

ALTERNATIVE DRIVES IN PUBLIC TRANSPORT VEHICLES AS A CHANCE FOR CITY DEVELOPMENT

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***Abstract:** For many years, the European Union is pursuing policy that leads to reduce the emission of negative combustion products into the environment. Balancing transport is one of components of that strategy. That idea aims, among others, to minimize exhaust emissions by using engines which emission of harmful substances is ever lower (Euro 6 standards), limiting of movement by cars with old diesel engines in cities and promoting vehicles with alternative drives such as electric and hybrid. This article focuses on presentation the differences in public transport vehicles with different types of engines and their impact on environment. In public transport may be observed a trend to replace vehicles with combustion engines by vehicles with alternative drives. A comparative analysis of combustion and electric engines in terms of their impact on environment, whether positive or negative is presented. Strengths and weaknesses of these vehicles as well as opportunities and threats for regions that decide to replace public transport fleet with combustion engines for those with alternative drives are presented. The PEST analysis shows factors affecting the public transport carriers to replace transport fleet. Also, cities in Poland where such replacement occurs are presented. Both, the method of analysis and criticism of literature and analysis of existing data are used.*

***Key words:** public transport, alternative drives, balancing transport*

***JEL codes:** H41, Q53, R49*

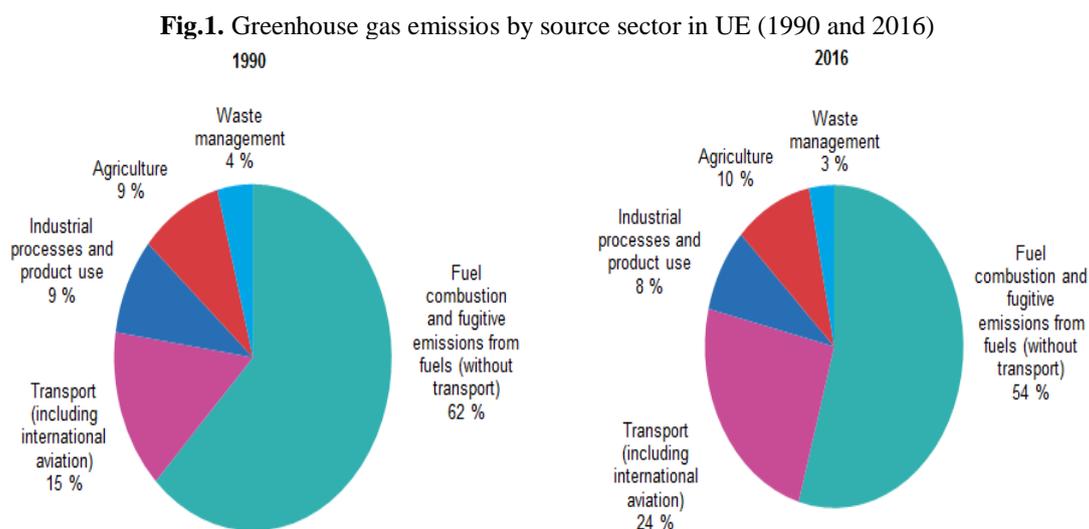
1. Introduction

Human activity has negative impact on natural environment all over the world. To dispose of that problem many organizations were established and many arrangements were signed. Their main purpose is to control human activity to reduce greenhouse gas emission. One of such

organizations is European Union, which strives to reduce the negative impact of people on the natural environment as much as possible (www1).

One element of that policy is European Union Emissions Trading System (EU ETS). It is a tool by which a greenhouse gas emission may be reduced. Main disadvantage of this that it comprises only industrial installations or airlines and these are not only sources of gas emissions to the atmosphere (www2). Another EU tool is to promote renewable energy sources and gradual departure from conventional coal-fired power plants (www3). The balancing of transport is also one of EU's goals.. Sustainable transport is to solve three categories of problems: environmental, economic and social by, among others, reduction of emissions, better use of renewable energy sources and improvement of the quality of life (Lejda et al. 2017). That is why EU's idea of electromobility is promoted. It is the idea that assumes to eliminate vehicles with conventional (combustion) drives from cities and replace them by those with alternative engines such as electric or hybrid (Schaumann, 2013). It also assumes to promote public transport above private cars and reduce number of cars moving among the streets (Gallet et al. 2018).

