Recharging Stations Implemantation for Electric Vehicles

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Abstract— Fluctuating oil prices and concerns over earth oil resources, with the advancement of battery technology, encourage the use of the electric vehicles in a cost-effective way. Furthermore, the widespread use of electric vehicles would result with a significant reduction of the greenhouse gas emissions. Due to these environmental and economic motivations, it is expected that the use of electric vehicles will become increasingly important in the coming decades. However, these benefits can be offset by a single important factor called range anxiety, which is the fear that the electric vehicle is not loaded enough to make his trip (s) and thus would be unsuccessful. Thus, charging infrastructure can be crucial in the wider adoption of electric vehicles. In this study, the benefits and adaptation scenarios of electric vehicles are discussed. Then, studies of the literature on the implementation of charging station infrastructure to increase accessibility were reviewed. Finally, a feasibility study is conducted for charging stations in Turkey.

Keywords—Energy management, sustainability and environmental development, electric vehicles, recharging stations

I. Introduction

Electric vehicles (EVs) have a long history, even preceding the history of gasoline vehicles, dating as far back as the mid-19th century. Although the dominance of electric vehicles in the first decade of the 20th century was remarkable, it was short lived. The last decade has been marked by a growing interest in electric vehicles, and many politicians have created incentives to make possession of an electric car more attractive. Fluctuating oil prices and concerns over oil supplies mean that electric vehicles offer more stability in the cost of ownership than traditional gasoline cars. The advancement of battery technology means that electric vehicles can go further than ever with a single charge. As power generation moves to renewable sources such as wind or solar energy, the environmental benefits of electric vehicles can be improved and developed.

Global carbon emissions will be much reduced if cars run on electricity produced in centralized power plants compared to conventional gasoline engines. The widespread use of electric vehicles can significantly reduce greenhouse gas emissions. Thus, the goals of reducing global greenhouse gas emissions can be achieved or at least approximated by the widespread adoption of plug-in electric vehicles (Fig1). Due to environmental and economic motivations, it is expected that the use of plug-in electric vehicles will become more and more important in the coming decades [1].

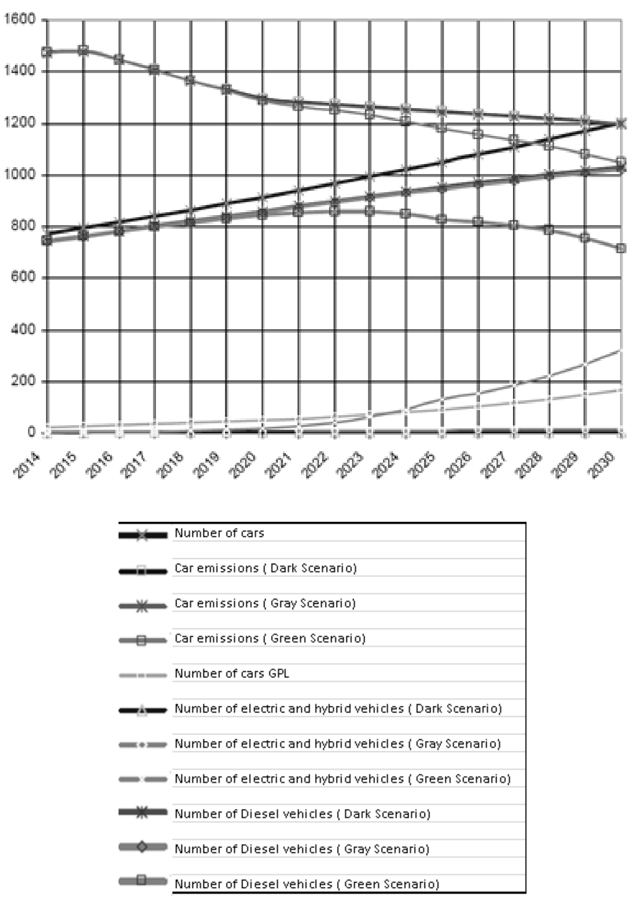

Fig 1: According to three different scenarios the total CO_2 emissions of cars in the world between 2014 and 2030

In the dark scenario, it is assumed that as of 2014 0.34% of all cars in the world would consist of electric and hybrid cars, and each year the number of LPG vehicles is expected to increase by 12.75%. And from 2030 electric and hybrid

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vehicles will account for 0.471% of all general cars.

