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BACHELOR'S THESIS

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ÚSTAV JAZYKŮ

ELECTRIC CARS AS THE ECOLOGICAL FUTURE OF TRANSPORT

ELEKTROMOBILY JAKO EKOLOGICKÁ BUDOUCNOST DOPRAVY

BACHELOR'S THESIS
BAKALÁŘSKÁ PRÁCE

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Emadi, A. (2017). Advanced electric drive vehicles. Boca Raton: CRC Press, Taylor & Francis Group.

Mom, G. (2013). Electric vehicle: technology and expectations in the automobile age. Baltimore: Johns Hopkins University Press.

Serra, J. V. F. (2012). Electric vehicles: technology, policy and commercial development. London: Routledge.

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Abstrakt

Cílem této práce je popsat elektrické dopravní prostředky s ohledem na jejich vliv na životní prostředí v porovnání s běžnými dopravními prostředky. V úvodu práce porovnává běžná auta a elektromobily a jejich vliv na životní prostředí. Další dvě kapitoly popisují historii elektromobilu a jeho principy. Čtvrtá kapitola pojednává o několika typech elektromobilů a popisuje jejich vlastnosti. Další tři kapitoly povídají o šetrnosti k životnímu prostředí elektrických vozidel, o jejich ekologických metodách nabíjení a recyklačních metodách použitých baterií. V následující kapitole popisují různé dopravní prostředky a jejich vlastnosti. Závěrečná kapitola vysvětluje budoucnost elektrických vozidel a možné koncepty pro zlepšení.

Klíčova slova

Elektromobily, ekologie, baterie, nabíječka, motor, budoucnost.

Abstract

The goal of this bachelor thesis is to describe electrical means of transport with regard to their impact on the environment in comparison with conventional means of transport. The introduction compares gasoline cars and electric vehicles and their impact on the environment. The next two chapters describe the history of the electric vehicle and the principle of the electric vehicle. The fourth chapter discusses several types of electric vehicles and describes their properties. The next three chapters discuss the environmental friendliness of electric vehicles, their environmentally friendly charging methods, and recycling methods for used batteries. The next chapter discusses public electric. The final chapter describes the future of electric vehicles and possible concepts for improvement.

Keywords

Electric vehicles, ecology, battery, charger, vehicle, future.

Bibliographic citation

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Prohlášení

Prohlašuji, že svou bakalářskou práci na téma Elektromobily jako ekologická budoucnost dopravy jsem vypracovala samostatně pod vedením vedoucího bakalářské práce a s použitím odborné literatury a dalších informačních zdrojů, které jsou všechny citovány v práci a uvedeny v seznamu literatury na konci práce. Jako autorka uvedené bakalářské práce dále prohlašuji, že v souvislosti s vytvořením této bakalářské práce jsem neporušila autorská práva třetích osob, zejména jsem nezasáhla nedovoleným způsobem do cizích autorských práv osobnostních a jsem si plně vědom následků porušení ustanovení § 11 a následujících autorského zákona č. 121/2000 Sb., včetně možných trestněprávních důsledků vyplývajících z ustanovení § 152 trestního zákona č. 140/1961 Sb.

V Brně dne..... .....

Alexandra Mironova

Poděkovaní

Dovolte mi prosím poděkovat paní Mgr. Janě Jaškové, Ph.D. za vedení bakalářské práce a cenné rady při jeji vypracování. Dále bych chtěla poděkovat své rodině za podporu během studia.

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LIST OF SYMBOLS AND ABBREVIATIONS

AC- alternating current
ATV- All-Terrain Vehicle
BEV- Battery Electric Vehicles
BNEF - Bloomberg New Energy Finance
CARB - The California Air Resources Board
COP- Coefficient of performance
DC- DIRECT CURRENT
EHIGHWAY - (Electrified Highway)
EVC - Everywhere Grand Challenge
EV1 - Electrical Vehicle 1
FCEV- Fuel Cell Electric Vehicles
HEV- Hybrid Electric Vehicles
ICE - Internal Combustion Engine
K- Discharge Coefficient of the Battery
LEV - Low Emission Vehicle
OICA -International Organization of Motor Vehicle Manufacturers.
PHEV -Plug in Hybrid Electric Vehicles
P- Power of the Charger [W]
T- Time [h]
W- Capacity of Battery [Wh]
ZEV- Zero Emission Vehicle

1. INTRODUCTION

The modern world requires a rational approach from us. With the growth of the population of our planet, the load on natural resources and the environment increases. The future comes today- this phrase most accurately describes the current situation. Each of us today must take care of the future of our planet, because only this can guarantee its occurrence. The car is one of the main sources of environmental pollution. In this case, it is especially important that the car is in close proximity to people, and this enhances its negative impact on humans, flora and fauna.

Every year, the number of cars in the world is growing at a faster pace. Determining their exact number on a planetary scale is almost impossible. Only an approximate number can be said. The latest study was conducted by the International Organization of Motor Vehicle Manufacturers (OICA) in 2015. According to OICA experts, at that time 1.2 billion cars (see Table 1) were used in the world with a population of 7.7 billion people (World vehicles in use, 2015). Now it's worth imagining what these 1.2 billion cars have harmful influence on flora and fauna. However, if these 1.2 billion were electric cars, the environment would not be exposed to daily pollution from gasoline cars. The hypothesis posed, leads readers to the topic of this bachelor thesis, what ecological future awaits our planet if electric cars will be the only mode of transport. Boer (2009) claims that, considering the environmental impact of transport, any serious action on climate change will lead to an increase in the transport sector. Today, for many people, electric cars are a symbol of an environmentally friendly and progressive tomorrow, but, electric cars have an exciting past, they even competed on equal footing with fuel cars.

Regions	2005	2006	2007	2008	2009
All countries	892 028	926 642	960 228	992 375	1 019 856
2010	2011	2012	2013	2014	2015
1 055 700	1 097 141	1 141 637	1 184 928	1 234 887	1 285 270

Table 1: Number of vehicles using around the world during the period 2005-2015 (OICA, 2015)

Thanks to recent advances, modern electric cars have become much more efficient than cars with an internal combustion engine. Currently, there is a massive introduction of electric vehicles, but it is impossible to make a quick switch to electric cars, since large-scale switching to electric cars will increase the consumption of electricity. Moreover, electric vehicles require the

creation of an appropriate charging infrastructure. This, in turn, will require the introduction of additional energy facilities and changes in the schedule of electrical load.

2. HISTORICAL DEVELOPMENT

Cars with electric traction today do not seem outlandish. For all the time of its existence, electric cars have experienced ups and downs. Alekseev (1989) wrote that the first electric car was invented in the year 1841, even before the creation of the internal combustion engine, and was an ordinary cart equipped with an electric motor.

At the end of the XIX century, electric vehicles outlined a number of achievements that showed the prospects for the development of this type of transport. As source in the first electric vehicles used two electric motors. The body of this vehicle was made of aluminum and tungsten and resembled a torpedo. At the beginning of the 20th century, between an electric vehicle and a powered vehicle internal combustion, there was intense competition. Both types of cars possessed approximately the same power, power reserve and speed, but each of them had its own certain problems. The main disadvantage of the electric car was regular charging batteries. In order to restore the battery charge, it was connected to an electric motor operating on alternating current. But since at that moment AC to DC converter has not yet been invented, this process was quite problematic. Despite the fact that in 1906 the first rectifier was invented, which lightened the charging of the electric car somewhat, this process was still difficult and uncomfortable. Because of this, cars powered by an internal combustion engine become more competitive in the transport market (Matulka, 2014). Thus, by the 20s of the 20th century, the number electric vehicles accounted for only 1% of the total number of vehicles. However, despite the low demand, engineers continued to work on improving the electric car and saw him have great prospects.

Fedotov and Shevelev (2014) state that “in the second half of the 20th century, the electric car literally got a ‘second chance’ in 60s, humanity was faced with environmental problems created by vehicles powered by an internal combustion engine, due to which humankind had to turn to cars that do not make harmful emissions in Earth's atmosphere. Then, in the 70s, energy crises began, provoking a sharp increase in the cost of fuel, thanks to which the electric car has strengthened its position in the transport market”. However, at the beginning of the next decade, interest in him began to decline again, fuel prices began to be set at an acceptable level, which renewed interest in fuel-powered cars. Electric cars again lost competitiveness, as significantly inferior to other modes of transport in its characteristics.

