocarbon fuel depending on the fuel type, average technical speed Vtech, and the distance to the filling station from the route when fueling every other day. Based on the calculation results by expression (8), it was found that the share of costs for fueling is from 0.25 to 7% of the total costs associated with the transportation process in the range of average technical speeds Vtech under consideration. The lowest values fall on fueling every other day, and with the increase of average technical speeds, the cost ratio monotonically decreases for all types of hydrocarbon fuels under consideration. From the condition of minimizing the ratio of fueling costs to the total costs of driving along the route, the least efficient is, as follows from Fig. 7, CNG motor fuel. In the range of average technical speeds under consideration typical for urbanized areas, the cost ratio falls monotonically with an increase in the average technical speed Vtech when the filling stations are located more than 7 kilometers away. However, it must be remembered that the CNG filling station infrastructure is currently underdeveloped, and therefore the cost ratio will be higher than for other fuels due to the long distances to the filling stations and the long fueling time.

DISCUSSION

Thus, the practice of daily fuel top-up is inefficient. It should also be noted that the most effective is diesel fuel, which has the lowest consumption and makes it possible to provide fueling once every three days with the existing design of the fuel system. Accordingly, to stimulate the use of CNG, it is necessary to solve the design problem associated with the increase in the vehicle range. CNG seems the least efficient due to the low range and high mileage to the fueling point. The results made it possible to determine the final costs associated with fueling, considering the average daily mileage of LDVs and the available infrastructure of filling stations. Lack of planning these costs will result in financial losses and reduced profits from transportation services. The rationale for choosing the fuel type in the freight transport by road should consider the fueling costs depending on the average daily mileage. It should be noted that the relative costs determined by the formula (6) are the lowest values since the costs associated with a possible queue for fueling and fluctuations in the values of operational indicators of transportation and fueling processes have not been considered, which will require additional research.

Further developing the CNG infrastructure in road transport by increasing the number of AGFCS will lead to a decrease in fueling costs in a hyperbolic law and an increase in the economic efficiency of using this type of motor fuel even with a low value of the average daily mileage. Accordingly, the total costs of the enterprise for the traffic flow will decrease. The evaluation findings of the fueling costs with different motor fuels make it possible to account for all costs arising in the transportation process for any enterprise that uses LDVs, considering the region's existing infrastructure under consideration.

CONCLUSION

For the first time, the average fueling costs and average vehicle movement costs along the route considering the use of different types of motor fuel have been compared. The nature of changes in fueling costs with hydrocarbon fuel depending on the frequency of fueling, the average technical speed of the rolling stock, and the distance to the filling station from the vehicle's route for different types of hydrocarbon fuel has been established. A criterion for assessing the economic efficiency of vehicle fueling depending on the selected type of hydrocarbon fuel is proposed. Based on the obtained results, specific practical recommendations were formulated related to the frequency of fueling of LDVs with hydrocarbon motor fuel and making a decision on its choice based on the criterion of economic efficiency assessment of vehicle fueling. The proposed approximating equation will make it possible to estimate the fueling costs of LDVs in the practical operation of the rolling stock. Accounting for these costs will minimize the financial losses associated with the transportation process, whose value will significantly increase with the number of LDVs of the transport enterprise. Despite the limitations adopted in this paper (only LDVs and hydrocarbon fuels are considered), the analytical dependencies presented can also be extended to studies related to cost estimation when using other alternative fuels and to vehicles of any carrying capacity. The study results provide a basis for further research related to the impact of infrastructure providing fueling of rolling stock on the economic efficiency of this process: the technical characteristics and distribution density of the filling stations regarding the road network and the direct consumer.

