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ANALYSIS OF INTERNAL COMBUSTION ENGINE VEHICLE, BATTERY ELECTRIC VEHICLE AND EMISSIONS FROM TRANSPORT

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Abstract:
This article devotes the issue of transport emissions, the EU's priorities and objectives in implementing emission standards. The first part deals with emissions from transport in general, by type of transport and later specifies emissions from electric cars based on ICCT study. The second part of our study deals with the issue of the ability of an electric car to fully replace a conventional motor. Four factors are evaluated, which influence the choice of means of transport at the time of purchase. The output of this study is to evaluate and present the best alternative to each factor and to present the facts that change the perspective to zero electric vehicle emissions.

Key words:
Transport emissions, BEV, ICEV, analysis, propulsions

INTRODUCTION

One of the main priorities of the EU and the Slovak Republic, as a member of this institution, is the fight against climate change. Europe is a world pioneer in this fight and is working hard to reduce greenhouse gas emissions, setting a good example for other countries or regions. The EU has set out several objectives, whether short-term or long-term. The first set of regulations was introduced in 2009 following a voluntary commitment by the car industry to reduce the average CO_2 emissions of vehicles. The aim was to reduce emissions for new passenger cars by 130 g/km by 2015 and 175 g/km for deliveries by 2017. The second set of regulations, approved in 2014, required average CO_2 emissions from new cars to fall to 95 $g.km^{-1}$ by 2021. In the case of new, larger cars, the target value by 2020 was 147 g/km. In terms of time, the most current targets for 2020 are a decrease in greenhouse gases by 20% compared to 1990, an increase in energy from RES (Renewable Energy Sources) in final energy consumption to 20% and a shift to increase energy efficiency by 20%. The greenhouse gas target is to reduce by at least 40% by 2030 compared to 1990 (Fig.1). The long-term target is known as Roadmap 2050, which aims, under the auspices of the EU, to reduce greenhouse gas emissions by at least 80% by 2050 compared to 1990 [1].

In 2019, greenhouse gas emissions fell by 3.7%, while the EU economy continued to grow. According to an approximate GHG inventory, EU27 GHG emissions (including international aviation) decreased by 24% in 2019 compared to 1990 levels. After including emissions and removals from land use, land use, land-use change and forestry (LULUCF), there was a net emission reduction of 25%. The EU thus remains well on track to meet its target under the UN Framework Convention on Climate Change, which is to reduce greenhouse gas emissions by 20% by 2020. Compared to 2018, in 2019 the number of emissions decreased by 3.7%. EU greenhouse gas emissions have thus reached their lowest level since 1990. Between 1990 and 2019, the EU's combined GDP increased by around 60%. The greenhouse gas emission intensity of the economy, defined as the ratio between emissions and GDP, fell to 282 g CO_2/EUR2015 equivalent, which is less than half the 1990 figure [2-3].

