

LAYOUT AND DESIGN OF ELECTROMOBILE CHARGING STATIONS AS URBAN ELEMENTS

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Keywords: electromobile, charging station, urban elements, design, layout

Abstract: The contribution is dedicated to the processing of the problems of the insufficient charging for the electric vehicles within the concrete urbanistic centre. It brings a different perspective on the mobility, which is shown in the form of electric energy as the alternative for the needs of urbanization of the cities. It analyses electromobility, new technologies in the field of electric vehicles and the charging stations as the elements of the urbanism. In terms of the solution, the contribution is focused on the Košice city and the location of the public charging stations. Košice do not have sufficient amount of the public charging stations and until the 2014 there was only one public charging station. The contribution is focused on the designing of the parking places with the charging station placed on the appropriate parking places. The resulting design is created in the CAD system, it brings the view of the layout of the charging station at the shopping centre in the open space and in the parking house.

1 Introduction

This article follows the previous article titled “Analyse of electromobile charging stations for the needs of urban projection” from the 3rd issue 2015 [1].

The contribution is dedicated to the processing of the problems of the insufficient charging for the electric vehicles within the concrete urbanistic centre. It brings a different perspective on the mobility, which is shown in the form of electric energy as the alternative for the needs of urbanization of the cities. It analyses electromobility, new technologies in the field of electric vehicles and the charging stations as the elements of the urbanism. In terms of the solution, the contribution is focused on the Košice city and the location of the public charging stations.

2 Multi-criteria decision making as means to solution of charging stations allocation and layout

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 (Table 1).

Table 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

Table 2 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

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Table 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 a_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 (Table 2, Table 3 [2]). 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". Points on the map (Figure 1) 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.

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 fast-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. 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 by adapt 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.

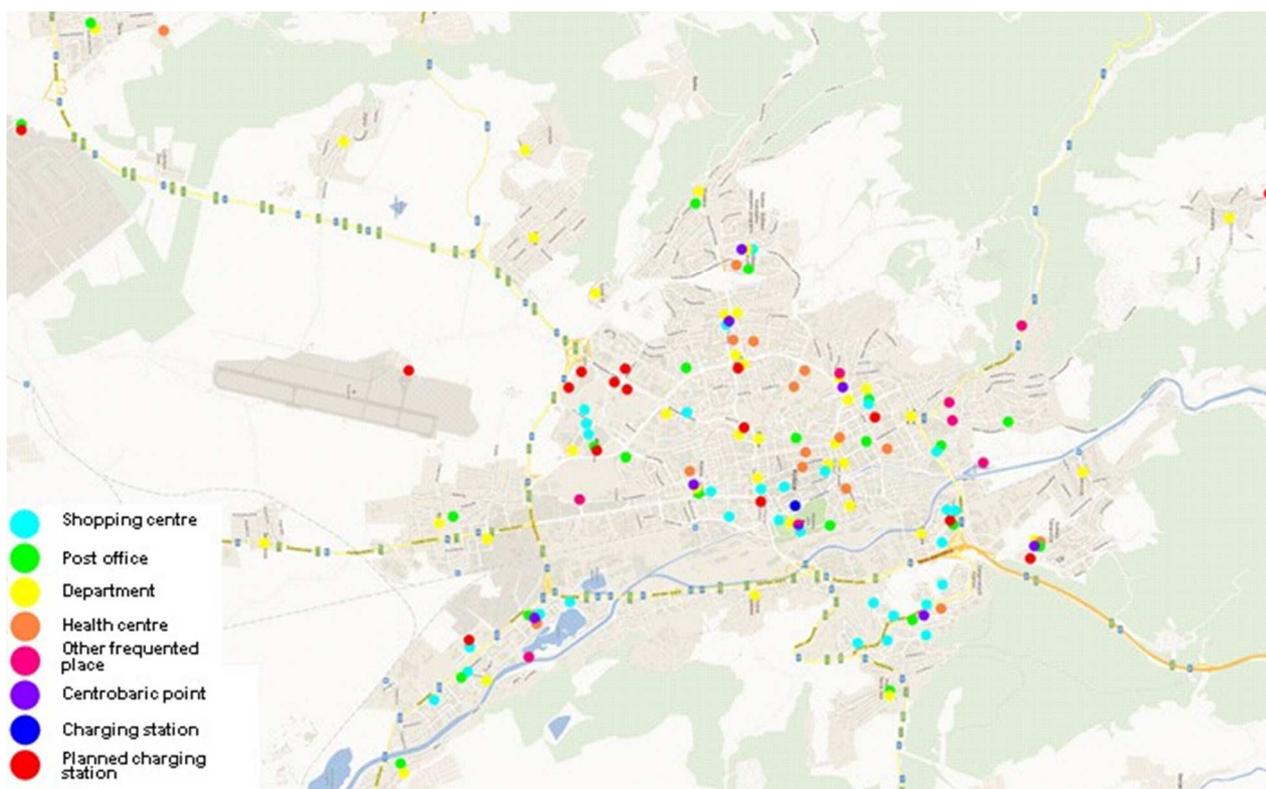


Figure 1 Marked points, layout of charging places building for electric cars in Kosice [2]

