

PASSENGER'S APPROACH TO ELECTRIC BUSES IN PUBLIC TRANSPORT

Anna Woźnica¹

¹ ORCID 0000-0003-3910-9743

University of Economics in Katowice
Faculty of Economy, Department of Transport
1 Maja 50, 40-287, Katowice, Poland
E-mail: anna.woznica@ue.katowice.pl

***Abstract:** Nowadays, more and more people are aware of climate change and factors affecting it. Also they are aware of the fact that changing daily habits may have lesser impact on the climate. Factors affecting climate change are, among others, waste management, industrial processes, fuel combustion and transport. In that last area many technological and behavioural solutions may be seen to decrease exhaust emission. One of ideas, connecting those two ways is public-electric transport. It consist in introducing buses powered with electricity from batteries assembled in vehicles. With more people changing their transport behaviour from private cars to buses which are electric the improvement with quality of air may be seen in the future. In this article the basic assumptions of sustainable transport and electromobility were presented. Also a survey on public transport passengers was carried out. The survey checked passenger's approach to electric buses in Jaworzno city and if it concurred to change in their transport behaviour. Respondents were chosen by snowball method then the results were statistically processed. The results showed, among others, that passengers are satisfied with electric buses, consider them as more comfortable and more ecological than combustion ones but they have not become the reason for changing transport behaviour. Also, most of passengers think that electric buses were a good investment and it may help to improve competitiveness of the city*

***Key words:** electromobility, electric buses, public transport passengers*

***JEL codes:** O18, L91, R40*

1. Introduction

The fact that the Earth's climate has changed all the time from its beginning is known. Ice periods interspersed with periods of warmth showed that the climate is not constant. However, as humans started to adapt land, water, plants and animals to their needs, those changes have

intensified (Quaschnig 2019). Despite the fact that climate protection has been talked about for many years, these voices has only recently started to gain strength by improving public awareness about climate and putting an emphasis on education in this field (Laiphrakpam et.al., 2019). There is more and more discussion about environment or air protection through people's change of daily behaviour and habits. Negative impact on environment may be minimalised, among others, by garbage segregation, forgoing of non-renewable resources for heating homes and apartments or by changing transport behaviours. All these actions are supposed to reduce emission of carbon dioxide (www1).

In terms of transport, European Union puts an emphasis on public transport, which should be characterized by high quality of service, accessibility, energy-efficient and will be integrated with other means of transport. All those factors are to contribute to reduce car traffic, and as a result, reduce related to it exhaust emission and create a friendly urban environment (European Commission 2017).

The European Union supports cities that are willing to improve public transport system by carrying out many projects. These include, among others, PROCEED (with tips how to introduce a high-quality transport in small and medium sized cities), MEDITATE (a methodology which helps to describe the availability of transport in Europe), 3IBS (it is a project which continues a pursuit to improve results, availability and efficiency of city bus system), and ZeEUS, which focuses on creating on zero-emission system of public transport (European Commission 2017).

Electric buses are a technological solution that meets requirements to public transport. They are an alternative to combustion buses and are introduced to reduce the negative impact on environment generated by urban transport system (Scarinci et.al, 2019). However, to minimize that negative impact, it should be driven by the electricity made from renewable energy sources (Globisch et. al., 2019). But still, one can say about local improvement of air quality by abandoning traditional buses at the expense of increased energy production.

The development of electromobility, including public transport, may be affected by factors such as a willingness to protect an environment, EU's policy in case of transport and passengers' expectations. Thanks to these pressures, new technologies and organizational solutions taking into account socio-economical aspects may arise and thus the effective public transport system may be created, which will be characterized by lack of negative emission (Krawiec et. al, 2016).

The social side of electromobility, assumes that electric buses will contribute not only to minimize the negative impact on environment but also to reduce a noise which has a negative impact on people's health and their productivity. Also, city carriers are positive about electric buses as they are quieter (Borén, 2019).

Introducing an electric bus system in cities is not a simple task. Especially a large-scale implementation of them all over the country, the increase in demand for electricity and problems with country's energy system should be taken into account. Also the cost of purchasing electric buses should be pay off within a reasonable time (Houbbadi, 2019). However, despite these problem more and more cities both in the world and in Poland are deciding to introduce electric buses to service cities.

