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ARE THE ELECTRIC CARS ENVIRONMENTALLY AND FINANCIALLY FRIENDLY SOLUTIONS? A YEAR AND A HALF LATER

Zoran Čekerevac[1], Zdenek Dvorak[2], Lyudmila Prigoda[3]
zoran@cekerevac.eu, zdenek.dvorak@uniza.sk, lv_prigoda@mail.ru

[1]Faculty of Business and Law, MB University
Teodora Drajzera 27, Beograd
THE REPUBLIC OF SERBIA
[2]Faculty of Security Engineering, University of Žilina
1. mája 32, Žilina
SLOVAKIA
[3]FSBEI HE Maikop State Technological University,
Ulitsa Pervomayskaya, 191, Maykop
RUSSIA

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Abstract: *The article analysis the justification for the substitution of internal combustion engines with electric motors for driving motor vehicles from the ecological and economic aspects. The authors compared the situation in Europe with the USA and several other countries placing specific emphasis on CO_2 emissions and the sources of emissions. In addition to CO_2 emissions caused by transport, the authors also considered other impacts. The situation in 2022 was specific in everything. The COVID-19 pandemic consequences, rising inflation, the war in Ukraine, and the related sanctions imposed by the EU and the USA on Russia are intertwined. The authors intend to determine the share of pollution from passenger vehicles in the total harmful emission. In the chapter Sources of CO_2 emissions, they also considered the impacts of forest fires, volcanoes, ruminant cultivation, and emissions of harmful gases because of wars. In the final part of the paper, the authors concluded that using electric propulsion in passenger cars is still impractical because the electric propulsion technology has not yet reached a mature phase. It would be more environmentally friendly to replace vehicles with old internal combustion engines with modern ones. The authors especially emphasize the importance of creating a new comprehensive strategy that would include educating the population on the economical use of available resources.*

INTRODUCTION

In the articles Are Electric Cars Now an Environmentally Friendly Solution? Yes, and No! [1] and Electric or Internal Combustion Engines for Passenger Cars? [2] the authors discussed the application of electric and hybrid cars by various producers. The authors have discussed the characteristics of vehicles from the driving, environmental, and economic aspects.

The testing of the set null hypotheses showed that:

H_{a1}: There are cases when electric cars are not more environmentally friendly than vehicles powered by internal combustion engines (ICEs) in terms of CO_2 emissions.

H_{a2}: There are cases when electric-powered cars are not more affordable than vehicles with internal combustion engines from an economic point of view. [1]

and

H_{a3}: Internal combustion engines are sometimes more environmentally friendly than electric motors to power passenger motor vehicles.

H_{a4}: The use of internal combustion engines is sometimes more economical than electric motors to drive passenger motor vehicles. [2]

Details of the research can be seen in the cited sources. We will only summarize the main characteristics and conclusions of the analysis here.

The analysis showed that to produce 1kWh of electricity, a coal-burning power plant will generate 0.94 kg of CO_2 emissions to the atmosphere. In the case of fuel oil, the emission is 0.8 kg/kWh. Only natural gas and alternative sources of electric energy (solar-, wind-, hydro-, and nuclear power plants) can give better CO_2 emissions than internal combustion engines. CO_2 is not a single pollutant. We must also think about electric vehicle batteries. Their lifespan is now about ten years, and most manufacturers have a five to eight-year warranty on their battery. Drivers in Europe use their cars for 21.8 years on average[1] (18.1 years in Western and 28.4 years in Eastern European countries) [3]. A battery for cars with internal combustion engines lasts three to five years, but their recycling is much simpler than in the case of lithium-ion-based batteries. There is also a specific problem with electric car battery recycling. Metal is the main factor that makes recycling batteries economical. If batteries are to be made without cobalt, researchers will face an unintended consequence because other materials, especially lithium, are (currently) cheaper to mine than to recycle. [4] What would we do with old batteries in that case?

Internal combustion engines we used to power vehicles for more than a century and were constantly improved. Modern technology enables high-quality engines and vehicles. With the rise of the quality of fuels, they have a long lifetime, work economically, and are environmentally more acceptable than engines from the XX century. No matter how small the impact of an individual vehicle is, they all together have a crushing influence on climate change. The use of electric cars releases cities of pollution but moves pollution to the place of electricity production. Any energy we use to power vehicles causes an increased thermal load on the atmosphere, especially in large cities. Also, no matter how the raw materials for the vehicle production we obtained, will affect the amount of waste we need to deal with.

As the best solution to solve the pollution of the planet Earth, the authors proposed a replacement of the ownership of vehicles by shared use of cars, car-sharing, on the principle of subscription. [2] Car-sharing already exists in many cities, but private car ownership is dominant.