In the 90s, some companies involved in the production of transport, among which included Honda, Ford, Toyota and General Motors, started developing electric vehicles and hybrids (cars equipped with both an electric motor and internal combustion engine), due to which quite a few

appeared on the market high-quality samples of these types of vehicles. It is worth noting that in the United States automobile companies were received very positively, as in the territory some states due to poor ecology, it was decided to introduce in operation a certain percentage of non-exhaust vehicles.

In 1990, CARB launched a Low Emission Vehicle (LEV) program to reduce air pollution from mobile sources. The LEV program included the ZEV (Zero Emission Vehicle) mandate, which established the requirements for ZEV production in subsequent years. In following years, some companies involved in the production of vehicles, including Honda, Ford, Toyota and General Motors, began to develop electric cars and hybrids (cars equipped with both an electric motor and an internal combustion engine), so many high-quality samples of these products appeared on vehicle market. One of them was an EV1 electric car (see Fig.1), released by General Motors (Shaheen, 2004).

Between 1996 and 2003, the EV1 gained widespread popularity among motorists and was leased to owners. By 2002, two generations of EV1 electric vehicles were produced with a total 1,117. However, as the story goes, in 2003 General Motors officially announced the cancellation of the EV1 program. GM stated that it could not sell enough of the cars to make the EV1 profitable. All electric vehicles were seized from users and destroyed. Only two copies survived and are stored in museums (Svatoš, 2016). But electric car manufacturers managed to make a quantum leap only in 2009, when they began to equip cars with the latest lithium batteries. It is these batteries that people use for their mobile computers and smartphones. This technical solution made it possible to double or even triple the power of electric machines (Fedotov & Shevelev, 2014). According to HEvCars, at present time such well-known companies as Tesla, Honda, Toyota, BMW, Nissan, Hyundai, and others produce various models of electric vehicles with different parameters (HEvCars.com.ua, 2017).

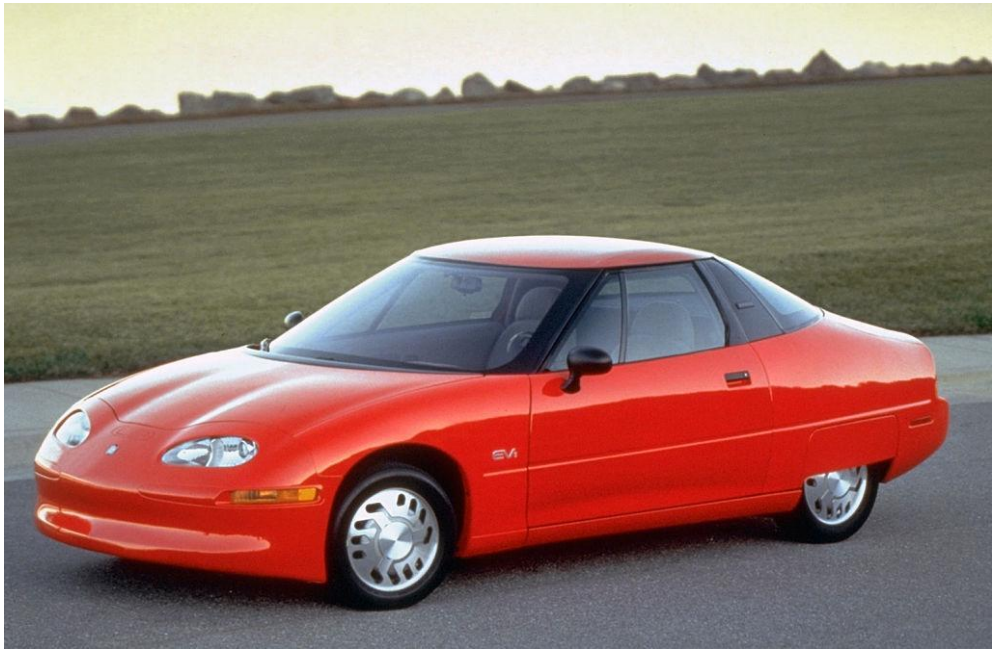

Figure 1: Electric vehicle GM EV1 (Svatoš, 2016)

3. WORKING PRINCILE OF ELECTRIC VEHICLE

Electric cars today are no longer a luxury, but a very popular means of transportation. At first sight, it might seem that the device of an electric car is similar to the device of conventional machines running on an internal combustion engine, and the only important difference is the presence of an electric motor. An electric car is a car that is driven by one or more electric motors. The power source is electricity, which is stored in an electric car in special batteries. After the exhaustion of electricity, the batteries are charged - after which the car can be used again. The duration of mileage and charging depends on the type of electric vehicle, as well as the method of recharging (Mom,2013).

All electric vehicles are equipped with a standard four-wheel transmission. During operation, the engine converts electrical energy into kinetic energy, which leads to the rotation of the wheels on the transmission (the movement of an electric vehicle). To select the direction of movement, a steering wheel is used that controls the rotation of the wheels - when the steering wheel is rotated, the direction of the wheel's changes, which leads to a change in the direction of movement.

As Mom (2013) described, for braking, electric vehicles are equipped with brake pads and discs. During braking, the engine is suspended + the discs approach the brake pads on the wheel, which slows the rotation of the wheels by converting the kinetic energy of rotation into heat. Please note that the braking system of electric vehicles wears out much more slowly due to the fact that the electric motor stops working almost immediately after pressing the brake pedal.

All electric cars are also equipped with various sensors and an advanced control system that tracks the operation of the electric car. Sensors monitor many parameters - driving speed, engine mode, temperature and so on. Some modern electric cars are also equipped with an autopilot, but in practice it is rarely used due to legislative uncertainty regarding the legality of using this system. Compared to ordinary cars, electric cars have a minimum number of moving elements - this has a positive effect on the performance and life of the electric car. Emadi (2017), took into account the main advantages of electric motors compared to internal combustion gasoline. engines, scientists distinguish several advantages:

1) Very high coefficient of performance (COP) - about 90-95%. Thanks to this, all the energy expended goes to the rotation of the wheels and is not wasted.
2) High environmental friendliness. During operation of the internal combustion engine, various gases and dust particles are formed that adversely affect the environment.

3) Light weight. The electric motor and all transmission elements are lightweight, so the electric car is safer for the roadway.

However, electric motors have several drawbacks. One of the minuses is a fairly fast energy consumption, so many modern electric cars have a charge reserve of 150-200 kilometers. Another minus is a sufficient long charge (about 5-6 hours), which reduces the versatility of electric vehicles. Concepts for solving these problems will be described in this work.

4. TYPES OF ELECTRIC VEHICLES AND THEIR PARAMETERS

Modern electric cars are distinguished not only by their functional purpose, but also by their technical base. As Fedotov and Shevelev (2014) mentioned, electric cars got a second chance in the 20th century, but the most dramatic changes take place in this century. In accordance with HEvCars, automakers have invested heavily in the development of various vehicles that use alternative fuels, such as hydrogen and compressed natural gas, or hybrid technologies that use both conventional internal combustion engines and electric engines (HEvCars.com.ua, 2017). These advanced technologies are available for sale as quickly as possible. Since consumers, as well as different regions of the world, prefer different technologies, car manufacturers are developing several cars that run on different types of fuel. In this section, cars with an electric motor and the principle of their operation will be described.

4.1 Battery Electric Vehicles

Almost all electric cars have a similar principle of operation. The movement of the electric vehicle is provided by an electric motor that uses the energy of the battery for its work (see Fig. 2). During braking, the electric motor is used as a generator and charges the battery, converting the kinetic energy of the car into electricity. As an auxiliary element, additional drives designed for efficient and rational distribution of energy can be installed on the driving wheels of electric vehicles. Driving an electric car does not have significant differences from cars with internal combustion engines. The only difference is the lack of sound when driving, as well as the need to perform standard maintenance procedures, like on cars with a gasoline engine, including changing the oil and consumables. The production of electric vehicles is carried out by such companies as Audi, BMW, Tesla, Citroen, Honda, Opel, Skoda and other 34 companies (Matulka ,2014).