Even the government implemented the Act of 11 January 2018 on electromobility and alternative fuels in Poland. It includes, among others, how many electric vehicles should have municipalities depending on the number of inhabitants (Journal of Laws 2018, item 317).

In the period from May 2015 to January 2019, 198 electric buses were registered. But in 2019 alone till August, 36 such buses were registered. It is worth noting that in that period of time a total of 648 vehicles were registered, so electric buses account for 5.5% of the registration (www2). Table 1 shows cities that has the largest number of electric buses. The total number of buses operating in given city and percentage share of electric buses in the fleet were also presented.

Tab. 1 Selected cities with electric buses in Poland

City	Number of buses	Number of electric buses	Percentage share [%]
Zielona Góra	89	43	48.3
Warszawa	1801	32	1.8
Kraków	567	26	4.6
Jaworzno	70	24	34.3
Inowrocław	41*	10	24.4
Stalowa Wola	no data	10	-
Szczecinek	23*	10	43.5
Rzeszów	no data	10	-
Katowice	250	5	2

Source: own elaboration based on: www2, www3, Zarząd Transportu Miejskiego w Warszawie, Informator Statystyczny Sierpień 2019, www4, www5, www6, www7, www8.

Cities in which residents also have an opportunity to ride an electric bus are:

- Ostrów Wielkopolski (4 buses)
- Bełchatów, Sosnowiec, Środa Śląska – 3 buses each
- Ostrołęka, Łomianki, Polkowice, Lublin – 2 buses each
- Ostróda, Chodzież, Ciechanów, Poznań, Wągrowiec, Września – 1 bus each (www2).

Also, two electric buses has the Regional Blood Donation and Blood Treatment Center in Katowice, which are the first buses of this type in the world (www9).

As it may be seen in Table 1, electric buses are not the main part of the fleet in any city. The best in this indicator are Zielona Góra (where approximately 48% of the fleet are electric buses), Szczecinek (43.5%) and Jaworzno (34.3%). However, one should also pay attention to the total number of buses that run in the city. Especially in Szczecinek, where a total number of 23 buses serve the entire city. In this case, an introduction of even a relatively small number of electric buses will give a large percentage share in the fleet. A similar situation is in Inowrocław. On the other hand, Krakow and Warsaw, despite the fact of relatively large number of electric buses, due to the size of cities and population, the percentage is small. Therefore, the larger the city with more buses, the more difficult it will be to meet the requirement of the Electromobility and Alternative Fuels Act.

Public transport is primarily to serve the residents and be organized in that way so that as many people as possible will be able to use it. Therefore, the implementation of electric buses should be carried out in such way that it benefits to passengers of public transport and even attracts new passengers and investors to the city. It was decided to examine the approach of public transport passengers of the selected city to electric buses. It was asked, among other, is it actually more comfortable to ride them, will they help to improve city competitiveness and if they are more ecological than traditional buses. The results of the survey are presented in chapter 3 of the article

2. Methodology and Data

An important issue related to urban transport is the passengers' opinion about efficiency and quality. As it was written in chapter 1, in Poland there are more and more cities that decide to buy electric buses. For the purposes of this article, a survey was conducted on the passengers of selected city and checked their approach to electric buses.

Chapter 1 presents cities with the largest percentage share of electric buses in the fleet. One of these cities was chosen – Jaworzno, where a survey was conducted. This city was chosen

due to the fact, that over 1/3 of buses in the fleet are electric. Zielona Góra was abandoned due to the problem of reaching respondents by the chosen method.

The snowball method was chosen to conduct the study and select respondent. This method is useful in the case of problems with reaching a specific population and does not use estimation of the characteristics of a given population (Drăgan, Isaic-Maniu, 2012). The method consist in interviewing the first subject of the survey by the interviewer and then asking for help in the survey by passing the questionnaire to people with similar characteristics required to conduct a survey (www10). The survey was conducted from November 18 to 24, 2019. 276 responses were received from the city's residents using PKM Jaworzno.

