

The foundation, methods and infrastructure proposal for electric vehicle charging stations in Bosnia and Herzegovina

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By focusing on the environmental resources and the exploitation of renewable energy sources, an analysis and description have been made concerning the basis and model for the construction of electrical cars, including the proposed infrastructure for electrical vehicle charging stations in Bosnia and Herzegovina. Keywords: ecology, electric vehicles, renewable energy sources, infrastructure, "green energy".

Introduction

An electric car is an automobile that is propelled by an electric motor, using electrical energy stored in the accumulator or another energy storage device.

They were popular at the end of the 19th, and the beginning of the 20th century. In the middle of the year 2000, the interest in electric car manufacturing renewed, mainly due to a concern about rapidly increasing oil prices. So, since September 2011, the models of serial production, available in some countries are: Tesla Roadster, REVAi, Buddy, Mitsubishi i-MiEV, Nissan Leaf, Smart ED and Wheego Whip LiFe.

Although they are more expensive in relation to conventional ones, the advantages of electric cars include a considerably lower level of air pollution in the cities, a lower greenhouse gas emissions, and they require considerably smaller investments and efforts in the development of the charging infrastructure.

Electric cars charging stations

In this chapter, the main features necessary for the existence of an electric car charging station are described.

Electric cars charging station models

There are four different ways of charging electric cars for which it is necessary to provide an appropriate infrastructure:

Model 1: A socket with an extension cord An electric car is connected to an electrical network (AC voltage, single-phase or three-phase 16A rated current) by a standardized connector and live lead, neutral wire and grounding.

Model 2: A socket and cable with a protection device. An electric car is connected to an electrical network (AC voltage, single-phase or three-phase 32A rated current) by a standardized connector and live lead, neutral wire and grounding, together with a signal line between the electric car and the socket.

Model 3: A specific socket on a dedicated circuit A direct connection between the electric car and the electrical network (AC voltage, single-phase or three-phase), established by using special equipment for the electric car power supply.

Model 4: Direct current (DC) connection for fast recharging An indirect connection of an electric car to an electrical network (AC voltage) established by

using an electric car charger where the signal line comes to the equipment permanently connected to the alternating network.

Modes 1 and 2 represent slow ways of charging and they serve for household sockets. Mode 3 supports both slow and fast ways of charging (depending on the rated current) and we need special equipment for it. Mode 4 represents a fast way of charging.

Electric vehicle charging time

A fully charged electric vehicle battery, produced by electric vehicle automakers (such as Nissan), has the capacity of about 20 kWh, providing it with an electrical autonomy of about 100 miles. Since February 2016, there are two models; a 70 kWh and a 90 kWh battery. Manufacturers have chosen two solutions for faster charging (a 22 kW, and even 43 kW and higher):

- Use the vehicle's built-in charger, designed to charge from 3 to 43 kW at a 230 V single-phase or a 400 V three-phase.
- Use an external charger, which converts AC current into DC current and charges the vehicle at 50 kW (e.g. Nissan Leaf) or higher (e.g. 120-135 kW Tesla Model S).

Table I. Charging

Charging time for 100 km	Power supply	Power	Voltage	Max. current
6-8 hours	Single phase	3.3 kW	230 V AC	16 A
3-4 hours	Single phase	7.4 kW	230 V AC	32 A
2-3 hours	Three phase	10 kW	400 V AC	16 A
1-2 hours	Three phase	22 kW	400 V AC	32 A
20-30 hours	Three phase	43 kW	400 V AC	63 A
20-30 minutes	Direct current	50 kW	400-500 V DC	100-125 A
10 minutes	Direct current	120 kW	300-500 V DC	300-350 A

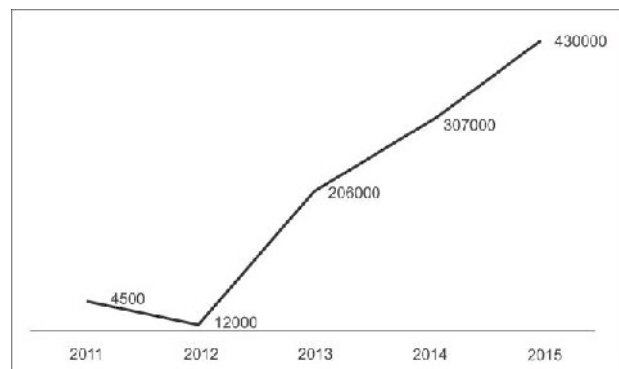
Charging station types

As the charging station types we can classify stations for fast charging within 30 minutes, stations with a medium charging speed that lasts 3 hours and household charging stations that enable car charging within 6 to 8 hours. Apart from the listed, we will mention:

