

# ANALYSIS AND COMPARISON OF SUPPROT SYSTEMS FOR THE DEVELOPMENT OF EMISSION-FREE PUBLIC TRANSPORT IN POLAND

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**Abstract:** The way of directive of the European Parliament and the Council in 2014/94 on October 22nd 2014 in the case of infrastructure development of alternative fuels which was specifically concerned with calls to reduce oil dependence on transport in European countries was imposed due to the necessity to formulate specific provisions in individual nations in the Union. In correlation to this, on the day of 11th January 2018 the act on electromobility and alternative fuels was passed, which came to be on the day of 1st September 2018 with changes implemented later on.

The regulations mentioned above oblige public transport to partially replace their diesel engine-based rolling stock and introducing changes to alternative fuels (compressed hydrogen in gaseous form belongs to such fuels). Support systems in Poland are an important element in the implementation of modern and ecological technologies. Very often those solutions are much more expensive compared to the ones used so far. The financing provided by them enables the realization of such projects in our environment. In this work, the idea of emission-free public transport operating on the basis of electric vehicles (Battery Electric Vehicles) as well as hydrogen (Fuel Cell Vehicles) will be presented. Both of these variants will be compared and their working principle are going to be shown.

The analysis of support systems for the development of emission-free public transport on a European, national and regional level will also be presented.

All collected information will form a compendium of information essential to implementing the public transport project in Polish conditions.

**Keywords:** emission-free public transport, FCEV, BEV, support systems

## 1. INTRODUCTION

During the last decades, national governments, including the ones in European countries started implementing policies supporting the transition into zero-emission transport. The results of those actions were first caused by the directive of the European Parliament and Council from 2014 on the case of alternative fuel infrastructure development. This directive came to be for a few reasons. The transport sector is one

of the main factors propelling global climate change and is the cause of global warming. It constitutes over 20% of global greenhouse gas emissions. A similar share of transport in greenhouse gas emissions also applies to countries of the European Union. Local pollutant emissions – especially nitric oxide and solid particles, as well as the emission of greenhouse gases – must be reduced especially in urbanized areas (Lajunen and Lipman, 2016).

Apart from problems related to the worsening of air quality in relation to the increasing level of urbanization and motorization, many cities in the world are also fighting noise pollution and the worsening of life quality and comfort of citizens. Zero-emission vehicles alleviate these types of problems related to local pollution and can also aid in lowering emissions of greenhouse gasses, under the condition that low-emission or emission-neutral electric energy is available. Utilizing this kind of transport is especially important because it constitutes a portion of the collective communication system, which covers a range of mainly high urbanized centers with a high population density per square meter. Its task is meeting transport needs of the community in the city and suburban area in terms of connecting places of residence with places of work and education, organs of public administration, stores and shopping centers, health care facilities as well as recreational centers, cultural institutions, and objects of religious worship. Limiting the negative effects of conventional communication will therefore have a positive influence on a major portion of the community in many aspects of their lives. One of the obstacles of zero-emission transport development and the purchase of such vehicles by the relevant units is the higher price in comparison to their combustion counterparts. Higher price as well as the necessity of infrastructure development did not constitute the most favorable solution money-wise, and the environmental aspect was not a sufficient argument for the organizers of public urban transport, to decide on spreading the modern solution.

The contribution of electric vehicles to total vehicle sales in the world is marginal at the current moment, as it stands at about 2.5%. However, at the turn of 2017 and 2018, there has been a 32.9% increase in their sales, which shows that the market is growing dynamically (Kokocińska and Kola, 2019).

The creation of the FCEV vehicle fleet in Poland is currently unobtainable due to lack of infrastructure allowing for the filling of tanks with compressed hydrogen under the pressure of 350 bar with the quality defined by the standard (ISO 14687-2, 2012) at the level of 99.97% purity. In order to eliminate the mentioned problem, the element of policies for the development of zero-emission transport are instruments stimulating the popularization of zero-emission vehicles.

Supportive systems in Poland are an important element in the implementation of modern and ecological technologies due to them being usually very expensive solutions compared to the ones currently used. Financing, which they ensure, ensure the realization of these kinds of projects in the realities of Polish cities

## **2. BEV AND FCEV BUSES**

The zero-emission bus has been defined in the Polish law by the Act on electromobility and alternative fuels as a vehicle using energy created using electric energy made with hydrogen in installed fuel cells or exclusively the engine, whose work cycle does not lead to the emission of greenhouse gases or other substances covered by the greenhouse gas emission management system as well as trolleybus.

Vehicles powered by hydrogen fuel (FCEV) as well as the electric ones (BEV) have a common trait – an electric engine. However, there is a major difference between the two. Electric cars and buses are charged using electric energy, which is stored in the battery and then used for propulsion, and in hydrogen-based vehicles, the electric energy is created on an ongoing basis from the stored hydrogen mixed by fuel cells with oxygen from the air – energy generating a hydrogen binding – oxygen is transformed under controlled conditions and directly used by the electric engine. The only side product of this process is water (Logan et al., 2020).

