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The Effects of Electric Vehicles on the Carbon Footprint in Türkiye

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Abstract: While human beings carry out many activities to continue their lives, they also pollute the nature in which they live. The negative effects of the result of this natural pollution are also first experienced by human beings. One of the negative effects that has become increasingly important in recent years is global warming. With the industrial revolution, carbon dioxide (CO_2) gas, the amount of which has increased exponentially every year, is the biggest component of the greenhouse gas that causes global warming. Combustion is the most important factor in air pollution. Combustion events can be of natural origin such as forest fires, vegetation fires, volcanoes. Combustion events can also be caused by domestic heating, industrial activities, and motor vehicle use. The carbon footprint is used to indicate the amount of greenhouse gases released into the atmosphere in terms of carbon dioxide equivalent. As a result of the activities of individuals and organizations, such as energy consumption and transportation, direct or indirect carbon emissions occur. In many countries of the world and in Türkiye, the most increasing footprint is caused by carbon. Countries sign agreements with organizations such as the Kyoto Protocol to reduce the impact of greenhouse gases. To reduce fuel consumption and reduce the gases released by fossil fuel vehicles to the environment, vehicles with electric vehicle technology have started to take their place on the roads today. In this study, information about internal combustion engine vehicles and electric vehicles is given. Then, the effects of electric vehicles on the carbon footprint in Türkiye are examined and suggestions are made.

Keywords: Türkiye, Carbon Footprint, Electric Vehicle.

1. INTRODUCTION

According to the United Nations Economic Commission for Europe (UNECE), some many different reasons and sectors cause CO_2 emissions into the atmosphere. Among these, transportation sector activities are one of the issues that require effective public intervention to reduce CO_2 emissions. The transportation sector is one of the sectors that needs precautions due to climate change and sets targets accordingly (Aslan, 2022). Currently, the transportation sector accounts for 27% of total greenhouse gas emissions in the European Union (EU). The transportation sector, as seen in Figure 1, is one of the main sources of greenhouse gas pollution (Sendek-Matysiak, 2019).

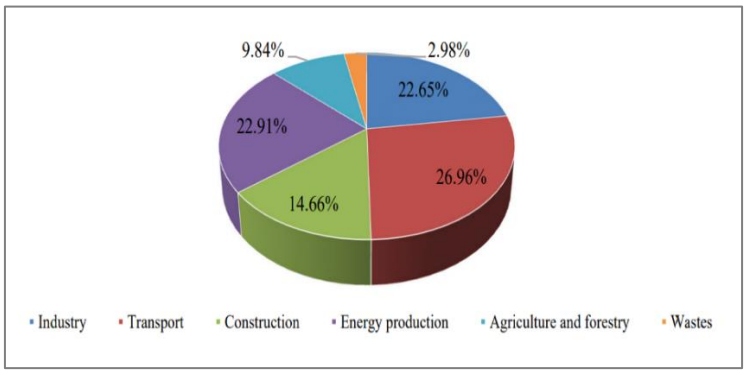

Figure 1. Distribution of factors causing greenhouse gas emission in the EU (2016).

According to the Intergovernmental Panel on Climate Change (IPCC), a reduction in global greenhouse gas emissions by up to half of 1990 levels is expected by 2050. Road transportation, which contributes highly to carbon emissions within the transportation sector, is a priority target in mitigating climate change. To fulfill this purpose, recommendations have been prepared by the ministers of transportation of many countries to reduce carbon emissions from the road sector and increase fuel efficiency (Altenburg et al., 2012). Some of those;

- Investing in innovative automobile technologies and advanced engine management systems
- Increasing the use of electric vehicles
- Prevent traffic congestion and encourage the use of multiple modes of transport
- Creating an improved transportation infrastructure with Intelligent Transportation Systems (ITS)
- Informing transportation sector consumers about issues such as eco-driving and public transportation
- Encouraging low carbon emission vehicles with tax exemptions and incentive policies
- Discouraging vehicles that cause intense carbon

2. ELECTRIC VEHICLES

When the vehicle technologies used as land vehicles are examined, it is seen that three different vehicle technologies are used according to the engine drive method and the energy source used. These are internal combustion engine vehicles, battery electric vehicles, and hybrid electric vehicles. Internal combustion engines are used in conventional vehicles, also called traditional vehicles. Fossil fuels such as gasoline, diesel, and LPG (Liquefied Petroleum Gas) are consumed as fuel. Thus, engine drive is provided by the fuel energy obtained from the fuel tank. The advantages of these vehicles are that they have an infrastructure, are affordable, have long driving distances, can store a high volume of liquid fuel in the fuel tank, and can access fuel easily and in a short time. The disadvantages of vehicles with internal combustion engines are that they require fossil fuels, have high CO_2 emissions, have mechanism noise, and the efficiency of the engine is below 30% (Özdemir Öztürk, 2022).