4.2 Hybrid Electric Vehicles

The hybrid electric car (HEV) combines the advantages of an electric motor and an internal combustion engine. Those electric cars are most often driven by electric motors - in conditions where they are more efficient than internal combustion engines (see Fig. 3). During braking, the electric motor acts as a generator and charges the battery, converting the kinetic energy of the into electricity. At present time, hybrid cars can drive exclusively on electric traction at a very limited distance, but they save fuel very well and increase the power reserve of the car at one gas station. Since hybrid electric cars are less dependent on the electric motor, smaller batteries can be used in

them than in electric cars. Unlike BEV, not many companies produce hybrid cars. There are 9 companies in the world: Ford, Honda, Nissan, Toyota, Lamborghini, Hyundai, Kia, Lexus and Polestar (HEvCars.com.ua, 2017).

4.3 Plug in Hybrid Electric Vehicle

The plug-in hybrid electric vehicle (PHEV) has the characteristics of both an electric vehicle and a conventional hybrid electric vehicle. The difference is that it is an electric motor that drives a car. A hybrid electric vehicle with mains power is equipped with a large block of high-capacity batteries (see Fig. 4). Thanks to this mechanism, plug-in hybrids have a huge range, minimal fuel consumption and are considered the most environmentally friendly version of a car with an internal combustion engine. Also, plug-in hybrid batteries can be recharged from household networks and use renewable energy sources. Under normal conditions, a hybrid electric vehicle that is charged from the mains is powered by electricity, and the internal combustion engine is used as a backup in the event of a battery discharge (Matulka, 2014).

4.4 Fuel Cell Electric Vehicles

Fuel cell electric vehicles (FCEVs) convert hydrogen to electrical energy, which makes the car move. All these reactions occur in a block of fuel cells, each of which is an electrochemical generator, inside of which there is a reaction in which hydrogen is oxidized and produces energy (see Fig. 5). The electric energy obtained as a result of this process feeds the electric motor and other systems of the car, and the battery is charged due to regeneration energy.

Gas station is carried out using special stations capable of independently producing hydrogen by electrolysis of water. Currently, there are only 3 electric car manufacturing companies engaged in the production of hydrogen cars: Honda, Hyundai and Toyota (HEvCars.com.ua, 2017).

Based on the description of these electric vehicles, it can be confirmed that the most environmentally friendly modes of transport are BEV and FCEV, since they only work on the charge of batteries inside. Analyzing the above, it is obvious that humanity is not ready for a sharp rejection of ICE cars (Internal Combustion Engine) in favor of electric vehicles. At the same time, the first steps towards the widespread introduction of electric vehicles in everyday life have already been taken. The point of no return is passed, and every year more and more electric cars will appear on the roads.

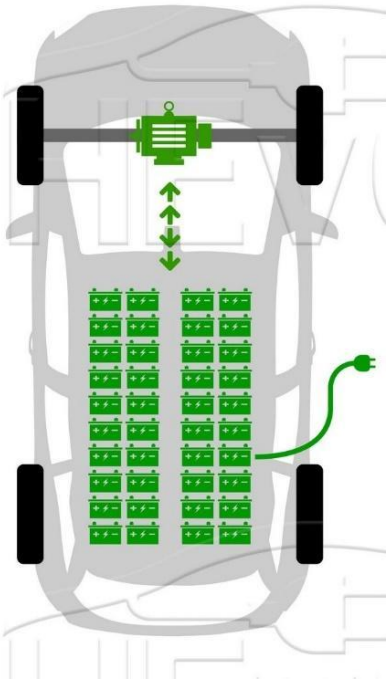

Figure 2: Structure of Battery Electric Vehicle

(HEvCars.com.ua, 2017)

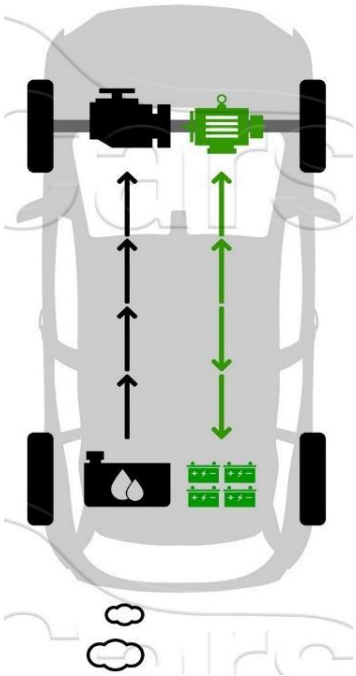

Figure 3: Structure of Hybrid Electric Vehicle

(HEvCars.com.ua, 2017)

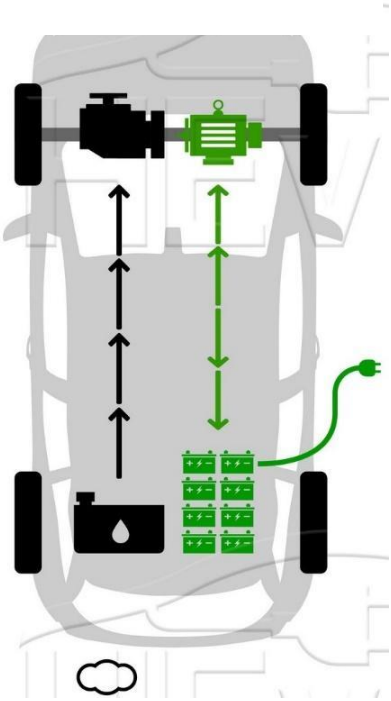

Figure 4: Structure of Plug in Hybrid Electric Vehicle

(HEvCars.com.ua, 2017)

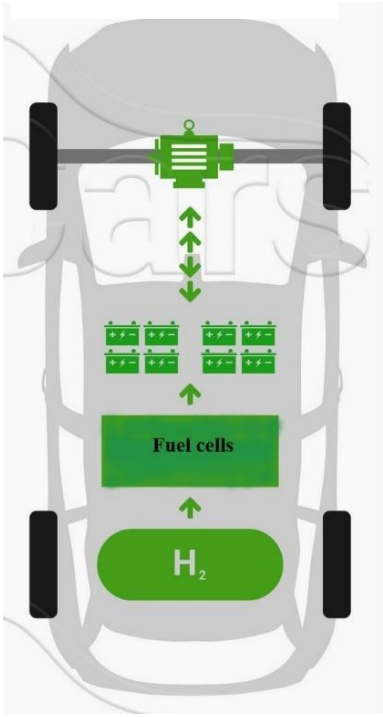

Figure 5: Structure of Fuel Cell Electric Vehicle

(HEvCars.com.ua, 2017)

5. ENVIRONMENTAL ELECTRIC CARS IMPACT

5.1 Tailpipe emissions

Electric vehicles such as BEV, FCEV have zero tailpipe emissions, but there are, of course, emissions involved in the production of electricity. One major benefit of electric vehicles is the "displacement" of harmful air pollutants from urban to rural areas, where population exposure is lower. Noise levels are also lower, particularly in urban driving conditions (Emadi, 2017).

According to Barder and Brennan, another main advantage of electric vehicles is their energy efficiency. Authors stated that with a tank-to-wheel efficiency in the range of 60 to 80 %, they outperform conventional cars four-fold. As a rule, electric cars demonstrate the greatest energy savings at low speeds and in situations associated with the often-changing driving dynamics that are often occur in megacities, which is another reason why cities are the main target market.

Thanks to their energy efficiency, and if electricity generation will be even greener in the future, electric vehicles could contribute to a considerable reduction in greenhouse gases. Given the ongoing debate on climate change, this could prove to be an important factor. Indeed, transport is responsible for more than a fifth of the EU's greenhouse gas emissions and it is the only sector with growing emissions. While the improvement of internal combustion engines still offers considerable potential for reducing emissions per kilometer driven, reductions in greenhouse gas emissions over and above 50% will require new technological solutions, such as the electric vehicle. Compared to conventional vehicles, and based on the current average European electricity supply, the modern electric cars pollute the air by 54% less than gasoline powered cars (Barder & Brennan,2016). Given the fact that the efficiency of electric vehicles is constantly increasing, and electricity production is becoming more environmentally friendly, this figure will continue to grow. Urban air will become cleaner and further benefits can be achieved if the intensity of energy use in the production of electricity continues to decline using more environmentally friendly and renewable energy sources.

There are, however, still some obstacles related to green electricity supply, the yet expensive battery technology, the limited driving range and the need for a dense network of electric charging facilities. To overcome these obstacles, innovative business models are being developed to help transform automotive transport. For example, since 1993 in USA there is a program “Clean Cities”. “Clean Cities” mission is to advance the nation’s economic, environmental, and energy security by supporting local decisions to adopt transportation practices that contribute to the reduction of petroleum consumption (U.S Department of Energy, n.d.).

