# ELECTRIC OPERATED VEHICLES ON TURKISH AIRPORT APRON OPERATIONS

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Transportation is a very important subject of today's rapidly changing world. As the concept of globalization spreads thought every country world and the information technologies evolving much faster than ever, more and more people demand high speed and economic transportation. Because of this reasons millions of people prefer transportation with aviation in Turkey. But, as the economy related to aviation rise rapidly, the air pollution problems caused by huge fuel consumption rises also.

The global aviation industry corporations and international regulations such as Kyoto Protocol, orders airport authorities to reduce their carbon emissions instead of everyday increasing passenger demand on air transportation globally. The only way to decrease these carbon emissions is to use new Technologies on airports such as electric driven apron fleet vehicles. In this paper, we will discuss feasibility of reduction of greenhouse gases by using electric driven fleet vehicles on TAV operated Turkish airports.

On the first analysis section of this paper, diesel and gasoline powered apron cars are compared with fully electric driven and hybrid powered cars. On the second part, diesel powered apron buses are compared with electrically driven buses. Finally, the future technologies on apron operation vehicles will be discussed.

## 1. Introduction

Transportation is a very important subject of today's rapidly changing world. As the concept of globalization spreads thought every country world and the information technologies evolving much faster than ever, more and more people demand high speed and economic transportation. Because of this reasons millions of people prefer transportation with aviation in Turkey. According to General Directorate of State Airports Authority of Turkey, the total number of passengers carried from Turkish airports is 181.698.362 passengers with an increase rate of 9,4 % from the previous year.[1] The majority of this passenger traffic ( approx. 50 % ) was handled just by the airports located in Istanbul. Because of high amount of passenger and plane traffic in Istanbul, the current Istanbul airports Ataturk and Sabiha Gokcen having some congestion problems. The main reason for this problems underlies in the growth strategy of our Turkish air carriers such as Turkish Airlines and Pegasus. According to Ceo of Turkish Airlines Kotil[2], 2016 Turkish Airlines is the airline which flies the most destinations globally and the airline will increase its service quality and frequency on most of the destinations within next decade. But passenger increase means traffic increase at the airports, so the congestion problems will be much worse than today's conditions. According to Pekcanatti[3], we need to build a new airport to Istanbul for not to deal with capacity issues up to 2050.

1 General Directorate of State Airports Authority of Turkey 2015 Passenger Statistics ( www.dhmi.gov.tr/istatistik.aspx )
2 Serdar Turan, ( 2016 ) Thinking Strategically and Operating Tactically, Interview with Temel Kotil. Harvard Business Review. 15 February 2016. ( http://www.hbrturkiye.com/x/stratejik-dusunup-taktik-hareket-etmek-2 )
3 Fatih Canatti, ( 2006 ) Istanbul Ataturk and Sabiha Gokcen Airports Capacity and Demand Evaluation Master Thesis, Istanbul Technical University

For to solve these congestion problems in Istanbul airports, a new project which is known as 3 th Airport Project by public is introduced at 2013. According to this project, the passenger capacity of the new airport will increase up to 200 million with 6 runways each of them will have 3750 m x 60 m asphalt coverage[1]. This new airport will serve as a major transportation hub for major airlines. After the end of the project, everything seems to be fine, a lot of planes will came and the economy related to aviation will rise rapidly. But what will happen to air pollution problems do not take into consideration.

According Can Erel[2], all of the countries of whom signed the Kyoto Protocol, has an obligation to reduce their carbon and sera gas emissions at least % 5,2 per year considering the year 1990 carbon emission rates. If the countries do not achieve this goal, they have to invest on Carbon Emission Exchange Credits. The Kyoto Protocol provides three mechanisms that enable countries or operators in developed countries to acquire greenhouse gas reduction credits which are described above[3];

a) Under Joint Implementation (JI) a developed country with relatively high costs of domestic greenhouse reduction would set up a project in another developed country.

1 https://tr.wikipedia.org/wiki/Istanbul_Yeni_Havalimanı ( Retrieved 18.03.2016 )
2 Can Erel, Aviation Environmental Effects and Precautions on Behalf of the Kyoto Protocol, Istanbul Technical University Foundation Press, July- September 2014 , ( 65 )
3 http://unfccc.int/kyoto_protocol/mechanisms/items/1673.php ( Retrieved 18.03.2016 )

b) Under the Clean Development Mechanism (CDM) a developed country can 'sponsor' a greenhouse gas reduction project in a developing country where the cost of greenhouse gas reduction project activities is usually much lower, but the atmospheric effect is globally equivalent. The developed country would be given credits for meeting its emission reduction targets, while the developing country would receive the capital investment and clean technology or beneficial change in land use.

c) Under International Emissions Trading (IET) countries can trade in the international carbon credit market to cover their shortfall in Assigned amount units. Countries with surplus units can sell them to countries that are exceeding their emission targets under Annex B of the Kyoto Protocol.

These carbon projects can be created by a national government or by an operator within the country. In reality, most of the transactions are not performed by national governments directly, but by operators who have been set quotas by their country. For considering airport operations, Airports Council International[1] ( ACI ) is the association of the world's airports. It is a non-profit organization, whose prime purpose is to advance the interests of airports and to promote professional excellence in airport management and operations. By fostering cooperation amongst airports, world aviation organizations and business partners, ACI makes a significant contribution to providing the traveling public with an air transport system that is safe, secure,efficient and environmentally responsible.

1 http://www.aci.aero/About-ACI ( Retrieved 18.03.2016 )

On June 2009, ACI launched Airport Carbon Accreditation Program[1]. By this program, ACI empowers airports to analyze, reduce and neutralize their carbon emissions. When the airports fulfills the carbon reduction requirements, they will be certified as green airport by the ACI. For the Turkish airports, Currently TAV Izmir Airport is on the carbon reduction section, TAV Istanbul Airport is on the carbon optimized section, TAV Ankara and ICF Antalya Airports are on the carbon neutralized section of the project. The General Directorate of State Airports Authority of Turkey also has a green airport regulation. According to this, if an airport meets the carbon reduction criteria which is %0,5 reduction per year, the airport will be rewarded with Green Airport Certificate[2].

According to ACI Guidance Manual for Airport Greenhouse Gas Emissions Management[3] Scope 1, one of the airport owned or controlled resource of carbon pollution is fleet vehicles. These are, airport-owned (or leased) vehicles for passenger transport, maintenance vehicles and machinery operating both air-side and land-side. According to Emirates Group 2013-2014 Environmental Report[4], the carbon emissions of ground operations is % 4,7 in the total emissions of entire Emirates operations of the In this paper, we will discuss feasibility of reduction of green house gases by using electric driven fleet vehicles on TAV operated Turkish airports.

1 http://www.airportcarbonaccredited.org/about/what-is-it.html ( Retrieved 18.03.2016 )
2 http://web.shgm.gov.tr/tr/kurumsal-projeler/194-yesil-havaalani-green-airport-projesi ( Retrieved 18.03.2016 )
3 ACI Guidance Manual: Airport Greenhouse Gas Emissions Management (2009)
4 *Emirates Group Environmental Report 2013 - 2014*, United Arab Emirates 2014 ( 39 )

## 2. Method of Evaluation

The current fleet vehicles operating at airports are listed as below;

a) Operation cars
b) Marshalling cars
c) Security cars
d) Passenger boarding steps/ramps car
e) Apron buses
f) Apron catering cars
g) Tugs and tractor cars
h) Push back cars
i) Sanitary services cars
j) Potable water services cars
k) Belt loading vehicles
l) Container loading cars
m) Deicing vehicles
n) Refueling vehicles
o) Fire fighting vehicles
p) Airport medical service cars

During aircraft turnaround time at the airport terminal, certain services must be performed on the aircraft, usually within a given time, to meet flight schedules. The general airport ground operations vehicles that are described above are special missioned vehicles that are necessary to fulfill aircraft turnaround missions. Figure 1 shows typical arrangements of ground support equipment during turnaround time on BOEING 777 Aircraft[1] . As noted,if the auxiliary power unit (APU) is used, the electrical, air start, and air-conditioning service vehicles would not be required. Passenger loading bridges or portable passenger stairs could be used to load or unload passengers.