- stations for battery swapping and
- solar stations

Electric cars charging stations in the world

In comparison with conventional cars, the number of electric cars in the world is very small. Less than 1% of the total car number belongs to the group of electric ones, but it is important to emphasize that a growth trend is recorded in that field. According to the data acquired by statistical agencies in September 2015, the number of electric cars, found in the world streets, exceeded one million. Also, a larger growth trend in the number of electric cars is expected in the future. According to the predictions, in 2030, the number of electric cars in the world should be 10.5% of the total car number. Based on this, we can conclude that there should be over 210 million electric cars found on the roads all around the world in 2035.



Picture 1. Number of new sold electric cars by years (total 1 million-December 2015)

In terms of electric cars, as a characteristic country in the world, among others, we can say that China possesses the biggest complex for electric cars charging points, built in Beijing. It is spread over 26500 square meters and has 30 places in total which provide a possibility of fast charging. Besides China, we will emphasize Estonia as the first European country which had the entire country area

covered with car charging stations, and Japan, as the first country with more electric than petrol car charging stations. It is needless to say anything about the network and connection of the charging stations. Only fast charging stations are shown in the picture below.



Picture 2. Electric car charging stations in Japan

In Europe, an improvement in this field is reflected in the plan that the number of cars, using conventional fuels, will be halved by 2030 in the cities, and that, by 2050, these cars will be completely replaced by electric ones.

The problem occurred during the creation of universal rules, mostly for connectors that will be used. However, the standard according to which, until December 2015, all European stations for electric car charging must use the so called Type 2 connector, is adopted.

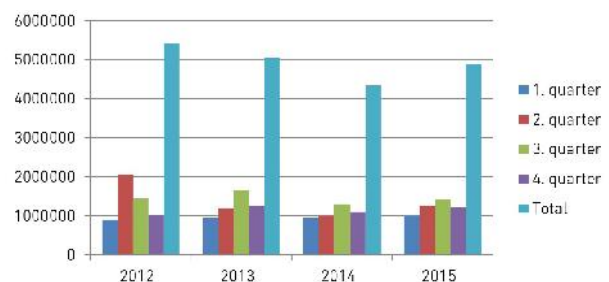


Picture 3. Type 2 connector

Electric cars and charging stations in Bosnia and Herzegovina

Although the concept of electric cars, and therefore charging stations of the same, is unknown in our region, taking into consideration the given and the data of the world statistical agencies, we can conclude that by 2035 we will have over 100 000 electrically operated cars on the roads.

Beside this, it should be emphasized that, due to its geographical location, Bosnia and Herzegovina is a transit country. Even if the concept of electric cars does not take hold, we must be aware of the fact that people who use Bosnia and Herzegovina as a transit country or those who come to Bosnia and Herzegovina as tourists have a need for electric car charging stations.



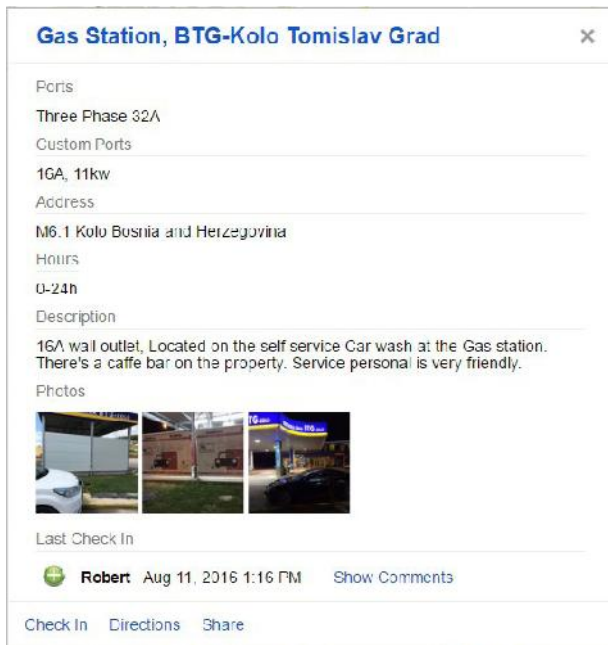
Graph 1. Number of foreign cars in Bosnia and Herzegovina (transit and tourists)

