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ELECTROMOBILITY MODELS AND SUSTAINABLE URBAN DEVELOPMENT - SARAJEVO CASE STUDY

Key words
Sustainable urban development;
Electro mobility;
Air pollution;
Efficiency of management

Abstract
The paper describes models of four electromobility segments, model of E bus, model of E bike, model of E taxi and model of E charge stations. Besides to the descriptions of individual models, the paper presents an analysis of the current state of electromobility in Sarajevo and several cities in the Europe. The method of financing and coverage of each of the electromobility models with elements of promotion and education of all interested segments of society are described. The paper analyzes the benefits and costs of new technologies when implemented in urban areas, especially taking into account their environmental aspects. For each model developed, implementation steps, proposed activities, and steps that need to be implemented in a specific area are given in order for these relatively new technologies to be accepted by the wider community. The goal of developing electromobility in urban areas is to provide users with attractive, convenient, fast and affordable public transport, with lower investment as possible, lower operating costs, and harmless and clean public transport.

1. INTRODUCTION

The most developed cities in Europe have action plans and established strategies for the development of sustainable transport and work intensively to inform and educate residents about the need to move from the current mode of transport to

sustainable transport. The experiences of cities that have passed the initial stages of project implementation show that educating the population is the first step in realizing such a project. Some of the benefits of sustainable transport are: a healthier life for citizens, less noise, less pollution, a nicer city. The concepts and determinants of sustainable development and urban mobility should be presented to the urban population in acceptable ways and that the citizens should be presenters of such development for the purpose of humane and safe living. More investment is needed in educating residents about the problems of globalization, climate change and alternative ways of solving them, is education should accompany infrastructural development to make the new mode of transport in a reality.

In addition to the redesign of public transport in cities and city of Sarajevo, it is necessary to analyze new technologies that are more present in Europe concerning the use of electric vehicles (passenger cars _E vehicles, buses _E Bus, electric bicycles E_bikes, E _ romobiles and scooters).

2. ELECTRIC VEHICLES

The following four main types of electric vehicles are used in EU cities: Hybrid Electric Vehicles; Plug-in hybrid electric vehicles; Electric vehicles with extended range; Electric vehicles with battery. The Commission's 2050 transport strategy aims to break the EU's dependency on gasoline transport and offers a target to reduce greenhouse gas emissions by 60% by 2050. In addition, vehicles using conventional fuels in urban transport should be halved by 2030 and gradually phased out by 2050. In some major cities, there is an obligation to build virtually carbon-free public transport by 2030. One of the basic motives for initiating the model of electro mobility in Sarajevo Canton stems from the strategic commitment to improving environmental conditions contained in numerous strategic documents at the state, entity and especially cantonal levels. The measures and objectives contained in the KEAP that relate to the electromobility models are:

- Implementation of measures from the Transport Strategy with the new concept of public transport system in Canton of Sarajevo for alternative modes of transport and walking.
- Renewal of rolling stock for public regular passenger transportation in Canton of Sarajevo - procurement of electric buses and trolleybuses,
- Establishment of a network of electric vehicle charging stations in Canton of Sarajevo [1].

3. MODELS OF ELECTRIC DRIVE TRAFFIC

The development of electro mobility in Canton of Sarajevo will take place through the development of four models for the introduction of electrically operated traffic in the Sarajevo Canton, namely:

a) model for development of electrically operated bus in public transportation
b) model for development of electric and/or hybrid taxi in public transportation

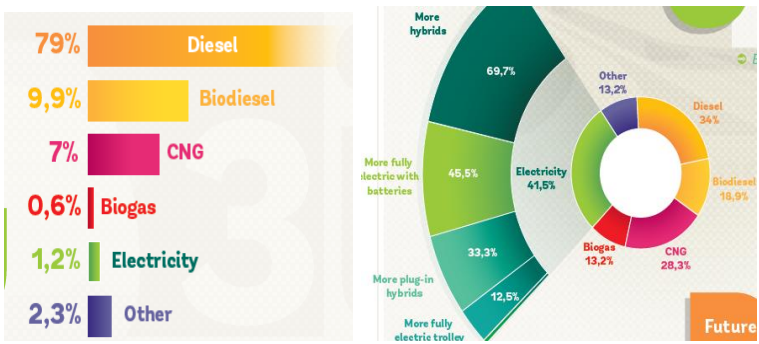
c) model of development of bike traffic with application of electric drive
d) model for the development of electric vehicle charging stations with the possibility of using renewable energy sources.

