assistant professor Beti Angelevska
assistant professor Blagoja Arapinoski
Department of traffic and transport engineering, Department of electrical engineering
Faculty of Technical Sciences, University "St. Kliment Ohridski", Bitola, Macedonia

The e-challenge in upgrading urban vehicle fleet

1. Introduction

Recently, the electric vehicles are becoming an increasingly effective alternative that contribute for air quality maintenance. However, this is more typical for developed countries [5].

Over the past years, markets for electric vehicles have witnessed an impressive growth worldwide. This increase has been in terms of sales, with over 550,000 vehicles being sold worldwide in 2015 representing a 70% growth relative to the year 2014, as well as in terms of the number of vehicle models being offered [7]. All this has been possible thanks to policy support. However, advancements have been concentrated in a relatively limited number of electric vehicles markets: the United States, the Netherlands, Norway, the United Kingdom, Japan, Germany, France and China [7]. Except for China, the rest of the countries belong to the so-called "developed world".

While the expansion of electric vehicles in developed countries is rising on everyday level, this is not a case in developing countries, including Macedonia, where the number of electric vehicles is very low. Even in a serious situation with high urban air pollution, the number of electric vehicles is insignificant – we have around 30 of these vehicles nationally.

Electric vehicles have significant advantages to be used for everyday urban journeys. Environmentalists confirm that e-vehicles will significantly contribute to reduction of air pollution, due to the decreased exhaust emissions and decreased dependence of oil import. Electric vehicles have strong and concrete potential to reduce dependence on fossil fuels by relying on a source of electricity that is mostly domestic and relatively inexpensive [7].

Still, there are several obstacles and limitations that interfere for the wider distribution and usage of electric vehicles. The main obstacles in comparison with conventional vehicles are: higher price and absence of energy infrastructure for refueling which limits the distance travelled.

It is not only the awareness of the public needed for promotion and widening of the electro-mobility. To support these vehicles comprehensive measures on national and local level are needed to be developed and implemented. Hence, this analysis at the beginning calculates the impact that electric vehicles have on air pollution in Bitola and presents the obstacles in developing countries that must be overcome. Then, a set of measures on national and local level are proposed in order to support the future growth of the number of electric vehicles in urban vehicle fleet.

2. Electric vehicles: advantages and disadvantages

When making an analysis from the aspect of potential buyer, as well as during the development of policies for the support of introduction of electric vehicles, the consideration of the pros and cons is vital. Electric cars have both, as any other thing.

However, the advantages do seem to outweigh the disadvantages for most drivers. Both of them are presented in the following tables:

Table 1: Advantages of electric vehicles

Characteristic	Fact
Cheaper operating cost	- cheaper electricity (in most parts of the world) compared to petroleum costs - cheaper insurance and road tax - free parking - less servicing and maintenance costs.
Cheaper as company car	- the same previously mentioned facts.
Recharging battery pack at home	- park & plug the electric vehicle in family houses.
Holding their value	- for example, the Tesla Model S has a value retention of 83%, 71% and 57% respectively after one, two and three years – much higher than any petroleum fuelled car in its category.
Quick & quiet	- silent and smooth - high torque (axle twisting power) - practical and easy to drive, particularly in urban start-stop journeys.
Safe to drive	- rigorous testing procedures - exposure to magnetic fields is lower than 20% of the value recommended by the International Commission on Non-Ionizing Radiation Protection (ICNIRP).
Growing popularity	- 70% more vehicles sold in 2015 compared with 2014.
Zero tailpipe emissions	- smaller environmental impact even in coal-dependent regions for electricity production - smaller ecological footprint than conventional vehicles.