On the graph we can see that, according to the statistical agency, about 5 million foreign cars annually go through Bosnia.

According to all predictions, this number will grow since tourism just begins to take hold in Bosnia, but if we view it as constant, we still see that from the 5 million cars, in 2035, 500000 should be electric ones.

A very small number of electric cars can be seen in Bosnia today. One of the main reasons for this is the lack of charging stations. The information that proves it is that in Bosnia there is just one electric car charging station. It is placed in Tomislavgrad.

Based on the prediction about the development and a potential number of electric cars in the world, and therefore in Bosnia (stated in the previous text), a much higher number of charging stations is necessary.



Picture 4. Electric car charging station in Bosnia and Herzegovina- Tomislavgrad

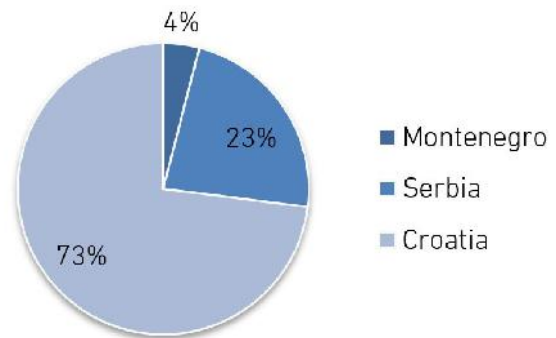
Infrastructure proposal for electric car charging stations in Bosnia

In this work, we decided to make a proposal for allocating electric car charging stations on the territory of Bosnia and Herzegovina. We will primarily focus on the stations the population, for whom Bosnia is a transit country, will use. In the second part, we will give the proposal for allocating particular charging station infrastructure that might be useful to all Bosnian residents. We will also propose to introduce a system of owning electric car charging stations with a three-phase connector, as well as building private solar stations for electric car charging by which we would get 100% "green" effect with 0% pollution in our country.

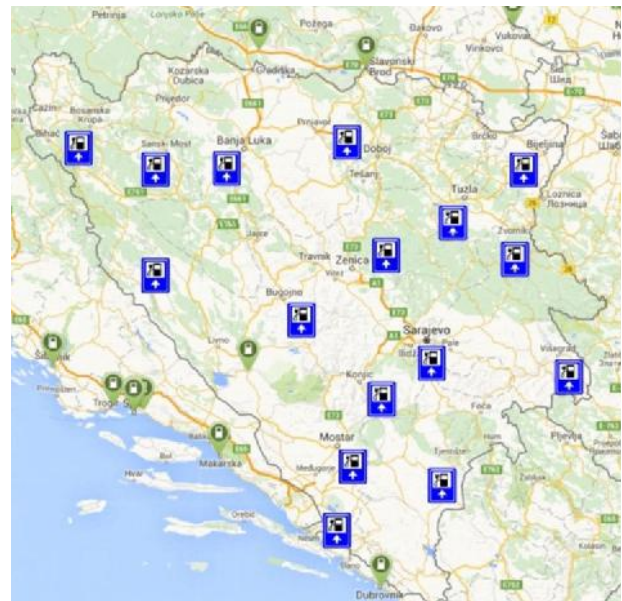
The transit network

Based on the charging stations in the region and alignment through Bosnia as well as planned alignments in development, we made a proposal of allocating electric car charging stations for cars that go through Bosnia, i.e. cars that use Bosnia and Herzegovina as a transit network. Therefore, our infrastructure would cover the whole area of Bosnia

and Herzegovina. We took into consideration the geographical position, as well as tourist locations and resorts so that people who pass by have a more pleasant stay and can spend quality time that is necessary for charging the car. The next chart shows, in percentages, the direction cars will take when travelling from Bosnia.



