MARMARA UNIVERSITY
INSTITUTE FOR GRADUATE STUDIES
IN INDUSTRIAL ENGINEERING

ELECTRIC LOAD STATIONS LOCATION AND AN APPLICATIONIN ISTANBUL

BÜŞRA GÜLNİHAN DAŞCIOĞLU

MASTER THESIS
Department of Industrial Engineering

Thesis Supervisor
Assoc. Prof. Dr. Gülfem TUZKAYA

Thesis CO- Supervisor
Assoc. Prof. Dr. Hüseyin Selçuk KILIÇ

ISTANBUL, 2020

MARMARA ÜNİVERSİTESİ
FEN BİLİMLERİ ENSTİTÜSÜ

ELEKTRİK ŞARJ İSTASYONU KURULUMU VE İSTANBUL'DA BİR UYGULAMA

BÜŞRA GÜLNİHAN DAŞCIOĞLU

YÜKSEK LİSANS TEZİ

Endüstri Mühendisliği Anabilim Dalı
Endüstri Mühendisliği Programı

DANIŞMAN
Doç. Dr. Gülfem TUZKAYA

EŞ-DANIŞMAN
Doç. Dr. Hüseyin Selçuk KILIÇ

İSTANBUL, 2020

MARMARA UNIVERSITY
INSTITUTE FOR GRADUATE STUDIES IN PURE AND APPLIED SCIENCES

Büşra Gülnihan DAŞCIOĞLU, a Master of Science student at Marmara University Institute for Graduate Studies in Pure and Applied Sciences, defended her thesis entitled "Electric Load Stations Location And An Application in Istanbul", on 14.01.2020 and has been found to be satisfactory by the jury members.

Jury Members

Doç.Dr. Gülfem Tuzkaya (Advisor)
Marmara University .....(SIGN).....

Doç.Dr. Serol Bulkan (Jury Member)
Marmara Üniversitesi .....(SIGN).....

Prof. Dr.Harun Reşit Yazgan (Jury Member)
Sakarya Üniversitesi .....(SIGN).....

APPROVAL

Marmara University Institute for Graduate Studies in Pure and Applied Sciences Executive Committee approves that Büşra Gülnihan DAŞCIOĞLU be granted the degree of Master of Science in Department of Industrial Engineering, Industrial Engineering Program on Jan 15 2020. (Resolution no: 2020/02-03).

Director of the Institute Prof. Dr. Adı SOYADI

MARMARA ÜNİVERSİTESİ
FEN BİLİMLERİ ENSTİTÜSÜ

Marmara Üniversitesi Fen Bilimleri Enstitüsü Yüksek Lisans Öğrencisi Büşra Gülnihan DAŞCIOĞLU'nun "Elektrik Şarj İstasyonu Kurulumu Ve Rotalama Problemi" başlıklı tez çalışması, 14.01.2020 tarihinde savunulmuş ve jüri üyeleri tarafından başarılı bulunmuştur.

Jüri Üyeleri

Doç. Dr. Gülfem Tuzkaya (Danışman)
Marmara Üniversitesi .....(İMZA) .....

Doç.Dr. Serol Bulkan (Üye)
Marmara Üniversitesi .....(İMZA) .....

Prof. Dr. Harun Reşit Yazgan (Üye)
Sakarya Üniversitesi .....(İMZA) .....

ONAY

Marmara Üniversitesi Fen Bilimleri Enstitüsü Yönetim Kurulu'nun 15.01.2020 tarih ve 2020/02-03sayılı kararı ile Büşra Gülnihan DAŞCIOĞLU'nun Endüstri Mühendisliği Anabilim Dalı Endüstri Mühendisliği Programında Yüksek Lisans derecesi alması onanmıştır.

Fen Bilimleri Enstitüsü Müdürü
Prof. Dr. Adı SOYADI

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

I would like to thank my thesis supervisors Assoc. Prof. Dr. Gülfem Tuzkaya and Assoc. Prof. Dr. Hüseyin Selçuk Kılıç for their patience and helping me through all the process of my thesis. I would like to thank my Dear Prof. Dr. Harun Reşit Yazgan for enlightening my academic vision about environmental studies.

I also want to thank my Dear colleague Elif Bilgin for helping my thesis. Lastly, I want to thank my father Yılmaz Daşcıoğlu, my mother Yasemin Daşcıoğlu and my brother Cahit Nuri Daşcıoğlu for always encouraging and supporting me.