THE CURRENT VIEW FOR PASSENGER VEHICLES APPLICATION IN EUROPE

Crucial changes in the energy supply appeared during the war in Ukraine. The reasons were the war actions and sanctions of the USA and the EU against the Russian Federation. We must note that these were not the only causes. That created new conditions in the exploitation of vehicles. Here we will consider the economic and some environmental aspects of the application of passenger vehicles in the new reality and compare them with the situation before the start of the war.

[1] standard deviation: 7.1 years

According to [5], in 2020, 281,975,401 vehicles were in use in the EU, EFTA, Russia, Turkey, and the UK, of which 246,345,770 were passenger vehicles. Most vehicles were petrol-powered (51.7%, see Table 1). The average age of passenger cars in the EU was 11.8 years.

Table 1 Distribution of passenger vehicles by type of drive

Type of motor fuel	Share in the total number of vehicles
Petrol	51.7%
Diesel	42.8%
Battery electric	.5%
Plug-in hybrid	.6%
Hybrid electric	1.2%
Natural gas	.5%
LPG	2.5%
Other	.1%
Unknown	.1%

Source [5]

According to the same source [5], in the EU, in 2020, 93.5% of buses were diesel-powered, 0.9% battery-electric, and 1.4% were hybrid electric. Their average age was 12.8 years. The share of diesel engines in trucks was even more dominant, 96.3%. Battery-electric trucks were represented by 0.2%.

In the EU in 2021, 12,125,310 motor vehicles were produced, from which passenger cars accounted for 82.0%, approximately 10 million vehicles. Roughly, if all manufactured vehicles were sold in Europe, it would take 25 years to replace the existing vehicles with fossil fuels. Given the growing population and the fact that the lifespan of electric cars is shorter than 25 years, one can conclude that with such dynamics and current methods, it is practically impossible to squeeze internal combustion engines out of use in the foreseeable future. The results of the sale at the Car Show held in Belgrade in 2022 speak in favor of that. Of all the cars sold, about 5% were electrically powered. [6]

In 2021, the EU produced 1069 TWh of energy from fossil fuels, about 37% of the EU electricity production. 436TWh was obtained by burning coal, and 524TWh by burning fossil gases. The rest was produced by burning other fossil fuels. The most environmentally unfavorable fuel is coal, but research shows that in certain situations the obtained kWh of electricity can be the cheapest, so countries with large coal reserves decide to keep this method of electricity production. Historically, renewable energy sources initially served to reduce the share of energy obtained from coal. The growth of natural gas prices began in early 2021 [7], and culminated at the beginning of the Ukrainian crisis. Although the price of coal also rose, due to the large increase in the price of gas, renewable energy sources began to be a substitute for gas instead of coal. Gas prices change every day, and the causes are various. Thus e.g., Dutch natural gas prices surged around 12% after an explosion shut a key US export terminal. For the same reason, the UK natural gas prices surged 33% in one day. Similarly, with the beginning of the Ukrainian war, from February 25 to March 7, 2022, the price of the EU Dutch natural gas increased from 94.42 to 227.2 euro/MWh. Until June 9, the price of LPG returned to the level it was before the start of the war, and then there was the explosion in the gas export terminal in Texas.

If we analyze the price of gasoline, the dominant fuel for cars, it can be noticed that it varies significantly from country to country. For example, in mid-June 2022, E5 (Super) petrol cost approximately €1.25 in Hungary, €2.36 in Finland and the Netherlands, and €0.82 in Russia. If we compare the price of this fuel in Germany, in May 2020, it was €1.19 [8], and

at the end of May 2022, €2.19 [9]. The inflation rate in Germany from May 2021 to May 2022 was 7.9% [10]

The price of diesel fuel (B7) is also diverse and in mid-June 2022 in Europe ranged from 0.45 (Azerbaijan) to 2.24 euro/lit (Switzerland). In Germany, the B7 diesel cost 2.04 euros/lit [9]. In May 2020, a liter of diesel fuel was € 1.04. [10] In June 2022 fuel prices in Saudi Arabia were: Gasoline 91 €0.55 per liter, Gasoline 95 €.59 per liter, and Diesel 0.16 euro/liter [12].

The price of electricity also largely depends on the location of consumers. At EU level 2020, the average price was 21.27 cents/kWh. While in Bulgaria it was 9.97 cents/kWh, in Germany 1kWh cost 30.34 cents. [11] In Serbia at that time, the price of electricity for households was 7.55 cents/kWh [12]. In the second half of 2021, the average price at the EU level was 23.69 cents/kWh, in Bulgaria 10.91 cents/kWh, and in Serbia, 8.11 cents/kWh. [13] Given the energy crisis in 2022, further growth in energy and electricity prices is expected. On June 13, 2022, in Russian Federation, one liter of gasoline with 95 octanes cost 0.865 euros. [16]

All these differences affect the future application of electric vehicles.