Graph 2. Travel directions of the cars from Bosnia and Herzegovina



Picture 5. Infrastructure proposal for electric car charging stations in Bosnia

Picture 5 shows a plan for building 16 new electric car charging stations. The stations are allocated so that they cover transit places, but also the whole territory of Bosnia and Herzegovina near town locations or border crossing, so that users can make the most of the time needed for charging car batteries to visit certain tourist attractions or simply use the time to rest in a town. The stations can be built within the already existing petrol stations, or

they can be individual stations with resorts. These stations would be listed in applications which show the locations and charging stations accessibility, and users could access them through different devices (computer, phone...) In the table, red colour shows the distance between two closest stations.

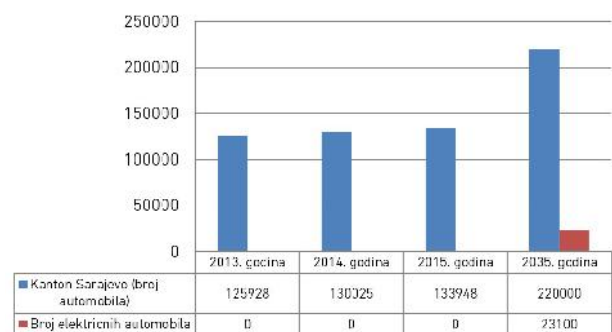
Keeping in mind that the electric car movement radius is in average 130 kilometres, it is taken into account, so in the table we see that the distance between the nearest stations does not go over 130 km, no matter the direction you take.

Table 2. Distance display in km between planned stations for electric car charging

	Banja Luka	Bihać	Bijeljina	Bos. Grahovo	Bugojno	Doboj	Gacko	Konjic	Mostar	Neum	Sanski Most	Sarajevo	Tomislavgrad	Tuzla	Višegrad	Zenica	Zvornik
Banja Luka		153	221	164	116	98	316	207	232	308	63	188	161	158	301	128	207
Bihać	153		362	112	196	239	390	288	303	363	120	307	224	299	419	246	348
Bijeljina	221	362		382	262	131	275	236	304	387	294	178	324	70	180	191	54
Bos. Grahovo	164	112	382		141	261	280	200	192	253	123	262	113	321	375	202	392
Bugojno	116	196	262	141		162	203	91	116	220	138	121	60	196	234	61	251
Doboj	98	239	131	261	162		287	202	270	353	171	159	222	71	272	91	120
Gacko	316	390	275	280	203	287		114	88	127	341	132	173	248	133	196	222
Konjic	207	288	236	200	91	202	114		69	152	230	60	84	165	174	111	195
Mostar	232	303	304	192	116	270	88	69		84	261	129	85	234	221	180	264
Neum	308	363	387	253	220	353	127	152	84		322	212	146	317	256	263	346
Sanski Most	63	120	294	123	138	171	341	230	261	322		249	175	231	361	188	280
Sarajevo	188	307	178	262	121	159	132	60	129	212	249		145	121	113	69	124
Tomislavgrad	161	224	324	113	60	222	173	84	85	146	175	145		256	258	121	279
Tuzla	158	299	70	321	196	71	248	165	234	317	231	121	256		171	140	47
Višegrad	301	419	180	375	234	272	133	174	221	256	361	113	258	171		182	126
Zenica	128	246	191	202	61	91	196	111	180	263	188	69	121	140	182		161
Zvornik	207	348	54	392	251	120	222	195	264	346	280	124	279	47	126	161	

Detailed network

By the time a lot of the residents of Bosnia and Herzegovina start using electric cars, a network should become more complex and every town should have public charging stations. Ultimately, the network, or electric car charging station infrastructure in Bosnia and Herzegovina should look at least as close to those in the European countries. On the basis of BIHAMK data about the number of registered cars in the area of Sarajevo Canton, an annual growth trend of about 3% is noticed, so we can assume the number of cars in Sarajevo Canton in 2035 will be around 220000. In comparison with the growth trend at world level, i.e. an increase in the number of cars by 2035, we conclude that there should be over 23000 electric cars in Sarajevo Canton. By this, we mean the ownership of private electric cars.



