Journal of Green Economy and Low-Carbon Development
https://www.acadlore.com/journals/JGELCD

Environmental Impact and Service Quality of Liquefied Petroleum Gas Vehicles: A Dual-Phase Assessment through Emission Analysis and SERVQUAL Evaluation

Marko Blagojević[1], Dimitrije Blagojević[2], Zdravko Tutnjević[3], Sandra Kasalica[4], Aleksandar Blagojević[4*]

[1] Faculty of Transport and Traffic Engineering, University of East Sarajevo, 74000 Doboj, Bosnia and Herzegovina
[2] Ministry of Defense of Bosnia and Herzegovina, Hamdije Kreševljakovića 98, 71000 Sarajevo, Bosnia and Herzegovina
[3] Agram d.d, Zvonimirova 40, 88320 Ljubuški, Bosnia and Herzegovina
[4] Academy of Technical and Artistic Professional Studies Belgrade, College of Railway Engineering, 11000 Belgrade, Serbia

[*] Correspondence: Aleksandar Blagojević (bealeksandar.blagojevic@vzs.edu.rs)

Received: 01-03-2025 **Revised:** 02-21-2025 **Accepted:** 03-06-2025

Citation: M. Blagojević, D. Blagojević, Z. Tutnjević, S. Kasalica, and A. Blagojević, "Environmental impact and service quality of liquefied petroleum gas vehicles: A dual-phase assessment through emission analysis and SERVQUAL evaluation," *J. Green Econ. Low-Carbon Dev.*, vol. 4, no. 1, pp. 17–27, 2025. https://doi.org/10.56578/jgelcd040102.

Abstract: The environmental performance and service quality of liquefied petroleum gas (LPG) vehicles were evaluated through a dual-phase analytical approach. In the first phase, exhaust emissions from LPG and petrol-powered vehicles were quantified using the CAPELEC 3010 gas analyzer, with concentrations of carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NOx), and hydrocarbons being measured. The results demonstrated that LPG vehicles emitted significantly lower CO levels (0.09% on average) compared to petrol vehicles (0.18%), with corrected CO values also reduced (0.08% vs. 0.19%). These findings reinforce the environmental advantages of LPG as a cleaner fuel alternative. In the second phase, the SERVQUAL model was employed to assess user perceptions of service quality, focusing on five dimensions: reliability, responsiveness, assurance, empathy, and overall service quality. A negative overall SERVQUAL gap (-0.806) was identified, with the most pronounced discrepancies observed in reliability (-1.061) and responsiveness (-0.933), indicating unmet expectations in key service aspects. Despite these gaps, LPG vehicles were perceived as cost-effective and environmentally sustainable. The findings underscore the necessity for technical refinements in LPG vehicle systems and improvements in service infrastructure to enhance user satisfaction. The insights derived from this study offer valuable guidance for policymakers and industry stakeholders seeking to promote LPG as a viable component of sustainable transportation strategies.

Keywords: Exhaust emissions; Liquefied Petroleum Gas (LPG); SERVQUAL model; Service quality; Sustainable transportation

1 Introduction

In the modern world, environmental protection and reduction of harmful gas emissions are key challenges in the transport sector. Traditional vehicles using petrol or diesel fuels contribute significantly to pollution, emitting CO, CO_2, NOx and other harmful substances that have a serious impact on human health and the ecosystem. Given these environmental challenges, it has become necessary to develop alternative energy sources for vehicles, among which LPG has a significant place. LPG is considered a more environmentally friendly alternative to traditional fuels because it contributes to the reduction of CO, CO_2, NOx and other pollutants, while offering economic advantages such as lower costs. This fuel is used in various types of vehicles, from private cars to commercial and public transport vehicles. Given the environmental and economic benefits, a growing number of countries are focusing their transport policies on promoting LPG as a sustainable alternative fuel.

However, in order to fully integrate LPG into the transport industry, it is not enough to only consider the technical aspects of its application, but also to analyze the user experience. The SERVQUAL model is a useful tool that enables a detailed analysis of service quality based on the difference between user expectations and actual experience. The research in this paper focuses on two aspects: The impact of LPG on environmental protection through the analysis of exhaust gas emissions using the CEPELEC 3010 measuring device, and the quality of service associated with LPG vehicles, using the SERVQUAL model. In the motor vehicle industry, service quality is becoming no less important than the product itself for customer satisfaction. Although LPG is recognized as an energy-efficient and environmentally friendly fuel, customers also expect a high level of service. Factors such as the availability of filling stations and the efficiency of service and after-sales services directly affect the customer experience. By analyzing these factors using the SERVQUAL model, it is possible to identify areas for improvement. The main objective of this paper is to gain insight into how customers perceive the use of LPG vehicles and to what extent this technology meets their needs in terms of service quality. LPG as an alternative fuel has the potential to significantly contribute to environmental protection and pollution reduction. However, its successful implementation depends on continuous improvement of service quality and analysis of user experience. Investment in education and promotion of LPG through appropriate political and economic initiatives can contribute to its wider application in the transport industry. In order to achieve wider application of LPG, it is necessary to solve specific challenges that arise in the market.

In Bosnia and Herzegovina, for example, the LPG market faces issues such as an outdated vehicle fleet, lower purchasing power, lack of regulation and illegal installation of LPG equipment. In order for LPG to be successfully implemented, it is necessary to regulate this area through legal norms and promote user education. The results of this research may provide useful guidelines for the further development and implementation of LPG vehicles, as well as for improving the quality of services provided to users. At the same time, the research could contribute to a better understanding of the environmental impact of these vehicles, as well as the efficiency of LPG as a sustainable fuel.

