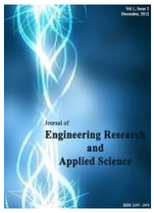
Journal of Engineering Research and Applied Science
Available at www.journaleras.com
Volume 9 (1), June 2020, pp 1308-1322
ISSN 2147-3471 © 2020



Comparison of hybrid and fuel cell vehicles and electricityal vehicles

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Accepted 12 January 2020

Abstract
Electricity and hybrid vehicles, which are expected to replace internal combustion engines in the near future, are currently under development. In this study, literature researches have been made for full Electricity, hybrid Electricity and fuel cell vehicles. Historical development, types and capacities and current market conditions are explained. The theoretical calculations of the Electricity vehicle and internal combustion engine vehicle are calculated by using the AVL CRUISE software. The advantages and disadvantages of these vehicles are discussed in details. The results of the comparisons, the availability of these vehicles in Turkey was discussed.

Keywords: Electricity motor; hybrid; fuel cell; fuel saving; exhaust gas emission.

1. Introduction

The number of vehicles with internal combustion engine is increasing day by day. In parallel with this, the need for fossil fuel increases, but the reserve of these fuels decreases. In addition, exhaust gas emissions, which are the main cause of the greenhouse effect, are caused by vehicles using fossil fuels. Therefore, governments have imposed strict restrictions on emissions and fuel consumption to reduce environmental pollution. Although battery-powered Electricity vehicles with zero fossil fuel consumption and emissions seem to be a solution to this problem, they have limitations such as high sales prices, short-range driving and long charging times. [1, 2]. Hybrid vehicles have been developed to eliminate the restrictions of internal combustion and Electricity vehicles A hybrid Electricity vehicle is formed by a combination of commonly used internal combustion engine and battery and Electricity motor components of Electricity vehicles. If you drive the hybrid Electricity vehicle in Electricity mode only, you will achieve zero emissions. Hybrid Electricity vehicles have less fuel consumption compared to vehicles with an internal combustion engine, but have a longer range compared to Electricity vehicles. Rechargeable hybrid vehicles, on the other hand, have a much longer range because they can be charged directly from the Electricityity network. Hybrid Electricity vehicles can help to address the current energy crisis and pollution, but high sales prices pose a problem for the expansion of hybrid Electricity vehicles However, the first vehicles on the market (eg Toyota Prius) show that hybrid Electricity vehicles are a real alternative to vehicles with an internal combustion engine. Moreover, sales trends in Europe and the Americas indicate that rechargeable hybrid vehicles will become a more attractive and promising solution. [3-5] As a final alternative, fuel cell vehicles will use fuel cells to generate Electricityity from hydrogen and air. Electricityity is used to drive vehicles directly or stored in energy storage devices such as battery packs or super capacitors. Fuel cell vehicles emit only water vapor and are highly efficient. However, there are some major problems: High price and limited service life of fuel cells; the problem of storing the built-in hydrogen because it requires improved energy density; hydrogen distribution and supply infrastructure to be built [6]. Fuel cell vehicles may be a long-term solution, but the potential of fuel cell vehicles, including hydrogen storage and distribution facilities, has not yet been proven, although some automobile companies have started mass production. In this study, Electricity vehicles, hybrid Electricity vehicles and fuel cell vehicles will be compared from different directions and availability in Turkey will be discussed.

2. Development of electricity, hybrid and fuel cell vehicles

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2.1. Electricity vehicles

Electricity vehicles were invented in 1834 and were produced by several companies in the United States, England and France in the late 19th century. However, due to limitations in vehicle batteries and the rapid development of vehicles with an internal combustion engine, it was almost erased from the stage of history after the 1930s. Nevertheless, the energy crisis in some countries in the early 1970s brought Electricity vehicles back on the agenda. Today, Electricity vehicles are often used in small vehicles and short-haul applications due to battery limitations. After the new zero-emission law, for example, 900 Electricity vehicles were introduced in central London. Some projects on the spread of these vehicles aim to use Electricity vehicles as shared vehicles. Work is also continuing on the possibility of traveling for longer periods by replacing it with another fully charged Electricity vehicle in the recreational facilities. [1]. Today, many Electricity vehicles with different ranges are available on the market. The model S produced by Tesla, the leader in Electricity vehicle technology, can drive up to 550 km on one charge. It can also accelerate from 0 to 100 km / h in as little as 2,5 s [7].

2.2. Hybrid electricity vehicles

In 1898, the German Dr. Ferdinand Porsche, the world's first front-wheel drive vehicle produced. Porsche's second vehicle was a hybrid vehicle. This vehicle supplied power to the Electricity motors placed in the wheel chambers of the vehicle by means of a generator rotated by the internal combustion engine. You could only go about 65 miles up the road with batteries. In the early 20th century, thousands of Electricity and hybrid vehicles were produced. Produced in 1903 by the Krieger company, the car was carrying a battery pack attached to the gasoline engine. A Belgian company developed a vehicle that would charge its own battery in normal driving and provide reinforcements to the petrol engine while climbing. In 1904, Henry Ford overcame the noise, vibration and odor problems of gasoline vehicles and built an assembly line that produced lighter, lower-priced vehicles. The rapid developments in Henry Ford's assembly line and gasoline engine led to a significant drop in hybrid vehicles until the 1920s. Hybrid and Electricity vehicles were not popular until the 1970s oil crisis. The rise in gasoline prices revived interest in Electricity vehicles. The US Department of Energy conducted tests with various Electricity and hybrid vehicles produced by many companies. The first modern Hybrid vehicle sold in Japan in 1997, the Toyota Prius, showed that the world has entered a new path in this regard. Two years later, the first hybrid vehicle Honda Insight was sold in the United States. After the launch of the Honda Civic Hybrid, radical changes began to take place in the market. Over the next years, over 20 hybrid passenger vehicles were launched. Currently, almost every company own unique hybrid vehicles are offered to customer.

2.3. Fuel cell vehicles

Fuel cells entered the agenda for the first time in 1839 with William Grove. At that time he did not produce very successful results because Electricityity was not well known. The first achievement belongs to Francis Bacon, who invented the alkali fuel cell system with porous electrodes in 1932. By the 1950s, fuel cells were used in the Apollo space program. The use of fuel cells in the space industry was because it was the best option: nuclear was very dangerous, solar was very weak, and batteries were very heavy. Fuel cells were used in Apollo, Gemini and space shuttles. In 1967, General Motor developed a 6-seater electro-van, but this vehicle was only used in-house. In the following years, many companies, including major automotive companies, have contributed to ongoing research into the use of fuel cells in vehicles and other applications. Developed by Toyota, the Mirai model is now the industry's leader with a tank filled in just 3 minutes and a range of about 500 kilometers.

3. Characterıstics and design of electricity, hybrid and fuel cell vehicles

Vehicles using fossil fuel are driven by internal combustion engines that use gasoline or diesel fuel. In Electricity vehicles, this is done by Electricity motors that use the Electricityity stored in the battery. Hybrid Electricity vehicles are formed by combining these two. The internal combustion engine provides a long range for the hybrid vehicle, while the Electricity motor stores fuel and energy generated by the internal combustion engine, saving fuel and efficiency. There are 3 types of hybrid Electricityal vehicle designs that allow the combination of these two powertrain: 1) Serial

Hybrid, 2) Parallel Hybrid 3) Serial-Parallel Hybrid. In these three types of series-parallel hybrids, there is a planetary gear group that enables the use of many subsystems in series and in parallel. Other designs are derived from this basic architectural scheme. Therefore, the series-parallel hybrid type will be examined in more detail in our discussion.