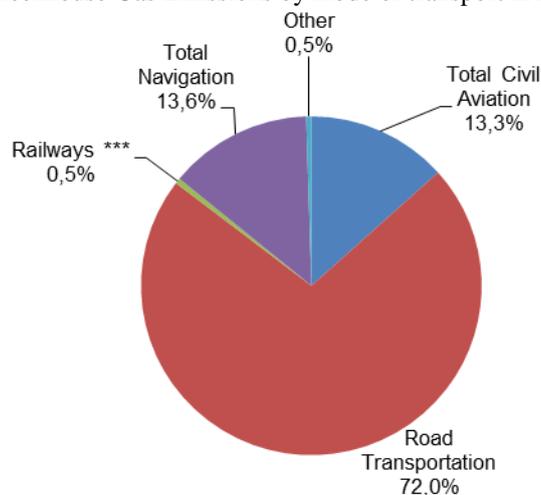
Figure 1 shows that 24% of greenhouse gas emission in EU 2016 was made by transport. There also was a significant increase by 9 percentage points since 1990.



Source: (www4)

As may be seen in figure 2, the biggest impact on environment pollution has road transport. Also, that mode of transport has the biggest amount of solutions which focus on reducing that pollution.

Fig. 2. Greenhouse Gas Emissions by mode of transport in EU (2016)



Source: (www5)

In recent years the technologies related to energy, its acquisition, storage and consumption have developed significantly. It has become the basis for introducing them also for low-emission transport through the use of batteries that are able to drive a city bus (May, 2018).

This paper aims to compare means of public transport with different types of engines (combustion and electric) in terms of their impact on the environment. Also, factors influencing the replacement the fleet from conventional ones to those with alternative engines are presented. Moreover, impact of these changes on city development are presented.

2. Methodology and Data

This paper applies only to public transport vehicles and compares two types of engines: combustion and electric. The method of analysis and criticism of literature is used to recognise advantages and disadvantages of those drives. Also, an attempt to comment and determine which type of drive is associated with which type of hazards. Moreover, a SWOT analysis to describe strengths and weaknesses of each type of drive as well as threats and opportunities related to them, is used. Afterwards, an attempt to determine whether a change in fleet of public transport is connected with positive changes in the city or has positive impact on its citizens. Thanks to PEST analysis, political, economic, social and technological factors that influence public transport carriers to decide to change their fleet are recognised. Final point of that article

was to recognise cities in Poland where electric buses are used and why city government and carriers decided to implement such solution.

3. A SWOT analysis

The main problem associated with so high exhaust emission by road transport is deterioration of air in cities. That problem increases especially in winter, when the gases being a by-product of low emission are also discharged into the air. The aim is for people to change their mobility habits, from private to public transport, but it is associated with reluctance and society's desire for comfort. An indirect step to achieve air purification in the city is to promote solutions related to public transport. In addition, it is intended that traditional buses with diesel engines be replaced with those with electric or hybrid engines.

In that part of paper a comparison analysis of combustion and electric engines is presented. Their influence on environment and legal conditions, that have significant impact of using those drives in cities, were taken into consideration.

A SWOT analysis is mainly used in terms of organization where its strengths and weaknesses are related to its interior while its threats and opportunities are related to its exterior (Phadermrod et.al, 2019). However, using those four areas, strengths and weaknesses different types of drives in buses can also be analysed. In addition, external factors that describe threats and opportunities may be determined as well. Thanks to that method, an attempt whether there is a better kind of drive or not is made. A SWOT analysis was made comparing two types of combustion and hybrid engines also exploitation of it was taken into consideration. It is shown in table 1.

