



LOCATION AND LAYOUT OF CHARGING STATIONS IN KOŠICE FOR NEEDS OF ELECTROMOBILES

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Abstract: Article is oriented to actual problems of charging stations building for needs of electromobiles in locality of Kosice. Because development of this fields is depending on possibilities fill up of energy which drive of means of transport is necessary to define location and layout of charging stations in concrete locality of Kosice. In term of the first electromobile drivers requests fulfilment is important charging of electromobile in the places, which are visiting very often and where are spending some time which is adequate for charging of electromobiles. For this reason was as possible places defined shopping centres, where is adequate place for building and customers there are spending adequate time too. The next possible places are parking before housing developments, offices and others. In the article are reasoning concrete restrictions, which are influencing of locality choosing with general project of future stage.

Key words: electromobil, charging station, layout, location

1 INTRODUCTION

Every year there are more and more electromobiles on the roads. In neighbouring countries runs building the charging infrastructure, informing people about new technologies and purchase of electric vehicles. People have realized that dependence on petroleum with its ever-rising prices is unbearable. Due to the low interest about electromobility in Slovakia people don't think about that. The reason is low level of edification for this issue.

Problem of ever-increasing fuel prices applies to the entire world. Petroleum reserves are running out so that it is necessary to have an alternative to be used before full depletion of stocks. One possibility is use the electric energy.

The growing trend in use of electric vehicles and related building of charging network is another associated problem. Due to expensive building of that network it is necessary to choose optimal allocation and layout so that a network of charging stations can be suggested. Allocation and layout is covered under “logistics” or more exactly “distribution logistics”.

A case study of electromobility was applied to the city of Kosice. Kosice by introducing its first charging station into operation on November 2010 has initiated electromobility in Slovakia [1].

2 LAYOUT AND LOCATION OF CHARGING STATIONS

It is a very important to think about the proper place when building the network of charging stations for electric vehicles even in case of new stations to be built on existed network.

The allocation is understood as spread of charging stations around the city of Košice. The proper location of charging stations can be done by determining the sites that are highly frequented in term of traffic rate nowadays and in the future. A principle of multi-criteria decision making was used to solve allocation problem of charging stations [1].

The layout is generally understood as a strategic decision about scheduling and allocation. The city of Košice is used in this article in order to demonstrate principles of allocation of charging stations. Allocation was used to determine a city ward suitable for building of charging station. Then, the layout principles were used in order to allocate charging stations on some concrete places in the city ward [2].

City of Košice currently runs the first phase of electromobility. The first charging station in Košice and all the Slovakia was introduced in November 2010 by VSE Company (local provider of electricity). The first electric vehicle Peugeot iOn was integrated into the fleet of VSE Company in the first half of 2011 [24]. At the end of 2011, the total number of registered passenger vehicles in Kosice was 76,506 and the total number of registered electric vehicles was 1. Number of electric vehicles did not change until the second quarter of 2012 [25].

A VSE Company is trying to inform their customers about the details of the testing of its electric vehicle. It is not easy without any support from government. It is insufficient to inform people about new technologies on the website. Purchase of new electric vehicles in the future also does not help.

The first charging station in Košice was an initial step to travel from Košice to Bratislava by electric vehicle [24]. There are another city in Slovakia that have followed Košice like Bratislava with its 1st charging station in May 2011, Poprad with its charging station in November 2011 or Nitra which introduced its first charging station on December 2011 (Figure 1). Connection between 2 largest cities Košice and Bratislava by electric vehicle is not yet possible due to the almost 260 km distance between Poprad and Nitra. It would be a good idea to build fifth charging station in Zvolen. Use of existing charging stations at this time is real only in urban traffic.

