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ELECTROMOBILITY IN THE SLOVAK REPUBLIC: A GREEN APPROACH

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Abstract: Nowadays, influenced by technology and new technologies in the automotive industry is increasingly experiencing the production of electric or hybrid cars. With the development of the automotive industry, the number of electromobiles operated is increasing. Electricity in the world is steadily growing. Several countries in the world are evolving forward in electromobility, dealing with alternative drive policies and applying it to transport strategies. The Slovak Republic does not develop sufficiently in electromobility as it lags behind the surrounding countries. Electromobiles in operation do not eliminate CO and CO2, which means they are more environmentally friendly.

1 Introduction

The development of electromobility in the Slovak Republic began in 19th century. In this century, at the Royal Academy in Bratislava, Professor of Physics and priest Anián Jedlik worked [1]. This physicist, in the years 1827-1829, first invented the electric motor model and, of course, demonstrably participated in the development of cars powered by electric power. In 1842, Anián Jedlik dealt with the construction of accumulators and galvanic cells and used the electromobiles to drive the cart on the rails. With the development of a power-driven car, the MicroEko project started in 1994 in Slovakia. Thanks to this development, an electromobile was created, which won the Gold Medal in Brno at the engineering fair and fulfilled the conditions for production. Its production was never started and it was the end of the first Slovak electric car. After 2010, mass production electromobility in Slovakia begin to be introduced. Volkswagen Automobile company, just to Bratislava, placed the production of the first serially produced electrictromobile [1,2].

The Slovak Republic belongs to the list of countries with the highest production of cars. Regularly, the highest number of vehicles produced per capita is achieved.

In addition to direct producers, the automotive industry in Slovakia is formed by several subcontractors, involved in employment. The Slovak Republic must keep up with the evolving trends in the automotive industry in order to maintain its position. The application of electromobility has a positive impact on the quality of life and a significant reduction in emissions and noise emanating from transport. The Slovak energy system produces electricity with the lowest CO_2 emission factor, which means that the benefits of electromobility would reduce emissions today [3]. The Slovak Republic should turn the current undeveloped electromobility to make the country a regional leader. This situation is based on the automotive industry system, on economic and social demands and on economic growth. In 2012, an association called Slovak Electric Vehicle Association (SEVA) was established in Bratislava [3,4]. The main priority for this association is the promotion and representation of transport infrastructure and the development of transport for electric vehicles in Slovakia. Their goal is to create an appropriate communication and partnership with foreign partners, public authorities and businesses involved in the preparation of documents and plans for the development of electromobility.

2 Charging stations for electromobiles

Prosperous charging stations create special needs for the integration of charging connectors, plugs and their placement in electric cars. In countries, the voltage and current characteristics are individually determined to determine the type of charging stations associated with the charging time of an electric car [1].

The charger is built-in electromobile or external. This unit is connected to the battery system during charging and recharges the vehicle's battery. Recharging of electric cars is governed by IEC 61851: 2001, it is actually charging electric cars via conducting an electric car, cable, with a power grid [2].

There are three ways to place the connectors that are used to connect an electric car with the charging station, which include them [4]:

- the connector is located only on the side of the station, the cable is fixed with the electric car charging unit (Fig.1 - 1a),
- the connectors are located on both sides of the cable (Fig.1-1b),
- the connector is only becoming electromobile, the cable is fixed with the charging station (Fig.1- 1c) [3].

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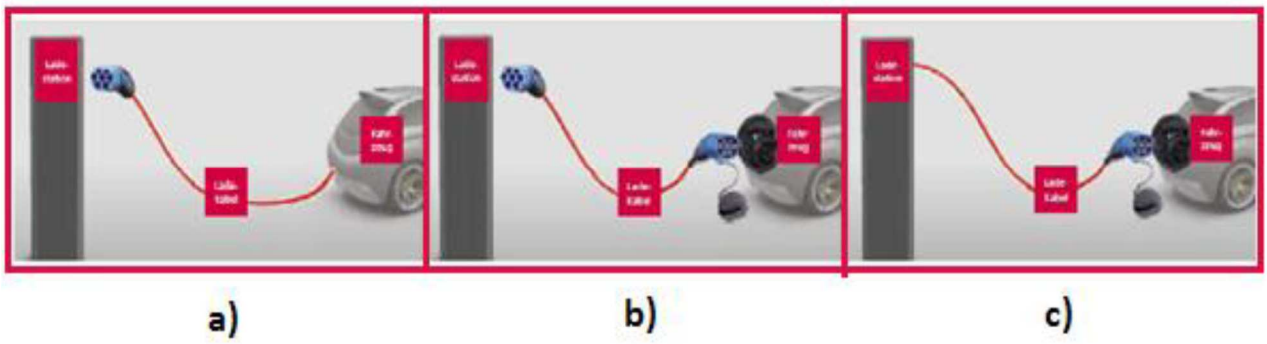