5.2 Ecological friendliness of electric vehicles

Electric cars, even if they receive electricity to recharge batteries from the most polluting coal-fired power plants, still do less harm to the environment than ordinary cars with diesel engines. This was the conclusion of the Belgian research organization Transport & Environment. Many developers of electric cars are confident that this type of transport will improve the environmental situation in the world due to the absence of emissions of harmful substances that are typical for cars with internal combustion engines.

At the same time, some experts believe that the massive transition to electric transport can potentially do more harm to the environment than cars with internal combustion engines. In particular, experts believe that an increase in the number of electric vehicles will increase the load on power plants, most of which operate on gas, coal and oil. An increase in the load on power plants will lead to an increase in emissions of harmful substances, including soot, carbon dioxide and sulphur compounds. In addition, opponents of electric vehicles believe that lithium-ion batteries used in electric vehicles are not at all environmentally friendly in production, and after disposal they can poison the soil. Researchers from Transport & Environment studied the data on emissions of power plants in several countries of the European Union, the production of electric vehicles and their elements, as well as data on emissions of cars with diesel engines. It is diesel engines from all internal combustion engines in automobiles that are considered the least environmentally friendly due to emissions of soot and sulphur and lead compounds.

Sulphur and lead in one form or another are always present in diesel fuel; their concentration may decrease depending on the applied cleaning technology, but there is no zero. Compounds of these substances in large quantities can cause poisoning. Soot emitted by diesel engines can cause severe pulmonary disease.

Based on the analysis, the researchers concluded that over the entire period of their existence, starting from production and ending with recycling, electric cars in Poland, the country with the largest share of thermal power plants in the European Union, will still produce almost 25 percent less harmful emissions. According to researchers, over a lifetime, a diesel car emits an average of 206.1 grams of carbon dioxide per kilometer. For comparison, emissions of an electric car in Poland over the same period will amount to 159.1 grams per kilometer, and in Sweden - only 30 grams per kilometer. On average, an electric vehicle in the European Union will emit 89.1 grams of carbon dioxide per kilometer during its life cycle. It should be noted that the study conducted by Transport & Environment deals only with carbon dioxide emissions from power plants, diesel cars and electric cars. Carbon dioxide is considered one of the main factors of global warming.

6. SAFE CHARGING SYSTEM

For the successful operation of electric vehicles, a charging system is required. Charging an electric vehicle can be fast (for 1 hour or less) and long (6 hours or more).

An electric vehicle can be charged from a station like a gas station and from a household network. In all cases, a special charger is required. The power of the charger P depends on the value of the battery capacity W, the duration of the charge T, the discharge coefficient of the battery K and is expressed by the formula P = W / TK [W] (Mom, 2013). From the presented expression it follows that the power of the charger is inversely proportional to the charge time and the discharge coefficient of the battery. Thus, Tesla offers a quick charge system up to 1 hour with a capacity of 7.2 kW and a cost of $ 3,300. In this case, the energy reserve will be enough for a trip of 40 km. In addition, in 2019, Tesla released a new electric car with a charging system for the electric ATV, which located in the trunk. This suggests that in the near future it will be possible to charge from an electric vehicle to an electric vehicle (Tesla, 2019).

Currently, electric car mileage is limited to approximately 200 kilometers. In public places, a dense charging infrastructure is needed to ensure frequent charging after hours. There is also an element of time for consideration. As already described in the first paragraph, recharging a battery can take from 3 to 8 hours, if it is connected to the network normally. Given that cars are parked on average 95% of the time, this should not be a problem if charging points are widely available. In addition, innovative charging solutions are under development. Powerful fast-charging stations can reduce charging times to less than 30 minutes. Intelligent power systems for the car's network interface can optimize battery charging. This, in turn, can become attractive to utility companies in terms of network management and fluctuations in energy supply and demand.

In 2011, an American startup company, Better Place, together with the Renault-Nissan alliance, planned to build a dense network of charging and exchange stations for electric vehicles. The company's plan was to ensure that the electricity of the network was completely generated from renewable energy from solar panels and wind power plants. The leasing scheme provided both a battery system and a power source. A subscription model, like the one for mobile phones, charged electric car drivers depending on the distance traveled. However, due to financial difficulties, the company crashed in 2013. Although this project lasted several years, the company managed to establish many charging stations in countries such as USA, Australia, Denmark, Netherlands, China, Hawaii and Israel (Gunther, 2013). This suggests that electric cars have a future. Our planet has an ecological future. There is the possibility of charging electric vehicles from renewable energy sources. However, in order to fully provide such stations, we need financial

stability in the world. But if we consider how many gasoline stations are built every year in any country, people can think about how many stations working on renewable energy sources can be built.

6.1 Electric sensor on a public road

If the production of mass charging stations for electric vehicles continues in the 21st century, then perhaps a century later, humanity will be more oriented towards environmentally friendly modes of transport that do not harm the world. In addition, some countries are not limited to the construction of charging stations. According to Daniel Boffey (2018), Sweden became the first country in the world to introduce an electric sensor on a public road. Thus, charging electric vehicles is possible not only at charging stations, but also during the trip (see Fig. 6).

Charging takes place by moving two contact rails embedded in a recess in the carriageway through a movable current collector that is mounted on the underbody of the car. The electrified road is divided into sections with a length of 50 m, while the voltage is supplied to each individual section only when the electric car is directly above it. If the car stops, the power supply also turns off. Engineers equipped the system with software that allows calculating the energy consumption of a car. Thus, the cost of electricity used is automatically credited to the user's account of the car. The main advantage is the lack of electricity on the surface. There are two conductors, as in a conventional outlet. Electricity passes at a depth of 6 centimetres. Even if the whole road is flooded with salt water, the voltage on the track surface is only one volt.

Figure 6: An electric sensor on a public road (Guardian,2018)

The construction of such a road amounts to 1 million euros per 1 kilometer. Which, in fact, is not such a large amount for states spending millions every year on the construction of gas stations and the production of combustible materials, which harm the flora and fauna. Although the road is still in pilot mode, the government plans to electrify all roads so that by 2030 they are completely independent of fuel.

6.2 Battery trailer

Along with Sweden, the Parisian start-up presented its new products. According to Paris start up EP Tender (2018), the problem of charging electric vehicles can be dealt with using a battery trailer (see Fig.7). It is planned that the trailer will autonomously connect to the rear of the electric vehicle, thereby adding an additional 60 kWh of energy to the onboard battery, enough to reach the destination or the next station. Trailers can be equipped with an additional axle with smaller wheels that lower down to facilitate backing up. In addition, when the trailers are not used, they can be connected to the network to give off electricity at peak times. According to EP Tender (2018) forecasts, the maximum rental price will be 34 euros ($ 37) per trailer.

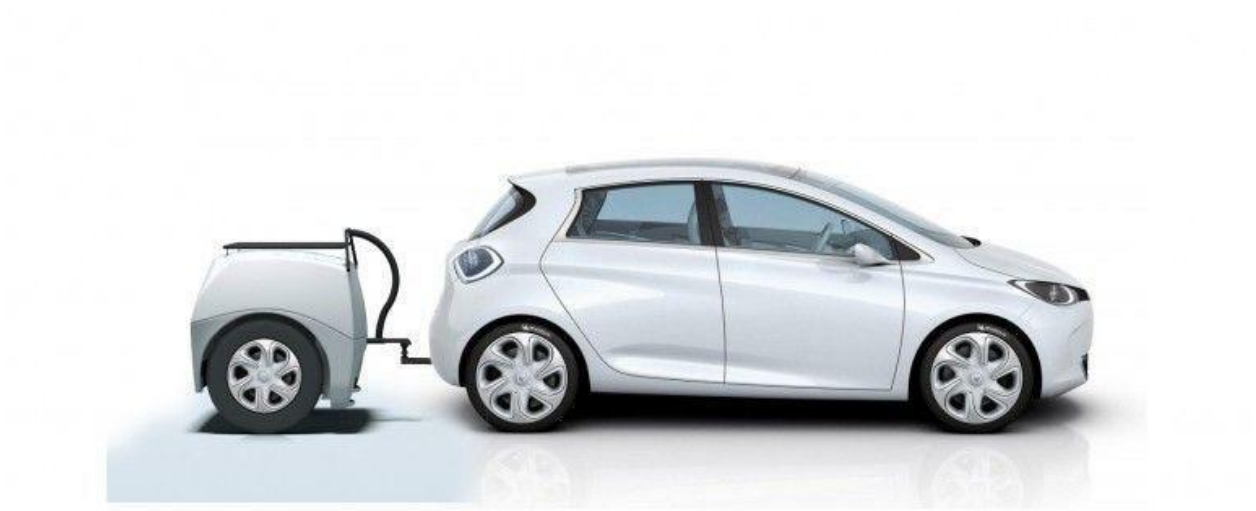

Figure 7: Mini trailer presented by EP Tender (EP Tender, 2018)

As mentioned at the beginning of the paragraph, switching to electric vehicles requires enough charging stations. EP Tender spoke on this subject and said that their project carries fewer risks due to the lack of many expensive charging stations necessary for the construction. Charging stations can be built in the city center or outside the city, they do not cause such harm to the environment as refuelling with gasoline station (see Fig.8).

