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Bachelor Thesis

Electromobility in selected European countries

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Electromobility in selected European countries

Objectives of thesis

The main aim of this thesis is to analyze in 4 selected European countries, namely the Czech Republic, Norway, France and Portugal and its approach to electromobility. In the Czech Republic, I compare an electric car with a petrol vehicle and also analyze the market share of individual brands.
The milestones are as follows for each country:
1. Analysis of the car market and share of electric cars
2. Development of the number of electric vehicles
3. Estimation of future production of cars and electric vehicles
4. Percentage of electromobility
Finally, their comparison and evaluation.

Methodology

In the theoretical part, the reader is acquainted with the main concept of electromobility, and more specifically with the electric vehicle industry. Development of electric cars from history to present, advantages and disadvantages of electric cars, charging station, its connectors and types of charging. All the information is then easier for the reader to understand in the practical part, where they are acquainted with the historical development of the car and electric market in selected European countries, namely the representative of the southern, western, northern and post-communist countries of Europe. An estimation of the linear trendiness of future production and the ratio of electric vehicles on the overall market in the countries is examined. The next section compares specific cars in the case study on comparable petrol and electric cars, the cost of their operation and cost-comparison analyses.

The proposed extent of the thesis

40 – 50 pages

Keywords

Electromobility, development of electromobility, charging stations, charging connectors, electric car market

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Declaration

I declare that I have worked on my bachelor thesis titled “Electromobility in selected European countries” by myself and I have used only the sources mentioned at the end of the thesis. As the author of the bachelor thesis, I declare that the thesis does not break copyrights of any their person.

In Prague on 23.3.2020 _____

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Electromobility in selected European countries

Abstract

The bachelor thesis is divided into two parts. The first theoretical part describes the concepts of Electromobility and its development in the EU. It describes the history of electric vehicles, types of drives, advantages and disadvantages of electric vehicles, charging stations, charging connectors and charging types.

The main objective of the practical part is the analysis or investigation of Electromobility development in selected European counties (Norway, France, Portugal, Czech Republic). Whether the Electromobility market has developed over the course of 6 years and what its potential future is.

Moreover, in the Czech Republic, an analysis of the market share of individual brands for both internal combustion engines and electric vehicles are examined, as well as an economic analysis of vehicle operating costs.

The results of the analysis showed that the electric vehicle is not as advance as it initially appeared. The key role here is the purchase price, which significantly exceeds the price, including the cost of servicing and the actual operation of the petrol vehicle.

Keywords: Electromobility, development of Electromobility, charging stations, charging connectors, electric car market

Elektromobilita ve vybraných evropských zemích

Abstrakt

Bakalářská práce je rozdělena do dvou částí. V první teoretické části se definují pojmy elektromobilita a její rozvoj v EU. Popsána je historie elektromobilů, typy pohonů, výhody a nevýhody elektromobilů, nabíjecí stanice, nabíjecí konektory a typy nabíjení.

Hlavním cílem praktické části je samotná analýza neboli zkoumání rozvoje elektromobility ve vybraných evropských státech (Norsko, Francie, Portugalsko, Česká republika). Zdali se v průběhu 6-ti let trh s elektromobility rozvinul a jaká je její potenciální budoucnost.

V České Republice je navíc zkoumána analýza podílu na trhu jednotlivých značek jak pro spalovací motory tak pro elektromobily a také je zde zpracována ekonomická analýza nákladů za provoz vozidel.

Výsledky analýzy ukázaly, že elektromobil není tak značně výhodný jak se ze začátku jevil. Klíčovou roli zde hraje pořizovací cena, která značně převyšuje cenu včetně nákladů za servis a samotného provozu, benzínového vozu.

Klíčová slova: Elektromobilita, vývoj elektromobility, nabíjecí stanice, nabíjecí konektory, trh elektromobilů

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1 Introduction

Nowadays, in the 21st century there are new trends in style innovations, technologies and the term Electromobility is one of them. Electromobility is one of the most up to date subject in the world today. Because the area of transport and tourism is still one of the most discussed topics along with it the pollution of the environment. Especially growing number of vehicles that is increasing every year is not improving our environment and health as well. Therefore, people are trying to find an alternative way that would at least contribute a little. With that being said, there was an idea to start with Electromobility including electric vehicles. Electric motors should replace internal combustion engines, and which would lead to sustainability. Next criteria why people should prefer electric vehicles to common ones is to preserve oil sources. Nobody knows when this time will come and if it really will disappear, but its price will one day increase and might be only accessible to other more important industries.

Electromobility in the Czech Republic is not yet as developed as in other countries, but our country is trying to develop and keep up with other countries for this improvement environment and health.

This is why this topic of Electromobility will be disassembled in my thesis. To bring awareness to readers and introduce them to this topic of Electromobility in the Czech Republic as well as in the rest of the world and why Electromobility should be a subject to give a thought to.

2 Objectives and Methodology

2.1 Objectives

The main aim of this thesis is to analyse in 4 selected European countries, namely the Czech Republic, Norway, France and Portugal and its approach to Electromobility. In the Czech Republic, I compare an electric car with a petrol vehicle and also analyse the market share of individual brands.

The milestones are as follows for each country:

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2.2 Methodology

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Theoretical part

3 Electromobility

„Electromobility represents the concept of using electric powertrain technologies, in-vehicle information, and communication technologies and connected infrastructures to enable the electric propulsion of vehicles and fleets. Powertrain technologies include full electric vehicles and plug-in hybrids, as well as hydrogen fuel cell vehicles that convert hydrogen into electricity. e-Mobility efforts are motivated by the need to address corporate fuel efficiency and emission requirements, as well as market demands for lower operational costs. “(6)

The main reason why Electromobility is brought back to our attention is the environment. That’s why the world-wide situation of the environment is getting worse than ever before the Electromobility is discuss more intensively. The most, attention is paid to zero local emission which pollute our big cities the most where the traffic is obscene. Even though Electromobility does not offer absolute zero carbon footprint. The electric vehicle is expected to last up to 1 mil kilometres. Electric vehicles can be equipped with A/C which can be turned on remotely. One of the main disadvantages of the electric vehicles is their dependency on the electric source, manufacture of batteries itself, higher purchase price and more. It will be discussed in following chapters. (33, p.149)

In the case of high dependency of the so-called dependent traction, it would be necessary to have such a power line infrastructure from which electricity would be drawn. With independent traction, electric vehicles require expensive batteries. Such a battery capacity limits finish mileage of electric vehicles and the infrastructure of charging station is not as developed. In addition, charging and fast charging is considerably longer compared to combustion engine vehicles. The battery loses its capacity during cold/ hot weather just as cell phones do. Which causes battery not to be able to be charged fully as a new one which also limits the finish mileage of the electric vehicles. People are most discouraged by the price of electric vehicles, which is at least half higher than a combustion engine vehicle of the same class. Before the Electromobility reaches its peak, it will take some time even though most countries are participating. (33, p.149)

3.1 Electromobility in EU

In Europe, the whole development of Electromobility has expanded, its speed is almost unbelievable, as it is growing in some states, and so in the future it is assumed that all EU countries will give in and start with a great development of Electromobility.
The European union of energetic policy on climate and energy in years 2030-2050 has big intension and goals to achieve an environmentally friendly and more sustainable economy and energy system in EU. By the year 2020 their goal is to reduce greenhouse emission by 20% and these emissions had been already reduced by 23%.
The European council has strategic goal to achieve to 2030 and 2050 following goals. For year 2050, the EU aims to be "clime-neutral" and have the net-zero greenhouse emissions. (3;5;8)

The 2030 goals:

- Rise up to 35 million of electric vehicles
- 40% reduction in greenhouse gas emissions
- 27% consumption of RES- renewable energy source in energy
- 30% reduction in primary energy consumption

The 2050 goals:

- Rise up to 190 million of electric vehicles
- 80-95% reduction in greenhouse gas emissions
- decarbonised transport system
- lower CO2 and air pollutant emissions
- 80% share of electric vehicles will reduce direct emissions from road transport

Another more goals according to J. Liebl to the year 2025 mostly in Europe will be about 5 milion of electric cars on the road. The main aim mostly of policies of climate is considerable decrese and reduction of CO2- emmisions by 60%. To the year 2050 reduction of use of combustion engines in cities is about 50%. With all technoligal smart technologies as well as incresingly price of oil (petroleum), it can be considerably said that the e-mobility in Europe is going up. After all the main aim of the increase of e-mobility is generation of energy from renewable sources used to decrease CO2 in coming years. The major opportunity is the fact that electric cars use batteries which helps to store the energy which

helps overcame an issue with renewable energy which is used for example when the sun is shining, and the wind is blowing. The function of battery and energy management system in the electric car can easily find out and control of availability of renewable energy. (20, p.288) Is should be mentioned the statistic of vehicles were registered by fuel type in the EU in 2019. According to ACEA- European Automobile Manufacturers Association the chart shows the percentage of market share of vehicles. Namely Petrol, Diesel and alternative-powered vehicle. Petrol vehicles make most of the EU market almost 60% while Diesel has only 30% and the APV the rest 13.2%. But in the last quarter of 2019 the demand for AVP significantly increased. Mostly the Electric vehicles was the main growth up to 80.5% 155,583 units in total across the EU. But the Hybrid vehicles are still the majority of AVP. Respectively 253,593 units were registrated in the last quarter 2019. (26)

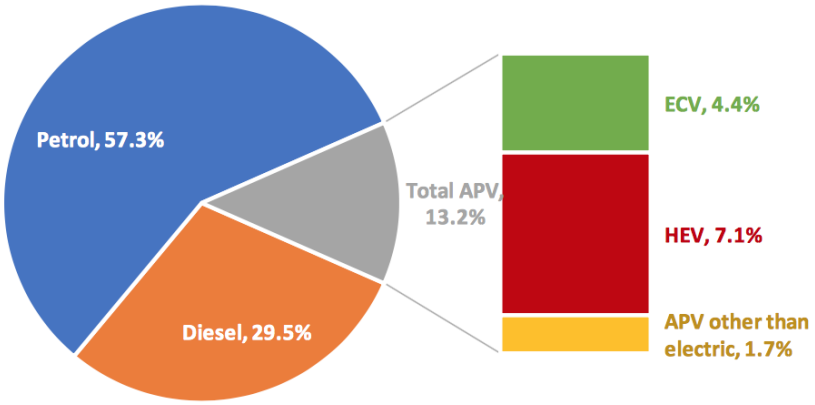


Figure 1 Fuel types of new cars in 2019 in EU
Source:https://www.acea.be/uploads/press_releases_files/20200206_PRPC_fuel_Q4_2019_FINAL.pdf

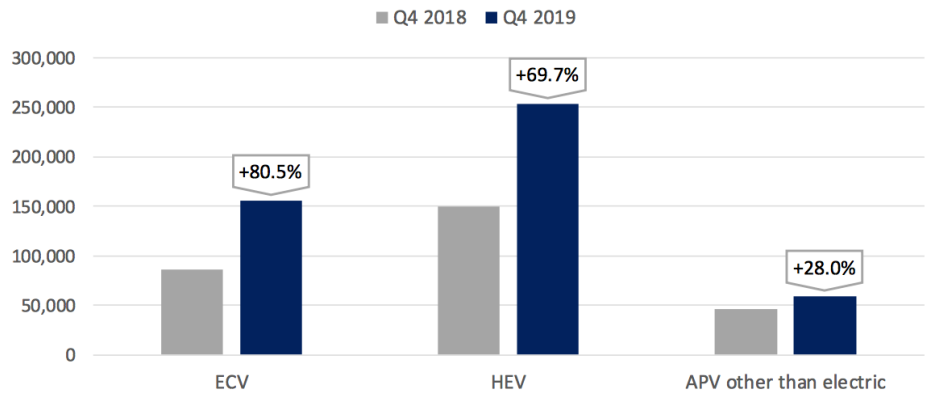


Figure 2 AVP registration from October to December 2019
Source:https://www.acea.be/uploads/press_releases_files/20200206_PRPC_fuel_Q4_2019_FINAL.pdf