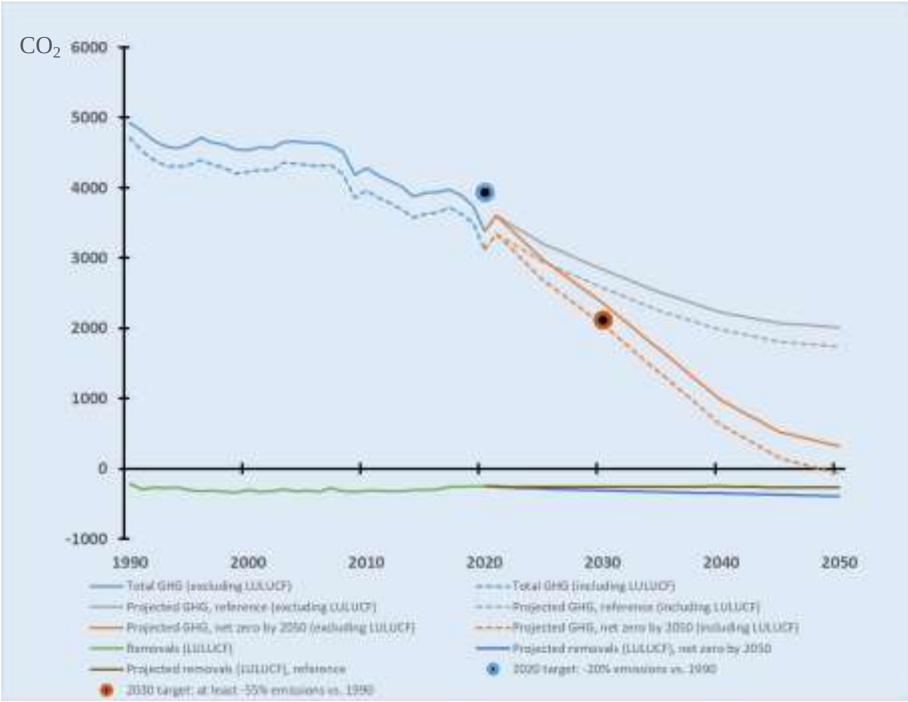

Fig. 1. *Total EU-27 greenhouse gas emissions (including emissions from international aviation) and emissions removed in 1990-2019, the current target for 2030 and projected emissions in 2020-2050 [7]*

The crisis caused by the COVID-19 pandemic is expected to lead to unprecedented emission reductions. Based on data from the Carbon Monitor project carried out by an international research consortium, it is estimated that EU27 emissions fell by 11% in the first half of 2020 compared to the same period last year. However, as has been shown in the past, rapid economic recovery can lead to a significant and rapid increase in emissions unless measures are taken in policy to stimulate green transformation. The first reliable data on the effects of the COVID-19 pandemic on EU emissions will be available in a report presented next year [3].

The aim of our study is based on the theoretical knowledge in the following sections to perform an analysis between BEV (battery electric vehicle) and ICEV (internal combustion engines vehicles). In the beginning, we choose 2 specific types of cars (BEV and ICEV) and through the data offered by car manufacturers and according to equations for our analysis, we determine the advantages and disadvantages of the mentioned types of drives.

1 EMISSIONS FROM TRANSPORT

With transport contributing around 5% to EU GDP and employing more than 10 million people in Europe, the transport system is crucial for European businesses and global supply chains [4]. At the same time, however, our company pays a considerable price for it: greenhouse gas and pollutant emissions, noise, traffic accidents or traffic jams. Climate change and environmental degradation pose an existential threat to Europe and the world. To address these threats, the European Green Agreement was introduced to transform the EU into a modern and competitive, resource-efficient economy. The Europe Green Agreement aims to ensure:

- net-zero greenhouse gas emissions by 2050,
- economic growth that does not depend on the use of resources,
- and no individual or region will be forgotten [4].

The European Green Agreement is also presented as a lifeline from the COVID-19 pandemic. One-third of the € 1.8 trillion investment from the Next Generation EU recovery plan will also go to the Europe Green Agreement and will also be financed from the EU's seven-year budget [4].

As a percentage, transport accounts for up to 30% of all CO_2 emissions in the EU. This was also one of the reasons for setting a target for the European Union and reducing CO_2 emissions from transport by up to 60% by 2050 compared to 1990 [5]. This plays an important role in reducing greenhouse gas emissions. This is an important step, especially if we realize that while CO_2 production is declining on average in other sectors, on the contrary, emissions in transport will increase with increasing mobility. The trend of developing higher fuel efficiency of new cars has stopped. In 2017, slightly higher CO_2 emissions were measured for new cars (on average 0.4 g per km more than in 2016). For this reason, the EU has started to set new targets to reduce CO_2 emissions. The goal is to reduce emission limits by 20.5% for new passenger cars, 31% for vans and 30% for trucks by 2030 compared to 2019 [5].

Cars clearly belong to the group of the largest CO_2 eminences (Fig.2). They account for up to 60.7% of total emissions in transport [6]. The idea that one car can become the most environmentally friendly mode of transport is realistic if more people are travelling by car. However, it is statistically proven that in Europe there is one car per 1.7 passengers, which means that other transport options such as bus appear to be a more environmentally friendly alternative [7].