Büşra Gülnihan Daşcıoğlu

ABSTRACT

ELECTRIC LOAD STATIONS LOCATION AND ROUTING PROBLEM: AN APPLICATION

It is common knowledge that transportation systems are one of the major cause of environmental problems. For reducing the negative impact of the conventional vehicles on the environment, the alternative fuel vehicles have been introduced to the drivers around the world. Alternative fuel vehicles have been gaining popularity with the help of the less pollution and greenhouse gas emission systems. However, the biggest problem with the alternative fuel vehicles is lack of recharging stations.

In the developing countries, the advancement of alternative fuel vehicles are quiet slowly. Turkey is one of these countries, where the development of alternative fuel vehicles is slow. In Turkey, it is not possible to drive electric alternative fuel vehicles fo a long distance due to lack of recharging stations. Thus, in this thesis, I proposed a location selection model for charge stationss of electric vehicles in Asian part of Istanbul. In order to find a solution to our problem, a mixed integer linear programming model based on flow-refuelling model is presented. Sensivity analysis is performed in order to test the system performance.

ÖZET

ELEKTRİK ŞARJ İSTASYONU KURULUMU VE ROTALAMA PROBLEMİ

Ulaşım sistemlerinin çevre sorunlarının başlıca nedenlerinden biri olduğu yaygın bir bilgidir. Konvansiyonel araçların çevre üzerindeki olumsuz etkilerini azaltmak için alternatif yakıt araçları dünyadaki sürücülere tanıtıldı. Alternatif yakıtlı araçlar daha az kirlilik ve sera gazı emisyon sistemleri sayesinde popülerlik kazanmaktadır. Bununla birlikte, alternatif yakıtlı araçlarla ilgili en büyük sorun şarj istasyonlarının eksikliğidir.

Gelişmekte olan ülkelerde, alternatif yakıt araçlarının gelişimi oldukça yavaştır. Türkiye, alternatif yakıtlı araçların geliştirilmesinin yavaş olduğu bu ülkelerden biridir. Türkiye'de şarj istasyonlarının bulunmaması nedeniyle elektrikli yakıtlı araçların uzun mesafelerde sürülmesi mümkün değildir. Bu tezde İstanbul'un Asya yakasında elektrikli araçların şarj istasyonları için bir yer seçim modeli önerildi. Bahsedilen soruna bir çözüm bulmak için, akış yakıt ikmali modeline dayanan karma bir tamsayılı doğrusal programlama modeli sunulmuştur. Kurulan modelin test edilmesi için duyarlılık analizi yapılmıştır.

DECLARATIONS

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

ABBREVIATIONS

EV : Electric Vehicle

EVCS : Electric Vehicles Charging Station

FRLM : Flow Refuelling Location Model

PHEV: Plug-in Hybrid Vehicles

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

Recent researches received further informations about the causes of environmental problems. One of the major cause of natural disasters and global warming is transportation sector. For reducing and solving the environmental problems alternative fuel vehicles are invented and presented to drivers all around the world. With less pollution and greenhouse gas emission alternative fuel vehicles gained popularity.

The researches about Electric Vehicles (EV) have increased in the last decade. One of the problems to consider at this point is locating the proper points of electric charging stations for EVs. In the developing countries such as Turkey, lack of charging stations is the main problem for EV.

In this study, a flow-refuelling location model is developed. The study is motivated by the fact that sale rates of alternative vehicles have been increasing day-by-day but there are not enough stations to cover the demand. To our knowledge, this solution methodology is not applied for Istanbul before. This study emphasizes the authorized electric charge station problem for electric and plug-in hybrid vehicles in Istanbul. The goal is to maximize the flow of all paths between districts of Anatolian part of Istanbul. Sensivity analysis is performed for testing the system performance with the impacts of driving range of the vehicle and flow values. The main contributions of this paper as follows:

- This research extends the previous articles and the first paper that considers all districts in Anatolian part of Istanbul.
- This study is the first paper to use flow-refuelling location problem in Istanbul, Turkey.

The second part of the study explains the EV in general. Third part is the literature review of EVCS studies and flow refueling location model. Fourth part deals with the fundamentals of the methods and in the second part, an application is given to investigate the effectiveness of the suggested approach and sensivity analysis. In the last part, the results and conclusions are presented.

2. ELECTRIC VEHICLES

In last decades, alternative fuel vehicles have become a critical issue for rescue studies of nature. CO_2 emission consumption is increased around 2.7% in 2018. More than 77% of this consumption was provided from transportation sector from 1990 to 2018 (https://edgar.jrc.ec.europa.eu/).