Figure 1 Connector location concept [1]

2.1 Sharing of charging stations according to the charging system

Accumulator batteries are usually charged with DC (Direct Current) but also AC (Alternating Current), which changes to DC while charging. Charging stations, according to the type and size of the current, are distinguished by [1,3]:

- AC Slow Charging:
  - ✓ It is a slow charging, alternating single phase (three-phase) current, 16 A (32 A),
  - ✓ it is usually used for home charging with a time of 5 to 8 hours,
  - ✓ the cost of operating such a charging station is relatively low.

- AC Fast Charging:
  - ✓ It is a fast charging, alternating current, with a value of 32 to 64 A,
  - ✓ is usually 2 to 4 times faster than slow charging.

- DC Slow Charging:
  - ✓ it is slow charging,
  - ✓ The charging power is 38 kW and 80 A DC.

- DC Fast Charging:
  - ✓ it is fast charging with a direct current,
  - ✓ The charging unit that is built into the station has a power output of 50 to 250 kW,
  - ✓ Electric car charging takes approximately 15 to 30 minutes,
  - ✓ Operating costs are higher than for DC charging stations [1].

AC chargers up to 22 kW are only connectors that transfer the current to the charger in the electric vehicle. In this case, the chargers are in the vehicle, i.e. on-board chargers. In the charger, this is located in the electric car, the alternating current changes to DC and is transferred to the rechargeable battery [1].

DC charging stations above 22 kW are chargers, from which the DC current is no longer transferred to the on-board charger but directly to the rechargeable battery. Mostly they have a power of 44 to 50 kW. These fast charging stations include the Supercharger Tesla super charger, the CHAdeMO fast charging station, and the news includes Combo Charging System Combo - CCS (Combined Charging System) [2].

3 Rechargeable infrastructure in the Slovak Republic

In the Slovak Republic, various pilot projects supported by the state are also being developed, which deal with the rechargeable infrastructure for electric vehicles. One of these projects is the VIBRATe project – BRATislava e-mobility Mobility. The main objective of this project is to build a charging infrastructure for charging stations between Bratislava and Vienna. Fast charging stations are built in the car parks in front of shopping malls, making this link to the highlights an ecological character. This project has so far not achieved much success, as it has been anticipated, since in 2014 only 119 electric vehicles were registered in the Slovak Republic [5].

For the development of electromobility, the following three parts are considered to be essential for achieving the objectives [6].

These basic pillars include:

- Public transport - Temporary financial and non-financial support from public institutions and governments is needed to reduce the risks of customers purchasing electric cars. Such support should take the form of financial subsidies or some tax exemptions. The automotive industry and the national government should strive to improve customer awareness, remove barriers to entry for new customers, adjust the area for reducing greenhouse gas emissions from transport, and set stricter CO_2 emission standards. These are all conditions for investment in electromobility in the Slovak Republic [2].