Source: [4], [6], [3]

Table 2: Disadvantages of electric vehicles

Characteristic	Facts for improving the disadvantage
Limited range (range anxiety)	- the average range is more than most drivers need (100-200 miles is plenty for most driving) - continuous improvement of cost and range of batteries.
Long refueling time and high investment costs	- public rapid charge points (additional 50 miles of range in around 20-25 minutes) - web-maps of charging points - improvement of the technology.
Higher purchase costs	- government subsidies for buying vehicle and installing a

	charging point at home lowers the expenses - competitive lease rates and lower maintenance costs.
Limited choice of electric vehicles	- available 30 models of electric cars and 10 models of vans with a potential to expand over time.

Source:[4], [6], [3]

However, regardless of their advantages, electric vehicles must still overcome a host of barriers (both technical and economic) if they are to compete with traditional vehicles [5].

3. E-vehicles in urban fleet in Bitola: air pollution impact

Urban transport in the town of Bitola, Macedonia, is characterized with insufficient participation of sustainable transport modes [1]. Public transport, serving the central town area with low service quality is not frequently used by the citizens. Other forms of sustainable transport (cycling and walking) don't have the needed developed and safe infrastructure. In this situation, passenger car (private car or taxi car) is always a first choice for urban journeys, even at short, walking distances.

Therefore, urban traffic flows over 90% are composed of passenger cars. Regardless of the used fuel type (petroleum, diesel and natural gas), everyday number of passenger cars at town's streets and their frequency of use is a good indicator that emission impact on air quality must not be neglected [1].

Number of vehicles (in percentage) for every category, according to the age of the vehicles, is given in figure 1.

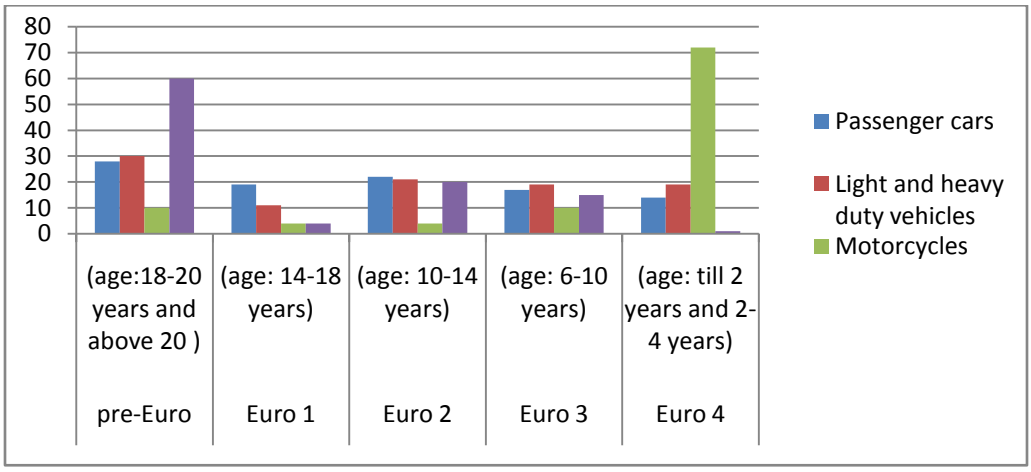

Fig. 1: Average age of the motor vehicles in the urban fleet, in percentage
Source: [1]

The social situation in the town of Bitola and in the state in general is a main contributor which defines average age of the motor vehicle fleet. Therefore, the biggest part of the vehicles (around 28%) comprises vehicles old from 18-20 years (and above 20 years); these vehicles don't belong at any of Euro standards categories. In the category of Euro I, with average age of 14-18 years, belong 19% of all vehicles in the urban fleet [1].

At the same time, exhaust emissions from these older vehicles are higher, because of the obsolete technical characteristic and out-of date equipment for exhaust gasses treatment (or total absence of this kind of equipment). On the other hand, these vehicles are actually those vehicles which are in everyday use and which realize the biggest part of passenger kilometers in the town, in respect to their

representativeness. All these facts clearly highlight the seriousness of the air pollution problem in the central area of the town [1].