In battery electric vehicles, the electrical energy provided by the battery is converted into mechanical energy and transferred to the wheels, thus providing movement. Electric battery-powered vehicles do not have internal combustion engines but consist of a battery for energy storage, an electric motor for the propulsion system, a generator, mechanical transmission and power control systems. In electric battery-powered vehicles, the energy required for engine drive is provided only by battery packs (Archer, 2014). As seen in Figure 2, there are two types of battery electric vehicles. The main difference between these two types is the size of the electric motor and the location of the electric motor. The most common type today is the central engine. The hub motor type is used in smaller vehicles (Nur, 2017).

Hybrid electric vehicles contain an internal combustion engine, an electric motor that works independently of each other, and a battery storage system that can be charged from an external energy source. Hybrid electric vehicles can use only the electric engine, only the internal combustion engine, or both, taking into account energy efficiency while driving. This results in less fuel consumption and an economic advantage. In some vehicles, the battery can even be charged by generating electricity through regenerative braking. Another main advantage of hybrid electric vehicles is that they provide very low greenhouse gas emissions and noise levels (Brant & Leitman, 2008).

Hybrid electric vehicles can be classified under two headings, series and parallel, in terms of power transfer principles, as shown in Figure 3 (Nur, 2017). In a series hybrid electric vehicles, the energy obtained from the internal combustion engine is converted into electrical energy with the help of a generator, and the engine is driven. Series hybrid electric vehicles enable the vehicle to move forward with only a single energy converter. The internal combustion engine runs the generator, enabling the electric motor to power the battery and preventing the battery from falling below a certain charge level. The power that enables the vehicle to move is provided by the electric motor. In parallel hybrid electric vehicles, energy is transferred between the electric motor and the internal combustion engine together or separately. In parallel

hybrid electric vehicles, multiple energy sources enable the vehicle to move forward. In these vehicles, the internal combustion engine and the electric motor are connected in parallel (Ustabaş, 2014).

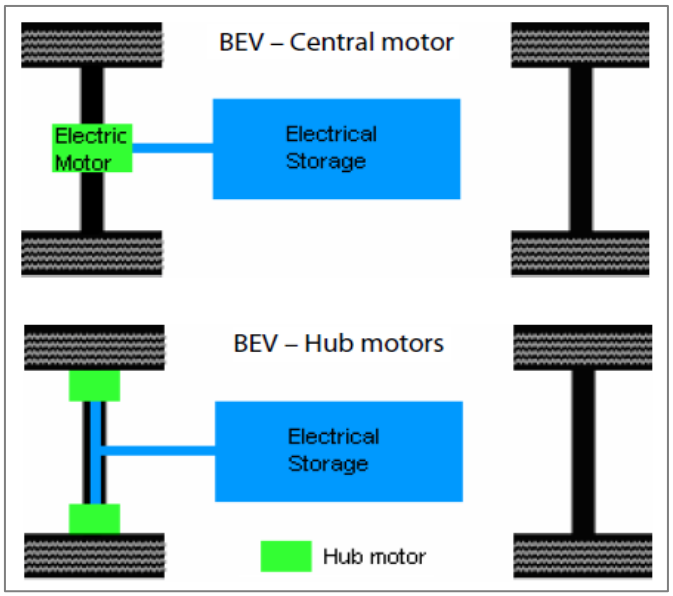

Figure 2. Types of battery electric vehicles.