In the gray scenario it is assumed that 1% of cars that are sold each year will consist of electric and hybrid cars and gasoline / diesel cars will be replaced by these cars in 2014. In this scenario, electric and hybrid vehicles will reach 1,23% of general cars from 2030.

In the green scenario, it is estimated that there will be around 13.7 million electric and hybrid cars by the end of 2019, 20 million electric and hybrid cars by the end of 2020.

CO_2 emissions in 2030, in the green scenario will be reduced by 12.5% compared to the black scenario, by 12.2% compared to the gray scenario. Each 1% increase in the number of these electric and hybrid vehicles will mean a reduction in CO_2 emissions of 0.475%.

These benefits can be outweighed by a single important factor called range anxiety, which is the fear that the EV is not loaded enough to make his trip(s) and thus would be unsuccessful. Unlike a gasoline vehicle that can get at least 200 miles over the range via a fast-refueling operation, recharging exhausted batteries can take several hours. Thus, charging infrastructure can be crucial in the wider adoption of electric vehicles.

As plug-in electric vehicles enter the market, a huge demand for charging stations is expected. To this end, providing adequate charging station infrastructure becomes a necessity for the success of electric vehicle technology on the market. If sufficient charging infrastructure is provided, there will be a possible increase in public motivation for this technology by reducing the current concerns of electric vehicle plug-ins on the mileage plate. Ease of access to plug-in electric vehicle charging stations can affect adoption rate, oil demand and electricity consumption in a day's time.

The use of EV is currently facing several weaknesses among which: the low energy density of the batteries compared to the fuel of combustion and motor vehicles, electric vehicles often require a long time to be recharged compared to the relatively fast process of a standard refueling process. This is compounded by the scarcity of public charging stations. In this study we will focus on the accessibility of electric vehicle charging stations.

Currently, there are three major EV charging technologies available. Level-1 charging uses a standard wall outlet, providing an 110V/15A connection. Typical EV batteries, which vary between 16 and 25 Kw per hour, can take 12 to 18 hours to fully charge using such a connection. Level-2 charge typically rated at 220V and between 15 and 30A. Level-3 charge is DC fast charge and uses-high voltage (often 400-500V) direct current and can fully charge a typical EV battery approximately in 30 minutes. From DC fast charging requires special equipment; it should not be deployed in a standard residential environment.

Regarding the type of the charger, three types of terminals are identified, charging points slow to implement in residential areas or long-term parking, mainly semi-fast charging points in public parks and fast charging stations along main highways and dense urban road traffic. Load standards are presented in Table1.

Table 1: Types of Electric Vehicle Charging Stations

Types of charging stations			
Level	Type	Power	Use
1	slow charging station	3.6	home, parking
2	semi-rapid charging station	22	office, public, park
3	rapid charging station	43-AC 50-DC	highway, urban area

Due to environmental and economic motivations, it is expected that the use of plug-in electric vehicles will become more and more important in the coming decades. Several studies on the share of electric vehicles on the market in the coming years support the same argument. Eliminating range anxiety which is the main obstacle to the widespread adoption of electric vehicles will accelerate the adoption of EV. Therefore, an adequate charging infrastructure can be crucial in the wider adoption of electric vehicles.

In the second part of the study, literature studies on the implementation of charging station infrastructure to increase accessibility will be examined. Firstly, the general problems of choice of sites will be studied and classified according to their approach, as heuristic approaches, methods of exact solutions and multi-criteria models of decision support. After the applications of positioning of charging stations has been studied.