The impact that current urban vehicles have on air pollution is estimated using the COPERT emission model. Also, using the same model, a supposed scenario is analyzed, in which the oldest vehicles (pre-Euro and Euro I vehicles) are excluded from the urban fleet and that 2% of their total number is substituted with electric vehicles. Hence, in the "after" situation, a renewed structure of urban fleet is assumed, introducing around 108 electric vehicles in Bitola.

In the current situation urban vehicle fleet is mainly composed of older vehicle generations, in which vehicles from pre-Euro and Euro I category are dominant (with 47%). In "after" situation, calculations are performed for technological structure of urban vehicle fleet in which these categories of vehicles are excluded and electric vehicles of around 2% of the number of oldest vehicles are introduced.

This change in the structure of urban fleet contributes for a significant decrease for all emissions calculated with COPERT. The results of the reduction in emission amounts for every vehicle category are given in table 3:

Table 3: Emission reduction, [t/god]

	CO	**VOC**	**NO_x**	**NO**	**$PM_{2.5}$**	**PM_{10}**
Passenger cars	689.71	59.38	64.38	61.19	2.22	2.6
Light duty vehicles	2.87	0.35	0.57	0.55	0	0.01
Heavy duty vehicles	7.27	2.8	31.59	28.12	1.33	1.47
Buses	1.76	0.59	8.75	7.79	0.37	0.41
Motorcycles	2.05	0.13	+0.02	0	0	0
Total	703.64	64.98	105.29	97.64	3.93	4.49

Source: [1]

Of all the pollutants, the highest decrease in total emission with a factor of 29,5 has been noticed for volatile organic compounds (VOC) and for carbon monoxide (CO) with a factor of 22.

This "before-after" analysis has shown that a reduction in the amounts of all analyzed pollutants has been accomplished. The biggest reduction in emission amounts is for passenger cars, as the most numerous category of vehicles in urban fleet.

The conclusion is that the higher prevalence of vehicles belonging to newer generation of standards, including electric vehicles as a partial substitution of the oldest vehicles, directly contributes for significant reduction of all emission amounts analyzed.

4. An electric start in developing countries

As the transition to e-mobility is still in the early stages, there is no right or wrong answer to how this can be achieved. However, there are a growing range of examples as to how this may be delivered and with careful consideration, elected officials, municipal representatives and other stakeholders can ensure that the approach taken is correct and appropriate for their location [3].

The problems of introduction of electric vehicle in developing country are not uniform – each city and country faces different circumstances – but all developing countries seem to display the same

types of barriers with different levels of intensity. These can be grouped into three main categories: policy, infrastructure and grid requirements [7].

4.1. Policy & regulatory framework

Developing countries still lack concrete and comprehensive support in the form of regulatory policies to frame the electric vehicles market and boost its development [7]. Policy interventions include introducing policy instruments to promote electric vehicles, setting up infrastructure and inducing consumers to switch to electric vehicles.

Policy-makers need to show a stronger commitment to creating favorable legislative and regulatory frameworks for electric vehicles [7]. Fiscal measures are needed because electric vehicles still have high up-front purchase prices compared to internal combustion vehicles and most of consumers cannot afford one. Even if electric vehicles offer long-term fuel saving opportunities, most consumers do not have a long-term mind-set. Subsidies, grants and tax exemptions can help them to afford an electric vehicle and foster a future-oriented perspective. Electric vehicles should be granted favorable treatment through reduced licensing requirements or sales tax incentives in order to be able to compete with conventional vehicles [7].

4.2. Infrastructure and grid

Electric vehicles require a well-functioning road infrastructure, which is often lacking in the developing world, and having the possibility of installing the hardware and software charging infrastructure, which ensures energy is transferred from the electric grid to the vehicle [7].

The adoption of electric vehicles adds additional requirement on the grid - charging electric vehicles causes the grid to be heavily loaded. Grid systems in developing countries do not have the power infrastructure to carry capacity to deal with this extra need of energy simultaneously.