When the trailer is attached to the car, exhaust emissions do not occur, as when driving an electric car. Trailers are charged from renewable energy sources: solar panels, windmills; the use of which is considered more environmentally friendly. In addition, trailers can be booked online, and car owners do not need to wait several hours for the electric car to fully charge. The widespread use of trailers significantly increases the mileage of any electric vehicle.

Figure 8: Trailer station concept (EP Tender, 2019)

7. BATTERY OPERATION

The benefits of using an electric car are numerous. They reduce CO2 emissions, reduce noise pollution in cities, save fuel and use energy more efficiently. Most modern electric cars use batteries, because batteries are important parts of electric vehicles. The most common is lithium-ion. The advantages of such power sources: high density of stored energy; higher voltage than other types of batteries; relatively long service life –10 years. But the creation of lithium-ion batteries is a complex process that involves the extraction of rare earth metals and their transportation over long distances, which can cause enormous damage to the environment.

The first thing a person can do with an old battery is recycle it. There are already several companies in the world that help consumers reuse and recycle electric car batteries. Leading manufacturers of electric vehicles offer an initial alternative to recycling: the use of used batteries in household energy storage systems from alternative sources. That is, to use the former electric vehicle batteries as batteries for storing energy produced by solar panels and wind generators. Incidentally, the idea is not new, because Tesla has been producing battery systems for a long time, not related to electric cars, but producing alternative energy for solar panels.

Other companies are developing new technologies in this direction. For example, in Japan, Nissan installed batteries to power streetlights (see Fig. 9). According to NissanNews (2018), a large number of used electric vehicle batteries are involved, which become available as their popularity grows around the world. Nissan and 4R have created a new type of outdoor lighting that is completely unplugged and does not require electrical cables or outlets. The companies designed the streetlamp in such a way that during the day the lamps accumulate energy using solar panels and store it in waste batteries.

Figure 9: Street lamp with solar panels (NissanNews, 2018)

Nissan is not the only company looking for battery reuse solutions. BMW has opened a factory for the repair and storage of used i3 batteries in Leipzig (see Fig.10). According to Müller (2017), the BMW i3 battery storage, processing and repair plant, after the vehicle has reached the end of its service life, can take up to 700 batteries at the same time. The BMW Battery Storage Farm project in Leipzig is part of an initiative to develop Wind NODE smart systems for the use and storage of renewable energy.

Figure 10: Storage of used BMW i3 batteries (BMW Group,2017)

Over the next two decades, electric cars are ready to seriously claim the status of the main vehicle. In such a situation, with a constant increase in volumes, reuse of batteries is the only correct way out. The circular principle of generating income on the same product should be laid in the basis of its production. From now on, automobile companies should not consider the car as the final product of their production, but its battery systems, which, after working out their resources on electric vehicles, should be adapted for use for another purpose and, accordingly, be profitable. Thus, the reuse of electric car batteries can change the existing way of the automotive and energy markets, creating a vicious circle with long-term use of the same product.

8. PUBLIC TRANSPORT AND OTHER VEHICLES

Against the background of environmental pollution, the topic of electric transport became very relevant in the 21st century. As already mentioned in this work, in order to preserve the environment, inventor engineers come up with new convenient and compact vehicles that are worthy of competition with cars and can facilitate the movement of public transport. This chapter will describe the types of electric vehicles from the largest to the smallest.

8.1 Environmental electric buses

Discussing the large-scale transition to electric cars, it is necessary to take into account the transition of public transport to a more environmentally friendly existence. By 2018, electric buses, which until recently were not taken seriously by anyone, turned out to be the lever with which you can turn the world of urban transport and radically affect the development of the oil industry. For public transport even on the street, electrification seems the obvious alternative to keep pace with urban growth and to care for the city environment at the same time, using full electric or electric hybrid buses. With the right charging technology, the advantages of electrified buses can be utilized: less energy consumption in comparison to buses with combustion engines, use of renewable energy, less noise, lower particle emissions, less CO2, lower lifecycle costs, and reliable service.

According to BNEF (Bloomberg New Energy Finance) estimates, every thousand electric buses will push about 500 barrels of diesel fuel per day out of the market. Given that 1.9 thousand electric buses are produced every week in China, the same amount is written off as waste, that is, it stops consuming diesel fuel. As a result of the release of Chinese electric buses in 2018, fuel consumption will decrease by almost 280 thousand barrels per day, i.e. by 37%. For comparison: in Greece, approximately the same amount of fuel is burned, while urban transport accounts for 233,000 barrels (Bloomberg New Energy Finance n.d.).

In China, every five weeks, 9.5 thousand electric buses are produced. By the end of 2017, 385 thousand such buses traveled around the world, and the predominant part - 99% - moved along the streets of Chinese cities. Electric buses make up 17% of this urban transport. Of course, such production rates significantly reduced the demand for fuel. Diesel-powered buses consume 30 times more fuel than automobiles, and the introduction of electric buses has had a much greater impact on the energy sector than all cars made by Tesla, Toyota and other companies combined.

The authorities of major cities in the world have long been trying to solve the problem of polluted air. The pressure from environmental organizations and international commitments is not

weakening, so buying electric buses will be extremely profitable, said Colin Mackercher, head of the London Transport Research Center. China has overtaken the whole world by replacing diesel urban transport with electric, but there is a reason for this - in the Chinese cities that developed rapidly in the 21st century, there were the most serious problems with air pollution. In the early 2000s, Shenzhen was a typical example of a thriving Chinese city with asphyxiating smog, and in 2009 the government selected it for a pilot program to save energy and introduce zero-emission vehicles.

In 2011, the Chinese company BYD launched the first electric buses, and by December 2017 the entire Shenzhen public transport fleet - 16 thousand units - consisted only of them. According to BYD estimates, the company's buses saved 6.8 billion liters of diesel, that is 18 million tons of carbon dioxide did not enter the atmosphere. For comparison, the European leader in urban electric transport, the UK, has a total of 344 electric buses, in France - only 75 units of electric public transport (see Fig. 11).

Drivers may ask if the electric bus will work in cold weather. Lithium-titanate batteries can withstand temperatures ranging from minus 45 to plus 45 degrees Celsius. The built-in storage drive heating system ensures operating efficiency at low temperatures. In addition, such batteries are quite suitable for short and frequent recharges. Although the cost of an electric bus is about twice that of a regular bus, charging with electricity is much cheaper than refueling with diesel fuel, and this type of vehicle is no longer dependent on rising gas prices.