3.2 History of Electromobility

The history of electric cars has been classified in 3 parts: The Early Years (1890-1929), Middle years (1930-1989) and the Current years (1990 - present). First countries who tried to develop electric cars were France and England about in 1895. In 1881 in France M. Raffard invented Hillman Socialbe tricycle. (1, p. 17)

In the Czech Republic in 1859, it needed to be thanked to Ing. František Křižík, who produced his first electric vehicle with the power of 3,7kW. This vehicle was powered by a direct current electric motor and was charged only with a lead-acid battery. Such a typical electric vehicle was driven by a lever later by a steering wheel, and the whole vehicle was driven classically by a pedal. The electric motor was located at the rear above the rear axle. After a huge success, he built other vehicle a hybrid vehicle that was powered by two electric motors with power 2x2,2kW. He had to add to this vehicle also a petrol motor with dynamo which recharged batteries and extend the finish mileage. (18, p. 4-5)

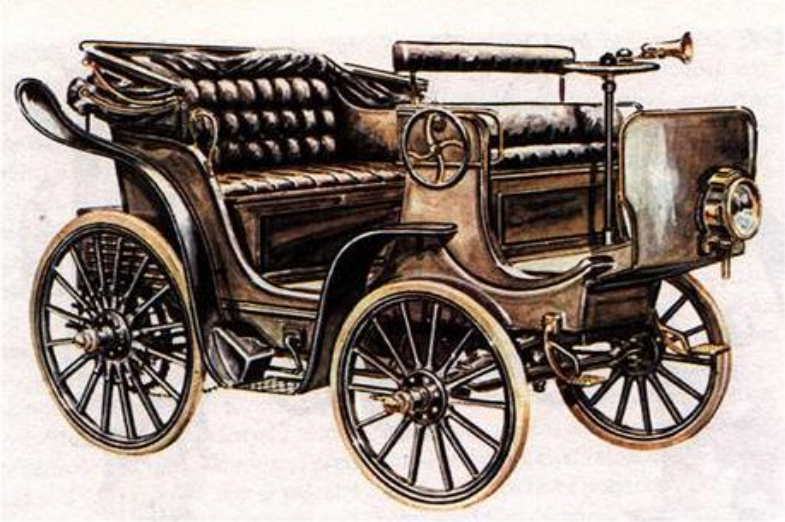


Figure 3 The elecric vehicle of František Křižík
Source: https://fdrive.cz/clanky/1-era-elektromobilu-185

The biggest boom of these vehicles became in the USA, where electric vehicles became less than 40% the main ways of transport. In the USA, especially in New York it is also mentioned the first electric taxi where politician William Whitney became famous. His goal was not to charge the batteries again and again but only replace them with a new one. However, storage of these batteries did not work, and taxi became faulty and politician Whitney began to lose. (12)

Electric vehicles seemed to be the best choice, the electric car is easily operated. Against the petrol cars it has noiseless motion, easier starting, does not pollute so much, cheaper cost of upkeep, no smell, no consumption of energy while car is stopped. However, the disadvantage of electric vehicles is high load capacity, maintance, battery renewal and rechargeable time. (1, p. 18)

In 1990's in the USA major decrease of production of spare parts for common vehicles overwhelmed the market as making of the batteries became costly. The vehicle was just cheaper in every way. That's why the combustion engine vehicles became number one on the vehicle market. The main contribution is due to Henry Ford which has created combustion engine vehicle called Model T, the model was about half of the price of the electric vehicles not that heavy, strong, simple design and everyone can easy to fix. Henry Ford has great success with this Model T so his goal was to manufacture Model T faster and for less money which would be available for everyone. (29, p.4-6)

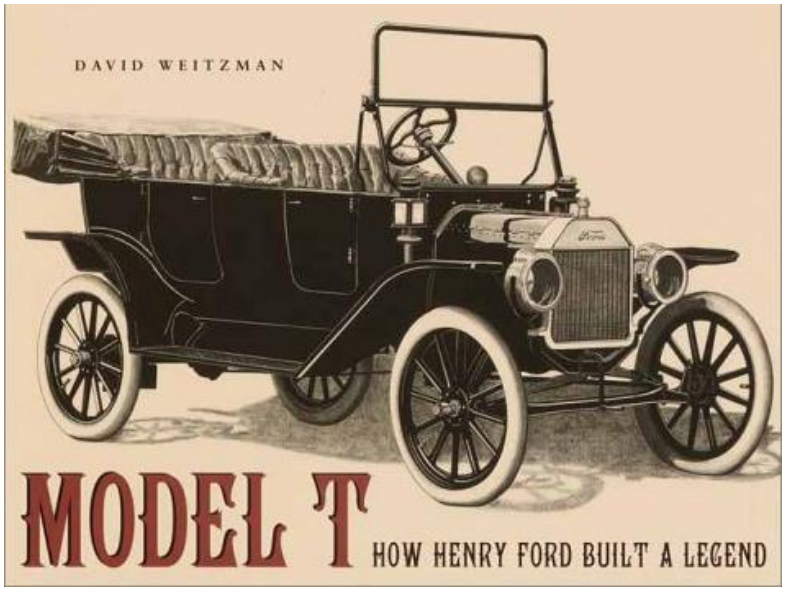


Figure 4 Model T of Henry Ford
Source: http://www.eurooldtimers.com/cze/historie-clanek/771-jenatzy-krizik-jeantaud-a-elektromobily.html

3.2.1 Electric vehicles nowadays

Electric vehicles have been manufactured for more than 150 years and nowadays so many electric vehicles are no different from combustion engine vehicles. The construction of the whole vehicle is very similar to the combustion engine vehicle, it could be said that the combustion engine vehicle is the model of electric vehicles. (12)

For driving of electric vehicles is only electric drive is used without any connection of a combustion engines. There is no multi-speed gearbox found and therefore no shift lever in the electric vehicle. The shift lever replaced only the drive control (forward / reverse and parking). The electric motor is easy to maintain there is no need for liquids or oils. The most problematic part of the whole electric vehicle are the batteries themselves. The batteries are the most expensive and heaviest part of electric vehicles. The whole battery affects the finish mileage of the entire electric vehicle and also its charging takes longer than refuelling a combustion engine vehicle. The average lifespan of combustion engine vehicles is around 14 years, while such an electric vehicle lasts 8-15 years depending on the number of charging cycles, hot/cold weather etc. (14, p. 123-124)

3.2.2 Most innovative vehicles nowadays

One of the best-selling designed electric vehicles in the world is the American company Tesla Motors which is known for its attractive design, technology and electric transport. Its best-known models are Model S, X,3 and of course the other types of Tesla. However, Tesla motor has also an innovative competitor called the Nikola Motor Company which is known for manufacturing electric vehicles components. This company tried to take a different approach and has been focused on the production of hydrogen-powered trucks that no one tried before. Nikola's one trucks will have a natural gas generator, in each wheel an electric motor and what is amazing the finish mileage will be around 1,930 km. The trucks will come to market this year with a price around 8,9 million CZK. (14, p. 126-127)

Figure 5 Electric truck of Nicola Motor Company
Source: https://autoroad.cz/technika/94406-nakladni-tahac-jako-obri-cisticka-vzduchu-nadejny-konkurent-tesly-slibuje-nevidane

3.2.3 Types of electric vehicles

It cannot be said that only one type of electric vehicles exists with only one type of traction. On the contrary, there are already many other combinations of how to use electric energy to drive electric vehicles. Only the main types of electric vehicles can be found in the column below. (32)

Types

1) **Battery electric vehicle (BEV)**- an electric vehicle mostly called EVs are fully electric because they use only electricity for their chargeable batteries. Battery is recharged by charging stations which are classified by power. This EVs has any harmful emissions while driving. (32)
   For example: Nissan Leaf, Kia Soul, Volkswagen e-Golf, Tesla Model S,3 etc.

2) **Hybrid electric vehicle (HEV)**- a hybrid electric vehicle that uses a combination of a combustion engine and electricity. The battery is recharged by own braking system called regenerative braking. Therefore, this hybrid vehicle cannot be charged from the charging station. HEV during starting off uses electric energy when the HEV is speeding up the combustion engine turns on. Everything is controlled by an internal computer which automatically selects an economic power source while driving. (32)
   For example: Ford Fusion Hybrid, Toyota Prius Hybrid, Hyundai Ioniq and others.

3) **Plug-in Hybrid Vehicle (PHEV)-** an electric vehicle that is similar with the HEV. Difference is just in charging. Battery can be recharged by regenerative braking and by the charging stations. PHEVs can drive without turning on the combustion engine almost 50 km. (32)
   For example: Kia Optima, BMWi8, volvoXC90 T8, Ford Fusion Energi etc.

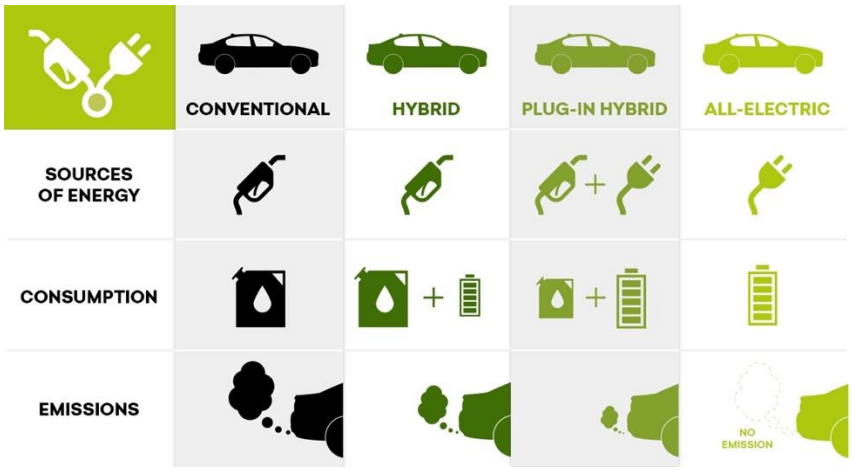


Figure 6 Division of electric vehicles
Source: https://www.skoda-storyboard.com/en/innovation/mobility/types-of-electric-vehicles-do-you-know-them-all/attachment/infographics-electrovehicles-english/

3.2.4 Advantages and disadvantages of electric vehicles

There will not be mention all the advantages of electric vehicles there are so many more and each of them would be an extensive topic. The only few important ones were chosen here which every owner should know about the vehicle. (13, p.47; 18, p. 8-17; 7)

Advantages

- **Zero emissions**

Anyone who thinks more about the environment and not just about saving their cost is without emission traffic. An electric vehicle may seem totally emission free, but the opposite is true. Manufacture of vehicles especially the batteries and the energy which the electric vehicles use while driving they get to the environment more pollution.

- **Lower operating costs**

People who buy electric vehicles they mainly think about their savings. If you calculate spending on electric energy is much lower than spending on petrol or diesel that is getting

higher every year. In addition, you can get the energy from renewable sources and the spending will be lower.

- **Charging from any power socket**

Drivers can charge the electric vehicle from any power socket within reach and from home. Unfortunately, charging is not as fast as from the fast charging stations. Building of these charging stations are still increasing mostly it can be found these on the parking lots near to large companies and on the parking lots next to shopping centres.