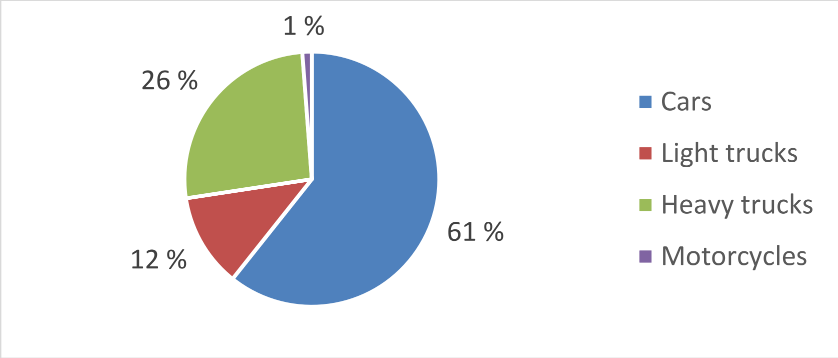

Fig. 2. *Share of emissions by mode of transport*
Source: Own research based on [7]

Efforts to eliminate CO_2 emissions know two real options: either by increasing the efficiency of internal combustion engines or by switching to other fuels and propulsion. In total, 59% of cars in the EU, represent ICEV but more and more electric cars cannot be overlooked. Demand and sales of electric cars in the EU increased by 51% at the turn of 2016 and 2017 [6]. Even though the number of registered electric cars is higher every year, they still represent only a small percentage of the market. However, in the debate we could have on greener transport, we cannot forget how much greenhouse gas a car emits into the air during use, or even how much the environment is polluted by the production or disposal of the car itself. An important factor to mention is that the production and disposal of electric cars put a much greater impact on the environment compared to conventional cars.

1.1 Emissions from electric cars

The public is convinced that the arrival of electric cars is the so-called salvation for excessive emissions in transport, but every product produced requires a life cycle review. From the extraction of raw materials to the pollution generated during its production, operation or the impact of waste generated during recycling. All this is part of the life cycle of an electric car. In the following sections of this chapter, we will take a closer look at how real "green" is the production, use and recycling of electric cars.

The International Clean Transport Council (ICCT), a non-profit organization that was also involved in detecting fraud called "Dieselgate", conducted a study comparing, among other things, emissions from electric cars and internal combustion cars, including their fuel/energy or production footprint [8]. The ICCT analysis examines not only CO_2 emissions but overall greenhouse gas emissions. Especially in the largest car markets (China, Europe, USA, India), where about 70% of all new cars are sold. ICCT considers greenhouse gas emissions at each stage of the life cycle of cars and "fuels". From the extraction and processing of raw materials, through refining and production, to operation and eventual recycling or disposal. The ICCT also compares the current findings with the projected situation in 2030. It is important to note that the average lifetime carbon footprint of fuel and electrical mixes was also included in the ICCT calculations. And changes in the intensity of the carbon footprint over the lifetime of vehicles should also be considered. Fuel and electricity consumption was also considered in the average use of vehicles in the real world, with analysts not relying only on official test values. The latest data on industrial-scale battery production and regional battery supply chains were also considered. Emissions from the production of batteries for electric vehicles were found to be significantly lower than in previous studies.

1.2 Results of the ICCT study

A new study buried the myth that electric cars are only as clean as the electrical network from which they are charged. And this is true regardless of the region. Throughout its life cycle (from raw material extraction to decommissioning), the electric car is 69% cleaner than a combustion car in Europe, the USA (a large share of renewables), China and India (a network heavily dependent on coal). Although countries around the world are setting specific dates for the ban on the sale of internal combustion cars (California and the EU in 2035, the United Kingdom in 2030, Norway in 2025), much of the car industry is still lobbying and convincing the public that electric cars are not so environmentally friendly when you include emissions from the production of electricity for their propulsion and emissions from the production of batteries. Facts and figures make it clear that the carbon footprint of electric cars is significantly lower than that of combustion cars. The ICCT report estimates emissions from medium-sized electric vehicles registered in 2021 in India, China, the US or Europe (markets representing 70% of new vehicle sales globally). It concluded that electric cars have 66 to 69% lower emissions than a combustion vehicle in their life cycle. In the USA, electric cars produce 60 to 68% fewer emissions. In China, where most energy is produced from coal, it is 37-45% less. India, which produces more than half of its energy from coal, still has 19-34% fewer emissions. (Fig. 3) [8].