Table 1. Characteristics of Electricity, Hybrid Electricity and Fuel Cell vehicles [1].

	Electricityal	**Hybrid**	**Fuel cell**
Drive mechanism	*Electricity motor	*Electricity motor	*Electricity motor
		*Internal-combustion engine	
Energy storage subsystem	*Battery	*Battery	*Hydrogen tank
	*Super capacitor	*Super capacitor	*Battery or super capacitor to increase power density
		*Fossil or alternative fuels	
Properties	*Zero exhaust gas emissions	*Low exhaust gas emission	*Zero exhaust gas emissions
	*High energy efficiency	*High fuel saving	*High energy efficiency
	*Not connected to fossil fuel	*Long range	*Not connected to fossil fuel
	*Relatively low range	*Fossil fuel	*High cost
	*High purchase cost	*Higher cost compared to fossil fuel vehicles	*There are models available on the market , being developed
	*Commercially available	*Commercially available	
Basic problems	*Battery sizing and management	*Battery sizing and management	*Fuel cell cost, life and reliability
	*Charging stations	*Optimization and management of multiple energy sources	*Hydrogen production and distribution infrastructure
	*Cost		*Cost
	*Battery life		

3.1. Main features of electricity, hybrid electricity and fuel cell vehicles

The main characteristics of Electricity, hybrid Electricity and fuel cell vehicles are shown in Table 1. When we compare these tools, the main problem is energy consumption. Well-to-wheel analyzes have been conducted by many authors about these tools [8, 9]. Even when Electricityity is produced from oil sources, it has been found that Electricity and hybrid vehicles provide greater fuel savings than internal combustion engine vehicles. In addition, the use of Electricityity and hybrid vehicles reduces harmful gas emissions. In fuel cells, this varies according to the way hydrogen is produced. Another important problem when comparing tools is reliability. However, it is not currently possible to perform a precise reliability analysis.. To put it briefly, the hybrid Electricity vehicles have a complex architecture with multiple subsystems, so the system has less global reliability than thermal internal combustion engines. In addition, some hybrid architectures enable operation by reducing or limiting the limitations of vehicles with an internal combustion engine. The reliability of fuel cell vehicles has not yet been established. The reliability of hybrid and fuel cell vehicles is an important issue for the commercial development of such vehicles.

3.1.1. Series-parallel hybrids

In such hybrid vehicles, a planetary gear (Fig. 1) may be used [2]. As shown in Figure 2, the Electricity motors are connected to the perimeter (R) and sun (S) gears of the planetary gear while the internal combustion engine is directly connected to the carrier (C). This architecture is designed to allow operation like other conventional architectures (eg parallel hybrid, serial hybrid, internal combustion engine or Electricity vehicles). Both the serial and parallel hybrid energy flow can be achieved by using the DC voltage bus and the planetary gear set.

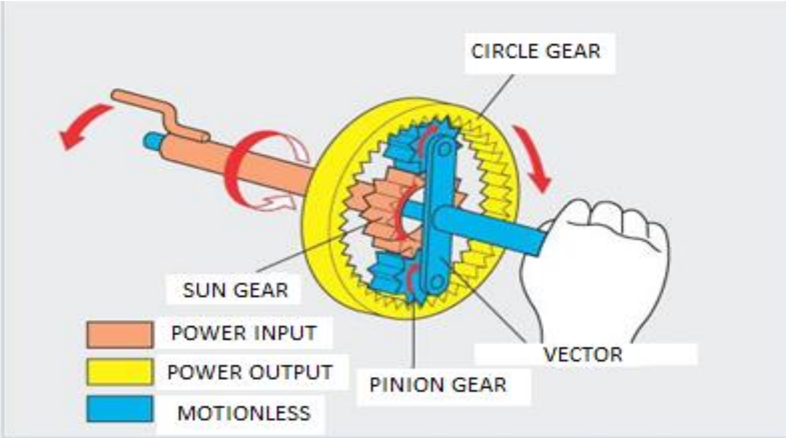

Figure 1. Planetary Gear Set.

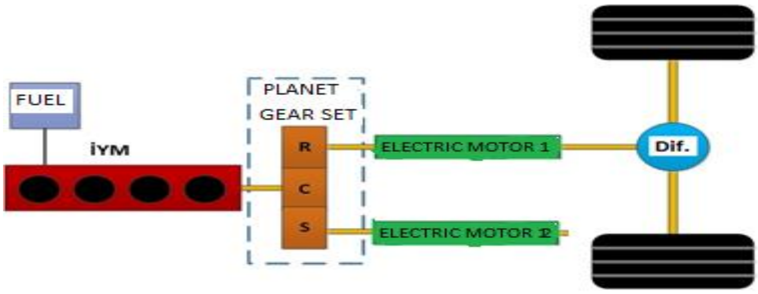

Figure 2. Series-Parallel Hybrid

Due to the planetary gear, the speed of the internal combustion engine is the weighted average of the first and second Electricity motors. 1. The speed of the Electricity motor is proportional to the speed of the vehicle. The speed of the 2nd Electricity motor at any given vehicle speed can be selected to adjust the speed of the internal combustion engine. The internal combustion engine is therefore located in an optimal region which can be adjusted by the speed of the second Electricity motor. Although it has the characteristics of both serial and parallel hybrids, serial-parallel hybrids are both complex and costly because they require three motors and require a planetary gear set. In addition, the control mechanisms are relatively complex. Instead of a planetary gear set, there is also a second type of serial-parallel hybrid that manages two Electricity motors using a power-split mechanism [10]. In this system, two existing motors can be combined into a single motor with two rotors to reduce weight and size [11]. In both systems (with planetary gear and power distribution unit), the speed ratio between the internal combustion engine shaft and the transmission shaft is continuous and variable.

3.1.2. Series hybrids

In series hybrids, all driving power is converted from Electricityity [12]. This Electricityal power is the sum of the energies obtained from the two power sources; Electricity engines and internal combustion engines. The internal combustion engine has no mechanical connection to the towing load, indicating that it cannot provide direct power to the vehicle. . This Electricity is sent directly to the wheels to charge the battery or by bypassing the battery bay. Due to the fact that the internal combustion engine and the drive wheels are separate, the series hybrids have the advantage of absolute flexibility in the positioning of the internal combustion engine generator (EM1 in Figure 3). This Electricity is sent directly to the wheels to charge the battery or by bypassing the battery bay. Due to the fact that the internal combustion engine and the drive wheels are separate, the series hybrids have the advantage of absolute flexibility in the positioning of the internal combustion engine generator (EM1 in Figure 3). For the same reason, the internal combustion engine can be operated in a very narrow and optimal range, regardless of the vehicle speed. Because there is only one torque source for the transmission (2nd Electricity motor), it is simple to control the series hybrids.