- **Simplicity and reliability**

An electric vehicle is very simple to operate and also very reliable. It has only few of components. There is no need to change so many components many times during driving as (filters, oil, brake pads, plugs etc.) as it in the combustion engine vehicle. In an electric car is needed to change the bearings and the battery after some mileage. The battery life depends on the number of charging cycles.

- **Acceleration and recuperation**

As it already known among other advantages is the quick start of the electric vehicle. Because there is no transmission as in combustion engine vehicles. So sometimes take off of electric cars are faster than the combustion engine vehicle. For example, Volkswagen E-golf can handle this acceleration from 0 to 100 km/h in less than 10 seconds. But there is also needed to think about the recuperation which is stored into the battery while the vehicle itself starts to slow down.

- **Silence**

Electric motors reduce noise pollution while driving so for people mainly lived in large cities is a big a relief (no noise, better sleep, comfort etc.)

Disadvantages

- **Higher price**

Price of electric vehicle is still high and most of us cannot afford to buy it. Its price is still higher above the price of combustion engine vehicles, so every buyer prefers to buy a cheaper option. Comparison of price of vehicle and petrol vehicle will be described in the practical part.

- **Short driving range**

What drivers worry about the most is the finish mileage of electric vehicle. Every vehicle has different finish mileage, some electric vehicles have the mileage about 300 km and

some just about 150 km. But it could be said for city driving suffice just around 50 km but otherwise, if one wants to go for a trip it need to be properly planed first and be aware of where the charging stations are and if there is the right power socket with.

- **Long-time charging**

If users will charge an electric vehicle at home from a normal power socket the time will be around 10-12 hours. Of course, there exists another type of electric stations, but it will be discussed later. If a longer trip is planed it is recommended to charge the electric vehicle to full, but it will surely affect the battery life / reduce number of charge cycles.

- **Low number of charging stations**

There are still a low numbers of charging stations in the Czech Republic and Europe. Building of charging stations cannot compare to production of electric vehicles. There are many vehicles per one charging stations.

- **Parking in the underground garages**

In the modern world, architects are always trying to figure out parking solution as there are less and less spaces and more and more vehicles. There is a solution to the problem in a form of underground garages which however are not very safe for electric vehicles. Should electric vehicle catch on fire it would make it very difficult for firemen to get heavy equipment down to the underground parking and let alone quickly put the fire out. Their lithium-ion batteries will melt and take dozens of minutes to put the fire out of them. To put the fire out completely it can take up to several days. Another issue can be that these batteries can set on the fire after being cooled down.

- **Silence**

Even though the silence is mostly advantage some can find it as a disadvantage. In some sense the silence can be quite dangerous for most pedestrians. This can be dangerous and can lead to accident as pedestrians are used to hear the motor engine.
(13, p.47;18, p. 8-17; 7)

3.3 Charging stations

Nowadays, charging stations are the main problem of many European countries. Charging stations are the main part of operation of electric vehicles, their development is increasing year by year. There were built almost 400 hundred public AC charging stations with a few kW and also a few of private charging stations in Czech Republic.

Distributors of charging stations

The main distributors of these stations in the Czech Republic are for example ČEZ, E. ON or PRE. PRE-energy is mainly use for city of Prague. It is important to know before a use of charging station that each has different regulations.

Identification

One can be notified via: key, personal identification number, transaction number, identification card also via smart phone, sms, app, website and also by charging cable communication (Plug & Charge).

Payment

There are several methods include: direct payment, credit card, via cell phone bill or with a registered card at the charging station operator.

The electric cars can be charge by several possibilities: Conductive charging, Inductive charging, battery switching. Conductive charging will be explained further. (38, p. 11-18; 28)

Figure 7 Charging station

Source: https://u92slc.com/life/new-charging-station-in-sandy/,

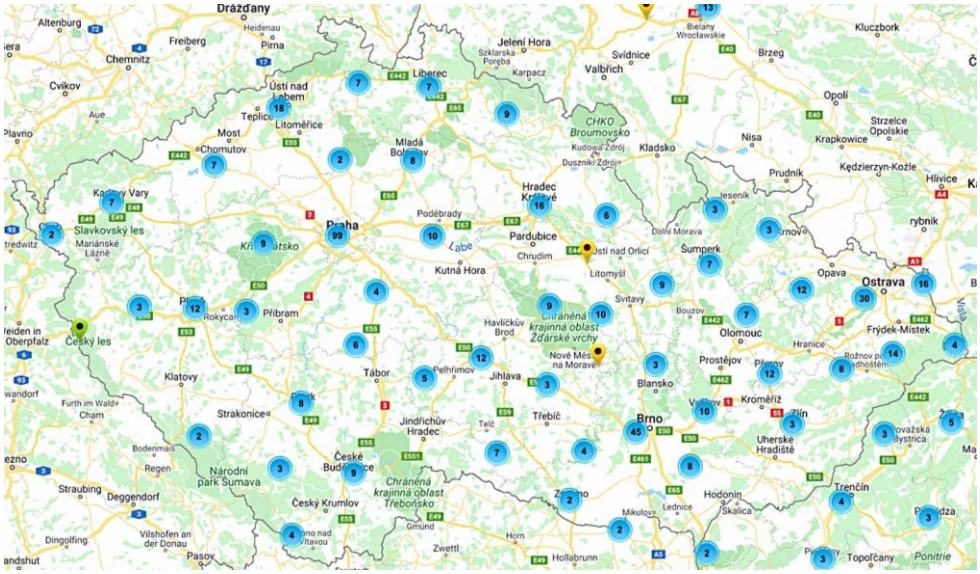


Figure 8 Map of charging stations in Czech Republic
Source: https://www.evmapa.cz/stanice?evmapa=1

3.3.1 Charging Connectors

Every charging station include specialized cable which can be connected to your electric vehicle. But there is a chance that some charging stations may be missing these cables therefore it is advices for drivers have their own. It is a good practise to check which type of connector each charging station has. (24)

These connectors are regularly described by standard IEC62196. Which outlines general description of electric vehicle and charging stations and also design of plugs, socket-outlets, vehicles connectors and inlets for AC/DC power. The type of connector has to be standardized which is the main goal of the EVS26 conference. Also, well-known producers have been striving to achieve this goal however it has not been reached yet. (34)

Figure 9 Charging connector types
Source:https://evcharging.enelx.com/eu/about/news/blog/552-ev-charging-connector-types

- **IEC 62196**

The most use charging connector it's called Mennekes Type 2. Used mainly in the EU since 2013. This type has a charging power up to 22kW. When charging for an hour, the electric car can be charged up to 100%. (24)

- **CCS 1 / CSS 2**

Next type in the European Union appeared so-called Combo connector type or CSS-Combined Charging System after agreement with North American car manufacturers. With this type, the charging is a little faster therefore the charging station calls fast charging stations using DC-direct current. By this type of charging there can be two vehicles charged at the same time. This type has power up to 50kW. In less than 20 minutes the electric vehicle can be charged from 0 to 80%. (24)

- **CHAdeMO**

This Japanese type (Charge de Move) is rare to find in the European countries. These charging stations are used primarily in Japan but can be found also in Germany and Great Britain. It is same fast charging station as CCS1/ CSS 2 using the DC. To view the differences, see the figure above. (24)

- **Tesla Supercharger**

These connectors are used for electric cars brand Tesla as it known from the name. This connector contains power up to 125kW. (16)

3.3.2 Types of charging stations

Conductive charging

Electric energy needs to be transferred to the electric vehicle via an electric cable and a connector. Which has been already mentioned. The battery needs to be charged via a direct electric current (DC) however, the electric vehicle can be also charged via alternative current (AC) which is modified to the DC.

Direct electric current (DC)/ off board - the charger is located outside the vehicle.

Alternating current (AC)/ on board- the charger is located inside the vehicle.

- **Slow charging**

a) Power: up to 3,7 kW (16 A, 230 V, AC)

- **Normal charging**

a) Power: up to 7,4 kW, (32 A, 230 V, AC), Time: full charge in 3 hours

b) Power: up to 13,9kW (20 A, 400 V, AC), Time: full charge in 1,5 hours

c) Power: up to 22,2 kW (32 A, 400 V, AC), Time: full charge in 1 hour

- **Fast charging**

a) Power: up to 43,6 kW (63 A, 400 V, AC), Time: full charge in 30 minutes

b) Power: up to 50kW (CHAdeMO, CSS, DC), Time: full charge in 26 minutes

- **Ultra-fast charging**

a) Power: over 50 kW

- **Tesla Supercharger**

a) Power: V2 up to 150 Kw

b) Power: V3 up to 250Kw

1) Home charging stations

Conventional charging stations or home charging stations are the easiest and most convenient way how to charge your electric vehicle from an ordinary home power socket. Classical power socket has 230V and from this socket can be charged every electric vehicle. From this power socket, electric vehicle changes the AC-alternative current on the DC- direct current. Every hour in the voltage can extend the mileage of electric vehicle about 14 kilometres. Another type of power socket with 16 V can be mostly found in family houses and used for example at circular saw. Electric vehicle can have mileage up to 55 kilometres with this power socket. However, a special connector is needed for this type. (28)

ČEZ, E. ON or PRE-energy are main producers or distributors of electric energy have special tariffs for electric vehicles C27d for companies and D27d for personal electric vehicles. Charging costs is reduced in half. The tariff can be used at least for 8 hours at time form 18.00 PM till 6AM. Common price of energy without any special tariffs is around 4,80 CZK/kWh for every distributor. Prices of stations are from 10,000-100,000 CZK same as for public stations, depending on the voltage. (17)

Example:

E. ON cost with/without tariff is 3 CZK/kWh - 4,10-4,5CZK/kWh.

Renault ZOE R110:

- Usage average cost of E. ON electric power without special tariff: 4,10 CZK/ kWh = average consumption: 17,2 kWh/100 km=71 CZK
- Usage average cost of E. ON electric power with special tariff: 3CZK/kWh=average consumption: 17,2Kwh/100 km= 52CZK

Wallbox or wall charging station up to 22kw/32A. Each wallbox has various socket outlets or connectors. These wallboxes reduce the charging time by half than the regular power socket but the price is higher. The price range of the wallbox runs from 10 thousand up to 60 thousand CZK. Even a cheaper variation of the wallbox can reduce charging time in half. (35)

Figure 10 Wallbox by E. ON

Source: https://www.ecofuture.cz/clanky/wallbox-nebo-zasuvka-co-se-vyplati-a-proc

2) Public / conventional charging stations

Conventional charging stations are found in public places. Such as parking lots, apartment buildings, commercial buildings, shopping centres, etc. Public charging stations are built to be accessible for people living around. Company called ČEZ and E. ON are the main distributors of these stations in the Czech Republic. Price of public stations are from 20,000-100,000 CZK. (25)

Public charging station has power up to 22 kW with 2 possibilities of power sockets (16A-32A). Understandably these charging stations are protected from dangerous and illegal use. (17)

3) Fast charging stations

Fast charging stations are available for public and include direct current- DC up to 50Kw and also the cable with CCS connector and CHAdeMO. It is possible to fast charge the

electric vehicle with this type of fast charging in little as 20-30 minutes up to 80% of the battery. Price of such station runs from 400,000 CZK-700,000CZK. (28)

4) Tesla Supercharger

Supercharger stations are design for fast, reliable and convenient long-distance travel. Tesla company started to build a new generation of charging stations called V3 which is faster than the previous station V2 which can be found in Europe as well. V2 charger has the power up to 150 kW and for the V3 up to 250 kW. This new V3 station has a new cable which is cooled by liquid and therefore it can deliver up to 250kW. There is also another innovation of full power from stations when charging more electric vehicle at the same time. (38, p.13-14)