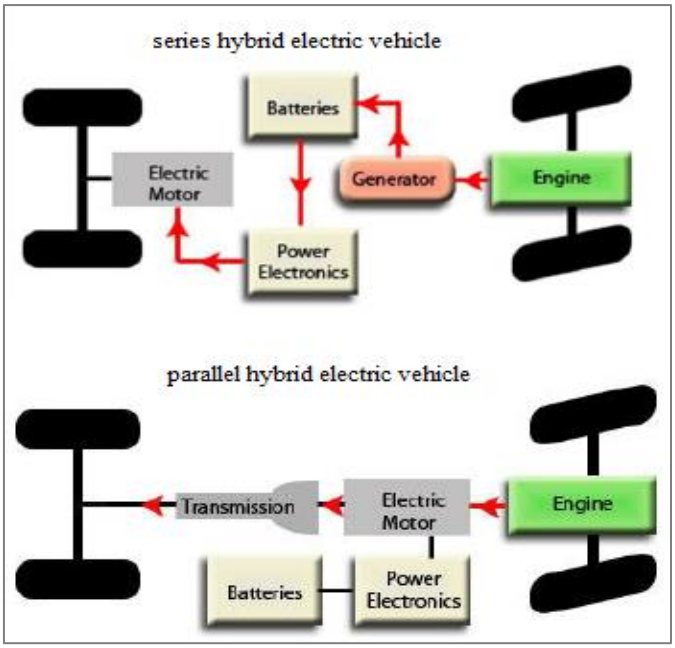

Figure 3. Types of hybrid electric vehicles.

Plug-in Hybrid Electric Vehicles (PHEV) are in the category of hybrid electric vehicles and have a larger battery and can reach a longer range since they can be charged externally (Kotter, 2013). In addition, since plug-in hybrid electric vehicles can be charged externally, they are more advantageous in terms of fuel economy than internally charged hybrid vehicles. The grouping of electric vehicles is briefly shown in Figure 4 (Sanguesa et al., 2021).

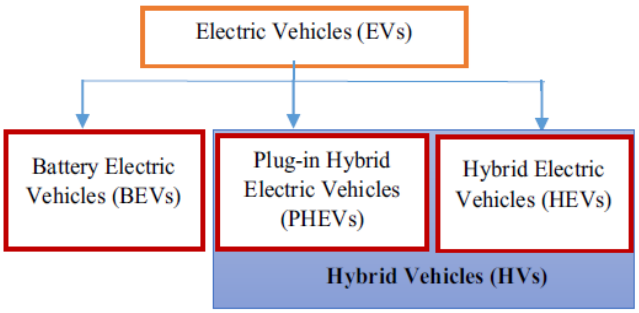

Figure 4. Electric vehicles classification.

3. THE EFFECT OF VEHICLES ON CARBON FOOTPRINT IN TÜRKİYE

As in most international countries, approximately 20% of global greenhouse gas emissions in Türkiye originate from the transportation sector. The largest producers of greenhouse gas emissions in the transportation sector in Türkiye are motor road vehicles. The motor vehicles that produce the most emissions are cars, sports utility vehicles, pickup trucks, mini vans, and light duty trucks. These vehicles account for more than half of the greenhouse gas emissions from the transportation sector (Tören & Mollahasanoğlu, 2022).

In Table 1, the carbon emission values of the number of motor vehicles in Türkiye between 1990 and 2021 are given in 5-year periods. The most important reason for fossil fuel emissions that cause air pollution and climate change is the use of these fuels by motor vehicles used in the transportation sector. Therefore, the numerical data in Table 1 is important for climate change, global warming, air pollution, and is also closely related to human health (TURKSTAT, 2021)

Table 1. Number of motor vehicles in traffic in Türkiye and CO_2 emissions.

Year	Number of Motor Vehicles	CO2 Emission (thousand tonnes)
1990	3.750.678	26,25
1995	5.922.859	33,180
2000	8.320.449	35,49
2005	11.145.826	41,03
2010	15.095.603	44,38
2015	19.994.472	74,27
2021	25.249.119	89,32

The distribution of cars registered in Türkiye by fuel type is given in Table 2. In Türkiye, automobiles generally consume gasoline, diesel and LPG fuels. In 2004, 75% of the cars registered to traffic in Türkiye used gasoline. In 2021, the most common fuel used in registered cars is diesel with 38%, followed by LPG with 36% and gasoline with 25%. As can be seen in Table 2, one of the feasible alternative methods to reduce harmful gases that cause environmental and air pollution is the widespread use of electric and hybrid vehicles. Table 2 shows that the interest in electric and hybrid vehicles in Türkiye has increased noticeably in recent years, although it is much less compared to other countries. This increase is mainly caused by the rise in oil prices and increased environmental awareness. For such reasons, it is estimated that the number of electric and hybrid vehicles will increase even more in the coming periods. Among the most obvious reasons why electric vehicles will become widespread today are their zero carbon emission value and their environmental friendliness (TURKSTAT, 2022).