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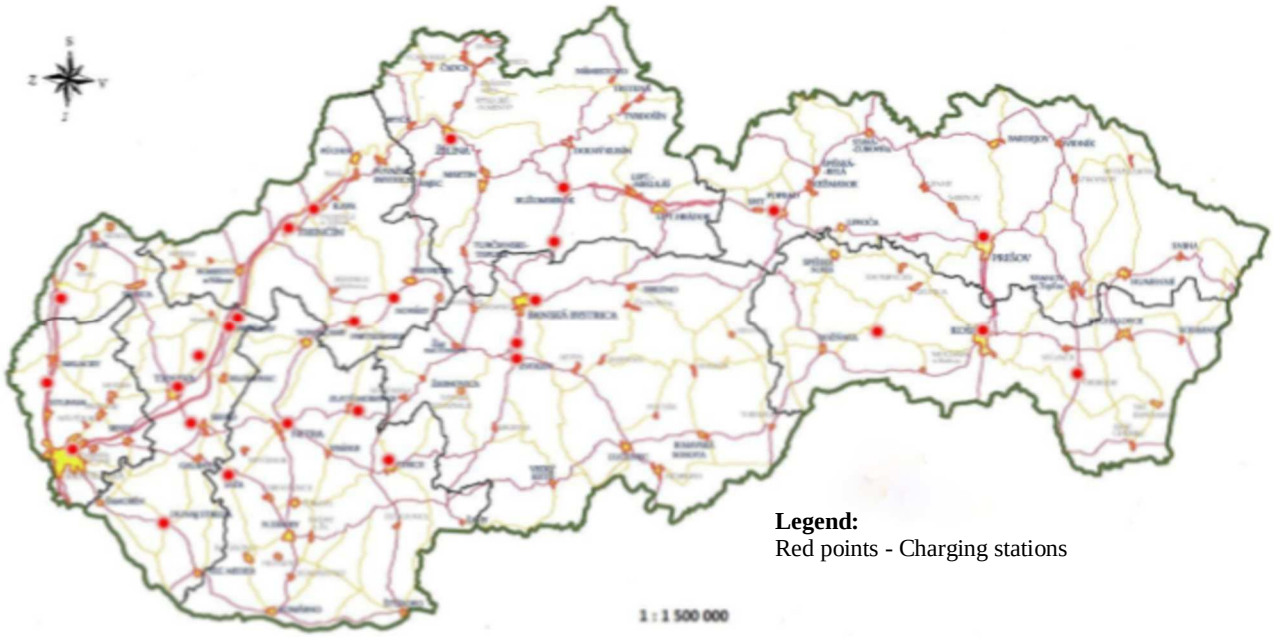

Figure 2 Charging stations in Slovak republic (high speed charging stations infrastructures including) [3]

In the Slovak Republic there are charging stations of various power and voltages. A network of fast charging stations, as well as slow-charge alternating current charging stations, is being created in the territory. These stations are 22 kW and a 32 A charging current. It cannot be built in any part of the country by the station and by high performance, but only in the places where the distribution network allows it. Fast charging stations need high power, for example, four charging stands from Tesla Motors require an input of approximately 265 kW. Because of this, Tesla Motors builds its own transformer stations, which they use to operate their charging stations. At higher power charging stations, an electric car is charging much faster than at a low-power station. Therefore, electric car owners use more power charging stations because they do not want to wait a few hours while charging at a slow charging station [1].

About 80 to 100 public and non-public charging stations are located in Slovakia. An average electric vehicle is 180 km, charging slowly in 11 to 13 hours, and charging at a fast charging station in about 15 to 20 minutes at 80% capacity. Fast charging stations are mostly located near highways, shopping centres and restaurants. Some stations, such as the fast charger in Partizánske, are only used to charge taxis. Public AC charging stations are less, because more chargers are used more quickly due to the charging rate. Slovakia is the second country in Europe through which the electric car can go across the territory. The following figure (Figure 3) shows the map of the Slovak Republic showing the locations where the public charging stations are located [3]. Charging station locations are color-coded according to their performance. Red points indicate fast charging stations with a power output of 44 to 50 kW. Blue points feature public AC charging stations with a power of 22 kW. The green dot with a colour ring indicates a charging station where you do not have to stay in order to charge, so it is a public charging station and the colour of the ring means what kind of charging it is. The black dot indicates the Supercharger Zvolen. It is the only Tesla Motors charging station in Slovakia. The light blue points on the map indicate charging stations with a power of 11 kW or less and are secured with a type 2 connector. Presented white points are for 16 A, 32 A sockets or home sockets.