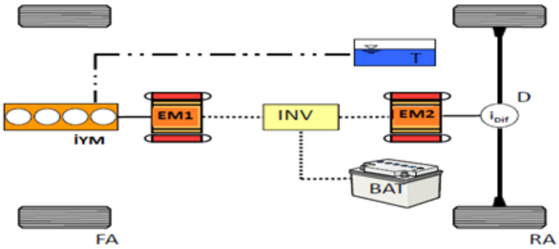

Figure 3. Series Hybrid

Due to the very high performance characteristic torque speed of Electricity drive, the series hybrids do not require a multiple gearbox and clutch. However, such a stepping system is relatively low efficient and is therefore necessary in all three engines. All three engines must be large to maintain continuous power at maximum. However, when designed as short-range, the internal combustion engine may be of relatively small size. Battery and Electricity motor dimensions, which make the serial hybrid expensive, are still a problem.

3.1.3. Parallel hybrids

When the second Electricity engine is removed from the serial-parallel hybrid architecture, a parallel hybrid is obtained (Figure 4). In a parallel power transmission, the energy node is located in the mechanical fasteners. These mechanical fasteners may be a common shaft or two shafts connected by a toothed or belt-pulley. The bearing capacity can only come from the internal combustion engine, only from the first Electricity motor or in situations where the two work together.

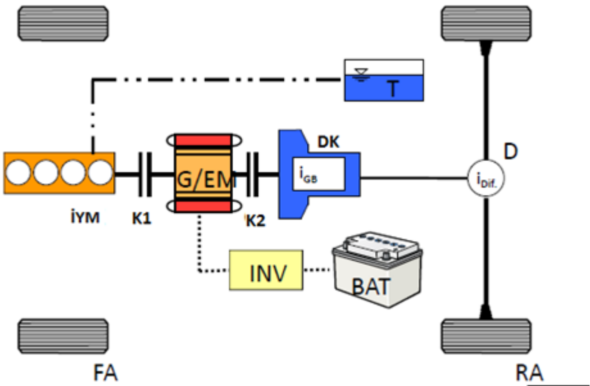

Figure 4. Parallel Hybrid

The first Electricity motor can be used to charge the battery when power is regenerated during braking or when the power generated in the internal combustion engine is greater than necessary to drive the vehicle. Parallel hybrid vehicles are more efficient than serial hybrids because they only have two engines. In connection with this, smaller motors can be used to achieve the same dynamic performance. However, due to the mechanical connection between the gearbox and the internal combustion engine, the internal combustion engine may not always work in the optimal zone and these reasons often require clutches.

3.2. Electricityal vehicles

If only one Electricity motor remains in the series parallel hybrid structure, the Electricity vehicle structure is formed (Figure 5-a). The vehicle is powered only from batteries or other Electricityal storage sources, resulting in zero emissions. Short driving range, long battery charging time and high purchase costs limit the use of Electricity vehicles. In addition, new Electricity vehicle architectures are being developed to extend the range and reduce charging times and costs by using different energy sources such as batteries, super capacitors, or even reduced power fuel cells connected to the same dc bus [13]. Figure 5-b and Figure 5-c illustrate the different Electricity vehicle architectures developed. In these architectures, instead of single Electricity motors, separate Electricity motors are installed on each wheel or only two wheels. These designs are developed with driving performance and range in mind.

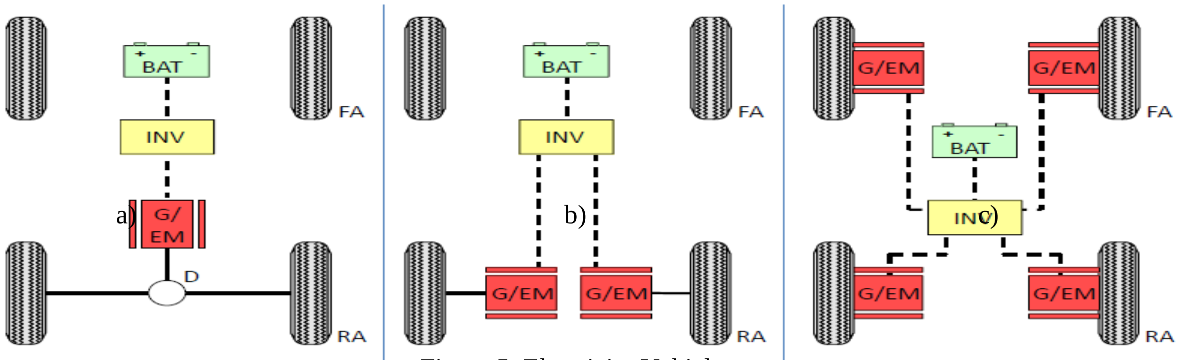

Figure 5. Electricity Vehicles

3.3. Fuel cell vehicles

Considering the power transmission architecture, the fuel cell vehicle can be considered as an Electricity vehicle. This is because a fuel cell vehicle is equipped with batteries and super capacitors as in Electricity vehicles [14]. The Electricity motor acts as a generator to produce Electricityity from hydrogen. This Electricityity is transmitted to the Electricity engine as power or stored in the battery or supercapacitor for future use [15]. This operating system is shown in Figure 6. Fuel cell energy is a potential power source that is expected to replace conventional power supplies. Examples of this range from mobile phones to vehicle applications.