REFERENCES

1. Mohamad, M., Shariff, S., Mohamed, W. (2020). Ranking the Logistics Uncertainty in Malaysian Road Transport Operations. 11th IEEE Control and System Graduate Research Colloquium, p. 371-374. https://doi.org/10.1109/ICSGRC49013.2020.9232626

2. Moschovou, T., Giannopoulos, A. (2021). Road freight transportation in a period of economic instability: A panel data study in four EU Mediterranean countries. Research in Transportation Business & Management, vol. 41, p. 100622. http://dx.doi.org/10.1016/j.rtbm.2021.100622
3. UISIS. State statistics Average consumer prices (tariffs) for goods and services, from https://www.fedstat.ru/indicator/31448, accessed on 2022-01-25
4. SKT-GROUP. First Russian charging stations: the official website, from https://skt-charge.ru/prices/, accessed on 2022-01-25
5. Ildarhanov, R., Basyrov, A., Kalimullina, A., Nuriev, F. (2020). Metodika vybora podvizhnogo sostava. Nauka I Biznes: Puti Razvitija, vol. 2, no. 104, p. 34-36.
6. Janczarska-Bergel, K. (2020). Proecological Solutions in Miejskie Przedsiebiorstwo Komunikacyjne S.A. in Krakow (Poland). Studies of The Industrial Geography Commission of the Polish Geographical Society, vol. 34, p. 124-137.
7. Navas-Anguita, Z., Garcia-Gusano, D., Iribarren, D. (2019). A review of techno-economic data for road transportation fuels. Renewable & Sustainable Energy Reviews, vol. 112, p. 11-26. https://doi.org/10.1016/j.rser.2019.05.041
8. Eltoumi, F., Becherif, M., Ramadan, H. (2021). The key issues of electric vehicle charging via hybrid power sources: Techno-economic viability, analysis, and recommendations. Renewable & Sustainable Energy Reviews, vol. 138, p. 110534. https://doi.org/10.1016/j.rser.2020.110534
9. Chatzikomis, C., Spentzas, K., Mamalis, A. (2014). Environmental and economic effects of widespread introduction of electric vehicles in Greece. European Transport Research Review, vol. 6, p. 365-376. https://doi.org/10.1007/s12544-014-0137-1
10. Fevang, E., Figenbaum, E., Raaum, O. (2021). Who goes electric? The anatomy of electric car ownership in Norway. Transportation Research Part D - Transport and Environment, vol. 92, p. 102727. https://doi.org/10.1016/j.trd.2021.102727
11. Slusarczyk, B., Kot, S., Pilarz, D. (2020). Potential Influence of Electric Cars on the Natural Environment: Chosen Aspects from Poland. 33rd International-Business-Information-Management-Association Conference, p. 3747-3753.
12. Pavlovic, T., Mirjanic, D., Stankovic, A.M. (2020). The Impact of Electric Cars Use on the Environment. New Technologies, Development and Application, vol. 2, p. 541-548. https://doi.org/10.1007/978-3-030-18072-0_62
13. Kampf, R., Hlatká, M., Gross, P. (2021). Optimisation of Distribution Routes: A Case Study. Communications - Scientific Letters of the University of Zilina, vol. 23, no. 1, p. A62-A73. https://doi.org/10.26552/com.C.2021.1.A62-A73
14. Yang, Q., Hu, X., Tao, S. (2021). Comparison of the impact of China's railway investment and road investment on the economy and air pollution emissions. Journal of Cleaner Production, vol. 93, p. 126100. https://doi.org/10.1016/j.jclepro.2021.126100
15. Zhou, Y., Zhou, Z. (2009). The current level of development of the Chinese CNG automobile market, its future trends and strategies. Natural Gas and LNG, vol. 10, p. 44-48. https://doi.org/10.1016/j.ngib.2018.04.010
16. Chhikara, R., Garg, R., Sakkhi, C., Udayan, K., Gautam, A. (2021). Factors affecting adoption of electric vehicles in India: An exploratory study. Transportation Research Part D: Transport and Environment, vol. 100, 103084. https://doi.org/10.1016/j.trd.2021.103084
17. Dhote, T., Chaitanya, P., Mandot, J. (2021). Mahindra Electric Cars: Challenges of Driving a Revolution in the Indian Market. Asian Journal of Management Cases. https://doi.org/10.1177/09728201211035038
18. Milojević, S. (2017). Sustainable application of natural gas as engine fuel in city buses – benefit and restrictions. Journal of Applied Engineering Science, vol. 15, no. 1, p. 81-88. http://dx.doi.org/10.5937/jaes15-12268
19. Tica, S., Živanović, P., Bajčetić, S., Milovanović, B., Nađ, A. (2019). Study of the fuel efficiency and ecological aspects of CNG buses in urban public transport in Belgrade. Journal of Applied Engineering Science, vol. 17, no. 1, p. 65-73. http://dx.doi.org/10.5937/jaes16-17035
20. Suvorov, A. (2019). Perevod rossiĭskogo avtotransporta na gazomotornoe toplivo osushhestvljaetsja medlenno. AvtoGazoZapravochnyj kompleks + Al'ternativnoe toplivo, vol. 18, no. 12, p. 556-557.
21. Timirhanova, L. (2020). Faktory razvitija rynka gazomotornogo topliva v regionah RF. Problemy Jekonomiki i Upravlenija Neftegazovym Kompleksom, vol. 8, no. 188, p. 37-46.
22. Xie, X., Wang, Y., Li, X. (2019). The Usage Analysis and Policy Choice of CNG Taxis Based on a Multi-Stage Dynamic Game Model. Computational Economics, vol. 54, p. 1379–1390. https://doi.org/10.1007/s10614-016-9645-5
23. Yan, Q., Qin, G., Zhang, M., Xiao, B. (2019). Research on Real Purchasing Behavior Analysis of Electric Cars in Beijing Based on Structural Equation Modeling and Multinomial Logit Model. Sustainability, vol. 11, p. 5870. https://doi.org/10.3390/su11205870
24. Priyatiningsih, K., Sutrisno, M. (2020). Road infrastructure asset management strategy and its impact on the environment. IOP Conference Series Materials Science and Engineering, vol. 830, no. 2, p. 022030. http://dx.doi.org/10.1088/1757-899X/830/2/022030