According to survey of Global Carbon Project, Figure 2.1 shows CO_2 emission from fossil fuels of the last 59 years (https://www.globalcarbonproject.org). Prediction of energy sector claims that there will have been serious loss of energy systems by 2040 (Nakata, 2000). This energy system loss is mostly caused by man-made energy resources, and researchers in this field claims that the damage could be prevented by technological developments of fossil fuel consumption rate. Thus, the studies about alternative vehicle usage have been increased. Carbon emission is expected to decrease by the increase in the usage of alternative fuel vehicles.

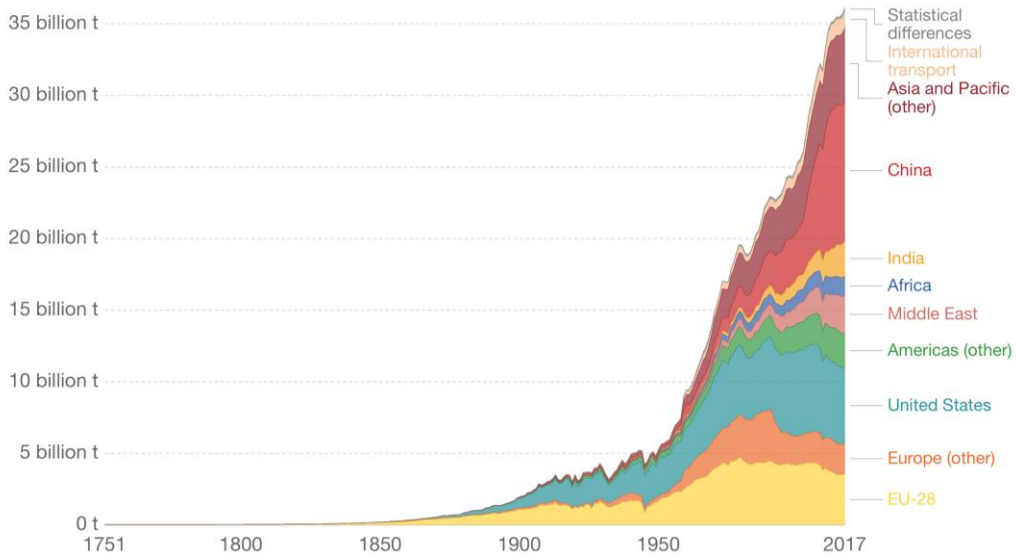

Figure 2.1 : The amount of CO_2 emissions of countries from using fossil fuels, 1959-2017 (https://www.globalcarbonproject.org).

Electronic vehicles have been hained popularity because of many reasons such as lower maintenance cost, reducing the amount of petroleum usage and reducing carbon emissions. EVs convert the electric energy from grid to power at the wheels around %59-62, while conventional vehicles converts gasoline power in %17-21 (Adderly et. al, 2018).

In Energy and Climate Convention, the European Union declared that CO_2 emission must be decreased up to %50-60 percent by 2050 in the developing countries. The transportation sector accounts for that %16 percent of CO_2 emissions and %41 percentage of this is caused by passenger cars. Therefore, transition to EVs can be a good solution for achieving the goal and reducing pollution. the CO_2 emission rate caused per car is currently around 180 g/km with the increasing number of EVs in transportation. It is expected to decrease by 50 g/km (https://www.europarl.europa.eu/RegData/etudes/BRIE/2019/631047/IPOL_BRI(2019)631047_EN.pdf).

2.1. Electric Vehicles

In 1835, Thomas Davenport invented the first known electric vehicle in the USA. The vehicle was a small locomotive with a battery, a pivot and two electro-magnets (Figure 2.1.1). Robert Anderson invented an EV which could not be recharged between 1832 and 1839. The golden era of EVs started after 1900, that year 4192 vehicles were produced in the USA, 28% of these vehicles were EV. First large scale EV company, Pope Manufacture, started producing EVs in the same year. The demand for EVs were competing with the demands of fossil fuel vehicles (https://www.energy.gov/articles/history-electric-car).

Figure 2.1.1 : First Electric Vehicle, Baker Model (https://ev.hedeffilo.com/elektrikli-arac-tarihcesi).

In those years, EVs were more preferable than the conventional vehicles because of vibration and noise problems. Henry Ford started mass-production of EVs in 1908. EVs were more expensive than conventional vehicles at that time. In 1920s, the demand for EVs were not preferable since it was easier to find a gas station, and horsepower of EVs were less than other types of vehicles. In 1990s, because of the air pollution and its causes Clean Air Law and Energy Policy Law increased the demand in EVs (https://www.energy.gov/articles/history-electric-car)..