Table 2. Distribution of cars registered to traffic in Türkiye according to the type of fuel.

Year	Total	Gasoline	(%)	Diesel	(%)	LPG	(%)	Electric and Hybrid	(%)
2004	5400440	4062486	75.2	252629	4.7	793081	14.7	-	-
2005	5772745	3883101	67.3	394617	6.8	259327	21.8	-	-
2006	6140992	3838598	62.5	583794	9.5	1522790	24.8	-	-
2007	6472156	3714973	57.4	763946	11.8	1826126	28.2	-	-
2008	6796629	3531763	52.0	947727	13.9	2214661	32.6	-	-
2009	7093964	3373875	47.6	1111822	15.7	2525449	35.6	-	-
2010	7544871	3191964	42.3	1381631	18.3	2900034	38.4	-	-
2011	8113111	3036129	37.4	1756034	21.6	3259288	40.2	47	0.0
2012	8648875	2929216	33.9	2101206	24.3	3569143	41.3	228	0.0
2013	9283923	2888610	31.1	2497209	26.9	3852336	41.5	436	0.0
2014	9857915	2855078	29.0	2882885	29.2	4076730	41.4	525	0.0
2015	10589337	2927720	27.6	3345951	31.6	4272044	40.3	889	0.0
2016	11317998	3031744	26.8	3803772	33.6	4439631	39.2	1160	0.0
2017	12035978	3120407	25.9	4256305	35.4	4616842	38.4	1685	0.0
2018	12398190	3089626	24.9	4568665	36.8	4695717	37.9	5367	0.0
2019	12503049	3020017	24.2	4769714	38.1	4661707	37.3	15053	0.1
2020	13099041	3201894	24.4	5014356	38.3	4810018	36.7	36487	0.3
2021	13706065	3495172	25.5	5158803	37.6	4923275	35.9	92949	0.7

Reducing greenhouse emissions in the transportation sector differs from other sectors in that it only considers tailpipe or direct emissions. For example, reducing exhaust emissions of road vehicles is dominant in EU policies. According to the EU Community regulation, CO_2 emissions per km for new cars have been determined as 130 gCO_2/km as of 2015. As of 2021, new vehicles must produce CO_2 emissions per km below 95 gCO_2/km. The EU aims to reduce CO_2 emissions to 59 gCO_2/km in 2030 with legal regulations. For Türkiye, the average CO_2 emissions of new vehicles until 2013 were low compared to the EU. In 2017, the average CO_2 emission values of EU countries and Türkiye, which have heavier and stronger fleets, were close to each other. Since there are no obligations for vehicle manufacturers in Türkiye, CO_2 emissions from motor vehicles are expected to decrease over the years and at a similar rate in previous years (approximately 2.5 gCO_2/km per year). Thus, by 2030, the average CO_2 emissions of the new vehicle fleet will be approximately 50% higher than the CO_2 emissions average of the EU's new vehicle fleet (Logan et al., 2021). Figure 5 shows the average CO_2 emission levels of new vehicles in Türkiye and the EU according to the New European Driving Cycle (NEDC) between 2007 and 2030 (Guliyev, 2022).