Massive investments will be needed not only to provide developing countries with adequate infrastructure to support smooth flowing of vehicle traffic, but also to re-shape urban space and how the cities are evolving [7]. Installing charging infrastructure should go hand in hand with grid reconstruction, as well as modernization and transformation for the inclusion of renewable energy sources into the electrical mix. This is where governments and institutional investors can participate in large scale and long-term investments into electric vehicle infrastructure [7].

4.3. Informed customers

Designing policies to target the industry is just one part of the story. Specialized forums such as workshops between policy-makers and industry groups can serve to fast-track effective policies. Similarly, detailed information on the life-cycle costs and environmental benefits should be made available to consumers to familiarize them with the beneficial aspects of the technology [7]. The customer must be familiar with all substantive information before making the decision for the choice of vehicle to be bought.

5. Measures for promotion of e-vehicle

A number of measures are available to encourage consumers to buy and to use an electric vehicle [2]. These measures can be applicable in developing countries as well. Such incentives are designed and implemented at different governance levels, from EU legislation that provides a framework promoting low-emission vehicles, through national measures such as introducing lower taxes for electric vehicles, to local incentives such as free parking and use of road lanes normally reserved for public transport [2].

The European Commission has established ambitious goals for the gradual phasing-out of conventionally fuelled vehicles from the urban environment to reduce our dependency on oil imports and reduce greenhouse gas emissions and local air and noise pollution [3].

Macedonia aims towards the participation into the European family; therefore the ratification of regulations and directives brought by the European Commission is applied at national level. Therefore, here, without enumerating the EU regulations signed and adopted by our country, only the measures at national and local level are presented.

Table 4: Two-level measures for promotion of e-vehicles

NATIONAL LEVEL
✓ purchasing subsidies: - reducing registration tax - exempting electric vehicles from value added tax – VAT, - co-funding purchases – grants or premiums ✓ reduced ownership costs - yearly tax exemptions or reductions.
LOCAL LEVEL
✓ public procurement of electric vehicles (local authorities use electric vehicle raising the public awareness and reducing their environmental footprint) ✓ provision of free parking places for electric vehicles ✓ provision of free charging at public stations ✓ use of lanes reserved for public transport ✓ access to restricted areas or city centers for low-polluting vehicles ✓ road-toll exemptions or discounts ✓ supporting measures to educate and promote electric vehicle use (promotion and dissemination of the information) ✓ grouping of authorities (sharing the experience between cities and stakeholders, such as manufacturers, infrastructure providers and energy companies).

Source: **[2]**

These measures have been implemented across Europe by national and local authorities, having a potential to encourage the uptake of electric vehicles. Often developed in conjunction with national authorities, to ensure that the appropriate legal basis for their implementation is in place, local measures are often (but not necessary) non-financial [2].

Today, many countries are implementing these, or similar, measures to facilitate the introduction and consolidation of the electric vehicle so that it might become the mode of transport of the future [5].

6. Conclusion

Despite the significant technological progress made over recent decades towards cleaner engines, traffic emissions account for a high proportion of Europe's air and greenhouse pollution [2]. Electric vehicles have a potential to reduce the burden that the transport system places on the environment. For the research and policy communities, it is clear that initiatives that drive vehicle technology

improvements and fleet renewal can be one of the main strategies for reducing emissions of both greenhouse gasses and air pollutants, significantly improving local air quality in cities [2].

Despite the barriers, expanding electric mobility in developing countries can offer environmental benefits. Most cities in developing countries have severe air pollution problems caused by a significant number of old and inefficient vehicles on the roads. Electric vehicles, coupled with broader clean transport and urban sustainable strategies, can be a key in reducing emissions from the transport sector and achieving climate change goals [7].

The shift to electric vehicles provides a significant opportunity to improve the environmental and economic performances, as well as a step change to sustainable mobility in cities [3].