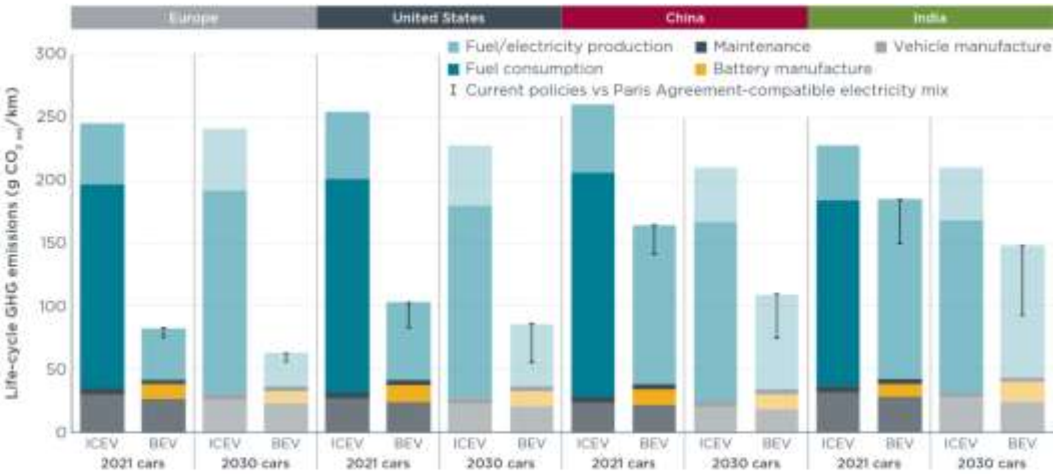

Fig. 3. *Comparison of electric car emissions versus internal combustion cars in the world*
Source: ICCT, 2021

The study only counted vehicles registered in 2021 and will drive for another 18 years or so. They counted on emissions with the current energy mix of countries, but also with the predictions of the International Energy Agency (IEA). It is very difficult to estimate how much energy production will go to renewables. Although the EU has set specific dates, these are not yet legal commitments. US President Joe Biden also announced his goal of producing 100% renewable energy by 2035. However, his plan has yet to go through negotiations and a congress, where Republicans and various opponents of clean energy also have their say. It is important to note that the study did not consider emissions from the extraction of raw materials and the amount of waste that will be produced/recycled at the end of the vehicle's life [8].

Today, the production of the electric car itself is still a bit more energy-intensive than the production of an internal combustion car. Massive battery recycling (today there is no capacity or enough batteries for mass recycling) will significantly reduce the carbon footprint of electric cars. Today, a conventional electric car takes about 1 year of use to equalize its emissions from production to the level of an internal combustion car [1]. This is achieved by charging from cleaner energy sources. Emissions from use represent only a small fraction of fossil fuel combustion emissions (Fig. 4).