II. Models Dedicated To The Implementation Of Recharge Stations

The problem of the distribution of charging stations has attracted many research efforts in the last decade. Most of the proposed methods and models come from the location of resources/work sites and emergency medical services. Table2 presents the main contributions to the field with the type of models, approaches and constraints considered for the subject of the EV charging station.

Studies in the field of electric vehicle charging station positioning to start after 2008. There are studies with a variety of constraints and objective function in this area. The most popular models are the works that uses set-covering approached aim to meet any request. Most studies aimed at minimizing costs and transport time of the charging station. The constraints also vary in the studies. Capacity, number of charging stations and the demand satisfaction are the main constraints. The type of charging station that will be placed is also important in the studies. This is a factor affecting the charging station capacity and charging time.

Table 2: Review of the literature on the problem of allocation of the charging station of electric vehicles

Title	Author(s), Year	Objective	Constraints	Approach
An optimum location choice model for recreation-oriented scooter recharge stations	Wang, 2007	Minimizing of the cost of charging station location for electric scooter	Demand satisfaction	*integer programming*
Locating battery exchange stations to serve tourism transport: A note	Wang, 2008	Minimizing the cost of the charging station's location	The amount of charging vehicles Number of stations	*integer programming*
Locating road-vehicle refueling stations	Wang and. Lin, 2009	Minimizing the cost of allocating charging stations	The amount of charging vehicles Number of stations	*mixed-integer optimization*
Locating passenger vehicle refueling stations	Wang and Wang, 2010	Minimizing of the cost of "maximum covering" and the “minimum allocation”	The amount of charging vehicles Number of stations	*mixed-integer optimization*
Optimal Location of Charging Stations for Electric Vehicles in a Neighborhood in Lisbon, Portugal	Frade et al. 2011	Maximizing coverage of clusters of demand during the morning and evening rush hour	Slot numbers in charging stations Number of stations	*mixed-integer optimization*
Electric Vehicle Charging Station Planning Based on Weighted Voronoi Diagram	Feng et al. 2012	Minimizing of losses of users on the road to the charging station	------	*weighted voronoi diagram*
Optimal Planning of Charging Station for Electric Vehicle Based on Particle Swarm Optimization	Liu et al. 2012	Minimizing of the annual cost of construction and operation	Demand satisfaction	*Particle Swarm Optimization*
A simulation-optimization model for location of a public electric vehicle charging infrastructure	Xi et al. 2013	Maximizing of loaded vehicles and recharged energy	The amount of charging vehicles Capacity	*integer program simulation*
The electric vehicle charging station location problem: A parking-based assignment method for Seattle	Chen et al. 2013	Minimizing of trips to charging stations	Demand satisfaction The number of VE loads	*mixed integer programming*
Modeling and optimization for electric vehicle charging infrastructure	John et al. 2013	Minimizing vehicle trips to a charging station set	Demand satisfaction The number of charging stations	*mixed-integer optimization*
Optimizing the electric charge station network of ESARJ	Gavranovic et al. 2014	Minimizing of trips to charging stations	Number of stations Capacity Demand satisfaction	*integer programming*
Efficient Allocation of Electric Vehicles Charging Stations Optimization Model and Application to a Dense Urban Network	Baouche et al. 2014	Minimizing of trips to charging stations Minimizing of the total cost of the charging station	Capacity Distance constraint between stations Demand satisfaction	*integer linear optimization program*
Optimal site selection of electric vehicle charging station by using fuzzy TOPSIS based on sustainability perspective	Guo and Zhao 2015	Selection of criteria for EVCS location	Subjective but significant criteria	*multi-criteria decision-making (MCDM) method*
Charging station location problem of plug-in electric vehicles	Zhi et al. 2016	Minimizing of the total cost of charging stations	Number of stations	*genetic algorithm-based method*
Electricity costs for an electric vehicle fueling station with Level 3 charging.	Flores et al. 2016	Minimizing the cost to buy electricity from a utility	Available electric utility rate structures	*genetic algorithm*

As shown in the Table 2, the studies mainly used integer programming. However, some papers approached to the charging station location problem with particle swarm optimization (PSO), Voronoi diagram, genetic algorithm and multi-criteria decision making (MCDM) models.

