Czech University of Life Sciences Prague

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Bachelor Thesis

Impact of European Emission Standards on the Automotive Industry

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Impact of European Emission Standards on the Automotive Industry

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Objectives of thesis

The main goal of this thesis is to analyze the problematics of Exhaust gases (CO2) in Europe and find out if there is any solution to minimize the air pollution and find out if electromobility can help to solve this problematics.

Methodology

The methodology will be based on Explanation, study and measuring. The data will be acquired through European laws, regulations and environmental pollution laws. There will also be used data from car manufacturers, car dealers and from the European Statistical Office to analyze and measure their sales and prices in Europe.

The proposed extent of the thesis

30 – 40 pages

Keywords

Emissions, CO2, cars, electromobility, regulations, environment, pollution

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Recommended information sources

Carbon Footprint and the Industrial Life Cycle, Roberto Álvarez Fernández, Sergio Zubelzu, Rodrigo Martínez, 201

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Declaration

I declare that I have worked on my bachelor thesis titled "Impact of European Emission Standards on the Automotive Industry" 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 any copyrights.

In Prague on 30.11.2022 _____

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Impact of European Emission Standards on the Automotive Industry

Abstract

This bachelor thesis deals with the problem of rising emissions from cars and of the air pollution. It analyses exhaust gas emissions from Czechia, Germany, Bulgaria and Netherlands. Between the countries are big differences in the amount of data. Germany sells more cars than the 3 other countries together. The main goal of this thesis is to find out if there is a way to minimize exhaust gas emissions and analyse how and if electric powered cars can help to solve this problem. Secondary goal is to analyse if end of combustion engines is necessary. For the problematic there will be used linear regression and beta convergence. In the thesis there is analyse of the car emissions. The practical part is about the comparison between car emissions and other emissions. There is also a verdict if car emissions have impact on total emissions. The finding of car emissions is supported by which powertrain the cars sell the most to find out if there is any relationship between powertrain and emissions.

Keywords: Emissions, CO_2, cars, electromobility, regulations, environment, pollution

Vliv evropských emisních norem na automobilový průmysl

Abstrakt

Tato bakalářská práce se zabývá problematikou rostoucích emisí z automobilů a znečištění ovzduší. Analyzuje emise výfukových plynů z Česka, Německa, Bulharska a Nizozemska. Mezi zeměmi jsou velké rozdíly v množství dat. Německo prodává více aut než ostatní 3 země dohromady. Hlavním cílem této práce je zjistit, zda existuje způsob, jak minimalizovat emise výfukových plynů a analyzovat, jak a zda mohou elektromobily pomoci tento problém vyřešit. Sekundárním cílem je analyzovat, zda je nutný konec spalovacích motorů. K problematice bude použita lineární regrese a beta konvergence. V práci je provedena analýza emisí automobilů. Praktická část se zabývá srovnáním emisí automobilů a ostatních emisí. Existuje také verdikt, zda emise automobilů mají dopad na celkové emise. Zjištění emisí automobilů je podpořeno tím, které pohonné ústrojí se vozy nejvíce prodávají, aby se zjistilo, zda existuje nějaký vztah mezi pohonným ústrojím a emisemi.

Klíčová slova: Emise, CO2, auta, elektromobilita, předpisy, životní prostředí, znečištění

Table of content

1 Introduction

What does the word emissions even mean?

Emissions are substances that pollute our air. The substances are mixed with air, and they come out less concentrated. The emissions have two different origins; one of them is natural and the second one is anthropogenic. The most significant concentration of the emissions is around its source; for example, the source of emissions of cars are exhausts or chimneys for the house and many more. We calculate the emissions by milligrams of the substance (CO2, NOx, SO2…) divided by hour, month, year, or kilometres (cars). Emissions are the wrong side of almost every aspect by which people simplify their lives. We produce emissions by electricity, which is the most significant part, and in today's life, almost everyone needs electricity to live, and most people can't live without it. The next part is Transportation which can be divided into road transportation and other Transportation like ships and planes. The second most extensive part of producing emissions is agriculture. The last two most prominent groups are industries and buildings.

How are we making emissions, and how can we possibly stop them?

There are two types of making emissions that leave a carbon footprint on our environment; we divide them into direct and indirect.

The direct carbon footprints are made by travelling by Transportation that is not fully electric, for example, by car, bus or any other city transport. We also travel by ship, the worst Transportation by far is by plane. Even if we divide the emissions that the plane produces by several people of the fully occupied plane, we still have an average of more than two times worse than travelling by car.

The indirect carbon footprints are connected to manufacturing. All the industries producing some commodities also produce a lot of emissions. The industries can be car manufacturers or even food industries that produce emissions.

Can we possibly stop the carbon footprint on our environment? There is no possible way to stop it, but we can try to lower our carbon footprint. We would have to eliminate the things that are simplifying our lives. For example, we can eat bio food that has not been artificially modified. We could also try to buy clothes that were made by hand or another way, but weren't made in big industries. We could also try to travel more by public transport and less with cars, especially if you have older cars with more significant engines or diesel engines that didn't need any regulations at the time they

were made. We would also have to skip travel with the help of air transport. We could heat less in our homes, try to use fewer lights, and maybe try living differently. On the other hand, some industries still will make the same amount of everything, and they will still do much more emissions than people like themselves would ever be made.

2 Objectives and Methodology

2.1 Objectives

The main goal of this thesis is to analyse the problems of Exhaust gases (CO2) in Europe and find out if there is any solution to minimise air pollution and find out if electromobility can help to solve these problems.

2.2 Methodology

The methodology is based on explanation, study, and measuring. The data will be acquired through European laws, regulations, and environmental pollution laws. Data from European Statistical Office will also be used to analyse and measure their sales and prices in Europe.

2.3 Beta convergence

Beta convergence is also based on the neoclassical economic growth concept, where growth depends on the initial economic level. This means that initially, poorer countries show higher growth dynamics, which leads to gradual convergence between regions.

The beta convergence measurement is applied to data collected from the European statistical office called Eurostat. the countries to which the beta convergence measurement was applied are Bulgaria, Germany, the Czech Republic and the Netherlands.

The measurement of Beta convergence was solved using the Excel system, in which the data were first transformed, the average data growth coefficient was determined, and then a linear regression model was created to determine whether beta convergence was present between the data.

The ordinary least squares method is used to determine the regression line equation. Subsequently, a planar graph is constructed, where the logarithms of the initial values are on the horizontal axis, and the logarithms of the average growth coefficients are plotted on the vertical axis (logarithms are used due to the elimination of positive asymmetry).

Subsequently, it is necessary to determine the model's tendency towards convergence or divergence.

- When β is lower than 0 then there is a tendency for convergence.

- When β is higher than 0, there is a tendency to divergence.
- When β is very close to 0, we cannot tell that there is a tendency.

Minařík et al. (2013) say that if there is a situation where there is no apparent convergence between the data, an analysis by quadrants will take place. First, you must divide the graph into four quadrants according to the average values.

- This is a highly evidential convergence if the monitored points are located primarily in the second and fourth quadrants.
- This is a highly evident divergence
- if the monitored units are located primarily in the first and third quadrants.
- The more the points are scattered between different quadrants, the more the robustness of the model decreases.
- Points in the first quadrant tend to move away from other points because they have an above-average initial value and an above-average growth rate.
- In the second quadrant, some points tend to reach the first quadrant with a below-average initial value and an above-average growth rate.
- In the third quadrant are found points that tend to lag behind other units because they have below-average initial values and, at the same time, below-average growth rates.
- Some points tend to move into the third quadrant area in the fourth quadrant because they have an above-average initial value and a below-average growth rate.

3 Literature Review

3.1 Emissions

Emissions are substances that are released in an energetic sense. Most of these are waste products of getting a worthwhile job. The most common emissions from energy are related to power generation and Transportation of people and goods. The specific chemistry of the emissions will depend on how these tasks were performed. Automobiles emit exhaust gases that can contain various pollutants and greenhouse gases. Electric vehicles also have emissions due to their manufacture and the need to generate electricity first. It is often helpful to isolate the emission types of interest and measure them separately. (Peters, Davis, Andrew 2012)

The increase in greenhouse gas emissions has slowed over the past decade compared to the last decade, but average greenhouse gas emissions over the past decade are at record highs.

The average annual growth rate from 2010 to 2019 was 1.1% per annum compared to 2.6% from 2000 to 2009. (United Nations Environment Programme 2022)

Reasons for the slowdown over the last decade include the following:

- global decline in new coal capacity building
- steady gas-to-coal substitution in the power sector of developed countries
- the pace of global renewables deployment and a decrease in net LULUCF (The LULUCF (Land Use, Land Use Change and Forestry) sector is used to report the CO2 flows between different terrestrial reservoirs (biomass, soils, etc.)
- the atmosphere that takes place on the managed surfaces of a territory.

Thus, it can constitute a net source or sink of CO2 emissions. This raises the question of whether global greenhouse gas emissions will plateau or whether slowing growth will continue for years to come. Average global GHG emissions from 2010 to 2019 were 54.4 gigatonnes of CO2 equivalent, peaking in 2019. (United Nations Environment Programme 2022)

Estimates of his LULUCF emissions for 2021 are pending, and no conclusions have been reached regarding his global GHG emissions for 2021(United Nations Environment Programme 2022)

3.1.1 Greenhouse gases

The greenhouse effect is primarily caused by the interaction of greenhouse gases such as carbon dioxide, methane, nitrous oxide and fluorinated gases in the Earth's atmosphere with solar energy. (Darkwah, Odum, Addae, Koomson, Kweku, Bismark, Maxwell, Desmond, Danso, Asante Oti-Mensah, Quachie, Adorama, Dopico 2018)

The leading driving gases for the greenhouse effect are:

- Carbon dioxide (CO2)
- Methane (CH4)
- Nitrous oxide (N2O)
- Fluorinated gases

The primary mechanism in the atmosphere (N2 and O2) is diatomic molecules, too tightly bound to vibrate, so they do not absorb heat and support the greenhouse effect 43% of total radiant energy emitted.