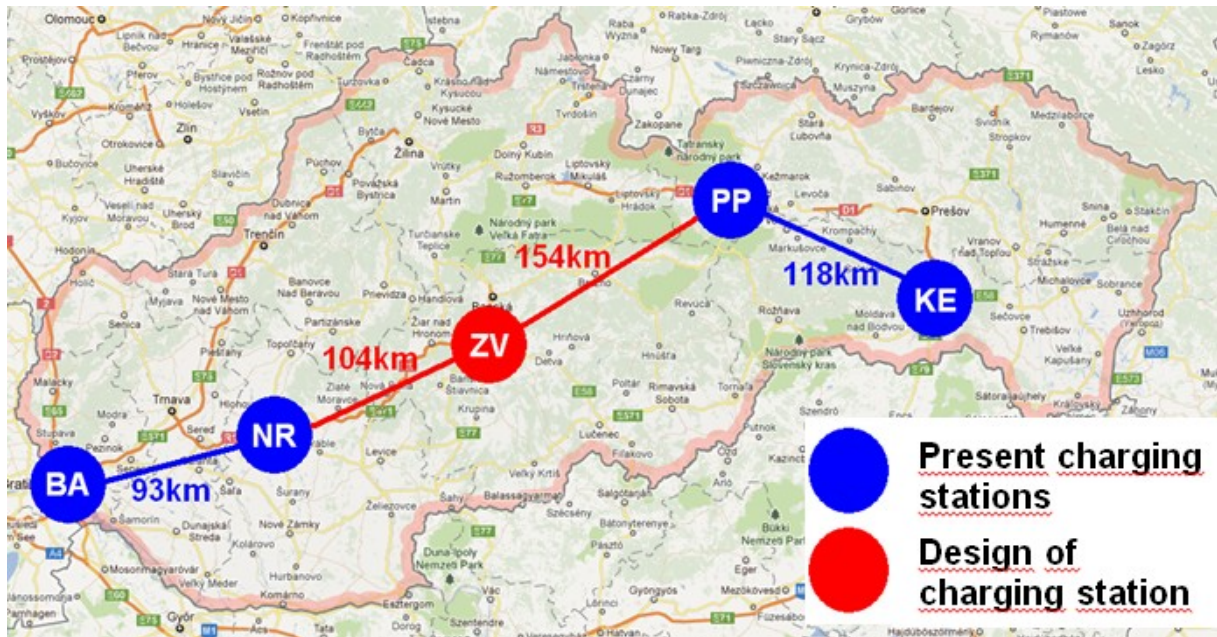


Fig.1 Charging stations in Slovakia

City of Košice as the initiator of electromobility in Slovakia could join the second phase namely delivery the charging stations on the market ie territory of Košice. Some people could argue that the Košice entered into the second phase by building its first charging station in November 2010. They're right, but from another point of view it would be a step back for electromobility not be expanded

City of Košice may become a prototype of Slovak city that think about future of transportation through electricity. All these activities can both: lead to more and more battery-driven vehicles on the roads and to help vehicle manufacturers not to be afraid put its electric vehicles on the Slovak market. It should be done by building a network of charging stations in the Košice. There are very good conditions to do that:

- The second largest city in Slovakia
- It covers the area of about 243 km²
- Regional capital city
- The center of eastern Slovakia
- Excellent geographical location near the Hungarian, Ukrainian and Polish border
- An international airport.

Project of electromobility is a long-term and challenging process requiring many resources including financial investments. In Košice and Slovakia there is no good charging network at this time. To be prepared for electromobility we need to have high quality infrastructure of charging stations for electric vehicles. This is related to the planning and selection of the most appropriate sites to charge as well as cost for the charging stations that is about thousands of euros. [26] Building of charging stations requires choosing a company to build and supply necessary equipment and will operate and maintain equipment. The chosen company should meet the technical parameters and communication provider-customer. Comfortable, safe and reliable use is a basis of the project [21].

3 CRITERIA FOR SELECTION OF CHARGING STATIONS

Košice is divided into 22 city wards. All Košice's city wards were considered while defining criteria for allocation of charging stations. Points for layout solution were selected according to the 5 criteria representing potentially suitable locations for charging stations of electric vehicles.

Definition of criteria:

1. Shopping centres – reason for selecting a shopping centre as a criterion is quite easy. Shopping centres are busy places where people spend enough time in order to recharge the battery. There is also parking places near each shopping centre so that reserving a few parking boxes for electric vehicles wouldn't be a problem.

2. Post offices – are the places with a lot of people all the day so that people often need to wait before are served. When the post office visit is joined with shopping there is a lot of time for charging process.

3. Authorities – are similar to the previous item in term of a lot people waiting to be served. While waiting will be served the electric vehicle can charged at the charging station. Statistically, the time spent at authorities is a little bit more than at post offices.

4. Health care institutions – there have a lot of patients anytime. Thousands of people are waiting many hours for health care on daily basis. Therefore that criterion is one of the most suitable for building charging stations. In Kosice all health care institutions including hospitals are considered.