III. THE SITUATION OF ELECTRIC VEHICLES AND RECHARGING STATIONS IN TURKEY

Turkey's first electric car was ordered from England by Abdulhamid II in 1888. The first vehicle was transported to Istanbul across the sea and the Minister of Finance made the driving test of this vehicle. Abdulhamid also tried the car in the Yildiz Palace.

Recently, Turkey showed interest in alternative fuel vehicles. Alternative fuel can be electricity, compressed natural gas, hydrogen, liquefied natural gas, petroleum gas liquefied, and some biological materials such as soybean oil or vegetable fuels. Among all alternative fuel vehicle options, the most notable is the electricity supplied.

The latter are supported by the Turkish government and the automobile industry, which have been particularly focused on electric vehicles. The progress that has been made in research and investment in electric vehicles has already made it possible to find some models of EV in the Turkish car market.

Turkey has become one of the countries that have recognized the importance of electric vehicles and research activities initiated accordingly on EVs. The Turkish Scientific and Technical Research Council (TUBITAK) is pursuing feasibility studies and research on electric vehicles that started in the early 2000s. Moreover, Renault, which is one of the world's leading automotive companies operating in Turkey, has launched new-battery electric vehicle models on the Turkish car market in 2011. In addition, Nissan, another global automotive company, has been considering introducing its battery electric vehicle models to the Turkish market in the near future. In addition, Toyota and Honda, the car manufacturers, have been offering their hybrid electric vehicle models to Turkish customers since 2000.

The development related to the domestic production of the electric car is also known. Recently Hacettepe University announced that the first electric car that is fully designed by Turkish engineers will be available in a few months.

Turkish Government has taken an important step towards eliminating social barriers by reducing the tax on battery electric vehicles. The excise duty of electric motor power vehicles for less than 85 kW is 3 percent, between 85 to 120 kW is 7 percent, and more than 120 kW is 15 percent. But hybrid models cannot benefit from tax relief. In addition, the electric cars were placed in the lowest class of the show on MTV (the car tax).

Table 3: Tax Rates for Electric Vehicles in Turkey

Engine Power	TBS (Special Consumption Tax) %
Less than 85 Kw	3
Between 85 - 120 Kw	7
More than 120 Kw	15

A. Electric Vehicle Data in Turkey

According to TURKSTAT data (TÜİK), there are 12,141,248 vehicles registered to traffic at the end of February 2018. The breakdown of these vehicles according to the type of fuel is in the table below.

Table 4: Distribution of cars by type of fuel in Turkey

Types of fuel	%
GPL	38,2
Diesel	35,6
Gasoline	25,8
Unknown fuel type	0,4

As shown in the Table 4, electric motor vehicles are not classified. In the typical case of unknown fuel are the fuel type cars left empty to the licensing process, car did the incorrect data entry inadvertently and electric cars. So we do not know the number of electric vehicles precisely. It is therefore difficult to predict the demand for charging stations.

B. Predictions of The Electric Vehicle Market in Turkey

The research of Turan and Yucel (2014) [1] shows that the market share of battery electric vehicles (BEVs) and hybrid electric vehicles (HEVs) is likely to reach approximately 19.76% and 20.77% respectively by 2042 in Istanbul. Technological development has an impact on sales growth. However, if battery technology cannot keep pace with technology or overtake conventional vehicle, technological improvements would be less likely to create a significant increase in BEV sales. In addition, even if no technological improvements have progressed BEVs would still likely to penetrate about 10% of the market with its current technology in 30 years. In addition, a sufficient number of charging stations can lead to a faster broadcast of BEV's, thus, causing more overall market share. Finally, the application of the 3% private consumption tax (PCT) instead of the 37% for the hybrid electric vehicle can increase sales of HEV but does not show a significant change in HEV sales.