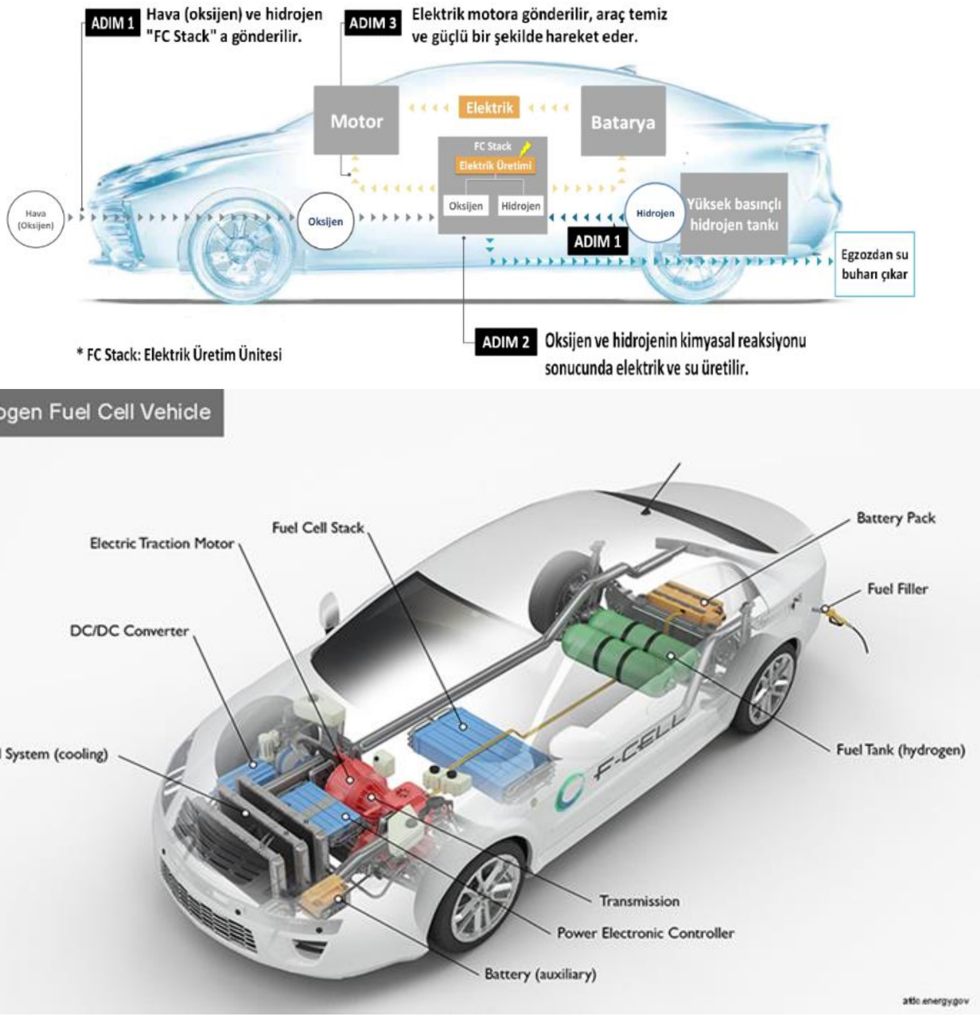

Figure 6. Fuel Cell vehicle operating system

4. Different functions of hybrid electricity vehicle species

Table 2. Different Functions of Hybrid Electricity Vehicle Types [1]

	small hybrid	Mild hybrid	Full hybrid	Plug in hybrid
Series-Parallel			x	x
Series			x	x
Parallel	x	x	x	

Various hybrid vehicle architectures offer different functions. These functions can be classified according to the power ratio between the internal combustion engine and Electricity motors.

4.1.Micro hybrid

Micro hybrid vehicles use limited power as the starting alternator [16] and are internal combustion engines that drive the vehicle. The Electricity motor assists the internal combustion engine to provide a better start at the beginning. The fast dynamic characteristics of the Electricity motor allow the internal combustion engine to be stopped and restarted when the vehicle stops. This feature is also referred to as the stop-and-go feature, so that when the vehicle stops at traffic lights, for example, it stops in the internal combustion engine and contributes 2 to 10% to the vehicle's fuel economy. It also reduces exhaust gas emissions by about 20% [17].

4.2. Mild hybrid

In addition to the stop-and-go feature of micro hybrid vehicles, mild hybrid vehicles provide a boost to the internal combustion engine by applying a supporting torque force during acceleration or braking. In conventional vehicles, mild hybrid vehicles store the power lost as heat and friction during braking in the battery with the regenerative braking system. The stored energy is then supplied to the internal combustion engine as propulsion. However, the Electricity motor alone cannot move the vehicle. It is estimated that the fuel saving in this system is between 10% and 20% [1].

4.3. Full hybrid

Full hybrid vehicles have a fully Electricity transport system. This means that Electricity motors can move the vehicle. Such vehicles are referred to as emisyon zero emission vehicles ında when they use full Electricityal systems. Zero Electricity vehicles can be used, for example, in city centers. However, the actuation systems of these vehicles are supported by an internal combustion engine or provided by a combination of Electricity motor and internal combustion engine. The fuel savings in these systems are between 20% and 50%.

4.4. Rechargeable hybrid

These hybrid vehicles can charge the batteries directly from the mains. In some cases, these hybrid vehicles can be a simple Electricity vehicle, reducing the function of the internal combustion engine. In cases where a long range is required, they can extend their range by using the internal combustion engine when the battery runs out of energy. These types of vehicles do not require an internal combustion engine in urban use, they can save up to 100% fuel. Battery sizes can be extended and their range extended, which contributes to a significant reduction in greenhouse gas emissions. Several studies have been carried out on rechargeable hybrid vehicles [2, 3]. Although the impact of rechargeable hybrid vehicles on the Electricityity grid needs to be examined in detail, such hybrid vehicles can reduce maximum demand without requiring more power plants [2]. Hybrid architectures have different levels of functionality. As shown in Table 2, some architectures may exhibit multiple hybrid behaviors. The reason that Electricity and fuel cell vehicles are not included in this table is that they use only Electricityal power.

5. Theoretical comparison of internal combustion vehicle and an electricity motor vehicle

In this section, a modification of the diesel vehicle model has been made and an internal combustion engine vehicle has been transformed into an Electricity vehicle. AVL CRUISE program was used in this transformation. The selected vehicle has a medium-sized, diesel-powered engine that has not previously been converted to an Electricity vehicle. The characteristics of the vehicle are shown in Table 3.

Table 3. Internal Combustion Vehicle Specifications

Volume	Cylinder	Tank	Max Velocity	Gear box
1248 cm^3	4	0,047 m^3	159 km/s	5 gears

5.1. Calculates for vehicle with internal combustion engine

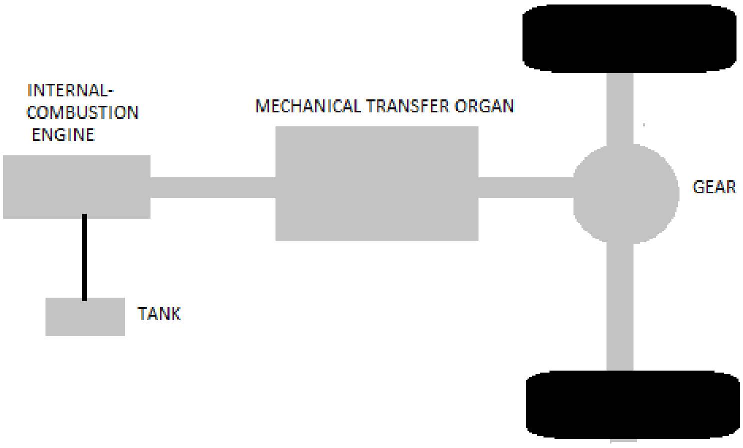

Figure 7. Internal Combustion Vehicle Power Transmission Mechanism.

Motor power;

$P = T * \frac{2*\pi*n}{60}$ (1)

will be calculated with the formula. Here, T is torque (Nm) and n is the speed (rpm). Taking into account the characteristics of the motor used, the torque is 66.958 Nm <T <180 Nm and the engine speed is 850 rev / d <n <1750 rev / d when calculating the power at full load. Engine power when torque is taken at 160,212 Nm:

$$P = 160{,}212 * \frac{2 * \pi * 2744{,}9}{60} = 46{,}052\text{kW}$$

in the form.