1*Boeing 777/200-300 Characteristics for Airport Planning*, Boeing Commercial Airplanes ( October 2002 )

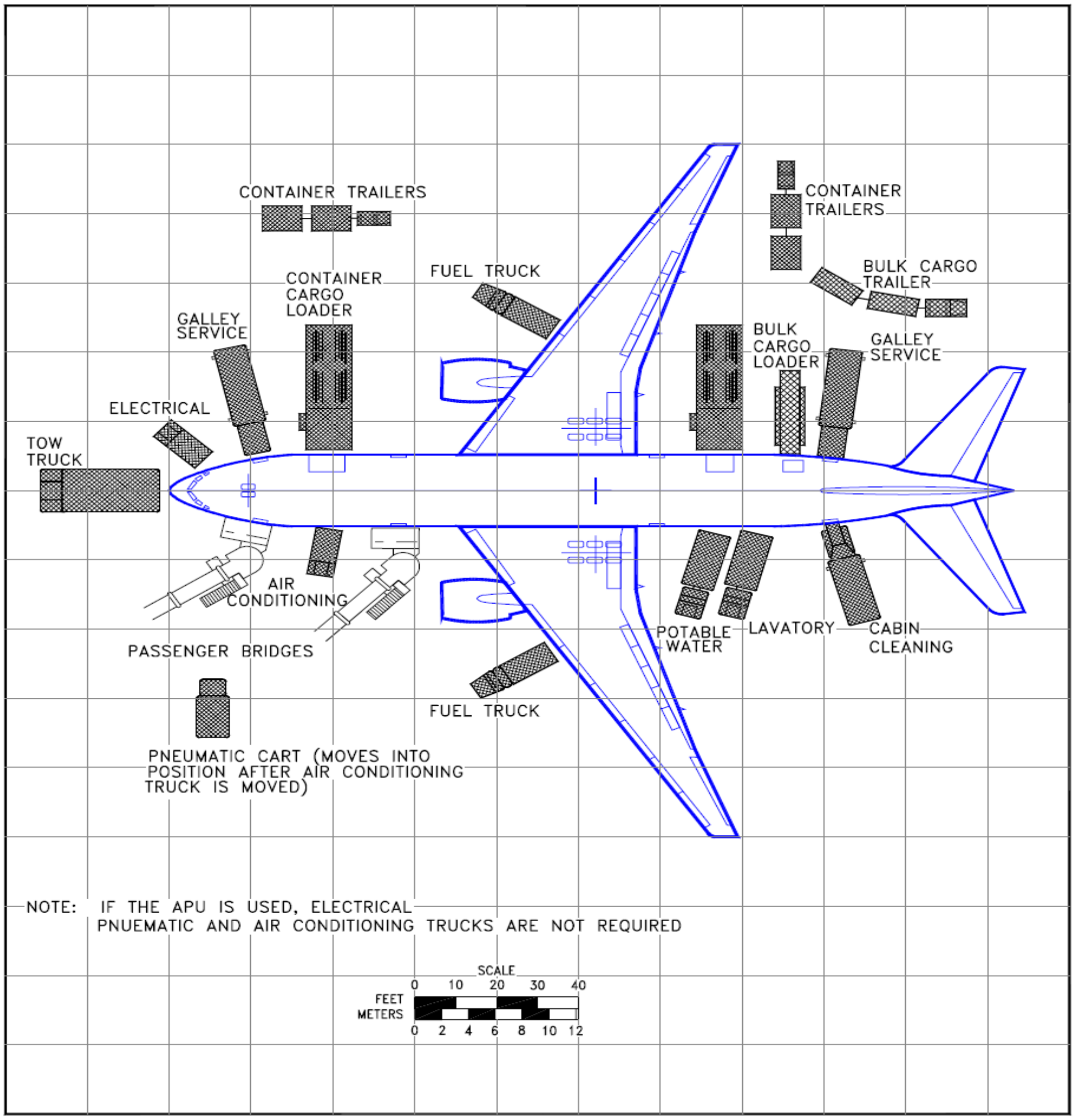


**Figure 1: Boeing 777 Ground service vehicles**

Within the apron operations vehicles described in this section, only the refueling vehicle and fire engine vehicle can not be operated by electric power. Because the refueling vehicle contains highly flammable jet fuel and any minor static electric on the vehicle may cause serious explosions. As for the fire engine, they usually needed on extremely urgent situations and they should be ready to operate at rough and unpleasant terrain conditions. The electric driven motors needs time to be recharge itself and the electric motors cannot operate on off road terrain conditions so that is why they need to be operated by diesel engine technology. Therefore all of the airport ground operations vehicles except the fuel end fire engine trucks can be operated by % 100 electrical energy without causing any gas emissions.

For to determine the feasibility analyses of using electric driven cars on Turkish airports, this research mainly focuses on feasibility analyses of electric driven operation cars and apron buses. Because this type of vehicles are the only type of electric driven apron vehicles available on sale on Turkish market. On the analyses section of this research paper, the current value and profitability of using electric driven vehicles in the airports will be determined by Net Present Value ( NPV ) analyses. On the calculation section of car models, electrically driven BMW i3 , Toyota Yaris Hybrid and Renault Zoe vehicles will be compared with diesel operated Toyota Yaris and Renault Clio models. For the calculation section of bus models, BYD electric bus which currently has 3 apron buses on Frankfurt International Airport[1] will be compared with same model conventional diesel powered bus. Then the future technologies on electric driven vehicles will be evaluated.

1 https://en.wikipedia.org/wiki/BYD_electric_bus#Europe Retrieved ( 05.04.2016 )

## 3. Calculation of Carbon Emissions on Turkish Airports

According to General Directorate of State Airports Authority of Turkey 2015 Passenger Statistics, airport in Turkey are used by a total number of 1.207.653 aircrafts, approximately %54 of these aircrafts are serviced by four major airports operated by TAV Airports[1]. The names of these four major airports are : Istanbul Ataturk, Ankara Esenboga, Izmır Adnan Menderes and Alanya Gazipasa. So we can use the TAV Airports Corporation's environmental sustainability charts as a sample for representing Turkish Airports carbon emission data. Below is the 2012-2013 sustainability chart of diesel and gasoline consummation of all  airline ground service vehicles operated at TAV Airports[2];

| | Unit | 2012 | 2013 | Change |
|---|---|---|---|---|
| Diesel | GJ | 2.642.442 | 2.576.965 | % -2,5 |
| Gasoline | GJ | 516.989 | 307.348 | % -40,6 |

**Figure 2: TAV Airports 2012- 2013 sustainability charts**

The unit of diesel and gasoline consummation on this charts are given as GJ (Giga Joule), which is a unit of energy after the fuel was burned. So we have to calculate the total amount of fuel consumed for to reach that amount of energy.