Table 5: The results of scenarios related to technological development

	Market Share 2012 (%)	Market Share 2042 (%)	Total sales until 20150 (million)
Base Run			
CV	99.99	59.47	6.987
BEV	0.003	19.76	1.036
HEV	0.007	20.77	1.129
Scenario A	Moderate Technology Improvement		
CV	99.99	57.98	6.905
BEV	0.003	22.49	1.183
HEV	0.007	19.53	1.063
Scenario B	Optimal rate of technological improvement and infrastructure		
CV	99.99	57.37	6.865
BEV	0.003	23.46	1.247
HEV	0.007	19.17	1.04
Scenario C	No technological improvement and poor infrastructure		
CV	99.99	64.94	7.269
BEV	0.003	9.52	0.514
HEV	0.007	25.54	1.369

The charging infrastructure is seen as an important criterion for customers, as the insufficient number of charging stations leads drivers to be stuck or stand in a queue for long hours to recharge. However, the future of many of the stations and the adequacy of these stations are uncertain and these uncertain factors may affect BEV penetration. As a result, two separate scenarios are constructed to assess the impact of the infrastructure on BEV delivery. The first one is called as an excellent infrastructure while the second is called as poor infrastructure. Excellent infrastructure represents a situation that the number of charging points would be sufficient to meet charging demand. Thus, there would be no loss of time from waiting in a queue or being blocked. On the other hand, in the case of poor infrastructure, the number of charging points would not be enough for BEV drivers and they have to wait for long hours to recharge it. The comparison of the results of these two scenarios is given in Fig2.

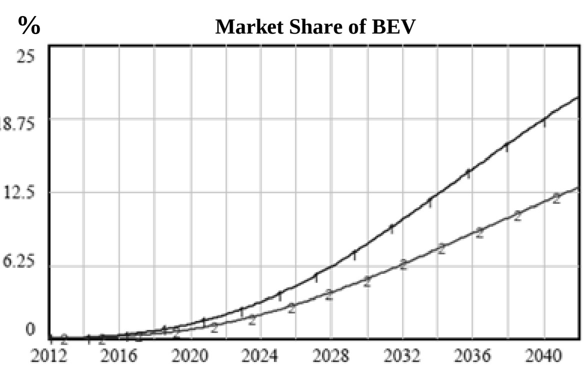

Fig 2: BEV market share under different infrastructure conditions.

Where the first line is employed for the poor infrastructure and the second line for the excellent infrastructure.

The results show that charging infrastructure is a relatively efficient factor on BEV penetration. For example, the BEV market share is expected to reach 12.5% by 2034 in the excellent infrastructure scenario, while at the same penetration rate of 12.5% by 2042 for poor infrastructure scenario. Thus, an insufficient infrastructure can delay the BEV broadcast.

The scenario summary results related to the charging infrastructure are given in Table 6.

Table 6: The results of scenarios related to charging infrastructure.

	Market Share 2012 (%)	Market Share 2042 (%)	Total sales until 2050 (million)
Base Run			
CV	99.99	59.47	6.987
BEV	0.003	19.76	1.036
HEV	0.007	20.77	1.129
	Excellent infrastructure		
CV	99.99	58.94	6.949
BEV	0.003	20.56	1.11
HEV	0.007	20.5	1.093
	Poor infrastructure		
CV	99.99	63.14	7.176
BEV	0.003	12.85	0.684
HEV	0.007	24.01	1.292

C. Recharging Stations for Electric Vehicles in Turkey

There are two companies that provide services for the electric vehicle charging station in Turkey. These are ESARJ and BDOTO. There are 37 BD 33 ESARJ charging stations in Istanbul while 71 BD 40 ESARJ in Turkey.