Classification of EVs is fourfold. Figure 2.1.2 shows the classification and detailed explanations of EVs are given below.

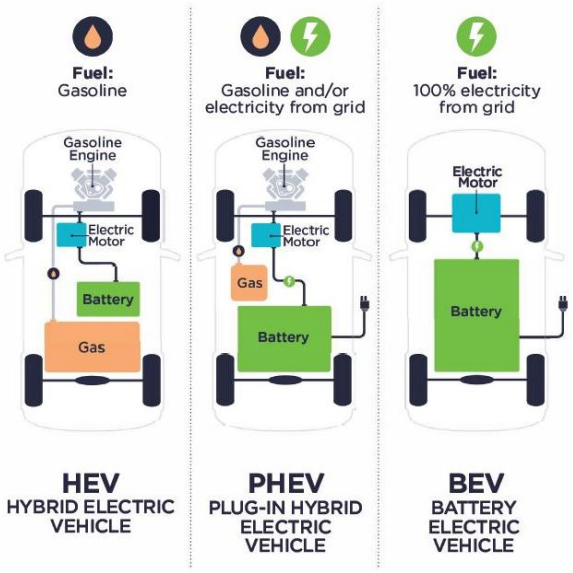

Figure 2.1.2 : Classification of Vehicle Types (https://www.epri.com) .

2.1.1. Hybrid Vehicles

Hybrid vehicles use both internal combustion and electric engine (Figure 2.1.1.1). The main mission of the electric engine is to support the internal combustion engine. A hybrid vehicle cannot be plugged into a socket for charging the battery. The electric engine is charged using an internal combustion engine and a regenerative brake system. After driver applies the brakes, the electric motor turns into a generator and charges the battery (https://afdc.energy.gov/vehicles).

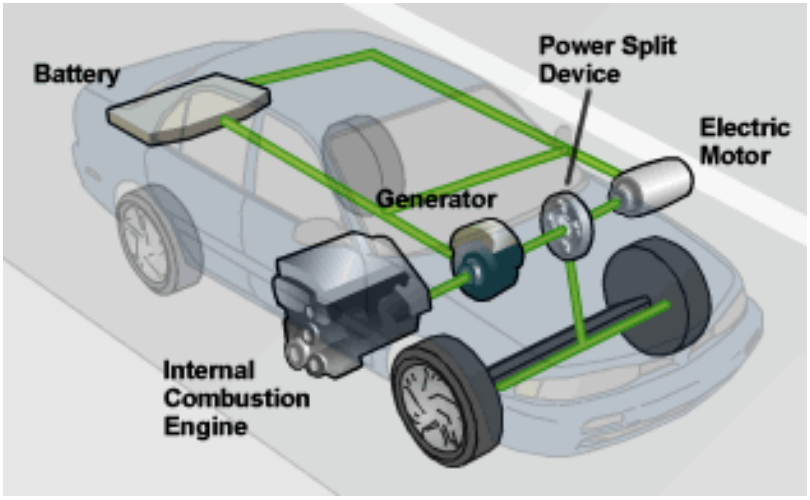

Figure 2.1.1.1 : Hybrid Vehicle (https://www.fueleconomy.gov/feg/hybridtech.shtml).

2.1.2. Plug-in Hybrid Vehicles

The working principtal of these types of vehicles is similar to Hybrid Vehicles; but these types of vehicles have bigger batteries and can be charged using a plug (Figure 2.1.3.1). The vehicles can be charged plugging into a socket or an internal combustion engine or a brake energy.

A standart driver uses around %40-60 of less fuel when using a PHEV than a conventional vehicle. Even though PHEV sale cost are higher for the consumer, less fuel cost compensate the cost of expenses for the driver. The vehicle can be charged through the gasoline but it is not possible for the vehicle to achieve maximum driving range (http://www.ieahev.org).

2.1.3. Range Extender Electric Vehicles

These vehicles also have both engine types. Instead of using internal combustion engine for thrust force, the internal combustion engine is only used for charging the electric engine or else the vehicle can be charged plugging into a socket or using a brake energy(Figure 2.1.3.1). When the battery is depleted, the vehicle can switch to hybrid at highway speed, but almost all of the time the vehicle drives with using the energy in electric engine (http://www.ieahev.org).