1General Directorate of State Airports Authority of Turkey 2015 Flight Statistics ( www.dhmi.gov.tr/istatistik.aspx )
2 http://www.airportsforfuture.org/tr/cevresel.html Retrieved ( 05.04.2016)

For to determine the total amount of fuel consumed by apron service cars on the airports, we need to have a conversation formula from consumed energy to fuel volume. Below is the conversation chart which is currently in use at The National Energy Board of Canada[1];

**Petroleum Products**

| Substance | Unit | Equivalent to |
|---|---|---|
| Asphalt | **1.0** Cubic metres ($m^3$) | **44.46** Gigajoules (GJ) |
| Aviation gasoline | **1.0** Cubic metres ($m^3$) | **33.52** Gigajoules (GJ) |
| Jet Fuel (Jet A-1) | **1.0** Cubic metres ($m^3$) | **34.70** Gigajoules (GJ) |
| Diesel | **1.0** Cubic metres ($m^3$) | **38.68** Gigajoules (GJ) |
| Heavy fuel oil | **1.0** Cubic metres ($m^3$) | **41.73** Gigajoules (GJ) |
| Kerosene | **1.0** Cubic metres ($m^3$) | **37.68** Gigajoules (GJ) |
| Heating Oil | **1.0** Cubic metres ($m^3$) | **36.72** Gigajoules (GJ) |
| Lubes and greases | **1.0** Cubic metres ($m^3$) | **39.16** Gigajoules (GJ) |
| Motor gasoline | **1.0** Cubic metres ($m^3$) | **34.66** Gigajoules (GJ) |
| Naphtha specialties | **1.0** Cubic metres ($m^3$) | **35.17** Gigajoules (GJ) |
| Petrochemical feedstock | **1.0** Cubic metres ($m^3$) | **34.17** Gigajoules (GJ) |
| Petroleum coke | **1.0** Cubic metres ($m^3$) | **42.38** Gigajoules (GJ) |
| Still gas | **1.0** Cubic metres ($m^3$) | **41.73** Gigajoules (GJ) |
| Other products | **1.0** Cubic metres ($m^3$) | **39.82** Gigajoules (GJ) |

**Figure 3: National Energy Board of Canada energy conversation chart as energy**

According to this chart, diesel conversation rate as 38,68 GJ per cubic meter and gasoline conversation rate as 34,66 GJ per cubic meter will be used on calculations.

1 https://www.neb-one.gc.ca/nrg/tl/cnvrsntbl/cnvrsntbl-eng.html Retrieved ( 10.04.2016 )

We can calculate the total volume of petroleum products consumed at TAV Airports by converting TAV sustainability charts energy units to volume units with conversation rates that are in use at National Energy Board of Canada. After this calculations, the results are shown at Figure 4 as;

| | Unit | 2012 | 2013 | Change |
|---|---|---|---|---|
| Diesel | m3 | 68.315 | 66.622 | % -2,5 |
| Gasoline | m3 | 14.916 | 8.887 | % -40,6 |

**Figure 4: TAV Airports 2012- 2013 fuel volume chart**

As it can be seen from this table that the total consummation of fuels are decreasing thanks to the sustainability program of ACI at TAV Airports. But the total amount of fuel consummation is very high. If we can calculate the daily fuel consumption by assuming a normal petroleum tanker will carry 40 m3 fuel, the total daily diesel fuel consummation at 4 airports operated by TAV Airports is 68315 / ( 40 x 365 ) = 4,67 petroleum tankers daily.

The total amount of carbon dioxide gases occurred at TAV airports can be calculated by average carbon dioxide calculation formula which is in use at United states Environmental Protection Agency as described below[1];

For to calculate $CO_2$ emissions from a gallon of fuel, the carbon emissions are multiplied by the ratio of the molecular weight of $CO_2$ (m.w. 44) to the molecular weight of carbon (m.w.12): 44/12.

$CO_2$ emissions from a gallon of gasoline = 2,421 grams x 0.99 x (44/12) = 8,788 grams = 8.8 Kg/gallon = 2,32 Kg/liter

$CO_2$ emissions from a gallon of diesel = 2,778 grams x 0.99 x (44/12) =10,084 grams = 10.1 Kg/gallon = 2.67 Kg/liter

The total amount of carbon emission occurred at TAV airports are calculated by these formulas in the Figure 5 as;

| | Unit | 2012 | 2013 | Change |
|---|---|---|---|---|
| Diesel | Tons | 182.401 | 177.880 | % -2,5 |
| Gasoline | Tons | 34.605 | 20.617 | % -40,6 |

**Figure 5: TAV Airports 2012- 2013 carbon emissions chart**

1*Emission Facts*, United States Environmental Protection Agency Office of transportation and Air Quality, EPA420-F-05-001, February 2005.

For environmental and legal purposes, TAV Airports must compensate these carbon emissions by investing on Carbon Emission Reduction ( CER ) credits. Generally, one allowance or CER is considered reduction equivalent to one metric ton of $CO_2$ emissions. These allowances can be sold privately or in the international market at the prevailing market price. These trade and settle internationally and hence allow allowances to be transferred between countries. Each international transfer is validated by the United Nations Framework Convention on Climate Change (UNFCCC). Each transfer of ownership within the European Union is additionally validated by the European Commission. The carbon emission reduction credit for 1 metric tons of Carbon Dioxide gas is approximately 24.000 Euro[1]. So the total amount of carbon reduction credit payment that the TAV Airports Corporation have to pay for to neutralize their carbon footprints is calculated on Figure 6 as ;

| | Unit | 2012 | 2013 | Change |
|---|---|---|---|---|
| Diesel | Euros | 4.377.624 | 4.269.120 | % -2,5 |
| Gasoline | Euros | 830.520 | 494.808 | % -40,6 |
| Total | Euros | 5.208.144 | 4.763.928 | % -8,5 |

**Figure 6: TAV Airports 2012- 2013 carbon emissions credits calculation chart**

1 https://co2.myclimate.org/en/cart Retrieved ( 10.04.2016 )

The total amount of money for purchasing the fuel required for TAV Airports ground operations are calculated at the Table 3.6 by assuming the price of diesel per liter on Turkish market is 1,42 TL / Liter for Diesel and 1,75 TL / Liter for Gasoline excluding taxes[1] regarding to tax free fuel regulation on air-side operations of the airports at Chicago Convention Article No 24.

| | Unit | 2012 | 2013 | Change |
|---|---|---|---|---|
| Diesel | TL | 97.007.300 | 94.603.240 | % -2,5 |
| Gasoline | TL | 26.103.000 | 15.552.250 | % -40,6 |
| Total | TL | 123.110.300 | 110.115.490 | % -10,6 |

**Figure 7: TAV Airports 2012- 2013 fuel price chart**

After the calculation of fuel prices, the total cost of fuel consumption can be calculated by the sum of the carbon emission credit calculation Table 3.5 and fuel price Figure 7-8 by assuming 1 Euro = 3,22 TL[2].

| | Unit | 2012 | 2013 | Change |
|---|---|---|---|---|
| Diesel | TL | 111.103.249 | 108.349.806 | % -2,5 |
| Gasoline | TL | 28.777.274 | 17.145.532 | % -40,6 |
| Total | TL | 139.880.524 | 125.495.338 | % -10,6 |

**Figure 8: TAV Airports 2012- 2013 total cost of fuel consumption**

1 https://www.opet.com.tr/guncel-akaryakit-fiyatlari#ankara Retrieved ( 14.04.2016 )
2 http://www.tcmb.gov.tr/kurlar/201604/14042016.xml Retrieved ( 14.04.2016 )

# 4. Feasibility Analyses of Electric Driven Vehicles on Airports

## 4.1 Feasibility analyses of electric cars on airports

For to analyze the electric driven cars on airports, three different type of electric driven cars on Turkish Market will be evaluated below as ;

### 4.1.1 Toyota Yaris

Toyota Yaris type of electric car on sale at Turkish market is not an fully electric driven car. Instead of this it is called as a HYBRID car. This hybrid vehicle is driven by an electric and diesel combined motor, functioning as an electric vehicle while the battery pack energy supply is sufficient, with an engine tuned for running as a generator when the battery pack is insufficient. The hybrid vehicle typically achieves greater fuel economy and lower emissions than conventional internal combustion engine vehicles (ICEVs), resulting in fewer emissions being generated. These savings are primarily achieved by three elements of a typical hybrid design described on the next page.

a) Relying on both the engine and the electric motors for peak power needs, resulting in a smaller engine size more for average usage rather than peak power usage. A smaller engine can have less internal losses and lower weight.

b) Having significant battery storage capacity to store and reuse recaptured energy, especially in stop-and-go traffic typical of the city driving cycle.

c) Recapturing significant amounts of energy during braking that are normally wasted as heat. This regenerative braking reduces vehicle speed by converting some of its kinetic energy into electricity, depending upon the power rating of the motor/generator.