The remaining 49-50% of the radiant energy is spread over wavelengths longer than visible light. The greenhouse effect and resulting global warming associated with increasing amounts of greenhouse gases are likely to have serious consequences, according to the near-universal consensus of scientists. (Darkwah, Odum, Addae, Koomson, Kweku, Bismark, Maxwell, Desmond, Danso, Asante Oti-Mensah, Quachie, Adorama, Dopico 2018)

The ability of certain implied gases to be relatively transparent to incident visible light from the Sun yet opaque to energy radiating from the Earth is one of the quietest processes in atmospheric science. This phenomenon, the greenhouse effect, makes the Earth a comfortable place for life. I applaud future efforts on greenhouse gases. (Darkwah, Odum, Addae, Koomson, Kweku, Bismark, Maxwell, Desmond, Danso, Asante Oti-Mensah, Quachie, Adorama, Dopico 2018)

Carbon dioxide (CO2)

Carbon dioxide (chemical formula CO2) is a compound composed of molecules that have a carbon atom covalently bonded to two oxygen atoms. It is in a gaseous state at room temperature. Organisms and geological phenomena have regulated the concentration in Earth's pre-industrial atmosphere since the end of the Precambrian.
Carbon dioxide is 53% denser than dry air but has a longer life and mixes perfectly with the atmosphere.(Du, Xie, Ouyang 2017)
About half of the excess CO2 emissions into the atmosphere are absorbed by land and ocean carbon sinks. These sinkholes can become saturated and volatile as CO2 is released into the atmosphere through decay and fires. Finally, CO2 is bound (long-term storage) in rocks and organic sediments such as coal, oil, and natural gas. (Du, Xie, Ouyang 2017)

Methane (CH4)

Methane (CH4) is a powerful global warming substance. It is often called the second most important greenhouse gas (GHG) after carbon dioxide (CO2) accounts for about 20% of direct greenhouse gas emissions. CH4's chemical pathway differs from CO2 in terms of its environmental impact. (Nielsen, Lund 2018)
Methane has both natural and anthropogenic sources. Wetlands (where CH4 is produced by microbial activity), fossil fuels, agriculture (livestock and rice), waste management (landfill), and fire Atmospheric concentration of CH4 and its transport It depends on the balance between these different sources and sinks. Emissions and concentrations of CH4 have been surprisingly increasing rapidly in recent years. CH4 in the atmosphere - started in 2007 and has accelerated since 2014 - followed by a brief period of stability from 2000 to 2007. Walderdorff, Butler 2022)
The scientific community has debated the precise explanation for the stabilisation and subsequent increase in atmospheric CH4 over the past two decades. A new study concludes that the recent rise can be almost equally attributed to fossil fuel emissions.(Mar, Unger, Walderdorff, Butler 2022)

Nitrous oxide (N2O)

Nitrous oxide (N2O) has a global warming potential 300 times that of carbon dioxide over a 100-year time horizon and is essential for depleting the stratospheric ozone layer. The climate sensitivity of N2O emissions is poorly understood, making it difficult to estimate how fertiliser use and climate change affect radiative forcing and the ozone layer. (Griffis, Chen, Baker, Wood, Millet, Lee, Ventura, Turner 2017)

Analysis of the hourly N2O mixing ratio from a very tall tower in the US Corn Belt, one of the most intensively agricultural regions in the world, over six years, combined with inverse modelling, yielded a significant reduction in N2O emissions. (Griffis, Chen, Baker, Wood, Millet, Lee, Ventura, Turner 2017)

Significant interannual variations in abundance are evident. This means that local emission factors are highly climate-sensitive. Year-to-year variability in total emissions was dominated by indirect emissions associated with runoff and leaching. (Griffis, Chen, Baker, Wood, Millet, Lee, Ventura, Turner 2017)

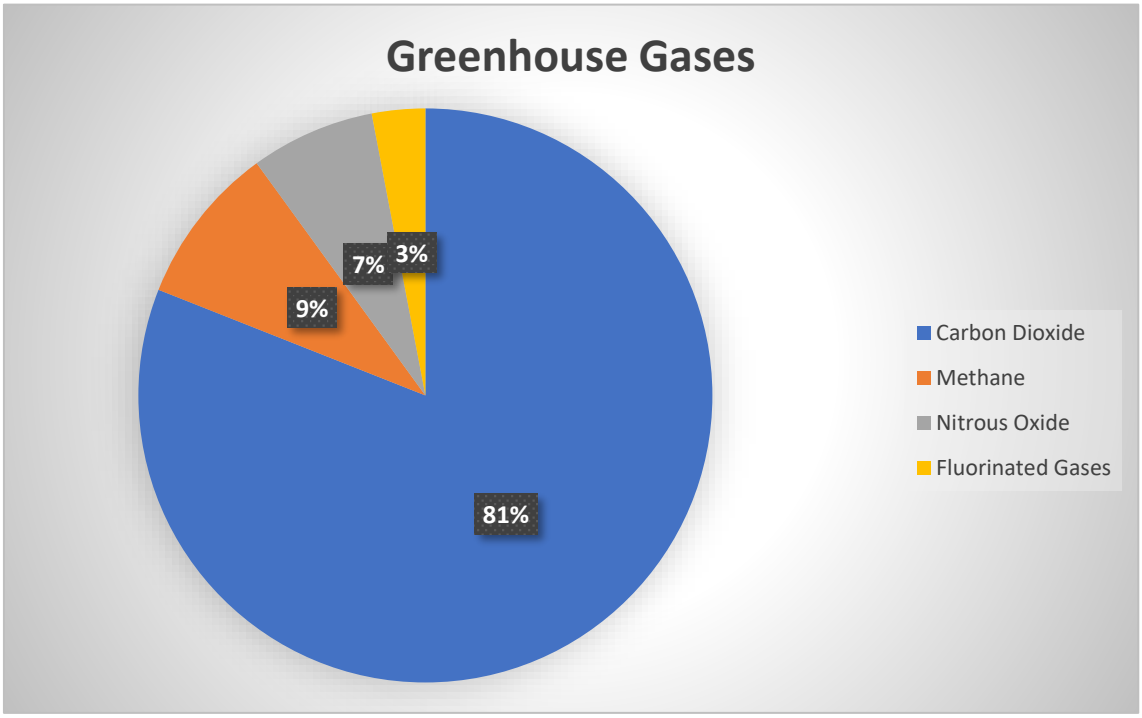


Figure 1

3.1.2 Emissions by type of Transportation

Road transport does the most % (76) of CO2 Emissions. It seems like Road Transport does almost all the CO2 Emissions. At first, we will have to look at the fact that almost everyone uses their cars daily to work, to shopping, on trips, for visits to doctors and much more. (European Commission 2021)We cannot say that fact about air traffic or travelling by ship. Road transport includes everything on our roads – cars, buses, trucks, working machines and much more. It is the most common transport on the planet, and almost everyone uses it. We need Road transport every time, even if we use a plane or ship because road transport needs to deliver the packages to the end because the ship can only deliver it to port and the plane can deliver the package to the airport. (European Commission 2021)

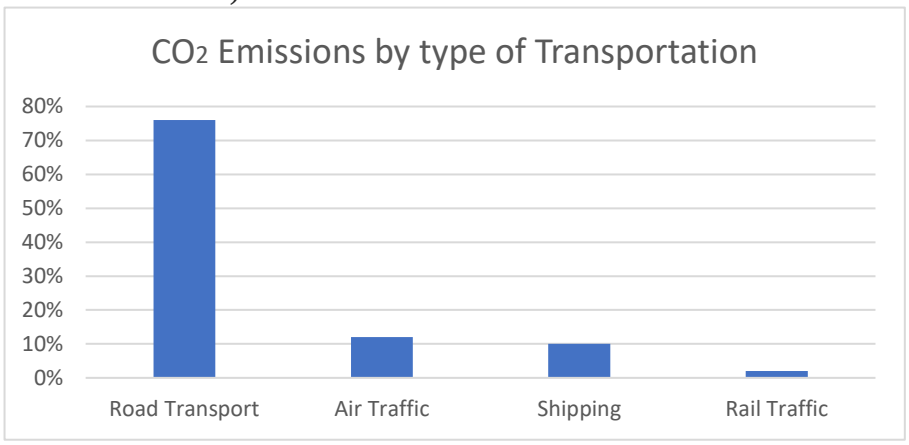


Figure 2

Transportation by ship does around 10% of those emissions. It includes all of the big ferries that transport everything that we need for living. You can fit a lot of big and small objects into those ships and ferries. It seems worth it to see how much those ships can carry. It may be true till there happens some accident and it starts to leak oil or fuel into the ocean. We have seen many of those accidents in the news which caused some terrible problems, for example, the accident in the Suez Canal, which happened in the year 2021. The ship was stuck in the Canal for a week, and other ships couldn't get through the Canal. (European Commission 2021)

Rail traffic is only around 2% of the CO2 emissions of Transportation emissions. In the Czech Republic, many people use it to get to work. There are also cargo trains to deliver products, materials and other stuff. (European Commission 2021)

The second biggest group is air traffic which has 12% of all transportation emissions; it's not common for anybody to travel by plane every day. In Europe, people use planes 1-2 times per year to get to their holiday, and it still makes 12% of all transportation emissions. There are also cargo planes delivering products and materials much faster than all other types of Transportation. (European Commission 2021)

Most aeroplanes use old engines, which are bad for the atmosphere. As I have found out, aeroplanes have a share of 2,5% of the total CO2 in our atmosphere, and there are only a small amount of aeroplanes besides cars.

