

## Alternative fuels for public transport vehicles – actual trends

Simeunović Milja, Associate Prof. Simeunović Milan, Pitka Pavle, Papić Zoran  
Faculty of Technical Sciences – University of Novi Sad, Novi Sad, Serbia<sup>1</sup>  
mlekovic@uns.ac.rs.

**Abstract:** Strategies for sustainable transport, and consequently sustainable mobility, require the use of cleaner vehicles without harmful emissions. The use of alternative fuels contributes to realization of set strategies and different types of alternative fuels are increasingly present in the transport sector. There is great potential in the use of alternative fuels in public transport systems, since this mode of transport plays a very important role in sustainable mobility. The aim is to replace the conventional bus fleets with vehicles with newer and cleaner technologies. Within this paper, alternative types of fuels used in public bus transport will be presented, as well as practical examples of the application of these modes of transport.

**Keywords:** SUSTAINABLE TRANSPORT, ALTERNATIVE FUELS, PUBLIC TRANSPORT

### 1. Introduction

The traditional approach to meeting the requirements for passenger vehicle travels by further building the capacity of the street network has been replaced by an approach that involves managing travel requests to make greater use of public transport system and other environmentally friendly modes of transport. In recent years, with the aim of identifying and reducing harmful agents by air, land and water, various strategies have been adopted and legislative and policy adjustments have been made, both nationally and internationally. The modes of traffic that can equally affect the living space and the ability to provide efficient service are emphasized. Particular emphasis is placed on reducing the use of conventional fuels by alternative fuels and promoting renewable energy sources. Developing technologies are pushing the boundaries we know today, and the future are the use of clean technologies, or technologies that are environmentally friendly. Although there has been a major improvement in internal combustion engines which has resulted in a reduction in specific fuel consumption at the level of total passenger transport activity by passenger cars, the efficiency has remained unchanged because at the same time there has been a negative effect of the reduction of occupancy of passenger cars. Therefore, the promotion of production of new vehicles that will use alternative fuels is encouraged.

### 2. European strategies

The global climate situation is worrying, so goals that have been set earlier need to be constantly revised and updated. The transport is one of the major pollutants [1], which is why there are specific strategies that apply only to the transport sector. The main challenges for the transport sector in the EU include creating a well-functioning single European transport area, connecting Europe with modern, multi-modal and safe transport infrastructure networks, and shifting towards low-emission mobility [2].

The use of alternative fuels is one of the measures for low-emission mobility achievement. In Europe, there is a generalized uncertainty about alternative fuels (in terms of fuel types, necessary infrastructure, technical and economic viability, sustainability) that leads to a fragmented market with unstable conditions [3]. Nevertheless, the use of alternative fuels is becoming more and more certain. There are different strategies, both nationally and globally, for implementing environmentally friendly vehicles and alternative fuels, especially those that can be obtained from renewable sources.

Concerned about the overuse of oil and its depletion, as well as the decarbonisation and combustion of fuel that is damaging to the environment, EU has adopted Directive 2014/94/EU of the European Parliament and of the Council [4], that seeks to encourage its members towards sustainable mobility and a healthier life. This document provides guidance for the use of alternative fuels and setting up of infrastructure that will enable supplied of vehicle with alternative fuels. The Directive sets out the minimum requirements that are necessary when planning infrastructure. The construction of the infrastructure must be technically and financially justified. It

must also enable the movement of alternative fuel vehicles in urban/suburban agglomerations and within the network developed by other EU Member States.

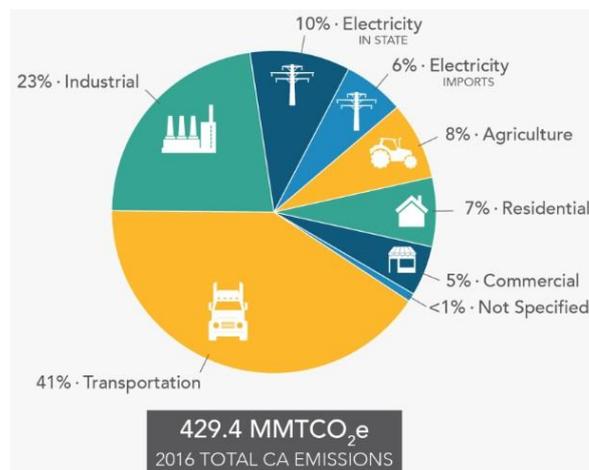


Fig. 1 Global greenhouse gas emission by sectors – data from 2016 [1].