25. Ghorbani, E., Alinaghian, M., Perboli, G.A. (2020). Survey on Environmentally Friendly Vehicle Routing Problem and a Proposal of Its Classification. Sustainability, vol. 12, no. 21, p. 1-72. https://doi.org/10.3390/su12219079
26. Huang, K., Lv, Y., Huang, C., Wang, Y., Niu, Y., Yang, W. (2014). Prediction of CNG automobile ownership by using the combined model. Journal of Chemical and Pharmaceutical Research, vol. 6, p. 2422-2427.
27. Putra A.A., Magribi L.O.M., Makmur M. (2020). Model of logistic transport distribution in the urban area. IOP Conference Series: Earth and Environmental Science, vol. 419, p. 012098. https://doi.org/10.1088/1755-1315/419/1/012098
28. Stoilova, S. (2020). Methodology for Multi-Criteria Selection of Transportation Technology in Transport Network. Sładkowski, A. (Ed.), Modelling of The Interaction of the Different Vehicles and Various Transport Modes. Springer, Cham, p. 1-103. https://doi.org/10.1007/978-3-030-11512-8_1
29. Hou, X., Cao, J., Jia, N. (2012). Index evaluation consequences of F and E Risk for CNG filling station. Journal of Southwest Petroleum University, vol. 34, p. 171-176.
30. Liu, R., Ding, Z.H., Liu, M.Z. (2021). The relationship between symbolic meanings and adoption intention of electric vehicles in China: The moderating effects of consumer self-identity and face consciousness. Journal of Cleaner Production, vol. 288, p. 125116. https://doi.org/10.1016/j.jclepro.2020.125116
31. Konovalova, T.V., Nadirjan, S. L. (2019). Algoritm vybora podvizhnogo sostava dlja perevozki gruzov. Gumanitarnye, social'no-jekonomicheskie i obshhestvennye nauki, vol. 10, p. 239-242.
32. Shi, T., Si, S., Chan, J., Zhou, L. (2021). The Carbon Emission Reduction Effect of Technological Innovation on the Transportation Industry and Its Spatial Heterogeneity: Evidence from China. Atmosphere, vol. 12, p. 1169. https://doi.org/10.3390/atmos12091169
33. Aytbagina, E., Vitvitskiy, E. (2020). Method of Two-Factor Analysis of Cars Operation in the Road Transport System of Cargo Transportation. 8th International Scientific Siberian Transport Forum (TransSiberia), p. 968-974. http://dx.doi.org/10.1007/978-3-030-37919-3_95
34. Gonzalez-Calderon, C.A., Sánchez-Díaz, I., Sarmiento-Ordosgoitia, I., Holguín-Veras, J. (2018). Characterization and analysis of metropolitan freight patterns in Medellin. Colombia. European Transport Research Review, vol. 10, no. 23. https://doi.org/10.1186/s12544-018-0290-z
35. Makarova, I., Buyvol, P., Shubenkova, K. (2020). Usage of Microscopic Simulation to Estimate the Environmental Impact of Road Transport. Transportation Research Procedia, vol. 44, p. 86-93. http://dx.doi.org/10.1016/j.trpro.2020.02.013
36. Lee, J., Heeseung, S., Papakonstantinou, I., Son, S. (2021). Optimal fleet, battery, and charging infrastructure planning for reliable electric bus operations. Transportation Research Part D: Transport and Environment, vol. 100, p. 103066. https://doi.org/10.1016/j.trd.2021.103066
37. Nikolin, V.I., Vitvickij, E.E., Mochalin, S.M. (2004). Gruzovye avtomobil'nye perevozki. SibADI, Omsk.
38. Nikolin, V.I. (2005). Ocenivaem jeffektivnost'. Gruzovoe i Passazhirskoe Avtohozjajstvo, vol. 10, p. 36-38.
39. Vojtenkov, S.S. (2015). K voprosu o terminologii na avtomobil'nom transporte. Vestnik Sibirskoj Gosudarstvennoj Avtomobil'no-Dorozhnoj Akademii, vol. 4, no. 44, p. 11-15.
40. Settey, T., Gnap, J., Synák, F., Skrúcaný, T., Dočkalik, M. (2021). Research into the Impacts of Driving Cycles and Load Weight on the Operation of a Light Commercial Electric Vehicle. Sustainability, vol. 13, p. 13872. https://doi.org/10.3390/su132413872
41. Trofimov, A.V., Zhuravskij, B.V., Trofimov., B.S. (2021). Normirovanie i kontrol' gorjuche-smazochnyh materialov na predprijatijah avtomobil'nogo transporta. SibADI, Omsk.
42. Author 1, Author 2, Bakunov, A.S. (2017). Article title.
43. Palander, T., Haavikko, H., Karha, K. (2020). Comparison of Energy Efficiency Indicators of Road Transportation for Modeling Environmental Sustainability in "Green" Circular Industry. Sustainability, vol. 12, no. 7, p. 2740. https://doi.org/10.3390/su12072740
44. Starinskaya, G. (2017). Kak v Rossii ustroen rynok AZS? Vedomosti. From https://www.vedomosti.ru/business/articles/2017/10/13/737707-kak-ustroen-rinok-azs, accessed on 2022-01-25
45. Gasoline prices and a map of gas stations in Russia, from https://www.benzin-price.ru/, accessed on 2022-01-25
46. ECARS24. Map of electric stations in Russia, from https://ecars24.info/karta-elektrozapravok, accessed on 2022-01-25