Due to the sampling method, it is not representative, but it allowed to reach users of urban transport who had contact with electric buses, thanks to which answers obtained, based on which, one can conclude what the city's residents' approach to investment in electric buses is.

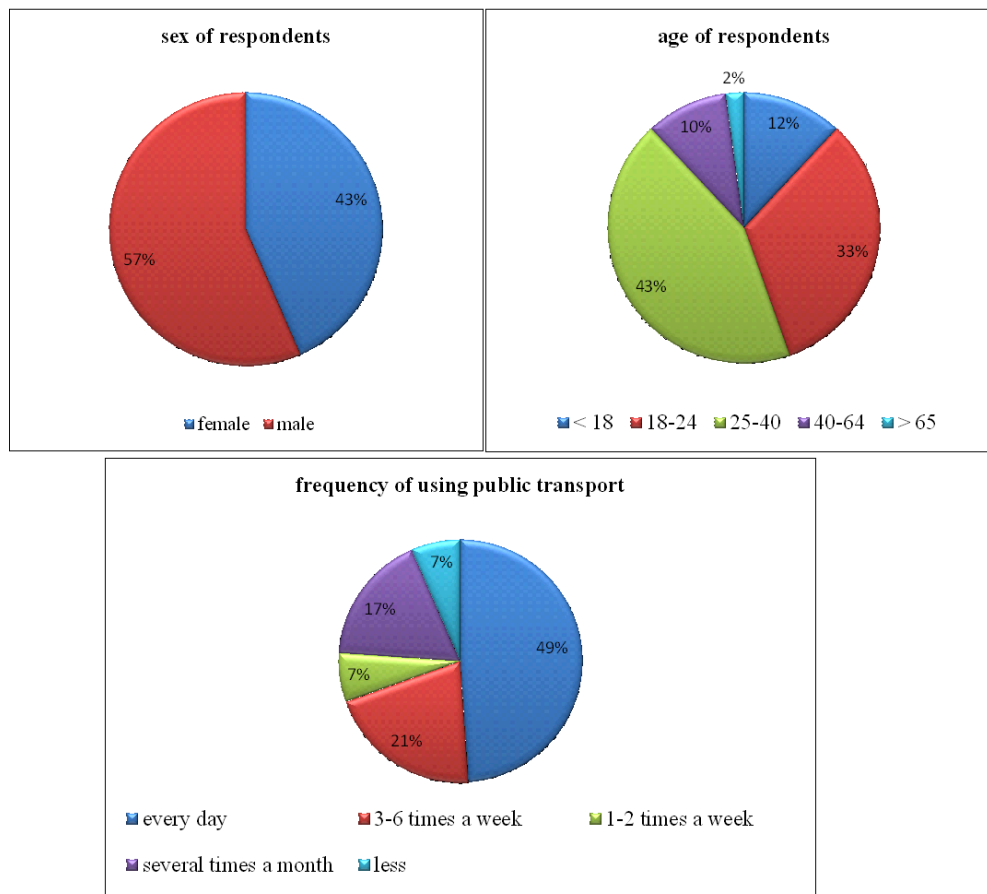
3. Results and Discussion

The survey allowed, among others, to determine the attitude of PKM Jaworzno's passengers to city buses, what do they think about electric buses, comfort of riding them, their ecology and competitiveness.

The survey was divided into three parts – a respondent's particulars, introductory questions about travelling in Jaworzno and a part about attitudes towards a given problem, where a Likert five-grade scale was used. Figure 1 presents the structure of sex, age and frequency of bus travel.

The vast majority of respondents were people aged 18 to 40 – a total of 76%. These people are usually students and working people who must travel at least five times a week. It is showed in the graph regarding the frequency of using public transport. 70% of respondents said that they travel at least three times a week.

Fig. 1 the structure of sex, age and frequency of bus travelling



Source: own elaboration based on conducted research

In the second part of the survey, the question was asked whether the respondent used electric bus in his city. A positive response was obtained for 99% of surveys. 15% of respondents indicated that they know someone who exchanged private car to electric bus. This may indicate that electric buses are perceived as less harmful for the environment and in some cases more comfortable than a car. Probably in cases connected with travelling in traffic jams or later with searching of parking place in city centre.