Graph 3. Growth trend of car number in Canton Sarajevo

In order to run smoothly, a much larger number of charging stations is necessary. In the next picture, the picture of Sarajevo city is represented together with a potential placement of electric car charging stations. They are necessary in order to satisfy the

needs of the population that primarily come from other cities, or the population that passes through, but also the needs of the local residents.



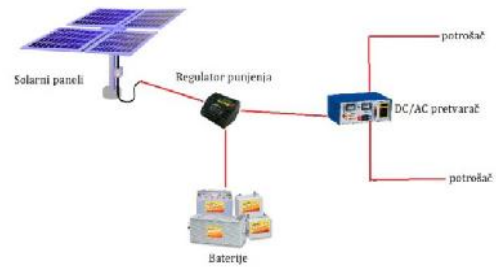
Picture 6. Proposed infrastructure of electric car charging stations in city of Sarajevo

A proposal of a private electric car charging system

Although it is considered that electric cars do not pollute the environment, that claim is not established in general.

The term known as "Well to Wheel" shows us that electric cars, indirectly, pollute the environment. An indirect way of polluting is reflected in the fact that they use electrical energy produced in objects that pollute the environment such as thermal and nuclear power plants.

In order to make our cars 100% "green", cars with 0% pollution, we propose building private solar charging stations.



Picture 7. An overview of solar system for charging

By a simple calculation, on the basis of the installed equipment technical data in the solar system, we can acquire information that an average user in our area needs an approximate surface of 55 square meters of solar panels to charge a battery of an average electric car.

Conclusion

In accordance with these conclusions, it is necessary to awaken citizen consciousness as well as the authorities in Bosnia and Herzegovina, so that electric cars find their place in our area. A European project "Transport 2050" shows us that, in the next 15 years, the whole of Europe is going to reduce the number of cars that use fossil fuels by 50%, and that electric cars are going to take their place. If we want to keep up with Europe, we must seriously dedicate ourselves to solving this problem. Taking into consideration our advantageous geographical position, electric car charging stations will decide if we will still be a transit European country, or a country that everyone will give a wide berth.

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References

1. http://www.bhas.ba/index.php?option=com_publikacija&view=publikacija_pregled&ids=5&id=22&n=Saobra
2. <https://bihamk.ba/dokumenti/statistike/registrovana%20vozila%2014%20new.pdf>
3. <http://www.solarno.hr/katalog/proizvod/TEKST6/elektricna-vozila-stanice-za-punjenje>
4. <http://www.chargepoint.com/>
5. <http://evobsession.com/electric-car-charging-101-types-of-charging-apps-more/>
6. http://web.mit.edu/evt/EVT2009_IAP_C_lass_Day1.pdf
7. https://www.iea.org/publications/global_outlook_2013.pdf

8. http://www.afdc.energy.gov/fuels/electricity_locations.html
 9. <http://www.plugshare.com/>
 10. <http://www.geindustrial.com/products/electric-vehicle-charging-stations>
 11. <http://re.jrc.ec.europa.eu/pvgis/apps4/pvest.php#>
 12. <http://www.gayot.com/lifestyle/auto-mobile/lists/electric-cars/fiat-500e.html>
 13. http://ec.europa.eu/transport/themes/strategies/consultations/doc/2009_03_27_future_of_transport/20090408_eabev_scientific_study.pdf
 14. https://en.wikipedia.org/wiki/Electric_car_use_by_country
 15. https://en.wikipedia.org/wiki/Electric_car_use_by_country
 16. <http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-1996-15.pdf>
 17. https://en.wikipedia.org/wiki/Charging_station
 18. <http://www.afdc.energy.gov/pdfs>
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Osnova, metode i prijedlog infrastrukture punionica električnih automobila u Bosni i Hercegovini

SAŽETAK

Fokusirajući se na ekološke resurse i iskorištavanje obnovljivih izvora energije zbog smanjenja emisije štetnih gasova, analizirani su i opisani osnova električnih automobila, modeli izgradnje, te prijedlog infrastrukture stanica za punjenje električnih automobila na području BiH.

Ključne riječi: ekologija, električni automobili, obnovljivi izvori energije, infrastruktura, "zelena energija".