Table 1. A SWOT analysis, comparison of using combustion and electric engine

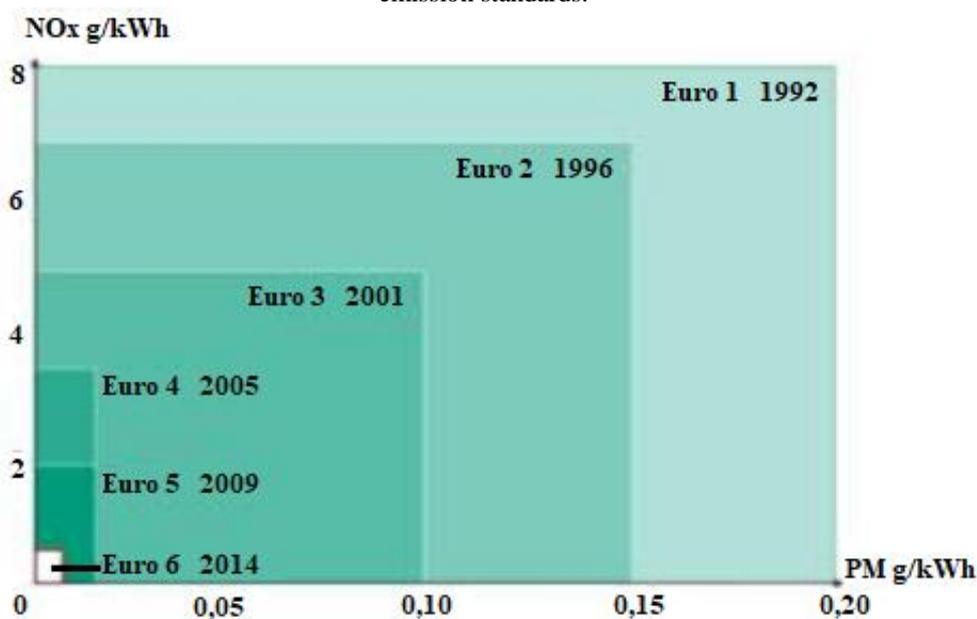
Combustion engine	Electric engine
Strengths	
Greater range No need for additional infrastructure	No emissions at the place of use Lower noise emission Better mechanical efficiency of the motor
Weaknesses	
Exhaust gas emissions at the place of use (along the whole route) Greater noise emission	Need to recharge Limited distance Adaptation of infrastructure is needed Higher bus weight
Opportunities	
Higher and higher Euro standards cause that the emitted gases have less and less negative components. High costs of buying an electric bus Rising electricity prices	Standards set by the EU to reduce emissions Promotion of electromobility

Threats	
Standards set by the EU to reduce emissions Promotion of electromobility	High purchase costs High costs of infrastructure adjustment Electricity from coal Rising electricity prices

Source: based on own elaboration

Many listed aspects in Table 2 are repeated. This is due to the fact that what for one drive is an opportunity for the other can be a threat. That is why e.g. promotion of electromobility by EU is a threat for combustion engines and also is an opportunity for electric vehicles. The chance for diesel buses may also be the somewhat increasing prices of electricity and the fact that a significant part of electricity generated in Poland comes from coal, which is in conflict with EU policy (www6). It can be said that the lack of emissions in one place, e.g. in a city during a bus ride, will increase the emission of power plants, which will have to produce more electricity to meet the demand resulting from the need to recharge the battery. Only using renewable sources of energy. In turn, the high costs of purchasing an electric bus (even twice as high as that of a conventional bus) are an opportunity for combustion buses, as public transport operators in some regions cannot afford such expenses (www7). For many years, great emphasis has been placed on the standards of permissible exhaust emissions in new vehicles in the EU. The European emission standards (Euro) is the generally accepted standard in the EU. Over the next years, that has become more and more restrictive and currently the Euro 6 standard is in force. Figure 3 shows how much less exhaust emissions of engines meeting this standard (Luft, S. Skrzek, T., 2016)

Fig. 3. Changes in PM and NOx content exigencies in the bus engine exhaust in the following European emission standards.



Source: Luft, S. Skrzek, T., 2016

The use of Euro 6 standards and the replacement of public transport fleet with vehicles with these engines may contribute to reducing the negative effects of exhaust emissions, however, it is necessary to completely change the fleet, which entails high purchase costs. Undoubted advantages of electric buses are lower noise emission, no emission of fumes at the place of use, e.g. on the route, better mechanical efficiency of the electric motor (Krawiec, 2017). Especially the first two aspects make these buses an ideal solution in cities, which increases quality of travel and awaiting for it. Noise intensity (already up to 55dB) causes a significant deterioration of people's health, an electric bus contributes to the reduction of noise in cities, which also positively affects the quality of life in them (Plan Rozwoju Elektromobilności w Polsce, 2016).