The third part of the survey consisted of questions to which respondents had to respond on a five-point Likert scale:

- I agree,
- I agree a little bit,
- I have no opinion,
- I disagree a little,
- I do not agree.

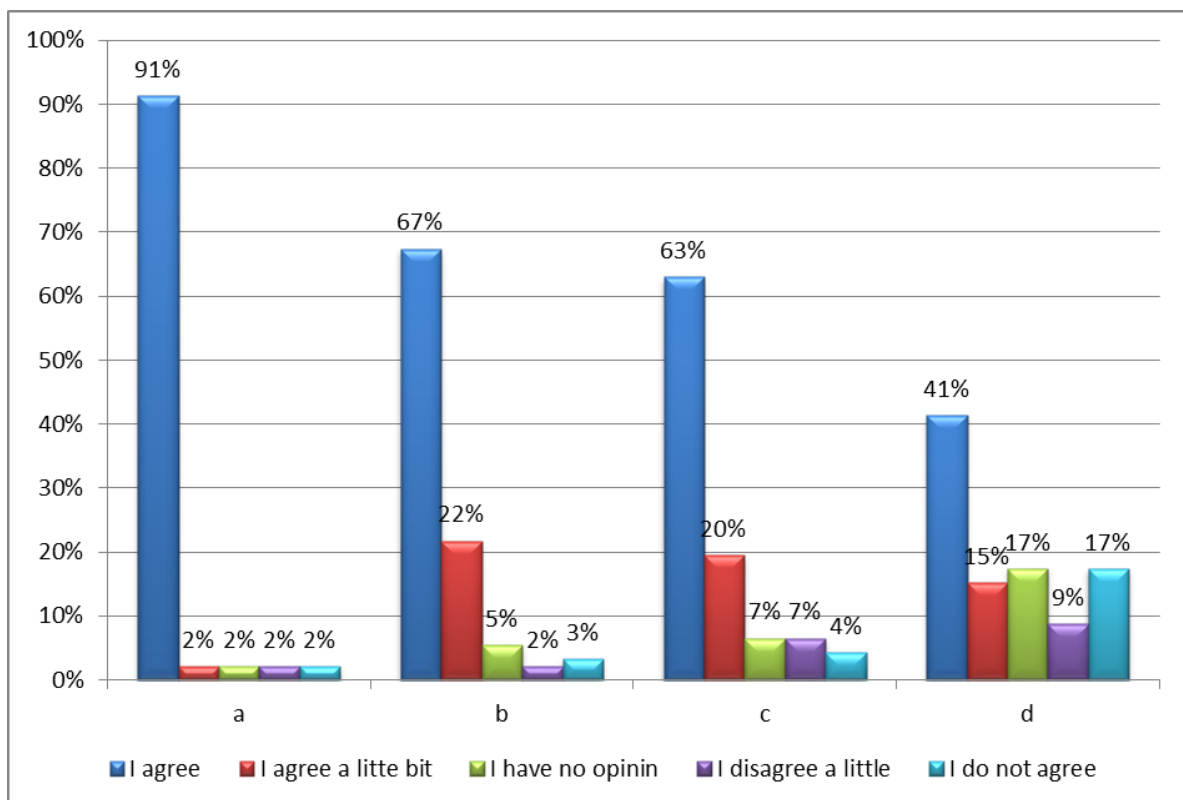
The questions in that section could be divided into four main groups:

1. regarding riding comfort,

2. ecology,
3. organizational issues,
4. city competitiveness,
5. other.

The first group included four questions about noise, vibration and general ride comfort. Figure 2 shows the distribution of answers to each of these questions.