All EU Member States were obliged to adopt plans for the construction of infrastructure for alternative fuel vehicles, with completion of construction planned for 2020 and 2025, respectively, depending on using of types of alternative fuel vehicles. The strategy presented under this Directive can be implemented through the national frameworks and policies of the EU Member States. This policy implies that it is necessary for national authorities to establish good cooperation with local and regional authorities within their own country and to facilitate the exchange of experiences of each individual local and regional government. In addition, cooperation with other EU Member States is crucial, to work on joint development and implementation of prescribed strategies. The Directive contains guidelines for the national policy framework that must be formed to meet infrastructure requirements, supply of traffic by electricity, hydrogen, natural gas and other alternative fuels. Aim of the Directive is dual: it is necessary to reduce the use of oil and to mitigate negative transport impacts on environmental. At the same time, the Directive agrees with the document White Paper adopted by the European Commission [5], where is a key part of the strategy phasing out of conventional cars in cities by 2050 - with switching to electric vehicles, hydrogen vehicles, hybrid vehicles, public transportation and walking or cycling.

It is also planned to reduce emissions of harmful gases to zero by the same period. Since it is already late in fulfilling the set plans and strategies, the long-term climate target alone will not be sufficient. Experts consider If the EU takes action now to drastically reduce emissions by 2030, we could prevent the most severe consequences for our planet [6].

### 3. Types of alternative fuels

The Directive [3] defines which substances are considered as alternative fuels

1. Electricity
2. Hydrogen
3. Biofuels
4. Natural gas – CNG (compressed natural gas) and LNG (liquefied natural gas)
5. Liquefied petroleum gas (LPG)

Electricity – Countries with a large production of electricity from renewable energy sources have great potential for the application of electric vehicles. Electricity is widely available so that it is possible to provide charging infrastructure on the entire street network.

Hydrogen – Hydrogen can be used in a converted petrol engine or to power a 'fuel cell', which acts rather like a battery. Hydrogen fuel can be produced by reforming steam from natural gas, by breaking down a hydrocarbon source (such as natural gas, fossil fuels or ethanol) or by the electrolysis of water[7].

Biofuels are renewable transport fuels that are made from biomass materials. There are different types of fuels covered by this name such as biomethane, biodiesel, bioethanol, etc. However, although biofuels are beneficial to the environment, many critics express concerns about the scope of the expansion of certain biofuels because of the economic and environmental costs associated with the refining process and the potential removal of vast areas of arable land from food production [8].

CNG is produced by compressing natural gas to less than 1% of its volume at standard atmospheric pressure. Using CNG as fuel reduces carbon monoxide and nitrogen oxide emissions by up to 80%, CO<sub>2</sub> emissions by up to 25%, and the proportion of methane hydrocarbons by up to 73%. Another advantage of CNG is that its processing into a fuel doesn't require any additives or complicated refining processes [9].

LNG is natural gas in its liquid form. LNG is produced by purifying natural gas and super-cooling it to -260°F to turn it into a liquid. During the process known as liquefaction, natural gas is cooled below its boiling point, removing most of the extraneous compounds found in the fuel. Because of LNG's relatively high production cost, as well as the need to store it in expensive cryogenic tanks, the fuel's widespread use in commercial applications has been limited [10].

LPG or autogas is an alternative fuel, derived from natural gas processing and oil refining, with a lower carbon footprint and significantly less pollutant emissions than conventional fuels [4].

Alternative fuels are essentially fuels that should be a substitute for conventional fuels, oil and coal. Environmentally, these fuels are a transitional solution in the search for more efficient and renewable energy. As world stocks and world production, as well as the monopoly of conventional fuels, shrink, alternative fuels become the ultimate solution. When we talk about alternative fuels, we mainly mean motor fuels for transport vehicles, which produce less pollution than conventional fuels. Which technology to choose largely depends on the local situation, political motives, specific operational and environmental requirements that need to be met.

The some basic criteria for evaluating alternative fuel are reflected in the following:

- Possibility of mass production as well as production from renewable sources.
- The overall economic aspect of the application of potential fuel, and thus the specific price; it is evaluated per energy unit, which has a direct impact on the transition to alternative fuels.

- The impact on the environment is becoming increasingly important, because the introduction of new fuels sets strict regulations for environmental protection.
- The degree of danger during manipulation is a criterion, which is also related to the impact of fuel on the environment, whereby the technological process of production and manipulation during exploitation must be taken into account.