With 250 kW of power can an electric vehicle be charged up to 120 km only in 5 minutes. Cost of this charging time in the Czech Republic now is 6,3 CZK /kWh. Tesla Model S 18,1kwh/100km= 114 CZK. Cost of this stations are around $270,000/ 6,750,000 CZK. Tesla supercharger is mostly located in the USA but also in Europe where are more than 4700 stations. In the Czech Republic, few of them are in Prague, Humpolec and in Olomouc and they are still increasing. (15; 25)

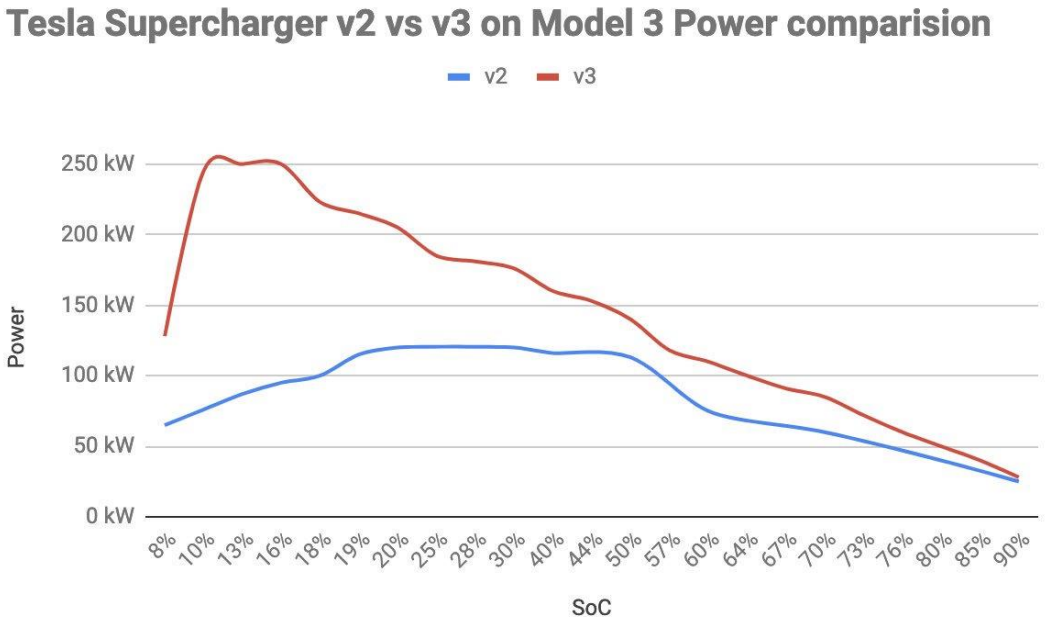


Figure 11 Tesla Supercgarger V2 versus V3
Source: https://www.elonx.cz/tesla-predstavila-vylepsenou-nabijecku-supercharger-v3-s-dvojnasobnym-vykonem/

3.3 Measurements of vehicle distributors

3.3.1 Market Share

„Market share can be defined as the representation of the percentage of the market's total revenue or of an industry which shall be earned by a particular firm over a specified period of time". (21)

Figure 12 Market Share formula

Source: https://www.wallstreetmojo.com/market-share-formula/

In this case, the market share helps to calculate in the practical part the % share of individual brands of electric vehicles and petrol/gas vehicle on the market. It is a calculation of individual sold vehicle brand divided by the whole sold vehicles x 100. The market share will be in % for each brand.

3.3.2 Herfindahl-Hirschman Index

„Herfindahl-Hirschman Index or HHI score refers to a measure of market concentration and is an indicator of the amount of competition in a particular industry.
E.g. if there's only one firm operating in an industry, holding 100% market share, it's respective HHI would be exactly 10,000 or 1 and would indicate a monopoly." (11)

The HHI helps to analyse and observe the level of competition of car brands in the practical part. First it is needed to calculate the market share of individual vehicle brand. To assess the level of concentration of each vehicle brands.

If the HHI is:

- less than 1,500= Market is competitive
- between 1,500-2,500=Market is moderately concentrated
- equal or greater than 2,500=Market is highly concentrated

The s_n is the market share percentage of firm n.

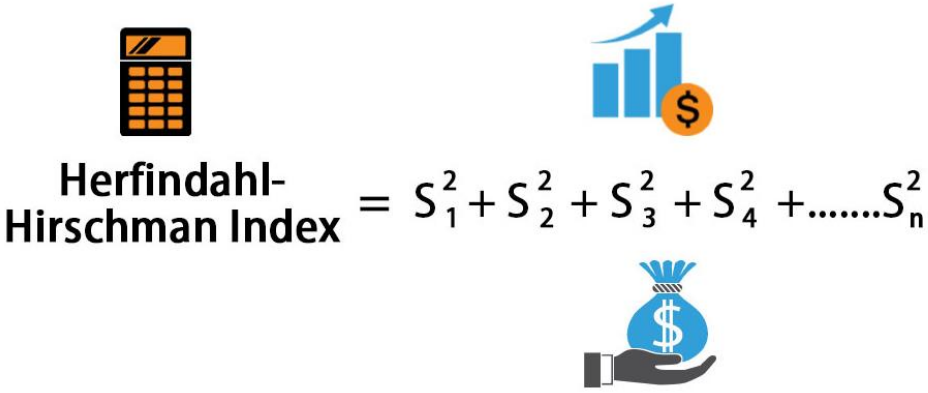


Figure 13 Herfindahl-Hirschman Index formula

Source: https://www.wallstreetmojo.com/herfindahl-hirschman-Index/

Practical part

4 Situation in selected European countries

First of all, it is important to introduce and define the Car market in selected European countries. Show the trend from previous years and calculate how the historic trend in E-Cars market in selected European countries looks like. As mentioned before, positive trend has been noticed in previous years in E-cars, especially in eco-friendly countries such as Norway, Sweden, Ireland, California and Netherlands. At the beginning of 21th century a report about Electromobility progress was published. Which one of these was written by Michael H. Westbrook in 2001. The prediction is that electric vehicles would have the highest market share from all kinds of vehicles in 2025. This estimate looks very realistic in some countries at the moment especially in those previously mentioned but globally is the situation bit different. Author's future forecast is not so optimistic, yet still, the position of E-Cars will strengthen. (36, p. 6-8)

4.1 Electromobility in the Czech Republic

For the Czech Republic to be on the level of comparing countries, The Czech Republic needs to get up to speed with net mobility.

Car industry in the Czech Republic needs to make changes and significant technological innovations. The number of electric cars in the Czech Republic is increasing but charging stations are behind. This year in 2020 ministry of transport has vision to let build 1,300 of charging stations and on the Czech road will be around 250, 000 of electric vehicles. However, this number is still low in the Czech Republic. Without increase of public charging stations and get the Electromobility up to speed is not possible to compete with other countries. (22)

Unfortunately, the Czech Republic with the development of Electromobility ranges on the 18th place, according to Lease Plan. To put things in prospective, the Czech Republic is lacking in the number of charging stations as it mentioned before. Also, with not much support from the government. (4; 37)

Financial incentives:

- Zero Road Tax
- Free parking in big cities
- Add allocation to Electromobility 50 million CZK for companies
- 33% subsidies for companies and public institutions to purchase electric vehicles
- 80% subsidy for companies and public institutions to buy a charging station

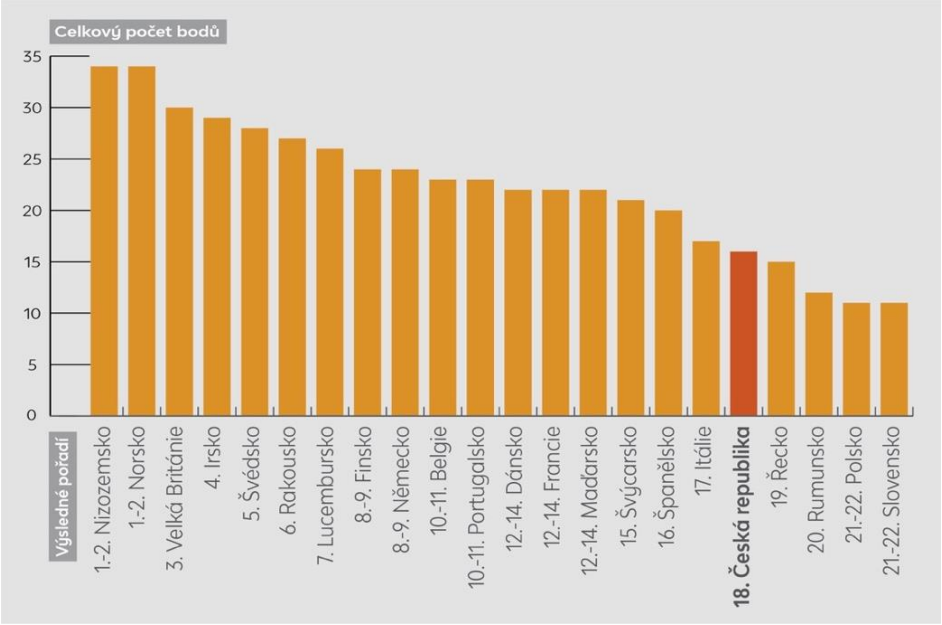


Figure 14 Index of Electromobility development in 22 countries
Source:http://www.e-flotila.cz/aktuality/2637-2020-leaseplan-elektromobilita-cesko-pruzkum-evropa

4.1.1 Electric vehicles sold in the Czech Republic

The chart below shows the progress of electric vehicles sold in 2013 up 2019. Only 37 units of electric vehicles were sold in the Czech Republic in 2013. The chart shows the yearly increase up to 1,232 units sold in 2019. However, the increase up to 3,000% in 7 years.

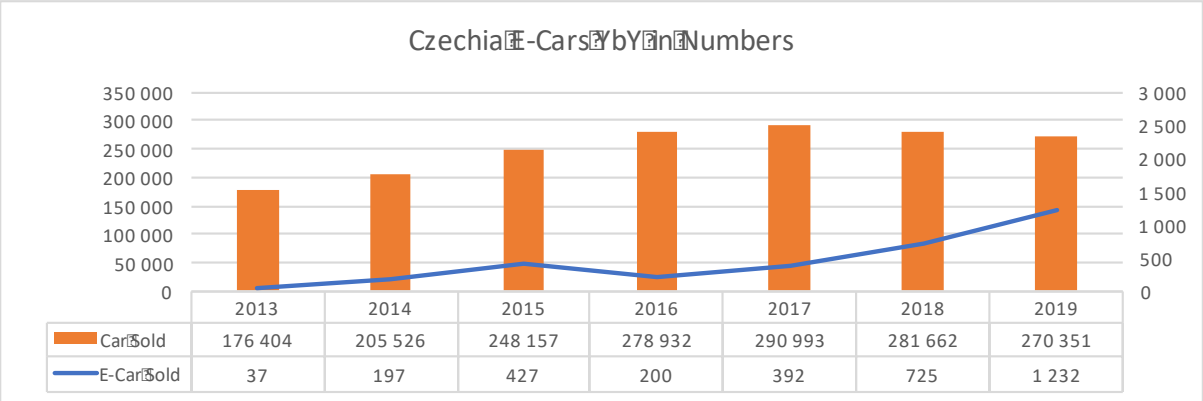


Figure 15 Electric vehicles sold in the Czech Republic
Source: MS Excel attachment