When finding the speed of the engine, for a lower engine speed than the idle speed ($\dot{\varphi}E,\ idle$) ($\dot{\varphi}E,out < \dot{\varphi}E,idle$):

$k_{E,operate} = -1$ (2)

ve $\dot{\varphi}E$, for $p_{E,vk,help}$ ve $p_{E,sk,help}$'in lineer enterpolasyonu:

$\Delta p = pE, vk, help - pE, sk, help$

$peff, sk = -\frac{\Delta p}{\varphi Eidle} * f_{E,sk} * \varphi E, out + p_{E,sk,help} + \Delta p * f_{E,sk}$ (3)

$peff, vk = peff, sk + \frac{\Delta p}{\varphi^2 E,idle} * \left(f_{E,sk} - 1\right) *$

$\varphi^3 E,out-- \frac{\Delta p}{\varphi^2 E,idle} * \left(f_{E,sk} - 2\right) * \varphi^2 out$ (4)

$f_{E,sk}$=1 (5)

(for automatic structure fE is considered to be sk = 4)

for a higher engine speed than the maximum speed ($\dot{\varphi}E,out > \dot{\varphi}E,max$);

$k_{E,operate}$= 1 (6)

$\dot{\varphi}E,max$ için $pE,vk,help$ ve $pE,sk,help$'in lineer enterpolasyonu:

$p_{eff,vk} = p_{E,VK,help} - |\varphi E, max - \varphi E, OUT| * \frac{N_{E,STROKE}*\pi}{V_{E,h}}$ (7)

$p_{eff,vk} = p_{E,VK,help} - |\varphi E, max - \varphi E, OUT| * \frac{N_{E,STROKE}*\pi}{V_{E,h}} * f_{E,sk}$ (8)

$f_{E,sk}$=1 (9)

($f_{E,sk}$ =0 for automatic structure)

For normal working conditions ($\dot{\varphi}E,idle < \dot{\varphi}E,out < \dot{\varphi}E,max$);

$kE,operate$=0 (10)

$\dot{\varphi}E$ is calculated as linear interpolation of $peff$, vk and $peff$ for p [12]. Here, the engine volume VE, h, the number of strokes çap; The average brake pressure in the motor curve for,, out is indicated by $peff$, sk, motion control kE, $operate$. AVL Cruise program makes the necessary calculations with reference to these equations.

5.2. Calculates for electricity motor vehicle

Figure 8 shows the conversion of the 1.3 liter diesel engine into an Electricity vehicle. Lithium ion battery is used in the model. The voltage is between 220 V and 420 V minimum. The Electricity motor is an asynchronous motor with a voltage of 320 V, moment of inertia of 1.0e-4 kgm2, speed ranging from 500 rev / d to 7500 rev / d and consequently efficiency between 65% and 93%. Based on these data, if we calculate the Electricityal power:

$$P_{elk} = V * I \qquad (11)$$

The values of the voltage are between 276,174 <V <345,07 and current values are between 15,827 <I <303.

If the power is calculated for the highest voltage and the lowest current:

$Pelk = 345{,}047 * 15{,}8276A = 5{,}461\ kW$

Efficiency from here:

$$\eta = \frac{\text{useful power}}{\text{Total power}} = \frac{P_{useful}}{P_{total}} \qquad (12)$$

Power loss (P_{loss});

$$P_{useful} = P_{total} + P_{loss} \qquad (13)$$

$5{,}461 < Ptotal < 83{,}764$ between and $1{,}33 < Ploss < 8{,}5$ between

$P_{fay} = 5{,}46 - 1{,}33 = 4{,}13\ kW$

$\eta = \frac{\text{useful power}}{\text{Total power}} = \frac{4{,}13kW}{5{,}46kW}$=%75,6 calculated as.

A real moment of power transmission:

$$M_{EM,dt} = M_{EM} - \Theta_{EM,nom}\ddot{\varphi}_{EM,out} \qquad (14)$$

It shaped. The following calculation is used for permanent field machines:

$$M_{EM}(T_{EM}) = (1 + \beta_{EM,REm}(T_{EM} - T_{EM,L}))M_{EM}(T_{EM,L}) \qquad (15)$$

Power transfer in the closed state:

$$M_{EM} = M_{EM,drag}(\dot{\varphi}_{EM}/\dot{\varphi}_{EM,max})^2 \qquad (16)$$

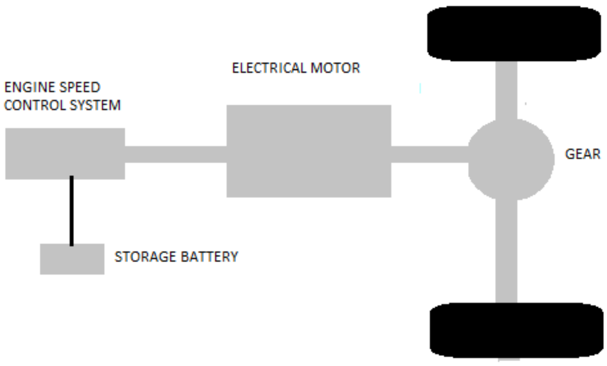

Figure 8. Electricity engine vehicle power transmission mechanism.

For permanent machines, iron losses should be considered.

Power transfer in the closed state:;

$M_{EM} = kM_{EM,max,mot}$, (eğer k>0 ise,) (17)

otherwise, $MEM = (-k)$ will be MEM, max, gen.

Electricityity Power:

$$P_{EM,el} = P_{EM,mec} + P_{EM,loss} \qquad (18)$$

It shaped. Loss of strength ($PEM, loss$) includes loss of iron, loss of copper and loss of friction. It turns completely into heat. Power transmission is defined by mechanical power:

$$P_{EM,mech} = \dot{\varphi}_{EM} M_{EM} \qquad (19)$$

is expressed with. The maximum torque is defined using the following power loss:

$$R_{th} = 1/\propto_{EM,th} \qquad (20)$$

$$I_{EM} = P_{EM,el}/U_{EM,net} \qquad (21)$$

Here, characteristic maps and curves (MEM), moment of inertia (ΘEM, nom), friction torque (MEM, $drag$), Magnet Induction Temperature coefficient βEM, REm, maximum torque of motor (MEM, max, mot), maximum torque of generator (MEM, max, gen), power loss (PEM, $loss$), maximum angular velocity φEM, max, actual Electricity power PEM, el, net voltage UEM, net, current IEM, motion [[18].

The 1.3 liter diesel vehicle model and the Electricity version of this model were simulated with AVL CRUISE program, torque, power and speed performances of the engines of two vehicles were examined and compared. The diesel internal combustion vehicle model and the Electricity vehicle model are shown in Figure 9, which was created using the AVL CRUISE program.

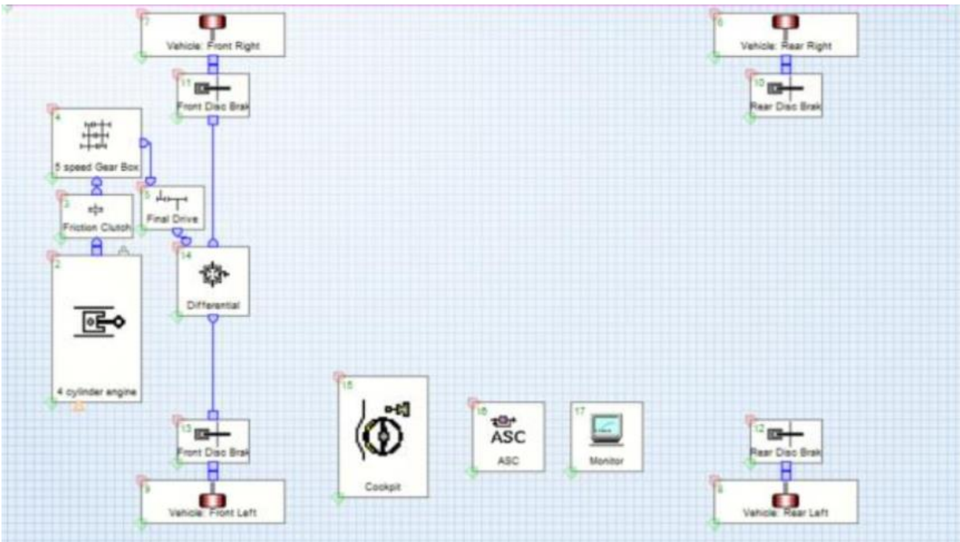

Figure 9. Internal Combustion Vehicle Model [19]