Fig. 2 Questions related to comfort of riding



Source: own elaboration based on conducted research

The legend to Figure 2 is as follows:

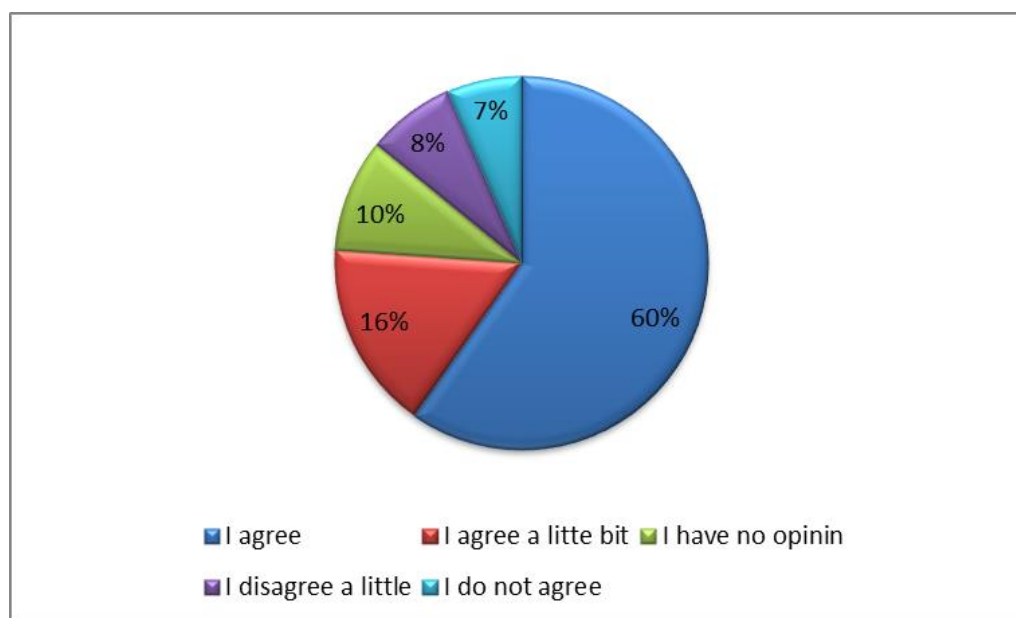
- a – electric buses are quieter than combustion ones,
- b – vibrations in electric buses are smaller than in combustion ones,
- c – the comfort of riding an electric bus is higher than in combustion one,
- d – the level of noise in electric buses is lower than in combustion ones, because passengers are quieter in them.

As it can be seen in Figure 2, the vast majority of respondents strongly agree or at least slightly agree with the statement that electric buses are quieter than combustion ones and vibrations are smaller in them. It can be assumed that thanks to electric buses, the quality of

public transport perceived by inhabitants has grown up and now they are more willing to use that mean of transport. On the other hand, the respondents were not as unanimous when asked about noise level resulting from passengers conversations, but it still can be seen that most of them agree that it is quieter in electric buses. This is also said by drivers, who believe that due to lack of noise generated by the engine, passengers are also limiting conversations on buses, because they do not want to be overheard (www11).

Another part of questions was related to the environmental performance of electric buses and how they are perceived by passengers in this aspect. 76% of respondents are satisfied with the introduction of electric buses in Jaworzno and they believe that they will contribute to improve the air quality in the city. Only 15% of them disagree with that statement and 10% has no opinion (Fig. 3).