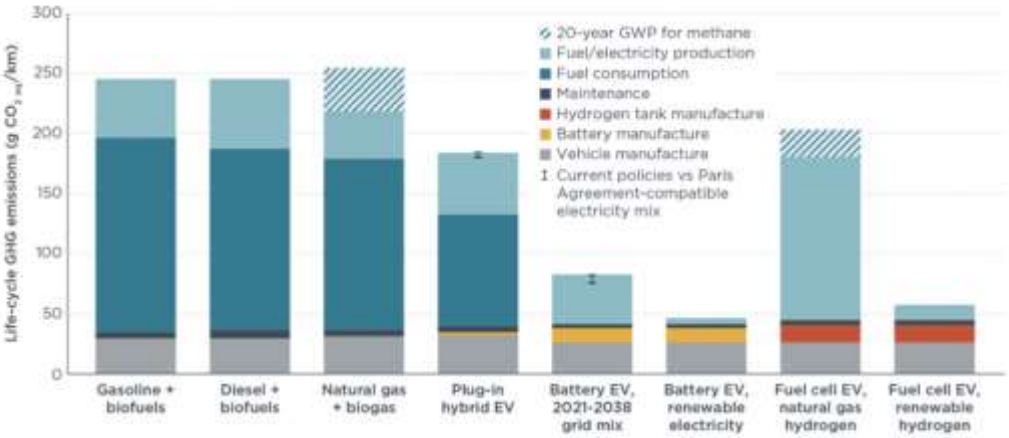

Fig. 4 *Life-cycle emissions from different types of propulsions*
Source: ICCT, 2021

The ICCT hopes that the published report will help politicians to make more informed decisions about the future of transport. International environmental experts are working to bring the carbon footprint of human activities to almost zero by 2050, in order to avoid the catastrophic consequences of global warming [8]. Switching to battery-electric cars and scrapping internal combustion vehicles is the only way to achieve this, according to the ICCT report. Switching to hybrid vehicles will not be enough. The ICCT does not recommend allowing the sale of new combustion vehicles after the late 1930s. This is the finding of ICCT's global analysis.

2 ANALYTICAL EXPERIMENT OF EMISSIONS PRODUCTION OF 2 DIFFERENT PROPULSIONS

Based on this knowledge, we have learned that, from the manufacturer's point of view, it is important to focus on reducing emissions according to a plan prepared by the EU until 2050. From the user's point of view, overall travel, time, and financial costs become a priority. For electric cars to function as a full-fledged means of transport, drivers should not consider whether one must plan stops before a long journey and calculate how many times the electric car will have to be recharged. Therefore, we decided to offer the results of our analysis in the next part of our study, where we will propose an analytical simulation that will evaluate important factors, either from the point of view of the manufacturer or the user. Drivers are different and have their own needs. This is one of the reasons why various alternative drives are being introduced to meet the expectations of every driver. The subject of our analysis will be the selection of two mutually different drives (ICEV and BEV), which will be statistically evaluated on a predetermined route in Slovakia, depending on the factors influencing the overall course of the route, respectively data offered by the car manufacturer. The expected production of emissions, the financial costs of fuel (charging), the total range of a full tank (battery) and the passage time of the route of individual cars will be evaluated. When choosing a route regarding the evaluation of selected cars in the given categories, it was necessary to plan a variety, respectively a combined route that would include both municipalities and 1st and 2nd class district roads. This is because we can use the so-called combined consumption (average consumption that the car achieves when changing speeds up to 50 km.h^{-1} and over 50 km.h^{-1}. The resulting route measures a total of 857.1 km, for more transparent calculations we rounded this number to 860 km. The starting point, ie the start of the route is Bratislava. The second point is Lučenec, followed by Prešov and Ružomberok, from Ružomberok we move back to Bratislava, which is also the destination point of the route. As far as the infrastructure of charging stations along the designated route is concerned, the current infrastructure of charging stations on our route is sufficient and does not represent any restrictions for the driver of an electric car. The selection of cars was very important for this analysis. The decisive parameters were the engine power, which is decisive for the simulation, as well as the price of the car, engine type, capacity of tanks (or batteries), range per charge, consumption, maximum speed and eliminated emissions per 1 km. When choosing cars, we wanted to achieve that all 2 types of vehicles have approximately the same parameters. Selected cars are Mercedes-Benz EQC 400 4MATIC (BEV) and Jaguar F-Pace (ICEV).

The first type of vehicle to pass our imaginary route was the BEV. The electric car has an engine power of 300 kW and a battery capacity of 80 kWh. Based on these values, the manufacturer states consumption of 25 kWh/100 km. The combined range is around 300 km. Emissions emitted when using an electric car are zero CO_2, i. j. 0 g.km^{-1} [9]. The second vehicle that we will subject to our analysis is the ICEV. Under the hood, we find an engine with an output of 300 kW. The capacity of the fuel tank is 82 liters, which in combined consumption is 8 l.km^{-1}. The emissions of CO_2 reported by the manufacturer are 180 g.km^{-1} [10].