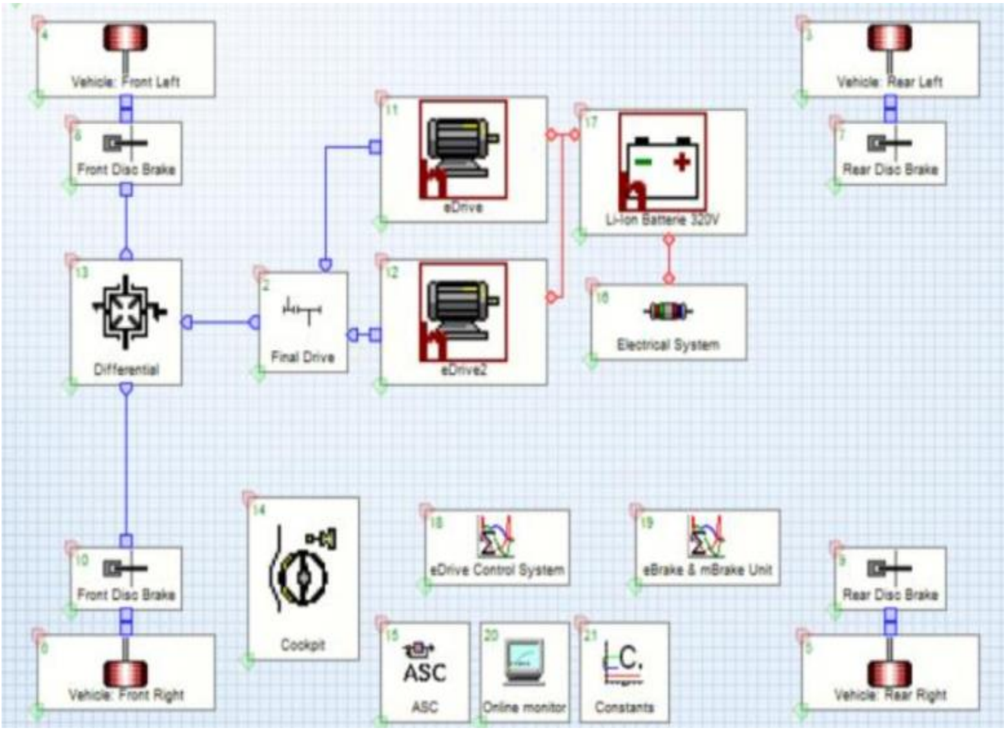

Figure 10. Electricity Vehicle Model [19]

If the performance graph of the 1.3 liter diesel vehicle in Figure 11 before the conversion is examined, the highest torque of the engine is 161.4 Nm; d. When the maximum speed of the vehicle's engine is 3905.65 rpm, the engine's power is 50,928 kW and the vehicle's running time is 15.3 s. The graph below shows the maximum torque of the engine at the moment the car is running, while this torque decreases as time progresses, and an increase in engine speed and power.

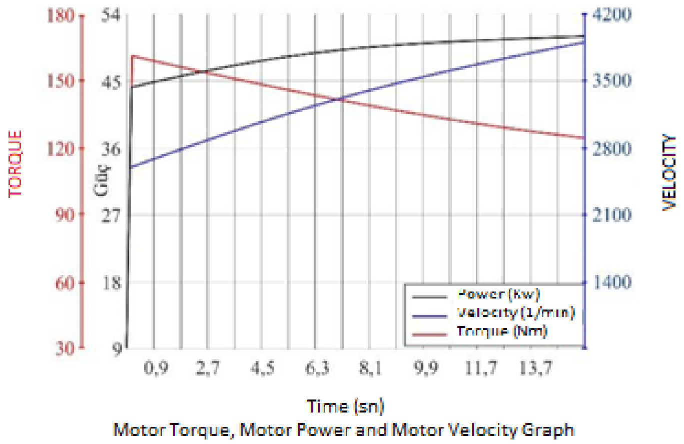

Figure 11. Torque Graph for Internal Combustion Vehicle.

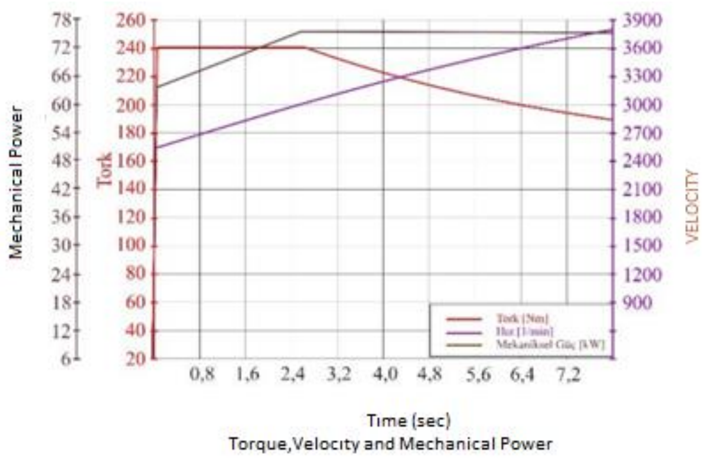

Figure 12. Torque Chart for Electricity Vehicle

Figure 12 above shows the performance graph of the 1.3 liter diesel internal combustion vehicle model after conversion to an Electricity vehicle. In this graph, the Electricity motor reaches the highest torque after 0.083 s after the vehicle starts. This value remains constant at 252 Nm for a while and then starts to decrease. While the torque of the Electricity motor is highest, the speed of the motor increases from 2560.18 rpm to 2999.57 rpm. Its mechanical power increases from 67.28 kW to 78.22kW. When the maximum speed of the engine is 3806.31 rpm, the power of the engine is 78.45 kW.

Referring to the graph above in Figure 13, which is formed by considering the same operating times (0-7.98 s), the engine torque increases when the diesel vehicle is turned into an Electricity vehicle. However, this value decreases after a certain period of time. Although the torque of the vehicle before the conversion is lower, this value has also decreased over time.

In Figure 14, the engine power of the electricity vehicle is higher than that of the internal combustion vehicle, but as time passes, the power of the electricity vehicle remains constant while the power of the internal combustion vehicle increases. In Figure 15, when the vehicles are first started, the speed of the internal combustion vehicle is higher than the Electricity. This then turns in favor of the Electricity vehicle, the speed of the Electricity vehicle exceeding the internal combustion vehicle.