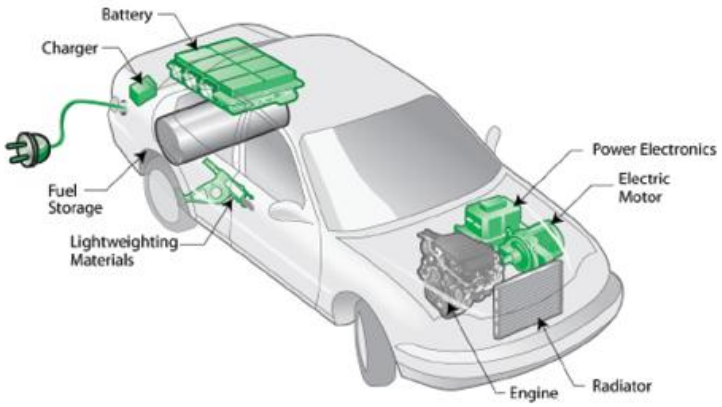

Figure 2.1.3.1 : Plug-In Hybrid and Range Extender Electric Vehicle (https://commons.wikimedia.org/wiki/File:Plug-in_hybrid_electric_vehicle_(PHEV)_diagram.jpg).

2.1.4. Electric Vehicles

These type of vehicles only have electric engine and motor thrust power is supported by that. Vehicles can be charged plugging into a socket or using a brake energy (Figure 2.1.4.1). Drivers of EV have the advantages like lower running cost. When the vehicle is charged, an EV can drive around three times more than a petrol vehicle as per kilometer (https://www.iea.org).

A battery does not have much moving parts such as conventional vehicles. Maintenance cost is less than conventional cars with the help of this opportunity. EV causes less noise pollution than conventional vehicles, as well.

Conventional cars produce lots of carbon emission and this cause air pollution and greenhouse gases to world. For saving the environment, alternative fuel vehicles such as EVs are a great step forward. Unfortunately, one of the biggest disadvantage of an EV is that there is not enough charging stations (http://tehad.org).

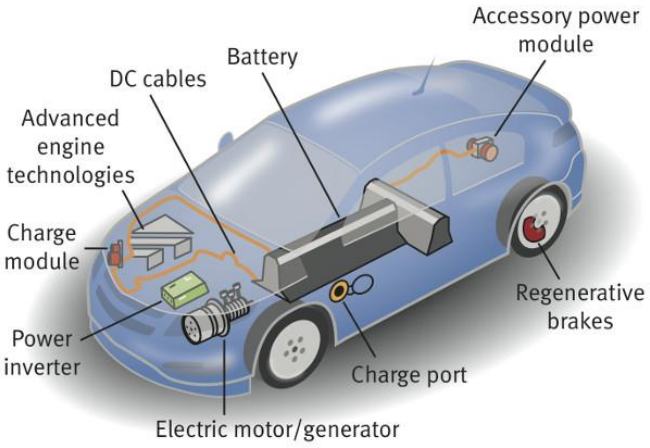

Figure 2.1.4.1 : Electric Vehicle (https://oli.cmu.edu/).

2.1.5. Advantages and Disadvantages of EV

There are several advantages and disadvantages of EV that are explored during the usage of

drivers. Some of them are explained below.

2.1.5.1. Advantages of EV

Eliminating Fuel Costs: Electricity is cheaper than gasoline and the price point is more stable than the gasoline, as well. Driving an EV can reduce the fuel cost or it can even eliminate it in the best case. With the improvement in battery technology, the cost per km for EV has been getting much more cheaper than a conventional vehicle (https://www.energy.gov).

Saving the Environment: Throughout the human history, mankind has destroyed the environment. CO_2 emissions from conventional vehicles has contributed to the greenhouse gases in the atmosphere and with the increasing emission climate change that is a upcoming problem which mankind will have to deal with. However, this damage can be stoppable and may be restored in future with the improvements and developments of alternative fuel vehicles. EVs can be charged with the electricity produced by renewable and natural sources such as wind, hydropower or solar. Carbon footprint and pollution impact can be reduced by driving an EV (https://www.ergon.com.au) .

Cheaper to Maintain: An EV has less moving parts than a conventional vehicle. For this reason, EVs need less car mechanic service and not having expensive exhaust systems, motor, fuel injection systems, radiator. Producers warrant EV batteries for around 8 year of using without needing to be changed (https://www.ergon.com.au).

Health Benefits: Reduced pollution provides better air quality and less health problems. EVs are much quieter which helps reducing noise pollution (https://www.ergon.com.au).