2 Literature Review

The quality of products and services is crucial for the success of companies, and customer satisfaction with the quality of service plays a central role in maintaining loyalty and constant profitability. The introduction of alternative fuels, such as LPG, significantly contributes to the reduction of harmful gas emissions, which has been confirmed in numerous studies. Mihajlov [1], emphasized that technologies based on alternative fuels reduce the presence of CO_2 and CO in urban areas, with the aim of reducing emissions in the short term and their complete elimination in the long term. Rakić [2] pointed out that LPG, thanks to its high octane number and resistance to auto ignition, is an ideal fuel for OTTO engines. Vehicles using LPG show better operating economy with minimal losses in traction characteristics. Similar results were obtained in the study by Pavlović and Nunić [3], who analyzed the performance of OTTO engines with installed LPG systems. The results show that LPG systems are technologically reliable and environmentally friendly, enabling optimization of engine performance while significantly reducing harmful gas emissions. In 2011, the European Commission adopted a "White Paper", a strategy that focuses on reducing the use of fossil fuels through the modernization of vehicles and infrastructure. This strategy emphasizes the role of alternative fuels in creating a sustainable transport system [4]. Negurescu et al. [5] pointed out that LPG has a higher lower heating value than conventional fuels, but also certain technical challenges for application in diesel engines. Its high octane number makes it ideal for OTTO engines, while performance deficiencies are minimal. Research by Selim et al. [6], experimentally proved that the use of LPG in combination with other fuels reduces CO and CO_2 emissions, as well as noise, making it suitable for urban transport. Tira et al. [7] highlighted the advantages of LPG in terms of storage, noting that it is cheaper and safer compared to other alternative fuels such as CNG and hydrogen. Ashok et al. [8] added that LPG, when used in combination with conventional fuels, reduces particulate matter and nitrogen oxide emissions. This is in line with the findings of Đurić et al. [9], who demonstrated a high level of adaptability of compressed natural gas (CNG) vehicles, as well as their positive environmental impact.

Numerous studies in the field of service quality conducted in recent decades have been devoted to the development of methods for measuring service quality, especially through the SERVQUAL model [10]. Parasuraman et al. [11] developed the SERVQUAL model to capture the gaps between customer expectations and their perceptions. The model is used to assess various dimensions of service quality, such as reliability, assurance, capability, empathy and tangibles. The authors Cronin and Taylor [12] argued in their research that SERVQUAL is not a fully adequate model, but that its dimensions have accurately defined service quality. Carrillat et al. [13] analyzed many studies on service quality and explain in their research that SERVQUAL is still the most widely accepted model for the diagnostic values of service quality. Similarly, Yarimoglu [14] confirmed that SERVQUAL is the most widely used model for assessing service quality, while Imrie et al. [15] argued that the global application of SERVQUAL is the result of a lack of credible alternatives.

There are no studies in the literature that have investigated the quality of LPG vehicles using the SERVQUAL model. Most studies use the SERVQUAL model to analyze the service quality of automotive service centers and the quality of public transport services. In the automotive industry, the SERVQUAL model is used to analyze the differences between customer expectations and perceptions, with special attention paid to the key dimensions of service quality: Reliability, responsiveness, empathy and tangibles. These dimensions allow for a detailed assessment of service quality in service centers, providing insight into areas that require improvement in order to meet customer needs and expectations. On the other hand, in the public transport sector, the focus is predominantly on reliability, punctuality and comfort, which are the most important factors in assessing service quality. These differences highlight the specific needs and priorities of customers in different industries, while confirming the flexibility and broad applicability of the SERVQUAL model.

Research using the SERVQUAL model in the automotive industry has shown significant results. Suhas [16] applied the SERVQUAL model to investigate the gap between expected and perceived service quality in auto repair shops in India, analyzing five dimensions of service quality: tangibles, reliability, responsiveness, assurance and empathy. The results of the study showed significant gaps in all dimensions, indicating the need to improve the quality of auto repair services. Furaida et al. [17] investigated customer satisfaction and service quality in car repair shops in Indonesia using the SERVQUAL method, and the results showed that service quality was below customer expectations. In their study, Yapa and Fernando [18] analyzed service quality in the Sri Lankan automotive industry using the SERVQUAL model, where the key dimensions were reliability, responsiveness, assurance, and tangibility, while empathy was not important. Jain et al. [19] investigated the impact of service quality, perceived service fairness, and convenience on customer satisfaction in the automotive maintenance and repair sector, with the results showing that service quality dimensions positively affect customer satisfaction. Famiyeh et al. [20] investigated the relationship between service quality, customer satisfaction and loyalty of car owners in Ghana, and the results showed that service quality positively affects customer satisfaction and loyalty. Also, Izogo and Ogba [21] investigated the relationship between service quality, customer satisfaction and loyalty in the automotive service sector in Nigeria, where the results showed that service quality significantly affects customer satisfaction and loyalty.

In the field of public transport, Mikhaylov et al. [22] applied the SERVQUAL model to reveal the gap between users' expectations and perceptions of public transport services in Kaliningrad, Russia, with the results showing that the tangibility dimension recorded the largest gap. Iglesias et al. [23] use the SERVQUAL model to analyze user satisfaction in public transport, which is significant for alternative fuel vehicles, as it reduces emissions and environmental characteristics of the vehicle and improves the overall user experience. Valenzo-Jiménez et al. [24] used the SERVQUAL model to assess the quality of public transport in Morelia, Mexico, and the results showed a difference between high user expectations and lower perceptions of actual service quality. Hajduk et al. [25] used the SERVQUAL model and investigated the factors that most influence user perceptions of public transport services in European countries, with reliability, punctuality and comfort being the key elements. Amponsah and Adams [26] investigated the relationship between service quality and user satisfaction in public transport in Canada, and the results showed a significant correlation between service quality and user satisfaction. Maksimović et al. [27] stated that the importance of transport can be seen through the simple fact that it is a necessary element in the functioning of all activities in the economy and society. The new lifestyle and communication have contributed to the need to increasingly adopt the rules of business in transport, where quality becomes the keyword, and the perception of transport service users is a measure of the quality of the public transport service offered.

Other research related to the SERVQUAL model has also contributed to the understanding of service quality in different sectors. Khan and Al-Debei [28], investigated the use of CNG vehicles and their impact on service quality and customer satisfaction, applying the SERVQUAL model, concluding that the use of CNG vehicles has a positive impact on the environmental aspects of transport. Buttle [29], critically analyzed the SERVQUAL model and provided guidelines for further research, including its application in the automotive industry. Ladhari [10] analyzed different models for measuring service quality, including SERVQUAL, and their application in different sectors.