4.1.2 Trend of electric vehicles in the Czech Republic

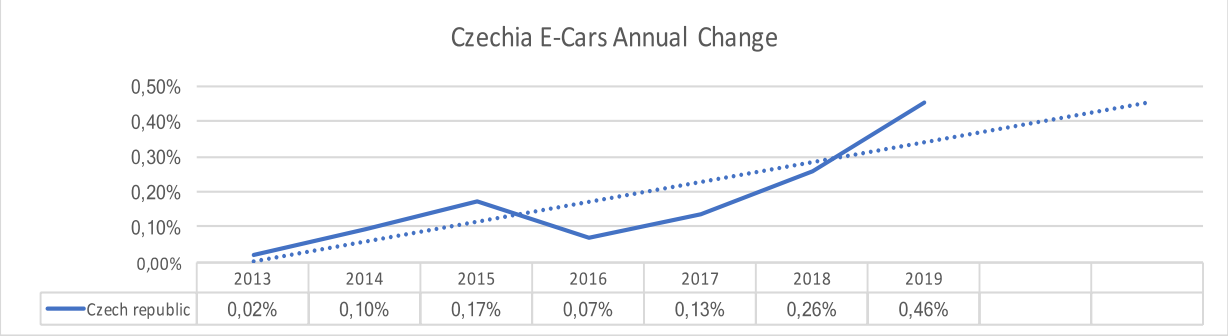


Figure 16 Trend of electric vehicles in the Czech Republic
Source: MS Excel attachment

Year	Chain Index E-Cars
2013	100
2014	532,4324324
2015	216,751269
2016	46,83840749
2017	196
2018	184,9489796
2019	169,9310345

Table 1 Chain Index of electric vehicles in the Czech Republic
Source: MS Excel attachment

When estimating the development of electric vehicle sales, it is important to first determine the historical development of the number of electric vehicles is decreasing or increasing and in what way. The table above shows the total annual sale percentage of electric vehicles. To compare the sale of electric vehicles increased by 0,13% in 2017. To better estimate, the trend in the table below the graph is calculated the Chain Index which is

always calculated year-on-year basis. The new year value divided by the previous years' value multiplied by 100.

It follows that:

- The Chain Index is equal to 100 = constant development
- The Chain Index is less than 100 = downward trend
- The Chain Index is higher than 100 = curve is increasing

A slight decline in sales can be seen In the Czech Republic except for 2016. Unlike in other years the increase is always significantly higher. This also follows from the annual ratio as seen in the graph where the curve resembles a linear trend.

4.1.3 Future forecast of electric vehicles in the Czech Republic

To illustrate the market progress of electric vehicles better there is a chart on estimate future development of electric vehicles sales below. Should this trend continue there might be up to 2,000 electric vehicles sold in 2024. This forecast is based on the calculation of linear trend for both vehicles as well as electronic vehicles. The author is aware this calculation does not include economical aspects, such as regression, financial crisis, etc. This is just to imagine what it might look like if the present trend continues for the next 5 years.

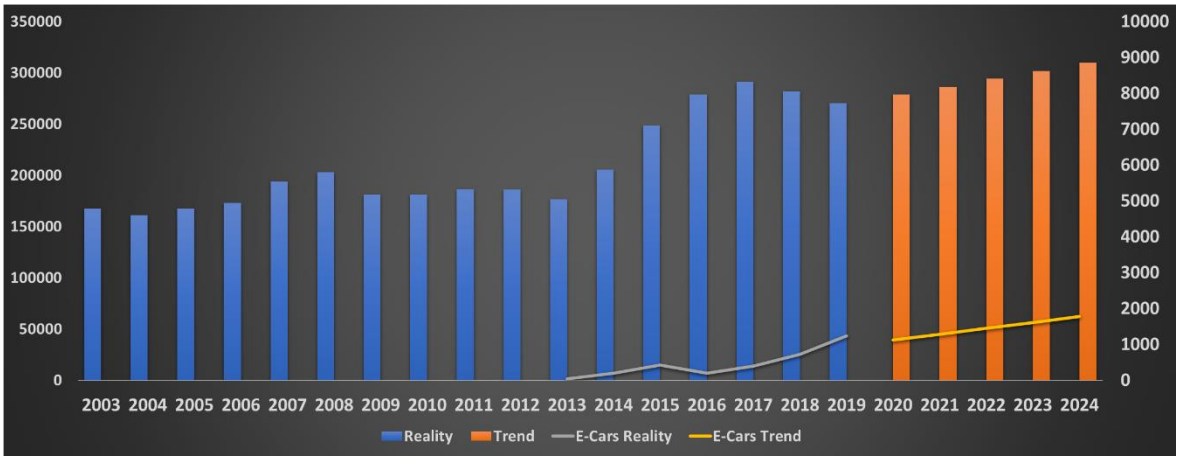


Figure 17 Forecast of electric vehicles in the Czech Republic
Source: MS Excel attachment

4.1.4 Market Analysis and Market Shares in the Czech Republic

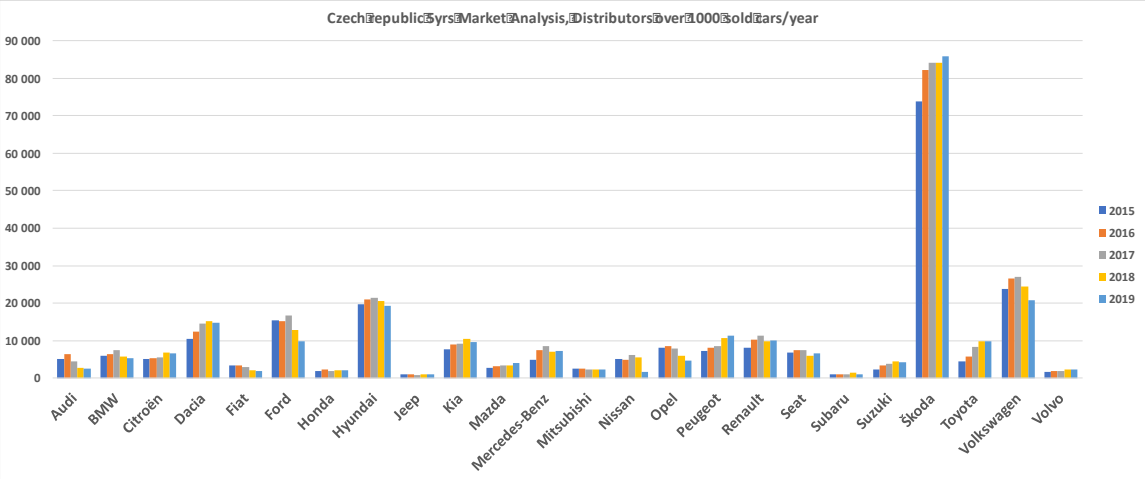


Figure 18 Market Analysis and Market Shares
Source: MS Excel attachment

In chart above shows total sold vehicles sorted by car brand each year. For example, Renault sold 10,000 vehicles in Czech Republic in 2019. By no surprise Škoda brand is the strongest one in past 5 years.

The table below shows the calculation of brand vehicle market shares in the Czech Republic. First of all is important to define the calculation method. It is number of sold vehicles of one brand divided by the total number of vehicles sold. Example of is that Renault sold 10,101 cars in 2019. Total number of vehicles sold in Czech Republic in 2019 is 249,915. The market share is 4,04%. Number data vehicles sold in this table are from Car Importers Association.

Top 10 brands are highlighted in this table with highest market share and Herfindahl-Hirschman Index. As previously mentioned before Škoda Auto has more than 33% market shares and is the strongest, which means one-third of the vehicle market in the Czech Republic is owned by Škoda Auto. An interesting decreasing trend of Opel and Seat and increasing position of Toyota and Dacia can be noticed by observing these brands. By Herfindahl-Hirschman Index as was mentioned before is evaluated market concentration and prospective monopoly or oligopoly on that market. The vehicle market in the Czech Republic has HH Index values between 1287,2 and 1470,2 which makes it a very competitive marketplace

CARS TOTAL										
Brand	Market Share					HH Index				
Brand	**2015**	**2016**	**2017**	**2018**	**2019**	**20150**	**20160**	**20170**	**20180**	**20190**
Škoda	32,02%	31,68%	30,98%	32,20%	34,37%	1 025,4632	1 003,5311	959,7118	1 036,8400	1 181,2969
Volkswagen	10,29%	10,24%	9,92%	9,32%	8,35%	105,8735	104,9005	98,4048	86,8624	69,7225
Hyundai	8,53%	8,08%	7,89%	7,83%	7,72%	72,7306	65,3412	62,2007	61,3089	59,5984
Ford	6,68%	5,88%	6,13%	4,91%	3,90%	44,6846	34,5656	37,5554	24,1081	15,2100
Dacia	4,55%	4,77%	5,34%	5,82%	5,92%	20,7341	22,7185	28,4953	33,8724	35,0464
Opel	3,51%	3,26%	2,91%	2,31%	1,89%	12,3107	10,6201	8,4394	5,3361	3,5721
Renault	3,50%	3,93%	4,13%	3,79%	4,04%	12,2318	15,4148	17,0786	14,3641	16,3216
Kia	3,29%	3,44%	3,40%	3,99%	3,87%	10,8435	11,8457	11,5519	15,9201	14,9769
Peugeot	3,10%	3,12%	3,17%	4,13%	4,54%	9,6085	9,7166	10,0569	17,0569	20,6116
Seat	2,93%	2,85%	2,77%	2,32%	2,67%	8,5719	8,1329	7,6970	5,3824	7,1289
BMW	2,55%	2,48%	2,72%	2,22%	2,16%	6,4984	6,1726	7,4076	4,9284	4,6656
Citroën	2,18%	2,04%	2,05%	2,57%	2,62%	4,7738	4,1636	4,2150	6,6049	6,8644
Audi	2,17%	2,45%	1,65%	1,08%	1,04%	4,7266	5,9997	2,7282	1,1664	1,0816
Nissan	2,17%	1,92%	2,31%	2,09%	0,69%	4,7040	3,6922	5,3347	4,3681	0,4761
Mercedes-Benz	2,09%	2,89%	3,15%	2,73%	2,93%	4,3628	8,3808	9,8988	7,4529	8,5849
Toyota	1,89%	2,20%	3,07%	3,75%	3,96%	3,5685	4,8531	9,4024	14,0625	15,6816
Fiat	1,47%	1,31%	1,12%	0,82%	0,74%	2,1742	1,7181	1,2487	0,6724	0,5476
Mazda	1,14%	1,20%	1,21%	1,27%	1,63%	1,3048	1,4314	1,4683	1,6129	2,6569
Mitsubishi	1,05%	1,01%	0,83%	0,86%	0,90%	1,1071	1,0155	0,6808	0,7396	0,8100
Suzuki	1,05%	1,29%	1,39%	1,73%	1,74%	1,0952	1,6740	1,9442	2,9929	3,0276
Honda	0,78%	0,87%	0,72%	0,77%	0,83%	0,6052	0,7573	0,5219	0,5929	0,6889
Volvo	0,75%	0,74%	0,72%	0,85%	0,93%	0,5590	0,5506	0,5219	0,7225	0,8649
HHI						**1 359,2203**	**1 327,8211**	**1 287,1998**	**1 347,7872**	**1 470,1542**

Table 2 Market Share and HHI of total vehicles
Source: MS Excel attachment

4.1.5 Market Analysis and Market Shares of electric vehicles in the Czech Republic

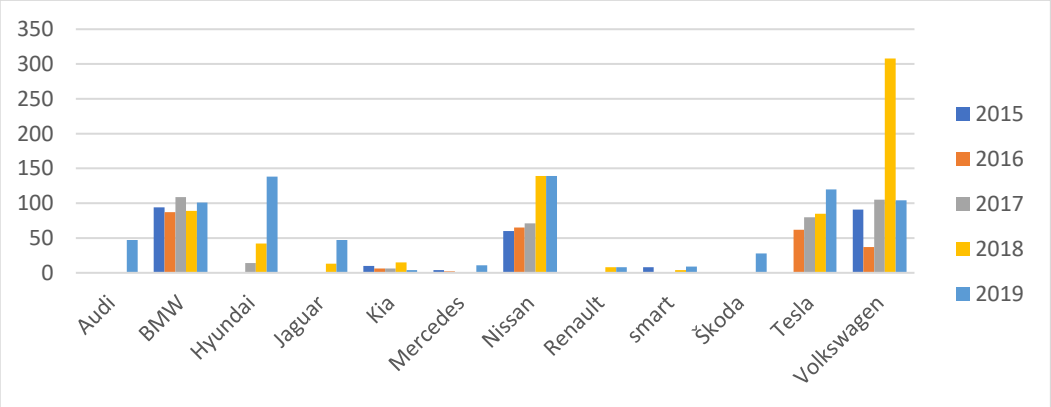


Figure 19 Market Analysis and Market Shares of electric vehicles
Source: MS Excel attachment

In chart above and table below are twelve most powerful vehicle brands on market with electric cars. It shows the strength of the position of vehicle brands such as Hyundai, Tesla and most likely in coming year it will also strengthen the position of Škoda Auto as a domestic company. The Škoda Auto is a leading brand in combustion car world but has been dedicated to electric vehicle since 2019. Recently there is an economic situation associated with the coronavirus so therefore there is a question how big of an impact it will have on Electromobility.