Fig. 3 Electric buses will contribute to improve air quality



Source: own elaboration based on conducted research

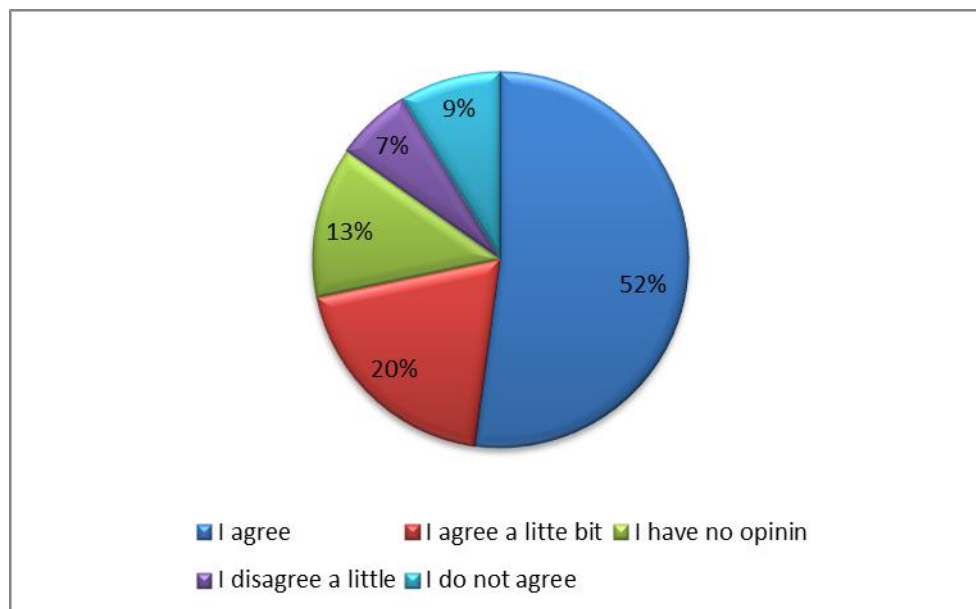
Figure 4 illustrates answers to the question: “Despite the significant share of coal-fired power plants in Poland, I think that electric buses are more ecological than combustion buses meeting Euro 6 requirements”. Also in this question, the percentage of answers agreeing with this statement was very high and amounted to 72%. However, already 16% of respondents disagreed and 13% did not have an opinion.

The distribution of answers to these two questions shows that electric buses are seen as environmentally friendly. It is true that reducing or even eliminating exhaust emissions locally,

e.g. at the place of use of a given bus in a city, it will bring measurable local benefits, but will transfer this harmful emission nearby power plant. It should be remembered that still in Poland approximately 70% of electricity is used in coal-powered power plant using non-renewable sources and polluting the environment during combustion (www12).

The question if electric buses are actually more environmentally friendly than traditional ones is to be answered in another study, which should take into consideration the entire life cycle of buses, from the process of production, through operation to disposal.

Fig. 4 Electric buses are more ecological than combustion ones meeting Euro 6 standards

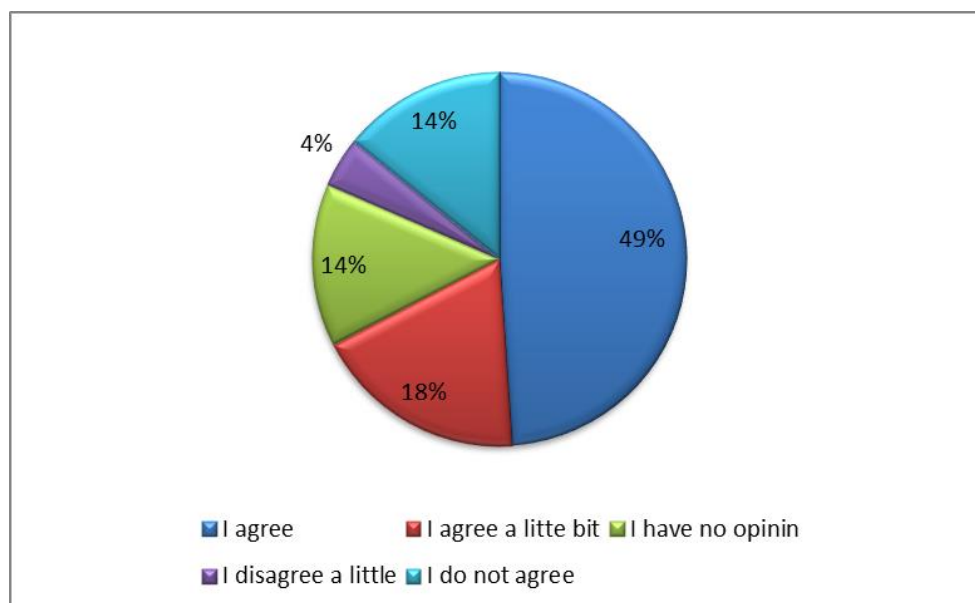


Source: own elaboration based on conducted research

Figure 5 shows the distribution of answers to questions about the city's competitiveness since it invested in electric buses.