2.1 Analysis methodology

When calculating the total financial cost of refuelling (charging), we will use a simple equation:

$$FC = f_{km}(ch_{km}) \cdot r, \tag{1}$$

where: FC - financial costs (EUR),
f_{km} (ch_{km}) *– fuel (charging) price (EUR per 1km),*
r- range of the selected route in (km).

In the case of the total range of a full tank, we start from the equation:

$$FT_R = \frac{C_t(C_b)}{C_c} \cdot 100\ km, \tag{2}$$

where: FT_R *– full tank range (km),*
$C_t(C_b)$ *– capacity of the tank (l), capacity of battery* (kWh),
C_c *- combined consumption (l) per 100 km*

Excluded emissions on the specified route are calculated according to the equation:

$$E_t = e_{km} \cdot r, \tag{3}$$

where: E_t *– total emissions (g),*
e_{km} *- emissions excluded per 1 km (given by the manufacturer) (g.km^{-1}),*

r- range of the selected route (km).

In the case of the time needed to cross the route, we will start from the equation:

$$T_t = \frac{r}{s_c}, \rightarrow ICEV \tag{4}$$

$$T_t = \frac{r}{s_c} + \frac{r}{FT_R} \cdot m_{ch}, \rightarrow BEV \tag{5}$$

where: T_t *– total time needed to cross the route (h),*
r – range of the selected route (km),
s_c *- combined speed on the route (km.h*$^{-1}$*),*
FT_R *– full tank range (km),*
m_{ch} *- total minutes needed for charging.*

Table 1 lists the data needed to calculate the individual parameters determined at the beginning of the analysis.

Tab. 1 *Data from car manufacturers needed for the calculation [9], [10]*

Parameters	BEV	ICEV
Consumption (kWh (l)/100 km)	25	8
Tank capacity (l), battery (kWh)	80	82
Combined range for full tank/battery (km)	320	not specified
Charging time (min)	65	-
Emissions (CO_2/1 km)	0	180

2.2 Results of the analysis

BEV - Battery electric vehicle

The first information that will be evaluated is the fuel price, respectively. electricity needed to complete the route. The average price for recharging for a range of 100 km, according to data obtained on the website of ZSE, is 4.75 €, so for 1 km, it is approximately 0.05 € [11]. The following calculation is based on this information, which determines the price for a total range of 860 km. The total amount to cross this route according to (1) and parameters from manufacturers is 43 €. This means that the electric car will have to recharge 2.7 times on the selected route. In the case of calculating the full battery range, for a combined route it will be according to (2) 320 km. As already mentioned, the electric car does not produce any CO_2 emissions during the use phase, so in the case of BEV, it is 0 g.km^{-1}.

The route is 860 km long, so if we count on an average speed of 70 km/h (90 km/h maximum speed outside restricted areas outside the village and 50 km/h maximum speed limit in restricted areas in the village, then both cars will cover this distance in 12.3 hours, i.e., 738 minutes. Our purpose is to focus on the electric car, which must stop several times during the journey and recharge the battery. According to the manufacturer, the real driving distance per charge is 320 km. This means that the electric car will have to stop 2.7 times on the 860 km long route. Because charging with a DC charger is fast and takes the electric car approximately 65 minutes, the time for which this vehicle travels a given distance is extended by 175.5 minutes, i.e., by 2.93 hours. Thus, according to (5), the approximate total time to cross the designated route for BEV will be 15.23 hours. The electric car itself is not the best choice for the impatient resp. time-limited people who need to move from point A to point B in the shortest possible time.

ICEV - Internal combustion engines vehicles

As we already know from Table 1, the capacity of the tank is 82 l. The average price of petrol from the end of October 2021 is 1.498 €/l (0.12 €/1km) [12], so the total cost of the specified route according to (1) is 103.2 €. In the case of a full tank range with combined consumption, we get according to (2) approximately 1,025 km. In terms of time, the car does not have to stop at the gas station. Due to its combined consumption and range, the vehicle will suffice. Therefore, in ideal conditions, the car should have a range of some 160 km under ideal conditions. The total time this type of car model needs to travel the route is 12.3 hours (from the previous calculation). In the case of total emissions excluded on the specified route, we know from the technical parameters of the vehicle the value of CO_2 is 180 g.km^{-1}. The total emissions that the car will emit during the route according to (3) are 154 800 g CO_2.