Kumar et al. [30] used the SERVQUAL model to measure the quality of banking services, but pointed out that the methodology can also be applied to the automotive industry. Yousapronpaiboon [31] used the SERVQUAL model to measure the quality of services in higher education, but pointed out that the methodology can be adapted for the automotive industry. Vesković et al. [32] applied the SERVQUAL model to investigate passenger satisfaction in transport, with special emphasis on rail transport, in order to increase the quality of service, and thus the efficiency of the system. The results of the research showed that the service quality of rail passenger transport is quite modest. Stević et al. [33] developed an integrated model for measuring service quality in reverse logistics, using the SERVQUAL model as a basis for analyzing service quality dimensions. Also, Prentkovskis et al. [34] applied the modified SERVQUAL model in combination with the Delphi multi-criteria decision-making methods and the FUCOM method to assess service quality in various sectors, including transport.

3 Methodology

The research methodology was conducted in two phases. In the first phase, exhaust gas testing was performed using the CAPELEC 3010 measuring device, and in the second phase, the quality of LPG-powered vehicles was investigated using the SERVQUAL model. Further on in the paper, the measuring device CAPELEC 3010 and the Servqual method for assessing the quality of LPG-powered vehicles are presented.

3.1 Measuring Device Capelec 3010

The Capelec 3010 is a modern device for precise exhaust gas analysis, developed in accordance with increasingly stringent environmental protection and emission control standards. Its advanced technology allows for the investigation of the performance of vehicles using LPG as fuel, making it a key tool for scientific studies and technical inspections aimed at reducing the environmental impact of transport. The device combines sophisticated sensors and advanced algorithms to provide high accuracy and reliability of measurements. Key components of the analysis include the detection of CO, CO_2, oxygen (O_2), Nox, and hydrocarbons. Integrated infrared spectroscopy (NDIR) and electrochemical sensors provide precise measurement of gas concentrations even in demanding operating conditions. A simple user interface allows the device to be connected to computers and mobile devices for data processing and archiving, while the compact and portable design allows its use in the field. The robust construction guarantees reliable operation in a variety of conditions, further increasing its practicality for technical inspections and research projects.

The Capelec 3010 is designed in accordance with international standards such as ISO 3930 and OIML R99, making it suitable for use in official inspections. Its modular design allows for easy integration into existing systems, while the automatic calibration function reduces the possibility of human error and improves the repeatability of results.

Due to the increasing popularity of LPG as a more environmentally friendly fuel, the Capelec 3010 stands out as a tool that allows for precise monitoring of exhaust emissions and contributes to the development of pollution reduction technologies. In scientific research, the device provides valid results that can be used to analyze and compare exhaust emissions of vehicles running on different fuels. Its ability to quickly and accurately measure exhaust emissions allows researchers to generate reliable data, necessary for decision-making and proposing strategies for a more sustainable development of the transport sector. In addition, the portability of the device allows for a wide range of applications in field and laboratory analyses. The Capelec 3010 not only facilitates the work of technical inspections and laboratory research, but also contributes to the improvement of air quality and the development of sustainable technologies, in line with modern environmental requirements. The appearance of the device is presented in Figure 1.

3.2 SERVQUAL (Service Quality) Model

The SERVQUAL model provides an effective conceptual framework for researching and measuring service quality. The model was developed by Parasuraman et al. [11], and its application enables research into service quality in various fields and industries. According to this model, service quality is a function of user perception, that is, the way the user experiences the service in relation to the expectations that he or she formed before using it. When there is a discrepancy between user expectations and perception, the so-called "service quality gap" occurs. It is crucial to identify this gap, because there is a direct link between service quality and user satisfaction. Unlike product quality, which can be objectively measured, service quality is abstract and complex to measure due to three basic properties: intangibility, heterogeneity and inseparability from the process of providing and using the service. The SERVQUAL model is one of the most widely used models for measuring customer perceptions and encompasses two key areas:

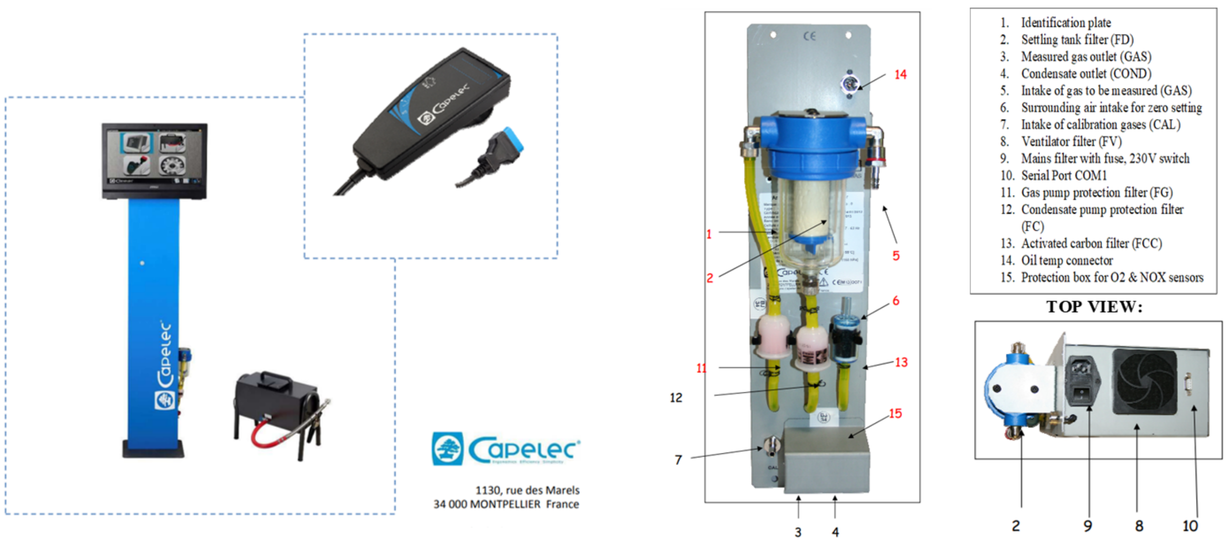

Figure 1. Appearance of the device and housing of CAPELEC 3010

Note: Capelec Catalog [35]

- User expectations: A set of 22 questions that examine user expectations regarding the service.

- Customer Perceptions: A set of 22 questions measuring how customers evaluate a specific category of service.