CO2 is one of the most contributing aspects of global warming. It is also not the only harmful gas that aeroplanes produce. It helps to a change of climate.
They produce a lot of nitrogen oxide (NOx). This type of gas can help to destroy the ozone layer. It applies only to aeroplanes that are flying at a more significant height above sea level – 8 or more kilometres.

The following harmful gas that aeroplanes produce is water steam (H2O) and condensation traces. It is a greenhouse gas that creates traces – the white traces on the sky that everyone knows. (European Commission 2021)

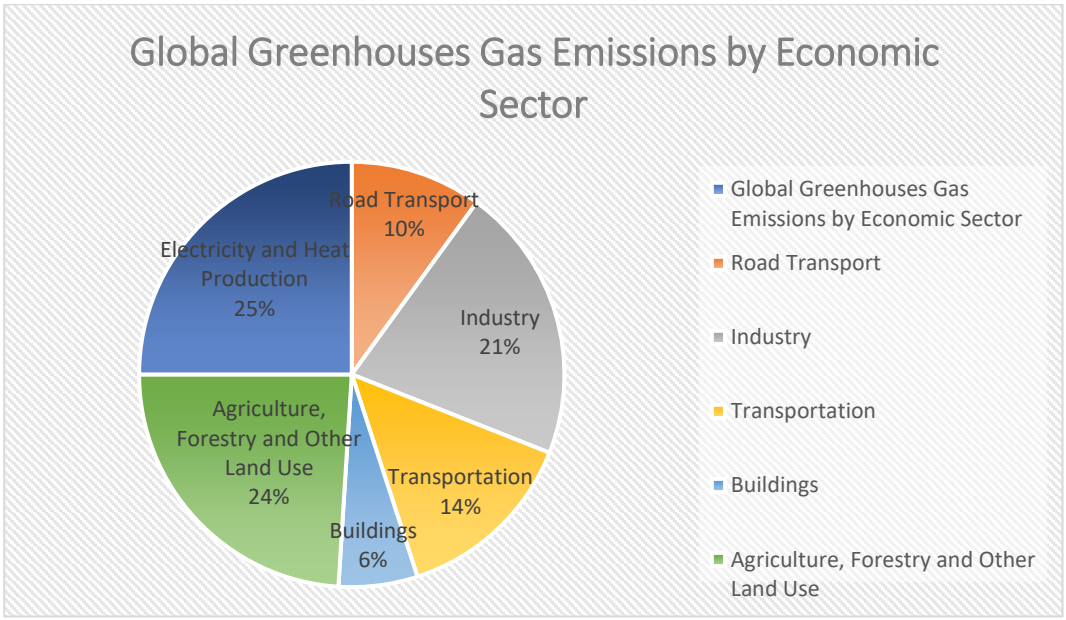
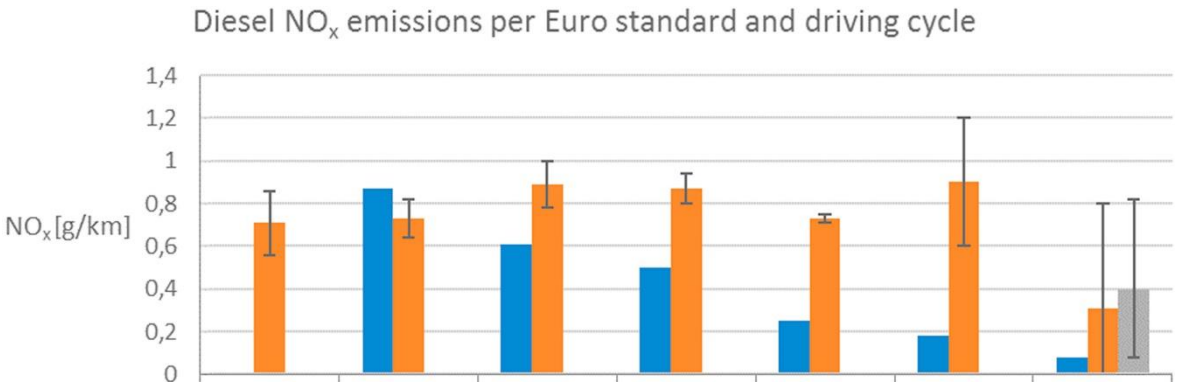


Figure 3

3.2 Emission norms and laws

Today we have 6 standards in Europe that cars have to fulfil. The European Union is trying to decide what will come in 2025. This year, there should be the EU 7 standard which could mean the end of non-hybrid / electric cars. The European Union is discussing the emissions, which should be around 20-30mg/km of carbon dioxide. For example, today's standards are 60mg/km for cars powered by Petrol and 80mg/km for cars with a diesel engine. There should be no difference between diesel and petrol cars. (European Commission 2021)



	Pre-EURO 1	EURO 1	EURO 2	EURO 3	EURO 4	EURO 5	EURO 6b
NEDC		0,87	0,61	0,5	0,25	0,18	0,08
CADC 1/3-Mix	0,71	0,73	0,89	0,87	0,73	0,9	0,31
WLTP							0,4

Figure 4

(Hooftman, Messagie, Van Mierlo, Coosemans 2018)

3.2.1 Strategy Europe 2020

The Strategy had five main objectives that this Strategy should achieve. It followed up on Lisbon Strategy. The Strategy Europe 2020 was valid from 2010 to 2020. The new Strategy, named strategy Europe 2030, has new objectives that it must achieve, valid now till 2030.

The five main objectives were employment, Poverty and social exclusion, education, research, development, and innovation. The last one which is the most important for us, is climate and energy policy.

The employment objective is focusing on a better unemployment rate for the whole population. The. The next objective wants to make fewer people poor and get a job. The

third objective of education is to make people stay longer in school and make them more qualified for a possible job.

3.2.2 Lisbon Strategy

Lisbon's strategy was a predecessor to Strategy Europe 2020.

Innovation, entrepreneurship, synergy (cooperation), and competitiveness are the four main pillars of the Lisbon Strategy (Steurer and Hametner, 2013).

The Lisbon Strategy's objectives were exceedingly lofty; however, it is well known that significant goals have not been reached. Europe 2020, the EU's most recent economic strategy, has taken the place of the Lisbon Strategy. The effects of the global financial crisis on economic development, as well as the goals and tools that support it, have been mainly taken into consideration. Defects in the Lisbon Treaty Strategy's execution, as well as revised development goals, obstacles, and priorities

Evaluation of the implementation's "technical" components, including funding, monitoring, etc.

Social communication was essential for implementing modifications to the Strategy, among other things (*The Europe 2020 Competitiveness Report Building a More Competitive Europe Insight Report 2014 Edition* 2014)(Stec, Grzebyk 2016)– Lisbon a strategy Europa 2020

3.2.3 Paris Agreement

This document summarises the history of global warming talks over the last three decades, focusing on the specifics of the Paris Agreement after the Paris conference and examining the foundation texts of the Intergovernmental Panel on Climate Change (IPCC) and the United Nations Framework Convention on Climate Change (UNFCCC). Conflicts over the rigour of international mitigation efforts have been seen in several Conferences of the Parties (COPs) since 1992—the Rio Earth Summit, the Kyoto Protocol, the Copenhagen Accord, the Cancun Agreement, the Durban Platform, and the Paris Agreement—as well as the primary outcomes, are discussed. (European Commission 2021)

The creation of a financial tool known as the Green Climate Fund (GCF) and the conflicts among fund participants are examined. After the Paris COP, the article outlines the present state of several international negotiations. The paper wraps up by outlining

potential future negotiation trajectories and ideal international policies that can be agreed upon that concentrate on adaptation, technology, incentives, and exchanges. (United Nations Environment Programme 2022)

3.3 Impact on automotive industry

In today's standards in Europe is a constant reduction of automobile emissions and its impact on car manufacturers.

Regarding reducing emissions from cars with internal combustion engines, mainly the particulate filter (OPF), which has been mandatory for all cars since 2019 and serves to filter some harmful substances from the exhaust and keep them to a minimum. (Darkwah, Odum, Addae, Koomson, Kweku, Bismark, Maxwell, Desmond, Danso, Asante Oti-Mensah, Quachie, Adorama, Dopico 2018)

However, these restrictions only apply in Europe. In the USA or Australia, they have nothing like those filters.

3.3.1 Development of cars based on emissions standards

Car manufacturers must adapt to the "new era" of electric/hybrid cars. Some car manufacturers will probably have to stop production because it will be liquidated for their economy. This will mean that the more prominent companies selling most of the cars on the market will sell even more, and the smaller ones will probably not be able to adapt, and they will probably end with their production. This is only an assumption, and it will not mean that only a few car manufacturers will sell cars. It will also be an opportunity for new manufacturers specialising in electro-automobiles. (United Nations Environment Programme 2022)

3.3.1.1 Development and trend

The demand for new cars in Europe is far worse than it was years ago. There are many reasons why. The biggest one is the price. The new cars are getting more expensive because European Union is collecting fines from car manufacturers for new cars that do not meet the standards. The car manufacturers must make the cars more expensive because they would not have any profit. They will lose if they keep the same price from previous years. New safety features cost money, and they must be in new cars. There are also the fines that manufacturers have to pay.