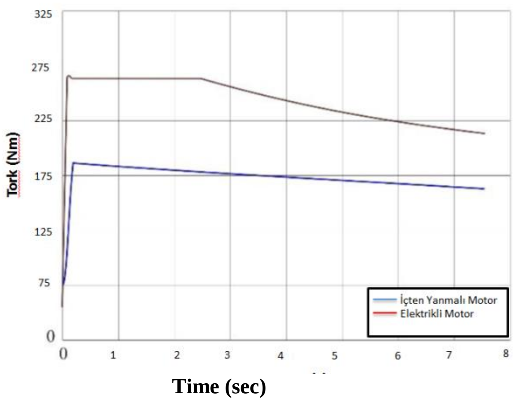

Figure 13. Torque comparison

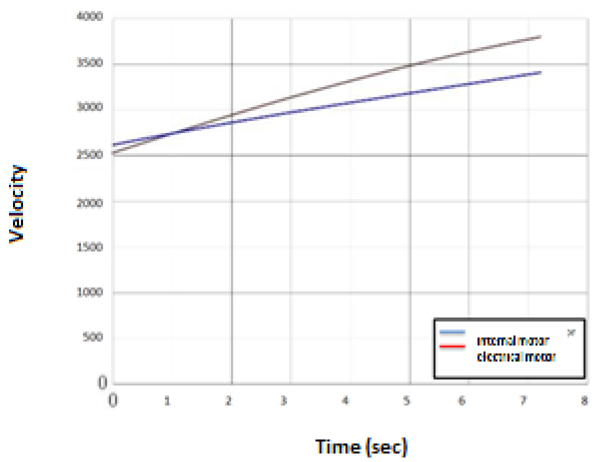

Figure 14. Power comparison

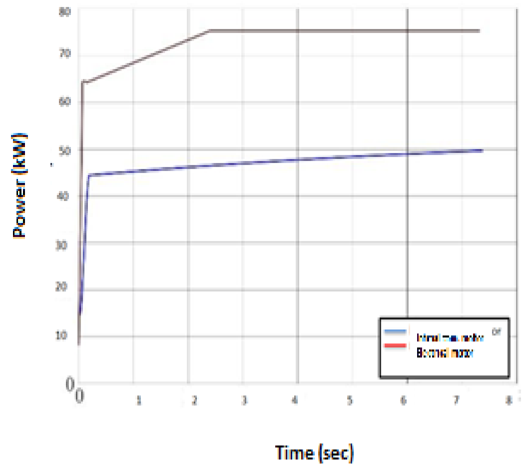

Figure 15. Speed comparison

Then there were fluctuations in the speed of the electricity vehicle. Efficiency is very high in Electricity vehicles, with some of the power obtained being converted to heat less, as in internal combustion engine vehicles, and there is no major difference between Electricityal power and mechanical power. The efficiency is solved as in equation 12. Since the Electricity motors will use the power in the battery, the negative power is taken as negative plus in the data. In addition, the Electricityal power plus parts are the moments when the vehicle stops.

After simulating the 1.3 liter diesel internal combustion engine and the Electricityal version of the same vehicle, the torque of the engines is higher compared to the internal combustion vehicle and is therefore preferred. The engine speed of the two vehicles does not change much. When the power is compared, the power of the internal combustion vehicle increases over time, while the power of the Electricity vehicle increases over time and remains constant after a while. When the Electricity vehicle is simulated in the New European Driving Cycle, it appears that the speed and mechanical power data correspond to each other and that the power received from the engine returns to the vehicle as speed. The high efficiency is due to the fact that vehicle losses are negligible. This is reflected in the power and speed of the vehicle. If the internal combustion vehicle is transformed into an Electricity vehicle, it becomes clear that there is no loss in the performance of the vehicle and a more environmentally friendly vehicle can be obtained. Different types of Electricity motors and batteries affect the performance of the car as it does in any car [19].

6. Electricity market in turkey, hybrid and fuel cell vehicles

Car sales in the rankings, which ranks 8th in Europe, Turkey is an important country as a potential market for Electricity vehicles. In addition, Turkey has signed the Kyoto Protocol was born on 5 February 2009 so that the obligation to reduce CO2 emissions in road transport. Industry and Trade Ministry of Industry Directorate General released in February 2011, "Turkey Automobile Sector Strategy Document and Action Plan" [20] in the context of a team to meet the requirements of the Kyoto protocol targets were set. These objectives include the introduction of a taxation system that encourages the use of environmentally friendly CO2 emissions and the necessary infrastructure for the dissemination of these vehicles.

Electricityity vehicle sales in Turkey is increasing day by day. While 184 Electricityity cars were sold until 2013, 31 Electricityity cars were sold in 2013, 47 electricity cars in 2014, 120 electricityity cars in 2015, 44 electricity cars in 2016, 76 electricityity cars in 2017 and 131 electricity cars in the first 11 months of 2018. Assuming continued until today sold a record traffic of electricity cars all there are 633 full-electricity vehicle in Turkey by road [21]. While the total number of electricity vehicles in Turkey 633, only 200 thousand electricity vehicles were sold in China in 2015, the same year in the United States is 110 thousand Electricity vehicles were sold. The increase in the rate of Electricity vehicle use depends on the expansion of the charging station network, while the increase in the rate of installation of the charging stations depends on the increase in the number of Electricity vehicles traveling on the roads. Simultaneous activation of these two interdependent variables with specific incentives will accelerate the increase in Electricity vehicle penetration rate in the market. Charging maps of the companies selling and installing charging stations were used in the study (Figure 16).

It is planned that the charging stations, whose network is planned to expand, will first be placed in the parking lots of the housing projects. Although there is no legal regulation on this issue, it is considered that a socket will be installed for every 100 vehicle parking area in order to give a more environmentalist appearance to the housing projects. In addition, it will be appropriate to install AC Mode 3 Type 2 charging stations in shopping malls, especially in İSPARK car parks and hotels with the “Park and Continue” application. DC fast charging is expected to become widespread in the parking spaces of recreational facilities, gas stations and vehicle fleets near the motorway where parking time is less than half an hour. In Turkey, private and public-use charging station is estimated that about 800-900 pieces found.

Figure 16. Map of Turkey Electricity Vehicle Charging Stations [22]

In Turkey, 'ÖTV' rates of plain Electricity motor vehicles have been kept low. The ‘ÖTV’ rates issued by the Revenue Administration of the Ministry of Finance on 22.09.2012 According to the List II numbered engine power;

- 3% in SEAs not exceeding 85 Kw
- 7% in SEA between 85 kW and 120 kW
- In SEAs exceeding 120 kW, it is 15%.

KDV in Turkey when added to the excise tax rates according to the tax burden on the engine power Electricity vehicles 21.5%, respectively, are 26.3% and 35.7%. Tax PwC Turkey had done the work of the service tax rate and encouraging movement in Turkey, comparison with countries with high penetration rate of EUR is given in Table 4.

Table 4. Electricity Vehicle Tax Rates.