These special characteristics of hybirid vehicles make them specially valuable choice on apron operations. The apron operation cars cannot exceed speeds greater than 25 Km per hour because of safety restrictions and the apron cars are assumed to be in use actively 5 hours per day with achieving a total of 125 km distance per day. But these cars generally put on halt position while the engine is running. This usage habit of diesel cars makes them extremely inefficient, because the maximum fuel consumption occurs at lower speed conditions as described on the Figure 9. On the contrary, the minimum fuel consumption for hybirid driven vehicles occurs at lower speed conditions.

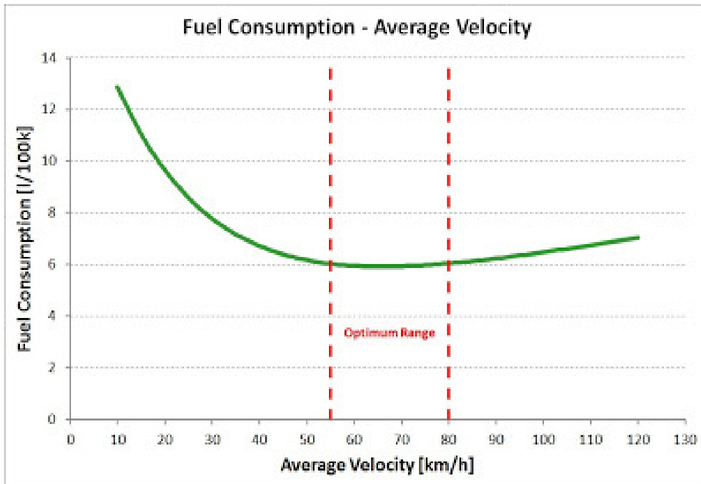


**Figure 9: Velocity and fuel consumption chart**

Toyota Yaris has two different type of engines these are called 1.33 Dual VVT-i Multi-drive S Automatic works with gasoline and 1.5 HSD e-CVT Automatic works with electric and gasoline combined. The current sale price of Yaris in Turkey driven with these motors are 61.500 TL[1] for Yaris Multi-drive S and 65.800 TL for Yaris Hybirid Cool including % 45 Special Consummation Tax.

1Toyota Efe Plaza ankara Marketing Documents Retrieved ( 15.04.2016 )

Both of the Yaris models needs a 10.000 km maintenance which costs approximately 475 TL. If we assume that the vehicle operates 5 hours daily with a maximum of 25 Km per hour speed limit, the interval between service periods can be calculated as 10.000 / ( 5 x 25 ) = 80 days.

The general service periods of these cars on the airports are approximately 4 years. So we can calculate the total number of services that the vehicle will need for the next 4 years as 365 x 4 / 80 = 18,25 approx 18 times.

According to Toyota[1], the fuel consumption of Yaris is 6,3 Lt per 100 kilometer for gasoline powered engine and 2,2 Lt per 100 kilometer for hybirid engine under apron conditions. Therefore the price of fuel consumptions, and the carbon credit investment that required to neutralize this consumptions for 1 year period, are calculated by using previous data's on section 3 is on the Figure 10 as;

| | Fuel Consumption (Lt) | Fuel Price (TL) | Carbon Emission (Kg) | Carbon Credit (TL) | Total Fuel Cost (TL) | Service Cost (TL) | Total Maintenance Cost (TL) |
|---|---|---|---|---|---|---|---|
| Yaris Gasoline | 3.103 | 5.429 | 7.198 | 556 | 5.986 | 2.137,5 | 8.123 |
| Yaris Hybirid | 1.004 | 1.757 | 2.329 | 180 | 1.937 | 2.137,5 | 4.074 |

**Figure 10: Yaris maintenance cost for 1 year**

1 Toyota 2016 Yaris Catalogue, December 2015 Ankara.

The selling price difference between Yaris hybirid and gasoline powered cars is; 65.800 TL - 61.500 TL = 4.300 TL and the total yearly maintenance saving of hybirid car is 8.123 TL - 4.074 TL = 4.049 TL. Now the Net Present Value ( NPV ) can be calculated for to determine the present value of this electric cars investment by the discounted sum of all cash flows received from the project. The formula for this discounted sum of all cash flows can be rewritten as;

$$NPV = -Initial\ Investment + \sum_{t=1}^{T} \frac{Net\ Cash\ Flow_t}{(1+i)^t}$$

$t = Cash\ Flow\ Period \quad i = Discount\ Rate\ or\ assumed\ interest\ rate$

The initial investment between the car models is 4.300 TL and yearly savings is 4.049 TL and if we assume the yearly interest rate as % 11,50 [1] , The result of NPV calculation is **NPV = 8.262 TL**. With the selection of Toyota Yaris Hybirid model instead of fully gasoline powered apron operation car, the airline ground operations company will save a total of 8.262 TL per car for a 4 year operation time.

1 http://www.tcmb.gov.tr/wps/wcm/connect/6121b7aa-7946-4353-b0f2-9cbab7e289b2/Turk+Lirasi.html?-MOD=AJPERES Retrieved ( 14.04.2016 )

### 4.1.2 Renault Zoe

The technology of Renault Zoe is completely different with the technology of hybirid driven vehicles. Because it is operated by a plug-in-electric motor. A plug-in hybrid electric vehicle (PHEV) is a hybrid electric vehicle that uses rechargeable batteries, or another energy storage device, that can be recharged by plugging it in to an external source of electric power A PHEV shares the characteristics both of a conventional hybrid electric vehicle, having an electric motor and an internal combustion engine (ICE), and of an all-electric vehicle, having a plug to connect to the electrical grid. Most PHEVs are passenger cars but there are also PHEV versions of commercial vehicles and vans, utility trucks, buses, trains, motorcycles, scooters, and military vehicles. The Renault Zoe's engine system operates fully on electric power. So it does not produce any single gram of carbon dioxide pollution to the environment. Thanks to the Turkish Government Environmental Legislations, this type of fully electrically operated cars only have % 3 Special Consummation Tax and they do not have to pay yearly governmental taxes.

The only problem with operation of the Renault Zoe is, it needs special charging devices for to recharge itself. There are two charging companies common on Turkish market. These are Full Charger and E-Sarj. Both of this companies have various types of charging solutions from personal use to heavy industrial use.

For the apron operations, the ideal mode of charging station is a normal charging device which can fully charge Renault Zoe in 1 hour. The approximate price of the charging station is 6.000 TL and it can charge 2 cars at the same time. The cars can be charged at non active periods of the airport so we can assume that at least 6 cars can be charged by this station during a full day. So the initial installation cost of this station will be 1.000 TL per car.

According to Renault Mais Ankara[1], the normal charging device can charge %80 of the battery in 1 hour. So the range of the vehicle will be 210 Km x %80 = 168 Km which is enough for 6,5 hours of operation. But the battery system in the car needs to be replaced every 200.000 km or 8 years of usage. The Renault does not require any extra payment for to replace the batteries. Instead of this Renault hires the battery system of Zoe with a 89 Euro rental fee per month. When the performance of the car decreases to a certain amount. The replacement of the battery will be made free of charge also. The service fee of every 10.000 Km usage of this vehicle is approximately 300 TL. The electric consumption of this vehicle is assumed as 68 Watt per kilometer on apron conditions. So for 100 kilometers it will consume 6,8 Kwh energy. The current electric Kw price of Turkey at April 2016 is approximately 0,32 TL per Kw[2] excluding governmental taxes according to Chicago Convention article No: 24. So the electric consumption price per 100 km is 0,32 x 6,8 = 2,17 TL. As a zero emission car, Renault Zoe is free of annual government tax which costs approximately 1.000 TL annually[3].