A Likert scale is used to measure responses (5 = strongly agree, 1 = strongly disagree). After collecting data, the model analyzes the results from the areas of expectations and perceptions and calculates the deviation between them. The reliability of the SERVQUAL model is measured by Cronbach's Alpha coefficient, which shows consistency and correlation within a group of questions. Coefficient values below 0.70 indicate an unacceptable level of reliability, while values above 0.70 indicate recommended measurement reliability. SERVQUAL can be used to investigate user satisfaction with LPG motor vehicles, where discrepancies between expectations and perceptions are analyzed to identify areas for improvement.

4 Results

4.1 Results of Research Using the CAPELEC 3010 Measuring Device

Experimental exhaust gas tests using the CAPELEC 3010 measuring device were carried out in the period from 08.07.2022 to 15.07.2023 at the technical inspections of Agram d.o.o. (Banja Luka, Doboj, Teslić). During the period, exhaust gas tests of vehicles with petrol and LPG fuels were carried out. During the test itself, the composition of the exhaust gases was analyzed and the content of CO, COcorr. and λ was measured as elimination factors. The results of the vehicle tests included in the research are given in Table 1. The research presented in this paper was measured in real conditions during the observed period, where records of exhaust gas values were kept.

Table 1. Test results using the CAPELEC 3010 measuring device

		Petrol			**LPG**		
Vehicle	**VIN**	**CO(%)**	**$C0_{corr}$(%)**	**λ**	**CO(%)**	**$C0_{corr}$(%)**	**λ**
ŠKODA Fabia 5J	TMBEB2NJ1HZ108101	0.26	0.26		0.13	0.13	
ŠKODA Fabia 5J	TMBEB2NJ5HZ112619	0.25	0.25	1.01	0.12	0.11	1.01
ŠKODA Fabia 5J	TMBEB2NJ0JZ154945	0.26	0.26	1	0.13	0.12	1
SKODA Fabia 5J	TMBEB2NJ3JZ155507	0.27	0.27	1.01	0.11	0.09	0.98
SKODA Fabia 5J	TMBEB2NJ2JZ160536	0.24	0.25	1.01	0.13	0.1	1
SKODA Fabia 5J	TMBEB2NJ4JZ157945	0.23	0.25	1	0.11	0.11	0.97
ŠKODA Fabia 5J	TMBEB2NJ4JZ159579	0.26	0.26	1	0.13	0.12	1.01
ŠKODA Fabia 5J	TMBEA15J9B3187735	0.27	0.27	1.01	0.11	0.08	1.02
ŠKODA Fabia 6J	TMBBB46YX23557202	0.25	0.25	1.01	0.1	0.08	0.99
FIAT Panda 169	ZFA16900001876250	0.12	0.13	1	0.06	0.1	0.99
FIAT Panda 169	ZFA16900001915482	0.11	0.12	1.03	0.09	0.11	1.02
FIAT Panda 169	ZFA16900001894893	0.12	0.13	1.02	0.09	0.09	1.01
FIAT Panda 169	ZFA16900001888069	0.13	0.14	1.03	0.01	0.02	1.02
RENAULT Clio	VF16RSN0A57592382	0.05	0.21	1.03	0.03	0.08	0.99
RENAULT Clio	VF1BB05CF26322952	0.06	0.19	1.03	0.02	0.02	1.03
RENAULT Megan	VF1BZ0H0541977172	0.04	0.18	1.01	0.03	0.03	1
RENAULT Megan	VF1BA1H0525916734	0.05	0.16	1.01	0.01	0.05	0.99
OPEL Meriva	W0L0XCE7554099690	0.09	0.11	1.01	0.06	0.05	0.98
OPEL Astra Caravan	W0L0TGF3532199350	0.1	0.1	1.03	0.08	0.05	1.01
FORD Focus	WF05XXGCD55M79196	0.02	0.12	1.03	0.01	0.05	1.01
FORD Focus	WF0BXXGCDB2L18862	0.02	0.11	1.01	0.01	0.01	1.01
PEUGEOT 207	VF3WEKFT0AW042268	0.16	0.12	1.01	0.09	0.01	1
PEUGEOT 3071, 6I	VF33ENFUC84076164	0.1	0.01	1.01	0.05	0.01	1.01
PEUGEOT 307 CC	VF33BRFNC83312846	0.11	0.01	0.99	0.05	0.01	0.97
TOYOTA RAV4	JTMBH31V306040017	0.22	0.22	1.01	0.06	0.05	0.99
TOYOTA RAV 4	JTMBD33V475097738	0.19	0.2	1	0.02	0.11	1
DAIMLERCHRYSLER 203 C200	WDB2030451F041049	0	0.2	1.02	0	0.11	1.01
DAIMLERCHRYSLER 168 A 160	WDB1680331J368338	0.01	0	1	0	0	0.97
SEAT Ibiza 6K	VSSZZZ6KZYR064100	0.05	0.22	1.01	0.02	0.09	0.99
MAZDA 3	JMZBK14Z251247991	0.16	0.03	1.01	0.06	0.01	1
DACIA Logan LS0E	UU1LSDAEH36865376	0.11	0.02	0.99	0.06	0.01	0.98
AUDI A4 8E	WAUZZZ8EZ1A013713	0.16	0.09	1.0	0.09	0.05	1
VW Passat 3BG	WVWZZZ3BZ1P137270	0.19	0.14	1.02	0.02	0.03	1.01
VW Passat 3BG	WVWZZZ3BZXE459589	0.11	0.18	1.01	0.01	0,03	1.01
VW Caddy 9KVF	WV1ZZZ9KZXR538491	0.2	0.16	0.98	0.08	0.09	0.97
CITROEN XSARA Picaso	VF7CHNFUC25853689	0.26	0.21	1.01	0.06	0.11	1
DAEWOO Lanos -	KLATF48YEYB464315	0.18	0.18	1.01	0.06	0.07	1.01

The results of the study showed that LPG vehicles had lower CO emissions compared to petrol vehicles, but both groups met technical standards. The lambda factor, which indicates the quality of combustion, was similar for both types of fuel, indicating efficient combustion. The corrected CO emissions of LPG vehicles were slightly lower than petrol vehicles, confirming a lower impact on environmental pollution. After a comparative analysis, it can be concluded that LPG vehicles are more environmentally friendly due to lower pollution, while meeting all technical requirements. Figure 2, Figure 3, and Figure 4 present comparative measured values of CO, corrected values of CO (COcorr) and Lambda (λ) factor for the observed cars.