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3 Project of parking places impact on urban planning for the needs of electromobility in Košice

The parts that are appropriate for the charging stations were chosen with the help of allocation. The allocation is followed by the layout, which sets the specific distribution of the stations throughout the town districts. All 22 town districts were used for the purposes of this work, which contained 5 criteria. Potential locations for charging the electromobile were added to the criteria – shopping centres, post offices, offices, healthcare facilities, other frequent locations.

There was also applied one additional criterion – adequate size of the parking area. According to the criteria, 137 potential points for the charging stations, from which, with the help of multi-criteria decision making methods (method of pairwise comparison, Saaty method), there were chosen 16 points, that are suitable for the construction of the charging stations in the second phase of electromobility. The second phase of electromobility consists of the construction of the charging infrastructure itself.

Table 4 Positions, which are suitable for the construction of the charging station in Košice

Numbers	Positions
1	Aupark (Liberator's square)
2	Baumax (Moldavská route)
3	Hornbach (Moldavská route)
4	Hypermarket Tesco (Trolejbusová street 1)
5	Kaufland (Popradská street 92)
6	Kika (Moldavská route)
7	Letisko (Čkalovova street)
8	Metro (Americká trieda 1/A)
9	OC Cassovia (Pri Prachárni 4)
10	OC Galéria (Toryská street 5)
11	OC Optima (Moldavská street)
12	Technická univerzita v Košiciach (Letná 9)
13	Tesco (Napájadlá 16)
14	U. S. Steel (Entry areal of U. S. Steel)
15	Ice stadium of Ladislav Troják (Nerudova street 12)
16	ZOO Košice (Široká 31)

Every point is specific. There are several factors affecting every point, which all allow us to use a specific type of charging technology. Inductive charging and photovoltaic panels are a future vision in our country. There is a lack of charging stations in Košice and generally in the whole Slovakia. There are not enough classical and fast-charging stations. Therefore the choosing was narrowed down to this two charging technologies.

On some points, classical charging stations might be inadequate. The fast-charging stations are not needed on all places. Classical charging stations can be chosen

according to the initial costs. How to decide? Where to use the particular charging technology? In order to simplify the choosing between the classical and fast-charging technology, indirect multi-criteria decision making method was used, specifically the method of pairwise comparison with allowed equality of values of criteria weight.

Defined criteria:

A – initial costs - This criterion was chosen from one reason. The cost difference between classical and fast-charging station is quite big. The candidate of extending the parking area with electromobile parking places will have to decide whether he buys one fast-charging station or several classical charging stations.

B – effectivity / speed of charging – There is a difference between charging the vehicle for 4 to 5 hours and 30 to 60 minutes.

C – usability (location of the parking place) – The charging station, which is located in a underground garage will prevent the candidate from additional costs. It does not need water-proof and dust-proof facilities.

D – charging time (available activities) – It is important, that the owner of a electromobile had several options of spending his “free” time during the charging.

E – maintenance – Fast-charging station has higher maintenance costs that the classical.

4 The First Level Heading 12 pt, Left

The purpose of design of the parking places is standardization, which brings unifying of the concept of electromobility and lowering of the costs, which are needed to construct the networks of charging stations not only in Košice. Before the realization of the parking places project, it is necessary to notify SPP, VVS and the telecommunications, whether the particular place for the charging stations and the excavation works involved do not affect the projects of this companies on the particular parking area. This parking area can be situated on a vacant area or in a parking house. The design was processed for both types.

Parking places shall be designed with longitudinal, diagonal or vertical queueing of vehicles (Figure 2).

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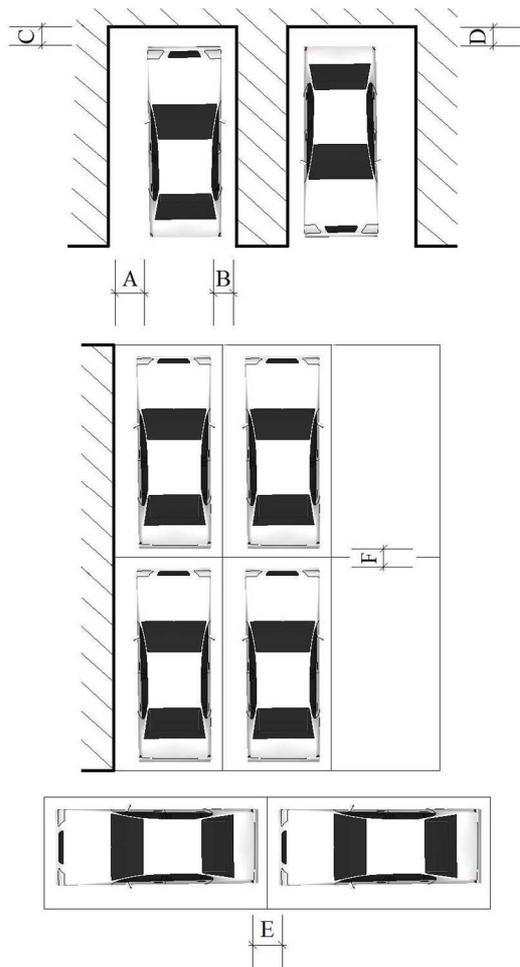