A difference that divides both of these types of vehicles constitutes the advantages of hydrogen fuel over pure electricity because hydrogen can store more energy than a battery, which automatically increases its distance. Additionally, refueling time taking up to 10 minutes is a great advantage – electric vehicles require much more time to charge their battery.

The travel distance of an electric bus powered by hydrogen fuel is similar to buses fueled by diesel fuels and stands at about 350 km. The precise distance of vehicle's ability to travel depends on the capacity of tanks which range from 30-45 kg. In comparison with diesel buses, which consume on average 30l/100km (for a bus length equal to 12m) – about 10 kg of hydrogen/100km is used (Solaris, 2020).

In the life cycle of a vehicle (estimated at around 12 years) the replacement of one diesel engine city bus with a hydrogen-powered vehicle can prevent the emission of 800 tons of carbon dioxide into the atmosphere. It is important to mention that in Poland coal stands for over 90% of electricity production. During such a process, the combustion method produces 810 kg CO<sub>2</sub> /MWh, 1,539 kg SO<sub>2</sub> /MWh, 0,968 kg NO<sub>x</sub> /MWh and 0,238 kg CO/MWh (Malkowska 2019). It does not occur in city centers, where emission could directly harm the citizens. Development in the field of filtration also limits the above indicators from year to year.

A complex action will therefore be the simultaneous implementation of renewable sources for the production of electric energy, as well as the popularization of zero-emission transport. Without taking into account emissions in the production of renewable infrastructure elements, only then will the emissions of CO<sub>2</sub> be equal to zero.

### **3. LEGAL ANALYSIS OF ZERO-EMISSION TRANSPORT IN POLAND**

The legal act regulating the realization of environmental goals in Poland is the Act on electromobility and alternative fuels from the 11th of January 2018. The Polish legislator, while implementing the regulations of the 2014/94/UE directive, regulated mainly rules of development and functioning of infrastructure which served to load electric energy, tanking natural gas in the form of compressed and liquified gas (CNG and LNG), including the gas from biomethane. To a limited extent, he additionally discussed the infrastructure including infrastructure related to fueling vehicles with compressed hydrogen. Furthermore, he imposed a schedule of percentage shares of zero-emission vehicles in the total number of vehicles

Articles 36 and 68 specify the requirements for the way in which urban transport services are being provided or commissioned (within the meaning of the Act on Public Collective Transport) by the community and other local government units, whose number of citizens is at about 50 thousand. In this case, a defined amount of percentage shares of zero-emission buses will be needed in the vehicle fleet used in the territory of a given local government unit. Dates and shares according to the above-mentioned act are listed in Table 1.

Table 1

The schedule for achieving subsequent degrees of percentage shares of zero-emission busses in the vehicle fleet

Date	Percentage contribution in the vehicle fleet
From 01.01.2021	5%
From 01.01.2023	10%
From 01.01.2025	20%
From 01.01.2028	30%

Source: Personal study based on legal Act

The obligation to ensure the adequate zero-emission bus participation to provide public transport services is not absolute, as, after the fulfillment of requirements in article 37 on the Act of electromobility and alternative fuels, a local government unit cannot fulfill this obligation.

Legal frameworks for public transport in Poland directly regulate the EU regulation no. 1370/2007 as well as the National Act on Public Collective Transport on the 16th of December 2010. According to the above act (chapter 1 article 7) the administrator of collective public transport can be a commune (commune head, mayor, city president), inter-commune association (inter-commune association board), county (mayor), county union (board of a county union) or voivodeship (voivodeship marshal), so a relevant local government unit. The administrator's tasks include planning out the development, organizing and managing collective public transport, and therefore creating an adequate number of electric vehicle charging stations, assuring their contribution in the vehicle fleet utilized in offices serving municipalities and for performing public tasks (specifically public transport services, also when outsourcing these tasks to third parties) as well as the creation of specific rules of using electric vehicles during road transport.

Communication companies may be structured differently. Most commonly, proceeds from tickets are transferred into the city's office, however, the Urban Transport Company earns money for every traveled kilometer. The functions of an administrator and carrier have been divided, which shows a comparison to other structures – it is much more favorable, because in such cities public transport is much cheaper, and vehicles are usually more modern (Mesjasz-Lech, 2014). The profitability of public transport is measured using percentage costs, which is covered by income obtained from ticket sales. Unfortunately, in most Polish cities, the revenue from tickets does not cover even half of the costs that are regulated by the city budget (Dybalski, 2012). On this basis, we can notice that additional financing for the development of modern electro-mobile communication is the only possibility of its growth, as communication activity alone does not generate sufficient profits in order to finance such an investment. Under legal aspects, it is worth bringing up the matter of restricted traffic areas mentioned in the Act on electromobility as clean transport zones. These zones, in accordance with Article 39, act 1, apply only to municipalities whose population exceeds 100 thousand. The aim of implementing these kinds of zones is preventing negative influence on the health of citizens and the environment in correlation to the emission of pollution from transport

#### 4. ANALYSIS OF SUPPORT SYSTEMS IN POLAND AND IN THE WORLD

As mentioned above, units responsible for the development of electromobility and providing percentage interest shares are relevant local government units. Their task is to search and submit applications for co-financing and the construction of infrastructure for zero-emission means of transport as well as vehicles themselves.