As regarding HH Index it is clear that in the electric vehicle market it is slightly larger which is due to a more concentrated market than in the previous table.

E-CARS										
	Market Share					HH Index				
Brand	2015	2016	2017	2018	2019	20150	20160	20170	20180	20190
Nissan	22,47%	25,00%	18,35%	19,77%	18,39%	504,9867	625,0000	336,5850	390,9480	338,0539
Hyundai	0,00%	0,38%	3,62%	5,97%	18,25%	0,0000	0,1479	13,0868	35,6934	333,2074
Tesla	0,00%	23,85%	20,67%	12,09%	15,87%	0,0000	568,6391	427,3247	146,1932	251,9526
Volkswagen	34,08%	14,23%	27,13%	43,81%	13,76%	1 161,6098	202,5148	736,1336	1 919,5118	189,2444
BMW	35,21%	33,46%	28,17%	12,66%	13,36%	1 239,4619	1 119,6746	793,2883	160,2763	178,4839
Audi	0,00%	0,00%	0,00%	0,00%	6,22%	0,0000	0,0000	0,0000	0,0000	38,6502
Jaguar	0,00%	0,00%	0,00%	1,85%	6,22%	0,0000	0,0000	0,0000	3,4196	38,6502
Škoda	0,00%	0,00%	0,00%	0,00%	3,70%	0,0000	0,0000	0,0000	0,0000	13,7174
Mercedes	1,50%	0,77%	0,26%	0,00%	1,46%	2,2444	0,5917	0,0668	0,0000	2,1171
smart	3,00%	0,00%	0,26%	0,57%	1,19%	8,9775	0,0000	0,0668	0,3237	1,4172
Renault	0,00%	0,00%	0,00%	1,14%	1,06%	0,0000	0,0000	0,0000	1,2950	1,1198
Kia	3,75%	2,31%	1,55%	2,13%	0,53%	14,0274	5,3254	2,4037	4,5527	0,2799
HHI						**2 931,3078**	**2 521,8935**	**2 308,9558**	**2 662,2138**	**1 386,8943**

Table 3 Market Share and HHI of electric vehicles
Source: MS Excel attachment

4.1.6 Herfindahl-Hirschman Index

The table below shows the Herfindahl-Hirschman Index for the vehicle market also for the electric vehicle market. As mentioned above the vehicle market is relatively very competitive market which is freely accessible. In the market, there are enough strong companies even though Škoda Auto occupies almost a third of the market. Other vehicle brands do not have such a strong position and the remaining 2/3 are divided among them.

In 2013 in the electric vehicle market there was a situation much less "healthy" and the market was divided among three strong vehicle brands. Fortunately, this market has been divided over the years and today there are five roughly equally strong companies selling electric vehicles and they are competing to move to better position on the Czech market. In addition, Škoda Auto is expected to come to the Czech market and start to join these strong companies in the coming years.

HHI	2015	2016	2017	2018	2019
CARS	1 359,2203	1 327,8211	1 287,1998	1 347,7872	1 470,1542
E-CARS	2 931,3078	2 521,8935	2 308,9558	2 662,2138	1 386,8943

Table 4 HHI of electric vehicles and vehicles
Source: MS Excel attachment

4.1.7 Cost Analysis of Renault Zoe vs. Renault Clio

With the advancement of Electromobility, many people are wondering whether to replace their common vehicle to the modern electric vehicle. Will such an electric vehicle really be cheaper and more environmentally friendly? Is such an exchange worthwhile?
These questions will be answered in following part by comparing two vehicles especially an electric vehicle Renault Zoe R110 vs. combustion engine vehicle Renault Clio Itens 1.0 Tce 100 5M/T. Renault Zoe is the best-selling electric vehicle in Europe and designed especially for the city. This type of Clio is very similar to Zoe as it seen in the table below. Both vehicles are easy to drive and with its small size, it can be parked anywhere. Their kWh/ fuel consumption is just perfect for driving in the city as well. For driving in the city (driving to work, shopping centre, home) is a 50km daily driving for both vehicles sufficiently.
All prices in the tables below are recent, mostly from March.

Technical parameters	Renault Zoe R110	Renaut Clio Intens 1,0 Tce 100 5M/T
Purchase price with VAT/CZK	695 000, 00	354 000,00
Price per 1 kWh / l in CZK	4,10	32,90
Average consumption per 100 km	17,2 kWh	5,6-6,5 l
kWh/fuel consumption per 50 km	8,6kWh	2,8l
kWh/fuel cost of 100km/CZK	70,52	184,24
kWh/fuel cost per 1 km/CZK	0,70	1,28
Maximum performance	80 kW/ 110 koní	74kW/ 100 koní
Maximum torque [Nm]	225	160
Maximal speed	135 km/h	187 km/h
Acceleration 0-100 km / h	11,4 seconds	11,8 seconds
Weight	1575kg	1178/1603 kg
Fuel	Electric energy	Petrol
Driving range in km	291-316	750

Table 5 Technical parameters
Sources: MS Excel attachment (https://www.autohled.cz/a/renault/clio/tce-100/6033, https://www.novinky.cz/auto/clanek/test-renaultu-zoe-slusny-dojezd-ale-stale-za-prilis-velke-penize-40276851, https://www.energie123.cz/elektrina/ceny-elektricke-energie/cena-1-kwh/, https://www.renault.cz/elektricke-vozy/zoe.html)

Financial Expenses	ZOE	CLIO	DIF.
Technical inspection service/MOT of EV 1100/2 years, vehicle 1600/2 years	550,00	800,00	
Insurance 1 year	1 193,00	6 245,00	
Annual service	863,00		
2yrs.	938,00		
3yrs.	863,00		
4yrs.	3 910,00		
5yrs.	1 433,00	18 538,00	
SUMA	**9 750,00**	**25 583,00**	**-15 833,00**

Table 6 Financial Expenses
Sources:MS Exel attachment (https://www.auto.cz/zaver-dlouhodobeho-testu-renaultu-zoe-nejlepsi-auto-pujceny-elektromobil-132702, https://autobible.euro.cz/test-renault-clio-2020-tce-100-nejen-pro-damy/, https://www.stkokrisky.cz/ceny-sluzeb/, http://www.hybrid.cz/majitele-elektromobilu-plati-nejnizsi-povinne-ruceni)

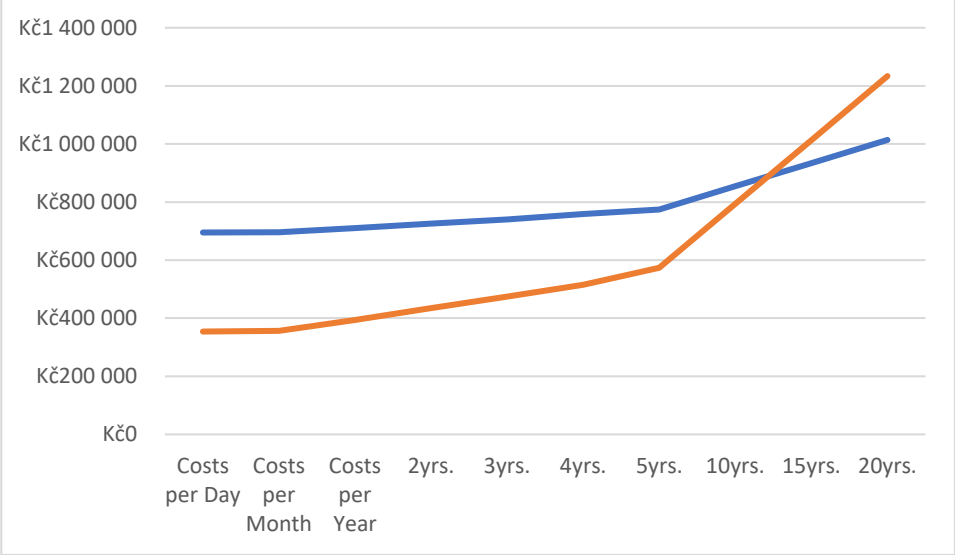


Figure 20 Comparison of electric vehicle with petrol vehicle
Source: MS Excel attachment

The graph shows that electric vehicle would pay back in about 14 years. The consumption and financial Expenses of both vehicles are in the graph. Even the electric vehicle requires a service inspection even though it has no engine oil or timing belt. The pollen filter, brake fluid, coolant, 12V battery etc. has to be replaced every 5 years. For the Renault Clio is also require replace the pollen filter, brake fluid, air filter, spark plugs, coolant, etc. every 5 years.

The average lifespan of combustion engine vehicles is about 14-15 years and the average lifespan of an electric vehicle is about 8-15 years mainly depending on the battery (number of charging cycles). In summary, it can seem that the electric vehicle is not wort it even though the Expenses of the combustion engine vehicle are higher, however the purchase price here is still crucial. Nevertheless, the price of fuel and electricity are going up and down. It can be changed if the price either of fuel or electric energy will changed in the coming years. Let mentioned that public could also use renewable sources and build photovoltaic at home and the electric vehicles will be driving for free. Everything is just a matter of time of these futuristic vehicles.