For many people, especially in the Czech Republic, the trend is to buy used old cars because they cost almost nothing compared to new ones, and they can repair them by themselves or buy another one. Also, many people have a company car that they can use. Companies are buying new commercial cars, but people in recent years are buying fewer than they used to. (Mar, Unger, Walderdorff, Butler 2022)

3.3.1.2 Sales and marketing

Due to covid and its restrictions, car manufacturers are not able to produce as many cars as they were able to do before. If you order a new car, your waiting time can be between 4 – 16 months, even when the car is almost essential. That is why many people started to buy cars that are 1-3 years old. These facts broke the car market, and the prices for those cars are ridiculous. For example, cars that are one year old now can be even more expensive than new ones. The new cars typically lose the most value in the first year but not now. The following problems, especially near me, are parking spaces. (United Nations Environment Programme 2022)

People want to avoid buying new cars to park them on the streets in tight parking spots. Anybody could scratch it, demolish it, or even steal it. It is different in each country but in the Czech Republic, where the average wage is higher than in Germany. The average monthly salary in Germany is almost 3000 euros, while it is around 1250 euros in the Czech Republic. Of course, it could be much worse. In Belarus, the average monthly salary is less than 400 Euros.

3.3.1.3 Customer needs

Ordinary people want a car that does not cost a fortune but also has some equipment. They also want the car to have low maintenance costs and fuel consumption. People who live in flats do not want electric cars because they need a place to charge them. Hybrid cars could be a solution, but it is expensive, and for most people, it is more comfortable to buy a diesel car.

3.3.2 Emission fines

The emission standards will be reduced in the future, and those standards are impossible to meet with non-electric cars. The limit now is 95g CO2/km. This limit is calculated for all cars sold under a certain brand or car group. That applies only to Europe. For every gram of CO2/km exceeded, there is a fine of 95 Euros. For example, ford will sell 1 million cars

in Europe in the year 2022, and the average emissions will be 98g CO2/km, which means the car manufacturer will pay a fine that can be calculated this way. 95 (euros) * 1,000,000 (cars sold) * 3 (exceeded grams of CO2). All of this means that new cars are and will be more expensive, as it is all paid for by customers who are buying the cars. (European Commission 2021)

3.3.3 Attitude and reaction of car companies

All the manufacturers that are not producing only electric vehicles have problems now with these limits. They must pay fines to European Union. However, it means that the vehicles will be more expensive, and there is no other way for them to do it because they cannot meet those standards with combustion engines.

For some car manufacturers, this situation can also mean extinction, or it could create new collaborations. The Fiat group, which has brands like Fiat, Alfa Romeo, and Maserati under their name, would only be able to meet these values after a while, and it could look like they would have to stop producing their cars soon. However, they are trying to team up with the electric car manufacturer Tesla, which has zero emissions from their exhausts, and this would possibly mean that the Fiat Group will not have to get any fines, so they could pay Tesla, which is allegedly losing on every vehicle that comes out of production. (Du, Xie, Ouyang 2017)

3.4 Alternate powertrains

There are many alternatives to standard combustion engines that need petrol or Diesel to run.

Some of them are combinations with these motors, like hybrids of petrol engines and electric motors. There are two types of those hybrids: running on petrol engines and electric engines working in cities, with stars, etc. It makes the petrol engine more efficient and charges by braking (recuperation). The car can run only on an electric motor, but only for a short period. You do not have to charge the battery; you use it as an average petrol automobile. The next type of hybrid is called plug-in hybrid. This hybrid drivetrain uses mainly the electric motor, which is much more efficient than an average hybrid. This type

is more expensive to buy but less expensive to run. It is called plug-in because you must charge the battery by cable and plug it into the car, but still, you must tank the petrol.

3.4.1 CNG

Compressed natural gas was efficient 2-3 years ago when the CNG prices were Much lower than petrol or Diesel. In today's World, CNG costs the same or even more. Also, not many gas stations are selling CNG. This type of drivetrain could also run-on petrol, but it is not worth buying for most people now. If we take the emissions, the CNG produce much less harmful gasses than typical combustion engines. (Du, Xie, Ouyang 2017)

3.4.2 LPG

Liquified petroleum gas is a mixture of hydrocarbon gases used as fuel for combustion vehicles and other appliances which can use LPG. LPG is much cheaper than petrol, but it takes more fuel consumption of 10-20%. It also does fewer emissions, and it is gentler for nature. Some cars have LPG built into as standard. It is also possible with the petrol engine to assign a propane-butane cylinder, which enables the car to use LPG when it has the required gas. There is a problem with this drivetrain about parking in closed spaces in shopping centres etc. There still can be danger of explosion or fire. (Du, Xie, Ouyang 2017)

3.4.3 Hydrogen cars

There are only a few cars on the market with this drivetrain, so we cannot talk about efficiency, emissions or possible impact. One of them is, for example, Hyundai NEXO or Toyota Mirai. For me, the worst part is that you cannot mine hydrogen; if we don't find how to do it, there cannot be only cars powered by hydrogen. (Darkwah, Odum, Addae, Koomson, Kweku, Bismark, Maxwell, Desmond, Danso, Asante Oti-Mensah, Quachie, Adorama, Dopico 2018)

3.4.4 Electric cars

The cars have big batteries, which power the cars, and you can charge the battery by the cable from a charger from charging stations or sockets at your home, work, etc. Many people think that electric cars are the future, but the future could be better because it brings many problems, which we will discuss in the following chapters.

4 Practical Part

4.1 Total Emissions

The Total emissions are slightly improving almost every year. Why is it? There are a lot of restrictions on emissions in every aspect. Everything is about to be more ecological. For example, energy industries are around 38% lower in the year 2019 than it was in 1990. Could it be because we are manufacturing less than in the year 1990? Of course not! There are many and many laws that nowadays industries must fulfil. The same goes for manufacturing and construction. But transport emissions have been rising every year since 2013. The reasons are simple. There are more people. The people need more things. Almost everyone buys stuff through the internet, and someone needs to deliver these items.

Let's look at the graph below, where we can find out the Total emissions for the years 1990, 1995, 2000, 2005, 2010-2019

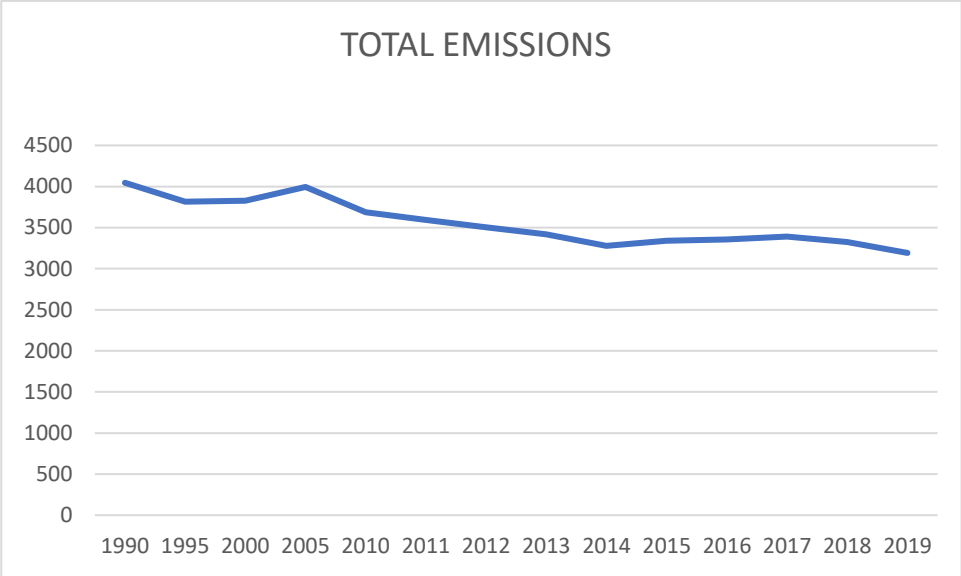


Figure 5

On the Y-axis we can find out the Emissions of CO2 in million tonnes. On the other axis, X, we can see the years that already wrote before. As you can see, in the last few years, there has been some trend, which is going downhill. The emissions are not less each year, but they are going down over a more extended period. It depends on each of the aspects that are changing each year. The biggest ones are Energy Industries, transport and agriculture. The lowest emissions were recorded in 2019, which were 3191,9 million tonnes of CO2, which is 853,7 million tonnes less than the year 1990, which was the worst from the years I have data from. The year 2019 was more than 4% better in total emissions than the year 2018, which is significant, and it was the most considerable improvement annually since 1990. If we continued the same way each year, we would have half the emissions than the year 2018 in 17 years.

4.1.1 Total Transport Emissions

The parts of transport emissions are from Road Transport, Navigation, aviation, railways and other Transportation lined up by the most used Transportation. Road transportation almost everyone uses daily. Travelling by plane is more common in the USA than in Europe, but road transport is used everywhere. From the graph below, you can see that the Total transport emissions are higher almost every year. If we take out the data, we can find out that in the year 1990, the Total transport emissions were around 20% of the Total emissions. The Total emissions are linearly going down each year, and

Transport Emissions are linearly going up. That means in 2019; the Total Transport Emissions were more than 34% of Total emissions. That's a significant rise-up. But for example, in 1990, there were only 500 million cars in the world; in 2019, there were more than 1,3 billion cars. And that counts only for cars, not trucks and other vehicles such as motorcycles, buses and others.