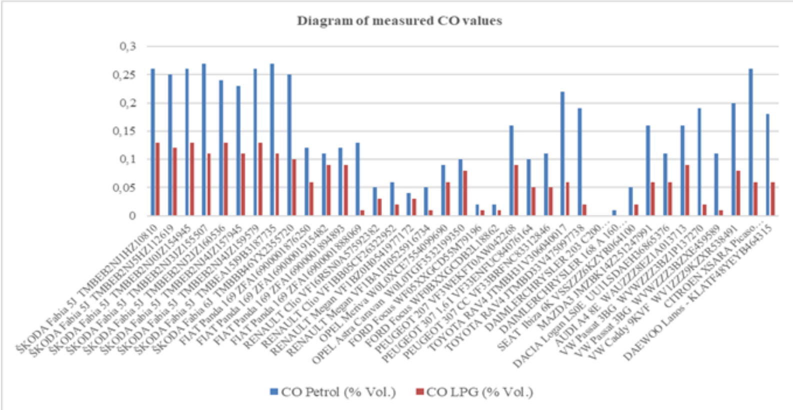

Figure 2. Comparative measured CO values for petrol and LPG vehicles

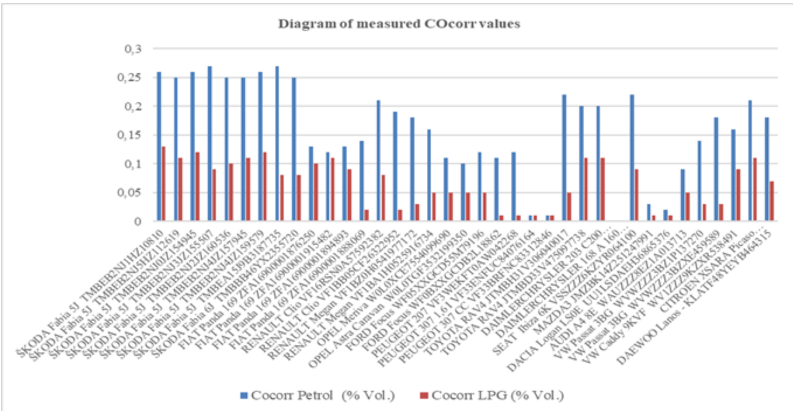

Figure 3. Comparative measured COcorr values for petrol and LPG vehicles

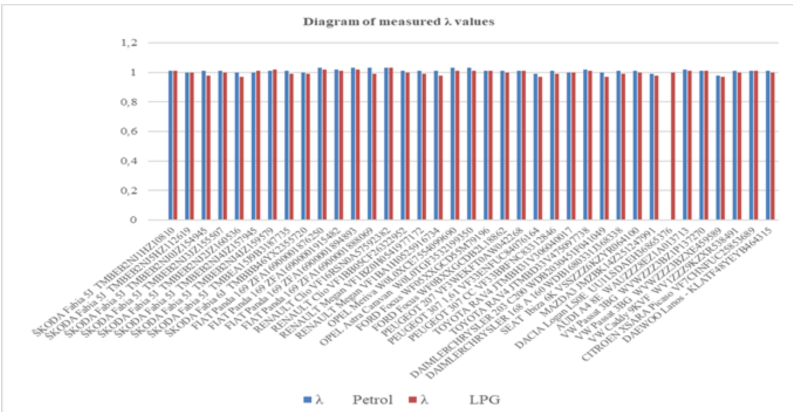

Figure 4. Comparative measured Lambda values for petrol and LPG vehicles

Table 2. Key parameters of our model

No.	Dimensions	Assertion	Expectations AV	Expectations SD	Perceptions AV	Perceptions SD	SERVQUAL Gap
1.	Reliability	How often have you experienced inconveniences due to the variability in the performance of your LPG-powered vehicle's engine?	4.216	0.703	3.432	0.823	-0.757
2.		How would you rate the stability of the LPG system in your vehicle during driving?	4.649	0.625	3.405	0.752	- 1.243
3.		How often have you experienced breakdowns or issues with the system in your vehicle?	4.405	0.591	3.432	0.638	-0.973
4.		How would you rate the reliability of the pressure regulator, valves, and other components of the LPG system in your vehicle?	4.703	0.563	3.459	0.682	-1.243
5.	Responsiveness	How many LPG stations are available in your area?	4.703	0.513	3.865	0.777	-0.838
6.		How would you rate the refueling speed of the LPG tank at the stations?	4.649	0.531	3.595	0.752	-1.054
7.		Do you feel that driving a LPG-powered vehicle is more practical than driving a vehicle with other fuels?	4.676	0.523	3.919	0.850	-0.757
8.		Do you believe that using LPG contributes to environmental protection?	4.892	0.388	3.811	0.691	- 1.081
9.	Assurance	How safe do you feel using LPG fuel in your vehicle regarding the risk of fire or explosion?	4.405	0.676	4.162	0.789	-0.243
10.		How would you rate the crash resistance of your LPG-powered vehicle compared to vehicles with other fuels?	4.135	0.704	3.649	0.813	-0.486
11.		Do you believe that the additional weight of the LPG tank affects the braking, acceleration, and handling of the vehicle?	4.514	0.642	3.838	0.678	-0.676
12.		How confident are you in the resistance of the LPG tank to leaks or damage that could lead to gas leakage?	4.459	0.682	3.757	0.713	-0.703
13.		How safe and reliable do you feel while driving a LPG-powered vehicle compared to vehicles with other fuels?	4.514	0.683	4.135	0.741	-0.378
14.	Empathy	How would you rate the level of support you receive from LPG system service providers in resolving specific issues?	4.595	0.591	3.784	0.843	-0.811
15.		How satisfied are you with the expertise and empathy of the staff providing support regarding the use of the LPG system?	4.459	0.597	3.784	0.703	-0.676
16.		How flexible are LPG system service providers in offering solutions for your specific needs or requirements?	4.514	0.598	3.784	0.621	-0.730
17.		Have you noticed that LPG system service providers tailor their support and advice to your specific needs?	4.432	0.679	3.622	0.850	-0.811
18.	Overall quality of LPG vehicles	How would you rate the overall performance of your LPG-powered vehicle compared to other types of fuel?	4.324	0.660	3.541	0.682	-0.784
19.		How would you rate the cost of purchasing a vehicle with an installed LPG system compared to vehicles that use other types of fuel?	4.541	0.597	3.649	0.666	-0.892
20.		How would you rate the price of LPG compared to other types of fuel?	4.162	0.593	3.486	0.642	-0.676
21.		Based on your experience, how high are the maintenance costs of the LPG system in your vehicle compared to vehicles with other types of fuel?	3.676	0.807	3.324	0.840	-0.351