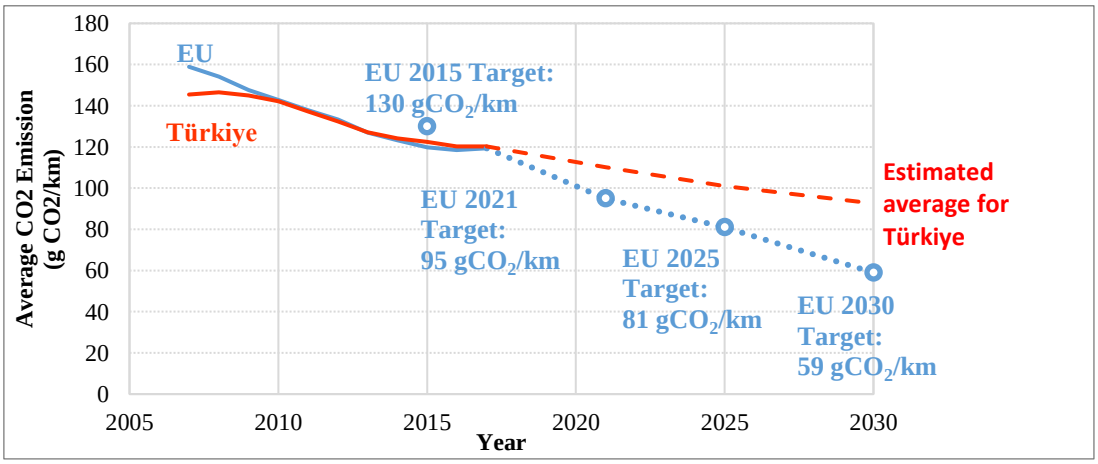

Figure 5. Average CO_2 emission levels of newly registered vehicles in Türkiye and the EU.

These tables have mobilized many countries to produce zero-emission electric cars. The dreams of producing a local and national car in our country for a long time have finally come true with zero emissions with Türkiye's Automobile Enterprise Group (TOGG). The domestic automobile joint venture group includes Anadolu Group, BMC, Kıraça Holding, Turkcell, and Zorlu Holding (Demir, 2020).

TOGG's intellectual and technical rights belong to Türkiye; It was stated that the design was made in Italy, the engine was purchased from Bosch, the battery group was purchased from China, and the integration of the vehicle was carried out by Germany's EDAG Engineering company. Offering two different battery options that provide a range of 300 km or 500 km, TOGG will be able to reach 80% traction battery charge level in 30 minutes with fast charging. The car, whose electric vehicle battery layout is shown in Figure 6, provides technical advantages such as lithium-ion traction battery technology and active thermal management systems and has a battery warranty for 8 years (Gürbüz, 2021).

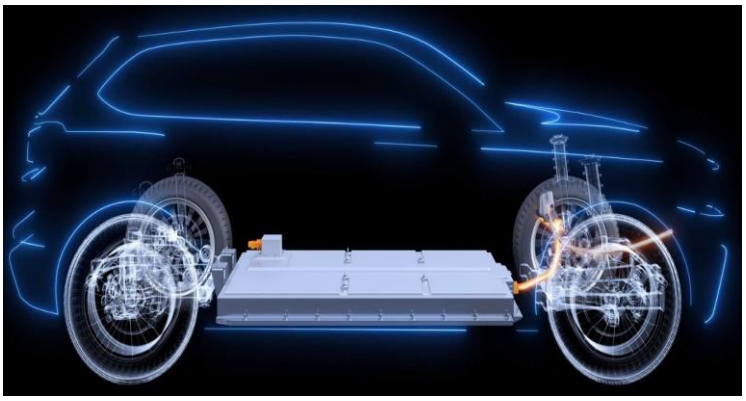

Figure 6. TOGG electric vehicle battery placement.

4. CONCLUSION

Türkiye should make efforts to minimize the use of fossil fuels in order to achieve the 2030 and 2053 targets specified in the Kyoto, Paris and Glasgow agreements within the framework of the United Nations Environmental Convention on Climate Change. To achieve this goal, efforts must be made to make the necessary investments and find financing sources for these investments, starting today. According to research conducted by the International Energy Agency (IEA), it is estimated that the number of electric cars on the market will be approximately 40 million in 2025. According to another study by the IEA, it is estimated that in 2040 there will be around 8% electric vehicles in the most pessimistic scenario and 26% in the most optimistic scenario. To increase these estimates even further, incentives and tax reductions given by local governments and national governments are important for electric vehicles to compete with other vehicles.

The future success of the electric car industry is also highly dependent on technological innovation. Especially in far eastern countries such as China, Korea, and Malaysia, policymakers draw attention to the technological innovations of electric cars and encourage policies for research and development on this subject. In this regard, Türkiye's design of the TOGG branded fully electric vehicle and its mass production by 2023 was an appropriate and correct decision to catch up with today's technology. However, today, internal combustion engine vehicles constitute the majority of total vehicles in Türkiye. Faster steps must be taken to increase the number of electric vehicles to reduce CO_2 emissions. Installing charging stations in the necessary places with route measurements, shortening charging times, increasing driving distance, reducing electricity prices, and selling electric vehicles cheaper will affect consumer preference and ensure the widespread use of electric vehicles. Additionally, it is necessary to provide necessary legal regulations, incentives and advantages such as tax exemption to facilitate access to electric vehicles.

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