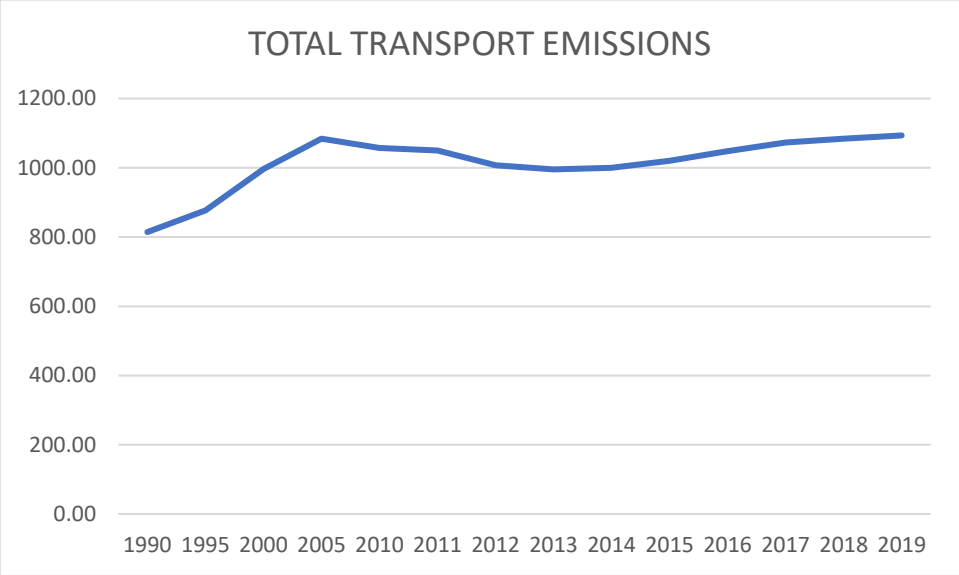


Figure 6

The figure 6 shows the Total Transport Emissions in a million tonnes of CO2, which we can find on the Y-axis for years which are written on the X-axis.

4.1.2 Emissions of Road Transport

Road Transport Emissions is the biggest group of whole transport emission. In road transport, many other groups are divided into Cars, heavy-duty trucks, light-duty trucks, motorcycles, and other road transport. Of those, the biggest group are cars, and the second one is the heavy-duty truck. This study is about car emissions and their regulations; let's focus on that. Cars make up around 60% of whole road transport. It is a lot, but as we all know, almost everyone owns a car nowadays.

It looks like it is never ending rising line. But in the upcoming years, my prognosis is that there will not be rise-up anymore as everyone who wants to drive a car drives it; you can buy a car for low as 200 Euros. Will that car be ecological? Of course not. But this will change soon as the old cars have more arduous conditions in technical control and measurement of emissions. And the new cars have more arduous conditions for emissions too. This will work even for the duty truck. Unfortunately, it's not as strict as for cars. But many companies are now trying to make trucks that could be fully powered by an electrical system, this could change a lot in Transportation.

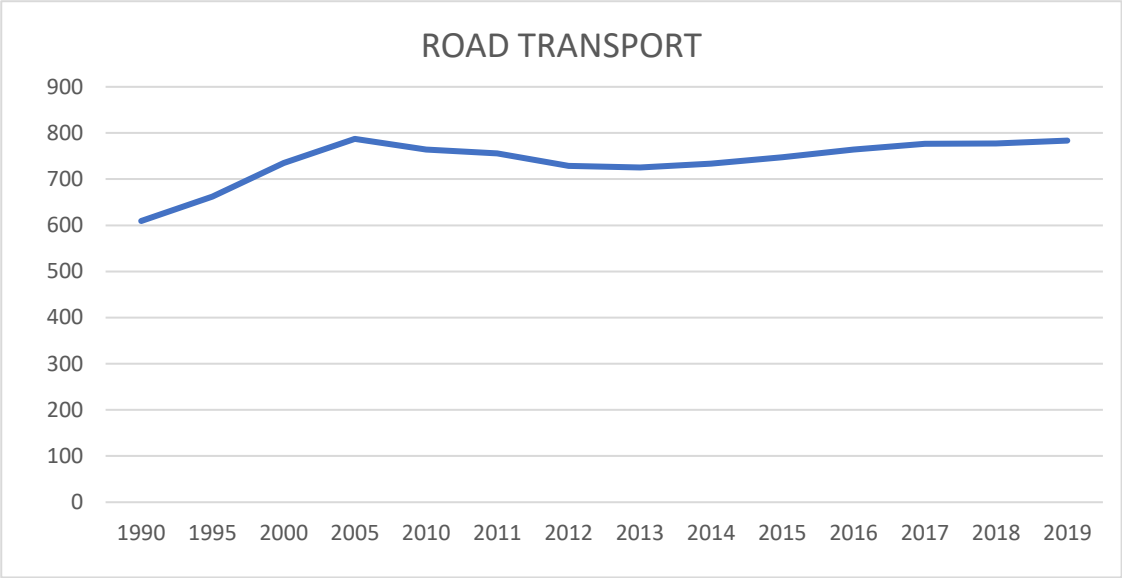


Figure 7

The figure 7 shows us emissions of a million tonnes of CO2 that are still rising from 2013. But if we look closely, the most significant peak was in 2005, when road transport emissions were 787,2 million tonnes of CO2, which is more than the year 2019. If we take down the data and spread out the data, we will find out that there were only half of the passenger cars in 2005 than in 2019, and the emissions were more extensive. In the figure 7, we can also find out that in 1990, there were 22,3% fewer emissions from road transport than in the year 2005 (the most significant peak).

4.1.3 Cars and duty trucks

Those are the two most prominent groups of the Road Transport Could we work without these 2 Road transport groups as they are "extremely unecological?" No, in our world, how everything is made, we cannot stop using cars and duty trucks; it is unreal. We need them for basically everything.

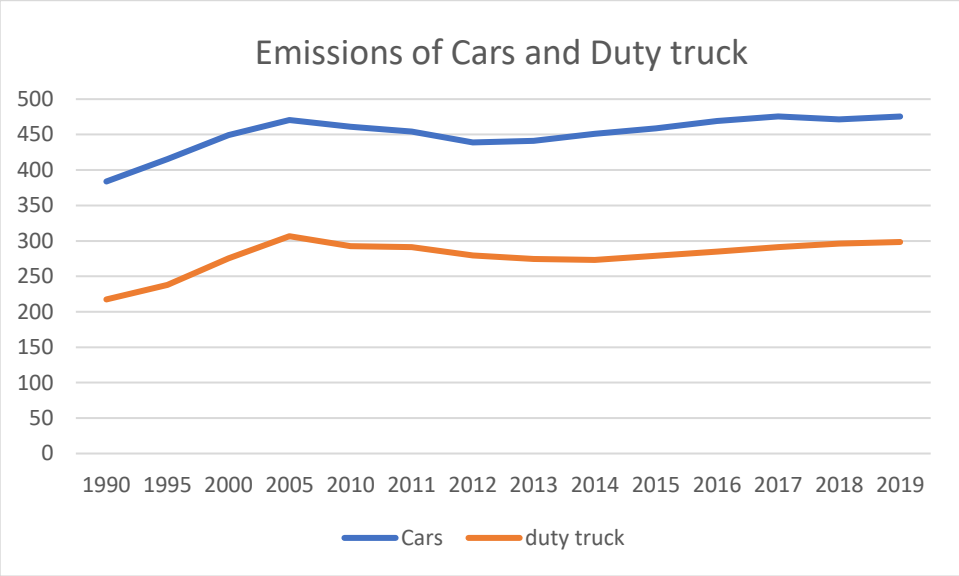


Figure 8

Let's take a look at the figure 8. We can see that the trend in lines is almost identical. But they are not. Car emissions had the worst emissions in the year 2017. The Emissions from cars for this year were 475,6 million tonnes of CO2. In the year 2019, the emissions were 475,4 million tonnes of CO2, and we can see that the emissions are not changing too much in the most recent years. The duty truck emissions were the worst in the year 2005, which amounted to 306,6 million tonnes of CO2; after the year 2005, the emissions for duty trucks were getting lower till the year 2014, after that it is slightly going up each year.

In my opinion, the emissions for duty-truck will still rise each year because of covid. Many people found out that it is more comfortable to order everything using online services, meaning everything must be shipped by truck to their homes. Electric trucks are not standard on our roads, and we will probably not see them for a few years as they are still developing, and they are not "drawn to the end", and they need some development. I

would say there will be a rising trend in emissions for duty trucks and a constant trend for cars in the upcoming years.

4.2 Comparison and determination of the Relationship

For The determination of the Relationship, I have used primarily linear regression and simple graphs.

4.2.1 Linear regression between total emissions and total transport emissions

I want to find the first Relationship between Total Emissions and Total Transport Emissions. I want to focus on if cars have such a negative impact on Total Transport and if the trend is the same (if the emissions from cars go up, the total emissions should also go up). For all those measurements, I used data from 2010 – 2019 for a better view, as data from 1990-2005 are not necessary for linear regression.