No.	Dimensions	Assertion	Expectations AV	Expectations SD	Perceptions AV	Perceptions SD	SERVQUAL Gap
22.		How would you rate the registration and insurance costs of a vehicle with an installed LPG system compared to vehicles that use other types of fuel?	4.189	0.765	2.973	0.788	- 1.216
		Overall average grade	4.446	0.623	3.655	0.742	-0.790

Table 3. Research results from the perspective of user expectations and perceptions

Dimension	Expectations				Perceptions				SERVQUAL Gap
	AV	SD	Wij	C-alfa	AV	SD	Wij	C-alfa	
Reliability	4.493	0.621	0.186	0.731	3.432	0.724	0.171	0.731	-1.061
Responsiveness	4.730	0.489	0.195	0.727	3.798	0.768	0.189	0.723	-0.933
Assurance	4.405	0.677	0.225	0.861	3.908	0.747	0.243	0.754	-0.497
Empathy	4.500	0.616	0.180	0.685	3.744	0.754	0.186	0.749	-0.757
Overall quality of LPG vehicles	4.178	0.684	0.214	0.724	3.395	0.724	0.211	0.746	-0.784
SERVQUAL	4.461	0.618	1.000	0.746	3.655	0.743	1.000	0.741	-0.806

4.2 Results of the Research on the Quality of LPG-Powered Motor Vehicles Using the Servqual Model

As part of the research on the quality of LPG motor vehicles, a modified Servqual model was applied in order to gain insight into the expectations and perceptions of users (drivers) about the quality of the vehicles and services offered. The survey of drivers of LPG motor vehicles was conducted at the vehicle technical inspection centers of Agram d.o.o. (in Banja Luka, Doboj and Teslić) in the period from 15.01.2024. to 30.06.2024. The distribution of survey questionnaires by technical inspections was preceded by prior announcement in writing and by telephone. The survey of motor vehicle drivers was anonymous. In addition, the survey of motor vehicle drivers was carried out using the "face-to-face" technique. The largest share of surveyed users belonged to the male population, which makes up 78% of the sample. The dominant age group of surveyed users is from 36 to 45, with 38%. Most of them have a higher or university degree, which amounts to 51%, while as many as 92% of the respondents are employed. These data indicate that the survey covers primarily a working population of middle age, with a relatively high educational profile.

In order to collect data on LPG and petrol vehicles, a survey consisting of 22 questions was conducted. The survey was primarily intended for drivers of LPG-powered vehicles, and its results were used exclusively for the purpose of this paper. The research used a structured SERVQUAL survey, which was adapted from the methodology of Parasuraman et al. [11, 36], The survey included five dimensions: reliability, responsiveness, assurance, empathy and overall quality of LPG vehicles, with each dimension being contained in 22 questions. The survey used a Likert scale from 1 to 5, where a rating of 1 indicated that a certain vehicle characteristic was "not important at all", while a rating of 5 indicated that it was "very important". All variables in the survey were independent. The following tables present the results of the descriptive statistical analysis, including the average ratings of drivers' expectations and perceptions based on dimension and individual questions. These data provide insight into drivers' attitudes and experiences related to the use of LPG vehicles, which is crucial for further analysis and conclusions in this paper.

According to the research results shown in Table 2, the average ratings for expectations and perceptions of the quality of LPG-powered vehicles were determined. The arithmetic means for expectations ranged from 3.676 to 4.892, with the overall average rating for expectations being 4.446. These data suggest that users have high expectations regarding the quality of LPG-powered vehicles. On the other hand, the average ratings for perceptions ranged from 2.973 to 4.162, with an overall average rating of 3.655. Although this value is lower compared to expectations, it still represents a relatively high-quality rating, indicating a satisfactory perception from users.

Based on the collected data, the SERVQUAL gap for the dimensions of LPG-powered vehicle quality was calculated and is presented in Table 3. This gap, obtained as the difference between the average ratings for expectations and perceptions, serves as a key indicator of the overall quality of LPG-powered vehicles. A negative gap, associated with 22 variables, indicates that users' perceptions were lower than their expectations. However, the differences were not significantly large, suggesting that there is room for improvement in quality, but the current state is still satisfactory. Additionally, based on the data from Table 2, the weights for the quality dimensions and the Cronbach alpha coefficient were calculated, as shown in Table 3. These results provide further insight into the reliability and structure of the dimensions used in the research, confirming the validity of the applied methodology and the conclusions drawn.

Analysis of the data presented in Table 3, which contains the research results by quality dimensions of LPG-powered vehicles, reveals that the average ratings for expectations were higher than the average ratings for perceptions in all dimensions. This resulted in a negative SERVQUAL gap across all dimensions, indicating that user experiences did not fully meet their expectations. The largest gaps were observed in the "reliability" (-1.061) and "responsiveness" (-0.933) dimensions, suggesting that users perceived these aspects as the least satisfactory compared to their expected standards. On the other hand, the "assurance" dimension showed the smallest gap (-0.497), indicating that users are the most satisfied with this aspect of LPG-powered vehicle quality. The research also revealed that users of LPG-powered vehicles assign the highest weight and importance to the “assurance” dimension, which confirms its key influence on the overall perception of quality.

To assess the reliability of the research, an internal consistency analysis was conducted using the Cronbach alpha coefficient. The results showed that all dimensions, except for "empathy," achieved a Cronbach alpha coefficient value greater than 0.7, indicating a high level of reliability and consistency in the research. Although the "empathy" dimension showed somewhat lower reliability, the overall conclusion is that the research was conducted at a high level of reliability, which confirms the validity of the obtained results.