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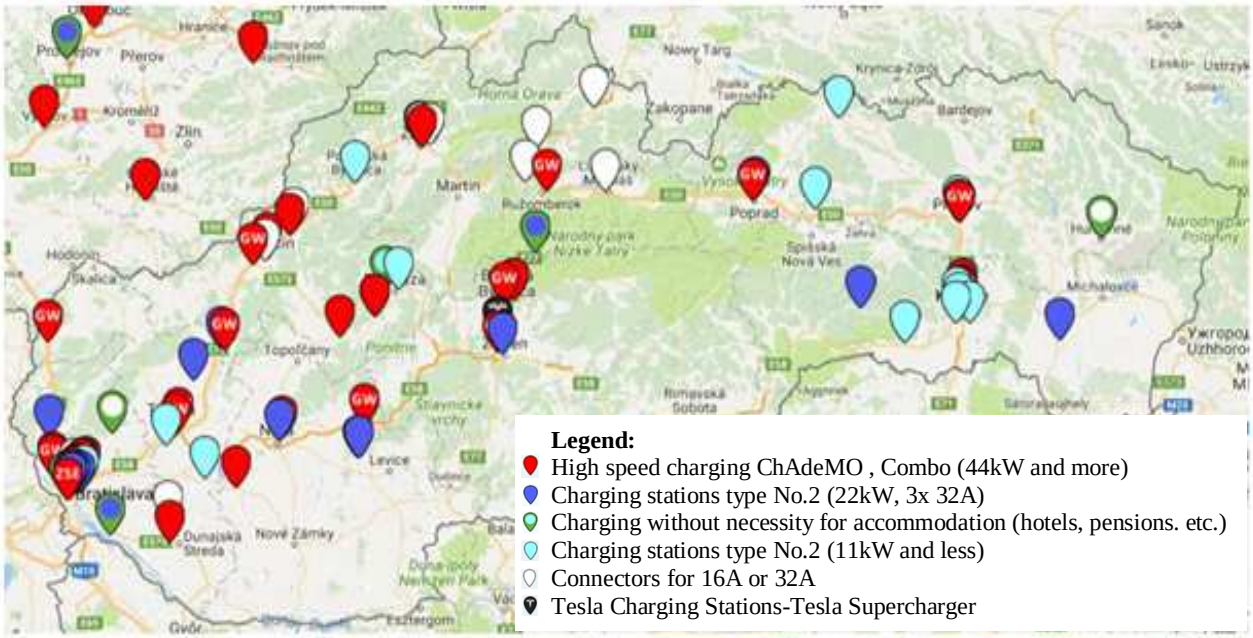

Figure 3 Charging stations situation in the Slovak republic [3]

There are different charging station operators in Slovakia, whether they provide public or non-public charging of electric vehicles. The network of fast charging stations is mainly provided by GreenWay. The list of major charging station operators is shown in the following table (Table 1). Operators are mainly divided according to the charging identification used to ensure charging performance and speed, as well as access. Table 1 describes overview of charging station operators in Slovak republic [6]. The Government of the Slovak Republic does not yet provide any benefits to the owners of electric vehicles. The Ministry of Economy of the Slovak Republic plans to implement a strategy to support electromobility. The main priority of this strategy is to promote the sale of vehicles, forgiveness of road tax and toll roads or to favour parking [2]. This support is intended to attract more low-emission, greener cars.

Table 1 Charging stations operators in Slovak republic [3]

Charging stations operators	GreenWay	Východoslovenská energetika-RWE	Západoslovenská energetika	Slovenské elektrárne	Tesla Motors
Parameter					
Capacity	44 kW	22kW	50 kW	44 kW	135 kW
Charging speed	more as 200 km/h	108 km/h	224 km/h	200 km/h	490 km/h
Connection	only for identified persons	all users	card	all users	only for Tesla
Identification	card	none	card	RFID	none
Price	fee including	for free	for free	for free	for free

4 Advantages of electric vehicles

The advantages of electric vehicles are:

- Compatible torque characteristics of the drive, due to the higher torque that acts from zero revolutions,
- The electric motor has a high performance in a wide range.
- Electricity production to drive an off-road electric car, use of renewable energy sources, the use of solar panels on the roof of the charging station to produce the energy needed to recharge the electric vehicle while reducing the dependence of the country on the import of the oil, [1,3].

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- Do not pollute the environment, thanks to zero emissions.
- The efficiency of the combustion piston engine (n = 35%) is lower than the efficiency of an electric car (> 90%), the electric car does not shrink when power is used to drive a car [4].
- Virtually no maintenance costs (no emissions on MOT, no oil change required).
- An electromotor does not require as much space as a combustion engine in a classic car.
- A part of the electric car is a sound generator due to the low operating noise that mimics the sound of the classic engine and thus serves as a warning for pedestrians to have electric cars in their vicinity.
- The cost of production and the weight of a car are reduced due to the lack of a multi-stage gearbox and a clutch coupling [5,7].

5 Conclusions

The creation of recharging infrastructure, for electric vehicles, has a very positive impact on society, not only by changing the concept of car transport but also by bringing it together with nature.

The basic advantages of electric vehicles are:

- the low transport costs and the environmental benefits of using renewable energy sources,
- reducing noise, emissions and dust particles.

A prerequisite for a significant reduction in the price of electric cars is that such vehicles are produced in series. According to research of the development of electromobility in the Slovak republic it can be constant:

- Lack of development in the surrounding countries.
- Cost-oriented economy at the expense of quality.
- Inadequately developed research and development, inadequate foundation of the automotive industry.
- The lack of greening and new solutions, the undeveloped infrastructure for charging electric vehicles.
- The harmonization of standards.

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