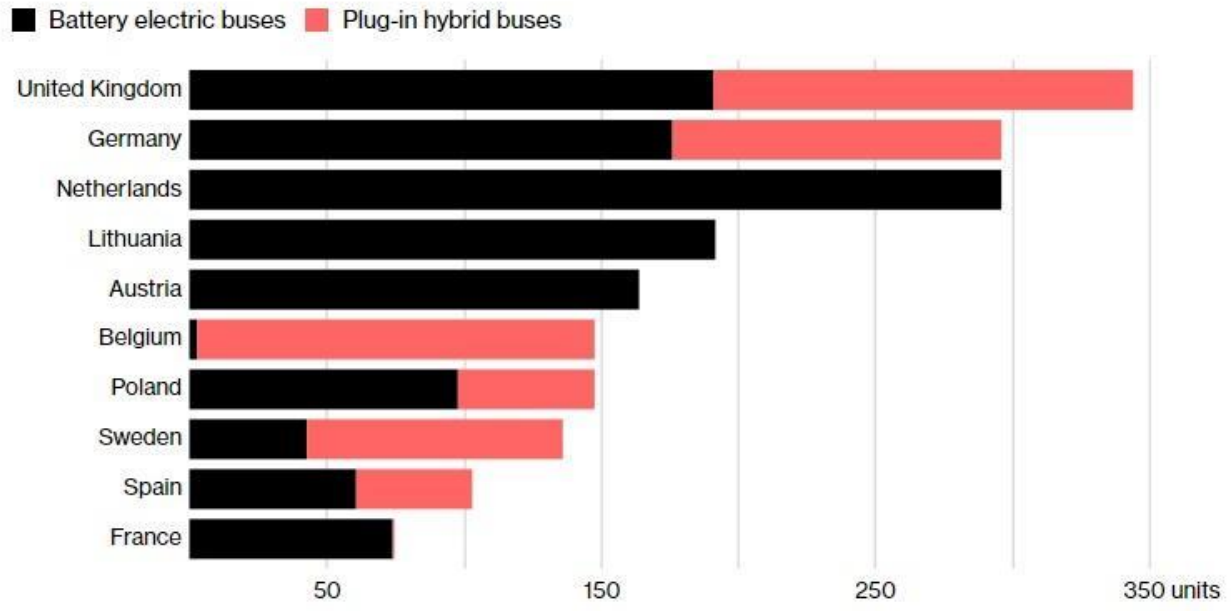

Figure 11: European countries with the largest introduction of electric buses, including hybrid cars (BloombergNEF, n.d)

Charging electric buses is not much different than charging electric cars, but their charging system cannot be ignored. For fast and independent charging of electric buses, various companies offer hundreds of ideas, but only a few companies manage to realize their concept.

Siemens proposed the idea of charging - this is a fast charging system, which is mainly used in cities with existing DC networks, such as trams, which is why it is called the On-board Bottom-up-Pantograph.

The most obvious feature of this charging solution is the bottom-up pantograph mounted on the roof of the bus. The electric bus is driven under a charging station, which consists of a bipolar contact network. The bus driver starts the charging procedure, raising the pantograph to the contact network, and stops it, again lowering the pantograph. In addition, electric buses are charged, like electric cars, charged through a connector.

But other cities are already taking an example from Shenzhen. Paris, London, Mexico City and Los Angeles, as well as nine other cities in the world, have announced the full transition to environmentally friendly public transport by 2025. London is gradually replacing its fleet of vehicles - four routes are already being served to the city center on electric buses and as part of the program it is planned to upgrade 5,000 old diesel buses (Bloomberg New Energy Finance, n.d.).

8.2 Electric scooters - compact vehicle

If humanity cares about environmental issues and people want to do more than just sort waste and use less plastic, then not only electric cars, but also electric scooters can help make our planet cleaner. In metropolitan areas, where the air is particularly polluted by exhaust gases, electric scooters help to preserve the environment. According to researchers from Transport &Environment, over a lifetime, a diesel car emits an average of 206.1 grams of carbon dioxide per kilometer. An electric scooter does not emit carbon dioxide and consumes very little electricity.

Although electric scooters are not suitable for traveling very long distances, it is still a great way to take care of nature. For residents of large cities, the journey to and from work takes a lot of time. Due to traffic jams and oversaturated traffic during peak hours, people are forced to leave in the morning much earlier and spend several hours on the road.

Time is one of the most valuable resources, and an electric scooter allows you to save it, no matter how far you have to travel. With an electric scooter, you don’t need to adapt to public transport (get to the stop, wait for the planned bus or drive in a crowded minibus). On average, on a single charge, most scooters can travel 20-30 km. But there are more “long-range” models - for

example, Xiaomi M365 Electric Scooter Pro is designed for 45 km of track without recharging (2016). If a person goes to work 5 days a week, traveling 5-6 kilometers per day, then one charge of an electric scooter is enough for the entire working week. An integral advantage of electric scooters is their economic profitability in comparison with other vehicles.

Firstly, electricity is much cheaper than gasoline. According to Xiaomi engineers, an average electric scooter consumes about 280 watts per hour of charging; A full car charge takes from 2 to 5 hours.

Secondly, when it comes to parking. We must not forget that you do not need to pay for parking on a scooter. Continuing the topic of the economic viability of an electric scooter, one cannot but mention the low costs of its maintenance. More precisely, it practically does not require maintenance. Once a month, make sure the bolts are tightened and lubricate if necessary, and it is all. If driver invest in a high-quality electric scooter, he will receive a reliable car with a manufacturer's guarantee and protect yourself from possible breakdowns.

Even if somebody have to replace a wheel, a flashlight, a tire or a broken mudguard, it will not seem significant to compared to the cost of servicing and repairing a car. Although electric scooters are easy to use, there are opponents of electric scooters among car owners who claim that people do not know how to handle them. But if people delve into history, as described in the second chapter, electric cars and cars appeared in the middle of the 19th century, and, as practice shows, not for all car owners, it turns out to cope with the car. In addition, it is necessary to take into account the simplicity of maneuverability, since the average speed of an electric scooter varies from 20 to 30 km / h. This scooter is easy to maneuver along winding roads and quickly move from one point to another. In addition, they can be used both on pedestrian and bicycle paths, and on public roads.

The topic of electric scooters has been discussed since the release of the first electric scooter, and Ajax Motor was launched in the early 1900s, but it did not gain much popularity. But every year their benefits began to grow. Today, unlike motorbikes or most bicycles (not to mention cars), electric scooters are very portable. The following advantages of their use follow from this:

• convenient transportation (light weight and compactness allow people to take an electric scooter to public transport or office, transport it in the trunk of a car);

• the scooter is easy to fold and unfold, just carry it from place to place or roll nearby (in case the battery suddenly runs out). If person choose the right model, even a fragile girl can pick up and carry a scooter;

• convenient storage - people not only do not need to worry about parking, they are automatically exempted from the need to buy / rent a garage or pay for parking a car. An electric scooter takes up less space than a motorcycle and even a bicycle.

At the beginning of this chapter, charging electric scooters was mentioned. This type of transport is not only cheap, but also very simple. It can be charged from absolutely any 220 V outlet (most importantly, use the original charger). This can be done at home, at work, even in a cafe.

It may seem that everything is said about electric scooters, but this is not so. An electric scooter is a great way to keep fit. Especially if a person cannot allocate time for morning exercises. When moving on a scooter, the main muscle groups are involved - the back, stomach, upper and lower limbs. This leads to their strengthening, which, in turn, improves the general condition of the body and physical fitness. However, no one will have to pedal like a bicycle. And this means that a person will start work without a deadline later, as after intensive training.

If persons take into account the fact that when riding an electric scooter, a person adds this fresh air instead of a stuffy bus filled with people. Caring for your health will become even more apparent when a passenger considers whether a sick person can be a companion in public transport. Thus, the use of electric scooters in the near future should be on a par with electric cars.

8.3 eHighway

The development of batteries, trailers for electric vehicles is already in a period of widespread use. Electric buses also move quietly through the streets of China. The issue of electric trucks is being discussed as intensively as the production of the first electric car was once discussed.

Trucks are multi-ton vehicles designed to transport goods on a loading platform. The operation of an internal combustion engine in a truck pollutes the environment no less than ordinary cars. Therefore, governments of different countries are taking measures to introduce electric roads for trucks.

For example, in November 2017, Siemens created the first road in the United States for electric trucks. A project called eHighway (Electrified Highway) was implemented in California. Siemens has deployed an electric contact line for electric and hybrid trucks on a 1.6 km long pilot section. After successful testing in the USA, the first electrified road for trucks was commissioned

in Germany in early May 2019. Siemens (2017), which implemented this project, hopes that it will be able to reduce harmful emissions from multi-ton cars. A 10 km motorway is located south of Frankfurt. Over this section of the autobahn, wires are stretched, similar to those that use trolleybuses in cities. Trucks equipped with upward current collectors receive the energy necessary for driving through these electric cables. Electric trucks moving along the eHighway can charge their batteries while driving, and hybrid vehicles can turn off auxiliary internal combustion engines and transfer electric motors to power from the mains tracks. Thanks to this, cars will be able to travel twice as long as traditional trucks. Although moving along this road is free, the maximum speed on the road is up to 90 km / h, which, according to the author, is the optimal speed for safe movement on the highway.

The German company (2017), claims that eHighway is "twice as efficient as internal combustion engines." According to Germany Siemens (2019), seeks to reduce carbon dioxide emissions by at least 80% by 2050 and, like many countries, plans to stop selling cars with gasoline and diesel engines by the 2030th (see Table 2).