1Interview with Renault Mais General Manager 30.03.2016
2 http://akillitarife.com/rehber/elektrik-fiyatlari-2016 Retrieved ( 15.04.2016 )
3 http://hesabet.com/Hesaplama/Motorlu_Tasitlar_Vergisi_Hesaplama Retrieved ( 15.04.2016 )

The diesel operated version of Renault Zoe is Renault Clio Joy 1.5 dCi 75 bg. The current sale price of this model car is 56.950 TL[1] including % 45 Special Consummation Tax while the current sale price of Renault Zoe is 66.550 TL[2] including % 3 Special Consummation Tax. The fuel consumption rate of Clio is 5,9 Liters of diesel per 100 Km. But the approximate 10.000 Km service of this car costs approximately 500 TL and Clio is subject to annual governmental taxes that described on the previous page. So the annual maintenance costs of both Renault Clio and Renault Zoe operating on same apron conditions as Toyota Yaris car is calculated on Figure 11 as;

| | Fuel Consumption (Lt) | Fuel Price (TL) | Carbon Emission (Kg) | Carbon Credit (TL) | Total Fuel Cost (TL) | Service Cost (TL) | Annual Tax (TL) | Total Maintenance Cost (TL) |
|---|---|---|---|---|---|---|---|---|
| **Renault Clio** | 2.692 | 3.822 | 7.187 | 555 | 4.378 | 2.250 | 1.000 | 7.628 |
| | Electric Consumption (Kwh) | Electric Price (TL) | Carbon Emission (Kg) | Carbon Credit (TL) | Total Fuel Cost (TL) | Service Cost (TL) | Battery Rent (TL) | Total Maintenance Cost (TL) |
| **Renault Zoe** | 3.102,5 | 992,8 | 0 | 0 | 992,8 | 1.350 | 3438 | 5.781 |

**Figure 11: Renault Clio & Zoe annual maintenance costs.**

1https://www.cdn.Renault.com/content/dam/Renault/TR/price-list/Renault_Binek_201604_v2.pdf Retrieved ( 15.04.2016 )
2 Renault Mais Price Information Sheets ( 15.03.2016 )

The selling price difference between Renault Zoe and Renault Clio cars is; 66.550 TL - 56.950 TL = 9.600 TL but Renault Zoe has a initial charging station investment calculated previously as 1.000 TL so the price difference between this two types of cars is actually 10.600 TL. The total yearly maintenance saving of electric driven car is 7.628 TL - 5.781 TL = 1.847 TL. The Net Present Value ( NPV ) can be calculated for the electric driven car investment by using the formula used at Toyota Yaris calculation with % 11,5 interest rate annually and 4 years operation time. After the calculations, NPV of electric driven car investment equals to **NPV = -4.930 TL**. So investment on Renault Zoe instead of Renault Clio is not feasible.

#### 4.1.3 BMW i 3

The BMW i3 model is another PHEV car operated by % 100 electrical energy. The energy consumption rates are almost same as Renault Zoe. But the charging time of BMW is up to 3 hours and the current sale price of this car is 145.000 TL[1] including % 15 Special Consummation Tax. This vehicle also do not subject to annual government taxes. But the extremely higher sale price of the car according to previous Toyota and Renault cars, make it unfeasible as a apron operation car. But TAV Esenboga Airport start using this car as operation car under a marketing campaign with BMW Turkey.

1 http://www.bmw.com.tr/tr/fastlane/fiyat-listesi.html Retrieved ( 15.04.2016 )

### 4.1.4 Comparison of Renault Zoe and Toyota Yaris

On the previous 4.1.1 and 4.1.2 sections, the investment two models of electric driven cars found as feasible according to NPV calculations. The sale price of Yaris Hybirid car is 65.800 TL and annual expenses are 4.074 TL. In the yaris calculations the annual government tax of 1.000TL does not included in the calculations because both of the vehicles are subject to tax. If we add this tax, the annual expenses increase to 5.074 TL. The sale price of Renault Zoe is 67.550 TL including charging station expenses and annual expense is 5.781 TL. The total annual maintenance saving between Yaris and Zoe is 5.781 TL - 5.074 TL = 707 TL. The NPV calculation of Renault Zoe investment regarding to Toyota Yaris is **NPV = - 3.870 TL**. So the most feasible electric driven apron operation car investment will be made on Toyota Yaris.

Only if the rental price of batteries does not apply on sale agreements, annual maintenance cost of Renault Zoe will be 5.781 TL - 3.438 TL = 2.343 TL and the total annual maintenance saving between Zoe and Yaris is 5.074 TL - 2.343 TL = 2.731 TL. Then, NPV calculation of Renault Zoe investment regarding to Toyota Yaris is **NPV = 6.663 TL** more feasible than Yaris on apron operations.

If the calculations made for Yaris and Zoe in land-side of the airport with % 60 fuel and % 20 electric taxes applied, the price of 1 liter of gasoline is 4,44 TL[1] and the price of 1 Kwh electric is 0,4117 TL[2]. The annual maintenance cost of both of the cars with the tax applied energy prices are calculated on Figure 12 as;

| | Fuel Consumption (Lt) | Fuel Price (TL) | Carbon Emission (Kg) | Carbon Credit (TL) | Total Fuel Cost (TL) | Service Cost (TL) | Annual Tax (TL) | Total Maintenance Cost (TL) |
|---|---|---|---|---|---|---|---|---|
| Yaris Hybirid | 1.004 | 4.457 | 2.680 | 207 | 4.664 | 2.137 | 1.000 | 7.801 |
| | Electric Consumption (Kw) | Electric Price (TL) | Carbon Emission (*Kg*) | Carbon Credit (TL) | Total Fuel Cost (TL) | Service Cost (TL) | Annual Battery Rent (TL) | Total Maintenance Cost (TL) |
| Renault Zoe | 3.103 | 1.277 | 0 | 0 | 1.277 | 1.350 | 3.439 | 6.066 |

**Figure 12: Yaris Hybirid and Renault Zoe annual maintenance costs for land-side use**

1 https://www.opet.com.tr/guncel-akaryakit-fiyatlari#ankara Retrieved ( 16.04.2016 )
2 http://akillitarife.com/rehber/elektrik-fiyatlari-2016 Retrieved ( 16.04.2016 )

The total annual maintenance saving after tax applied energy prices between Yaris and Zoe is 7.801 TL - 6.066 TL = 1.735 TL. Then, NPV calculation of Renault Zoe investment regarding to Toyota Yaris is **NPV = 3.575 TL** more feasible than Yaris on airport land-side operations.

The land-side usage of Zoe and Yaris can be calculated by without battery rental fee. Than the annual maintenance cost of Renault Zoe will be 6.066 TL - 3.438 TL = 2.628 TL and the total annual maintenance saving between Zoe and Yaris is 7.801 TL - 2.628 TL = 5.173 TL. Then, NPV calculation of Renault Zoe investment regarding to Toyota Yaris on land-side usage on airports without battery rental fee is **NPV = 14.129 TL** more feasible than Yaris again.

According to these calculations, the battery rental fee takes Renault Zoe to a disadvantaged position against Toyota Yaris on apron operations because the energy consumed at airports are free from taxes. But on land-side usage of Zoe in airports with taxed energy costs is every-time feasible than Yaris even if the monthly battery rental charges on the car. Turkey ranks sixth in European automobile sales rankings[1]. As for engine volumes for the period January - October 2015, the biggest market share with 526.280 ( % 95,89 ) belonged to automobiles with low motor volume. During this period only 101 electric cars sold on Turkey. So according to this feasibility calculations, Turkey is a very ideal place for electric driven car investments.