Table 7: The number of charging stations in Turkey

	BD	ESARJ
Istanbul	37	33
Turkey	71	40

In addition, Istanbul Metropolitan Municipality (IBB) supports the construction of charging points that are required for the infrastructure. Metropolitan Municipality of Istanbul, builds charging stations in open car parks and floors through ISPARK. In the first stage of the project, the charging stations were installed in parking lots belonging to ISPARK in Bostanci and Cihangir. Then the charging stations were installed in Besiktas and Kadıköy. These developments are encouraging for the future of the use of EV technology in Turkey.

Fig 3: ESARJ charging stations in Istanbul

Fig4: BD OTO charging stations in Istanbul

The capacity factors of 20 ESARJ charging stations in Istanbul are given in Table 8.

Table 8: Capacity factors of 20 ESARJ charging stations

Station Name	Capacity Factor (%) April 2015	Station Name	Capacity Factor (%) April 2015
KANYON AVM	7,20%	BUYAKA AVM	0,20%
FLYINN AVM	3,20%	TORIUM AVM	0,20%
PALLADIUM AVM	2,10%	PANORA AVM - ANKARA	0,10%
SELENIUM AVM	0,60%	TEPE NAUTILUS AVM	0,40%
ISPARK BALMUMCU	0,60%	MALTEPE PARK AVM	0,30%
AKBATI AVM	1,70%	BILKENT CENTER - ANKARA	0,00%
AKASYA ACIBADEM AVM	2,10%	TAV ATATURK HAVALIMANI	0,10%
THE MARMARA PERA	0,40%	PARKTURK ZEYTINBURNU	0,60%
BIKA MIMARSINAN	0,80%	SERDIVAN AVM	0,40%
OPTIMUM AVM	1,40%	SABANCI UNI	0,20%

One of the most important points to consider in choosing the location is that the location should be a point of interest. The loading is relatively long, so it is important to select the point that people already visit and spend their time (and in the meantime, they can charge their vehicles). The conditions in Turkey, it seems the shopping centers. In addition, after selecting the location, it is necessary to determine the appropriate type of rental. People spend 1.5-2 hours in shopping centers. Therefore, the charging time must be close to the time spent in shopping centers. If the charging station located, but not a point of interest, it is necessary to choose the fast charger (type 3). ESARJ says they are setting up stations in the semi-fast and fast level.

Other site selection criteria are population density, income levels, Jam traffic (actual driving time), distance to the other station etc.

In order to increase the use of electric vehicles in Turkey, it is necessary to improve the existing infrastructure and a sufficient number of charging stations must be installed regardless of vehicle sales.

IV. A FEASIBILITY STUDY

In this section, after researching the situation of electric vehicles and charging stations in Turkey, it has been noticed that Turkey has an interest in electric vehicles. But there is not enough data on demand. Therefore, instead of examining a location selection study, we preferred to realize a feasibility study which may be employed as a preliminary study for further investigations, studies and applications.

The business case for the charging station and the investment is influenced by a multitude of factors. Table 9 illustrates the composition of the cost and revenue arising from the operation of an EV charging station. The main revenue drivers are fare, capacity and utilization rates. The cost components include initial capital expenditures (CAPEX) and operating expenses (OPEX), which include electricity costs, maintenance and other operating costs (O & M).

Table 9: Costs of the charging station (Schroeder and Traber, 2012)

	AC Public Level II
Life of the station (years)	10–15
Charge limit (Volt)	230(1 phase)
Charge limit (Amperes)	16
Current	AC
The power limit (kW)	3,6
Charge cycle time of 20 kWh (min)	333
The maximum number of charges 20 kWh EV per day	4
The cost of materials (EUR)	2000
Grid Reinforcement Cost / Civilians (EUR)	1000
Total capital expenditure (EUR)	3000
Maintenance and repair (EUR / year)	200
Total operating expenses (EUR)	2000
Total investment cost (EUR)	5000
Cost per unit of power (EUR/kW)	1388
Approximate number of RS	40
Total cost	200000

In this feasibility study the information contained in ESARJ one of the leading companies in the industry.