4.2 Electromobility in Norway

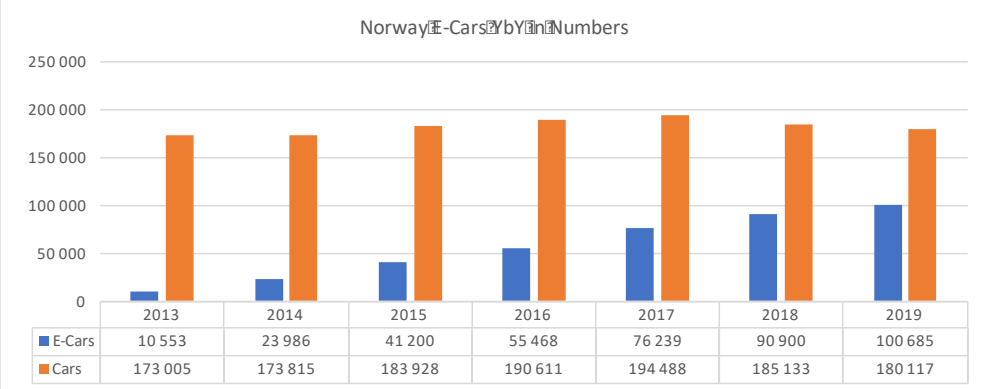
Norway's Electromobility is the most developed country, this country has the largest share of electric vehicles in proportion to the population from selected countries. Norway shares the top place with the Netherlands in the development of Electromobility according to Netherlands. In 2017 Norway become the first country where electric vehicles outperformed 50% of new cars. There should be only emission-free vehicles sold by 2025. Energy mostly pumped of hydropower plants became major boom in Norway which is clean and ecological alternative for the Norwegians. The state administration is the largest contributor to the promotion of Electromobility in the country. (27)

Financial incentives

- No road tax and on toll roads
- Free tolls on motorways, tunnels and ferries
- 0% VAT
- No registration fees
- Free parking
- Use of bus lanes
- Construction of fast charging stations

4.2.1 Electric vehicles sold in Norway

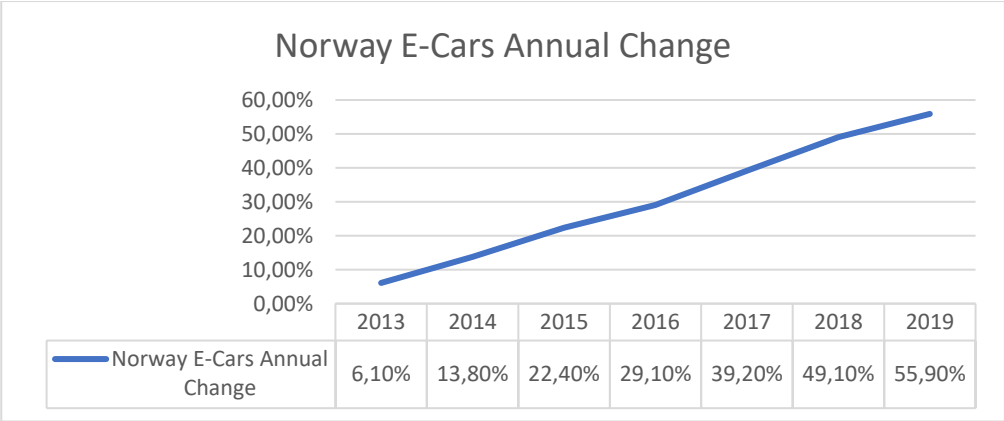
The chart below shows a sale of 10,553 units of electric vehicles in 2013 and a sale of 100,685 units in 2019. It shows that Norway is trying to do its best with the development of Electromobility.



	2013	2014	2015	2016	2017	2018	2019
E-Cars	10 553	23 986	41 200	55 468	76 239	90 900	100 685
Cars	173 005	173 815	183 928	190 611	194 488	185 133	180 117

Figure 21 Electric vehicles sold in Norway
Source: MS Excel attachment

4.2.2 Trend of electric vehicles in Norway



	2013	2014	2015	2016	2017	2018	2019
Norway E-Cars Annual Change	6,10%	13,80%	22,40%	29,10%	39,20%	49,10%	55,90%

Figure 22 Trend of electric vehicles in Norway
Source: MS Excel attachment

The chart above focuses on the percentage of electric vehicles sold in Norway from the total vehicle sold there. It started in 2013 with just 6,1% and within six years it reached 55,9% of the whole vehicle market in Norway. In the table below with Chain Index are all values over 100, which means increasing trend, even though the increase of the electric vehicle starts to slow down every year. The trend is still linear as it can be seen on the curve in the first chart.

Year	Chain Index E-Cars
2013	100
2014	227,2887024
2015	171,7629647
2016	134,6310032
2017	137,4478429
2018	119,2302497
2019	110,7646506

Table 7 Chart Index of electric vehicles in Norway
Source: MS Excel attachment

4.2.3 Future forecast of electric vehicles in Norway

With calculating linear trend estimation, there is a huge probability that the percentage of electric vehicles will be still increasing in years to come, if there will not be any unexpected circumstance influencing the market, the percentage of electric vehicles should be 89,76% of total sales by 2024. The year after there should be zero-emission in the whole country as the Norwegian Parliament said. The chart below shows the trend. (27)

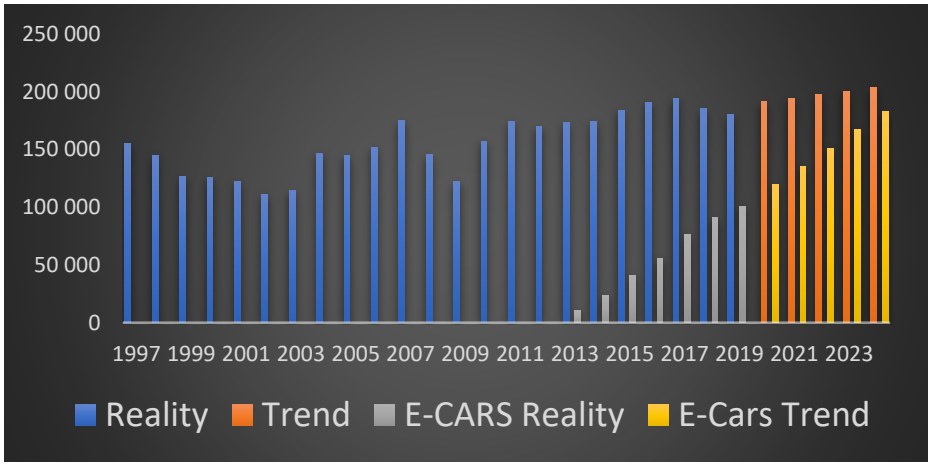


Figure 23 Forecast of electric vehicles in Norway
Source: MS Excel Attachement

4.3Electromobility in France

France is ranked number 13th place with development of Electromobility and it is still improving according to LeasePlan. France belongs to the most dynamic markets in the whole world. In the future, the country wants to invest 700 million EUR to its own production of batteries and thereby reduce battery production from Asian companies. (9;10;19;37)

Support of Electromobility:

- A contribution for a new electric car up to € 8,300
- Road tax exemption for 10 years
- A contribution up to 4,000 euros for the destruction of a combustion car older than 13 years
- tax relief or charging stations for an individual it costs € 8,000 for a married couple € 16,000
- development of charging stations within projects (INCIT EV project)
- tax deductions for French companies to install charging stations

4.3.1 Electric vehicles sold in France

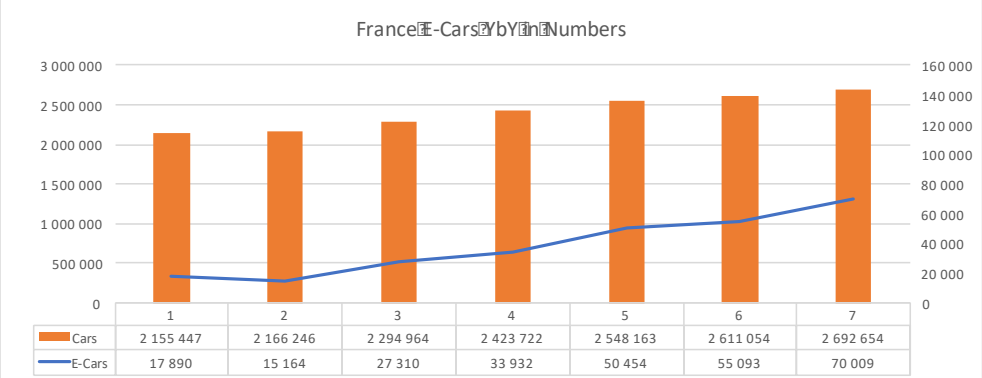


Figure 24 Electric vehicles sold in France
Source: MS Excel attachment

4.3.2 Trend of electric vehicles in France

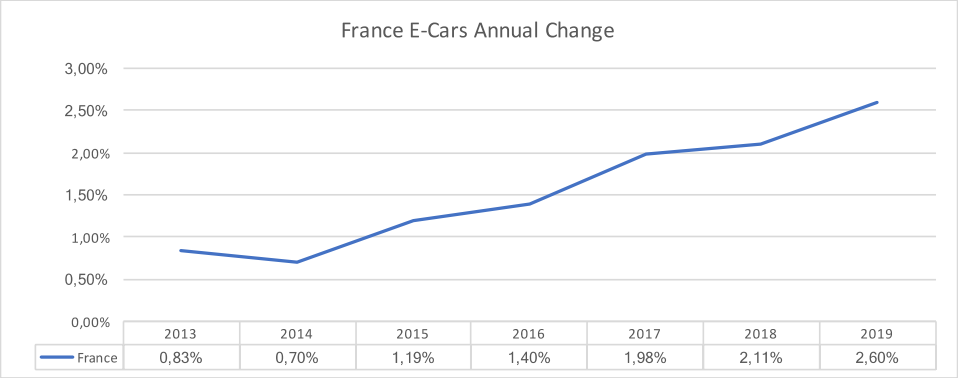


Figure 25 Trend of electric vehicles in France
Source: MS Excel attachment

Year	Chain Index E-Cars
2013	100
2014	84,75988776
2015	180,1013735
2016	124,2475981
2017	148,6899293
2018	109,1957947
2019	127,073675

Table 8 Chain Index of electric vehicles in France
Source: MS Excel attachment

In France, as it shows the electric vehicle curve is greatly increasing due to the huge support from government. The curve in the chart with the annual percentage of electric vehicle sold from total vehicles sold has a linear appearance. There is only one exception in table with Chain Index when was a little regress in 2014. The Index is over 100 every single year, yet.

4.3.3 Future forecast of electric vehicles in France

As in previous countries, the trend of electric vehicle sales in France is increasing. Interesting is the fact that the total vehicle market is almost constant in France, unlike the Czech Republic and Norway. It is ranging from 2,200,000-2,500,000 vehicles sold annually. The total share of electric vehicles should reach up to 4.47% of the whole total.

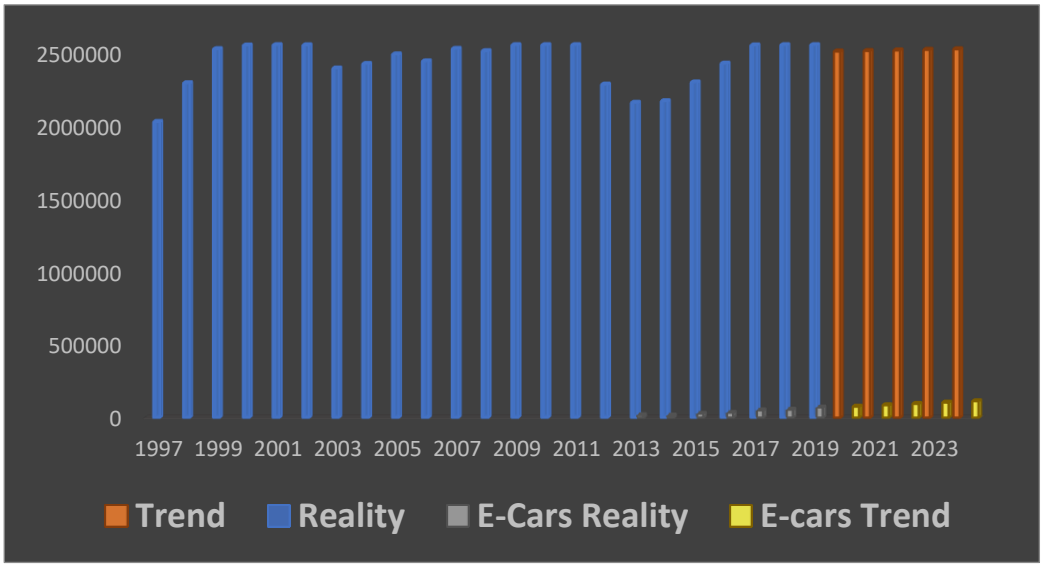


Figure 26 Forecast of electric vehicles in France
Source: MS Excel attachment

4.4Electromobility in Portugal

Development of Electromobility in Portugal increased from the inactive to very active country. Portugal ranks to number 11th which is two places ahead of France and fourth place ahead of Czech Republic, according to LeasePlan with development of Electromobility. The government has a clear vision for the future. Emission should be reduced by 50% by 2030 and the country should be emission free by 2050, completely carbon-neutral. Portugal build a bridge with China with focus on transport connections and energy because China invest heavily in Electromobility and in reduction of air pollution. Portugal said that is good to have a China on their beside. (2; 37; 23)

Financial incentives:

- Without any registration fees
- No vehicle tax and road tax
- A contribution up to 4,500 EUR for the destruction of a combustion engine vehicle and buying electric vehicle
- Preferential parking in cities/ parking fee discounts
- Companies benefit form autonomous taxation and deduction VAT

4.4.1 Electric vehicle sold in Portugal

The chart below shows that the market position of E-Cars in Portugal is not as strong as in Norway. There were only 5,70% E-Cars of the total sold in 2019. E-Cars market is increasing and is about to become a game-changer soon. However, not suitable infrastructure is a barrier from a quicker increase. But compare the Czech Republic to Portugal, the Portugal more ahead. There were 15 thousand electric vehicles sold in 2019 versus the Czech Republic however, there were only 1,200 electric vehicles sold. The year 2017 became a turning point for Portugal.