1*A Car That Works Like a Dream*, Iskefli Tugba BORAJET Magazine December 2015 Istanbul. ( 67 )

### 4.2 Feasibility analyses of electric apron buses on airports

There are two major companies who manufactures electrically operated apron buses exists. These companies are Siemens[1] and Build Your Dreams ( BYD ). For to analyze the electric driven apron buses on airports, BYD % 100 electric operated bus system will be compared with same model traditional diesel operated bus system.

In this research we prefer to analyze BYD electric driven bus systems because BYD company employs many advanced technologies developed in-house by more than 15,000 R&D engineers. These technology includes the advanced environmentally friendly Iron-Phosphate ( Fe ) batteries, in-wheel hub motors and regenerative braking system. The Iron-Phosphate battery technology is fire-safe and non-toxic. The BYD electric bus delivers a host of operational and environmental benefits such as very quiet ride without vibrations, jerks or noise associated with diesel operated models. According to company, BYD electric bus has completed more than 20 million kilometers[2] of “in revenue service” and has been evaluated in many major countries all over the world such as Netherlands, Finland, Germany, Hungary and Spain and Denmark or cities such as Bremen and Bonn, Helsinki, Amsterdam, Copenhagen, Madrid and Barcelona[3]. The BYD electric apron buses are currently in use at Amsterdam Schiphol Airport with a fleet of 35 buses[4]. Another airport ground service provider Carbridge also prefers BYD electric apron buses on Australian airport operations also.

1 Siemens Electric Bus for Airports Solution for Sustainable Passenger Transport, Germany, 2013
2 http://www.byd.com/news/news-266.html Retrieved ( 26.04.2016 )
3 https://en.wikipedia.org/wiki/BYD_electric_bus Retrieved ( 26.04.2016 )
4 http://www.byd.com/news/news-169.html Retrieved ( 26.04.2016 )

According to BYD[1], the battery of electric driven bus can fully be charged in 5 hours. And the range of the bus is up to 250 Km on normal city conditions which is the highest in the world. Beyond of this advantage, the battery system of the bus does not requires replacement up to 8 years of usage. The BYD does not require any extra rental charge for the batteries. The electric consumption of the electric bus is assumed as 650 Watt per kilometer on apron conditions. So for 100 kilometers it will consume 65 Kwh energy whereas the same model diesel powered bus consumes 60 Lt diesel fuel. The current electric Kw price of Turkey is 0,32 TL per Kw[2] excluding governmental taxes according to Chicago Convention article No: 24. So the electric consumption price per 100 km is 0,32 x 65 = 20,80 TL. As a zero emission bus, BYD is free of annual government taxes and which costs approximately 3.000 TL annually[3]. The price of BYD electric bus is 391.400 Euros including % 3 special consummation tax whereas the diesel powered model is 406.000 Euros including % 45 consummation tax in Turkey[4]. The prices at Turkish Lira currencies on 25 th April 2016 is 1.252.480 TL for electric driven bus and 1.299.200 TL for diesel powered bus[5]. The annual maintenance cost of a diesel operated bus is approximately 30.000 TL whereas the annual cost of electrically operated bus is 18.000 TL % 40 less than diesel bus.

1 http://www.byd.com/ap/ebus.html Retrieved ( 15.04.2016 )
2 http://akillitarife.com/rehber/elektrik-fiyatlari-2016 Retrieved ( 15.04.2016 )
3 http://hesabet.com/Hesaplama/Motorlu_Tasitlar_Vergisi_Hesaplama Retrieved ( 15.04.2016 )
4 Busse aus China: Elektroschock für Daimler und Co. Der Spiegel. Reportage ( 17.02.2016 )
5 http://www.tcmb.gov.tr/kurlar/201604/25042016.xml Retrieved ( 26.04.2016 )

The electrically driven BYD bus needs 2 x 30 Kw special charging station for re-charging. But due to higher charging time comparing to cars, every single electric driven bus can be charged with one special charger specified for the bus. So the initial installation cost of this charging station can not be shared with another bus ant it will approximately cost 6.000 TL per bus. The daily active operation time of this buses is assumed 8 hours with a coverage of 250 km distance. According to these data's and the fuel costs calculated on section 3 of this paper, the annual maintenance cost of electric and diesel powered buses are calculated on Figure 13 as below ;

| | Fuel Consumption (Lt) | Fuel Price (TL) | Carbon Emission (Kg) | Carbon Credit (TL) | Total Fuel Cost (TL) | Service Cost (TL) | Annual Tax (TL) | Total Maintenance Cost (TL) |
|---|---|---|---|---|---|---|---|---|
| BYD Diesel Bus | 54.750 | 77.745 | 146.183 | 11.297 | 89.042 | 30.000 | 3.000 | 122.042 |
| | Electric Consumption (Kw) | Electric Price (TL) | Carbon Emission (Kg) | Carbon Credit (TL) | Total Fuel Cost (TL) | Service Cost (TL) | Annual Tax (TL) | Total Maintenance Cost (TL) |
| BYD Electric Bus | 59.313 | 18.980 | 0 | 0 | 18.980 | 18.000 | 0 | 36.980 |

**Figure 13: BYD Diesel and Electric buses annual maintenance costs**

The selling price difference between BYD electric and diesel buses is; 1.299.200 TL - 1.252.480 TL = 46.720 TL but electric bus has a initial charging station investment calculated previously as 6.000 TL so the price difference between this two types of buses is actually 40.720 TL. The total yearly maintenance saving of electric driven bus is 122.042 TL - 36.980 TL = 85.062 TL. The Net Present Value ( NPV ) can be calculated for the electric driven car investment by using the formula used at car calculations with % 11,5 interest rate annually and 8 years operation time. After the calculations, NPV of electric driven apron bus investment equals to **NPV = 470.762 TL**. So investment on electrically operated apron buses instead of diesel operated ones is a extremely profitable investment.

If the calculations made for BYD electric and diesel operated buses in land-side usage with % 60 fuel and % 20 electric taxes applied as on car calculations, the annual maintenance cost of both of the buses are calculated on Figure 14 as;

| | Fuel Consumption (Lt) | Fuel Price (TL) | Carbon Emission (Kg) | Carbon Credit (TL) | Total Fuel Cost (TL) | Service Cost (TL) | Annual Tax (TL) | Total Maintenance Cost (TL) |
|---|---|---|---|---|---|---|---|---|
| BYD Diesel Bus | 54.750 | 243.090 | 146.183 | 11.297 | 254.387 | 30.000 | 3.000 | 287.387 |
| | Electric Consumption (Kw) | Electric Price (TL) | Carbon Emission (Kg) | Carbon Credit (TL) | Total Fuel Cost (TL) | Service Cost (TL) | Annual Tax (TL) | Total Maintenance Cost (TL) |
| BYD Electric Bus | 59.313 | 24.419 | 0 | 0 | 24.419 | 18.000 | 0 | 42.419 |

**Figure 14: BYD Diesel and Electric buses annual maintenance costs for land-side use**

The total annual maintenance saving after tax applied energy prices between BYD electric and diesel powered bus is 287.387 TL - 42.419 TL = 244.468 TL. Then, NPV calculation of BYD electric bus investment regarding to diesel is **NPV = 1.276.661 TL.** So investment on electrically operated buses instead of diesel operated ones on everyday usage is a very high profitable investment also.

The companies operating electric buses will save more than the investment of the bus itself. One of the many reasons behind this amount of operational saving on BYD electric buses is in wheel motor drive axle technology. With this technology, in-wheel motor drives the left and right wheels separately by controlling left and right torque independently. For example, when a driver turns left, the right-hand torque can be controlled greater than the left in accordance with how much the driver is steering, and this allows the driver to generate the power to steer the car to the left. By using an in-wheel motor, not only is the torque reduced, it can also control the increasing of torque, broadening the range of control and saving much more energy than other electrically operated buses.