67% of respondents agree with the statement that such investment may contribute to the increase of competitiveness of the city and will increase interest of investors in starting their business activity in Jaworzno. Respondents believe that it is an additional stimulation of development. In contrast, 18% of respondents do not agree with this statement. One can conclude that electric buses have no impact or have little impact on investor's interest in the city and other factors are more important for them when considering entering a given market.

Fig. 5 Jaworzno may become more competitive to investors thanks to electric buses

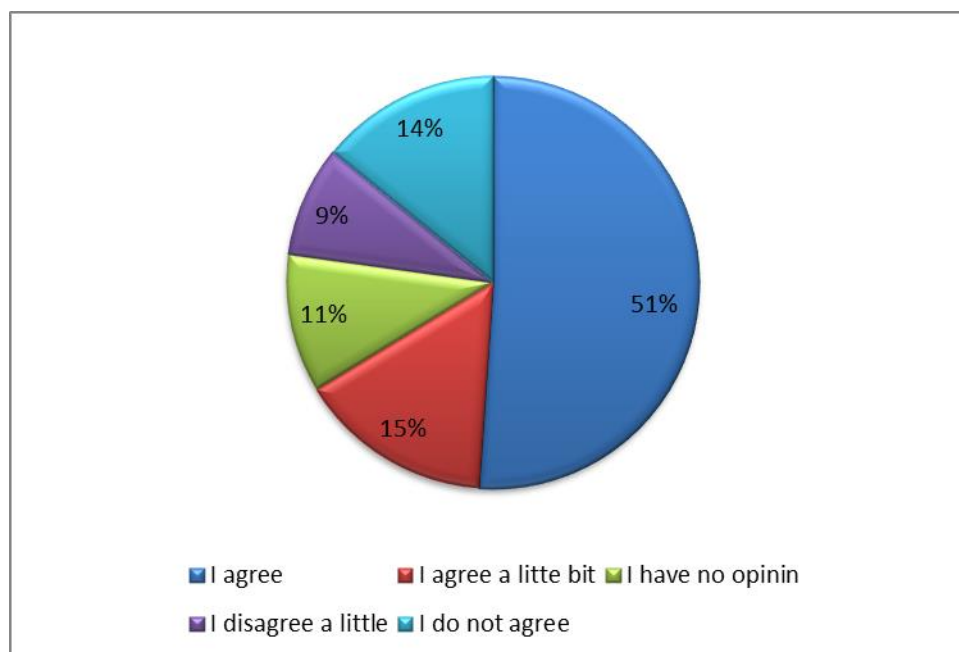


Source: own elaboration based on conducted research

In the case of part related to organization of transport in Jaworzno, the purpose of one question was to find out whether the service of a given route by electric bus is properly marked in timetable (Fig. 6). 66% of respondents stated that they exactly know which route is served by electric bus. Signing such information in timetable, PKM Jaworzno may want to attract more inhabitants to public transport. This form of information is also a way of advertising such vehicles in city. Still 23% of respondents indicated that they disagree with that statement. This state of affairs can be a sign of dynamic introduction of electric buses for passengers service. Thus, there is not always possible to change the timetable on time in every place to one that would immediately inform about the type of bus serving the given route.

Thanks to the survey it was possible to find out that electric buses offer the same additional services as combustion buses. Additional services include possibility of charging the mobile phone, screens informing about the route and voice information. Thanks to those solutions, passengers may enjoy the same services as were offered in traditional buses and additionally comfort of riding is higher due to less noise and vehicle vibration.

Fig. 6 The passengers know whether electric bus will serve a given route



Source: own elaboration based on conducted research

4. Conclusions

This study examined the approach of passengers of PKM Jaworzno to electric buses in this city. Questions about driving comfort, the competitiveness of public transport, and how electric buses will affect the competitiveness of the city were asked. Also the survey contained questions pertained ecological aspects of buses and how the environmental performance of electric buses is perceived in relation to combustion buses and in the light of coal-fired power plants. It was found out that thanks to purchasing electric buses offering similar additional services, passengers can enjoy greater comfort of ride. Result of the survey show that passengers are satisfied with electric buses in Jaworzno. They agree with the fact that comfort of riding an electric bus is higher due to the minimization of noise and vibration. Passengers believe that electric buses will improve air quality in their city. In addition, they are perceived as more ecological than combustion buses even those that meet Euro 6 standards. Inhabitants also agree that they know which route is served by an electric bus, which allows to make better transport decisions. The survey showed that the PKM Jaworzno passengers' attitude towards electric buses is positive, however, the question of whether electric buses are actually more ecological than diesel ones should still be answered.