Making the models for the development of electric traffic in Sarajevo Canton will include:

- Analysis of the current state of investment justification for the development of electrically operated traffic with set goals;
- Coverage of the model of electric traffic development;
- Method of financing the electro mobility traffic models;
- Plan and program of education for participants in the implementation of the electro mobility traffic models;
- Communication framework for promotion of the electro mobility traffic models;
- Roles and responsibilities of participants / relevant bodies / institutions / organizations / enterprises [2].

3.1. Model of E-bus

The rapid development of electricity storage technology and charging systems have made the concept of electric bus more and more prevalent in many European cities and around the world in recent years. According to the EU ZeEUS (Zero emission Urban System) project report from October 2017, 85 cities in Europe use purely electric buses [3]. The representation of buses by type of EU drive in 2013 and the expected representation of buses by type of EU drive in 2030 are shown in the Figure 1. An overview of individual solutions and layout of E-bus is shown in the Figure 2.



Source: Bus system in Europe-current fleets and future trends, 3IBS project EU,2012-2015

Figure 1. E-bus in 2013 and predicted share of E-bus in 2030

E-Bus in Luksemburg

E-bus in Belgrade

E-bus in Graz

E-bus in Frankfurt

E-bus in Bremen

E-bus in Berlin

Figure 2. Photos of E-bus in several EU cities

In the case of introducing an e-bus into public transport, a simulation of the use of electric buses was carried out on some of the already existing bus lines in Sarajevo Canton. For this purpose, a comparison of electricity and motor fuel consumption (diesel or CNG) was made. Also other exploitation and environmental parameters for the introduction of electric buses (vehicles) were defined. The simulation analysis was performed on the current public transport bus route Sutjeska - Vogosca - Sutjeska, which is today covered by diesel-powered and CNG buses and connects the central part of Sarajevo with the settlement of Vogosca. By its character, the line is a suburban city with pronounced ups and downs on individual sections. This line is part of a line that was once covered by a trolleybus before the war in Bosnia and Herzegovina where a contact network was destroyed. Today, there are plans to re-cover the line using a trolleybus, but there are additional costs involved in training part or all of the contact network. The analysis conducted on the line Sutjeska - Vogosca - Sutjeska has proved that the Electric bus with super capacitor design has the least cost in the observed life span of 14 years, amounting to 11.39 million Euros. Higher overall costs are attributed to the exploitation of CNG buses (13.14 million), while the highest total costs are associated with the introduction of a trolleybus into the transportation system. The budget shows that a trolleybus with autonomy has a lower total cost (14.9 million Euros) compared to a trolleybus without autonomy of 16.31 million Euros, since in this case it is necessary to build 6.3 km of contact network instead of 9.2 km to be built in the event of the introduction of a trolley without autonomy. If we compare the operation of E-bus and CNG buses in the observed period, at the end of 10-year the total costs equals, while in the period 11-14 years the cost is higher for CNG buses.

The analysis showed that a more cost-effective solution was to implemented an E-bus electrically operated bus that uses a 40 kWh super capacitor and fast chargers installed at terminals compared to the introduction of a trolleybus and CNG bus.

The supercapacitor e-bus has a lower unit cost, lower infrastructure costs, higher energy efficiency, lower maintenance costs compared to trolley buses [4].

3.2. Model of E-bike

The main advantages and benefits of using a E-bike model would be:

- reducing the need to use cars and taxis especially in the city center and in the inner city area,
- simply and easy access to venues for various cultural and sports events of mass character (downtown, gyms, stadiums), important tourist destinations, theaters, restaurants and city and cantonal institutions
- environmentally friendly, non-polluting substances are used, contributing to the improvement of air quality
- electric bike can be used multiple times a day by multiple users (approx. 10 to 50 users)
- no need to search for parking space.