Presented analysis for the e-renewal in urban vehicle fleet in Bitola supports the claims of the potential positive impacts that electric vehicles have on air quality. By calculating the vehicle exhaust emissions for the current situation and for the assumed renewed structure of urban vehicle fleet, where oldest vehicle have been exempted and partially replaced with electric vehicles, the results quantitatively support introduction of the e-technology. Further, for accelerating electric vehicle market development, a combination of supporting incentives and measures, both at national and local level are proposed. In the near future, is it clear that considerable effort is required for the replacement of conventional vehicles with electric ones; and this analysis provides a good starting point for the changes towards e-mobility.

References

[1]. Angelevska, B., Markoski, A., The role of urban vehicle fleet technology in exhaust emission amount – example of Bitola town, Suvremeni promet, Vol. 35, No. 3-4, Zagreb, Croatia, 2015, pp. 222-226.

[2]. Electric vehicles in Europe, EEA report, No 20, Publication office of European Union Luxembourg, 2016, pp. 39.

[3]. European Commission, European program for sustainable urban development, EVUE Electric vehicles in urban Europe, pp. 90.

[4]. http://justenergysolutions.com/electric-vehicles-pros-cons.html

[5]. Perdiguero, J., Juan Luis Jiménez, J. L., Policy options for the promotion of electric vehicles: a review, Research Institute of Applied Economics, Universitat de Barcelona, Spain, working paper 2012/08, pp. 44.

[6]. http://plugin-magazine.com/guides/owning-an-electric-car-pros-and-cons/

[7]. http://revolve.media/the-other-side-of-the-road-electric-vehicles-in-the-developing-world/

assistant professor Beti Angelevska
assistant professor Blagoja Arapinoski

The e-challenge in upgrading urban vehicle fleet

Summary

Measures that encourage the continuous development and uptake of clean technologies in the transport sector will be fundamental for the future reduction of transport's impacts on the environment [2]. Electric vehicles are just one of the potential ways towards a more sustainable transport system.

Making internal combustion engines more efficient is unlikely to be sufficient by itself to achieve the EU's long-term goals of reducing emissions [2]. For introduction of electric vehicles, an integrated approach is needed, covering promotion of the potential that e-vehicles have on the environment together with the measures at national and local level for their wider use. Replacement of conventional vehicles with electric vehicles can help to reduce emissions, but it must be supported with implementation of measures that booster e-vehicles in the market in developing countries. This will require a considerable effort, especially from the local and national authorities in removing obstacles to the path towards the electrification in transport and zero-emission vehicles.

Key words: electric vehicles, introduction, measures

docent d-r Beti Angelevska
docent d-r Blagoja Arapinoski

E-izazov u nadgradnji urbanog voznog parka

Sažetak

Mjere koje podupiru kontinuirani razvoj i usvajanje čistih tehnologija u prometnom sektoru biće fundamentalne za buduće smanjenje transportnih utjecaja na okoliš [2]. Električna vozila su samo jedan od potencijalnih načina prema održivom prometnom sustavu.

Veća učinkovitost motora sa unutarnjim izgaranjem nije vjerovatno da će biti dovoljno samo po sebi u postizanju dugoročnih EU ciljeva za smanjenje emisija [2]. Za uvođenje električnih vozila, potreban je integrirani pristup, koji pokriva promovisanje potencijala koja e-vozila imaju na okoliš, zajedno sa mjerama na državnoj i lokalnom razini radi njihovu širu uporabu. Zamjena konvencionalnih vozila s električnim vozilima može pomoći u smanjenju emisija, ali to mora biti poddržano s implementacijom mjera koje podupiru e-vozila na tržište zemljama u razvoju. Ovo zahteva značajan napor, posebno od strane lokalnih i nacionalnih vlasti u uklanjanju zapreka na putu ka elektrifikacije u prometu i vozilima sa nultom emisijom.

Ključne riječi: električna vozila, uvođenje, mjere