47. TADVISER. Business. IT. Electric vehicle charging stations, from https://www.tadviser.ru/index.php/%D0%A1%D1%82%D0%B0%D1%82%D1%8C%D1%8F:%D0%AD%D0%BB%D0%B5%D0%BA%D1%82%D1%80%D0%BE%D0%B7%D0%B0%D0%BF%D1%80%D0%B0%D0%B2%D0%BA%D0%B8_(%D1%8D%D0%BB%D0%B5%D0%BA%D1%82%D1%80%D0%BE%D0%B7%D0%B0%D1%80%D1%8F%D0%B4%D0%BD%D1%8B%D0%B5_%D1%81%D1%82%D0%B0%D0%BD%D1%86%D0%B8%D0%B8,_%D0%AD%D0%97%D0%A1), accessed on 2022-01-25
48. AUTOSTAT analytic agency. The vehicle fleet in the Russian Federation, from https://www.autostat.ru/, accessed on 2022-01-25
49. LLC Plant "Saratovgazavtomatika". Automobile gas-filling compressor stations (AGFCS), from http://sargaz.gazprom-auto.ru/products_services/product_catalogue/avtomobilnye-gazonapolnitelnye-stantsii-agnks1449/avtomobilnye-gazonapolnitelnye-kompressornye-stantsii-agnks.php, accessed on 2022-01-25

Paper submitted: 27.02.2022.
Paper accepted: 07.04.2022.