The numbers of charging stations to be installed across Istanbul have been selected as 40 which are the value that aims to achieve in the year by the ESARJ. The type of charging stations has been identified; the level 2 station is considered the most preferred type by ESARJ. The level 2 charging station is preferred because it is the most appropriate type with points of interest.

Investment costs are divided into the cost of capital and operating expenses. Capital costs include the cost of materials and the cost of grid reinforcement. Operating expenses are the sum of maintenance and repair costs. Annual maintenance and repair costs are calculated as 10% of material costs, as a general rule. Total operating expenses are maintenance and repair costs over the life of the charging station. It is calculated as (yearly maintenance and repair costs) * (the life of the station). The total investment cost is CAPEX + OPEX, and this is the total cost of the investment of 10 years.

The economic evaluation of the operation of the charging station carried out here confines to a charging of 3.6 kW. The revenues generated by the sale of electricity are determined and then authorize the operational cost. The annual net operating profit of the charging station is then compared to its discounted investment cost so as to obtain a return on investment (ROI) which is taken into account as an indicator of profitability. Minimum margins are determined and reach positive ROI. ROI can be expressed as a percentage value as in equation 1.

$$ROI = \left(\frac{\text{average net profit}}{\text{discounted investment cost}} - 1\right) x100 \qquad (1)$$

This ROI formulation represents a short-term horizon assessment that indicates what contribution margin a loading station can achieve under various conditions. The concept of ROI is a simple measure so that it does not require assumptions about the uncertain long-term dynamics of costs and revenues.

For the calculation of contribution margins, the cost of the total investment must be distinguished and discounted. While the total cost refers to CAPEX and total OPEX. The discounted investment cost each year distributes the total cost over all years and is calculated under equation 2 and 3, where *i* is the interest rate and *n* the life of the project [14].

$$\frac{\text{cost}}{\textit{year}} = \textit{annuity factor} \qquad (2)$$

$$\textit{annuity factor} = \frac{(1+i)^n * i}{(1+i)^n - 1} \qquad (3)$$

With interest set at 6% and a project life of 10 years, a pension factor of 0.1359 is obtained. This implies an annual cost of 13.59% of the total cost. A half-speed charging station with a total cost of EUR 5,000 would therefore require a discounted cost of EUR 679,5 per year.

If the service charge is set at € 7, the dead point would be the 98th customer. This means that, starting from the 98th customer each year, which means at least 8 customers a month, the company is starting to make a profit.

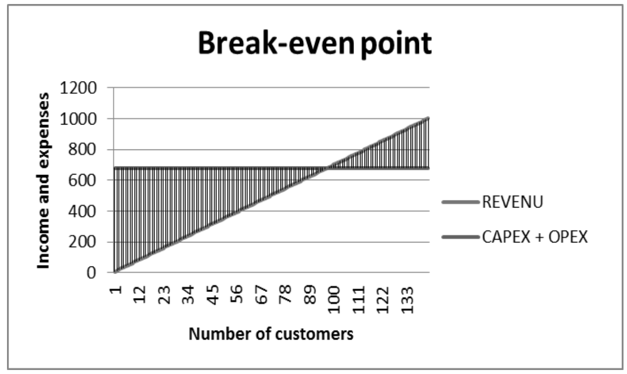

Fig 5: Break-even point for service charges is set at € 7

If the service charge increases to € 10, this time the company starts to generate profits from the 68th customer each year. This means at least 5 customers a month.

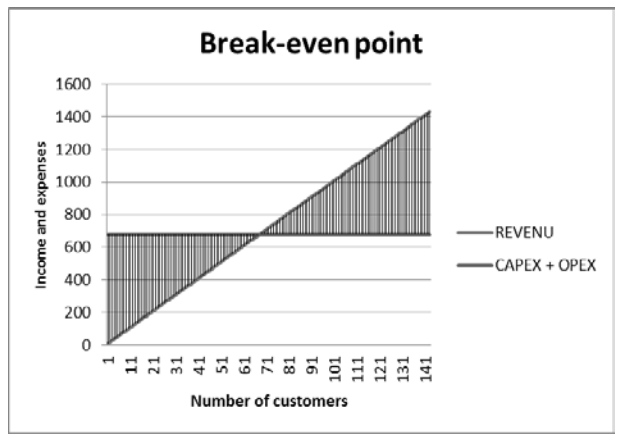

Fig 6: Break-even point for service charges is set at € 10

In the case of service charges is set at € 10 and 10 clients per month, return on investment (ROI) would be 76%.