Compared with a normal motor, the drive axle system in the BYD electric bus has no gear box, no transmission shaft, and no differential mechanism. The power from the motor is directly transmitted to the wheels, so that significant improvements are achieved in transmission efficiency and reductions in noise and vibration. In addition, the bus weight can be cut by 300 Kg, and interior space is greatly saved.

As it mentioned before, one of the users of BYD electric bus is Carbridge Ground Services Corp. at Australia. Carbridge is Australia's largest Aviation bus company with operations at Brisbane, Sydney, Adelaide, Perth and Melbourne Airports. Carbridge currently employs over 250[1] staff and operates a fleet of 200 airport buses both air-side and land-side. Carbridge transfers over 24 million passengers each year and services over 153,000 flights[2] transporting passengers from "aircraft stands" to and from terminal buildings. According to General Directorate of State Airports Authority of Turkey, the total number of commercial flights from Turkish airports is 1.254.615 with an increase rate of 8,2 % from the previous year[3] and according to Australian Government Department of Infrastructure and Regional Development, the total number of commercial flights from Australian airports is 1.447.998 with an increase rate of 0,037 % from the previous year[4]. Comparing the annual flights and bus transportation operation data of Australian ground services company, we can assume that the airport operation bus amount in Turkish airports operated by TAV is approximately same as Carbridge Australia Company. If all of these buses changed with electric driven technology, the net present value of these investment on upcoming 8 year operating period will be equals to 200 x 470.762 TL = 94.152.400 TL or approximately 30 million Euros.

1 http://www.carbridge.com.au/ Retrieved ( 27.04.2016 )
2 http://www.byd.com/news/news-266.html Retrieved ( 27.04.2016 )
3 General Directorate of State Airports Authority of Turkey 2015 Commercial Flight Statistics ( www.dhmi.gov.tr/istatistik.aspx )
4 Australian Government Department of Infrastructure and Regional Development 2015 Commercial Flight Statistics ( https://bitre.gov.au/publications/ongoing/airport_traffic_data.aspx )

### 4.3 Future technologies on electric driven vehicles on airports

#### 4.3.1 Production of electric energy by airports

Production of electric energy by the airport authorities itself is another low cost energy solution without effecting from national electric grid price fluctuations. With the low cost of energy, the NPV calculations of electric driven buses and cars will rise so the investment of electric driven cars will be more profitable with using on site production of electricity at the airports. On Ankara Esenboga Airport, a mini natural gas operated electric plant is operated by 2 x 2000 Kw capacity which is currently producing enough energy for a town consist of 1.000 households.

Another airport example generating it's own energy by alternative resources rather than using the electric grid is Amsterdam Schiphol Airport. Amsterdam Airport Schiphol and technical services provider Imtech have installed a total of 9,500 m2 of solar panels at Schiphol-Northwest[1]. The solar panels have been installed as a addition to previously installed panels on the roofs of the transport office buildings, the Schiphol Group headquarters and Cargo Building 19. These panels are installed as a trial to determine whether the generation of large-scale cost-effective solar energy has a future at Amsterdam Airport Schiphol. The solar panels yield approximately 440.000 Kwh[2] of green energy each year, which is the amount of electricity 120.000 households consume on average on an annual basis.

1Schiphol Airport Press Release 18.07.2012
2 *Schiphol Gives Large Scale Solar Energy a Trial Run* Blair, Carly 23.07.2012 I am Expat Netherlands

Like Schiphol Airport, Malaysia's first airport solar power system installed at Kuala Lumpur International Airport. The 26.000 Kwh[1] system, which is the largest in Malaysia in terms of interconnection, combines ground-mount, parking canopy and roof-top systems to maximize the return on investment and electricity savings while minimizing use of space. Utilizing airport rooftop space and land surrounding the airport will allow electricity to be generated at the point of consumption to further improve efficiency by removing the need for transmission lines. According to Malaysia Airport Authority, the annual energy saving of these solar panels is 550.000 USD. What makes this project unique is the tracker system which enables the panels to follow the sun's path in order to tap maximum sunlight. So the 17,000 solar panels in the farm will face either East or West, depending on the time of the day, and will sit horizontally when the sun is directly overhead. According to Malaysian Photo-Voltaic Industry Association President Ahmad Shadzli Abdul Wahab[2] : "Solar will buffer against the impact of future fluctuations in fossil fuel prices. It improves energy security as it reduces dependence on gas and coal. Solar power will be produced during peak demand hours, thus benefiting TNB, which need not run expensive gas-fired power plants to meet the daily maximum demand. It will also save on foreign exchange on imported gas,"

1 *Malaysia's first airport solar power system installed at Kuala Lumpur International* Passenger Terminal World 29.01.2014 , Malaysia
2*Energized by The Sun* Li, Tang Cheng The Star 24.02.2014 Malaysia

### 4.3.2 Charging station solutions

Airports are one of the toughest place to find a available space for recharging electric vehicles. Because of the passenger traffic especially at major airline hub cities like Istanbul, every available space is covered with one or another ground operations equipment. For to solve the space problems related with electric driven vehicle charging stations, BYD Company[1] introduces multi story electric charging stations. These types of stations will be build on any available space on airports.

1 http://bydeurope.com/innovations/technology/index.php Retrieved ( 25.04.2016 )

### 4.3.3 Electric vehicle to grid energy transfer

By using the electric driven vehicle technology, it is possible to use energy stored in the car batteries to power something in case of emergency and high power demands. The electric vehicle to energy grid system energy transfer is described on Figure 15 as below ;