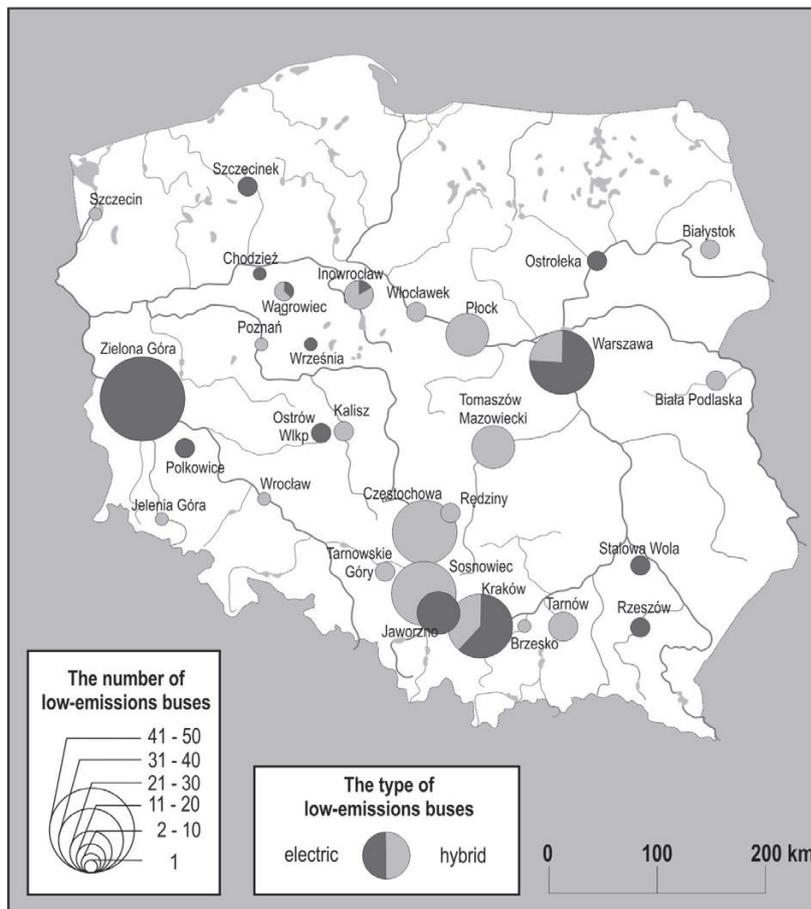
Electric buses also has disadvantages. One of them is limited range, much shorter than combustion ones. While the conventional buses may drive all day without necessity of filling the tank, the electric ones may drive about 200 - 250 km. The range depends on the climate, road traffic and capacity of batteries (Bakker S., Konings R., 2018). Necessity of often recharging and adapting infrastructure (e.g. stations' montage) are the factors that limit fast implementation of higher amount of electric buses to public transport fleet. Also, batteries assembled in buses are very heavy, and increasing their capacity makes them even heavier (Autobusy elektryczne - Kompendium..., 2017). It can also affect faster road damage through moving buses.

Electric buses producers have to find a golden mean between range of bus and weight of batteries. Increasing its capacity, a range increases also, which is a positive aspect. But also, a weight of bus increases which is negative. Because of that, the weight of other elements must be decreased to reassure that necessary amount of passenger can be taken inside. Reducing the capacity of the battery results in the fact that the bus has a smaller range, so you need to properly adapt the infrastructure necessary to load buses on the route, so that drive the whole one (www8). In SWOT analysis factors connected to choosing public transport over private were ignored because that paper focuses on comparison of different drives types, not comparison public and other types of transport. That analysis, however, may be extended by hybrid drive which also is an alternative to combustion one. In comparison to electric engines, they can drive in longer distances using smaller batteries, but also use a combustion drive which cause damage to an environment but in smaller scope than conventional vehicle (Wang et.al., 2018)

4. A PEST analysis

The idea of electromobility is becoming more and more popular in Polish cities. Nonetheless, first purchasing of electric buses were just in 2015. Although Poznań in 2008 bought first hybrid bus but it is Jaworzno and Ostrołęka, where first fully electric buses were purchased. In November 2016 in five polish cities were 23 electric buses, whereas year later there were 78 buses in 7 cities. In 2018 that number (counting orders as well) should, increase to 170 buses (Taczanowski, et.al., 2018).