Figure 2 Parking places and their projection [3]

Outside parking areas create the base of suitable places for the allocation and layout of the charging stations in Košice. From the 16 chosen places, 14 of them is situated outside, 10 of those near shopping centres. This design is operating with the parking places for electromobiles in front of shopping centres. The area for parking places should be as close to the entrance to the shopping centre as possible. It would be a benefit for the electromobile owner and the electromobility would be visualized and brought to the awareness of people and potential customers. This allocation within the parking area is going to affect the costs, especially the costs for the excavation works and used material. According to the preview of the design, the position of electromobile parking place was at the Tesco hypermarket (Trolejbusová street 1) (Figure 3). The parking place was designed near the entrance to the shopping centre. The second phase of electromobility, – the construction of charging stations near the Tesco hypermarket counts with 4 reserved parking places and 2 charging stations [4].

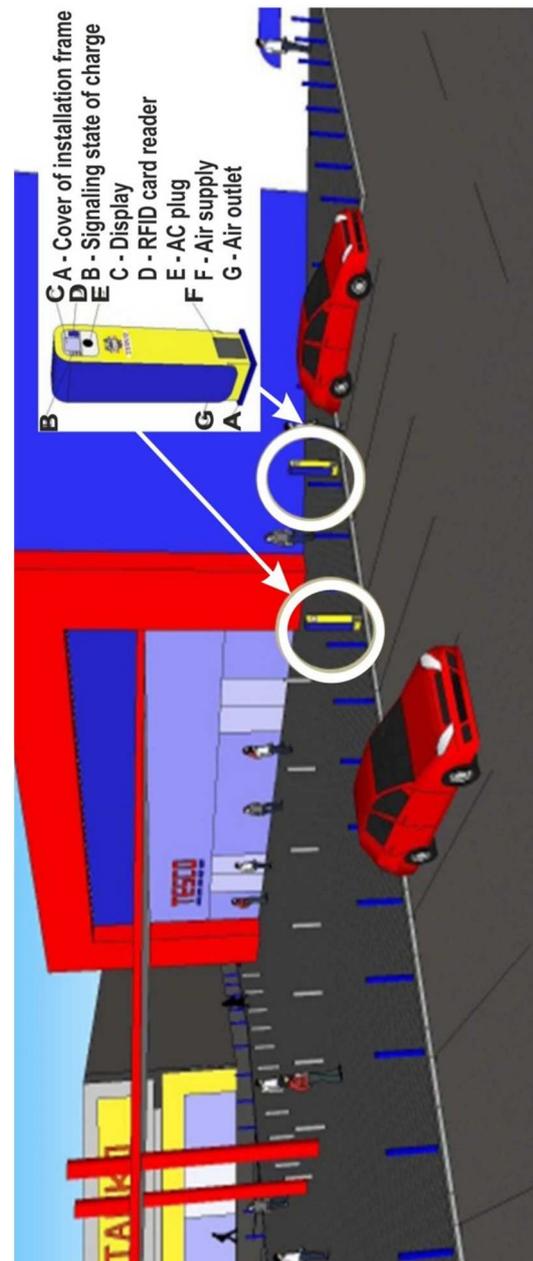


Figure 3 Location of two charging stations near the Tesco hypermarket

The excavation works will be done in thee complete length of 6.6 m (the length between the stations is 4.8 m and the length between the stations and the building is 1.8 m). The cable will be places into sand lode and marked with a foil. The whole length of the cables will be cca 20 m. The project of construction of the new parking places requires a planning permission. The documentation has to be verified in the construction proceedings. From 16 places, that were chosen, two of them are situated in a parking house (Shopping Centre Aupark, Ice stadium of Ladislav Troják). The parking house in the shopping centre Aupark is a frequent place situated near the downtown. The location of the charging station on this

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place is important and has a strategic character according to the shopping in this shopping centre and thanks to the free parking for 3 hours, the vehicle can be charged here while the owner can do all the necessary things in the downtown.