All the above criteria are important when choosing an alternative fuel and its subsequent development. In road transport, it is most realistic to expect that the economic aspect will decide, especially because the price of the fuel itself affects the price of transport, and especially the price of freight transport. It should be taken into account that the prices of alternative fuel vehicles are significantly higher than the prices of conventional vehicles. The availability of alternative fuels also reduces their use, as petrol stations for conventional fuels are currently incomparably more accessible than the infrastructure for refueling with alternative fuels. It is expected that alternative fuels will only gain in importance in the coming years, since many European and world countries have started the production and application of vehicles with alternative fuels. The development of infrastructure and the application of vehicles on alternative fuels have recorded significant growth in the last few years. Technological innovations which significant investments are made and pilot projects implemented within individual countries, contribute to the fulfillment of the set European strategies on cleaner vehicles. Many cities, encouraged by European Union policies, have implemented a range of measures that have resulted in reduced dependence on car use and greater use of environmentally friendly modes of transport, including public transport.

### 4. Use of vehicles with alternative fuels in public transport – practical application

Public transport has very important role in sustainable transport, apropos in sustainable mobility. Therefore, it is very important that public transport of passengers is performed by vehicles that use alternative types of fuel. Many more developed countries and cities, which have adopted different environmental strategies, are gradually replacing conventional fuel buses with buses that use alternative fuels.

Although the purchase of new buses cost twice as much as conventional vehicles, the savings resulting from the use of these vehicles are numerous. In addition to reduced noise in the city center, the most obvious result is certainly a reduction in fuel costs, as well as the absence of harmful gas emissions. According to calculations of the Technical University of Graz, electric buses will reduce emissions of CO<sub>2</sub> by 5.3t, of NO by 1.7t and of NO<sub>2</sub> by 0.06t per year compared to the liquid gas buses which had been used before [11].

The Reading public transport operator (UK) introduced 34 CNG buses in april 2013. which at the time was the largest fleet of CNG buses in that country. A major advantage of using CNG over the Euro V diesel buses (the comparable traditional technology at the time of purchase) was the reduction of harmful tailpipe emissions including particulates, which are negligible. Estimates from Reading Transport are that NO<sub>x</sub> emissions of their fleet of biomethane buses are 30%-50% lower than comparable Euro V diesel buses. As well as low emissions the buses are smoother and quieter than conventional diesel engine buses [12].

In the autumn of 2019, London got two routes 43 and 134, which are the first bus lines in the UK that use only electric double-decker buses. It has the largest electric bus fleet, with over 200 electric buses. For this year, an increase in this number of electric buses is planned, as Transport for London (TfL) has awarded contracts to operators for a further 78 electric double-decker buses. Generally, for the past 10 years, London has been considered a city

that has one of the largest fleet of green buses in Europe. In some areas of the city there were 90 per cent fall NOx emissions [13].

The Italian city of Turin has also replaced existing vehicles with electric buses in the city center. In addition to the stated advantages of zero emissions, vehicle maintenance costs have been reduced by 20%, while the life of the vehicle has been extended by also 20%. The overall experiences of the operator and passengers have been very positive [14].

Porto's public transport operator (STCP) has operated a fleet of 255 standard and articulated CNG buses since 2009. The models used are MAN NL 233 CNG and MAN NL 310 CNG. These vehicles performed better in terms of emissions than comparable diesel models, produced less noise emissions and have been well accepted by drivers and passengers [14].

In 2011, the city of Umea in Sweden tested electric buses on certain bus routes, with very good results. According to data from 2016. in the city of Umea there were nine electric buses and two hybrid buses on three lines 6, 9 and 80. In June 2019, an additional 25 electric buses are planned to be introduced [15]. Due to the fact that there is clean wind energy and hydroelectric power plants in Umea, buses can run entirely on clean energy. Buses use LTO batteries that can be charged within 6 minutes for an hour's drive [16].

In the summer of 2019, the formation of public transport lines with zero emission in Barcelona has begun. TMB company has procured 23 e-buses, which will replace existing diesel vehicles. They has a plan to renew the fleet of city buses in Barcelona with the introduction of 266 electric, hybrid and natural gas buses in the period 2019-2021. The final plan is that by 2030 the whole TMB fleet will be made only of alternative drive buses [17].

## 5. Conclusion

With the global energy system at a crossroads and current European and global trends largely based on fossil fuels, the future of alternative fuels and vehicles using alternative fuels is yet to come. It seems that the demands of climate policy and the economic interests that are placed before society have found their place in the politics of most European and world countries. Attempts are being made to change the current position on mobility, ie transport, in favor of modern and obviously necessary strategies on sustainability. Since there are different alternative fuels, it is necessary to make a detailed analysis before introducing vehicles with these types of fuels into the transport system. Countries that have not yet started using vehicles with alternative fuels can use the experience of countries that have already started using them.

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