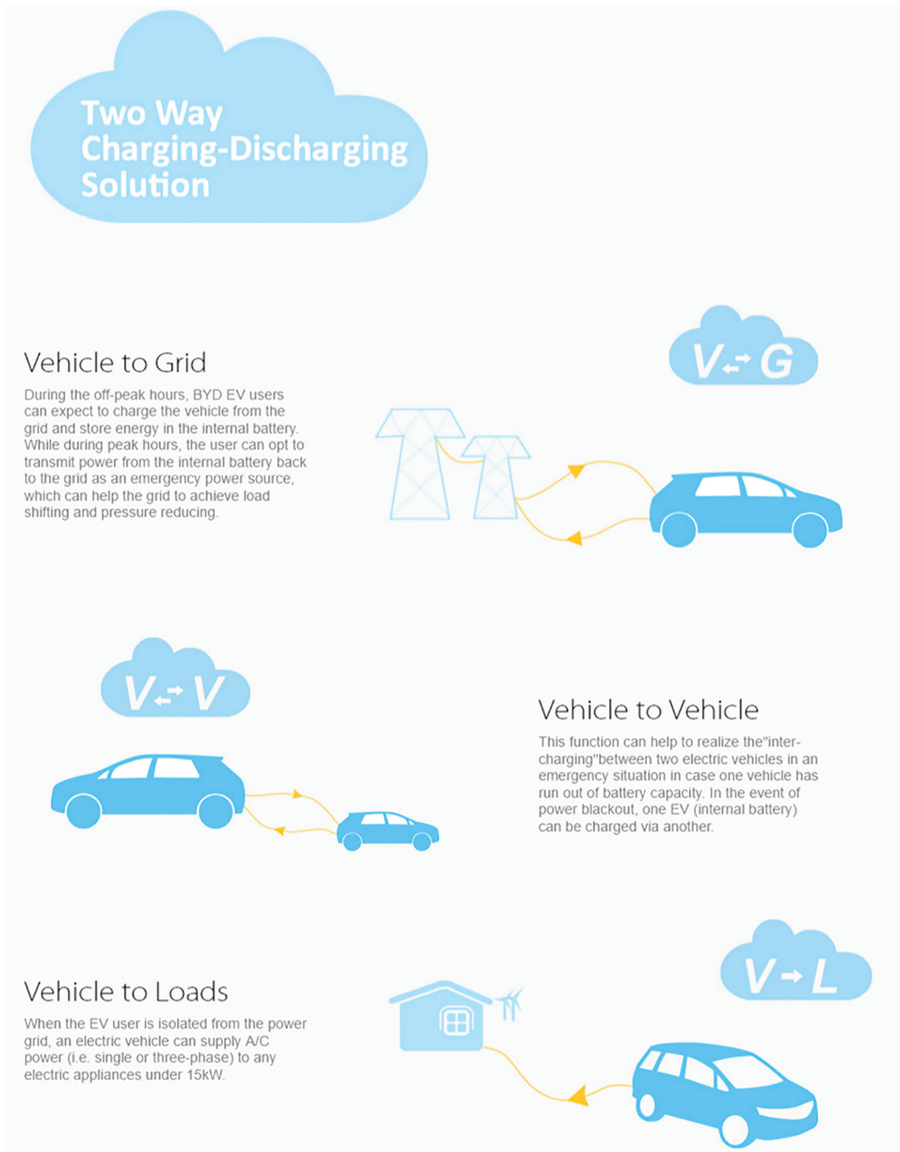


**Figure 15: Two way charging solution on electric vehicles**

#### 4.3.4 Hydrogen operated car technology

the only Hydrogen operated car on the worldwide market is Toyota Mirai. Toyota Mirai is based on the Toyota FCV (Fuel Cell Vehicle) concept car, which was unveiled at the 2013 Tokyo Motor Show. The  FCV concept was a bright blue sedan shaped like a drop of water “to emphasize that water is the only substance that hydrogen-powered cars emit from their tailpipes.” The FCV has a large grille and other openings to allow cooling air and oxygen intake for use by the fuel cell. The FCV concept also uses the Toyota’s previously described Hybrid technology including the electric motor, power control unit and other parts and components from its hybrid vehicles to and minimize operational costs. The hybrid technology is also used to work together with the fuel cell. At low speeds such as city driving, the FCV runs just like a electric car by using the energy stored in its battery, which is charged through regenerative braking. At higher speeds, the hydrogen fuel cell alone powers the electric motor. When more power is needed, for example during sudden acceleration, the battery supports the fuel cell system as both work together to provide necessary energy.

The according to Toyota Turkey, Mirai model will be available for sale on Europe markets on 2017. But before the entry of the European market, a comparison made between the hydrogen powered cars in U.S. by U.S. Environmental Protection Agency[1] is shown above on Figure 16 as ;

| | 2016 Hyundai Tucson Fuel Cell  | 2016 Toyota Mirai  |
|---|---|---|
| | **Fuel Economy and Related Estimates** | |
| **Fuel Economy (mi/kg)** | 50 comb; 49 city; 51 hwy | 66 comb; 66 city; 66 hwy |
| **Range (miles)** | 265 | 312 |
| **Annual Fuel Cost *** | $1,700 | $1,250 |
| | **Vehicle Characteristics** | |
| **Vehicle Class** | Small SUV | Subcompact Car |
| **Motor** | AC Induction (100kW) | |
| **Battery** | 180 V Lithium Ion | 245 V NiMH |
| **Availability** | Select dealers in California (lease only) | Select dealers in California initially (sale or lease) |

* Annual fuel cost calculated assuming a hydrogen cost of $5.55/kg, 15,000 annual miles of travel, and 55% city and 45% highway driving.

kW = kilowatt; V = volt; kg = kilogram

**Figure 16: Toyota Mirai and Hyundai Tucson annual operating cost in U.S.**

The calculations on Figure 16 is made assuming the vehicle covers a 65 km distance daily. But according to our previous calculations made for Toyota Yaris and Renault Zoe, the daily distance coverage at the airport is assumed as 125 km. So the annual cost of fuel of Mirai will be 2.500 USD on apron driving conditions. This amount on Turkish Lira currency equals to 7.075 TL[2] without annual taxes which is higher than electric driven cars. The price of Mirai in Japan is approximately 77.000 USD[3]. So the fuel cell hybirid technology is not feasible on our research.

1 http://www.fueleconomy.gov/feg/fcv_sbs.shtml Retrieved ( 27.04.2016 )
2 http://www.tcmb.gov.tr/kurlar/201604/26042016.xml Retrieved ( 27.04.2016 )
3 https://en.wikipedia.org/wiki/Toyota_Mirai#cite_note-FCVs-5 Retrieved ( 27.04.2016 )

## 5. Conclusion

Global warming and climate change are terms for the observed century-scale rise in the average temperature of the Earth's climate system and its related effects. Multiple lines of scientific evidence show that the climate system is warming. As the scientific understanding of global warming is increasing everyday, The Intergovernmental Panel on Climate Change ( IPCC ) reported in 2014 that, scientists were more than 95% certain that global warming is mostly being caused by increasing concentrations of greenhouse gases ( GHG ) and other human activities[1]. The world's climate is not only an environmental issue. The global warming is a crucial concern for human civilization. With that policy The 21st Session of the Parties to the United Nations Framework Convention on Climate Change ( COP 21 ) took place at Paris on December 2015. In the convention more than 80 world class speakers included country Ministers, industry CEO's and international thought-leaders briefed approximately 1.000 delegates around the world which is the largest number of global stakeholders at any commercially-inclusive side event on climate change. The conference negotiated the Paris Agreement, a global agreement on the reduction of climate change, the text of which represented a consensus of the representatives of the 196 parties attending it[2]. The agreement will become legally binding if joined by at least 55 countries which together represent at least 55 percent of global greenhouse emissions. Such parties will need to sign the agreement in New York between 22 April 2016 (Earth Day) and 21 April 2017, and also adopt it within their own legal systems (through ratification, acceptance, approval, or accession).

1 Climate Change Synthesis Report Summary for Policymakers 2014

2 Obama: Climate agreement 'best chance we have' to save the planet, John D. Sutter, Joshua Berlinger and Ralph Ellis, CNN International 14.12.2015

Due to its particular characteristics and its international nature, air transport requires a specific approach. As a result, it does not fall within the scope of COP 21 negotiations. It is subject to another authority , the ICAO which will have to put forward a global agreement for aviation during its general assembly in September 2016. The Airport Carbon Accreditation Program[1] launched by ACI is the only carbon reduction regulation worldwide recognized.

By linking people, economies and cultures, aviation is a powerful driving force for change in the regions we are based in and fly to. With its growing economy, Turkey faces a rising demand for aviation. The airports in the country start a on-going developing process with the liberalization of commercial airlines. In these development processes some of the airport ground operation companies tested some technologies like CNG Buses Powered by Compressed Natural Gas or very low motor capasitated cars. But none of these technologies are pollution free. The only way to utilizing carbon free emission operations in airports is using new electric driven technologies instead of petroleum related products. The Air France - KLM partnership, starts using fully electric driven vehicles on their apron operations[2]. With the use of advanced technologies, the carbon footprint of the group is % 6,7 less than 2011 emissions.

1 http://www.airportcarbonaccredited.org/about/what-is-it.html ( Retrieved 18.03.2016 )
2 *Air France and KLM are Engaging for Climate*, Air France News COP 21 December 2015

From the feasibility analyses conducted on section 4, using electric driven technologies on airport land-side and air-side operations is a carbon free and highly profitable solution. The NPV calculation of electric driven bus investment is extremely higher than cars because of the higher fuel consumption of the vehicle. Beyond of this ,some of the airports start producing their own electricity from renewable energy sources with a cheaper expense. So the investment of electric driven vehicle technologies both air-side and land-side operations will become more profitable as the renewable energy investments on the airports increased in the Turkey.

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*A Car That Works Like a Dream*, Iskefli Tugba BORAJET Magazine December 2015 Istanbul. (67)

*Electric Bus for Airports Solution for Sustainable Passenger Transport,* Siemens AG Infrastructure & Cities Sector Rail Systems Division 2013, Germany, TH 325-131010 DB 11131.5

*Emirates Group Environmental Report 2013 - 2014*, United Arab Emirates 2014 ( 39 )