The location of the parking places should be situated close to the escalator in the first underground floor of the shopping centre. It would bring the same benefit as with the outside parking areas. The electromobility would be visualized and brought to the awareness of people and potential customers. The second phase of electromobility – the construction of charging stations near the shopping centre Aupark counts with 6 reserved parking places and 6 charging stations (Figure 4) [4]. The charging stations will be connected by a 12 m long cable (which corresponds to the length of 5 parking places). One of the charging stations will be connected to the power distribution box by a cable with a length of 20 m.

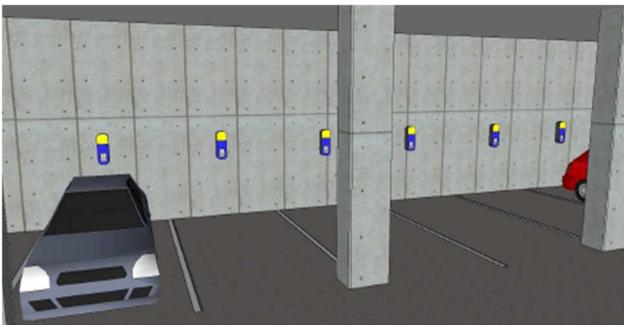


Figure 4 Location of charging stations in underground garage of a shopping centre

The parking place for charging electromobles consists of several elements (Figure 5). Classical charging station requires the area of 500 x 400 mm. This area can be calculated with the following method:

- the size of the charging station is (H x W x T): 1460 x 300 x 200 mm,
- 100 mm are required from every side.

It is necessary to take the necessary precautions in order to prevent things and weather conditions from blocking the air circulation.

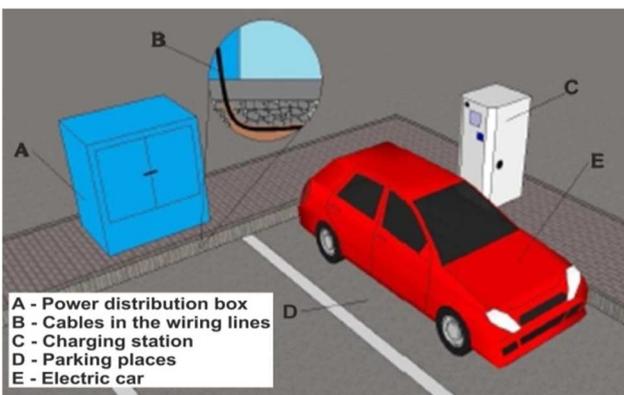


Figure 5 Design of the area for electromobile charging

Fast-charging station Terra requires the area of 1730 x 1460 mm. This area can be calculated with the following method:

- The size of the station is (H x W x T): 1900 x 760 x 525 mm,
- the front side requires an extra space of 600 mm, in order to be able to access the panel from the front side,
- left and right side require an extra space of 600 mm, in order to be able to access the panel from the left and right side,
- the back size requires an extra space of 100 mm, in order to ensure the air circulation,
- the fast-charging station has the air entrance on the right side and the air exhaust on the back size.

It is necessary to take the necessary precautions in order to prevent things and weather conditions from blocking the air circulation. Electrical installation has to be finished according to the electrotechnical security and legal rules. The cable diameter (depending on the length of the cable and the distance from the source), the way of installation is set by the supplier.

Conclusions

Space for the electric vehicles should be situated as closest to the entrance of the shopping center as it is possible. It would be a benefit for the owner of the electric vehicle and the electromobility would be visualized by such a way and would be brought to the awareness of the people and potential customers. This allocation, within the parking place, will have the impact on the costs, concretely on the excavation works and the material used. The result of the project of the parking places is the standardization, which will unify the conception of the electromobility and the reducing of the costs needed for construction of the charging station networks in the Košice.

Parking places for the electric vehicles were variant designed on the free spaces and in the parking houses based on the analysis and there was designed graphical design of the charging stations. The work brought another view to the mobility, which is shown in the form of the electric energy, analyses the electromobility, new technologies in the field of the electric vehicles and the charging stations, thereby it meets the goal to inform, to get the electromobility into the awareness of the wide public. Based on the five criteria the appropriate technology of charging was selected with the form of a classical charging station or fast-charging station with the help of the pairwise comparison method. The location of the charging stations was previewed with the form of a graphical design. The projecting of the location of the charging stations designed within this article might help by the creation and projecting of the electromobility not only in Košice or Slovakia.

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Acknowledgement

Publication has been created with the support of VEGA grant agency, in the framework of grant task VEGA 1/0036/12 “Methods development and new approaches to design of input, interoperable and output warehouses and their location in mining, metallurgy and building industries“ and grant task VEGA 1/0216/2013 “Methods and new approaches study to measurement, evaluation and diagnostic performance of business processes in the context of logistics management company”.

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Review process

Single-blind peer reviewed process by two reviewers.