Nation	KDV%		VT %		CASH SUPPORT
	CV	**EA**	**CV**	**EA**	
Norway	25	0	*	0	0
Netherlands	21	21	*	0	0
USA	8,4	8,4	0	0	3.000 $ 5.300$
France	20	20	≈1	≈1	5.000$ 6.500$
Japan	8	8	5	0	5.000$ 6.500$
Turkey	18	18	min 45 max 145	3 15	0
VT	:Vehicle tax				
CVv	:Conventional vehicle				
*****	:Depending on CO_2 Emission Ratio				

Turkey hybrid car market also continues to grow at an exponentially increasing rate each year. Turkey Electricity and Hybrid Vehicle Platform (TEHAD), according to data 2018 in the months of January-June 2263 total sales of hybrid cars have been realized. In the first 6 months of 2018, the most popular vehicle model was the Toyota C-HR, as in the previous year. In the first 6 months, 1568 Toyota C-HR hybrid cars were sold. According to the law, 'OTV' rates in hybrid automobiles are 45% for automobiles with a cylinder volume not exceeding 1800 cm3 and Electricity motor power exceeding 50 kW. In vehicles with a cylinder volume not exceeding 2500 cm3 and Electricity motor power exceeding 100 kW, it is 90% [23]. Fuel cell vehicles are vehicles that have just started production. The first hydrogen filling station in Turkey was established in 2012 in Istanbul Turkey, but hydrogen cars are at the test drive in traffic. fuel cell vehicles on the market in Japan has not yet been submitted to the official sales in Turkey. Therefore, no legislation or statistics related to these instruments are currently available. In the coming years it is expected to enter the market these cars to Turkey.

7. Result

As a result of the comparisons, although it is seen that the vehicle with internal combustion engine can be faster, it is seen that an Electricity motor vehicle is obviously more advantageous in parameters such as efficiency and torque. Taking into account the exhaust gas emissions and fuel savings, Electricity vehicles are much more advantageous. Due to these advantages, Electricity and hybrid Electricity cars are expected to have a large share in the passenger car market in the coming years. However, the fact that these vehicles will supply some of the energy they need from the sockets in the parking spaces will cause a large load increase in the distribution system and may cause capacity difficulties on all components of the Electricityal energy system (power plants, lines, transformers, etc.). It has been revealed in a study that the increase in peak power demand in the evening will be seen by adding the additional loads to the system without making any regulation by the widespread use of Electricity cars [24]. Considering the long term, necessary infrastructure investments should be made. With the help of smart grid, smart meter technologies and methods such as load spreading, residential load control, possible capacity constraints can be prevented by ensuring that the batteries of the Electricity cars are charged during the day when the power demand is low during the day. Electricity and hybrid vehicles have an increasing demand for purchase by users despite high purchasing costs. This demand, further lowering the tax rates in Turkey market and will accelerate further with the creation of infrastructure. After eliminating the range and reliability problems of these vehicles, it is thought that the majority of internal combustion engines will be lost in the market. Since fuel cell vehicles are still developing, they will take their place in the market after their current problems are solved.

References

[1] Chan, C.C., The state of the art of Electricity, hybrid, and fuel cell vehicles. Proceedings of the IEEE, 2007. 95(4): p. 704-718.
[2] Emadi, A., et al., Topological overview of hybrid Electricity and fuel cell vehicular power system architectures and configurations. IEEE Transactions on Vehicular Technology, 2005. 54(3): p. 763-770.
[3] Jones, W.D., Take this car and plug it [plug-in hybrid vehicles]. IEEE spectrum, 2005. 42(7): p. 10-13.
[4] Wirasingha, S.G., N. Schofield, and A. Emadi. Plug-in hybrid Electricity vehicle developments in the US: Trends, barriers, and economic feasibility. in Vehicle Power and Propulsion Conference, 2008. VPPC'08. IEEE. 2008. IEEE.
[5] Shahan, Z. European Electricity Car Sales Increased 42% In H1 2018 vs H1 2017. 2018; Available from: https://cleantechnica.com/2018/08/27/european-Electricity-car-sales-increased-42-in-h1-2018-vs-h1-2017/.
[6] Gehrer, C. and V. Hacker, International Energy Agency-Implementing Agreement on Advanced Fuel Cells. 2013.
[7] GORZELANY, J. 10 Longest-Range Electricity Vehicles For 2018. 2018; Available from: https://www.motor1.com/features/228379/longest-range-evs/.
[8] Brinkman, N., et al., Well-to-wheels analysis of advanced fuel/vehicle systems: A North American study of energy use, greenhouse gas emissions, and criteria pollutant emissions. 2005, EERE Publication and Product Library.
[9] Williamson, S.S. and A. Emadi, Comparative assessment of hybrid Electricity and fuel cell vehicles based on comprehensive well-to-wheels efficiency analysis. IEEE Transactions on Vehicular Technology, 2005. 54(3): p. 856-862.
[10] Hoeijmakers, M.J. and J.A. Ferreira, The Electricity variable transmission. IEEE transactions on industry applications, 2006. 42(4): p. 1092-1100.
[11] Chau, K., C.C. Chan, and C. Liu, Overview of permanent-magnet brushless drives for Electricity and hybrid Electricity vehicles. IEEE Transactions on industrial electronics, 2008. 55(6): p. 2246-2257.
[12] Ceraolo, M., A. Di Donato, and G. Franceschi, A General Approach to Energy Optimization of Hybrid Electricity Vehicles. IEEE Trans. Vehicular Technology, 2008. 57(3): p. 1433-1441.
[13] Ferreira, A.A., et al., Energy management fuzzy logic supervisory for Electricity vehicle power supplies system. IEEE Transactions on Power Electronics, 2008. 23(1): p. 107-115.
[14] Lai, J.-S. and D.J. Nelson, Energy management power converters in hybrid Electricity and fuel cell vehicles. Proceedings of the IEEE, 2007. 95(4): p. 766-777.
[15] Boulon, L., et al. Maximal and practical control structure of a PEM fuel cell system based on Energetic Macroscopic Representation. in Fundamentals and Development of Fuel Cells Conference (FDFC’08), Nancy, France, Dec. 2008.
[16] Sepe, R., et al. High efficiency operation of a hybrid Electricity vehicle starter/generator over road profiles. in Industry Applications Conference, 2001. Thirty-Sixth IAS Annual Meeting. Conference Record of the 2001 IEEE. 2001. IEEE.
[17] Fonseca, N., J. Casanova, and M. Valdes, Influence of the stop/start system on CO2 emissions of a diesel vehicle in urban traffic. Transportation Research Part D: Transport and Environment, 2011. 16(2): p. 194-200.
[18] Cruise, A., Theory manual. AVL list GmbH, Graz, Austria, Document, 2009(04.0108).
[19] Mengi, O.Ö., Dizel Bir Aracın Elektrikli Araca Dönüşüm Performansının Değerlendirilmesi. Fırat Üniversitesi Mühendislik Bilimleri Dergisi, 2018. 30(1): p. 175-182.
[20] Sanayi, T. and T.B.S.G. Müdürlüğü, Türkiye otomotiv sektörü strateji belgesi ve eylem planı 2011-2014. Erişim Tarihi, 2011. 11: p. 2012.
[21] Türkiye'deki Elektrikli Otomobil Sayısı. 12.2018; Available from: http://www.enerjiatlasi.com/haber/turkiye-deki-elektrikli-otomobil-sayisi.
[22] Esarj Harita. 2018; Available from: https://esarj.com/harita.
[23] Emir. Hibrit Otomobillere Beklenen ÖTV İndirimi Geldi, Ancak Kapsamı Çok Dar. 2016; Available from: http://teslaturk.com/hibrit-otomobillere-otv-indirimi-geldi/.
[24] Akcanca, M.A. and S. Taşkın, Akıllı şebeke uygulanabilirliği açısından türkiye elektrik enerji sisteminin incelenmesi. Akıllı Şebekeler ve Türkiye Elektrik Şebekesinin Geleceği Sempozyumu, 2011: p. 26-27.