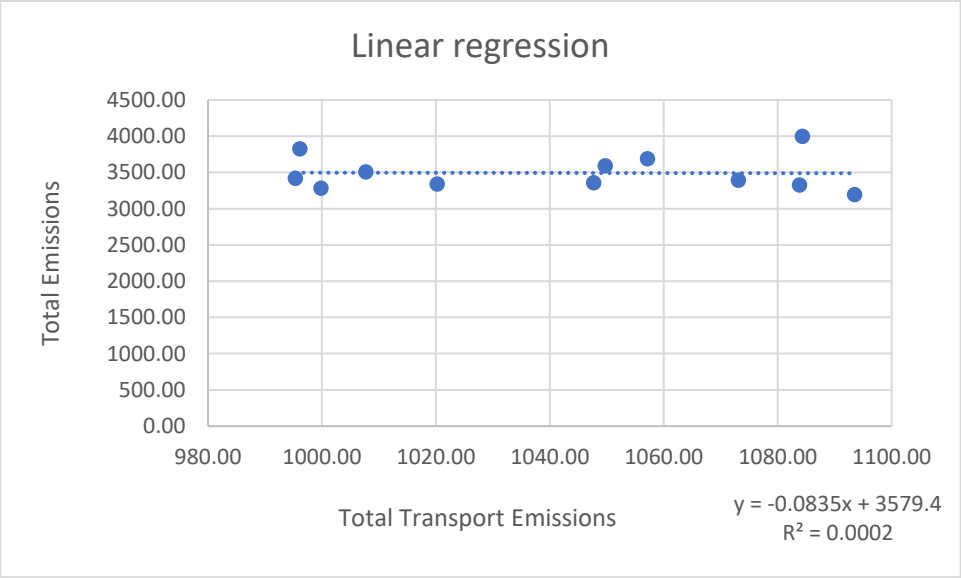


Figure 9

In the figure 9 above, we can find out the Linear regression of Total emissions and Total Transport Emissions. On The Y-axis, there are Total Emissions produced in millions of tonnes of CO2 annually; on the X-axis, there are Total Transport Emissions in millions of tonnes of CO2 from each year 2010 – 2019.

Y and X relationship – The R Square (R2) Equals 0,0002. That means only 0,02% of the Total emissions on the Y-Axis is explained by Total Transport Emissions on X-axis. The correlation (R) equals -0,0141. That tells she is there is a fragile inverse relationship between our X and Y. The Relationship is weak, meaning there is almost no continuity.

4.2.2 Linear regression between road transport emissions and total transport emissions

Next on the list is the Linear regression of Road Transport Emissions and Total Transport Emissions. This topic should tell us more about the Whole transport emissions and bring us closer to whether car emissions make a difference in the emissions to our air and how serious it is for air pollution. As I have mentioned, the Total Transport emissions are part of the Total emissions. Road transport is part of Total Transport. Now we will find out if there is some relationship between them.

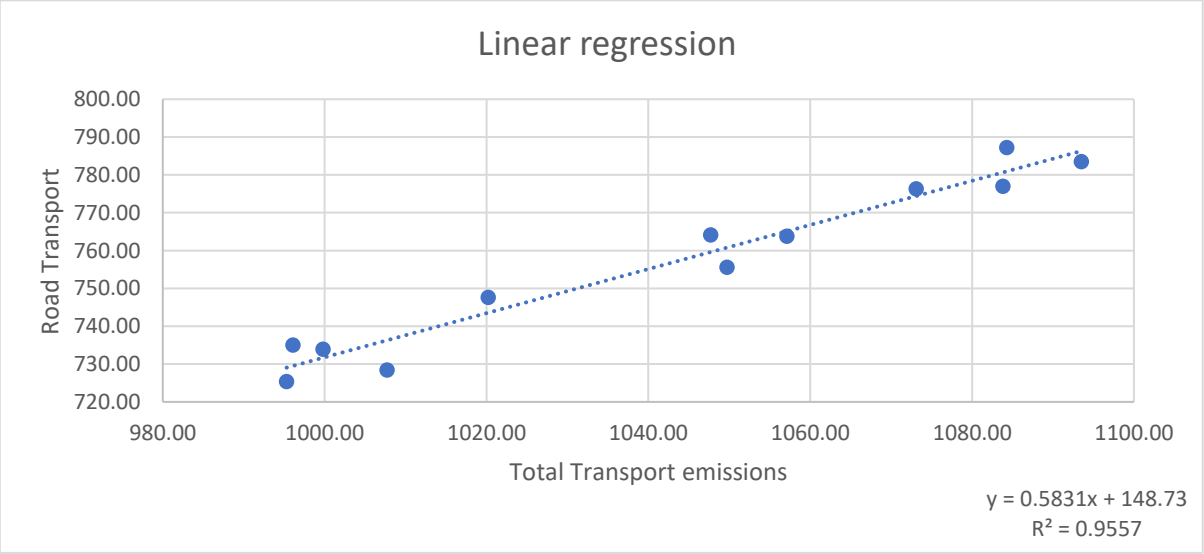


Figure 10

In the figure 10, you can find Road Transport on the Y-axis and Total Transport Emissions on the X-axis. Both values are in millions of tonnes of CO2 from the years 2010 - 2019.

The first look tells us that there is something different going on than the figure 10 . The line is still going up, and the one before was still the same. In the following steps, we will find out why it is so different.

Relationship between Road Transport emissions and Total transport emissions – R Square (R2) equals 0,9557. It means that 95,57% of the variability of Y is explained by X. Correlation (R) equals 0,9776; this information tells us that there is a direct relationship between X and Y. It means that when the value of Total Transport emissions goes up, the value of Road transport emissions also goes up by a significant margin. The fact causes it that Road Transport is the most significant part of Total Transport and produces the most emissions.

4.2.3 Linear Regression of total emissions and car emissions

Do emissions that cars produce have a significant influence on Total Emissions in our air?

We know it does have some, but is it that considerable number when the European Union wants to determine all of the combustion engines from our roads? Let’s take a look at the data that I have put into the graph to see more.

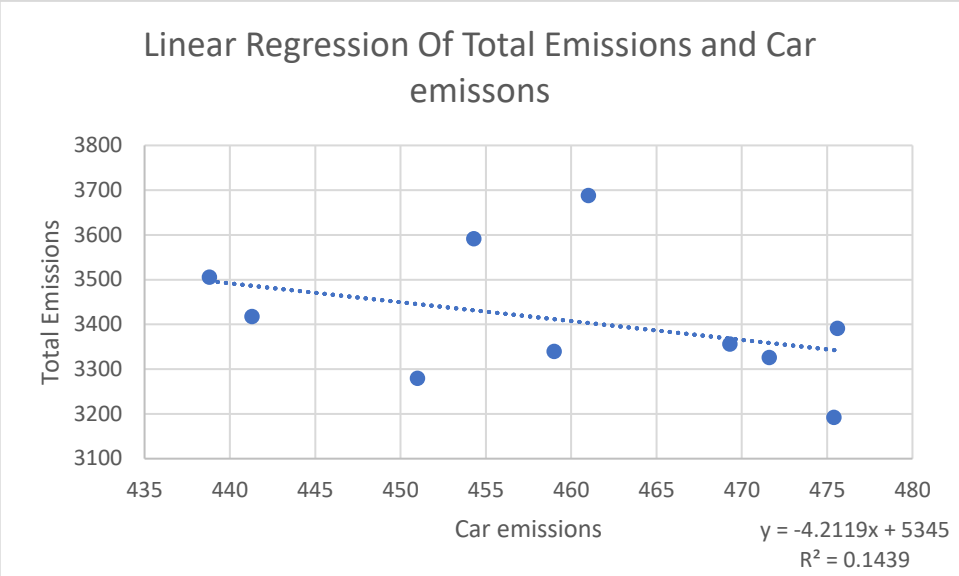


Figure 11

In the first place in the figure above, we can see that the trend line is going down for the first time. What does it mean? We need to analyse the data first, and we will find out.

On the graph, we can see that R squared (R2) is 0,1439, which means that 14,4% of the variability of our y is explained by x.

Correlation (R) equals -0,3794. That means there is a weak inverse relationship between Car Emissions and Total Emissions. It tells us that their relationship isn't much bound, but when car emissions go up, the total emissions should go down the other way around. From this graph, we can see that the Total emissions go down almost every year and the slowly rising emissions from cars don't have much effect.

4.3 New Cars in Europe and their emissions

In this section, I want to give space to emissions of new cars sold in Europe. I want to determine if the trend is increasing, decreasing or still the same. I have chosen for this topic four countries. Bulgaria, Czechia, Germany, and Netherlands.

Why did I choose those countries?

I chose Bulgaria because they have the most un ecologic new cars on average that they sell each year. On the Other hand, the Netherlands sold the cleanest cars in Europe each year from 2009-2020

The Second observer is Czechia. I chose this country because we live there.
The Third one is Germany. The reason why I took data from this country is that I have found there is the most data from all the countries in Europe, and there are most sales from all the states in Europe
For the last one - the Netherlands, I needed data from the country with the most ecological cars sold, and it has been the Netherlands.

4.3.1 Average CO2 Emissions per km from new passenger cars

Table 1

Year	Bulgaria	Czechia	Germany	Netherlands
2009	172.1	155.5	154	146.9
2010	158.9	148.9	151.1	135.8
2011	151.4	144.5	145.6	126.1
2012	149.2	140.8	141.6	118.6
2013	141.7	134.6	146.1	109.1
2014	135.9	131.6	132.5	107.3
2015	130.3	126.3	128.3	101.2
2016	125.8	121.2	126.9	105.9
2017	126.2	124.1	127.2	108.3
2018	126.7	126	129.5	105.5
2019	130.2	128.7	131.2	98.4
2020	133	120.9	113.6	82.3

Source: Eurostat

The table above contains data from Eurostat, which is a European statistical office. These data are taken from 2009-2020 from each year. We will use those data in successive steps to analyse each country. From the table, there is evidence that Bulgaria has the worst average CO2 emissions per km from new passenger cars, and the Netherlands does the best among our subjects. The Czechia and Germany are in the middle.