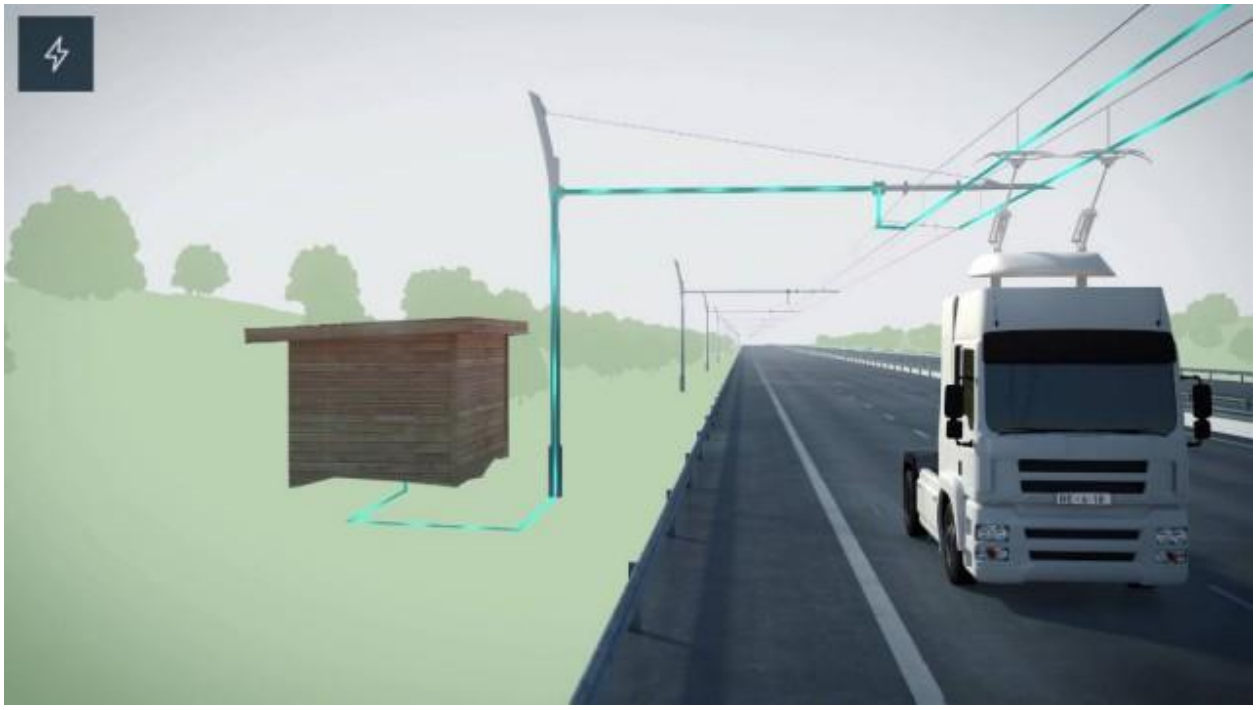

Figure 11: eHighway charging system (Siemens,2017)

9. THE FUTURE OF ELECTRIC CARS

There is no exact deadline where the future will take electric vehicles, but it is clear they hold a lot of potential for creating a more sustainable future. Danielson (2013) said, what if the population of the United States converted all light cars to hybrids or plug-in electric vehicles using our current set of technologies, we could reduce our dependence on foreign oil by 30-60 percent, while reducing carbon pollution from the transport sector by as much as 20 percent. To help reach these emissions savings, in 2012 ex-President Obama launched the EV Everywhere Grand Challenge - to make plug-in electric vehicles more as affordable as today's gasoline-powered vehicles by 2022. On the battery front, the Department's Joint Center for Energy Storage Research at Argonne National Laboratory was working to overcome the biggest scientific and technical barriers that prevent large-scale improvements of batteries.

In addition to the United States, several urbanized countries are currently planning to ban or stop selling new gasoline and diesel cars. The table below (see Table 2) shows the countries and expected years of abandonment of the above gasoline cars and switching to electric cars (Schwanen, 2019).

Besides that, some of these countries are doing their best to efficiently charge electric vehicles. Since March 2019, Norway has launched a project to install wireless charging systems for electric taxis. Oslo will be the first city in the world to have such charges installed. Norway launched this initiative in the hope of making charging fast and efficient enough to launch an environmentally friendly taxi fleet as soon as possible. The project will use induction technology: charging plates will be installed on the road near taxi stops, and receivers in the vehicles themselves. By 2023, all taxis in Oslo should become non-waste, and by 2025 all transport in Norway is supposed to be non-waste. Similar goals, but only for the year 2040, set themselves the UK and France (see Table 2). The Finnish non-waste production service Fortum (2018), which is working on a project in collaboration with the American company Momentum Dynamics, said that the infrastructure was still the biggest obstacle to taxi electrification: taxi drivers had to spend too much time looking for a charger, connecting and charging itself. Induction is more energy-efficient and allows you to charge a taxi while the cars are in slow-moving lines at special parking lots, which is reasonable, each vehicle needs to be charged. As stated in the previous chapter, there are charging stations for bulky cars, cars and even electric scooters. Specially designated charging stations for electric taxis save charging time for both taxi drivers and car enthusiasts. The taxi driver does not have to wait in the general queue for charging, as he can use the wireless charging system designed specifically for taxis.

Norway has the highest prevalence of electric vehicles in the world per share, due in part to long-term benefits such as reduced tolls and free parking. In 2018, almost every third car sold in Norway was an electric car. The government also exempts electric vehicles from taxes on traditional vehicles, which are very high in the country without their own auto industry.

According to the European Automobile Manufacturers Association, in 2018, Norway, home to just 5 million people, bought 46,433 new electric vehicles, making it the largest electric car market in Europe.

Ban/target date	Country
2025	Norway
2030	Iceland, Ireland, Israel, Slovenia, Netherlands, Sweden, Germany
2035	Denmark
2040	United Kingdom (except Scotland), Canada, Spain, Portugal, France, Sri Lanka
2050	Costa Rica

*Table 2: List of countries planning to ban gasoline and diesel cars (*Schwanen, 2019*)*

Today's battery costs have a price premium of EUR 15,000 to 40,000. As technological progress is made and economies of scale begin to kick in, this could decrease to under EUR 10,000 in the mid-term and EUR 5,000 in the longer-term. To compensate for these higher costs, some countries and cities have announced important incentives, such as tax rebates and subsidies, free parking in urban areas and exemption from congestion charges and road taxes (Barder &Brennan, 2016).

Another promising way to limit battery costs was mentioned by Schwanen (2019). This is a battery leasing formula in which the electricity company owns the batteries and rents them out to car owners. The Norwegian THINK City electric vehicle initiative already offers such a battery-leasing concept. The vehicle manufacturer retains the ownership of the batteries, which also guarantees the supply of the most advanced battery technology and replacement in the event of deteriorating performance. The logical chain of these actions is clear, because until 2025, Norway set a goal to transfer all vehicles to electric vehicles (see Table 2).

Since the topic of charging was mentioned in the previous paragraph, the Japanese motor concern Honda Motor announced its intention to solve one of the main problems hindering the mass introduction of electric vehicles. By 2022, the company plans to produce electric vehicles that will charge in just 15 minutes. According to the publication, most modern electric vehicles require at least half an hour to charge batteries by 80% even when using special high-speed chargers. Honda promises to halve this time and in five years to release electric cars, which will be enough for a 15-minute recharge of batteries to travel 240 km. To implement its plan, Honda is going to develop high-capacity batteries that support ultra-fast charging. As Honda Motors reported of November 2017, the Japanese manufacturer is buying batteries for its hybrid cars from Panasonic and other suppliers, but in the future the company wants to release its own batteries.

In addition, to increase the mileage of an electric vehicle on a single charge, Honda intends to lighten its body and improve the automated power management system. According to 2017 data, in Japan the maximum output power of high-speed charging stations is 150 kW, but in 2020 it is increased to 350 kW. It is assumed that by this time in Europe there will be a whole network of several thousand chargers with a capacity that Honda is going to use. Meanwhile, Nissan, one of the world's largest electric cars, Nissan Leaf, also plans to speed up battery charging. The Leaf 2022 modification will not only be able to charge faster but will also go away from a single charge: mileage will increase by 30% to more than 500 km, Nissan promises (2018).