5. Other major places – other places include such a places that are associated with relax activities or entertainment. In addition this category includes a parking area near the largest company in the east Slovakia – U.S.Steel, Ltd.

An another one additional criterion is used commonly with the existing criteria which have considered about the fact if the selected point for charging stations according to defined 5 criteria has or has not a parking area to be quite enough. Take parking areas was marked directly on the maps. All the parking places are allocated near the areas where a lot of people are. These criteria include 137 places potentially suitable as charging stations for electric vehicles in the Košice [1].

According to the data collected on 1.8.2010, the city of Košice had 238,725 inhabitants [22]. Compared to the 137 suitable places it should be reduced.

4 PROPOSALS FOR LOCATION OF CHARGING STATIONS UTILIZING A METHOD OF MULTI-CRITERIA DECISION MAKING

In order to reduce number of suitable points for charging stations *i* this used a couple of indirect multi-criteria decision making methods, specifically, the pairwise comparison method with allowed parity of values of weighting criteria (MPP method) and Saaty method. Saaty method was used in order to verify the previous method. Saaty method also gives more accurate values than in the case of MPP method. Each criteria have been marked alphabetically, A - shopping centres, B - post offices, C - the authorities, D - health care institutions, E - other major places.

By Saaty method is based on comparison 2 criteria each other. The evaluation of results is done by 9 different grades (Tab.1).

Tab. 1 Description of points scale, Saaty method

Points x	Description
1	The criteria are equally important
3	The first criterion is slightly significant than the second criterion
5	The first criterion is quite significant than the second criterion
7	The first criterion is much significant than the second criterion
9	The first criterion is absolute significant than the second criterion
	For the finer distinction can be used values 2, 4, 6, 8

Tab. 21 The total score in the whole matrix and counting of values in each columns, Saaty method

Criteria x_i	A	B	C	D	E
A	1,00	9,00	7,00	5,00	5,00
B	0,11	1,00	0,33	0,20	0,14
C	0,14	3,00	1,00	0,20	0,11
D	0,20	5,00	5,00	1,00	5,00
E	0,20	7,00	9,00	0,20	1,00
Sum	1,65	25,00	22,33	6,60	11,25

Tab. 3 Calculate new values of the matrix and calculation of standardized weights for each criterion, Saaty method

Criteria x_i	A	B	C	D	E	Sum	Standardized weights α_i
A	0,60	0,36	0,31	0,76	0,44	2,48	0,496
B	0,07	0,04	0,01	0,03	0,01	0,17	0,033
C	0,09	0,12	0,04	0,03	0,01	0,29	0,058
D	0,12	0,20	0,22	0,15	0,44	1,14	0,228
E	0,12	0,28	0,40	0,03	0,09	0,92	0,185
Sum	1,00	1,00	1,00	1,00	1,00	5,00	1,00

The most important is criterion A. It is followed by criteria D, E, C and B (Tab.2, Tab.3). Using multi-criteria decision making, it is clear that the appropriate place for charging station layout is actually shopping centres. There are 43 shopping centres marked on the map. Therefore, an additional criterion was used - large enough car parks - which had the effect on selection of sites for allocation. Considering that additional criterion in the city of Košice there are just 16 large enough car parks. However, only 11 large enough car parks are close to the shopping centres. The remaining 5 car parks falls within the criteria “other major places”. It follows that an additional criterion was a part of Variant 1 [1].

Points on the map symbolize some of the five criteria, additional criteria - large enough parking place, the core point, etc... The decisive role point indicates the place of potential midway between three or more points. It symbolizes the parking area with multiple parking spaces or an open area where it would be possible to create several parking spaces for electric vehicles. Just large car parks have priority while in early stages of building of charging stations for electric vehicles [1].

5 OUTLOOK ON BUILDING THE CHARGING STATIONS

With the growing number of electric vehicles on the road it will be necessary to extend the network of charging stations. Due to the price, the classical charging stations will prevail at the beginning. After the launch of the second phase of electromobility the demand of users will lead to quickly-charging stations with an output of 22kW and charging time of around one hour or with an output of 44kW and charging time about 30min.