4.3.2 Calculations

Table 2

n=11	Country	Indicator		Logarithm of the indicator	
		Emissions per km from new passenger cars	Average growth rate	log y_0	log k
		y_0 (co2/km)	k		
	Bulgaria	172.1	0.976842655	2.23578087	-0.010175384
	Czechia	155.5	0.977379587	2.191730393	-0.009936736
	Germany	154	0.972718231	2.187520721	-0.012012944
	Netherlands	146.9	0.948692083	2.167021796	-0.022874724
	Mean	157.125	0.968908139	2.195513445	-0.013749947

Source: Calculations

In this table, you can find initial data from 2009 and its average growth rate from each year. For calculations of the average growth rate, we need the data from the newest year (2020) and the oldest that we have (2009) and divide the newest by the oldest. After that, we must look at how many years we have data from; in our case, it's 11. We need this number to get it into the formula for exponent. We will divide one by the number of the years (11) and use it for the exponent.

The final formula with our data for Bulgaria will be = (133/172,1) ^ (1/11), which is 0.976842655, and this is our average growth rate for Bulgaria.

The mean of Emissions per km from new passenger cars is just about taking data from Each country, summing up them and dividing them by several observations - in our case, 4. Now we have a mean from 4 countries, and we can see that only Bulgaria is above the mean and other countries below average. The emissions from Bulgaria are so high that they are only one above the line.

The same formula calculates the mean of the Average growth rate. In this case, only the Netherlands are below average, and other countries are above the mean. The three countries have almost identical average growth rates. As we closely look at the data, we can tell that the Netherlands had the best emissions at the start, and they are even improving faster than other countries that we observe!

4.3.3 Analysis

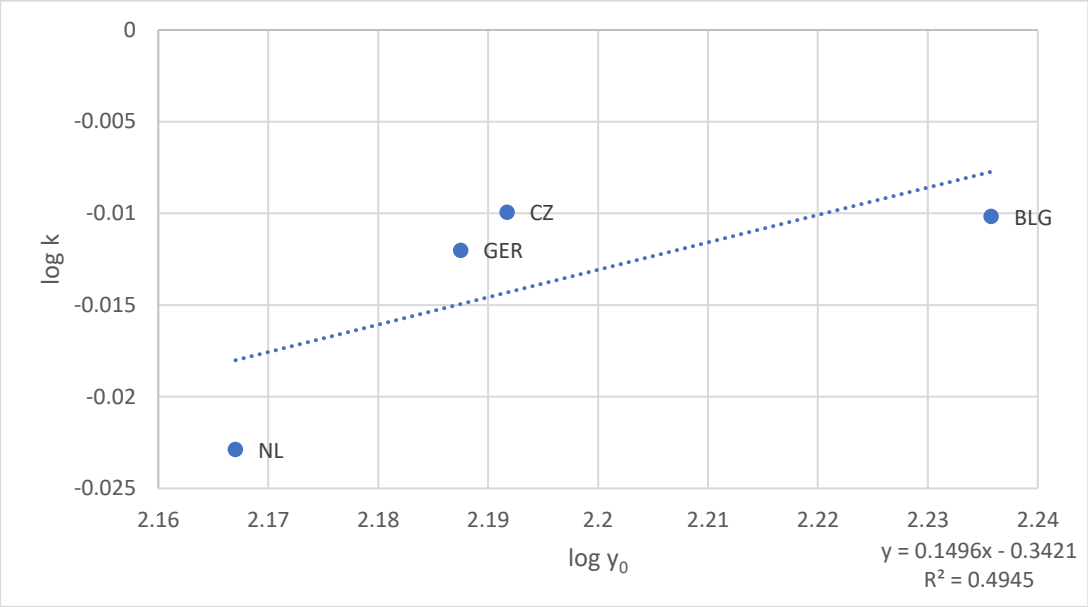


Figure 12

For The analysis, I used the logarithm of the indicators, where y0 is Emissions per km from new passenger cars and k is the average growth rate. On the y-axis, you can find log k, and on the x-axis, you can find log y0. The figure 12 shows us the points obtained by the values from the section logarithm of the indicator from the table… A regression line has a positive value, which means that there is a divergence between our countries. The R Squared (R2) is 0,4945. That means there is a 49,45% tendency for our countries to have the same trend – they are moving in the same ways.

4.3.4 Beta convergence

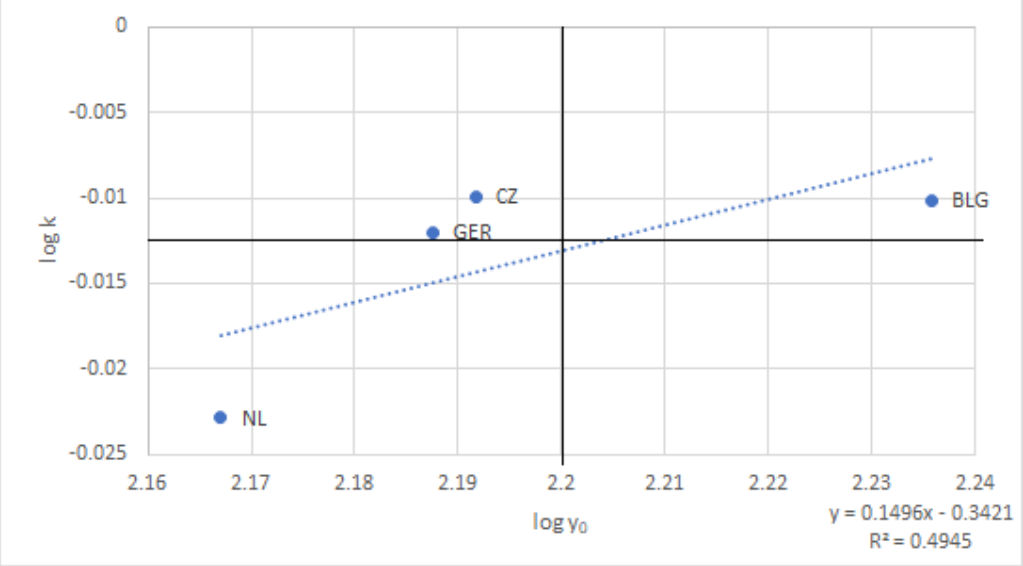


Figure 13

I have split the graph into four quadrants.

Bulgaria is in the first quadrant, which means that the CO2/km is above average. Bulgaria has a high initial value and below-average decline.

Czechia And Germany are in the second quadrant. In the second quadrant, there are states which have below-average initial values and below-average decline.

In the third quadrant, there is the Netherlands which says there has been below-average initial value and above-average decline.

In the fourth quadrant, there are none of our subjects.

4.4 New registrations of passenger cars by type of motor energy

For this analysis and research, I have chosen Germany and Netherlands because from Germany; we have the most data and Netherlands have the cleanest CO2 emissions per km, which we found in the previous chapter.

We have four groups by which we divide the powertrain of cars. The first one is Petrol; the second one is diesel, which was the most common powertrain used in the past. The presence is different. The group is electricity, and the last one is alternative energy.

4.4.1 Petrol

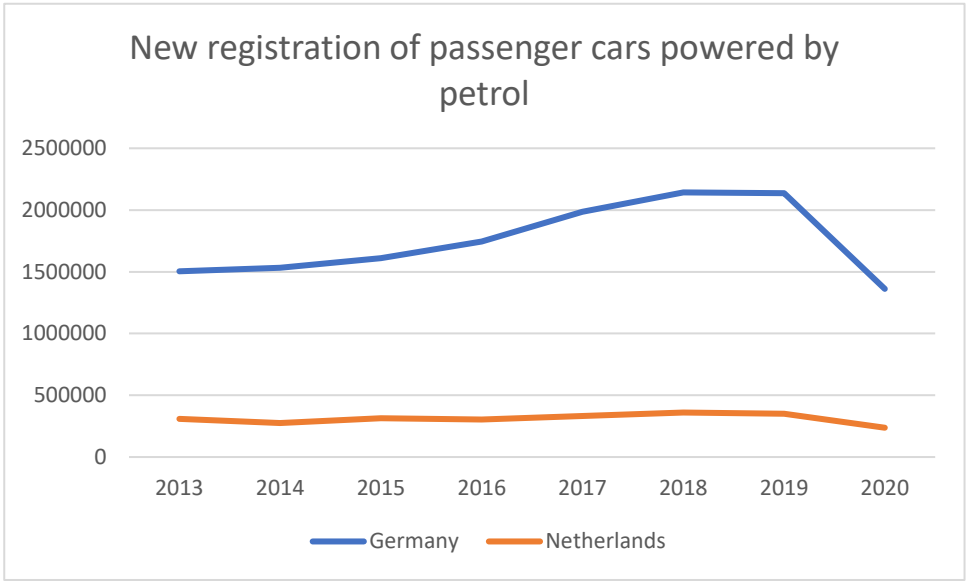


Figure 14

In the figure 14 we can see that there has been a massive demand for petrol cars in the first place, but in 2018 for Germany, this was the turning point when the demand stopped rising. People started buying electric vehicles and vehicles powered by alternative energy. We can say that the increase in selling electric vehicles harms selling petrol cars. In the Netherlands, the trend is almost the same from 2013-2019. Only in the year 2020, there has been a drop of 32,2% by one year. This comes from the same source reason as the decrease in Germany.