Ultimately, according to Danielson (2013), technology improvements come at a cost - and whether in dollars, greenhouse gas emissions or human health effects, BEVs are a complex set economic and environmental trade-offs in which achievements in one area are inevitably associated with impacts in another. Everything these trade-offs must be considered holistically when weighing the impact of evolving passenger vehicle technologies and potential for wider adoption of BEV in the global market. Speaking about electric vehicles as ecological transport of the future, we can say with confidence that this is possible, not forgetting its advantages:

Local emission-free, low noise, reliable.

Use of energy from renewable sources.

No compromises regarding availability, transport capabilities and passenger comfort.

10. CONCLUSION

Many electric cars produced in the mid-90s are still on the roads of the USA and European countries, delighting their owners. It is a pity that the wave of electric vehicles, which began to intensify at that time, was interrupted at the very beginning of century. There are many reasons and versions of why this happened - the opposition of oil companies and the cheapening of oil at the end of the 90s, the imperfection of technologies (primarily batteries) and simply the unpreparedness of ordinary consumers for electric vehicles.

Many people still believe that electric cars are unprofitable, that charging electric cars is more expensive than refueling, people are more concerned about mileage, how much the electric car will ride without charging. But few people think about the environment, about their health and the health of future generations. If the first generations of electric vehicles were successful, the current state of our ecology would be completely different. Our cities would not be black from smoking automobile pipes, and the level of risk of respiratory diseases was not so high. If people want to live on our clean planet, not exhausted and not tired of the constant emissions of harmful substances into it, then we all need to think about an environmentally friendly mode of transport. The ecological transport future depends not only on the automakers who produce electric cars, but also on humanity. Huge work has been done in the field of production and improvement of electric vehicles; it remains only to take advantage of this.

The 21st century is a turning point in transport structure. The world is changing, and today there are all prerequisites for a new revival of electric vehicles, but at a completely new level. Today, oil is not as cheap as before, and the largest industrial countries are worried about their dependence on their suppliers. Battery technology has advanced significantly. Ecologically friendly electric vehicles are advancing rapidly. And the trends of the past few years in the global automotive industry inspire hope that in the near future humanity will see the environmental generation of electric vehicles.

EXTENDED ABSTRACT IN CZECH LANGUAGE

Cílem práce je popsat elektrická vozidla z hlediska jejich vlivu na životní prostředí. Samotný text je rozdělen do devíti částí. V úvodní části autorka seznamuje čtenáře s potřebou zavádění ekologických vozidel do moderního světa. Druhá část je věnována historickému vývoji elektromobilů od roku 1841 do současnosti: automobily mají velmi bohatou historii, včetně úspěšných a neúspěšných okamžiků, ale nyní si získávají popularitu elektromobily. Hlavně kvůli vývoji baterií a nabíjecích stanic. V třetí a čtvrté částích autorka popisuje princip provozu elektrických vozidel a identifikuje také typy elektrtomobilu, které se liší v principu provozu a nabíjecím systému. Elektromobily neprodukují svým provozem výfukové plyny, tím pádem započítáním výroby elektrické energie z různých zdrojů je jejich bilance vlivu na životní prostředí lepší než u automobilů se spalovacími motory. Pátá část je věnována vlivu elektromobilů na životní prostředí a porovnává je s ostatními typy automobilů z hlediska emisí výfukových plynů, systémů nabíjení a jejich budoucnosti ve vztahu k environmentální politice jednotlivých států. V případě, že je elektromobil nabit elektřinou vytvořenou pouze spalováním fosilních paliv, tak je pro jeho jízdu potřeba značně menší množství fosilních paliv než u spalovacího motoru. Spalovací motor použije o třetinu více energie na jednotku ujeté vzdálenosti než je spotřebuje z fosilních paliv. V případě nabíjení elektřinou z jaderných nebo obnovitelných zdrojů jsou emise skleníkových plynů a uhlíková stopa téměř nulové.

Další část této práce je více věnována bezpečnému nabíjení. Elektromobily lze nabíjet z jakýchkoliv zásuvek v budovách nebo garážích. Využít se dá běžné 230 V zásuvky. Hodina dobíjení z vícefázové zásuvky zvýší dojezd elektromobilu až o 55 km. Další variantou je využití nabíjecích stanic, jejichž infrastruktura se rapidně rozšiřuje ve městech, v blízkosti silnic a v hromadných garážích. Stále se rozšiřující síť nabíjecích stanic snižuje problém omezeného dojezdu některých elektromobilů. Pařížský startup představil svůj nový produkt, podle němu lze problém nabíjení elektromobilu vyřešit pomocí přívěsu poháněného bateriemi. Plánuje se, že se přívěs autonomně připojí k zadní části elektrického vozidla, čímž přidá dalších 60 kWh energie k palubní baterii, což je dostatečně pro dosažení cíle nebo jiné nabíjecí stanice.

Praktické využívání elektromobilu skýtá mnoho výhod. Snižují emise CO2, snižují hluk ve městech, šetří palivo a efektivněji využívají energii. Nezbytnou součástí každého elektromobilu je baterie. Existuje několik typů bezpečných baterii, nejběžnější jsou lithium-iont. Šestá část této práce je věnována likvidaci baterií a jejich budoucímu využití. Výhodou těchto zdrojů energie jsou vysoká hustota akumulované energie a vyšší napětí než jiné typy baterií. Další výhodou je relativně dlouhá životnost, která dosahuje až deset let. Tvorba lithium-iontových baterií je však

složitý proces, který zahrnuje těžbu vzácných kovů a jejich transport na velké vzdálenosti, což může způsobit obrovský dopad na životní prostředí a jeho znečištění.

První věc, kterou může člověk udělat se starou baterií, je recyklace. Na světě již existuje několik společností, které pomáhají spotřebitelům znovu použít a recyklovat elektrické autobaterie. Přední výrobci elektrických vozidel nabízejí počáteční alternativu k recyklaci: užití použitých baterií v domácích systémech a její skladování energie z alternativních zdrojů. To znamená, že použité baterie elektromobilu se použijí jako baterie pro ukládání energie vyrobené solárními panely a větrnými generátory. Tento návrh není nový, protože společnost Tesla dlouhodobě vyrábí bateriové systémy, které se nezaměřuji elektrických automobilů, ale vyrábějí alternativní energii pro solární panely.

V souvislosti se znečištěním životního prostředí se téma elektrické dopravy stalo v 21. století velmi důležitým. Jak již bylo uvedeno v této práci, konstruktéři vynálezů přicházejí kvůli ochraně životního prostředí s novými pohodlnými a kompaktními elektromobily, které dokáží konkurovat automobilům a mohou přispět k rozvoji elektromobility ve veřejné dopravě. Sedma kapitola popisuje typy elektromobilu od největších po nejmenší. Elektrické autobusy, které donedávna nebyly brány vážně, mohou proměnit svět městské dopravy a významně ovlivnit rozvoj ropného průmyslu. U veřejné dopravy se elektrifikace zdá být samozřejmou alternativou, jak udržet krok s městským růstem a současně se starat o městské prostředí, pomocí plně elektrických nebo hybridních autobusů. Se správnou technologií nabíjení lze využít výhody elektrifikovaných autobusů. Jedná se o menší spotřebu energii ve srovnání s autobusy se spalovacími motory, využití obnovitelné energie, menší hluk, nižší emise částic, méně CO2, nižší náklady na životní cyklus a spolehlivý servis. Autorka práce také vzala v potaz, že pokud se lidstvo zajímá o problémy životního prostředí a lidé chtějí dělat víc, než jen třídit odpad a používat méně plastů, pak nejen elektromobily, ale také elektrické skútry mohou pomoci naší planetě k menšímu znečištění.

Závěrečná část se zabývá vlivem ceny ropy na produkci elektrických dopravních prostředků a představuje prognózu dalšího vývoje. 21. století je zlomem v dopravní infrastruktuře. Svět se mění a dnes existují všechny předpoklady pro velký rozvoj elektromobilů, ale na zcela nové úrovni. Dnes není ropa tak levná jako dříve a největší průmyslové země se obávají své závislosti na svých dodavatelích. Technologie baterií výrazně pokročila. Ekologicky šetrná elektrická auta postupují rychle ve vývoji. Trendy posledních let v globálním automobilovém průmyslu slibuji naději, že v blízké budoucnosti bude možné pozorovat pozitivní vliv elektromobility na životní prostředí.

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