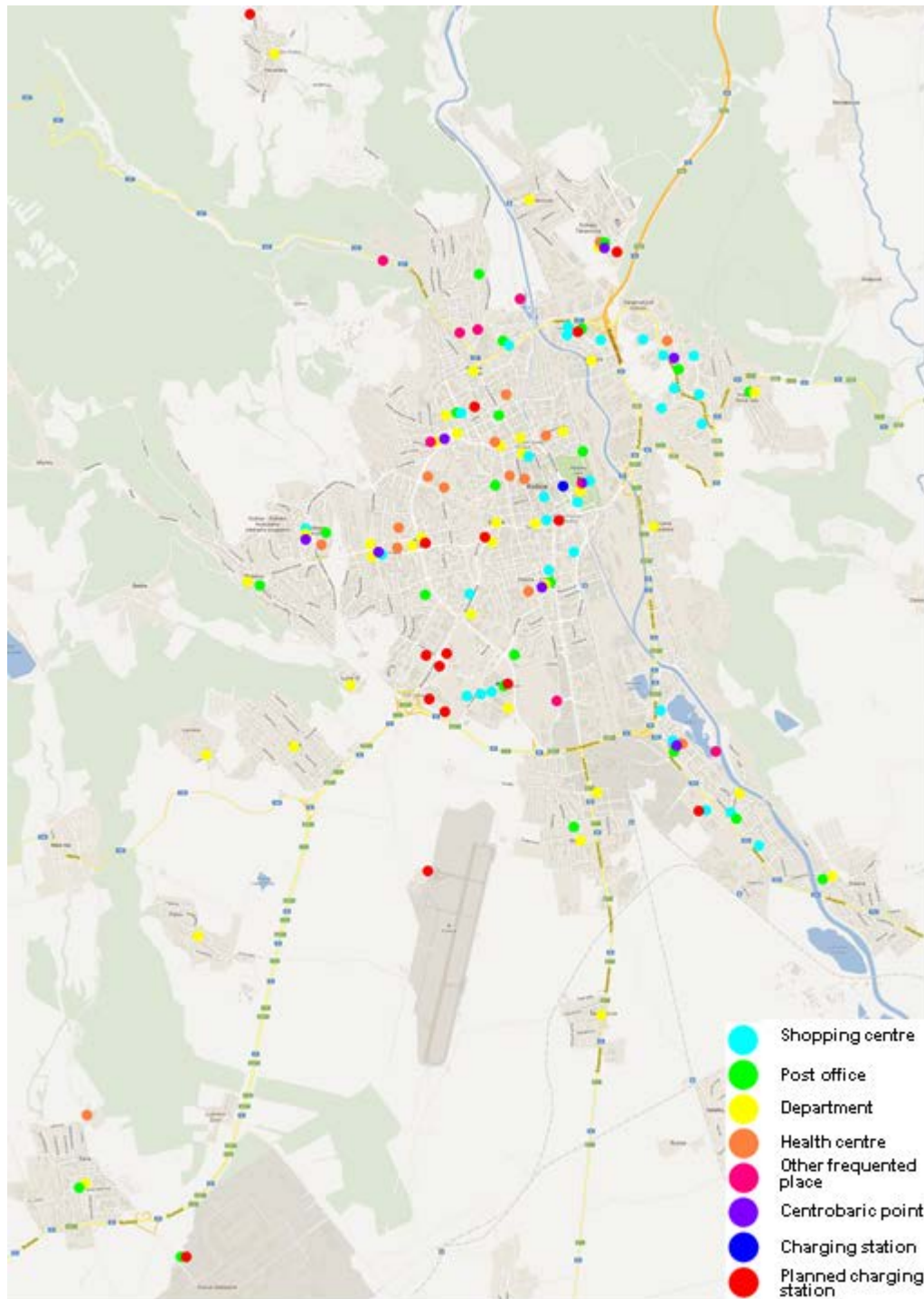


Fig.2 Marked points of the first to the fourth phases of building charging stations

Building of charging network in a several stages appears to be an ideal solution. Network building will be subjected to the result of a multi-criteria decision making. Master plan should be adapted according to the multi-criteria decision making results. For newly constructed buildings with adjacent car parks the charging stations will be considered in the phase of project. The figure 2 represents building a network of charging stations in the city of Košice from 1st to 4th phases [1].

6 CONCLUSIONS

Based on five main and one additional criteria have it been proposed 137 points to place charging stations. By the method of multi-criteria decision making were selected a few optimal points so that charging station should be used as much as possible. Based on analysis and above mentioned method 16 points were selected as a good places to have a charging station.

The proposed layout of charging stations should be helpful while solving and planning electromobility in Košice. Also method of multicriteria decision making could be used while planning electromobility in Slovakia or other countries.

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