4.4.2 Diesel

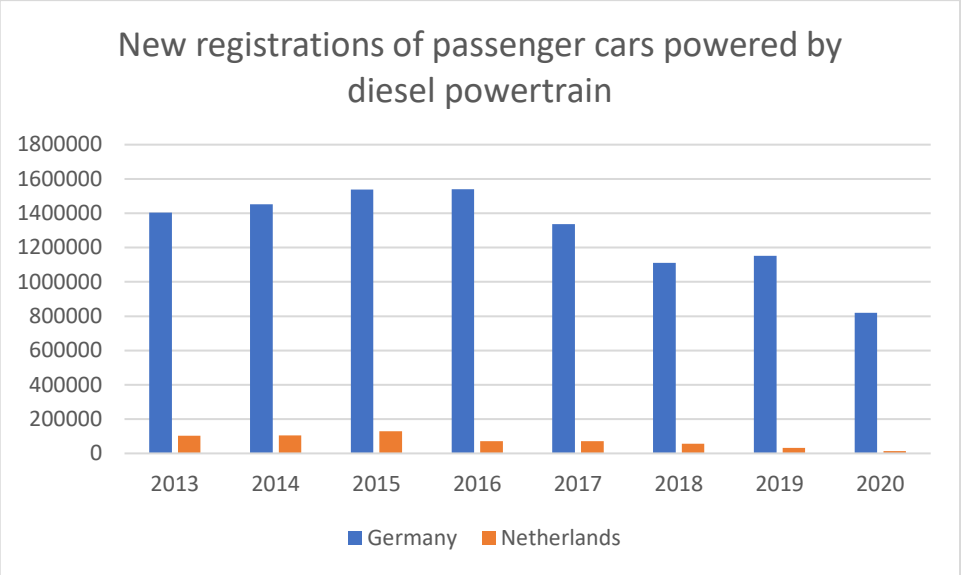


Figure 15

From the graph above, there is a significant difference between sales of diesel cars in Germany and the Netherlands. Diesel Cars in the Netherlands are not popular because they use different powertrains. Germany is a big country, and diesel is better for more extended travelling. The Netherlands also has problems with diesel-powered cars in big cities. In the graph above, you can hardly see the sales for the year 2020 in the Netherlands. But in the last few years, sales have decreased even in Germany.

Table 3

Year	Germany	Netherlands
2013	1403113	103657
2014	1452565	105014
2015	1538451	129768
2016	1539596	72355
2017	1336776	72265
2018	1111130	56996
2019	1152733	32685
2020	819896	12963

In the Year 2013, Germany had 1253,61% more sales for diesel-powered cars than the Netherlands; in the newest that we have (the year 2020), the difference is much bigger. Germany had 819896 sales and Netherlands only 12963, which means the difference is 6224,89%. The difference is five times bigger than it was in the year 2013.

4.4.3 Electricity

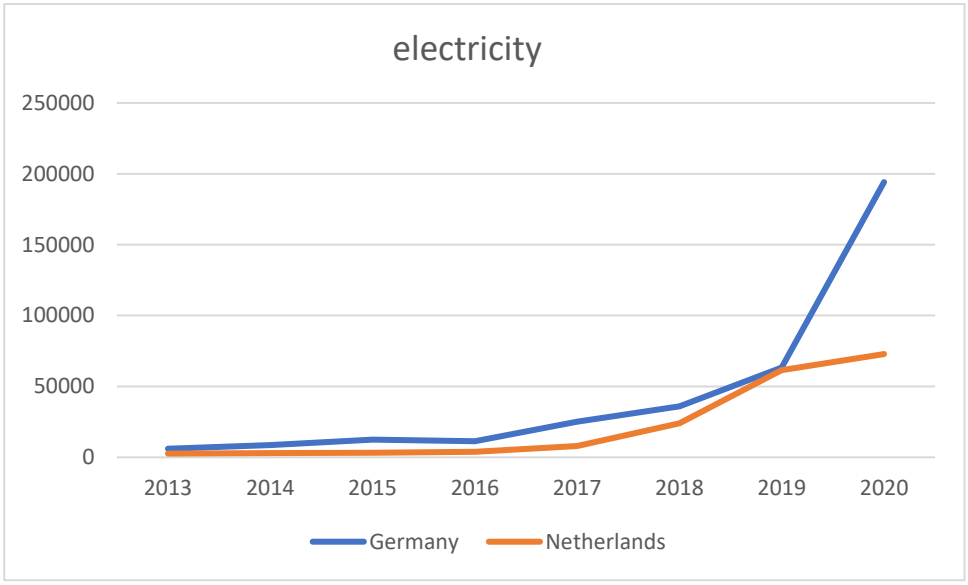


Figure 16

In the figure 16 you can see new registration of passenger cars powered by electricity. In the year 2013, there were almost no electric vehicles you could buy. That changed over time, and now it has significant sales. People want electric cars because Petrol and diesel are getting more expensive. Also, the European Union and almost every Country are trying to support electric vehicles, and they are giving subsidies to make those cars cheaper for people trying to buy them, but they are still more pricey than cars with combustion engines.

4.4.3.1 Problems with the electric cars

Why doesn’t everyone have an electric car?

The high price of the vehicles. Regular people who work every day as ordinary employees have no way of buying one on their own. Most of them cannot afford a new car that is not even electric, and they cost much less than electric ones. It could work if people would get a subsidy from the state/city/European Union, and those cars would cost the same.

Charging and battery problems. There is a problem with charging as people who live in housing estates etc., don't have a chance to charge their car at home. The charging is not fast, and you don't want to stay 45 minutes next to the car until it charges from the charger. Those chargers are like gas stations. You park the car next to it, plug the cable into the car, and you will pay for how much you charge. There are some possible solutions for charging, for example, giving charging stations next to the hotel, shops, etc. But if you go for fast shopping, it will not charge your car as much as you would want. You also must always bring your cable to charge your car. In our country, there are not enough of these chargers, and if you don't have a chance to charge your car at work or home, you must always think about how you will travel and have extra time for charging.

Driving is not that comfortable if you still have to think about where and when to charge your car. Those cars also don't have as much range as regular cars; some of them can travel for 200km, and some of them for 500 (which could be enough but not for everyone). Some people can travel up to 1000km per day and don't want to think about where to charge their car 2-5 times for 45 minutes throughout the way they want to travel.

4.4.4 Alternative energy

Table 4

Year	Germany	Netherlands
2013	46534	5248
2014	50482	7135
2015	56202	4256
2016	65703	5514
2017	117998	10433
2018	181948	25960
2019	317634	62518
2020	736059	74986

This table shows the data from Alternative energy-powered cars in Germany and Netherlands. We can see that in Germany, there is much more demand for Alternative energy-powered cars than electric cars. In the Netherlands, it is almost identical to electric cars. In Germany in the year 2020, they sold 131,7% more Alternative energy-powered vehicles than in the year 2019, which is a considerable increase in 1 year!

5 Results and Discussion

5.1 Car emissions and impact on Total CO2 emissions

The Relationship between car emissions and total emissions isn't heavy. As we have found out in calculations, Car emissions in the last years have gone slightly up, but Total emissions go down almost every year. Also, car emissions make up only a tiny percentage of total emissions. If we want to make our pollution smaller and air cleaner, we have to focus on more things than only lowering emissions for cars and collecting fines from sales of cars. I have also discovered that electric cars can help with CO2 emissions. However, it cannot help with greenhouse gas emissions. Overall, as the production of batteries makes a

lot of greenhouse gases, the charging and production of electricity do it too. Also, there are emissions from rubber rubbing the ground by the car's wheels travelling. The worst part about electric cars is the liquidation of batteries because we haven't found an ecological way to get rid of them.

5.2 Average CO2 emissions from new cars

In the thesis, I found out that the CO2 Emissions from new cars are more minor almost every year. It is accompanied by emission standards, norms, laws and fines for exceeding the permissible limit of CO2 emissions per km. That means every new car (that is more ecological than old ones) is more expensive. People are driving old unecological cars because they don't have money for new ones, and for me, this is counterproductive. There should be more considerable fines for driving old cars because they are more unecological than any new cars. If people did not have money to operate old cars, they would be forced to buy new ones with fewer emissions or drive by public Transportation and produce even fewer emissions.

5.3 New passenger cars

From our data taken from Eurostat, I have found that fewer people are buying diesel-powered cars. The petrol ones are still the best-selling, but the electric powered cars are in trend in most recent years, and if the trend continues, electricity will soon be the most selling powertrain on our market.

6 Conclusion

The main goal of this thesis was to analyse the problematics of Exhaust gases (CO2) in Europe and find out if there is any solution to minimise air pollution and find out if electromobility can help to solve these problems.

In the thesis, we have found that we can minimise air pollution by putting out old cars or minimising them. The electromobility can also help to minimise air pollution because they don't make any Exhaust gases. But they are not fully clean as they produce many other greenhouse gases in the production of batteries, in manufacturing, when charging and when the battery is no longer usable as there is no ecological way to dispose of the battery. But this is another topic I would like to discuss in my diploma thesis. This topic would open another dimension to research electric cars and their greenhouse gases. The author of this thesis would like to calculate every aspect that electric cars perform to find out if they are a solution for our climate and air pollution in all ways, not only in Exhaust gas emissions.

The new cars have much fewer emissions than before, even if they are not electrical. We also make significant progress in not buying new diesel cars that produce more CO2 than petrol cars. Alternative energy is also growing every year. The overall emissions from cars are not decreasing, but we must consider that people are more demanding, and everyone wants to drive their car and have their comfort and peace without any other people.

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8 List of pictures, tables, graphs and abbreviations

8.1 List of tables

8.2 List of graphs

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