In the following part of this article, we will summarize the results of our statistical analysis, we will compare the obtained values of each factor of individual car models so that we can finally evaluate the best alternative for the route. The task will therefore be to characterize each factor as such. We can see in Table 2 below a representation of the obtained results of individual types of propulsions.

Tab. 2 *Summary results of the analysis*

Parameters	BEV	ICEV
Total costs (€)	43	103.2
Full tank (battery) range (km)	320	1 025
Total time (h)	15.23	12.3
Total emissions (g CO_2)	0	154 800

Source: Own research

3 DISCUSSION

The total route costs for selected models vary concerning consumption and drive type. In our research, we focused only on fuel, but there are many more factors that affect the total cost of driving. We can mention tire wear, maintenance, fines, unexpected expenses during the trip and much more. However, we planned to focus only on fuel under ideal conditions throughout the trip, respectively. the course of the route would be smooth and without incidental expenses. According to what we detected, 1kWh costs € 0.19 [11]. Through calculations, we have worked to ensure that the electric car pays € 0.05 for 1 km of energy consumed. At first glance, this amount seems ridiculous, but after a sharp rise in charging prices, the alternative of using only an electric car seems to be a nightmare. The advantage should be the mentioned packages from the manufacturers, which are to reduce the total amount per 1 kWh.

As with the economic factor, we must not forget the factors that affect the overall range of the car in terms of mileage. Our two models have different drives and consumption, which are key to the overall range. In the case of an electric car, it is an electric motor with a battery, which has the appropriate capacity, and which affects the range of the vehicle itself. Of course, we must not forget the fact that the total battery consumption depends on e.g., from the outside air temperature but also the driving style, so in our case, we approached the already mentioned plan with ideal conditions, t. j. average speed 70 km / h, when the total range of the electric car is the most ideal. There is no need to argue when driving a car with an internal combustion engine. The car will have a combined consumption under ideal conditions, the maximum range that suits our analysis.

An interesting but scientifically irrelevant criterion is time. Interesting because in today's modern age, full of hurried people, unfortunately, it is true: Time means money. Meaning, we want to either save the most or earn the most in the shortest possible time. For an even more detailed explanation, we will use the following example. Imagine a courier who has to deliver a shipment to the customer. It will be important for both the customer and the employer to deliver the shipment as soon as possible. From the customer's point of view, the reason is simple, it is mainly about impatience and the anticipated need for the ordered goods. The reason from the employer's point of view is certainly the satisfaction and good response of the customer when delivering the shipment in the shortest possible time, but the main reason on the part of the employer is to save the most time from which the total courier salary is derived. From this example, it is clear to us that time plays a big role today.

As well as the total cost, full tank range and total time are affected by a myriad of factors, the case of excluded emissions will not be an exception. For each of its models, the manufacturer shall state the number of emissions emitted per km. This was not the case with our models either. The calculation of total emissions in each of the selected models was based on this value, which was then multiplied by the number of kilometres. Of course, we know that the value of emissions can rise or fall, depending on the driving style and especially the consumption, but in our case, we considered the ideal conditions for maintaining the value stated by the manufacturer. For the ecological enthusiast, the resulting emission value for the electric car will be a finished gold mine. As it is a purely electric drive, the emissions that are eliminated on our route are equal to a beautiful green zero. Compared to an internal combustion engine, 154 800 g of CO_2 are emitted on a given route. Let us have a driver who is financially willing to spend a maximum of 80 € on the total cost, is not limited in time and wants to keep the value of excluded emissions as low as possible. If he considers ICEV, it will not satisfy him by the number of emissions and the total cost. From the point of view of the requirements of a potential driver, only an electric car whose budget is in the desired price category and emissions are zero would meet, although the total time spent on the route is the longest.