SOURCES OF CO_2 EMISSIONS

Motor vehicles

According to [14], the COVID-19 pandemic in 2020 caused a significant drop in new vehicle registrations in the EU. A total of 11.7 million new cars were registered, 25% less than in 2019. Vehicles from the SUV - sport utility vehicles segment (39%) and vehicles from the Lower Medium segment (22%) were mostly purchased. The market share of battery-electric (BEV) and plug-in hybrid electric vehicles (PHEVs) rose to roughly 11%. As measured in the laboratory via the New European Driving Cycle (NEDC) type-approval test procedure, the official level of average carbon dioxide (CO_2) emissions from new passenger cars decreased to 108 g/km in 2020, which is 14 g/km lower than in the previous year. As CO_2 emissions and fuel consumption correspond to each other, fleetwide average fuel efficiency was 4.7 liters/100 km [15] (approximately 3.7 kg/100 km).

Of the newly produced passenger vehicles, 9% were battery electric vehicles, which means that approximately 10.6 million passenger motor vehicles in 2020 had some internal combustion engine. If these vehicles were powered by pure electricity and covered 11,300 km per year [16], with the stated fuel consumption only for vehicles produced that year in Europe, it would be necessary to provide 54 terawatt-hours of electricity. It should be borne in mind that the long-term specific consumption of new cars in the EU in 2019 was 5.1 l/100km [16]. For older vehicles, it is significantly higher[2]. Even with a consumption of 4 kg/100km to drive all passenger vehicles in the EU, EFTA, Russia, Turkey, and the UK, countries should provide about 1400 terawatt-hours of electricity, and in 2020 Europe and the CIS produced a total of 5274 TWh of electricity. [17] The complete transition of all vehicles from internal combustion engines to electric propulsion is not feasible in the near future unless the philosophy of passenger traffic is changed, especially in urban passenger traffic. We can expect that the application of Internet-of-things will have a favorable impact on changing the philosophy [18].

[2] In the USA, fuel consumption per vehicle is higher, as well as the annual number of kilometers traveled. A typical passenger vehicle emits about 4600kg of carbon dioxide per year. This assumes the average gasoline vehicle on the road today has a fuel economy of about 10.7 l/100km and drives around 18,500 kilometers per year. Every liter of gasoline burned creates about 2,348 grams of CO_2. [28]

Impacts of fires, volcanoes, and cattle breeding

Frequent and extreme forest fires are significant emitters of soot and CO_2. Instead of forests absorbing CO_2 from the atmosphere, in case of burning they emit soot, particles, CO_2, and other greenhouse gases. It is estimated that about 8 billion tons of 8 billion tons of CO_2 are emitted into the atmosphere due to wildfires. According to the International Energy Agency, this would correspond to one-quarter of total CO_2, emissions in 2017, but due to forest regeneration in areas affected by fires, CO_2 emissions caused by fires are estimated at 5-10% of total CO_2 emissions. [19] Large forest fires occur every year and the most famous are those that occur in the northern hemisphere. Thus, the fire that devastated Northern California's wine country in October 2017 emitted as much CO_2 in one week as all of California's cars and trucks do for a year. With the released heat, the fires locally heat the atmosphere, creating winds and drying the surrounding areas, which additionally negatively impact the environment. The created winds can blow away the combustion products by hundreds and thousands of kilometers. Paradoxically, scientists cannot say with certainty whether forest fires contribute to warming or cooling the atmosphere because, together with CO_2 fires emit ash, soot, ozone, and organic particles (aerosols).

Forest fires are not the only ones that emit enormous amounts of CO_2. Volcanoes release between about 180 and 440 million tons of carbon dioxide yearly. [20] There is also cattle breeding, above all ruminants. Livestock is responsible for 14.5% of global greenhouse gases, and cows and other ruminants in the US emit 4% of all greenhouse gases. [21]

Emissions of harmful gases caused by war

The emission of harmful gases and soot is also affected by wars, from the bombings during the Second World War, wars in Vietnam, Kuwait, Iraq, Libya, and Syria, to the latest Ukraine war. In all war operations, houses, forests, vehicles, fuel depots, mines, grenades, rockets, and means used burned. They greatly damage the environment. It has been practically impossible to determine the real impact of the wars on the climate and the emission of harmful substances because such measurements have not been carried out. The research on the World War II impact on global cooling [22] has not confirmed that tropospheric aerosols were a significant cause of 1944 and 1945 temperature changes. The aerosol impact was local and short-lived, although any local change in the atmosphere entails other changes[3].