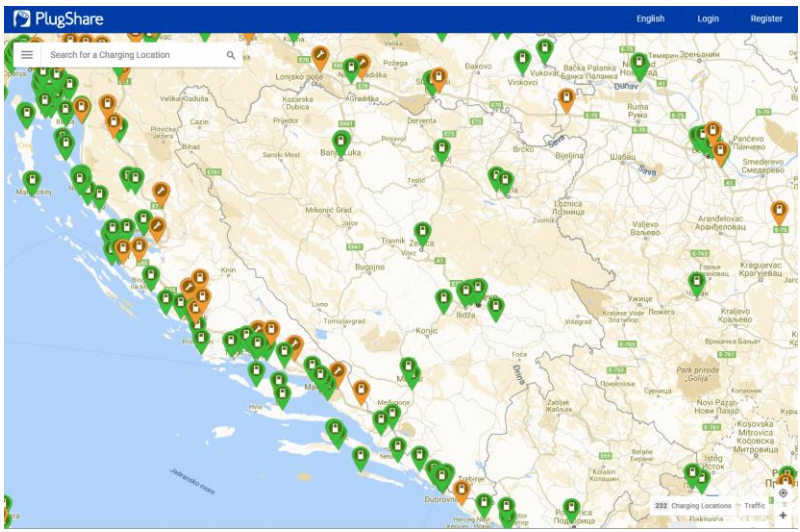
Implementation of the model of E-bike traffic and transportation according to the presented concept would result in the introduction of a new and very attractive mode of transport by E-bike and scooter, which would significantly reduce the need for use of cars and taxis especially in the city center and the inner city area. It would also provide quick and easy access to all places of interest to citizens and tourists with environmentally friendly means of transport without pollutant emissions [5].

3.3. Model of E-taxi

The introduction of electric vehicles in the taxi service fleet will provide service users with quality, fast and safe driving. Through the popularization of electric vehicles, popularizing the use of electric vehicles not only through taxi transportation but also for personal use, people directly affect the quality of life in the city. The model for introducing electric vehicles into public transit will be based on the following: procurement of hybrid or electric taxi vehicles (about 10-20 percent of the current taxi fleet) in the first phase, E-taxi vehicles would be procured through state subvention (cantonal government, city administration, etc., subvention of vehicle distributors, credit lines of commercial banks, taxi stands would be installed and electric chargers for faster replenishment of hybrids/plug in). The additional system would be provided for use of taxis and electric vehicles through the application the same platform would be put at the disposal of citizens for the use (calls) of hybrid (eco) taxis, but also for the use of electric cars (their reservations, retrieval and driving). The whole process would also be harmonized with air pollution data, potentially from one place, to the application section of E-taxi it could have partners in Google, Master card, Telecom and international regional development partners [6].

3.4. Model of charging stations

According to data from 2018 [2], a total of 501 passenger vehicles have been registered in Bosnia and Herzegovina, which can use electricity as fuel. Of these, 15 were registered as pure electric vehicles and 486 as hybrid (gasoline / electric or diesel / electric vehicles). Currently, there are over 20 electric vehicle charging stations in Bosnia and Herzegovina (2019), of which 10 are in the Sarajevo Canton (Figure 3) [7].



Source: https://www.plugshare.com.

Figure 3. Map of charging station in Bosnia and Herzegovina according to the PlugShare map (June, 2019)

Charging infrastructure is a prerequisite for the development of the electro mobility market. The impact of (non)existence of charging infrastructure on the sale of electric vehicles in Bosnia and Herzegovina can be seen in the context of three different charging stations technologies: home charging stations, public AC charging stations and fast DC charging stations). Charges on public parking lots and sidewalks adjacent to buildings - for drivers who do not have access to a private garage with a home and home charge. Semi-private or public AC charging stations with business facilities - for public fleet owners or corporate users, taxis and car rental companies, etc. Public AC filling stations in cities and larger settlements in frequency locations (e.g. city centers), shopping malls, sports halls, hotels, picnics, etc.) - to recharge the batteries of local drivers. Fast DC charging stations - for transit passengers from the EU to Bosnia and Herzegovina and vice versa (diaspora, tourists, other users), as well as for transport between cities within Bosnia and Herzegovina. Also, it is limited number of DC filling stations in the city for fast charging for local drivers (e.g. taxi vehicles) [8].

4. CONCLUSION

Electro mobility in cities in the coming period will be increasingly present in all forms of its observation. Electric vehicles and electric means of transportation will be a form of public transport in most cities. Electric charging stations will be more and more present in all parts of cities and areas and will most likely experience their standardization. With new technologies of charging and autonomy, E-buses will be the technology that, in addition to the environment, has its economic side as a technology that will be increasingly affordable and comparable to all other technologies. Sarajevo has started the development of four models of electro mobility (E-bus, E-taxi, E-bike and E-charging stations). This approach will provide clear procedures and conditions for the introduction and construction of all models and lower prices for all segments of e-vehicle technology.

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