References

- Borén, S. (2019). Electric buses' sustainability effects, noise, energy use, and cost, *International Journal of Sustainable Transportation*, 1.
- Drăgan, I., M., Isaic-Maniu, A. (2012), Snowball Sampling Developments used in Marketing Research, *International Journal of Arts and Commerce* Vol. 1 No. 6, 214-215.
- Dziennik Ustaw 2018 poz. 317, Ustawa z dnia 11 stycznia 2018 o elektromobilności i paliwach alternatywnych.
- European Commission, *Sustainable Urban Mobility: European Policy, Practice and Solutions*, European Union, 2017, 19.
- Globisch, J., Plötz, P., Dütschke, E., Wietschel M. (2019). Consumer preferences for public charging infrastructure for electric vehicles, *Transport Policy* 81, 54.
- Houbbadi, A., Trigui, R., Pelissier, S., Redondo-Iglesias, E., Bouton T. (2019). Optimal Scheduling to Manage an Electric Bus Fleet Overnight Charging, *Energies* 12(14):2727, 2.
- Krawiec, S., Łazarz, B., Markusik, S., Karoń, G., Sierpiński, G., Krawiec, K., Janecki, R. (2016). Urban public transport with the use of electric buses – development tendencies. *Transport Problems*, vol 11 issue 4, 128.
- Laiphrakpam, M., Aroonsrimorakot, S., Shanker, A. R. (2019). Environmental education and awareness among students in India, Japan and Thailand for sustainable development, *Journal of Thai Interdisciplinary Research*, Vol 14 No 2, 48.
- Quaschnig, V. V., (2019). *Renewable Energy and Climate Change*. Second Edition., John Wiley & Sons Ltd. Published 2020 by John Wiley & Sons Ltd, 27.
- Scarinci, R., Zanarini, A., Bierlaire M. (2019). Electrification of urban mobility: The case of catenary-free buses, *Transport Policy* 80, 40.
- Zarząd Transportu Miejskiego w Warszawie, Informator Statystyczny Sierpień 2019, nr VIII, 22.

Online sources

- (www1) <http://ekoswiat.eu/jak-chronic-srodowisko-dla-dzieci-i-doroslych/>
- (www2) http://infobus.pl/polski-rynek-autobusow-elektrycznych-w-sierpniu-2019-r-_more_118173.html
- (www3) <https://www.mzk.zgora.pl/index.php?bmF2PTkmbGFuZz1wbCZkYmlfaWQ9MCZkYnNfc2VhcmNoPXRhYm9y>
- (www4) <http://www.mpk.krakow.pl/pl/tabor/autobusy/>
- (www5) <https://www.pkm.jaworzno.pl/www/inne/o-spolce/eksploatowany-tabor/>
- (www6) https://pl.wikipedia.org/wiki/Miejskie_Przedsiębiorstwo_Komunikacyjne_w_Inowrocławiu
- (www7) https://pl.wikipedia.org/wiki/Komunikacja_Miejska_w_Szczecinku
- (www8) <http://www.pkm.katowice.pl/profil.php>
- (www9) <https://gramzielone.pl/auto-ekologiczne/27578/katowice-pierwsze-na-swiecie-autobusy-elektryczne-do-poboru-krwi>
- (www10) <http://web.archive.org/web/20120616035909/http://www.experiment-resources.com:80/snowball-sampling.html>
- (www11) http://m.infobike.pl/idealnie-cichy-autobus-_more_75703.html
- (www12) <https://stiloenergy.pl/2019/06/27/produkcja-energii-elektrycznej-w-polsce-udzial-oze-w-rynku/>