Impact of the COVID-19 pandemic and lockdown

According to the IEA [23], Global energy-related CO_2 emissions rose by 6% in 2021 to their highest ever level, 36.3 billion tons, as the world economy rebounded from the Covid-19 crisis. This recovery relied heavily on coal, according to a new IEA analysis released in March 2022. The two billion tons increase in global CO_2 emissions was the largest in history in absolute terms, more than the previous year's pandemic-induced decline. Liu, Deng, Davis, Giron & Ciais [24] published different data for CO_2 emission (see figure 1).

But both sources declare a significant lowering of CO_2 emission in 2020. With a reduction in restrictive policies, the impact of pandemics lowers.

Increased energy demands in 2021 coincided with rising natural gas prices, so many returned to cheaper coal. However, it should be added that energy production from renewable sources recorded the highest growth ever. The COVID-19 pandemic and lockdowns have significantly affected how people live and work. They have limited people's mobility, changed how they do business, and had the highest impact on transportation and production.

[3] In literature frequently cited *the butterfly effect*.

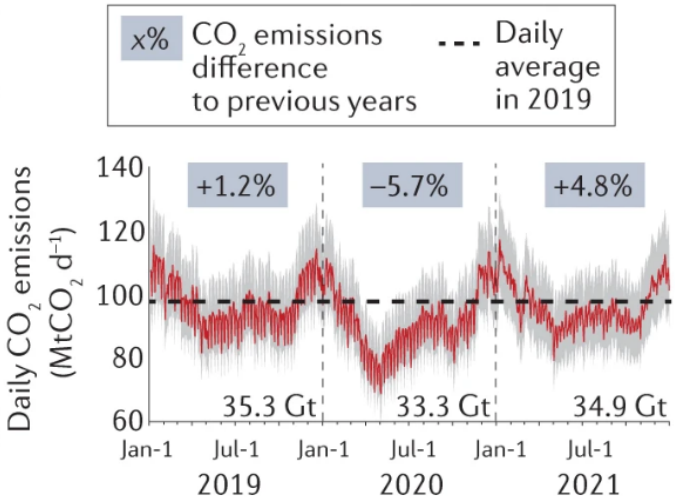

Fig. 1 Global CO_2 emission trends during the COVID-19 pandemic [24]

By reaching an all-time high of 15.3 billion tons, coal accounted for over 40% of the overall growth in global CO2 emissions in 2021. The emissions of 7.5 billion tons of CO_2 from natural gas burning rebounded well above their 2019 levels. At 10.7 billion tons, CO_2 emissions from oil remained significantly below pre-pandemic levels because of the limited recovery in global transport activity in 2021, mainly in the aviation sector. [23]

During the pandemic, China was the only large economy to record economic growth in 2020 and 2021. In doing so, in 2021, CO_2 emissions in China rose above 11.9 billion tons, accounting for 33% of the global total [23].

CONCLUSIONS

People are largely responsible for the increased emissions of carbon dioxide and greenhouse gases, but not only using vehicles.

Considering the above-mentioned sources of air pollution and CO_2, emissions, uneven technological development in different regions, world crises, natural disasters, and other impacts on air pollution, one can ask the question. Will electric vehicles overcome or at least alleviate problems related to greenhouse gas emissions, primarily CO_2 emissions?

The answer would still be: Yes, and no! Electric vehicles can alleviate environmental problems if they do not cause new environmental problems. They cannot solve environmental problems, because even if they have zero emissions, road motor vehicles are a relatively small source of CO_2.

This paper concludes that the electrification of vehicles is still going populistic, that electric cars are still immature for mass use, and that governments are unjustifiably subsidizing the purchase of electric cars. That could significantly contribute to the improvement of the environment is a change in the way people think and meeting the real needs of people economically by using the necessary resources.

If the average car in Europe consumes 5 liters of fuel per 100 km, and in the US 10, the question could be asked: Can these vehicles reduce fuel consumption by half? We also believe that replacing obsolete vehicles, used in much of the world, with new-generation vehicles would bring more benefits than insisting on electric vehicles.

The use of electric vehicles powered by energy from coal-fired thermal power plants can hardly be said to be justified and environmentally friendly.

Also, people must pay much more attention to the safety of transport, storage, and gas- and oil refining. What is the use for nature if all vehicles run on electricity in Port Harcourt (Rivers, Nigeria) and an illegal oil depot catches fire nearby? [25] Or, if the whole of Novi Sad (Serbia) drives electric vehicles, and due to the bombing of Serbia in 1999, 66212 tons of

oil were burned in Novi Sad alone [26] For the same reason, it burned (or spilled) in Belgrade in April 1999. 1650 tons of fuel oil and 1410 tons of crude gasoline [27]. And let us not go back to the distant past, it is enough to remember the burning oil fields in Kuwait in 1991 and the conflicts until the latest war and a series of large fires in Ukraine and Russia.

It is high time to comprehensively review the state of the environment and take the proper measures to that end in all spheres of life, including education.

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