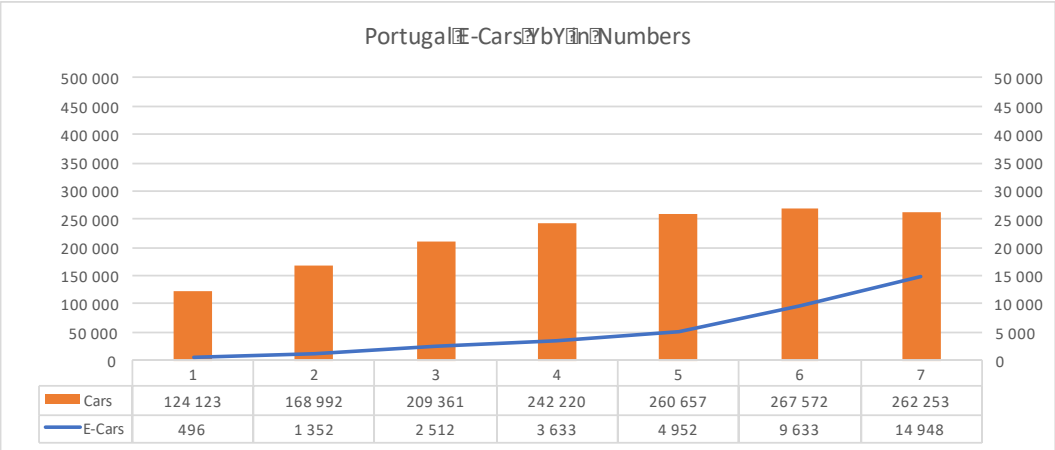


Figure 27 Electric vehicles sold in Portugal
Source: MS Excel attachment

4.4.2 Trend of electric vehicles in Portugal

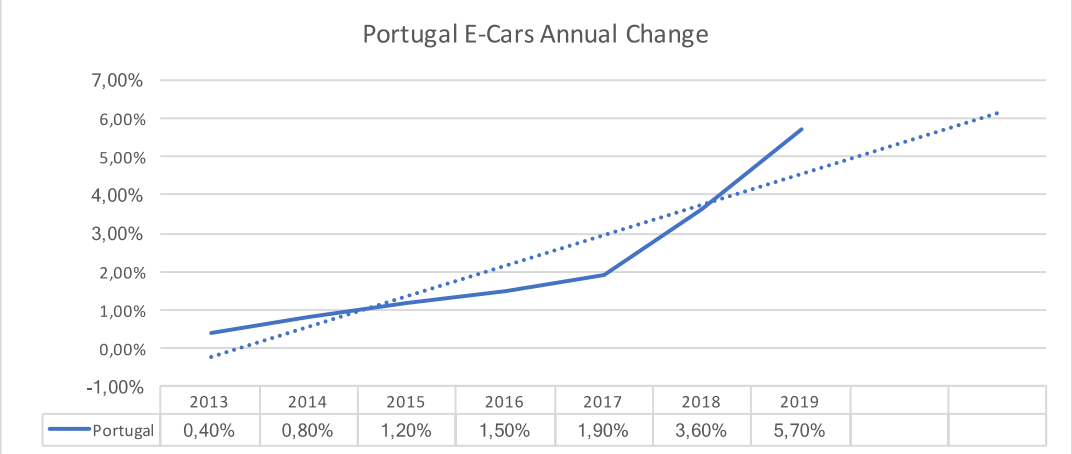


Figure 28 Trend of electric vehicles in Portugal
Source: MS Excel attachment

Year	Chain Index E-Cars
2013	100
2014	272,2976402
2015	185,8321696
2016	144,6186252
2017	136,3081221
2018	194,5002537
2019	155,1858627

Table 9 Chain Index of electric vehicles in Portugal
Source: MS Excel attachment

4.4.3 Future forecast of electric vehicles in Portugal

The vehicle market in Portugal is relatively similar in terms of total vehicle sales to the Czech Republic. With the focus on an Electromobility alone the Portugal sold more than ten times more electric vehicles than the Czech Republic in 2019. Due to this higher increase than in the Czech Republic is expected which should reach 23,177 sold electric vehicles in 2024 which makes it 16.23% of all sold vehicles in a given year.

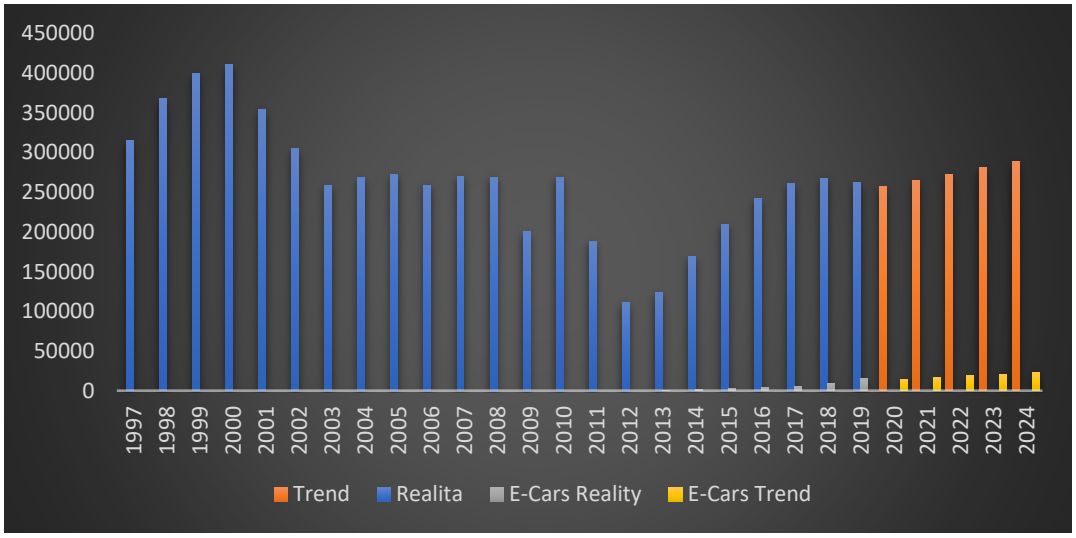


Figure 29 Forecast of electric vehicles in Portugal
Source: MS Excel attachment

5 Results and discussion

The practical part consisted of several segments which brought different results to the given issue. Let's take a look at the situation in each country individually.
Norway is one of the most advanced countries in terms of electric vehicles and their support of government, which set the regulation 150/15/COL for 0 % VAT in 2015 and became valid in 2001. Result of this can be seen in the demand and sales of electric vehicles which is clearly the highest of all surveyed countries. More than 50% of all vehicles sold annually are electric vehicle already.

France, the situation is quite different is most likely due to greater social differences and of course the size of the country. The vehicle market is fourteen times greater in France than in Norway. Should specific numbers be looked at there were 100,685 electric vehicles sold in Norway and 70,009 electric vehicles in France in 2019. With a massive market which counts more than 2,69 million sold vehicles each year this number can seem quit minor, only 2,60%

The third of the surveyed countries was a representative of southern Europe - Portugal. Portugal can be used for comparison with the Czech market because in terms of demographic aspects of these countries are similar in many ways. For example, they have a similar size, population and one large city which is significantly larger than the others. The vehicle market is very similar in both countries. About 250,000 sold cars annually. Portugal in Electromobility is one step further according to data of electric vehicles sold in past 6 years. As far as representation of electric vehicle goes Portugal is one step further. The annual sale is about ten times bigger in recent times and compare to the Czech Republic the overall attitude of these society to electric vehicle trend is very open and due to Roteiro para a Neutralidade Carbónica RNC2050 wants Portugal to be emission free and decarbonized till 2050. (39)

The Czech Republic, Electromobility development is at its beginning just about 0,5% from whole market however it is noticeable that much of the attention is paid too its development. The Czech government support the Electromobility in ways as 0% road set by law n. 16/1993 Sb., free parking and give subsidies up to 33% to purchase the electric

vehicles for companies and public institutions. Very important for the future development will be cars from the Škoda brand which is historically a leading brand on the market. With adding electric vehicles to their portfolio, it could influence Czech society in this direction.

Next part is devoted to comparing Market Shares in the Czech Republic and calculating the Herfindahl-Hirschman Index. The main leader on the Czech vehicles market is Škoda Auto brand followed by Volkswagen, Hyundai and Dacia brands. Top sellers on the electric vehicle market are Nissan, Hyundai and Tesla. Looking at the HH Index it shows that the vehicle market is considerably diversified while the electric vehicle market is still with a few companies and shows oligopolistic market brands only.

At last in the practical part, there are combustion as well as electric vehicle compared which both of them are made by Renault. Renault Zoe R110 an electric vehicle and the combustion engine vehicle Renault Clio Intens. All operating costs included associated with both vehicles, I found out that an electric vehicle would pay back in 14 years driving. As I already mentioned an electric vehicle has a high purchase price and still makes a very big difference between both cars even if the costs of gasoline vehicle and there are expensive by a half.

6 Conclusion

In this part, I will mostly focus on the comparison of electric vehicles and combustion engine vehicles which was the main focus of this work. Except from Norway we can mainly see that traditional propulsion (diesel, petrol) is still mainly used in most countries. As mentioned already the actual comparison of individual vehicles was on the city vehicles. The main focus for electric vehicles is the city due to the availability of charging stations and short distance. Another advantage of electric vehicles is emissions and environmental impact which again in large cities speaks more for electric vehicles.

On the other hand, its needed to take into account the purchase price of an electric vehicle is significantly higher than for combustion engine vehicles. Even with lower operating costs the payback period of the electric vehicle is up to 14 years. This is currently below the average of vehicles in the Czech Republic. Still the question about how long the battery lasts remains on the rise. The lifespan of electric vehicles to be around 8-15 years but it all depends on the usage of electric vehicle itself and on the battery. The main problem in this is the production of batteries itself. Batteries produces many emissions to the environment.

This is why at time I think the Electromobility is a good idea on how to involve the environment but there is still a need to think about what to still improve in that way. Let's consider manufactory of batteries more, get the price more available for consumers, development of charging infrastructure. I also must mention to use more of the renewable resources because the price of petroleum will be increasing in coming years. The usage of renewable resources will be friendlier for population as well as for the environment. According to data in the thesis is the development of the Electromobility itself on a good way in mentioned four countries.

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