4 CONCLUSIONS

Based on the evaluation, our analysis is an ideal case, which we would find very difficult in everyday life. It is necessary to mention that errors and uncertainties arise mainly because we have adapted the problem to the least expected course of the route. Few people adhere to a precise speed in and out of municipalities, so the average speed in practice was certainly higher than 70 km/h. As for the condition of the road and the route, it is unnecessary to argue that it will be as ideal as we imagined in the design and the car would not suffer any technical failure. Not to mention unexpected traffic restrictions, construction/repair of roads, which would significantly affect the total time of the route. As the average speed increases, so do consumption, and thus the expected range decreases. With declining mileage, fuel costs would also increase in some drive cases. For example, in the case of an electric car, the total consumption changes only when the weather changes. In this way, we would be able to go on indefinitely and find many factors that would affect our analysis in real life. To create our ideal conditions, we would have to make every effort in real life to reduce the high number of adverse factors.

Transport connects people, cities, countries, and the economy and supports growth and employment. However, transport also damages the climate, the environment and human health. To reduce these effects, Europe needs to move towards a more sustainable circular economy and a decarbonised transport system. From the theoretical knowledge gained at the beginning of our article, we know that, despite previous technological improvements, the transport sector is responsible for about a quarter of Europe's greenhouse gas emissions, which contributes to climate change. Emissions from road vehicles also contribute to high concentrations of air pollutants in many European cities, which often do not meet air quality standards set by the European Union and the WHO (World Health Organization). In addition, road transport is a major source of environmental pollution in Europe and damages human health and well-being.

From an ecological point of view, the option of an electric car seems to be the best alternative, as we know from theoretical knowledge that emissions from transport are constantly rising and it is necessary to look for new, more environmentally friendly ways to gradually reduce emissions. Based on the results shown in Table 2, from an environmental point of view, the electric car is the best choice for the future. Of course, every coin has two sides, everything has its advantages and disadvantages, and so it is with electric cars. Although the use phase of the electric car offers zero emissions, drivers inadvertently have to limit the state of charged batteries and sacrifice time at power stations. In case the driver is going to drive a longer route, it is important to plan the trip so that he is able to charge his battery during the trip, which forces the driver to give up his comfort and sacrifice several times for a long time on "electric gasoline" than in case of convention car. The advantages and disadvantages of individual propulsions can be continued indefinitely. Today, the question of whether an electric car can fully replace conventional engines, due to high emissions, is probably posed by anyone involved in the field of cars. This question can also be partially answered based on a statistical experiment and its evaluation. We statistically calculated how many financial costs the driver would need, based on the technical parameters of the vehicle we were able to calculate the estimated range and total emissions and due to the first two factors we were able to determine the estimated total time to cross the route. The result of our research was the example of a driver whose requirements were unique, ie intended exclusively for his person. With a specific example, however, we wanted to point out the diversity of requirements of each driver. From the point of view of the potential user, we can therefore state that none of the options can be assessed as the best in general. Based on the evaluation, each of us can form our own opinion and choose the best option for ourselves, which means that the electric car would be able to meet the expectations of each driver, only to the extent that the driver's demands allow.

For many people, an electric car is a means of eliminating zero emissions and thus saving the environment. However, this fact has a dark behind the scenes, as most charging stations draw energy from non-ecological power plants. In addition, in the results of the ICCT study, the production of electric cars and batteries is more environmentally demanding compared to the production of ICEV. So, what is presented as a way out of the hell of emissions could probably do us more harm than good. The subject of further studies should therefore be to find a way to make the production processes in the production of electric cars and batteries, together with the energy source itself, as environmentally friendly as possible. Only in this case could we call electric cars ecological friends on the road.

Due to the current pandemic situation, this analysis was performed statistically or under ideal conditions, based on data obtained from car manufacturers and our assumptions, which we determined at the beginning of the analysis. If the pandemic situation allows, the subject of the future study should be a realistic analysis of two alternative propulsions, in real conditions, which means adequate road conditions, weather conditions, battery life, unexpected road restrictions, car service, etc. Such a real analysis will provide real dynamic results and a much more realistic indication of the advantages and disadvantages of individual propulsions.

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