5 Conclusions

A comparative analysis of the exhaust emissions from petrol-powered vehicles and vehicles using LPG is crucial for understanding the ecological and economic performance of these systems. Using LPG as an alternative fuel offers several advantages, particularly in reducing harmful gas emissions, making it an attractive choice in the context of global efforts to reduce pollution and mitigate climate change. In addition to its ecological benefits, LPG also provides economic advantages, such as lower fuel costs and the ease of upgrading existing petrol systems.

The research results show that LPG is more efficient in reducing emissions of CO and CO_2 compared to petrol. For example, CO emissions when using LPG are significantly lower, which directly contributes to reducing air pollution. Additionally, LPG produces fewer particles and other harmful gases, making it a more environmentally friendly option. This reduced emission of gases that contribute to global warming makes LPG an important element in sustainable transportation strategies. In addition to its ecological benefits, LPG offers economic advantages. The price of LPG is usually lower than petrol, resulting in significant savings for users. Upgrading existing vehicles to use LPG is relatively simple and cost-effective, which further enhances its appeal. Although the performance of LPG-powered vehicles is generally satisfactory, there are opportunities for further improvements in engine efficiency and emissions reduction through ongoing research and development of technologies.

The application of the SERVQUAL model in the research of LPG-powered vehicle quality provides valuable insights into user expectations and perceptions. The research results show that users have high expectations regarding vehicle quality, as confirmed by the high average ratings for expectations (4.446). However, user perceptions, although relatively high (average rating of 3.655), did not fully meet their standards, resulting in a negative SERVQUAL gap across all dimensions. This indicates a need for further improvements, particularly in the dimensions of reliability and responsiveness.

The research has certain limitations, including the use of a sample composed of technical inspections at a limited number of locations (Agram d.o.o. in Banja Luka, Doboj, and Teslić). To obtain more comprehensive results, it is recommended to expand the sample to other regions in Bosnia and Herzegovina. Additionally, the SERVQUAL survey can be extended to include additional quality dimensions. Despite these limitations, the research has shown that the adapted SERVQUAL model is highly reliable for analyzing the quality of LPG-powered vehicles.

The comparative analysis of exhaust emissions from petrol and LPG-powered vehicles clearly demonstrates that LPG offers significant ecological and economic advantages. However, there is room for further improvement, both in terms of technical performance and user satisfaction. Further research should focus on optimizing the combustion of LPG to reduce emissions and increase engine efficiency, as well as expanding the SERVQUAL model to better understand user needs. The promotion and implementation of the LPG system should be part of a broader strategy aimed at reducing emissions and enhancing sustainability in the transport sector.

Data Availability

The data supporting our research results are included within the article or supplementary material.

Conflicts of Interest

The authors declare no conflict of interest.

References

[1] A. Mihajlov, *Sustainable Development and Environment Towards Europe in 95+ Steps*. Beograd: Privredna Komora Srbije i Ambasadori životne Sredine, 2005.

[2] S. Rakić, “Analysis of application of liquefied petroleum gas as an ic engine fuel,” *Mil. Tech. Cour.*, vol. 56, no. 1, pp. 74–90, 2008. https://doi.org/110.5937/vojtehg0801074R

[3] M. Pavlović and Z. Nunić, “Comparative performance analysis of an OTTO engine equipped for petrol or liquefied petroleum gas propulsion,” in *Proceedings of the First International Conference on Advances in Traffic and Communication Technologies (ICATC 2022)*. Bosnia and Herzegovina: University of Sarajevo Faculty of Traffic and Communications, 2022, pp. 149–156.

[4] “White Paper, Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system,” European Commission, Tech. Rep., 2011.

[5] N. Negurescu, C. Pana, and A. Cernat, “Theoretical and experimental investigations on the LPG fuelled diesel engine,” in *Proceedings of FISITA 2012 World Automotive Congress*. Springer Nature, 2013, pp. 37–49. https://doi.org/10.1007/978-3-642-33777-2

[6] M. Selim, S. Al-Omari, and A. Al-Aseery, “Effects of steam injection to dual fuel engine on performance, noise and exhaust emission,” SAE, Tech. Rep. 2009-01-1831, 2009. https://doi.org/10.4271/2009-01-1831

[7] H. S. Tira, J. M. Herreros, A. Tsolakis, and M. L. Wyszynski, "Characteristics of LPG–diesel dual fuelled engine operated with rapeseed methyl ester and gas-to-liquid diesel fuels," *J. Energy*, vol. 47, no. 1, pp. 620–629, 2012. https://doi.org/10.1016/j.energy.2012.09.046

[8] B. Ashok, D. Ashok, and R. Kumar, "LPG diesel dual fuel engine – A critical review," *Alexandria Eng. J.*, vol. 54, no. 2, pp. 105–126, 2015.

[9] B. Đurić, M. Mošić, and A. Trifunović, "The research on the environmental impact of buses and engines powered by compressed natural gas," *J. Road Traffic Eng.*, vol. 65, no. 1, pp. 43–49, 2019. https://doi.org/10.31075/PIS.65.01.07

[10] R. Ladhari, "Alternative measures of service quality: A review," *Manag. Serv. Qual.*, vol. 18, no. 1, pp. 65–86, 2008. https://doi.org/10.1108/0960452081084

[11] A. Parasuraman, V. A. Zeithaml, and L. L. Berry, "A conceptual model of service quality and its implications for future research," *J. Mark.*, vol. 49, no. 4, pp. 41–50, 1985. https://doi.org/10.1177/002224298504900403

[12] J. J. Cronin and S. A. Taylor, "Measuring service quality: A reexamination and extension," *J. Mark.*, vol. 56, no. 3, pp. 55–68, 1992. https://doi.org/10.2307/1252296

[13] F. A. Carrillat, F. Jaramillo, and J. P. Mulki, "The validity of the SERVQUAL and SERVPERF scales: A meta-analytic view of 17 years of research across five continents," *Int. J. Serv. Ind. Manag.*, vol. 18, no. 5, pp. 472–490, 2007. https://doi.org/10.1108/09564230710826250