Fig. 4. Low-emissions buses used and purchased in public urban transport in Poland (November 2017)



Source: Taczanowski, et.al., 2018

In figure 4, 30 cities where alternative drive buses are or will be in near future used were marked. However, in 16 of them only hybrid buses are used and it is not a subject of this paper. Only 2 of remaining 14 cities have number of citizens bigger than 500 000 (Warszawa and Kraków). Rest of them have less than 200 000 inhabitants (www9). This proves that small cities with a small public transport network and fewer vehicles are more willing to invest in alternative drives than large cities, where the problem is much more complex.

Using PEST analysis that is distinguishing political, economic, socio-cultural and technological factors (Ha, Choghull, 2008) it can be stated what causes that the city authorities introduce buses with alternative drives into the fleet of public transport vehicles. On the basis of own observations and interviews with city presidents (www10), in which electric buses were introduced in public transport, factors that have a decisive impact on such a city policy were identified.

Political factors may be as follows:

- EU aims to promote alternative drives,
- plan to implement electromobility in Poland.

First factor has been already discussed in this article. Also, in 2016 in Poland a Plan of developing electromobility has been presented. In that plan challenges connected with introducing it, aims which should be accomplished and their measures have been presented. One of its elements is to implement electric vehicles into private as well as into public transport. It aims to purge air in Polish cities and improve quality of life in them (Plan Rozwoju..., 2016).

Economic factors:

- the potential lower operating cost,
- lower fees for charging at night (night tariffs),
- funds (e.g. EU, Polish),
- increase in the number of passengers in public transport.

In Lublin, where trolleybuses also run, the costs of operating electric buses are lower than in other cities, because the infrastructure in this city is already somewhat adapted to recharge the battery. Though, in other cities these costs are much higher than in the case of combustion buses, precisely because of the need to adapt this infrastructure (www10). In addition, cities may obtain a funding from National Fund for Environmental Protection and Water Management (Narodowy Fundusz Ochrony Środowiska i Gospodarki Wodnej) for modernization of infrastructure and purchase of new public transport fleet (www11). In addition, cities that invested in electric buses saw an increase of public transport passengers (www8), which is doubtlessly a positive phenomenon.

Socio - cultural factors are as follows:

- image of the city as environmentally friendly,
- fashion,
- to imitate other cities.

Many cities which introduce electric buses in public transport, promote themselves as an environmentally friendly and caring about air. They also imitate good practices of other cities and follow fashion that currently occurs on vehicles with alternative drives.

Technological factors:

- lower level of noise and vibrations,
- lack of gas emission in place of use.

Listed technological factors are very important to passengers of public transport. By reducing level of vibrations, noise and emission, travel by bus is more pleasant and eagerly chosen by citizens.

The factors mentioned above are most often quoted by electric buses supporters. Taking into consideration only the period of using these vehicles in cities may be said that they are more environmentally friendly. But ones should also take into consideration the process of production such vehicles and utilization of them and batteries. Only an analysis of whole life cycle within long period of time may give an answer whether alternative drives are indeed a chance to improve air quality.

5. Conclusions

Electromobility is a current and engaging subject of many entities, from public transport users, through its organizers to the city authorities. Global efforts to reduce emissions lead to minimizing the use of private transport for the public as much as possible. In addition, the transport aims to replace existing combustion buses with those with alternative drives. The often repeated advantages of these buses are lack of exhaust emissions at the place of use and less noise emission, which significantly contributes to the increase of the quality of life in the city and increases the number of public transport passengers. However, the problem should be viewed from more perspectives. In this article only one problem – usage, was presented. Nevertheless, ones should remember of two remaining problems such as production and utilization those buses. These two stages also contains benefits and drawbacks of different types of drives. These factors, in longer period of time, may have decisive influence whether electric or combustion buses should be chosen by public transport carriers.

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