Currently in Poland there are a couple of support programs, which enable financial sourcing for the development infrastructure for zero-emission communication. One of them is the Operational Program Infrastructure and Environment (OPIE). It is a national program supporting a low-carbon economy, environmental protection, counteracting climate change, and adapting to these changes, energetic transport, and security, as well as investments in areas of healthcare and cultural heritage. It's the biggest program financed with European Funds not only in Poland but in the entire European Union. It was defined for the years 2014-2020 (OPIE 2014-2020).

With the utilization of funds from measure 6.1 "Development of public collective transport in cities" OPIE in total, 13 contracts were signed which allowed for the purchase of 190 buses for cities that are trying to comprehensively approach the policy of reducing noise and air pollution. From the finances allocated for the realization of the program, plug-in chargers, charging stations, and pantographs have also been purchased. The budget of the project in total amounted to 460 million zł (GOV, 2020). New zero-emission vehicles will appear in Gdynia, Zielona Góra, Sosnowiec, Gliwice, Gorzów Wielkopolski, Radom, Opole, Malbork and Pila. European Union funds to support the purchase of modern rolling stock have already reached carriers from Poznan, Krakow and Szczecin (GOV).

The next national program is the Low Emission Transport Fund created on the basis of the Act of June 6th, 2018 amending the act on bio components and liquid biofuels as well as some other acts. The fund's task is financing projects related to the development of electromobility and transport based on alternative fuels. It differs from the Operational Program Infrastructure and Environment by the financing method because the revenues to be allocated will be funds from the state budget as a part of excise tax revenues, earnings from substitution fees, and funds transferred by the electro-energetic transmission system operator (GOV, 2020). Thanks to funding, the following activities will be implemented: The National Framework for Development of Alternative Fuels Infrastructure, the Electromobility Development Plan in Poland and in the Act of 11th January 2018 on electromobility and alternative fuels i.e. documents implementing the provisions of EU regulations on the development of alternative fuel infrastructure into Polish law. In practice, this means funding for each purchase of a zero-emission vehicle. Currently, financing for the purchase of zero-emission buses is not yet operational and the specific start date of the call for proposals is not yet known (GOVa, 2020).

Specific units can also apply for funding from European funds such as Fuel Cells and Hydrogen Joint Undertaking. It is a joint venture for fuel cells and hydrogen technologies (FCH JU). It is composed of public and private units such as the European Commission and Hydrogen Europe, which support research, technological development and demonstration activities (RTD) in fuel cell and hydrogen technology in Europe. The aim of the project is to accelerate the commercialization of technologies that are not based on coal, as well as reducing carbon emissions and contributing to economic growth and improving the well-being of Europeans through all activities. In June this year (2020) 11

out of 35 submitted projects were selected for co-financing. Among the selected was a consortium of cities located in the Pomeranian Voivodeship (FCH, 2020).

The best example which confirms the effectiveness of such incentives is the results of various European countries with the largest share of these vehicles. Norway, Germany, France, Great Britain, and Holland have all introduced a diverse system of incentives for the promotion of electric vehicles in both monetary and non-monetary forms. In Norway, funding was implemented at such a level that the price of a zero-emission vehicle equaled the price of a vehicle with a combustion-based engine. The multi-level approach to the implementation of electromobility policies by implementing support systems at central and local levels allowed for an increase in shares of zero-emission vehicles (Cansino, 2018)

## 5. CONCLUSION

Currently, zero-emission transport is much more expensive in terms of infrastructure and the purchase of new vehicles. This is mainly due to the need to build all facilities needed for this type of transport from scratch.

Without support systems, public transport managers have no chance of reaching the required percentage shares, especially when the obligation to ensure an appropriate percentage is not absolute and you can try to apply for an exemption.

Thanks to support systems, the infrastructure of zero-emission vehicles in public communication has a chance to develop, which ensures a better-quality environment. Limiting the emission of pollution to the atmosphere, mainly carbon dioxide, and limiting the emission of noise pollution in the vicinity of homes will result in an improvement in the quality of the natural environment, which will definitely improve the quality of urban residents' life.

In order to achieve the establishments of the Act and achieve the objectives of the Regulation, a much larger-scale program and simplification of procedures are necessary so that not only large cities will have the opportunity to develop zero-emission transport.

Programs offering support for the development of infrastructure exist, however, most of them will cease to function by the end of 2020. According to predictions, subsequent program editions and calls for proposals related to them will begin with the year 2021. Unfortunately, there is no decisive action by the Government of the Republic of Poland on the above-mentioned issue. It ought to launch and systematize a continuous support system to help individuals interested in obtaining help in meeting the requirements of the act adopted in this particular matter

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