$$ROI = \left(\frac{\text{Average Net Profit}}{\text{Discounted Investment}} - 1\right) * 100$$

$$ROI = \left(\frac{10 * 12 * 10}{680} - 1\right) * 100 = 76$$

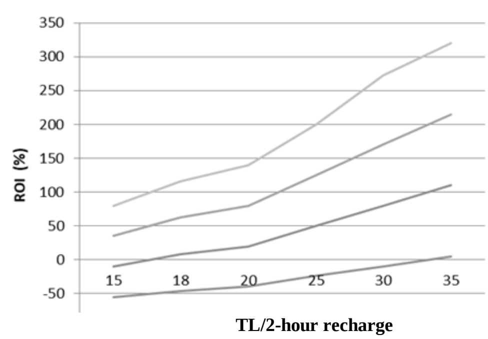

Fig 7: Return on investment for a charging station.

Where the upper line stands for 5 EV per month, second line for 10 EV per month, the third line for 15 EV per month and bottom line for 20 EV per month.

Fig7 shows how the two key parameters, price and demand; affect the profitability of a level II charging station. It illustrates how ROI evolves with charging prices and also determines the minimum price needed to recover CAPEX and OPEX. For reference, the information was included in the price would correspond to the variable cost level of a Volkswagen Passat (as a family car) (here 7.7 LT/100 km, 36 TL/100 km). It can be argued that this threshold corresponds to the willingness to pay-maximum of a EV owner. As another reference, the price of ESARJ is taken (TL 0.30 per minute 18 TL per recharge). If the cost of using EVs is higher than the use of conventional cars, electric vehicles and charging will likely disappear. For the sake of illustration, the number of EVs per station per month is approached and it is considered that each vehicle recharges 2 hours per visit.

In realistic usage rates, 10-15 EV per month and 18 TL per charge, charging station benefit is between 0 - 50%. With a price of 15 TL per recharge, request to a single station should exceed 20 EV per month to prove the benefit of the investment

In the optimistic case, a price of 25 TL brings positive benefits from the project (from 200%) to a demand rate above 20 EV per month (utilization rate of 0.2%). Still this demand rate reflects the realistic projections since sockets are used exclusively by means of 2% of their capacity in 2017 April.

V. Conclusion

In this feasibility study the information contained in ESARJ one of the leading companies in the industry and an article. The cost components calculate as initial capital expenditures (CAPEX) and operating expenses (OPEX), include costs for electricity, maintenance and other operating costs (O&M). We calculated annual maintenance and repair costs as 10% of material costs, by default. The numbers of charging stations to be installed across Istanbul have been selected as 40 which are the value that aims to achieve in the year by the ESARJ. The type of charging stations has been identified; the level 2 station is considered the most preferred type by ESARJ. The total investment cost is CAPEX + OPEX, and this is the total cost of the 10-year investment. With a fixed interest i and a lifetime of n = 10 years from the project, a rent factor is obtained and we use it to calculate discounted cost of investment per year. After we calculate the return on investment in the different scenarios according to price and demand. The results of the feasibility study, it seems to be an investment of charging stations is profitable.

But in order to increase the use of electric vehicles in Turkey, it is necessary to improve the existing infrastructure and a sufficient number of charging stations must be installed regardless of vehicle sales. The relationship between electric vehicle sales and the number of charging stations is a chicken-and-egg cycle. Many of the charging stations need to be increased to increase the number of electric vehicles. And conversely if the number of electric vehicles increases, the number of charging stations increases to meet demand.

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