[14] E. K. Yarimoglu, "A review on dimensions of service quality models," *J. Mark. Manag.*, vol. 2, no. 2, pp. 79–93, 2014. https://jmm.thebrpi.org/journals/jmm/Vol_2_No_2_June_2014/5.pdf

[15] B. C. Imrie, J. W. Cadogan, and R. McNaughton, "The service quality construct on a global stage," *Manag. Serv. Qual.*, vol. 12, no. 1, pp. 10–18, 2002. https://doi.org/10.1108/09604520210415353

[16] A. Suhas, "Service quality gap analysis of automobile service centres," *Indian J. Res. Manag. Bus. Soc. Sci.*, vol. 1, no. 1, pp. 38–41, 2013. https://doi.org/10.13140/2.1.1023.0407

[17] S. Furaida, M. Dachyar, and D. S. Gabriel, "Measuring customer satisfaction and service quality in automobile repair," in *International Conference On Multidisciplinary Academic (ICMA)*, 2018, pp. 1–6.

[18] S. Yapa and R. Fernando, "An assessment of service quality in the automobile service industry: A study of a developing country," *Proc. Eng. Sci.*, vol. 5, no. 1, pp. 85–96, 2023. https://doi.org/10.24874/PES05.01.008

[19] N. Jain, A. K. Singh, and K. Kaushik, "Evaluating service quality in automobile maintenance and repair industry," *Asia Pac. J. Mark. Logist.*, vol. 32, no. 1, pp. 117–134, 2019. https://doi.org/10.1108/APJML-07-2018-0277

[20] S. Famiyeh, A. Kwarteng, and D. A. Darko, "Service quality, customer satisfaction and loyalty in automobile maintenance services: Evidence from a developing country," *J. Qual. Maint. Eng.*, vol. 24, no. 3, pp. 262–279, 2018. https://doi.org/10.1108/JQME-10-2016-0056

[21] E. E. Izogo and I. E. Ogba, "Service quality, customer satisfaction and loyalty in automobile repair services sector," *Int. J. Qual. Reliab. Manag.*, vol. 32, no. 3, pp. 250–269, 2015. http://dx.doi.org/10.1108/IJQRM-05-2013-0075

[22] A. S. Mikhaylov, I. S. Gumenuk, and A. A. Mikhaylova, "The SERVQUAL model in measuring service quality of public transportation: Evidence from Russia," *Qual. Access Success*, vol. 16, no. 144, pp. 78–83, 2015.

[23] O. Iglesias, J. Singh, and J. M. Batista-Foguet, "The role of brand experience and affective commitment in determining brand loyalty," *J. Brand Manag.*, vol. 18, pp. 570–582, 2011. https://doi.org/10.1057/bm.2010.58

[24] M. A. Valenzo-Jiménez, D. A. Lázaro-López, and J. A. Martínez-Arroyo, "Application of the SERVQUAL model to evaluate the quality in the transportation service in Morelia," *DYNA*, vol. 86, no. 211, 2019. https://doi.org/10.15446/dyna.v86n211.78368

[25] I. Hajduk, M. Poliak, and J. Gašparík, "Quality of transport services and customer satisfaction measurement," *Arch. Automot. Eng.*, vol. 96, no. 2, pp. 51–76, 2022. https://doi.org/10.14669/AM/151707

[26] C. T. Amponsah and S. Adams, "Service quality and customer satisfaction in public transport operations," *Int. J. Serv. Oper. Manag.*, vol. 25, no. 4, pp. 531–549, 2016. https://doi.org/10.1504/IJSOM.2016.080279

[27] M. V. Maksimović, B. S. Đorđević, M. D. Brzaković, and M. M. Grahovac, "Transport services quality measurement using SERVQUAL model," *Tehnika*, vol. 72, no. 6, pp. 928–935, 2017. https://doi.org/10.5937/tehnika1706928M

[28] M. S. Khan and M. M. Al-Debei, "Service quality and customer satisfaction in transportation: A case study on the adoption of compressed natural gas vehicles," *Energy Policy*, vol. 68, pp. 123–135, 2014. https://doi.org/10.1016/j.enpol.2014.01.017

[29] F. Buttle, "Servqual: Review, critique, research agenda," *Eur. J. Mark.*, vol. 30, no. 1, pp. 8–32, 1996. https://doi.org/10.1108/03090569610105762

[30] M. Kumar, F. T. Kee, and A. T. Manshor, "Determining the relative importance of critical factors in delivering service quality of banks: An application of dominance analysis in SERVQUAL model," *Manag. Serv. Qual.*, vol. 19, no. 2, pp. 211–228, 2009. https://doi.org/10.1108/09604520910943198

[31] K. Yousapronpaiboon, "Servqual: Measuring higher education service quality in Thailand," *Proc. Soc. Behav. Sci.*, vol. 116, pp. 1088–1095, 2014. https://doi.org/10.1016/j.sbspro.2014.01.350

[32] S. Vesković, M. Kuravica, K. Dimanoski, G. Stojić, and A. Blagojević, "Modeling the quality of railway transport services by application of the Serqual method," *Železnice*, vol. 64, no. 1, pp. 29–47, 2019. https://www.casopis-zeleznice.rs/index.php/zeleznice/article/view/59

[33] Ž. Stević, I. Tanackov, A. Puška, G. Jovanov, J. Vasiljević, and D. Lojančić, "Development of modified SERVQUAL–MCDM model for quality determination in reverse logistics," *Sustainability*, vol. 13, no. 10, p. 5734, 2021. https://doi.org/10.3390/su13105734

[34] O. Prentkovskis, Ž. Erceg, Ž. Stević, I. Tanackov, M. Vasiljević, and M. Gavranović, “A new methodology for improving service quality measurement: Delphi-FUCOM-SERVQUAL model,” *Symmetry*, vol. 10, no. 12, p. 757, 2018. https://doi.org/10.3390/sym10120757

[35] “Capelec catalog,” https://www.capelec.com/en, 2025.

[36] A. Parasuraman, V. A. Zeithaml, and L. L. Berry, “Reassessment of expectations as a comparison standard in measuring service quality: Implications for further research,” *J. Mark.*, vol. 58, no. 1, pp. 111–124, 1994. https://doi.org/10.1177/002224299405800109