2.1.5.2. Disadvantages of EV

Recharge Points: Since EVs are not popular yet, the recharging stations are not enough to drive for long hours or long distances without recharging (https://autowise.com).

Short Driving Range and Speed: The driver can drive an EV 80 to 150 km without recharging. The limited range and speed is expected to improve in the future but it is not possible for long distances for now (https://autowise.com).

Longer Recharge Time: An EV needs approxiamely 4-6 hours for a full battery depending on the station type, but it takes a couple of minutes for fuelling up (https://autowise.com).

2.1.6. Charge Station Types of Electric Vehicles

There are three categories of chargers based on the amount of power that charger provides to the battery of a vehicle. Table 2.1.6.1 shows the difference of charger types (Genevois and Kocaman, 2018).

Level 1 charger type does not require implementing additional charging equipment and provides 120 Volt AC plug. It provides 3 to 8 km driving distance per hour of charging. This type of charger is mostly used at homes and workplaces (https://www.zap-map.com/charge-points/) .

Level 2 charger type needs installing additional charging equipment and provides 240 to 280 V AC plug. It provides 16 to 32 km driving distance per hour of charging. This type of charger is mostly used at homes, workplaces and for public chargers (https://www.zap-map.com/charge-points/) .

Level 3 charger type aka DC Fast charger is used in the third type of charging station. Station requires high-powered, specialized equipments and also the vehicle needs to have a special equipment for converting the energy from DC to AC since the vehicle's plug type is AC. The station provides 480 V AC plug and it provides 96 to 128 km driving range per 20 minutes of charging. These types of chargers are mostly used in public charging stations and express ways (https://www.zap-map.com/charge-points/).

Fully charging the vehicle and driving range depends on the type of battery and its capacity. Electric vehicles usually have more battery capacity than the hybrid and plug-in hybrid vehicles.

Charging the electric vehicle full takes much more time from charging other types of vehicles full.

Table 2.1.6.1 : Specialites of the Stations (Genevois and Kocaman, 2018).

Type No	Supply Power	Charging Time
1	220-240 V/ 16 A	6-8 Hours
2	380 V/16 A	2-4 Hours
3	380 V/32 A	30 Min. - 1 Hour

2.2. Electric Vehicles Developments In Turkey

In 2019, sales rate of diesel vehicles in Europe dropped down to %36, this has been the lowest rate since 2001 (https://www.jato.com) . European drivers has been leaving diesel engine vehicles and choosing alternative fuel vehicles over them. Almost 1000 EVs has been used in Turkey since 2011. The sales rate dropped in 2016 but the sale rates started growing significantly in 2017 after new developments in the EV sector like 400 km driving range vehicles. Table 2.2.1 shows electric and hybrid automobile sales numbers (http://tehad.org). As it can be seen in the table, 7562 electric and hybrid automobiles are sold in Turkey in the first 9 months of 2019.

Table 2.2.1 : Electric and Hybrid Automobile Sales Numbers (http://tehad.org).

Year	Sales Numbers	Cumulative Sales Numbers
2015	225	225
2016	994	1219
2017	4528	5747
2018	4031	9778
2019 (First 9 months)	7562	17340

The current infrastructure is insufficient and the infrastructure of establishing new electric charge stations cost a lot; development of electric vehicles in developing countries is slow. Turkey is one of the developing country that alternative fuel technology develops slowly. EVs and charging stations are two main things in electric transportation. Considering this along with the increasing vehicle sales, infrastructure of charging stations are needed to be renewed. The number of charging stations is around 400 in 2019 in Turkey (http://tehad.org). The capacity is

not enough and locations of the stations are not widely distributed considering the amount of the vehicle in Turkey.

2.3. The Locating EVCS Problem

The increase in demand and sales rate of electric vehicles causes the increase of the need for electric charge stations. The major problem to be focused on an EV charging station area is locating optimal capacitated charging stations to the best possible locations available (Awasthi et. al, 2017).

Charging station infrastructures are divided in two groups; intra- and intercity developments. Intra-city developments use node-based approach and this type of stations meets the demands when the vehicle is in the parking area (Hakimi, 1964). On the other hand, intercity developments meet the demands during long journeys and in general use flow-based development approach (Hodgson, 1990). In intra-city charging process, the charging is carried out at the end of the trip of vehicle; in intercity, the process interrupts the trip of the vehicle (Csonka et. al, 2017).

3. LITERATURE REVIEW

In this study, a charge station location problem of EVs is solved to determine charge stations using flow-refuelling algorithm. Therefore, our literature survey is limited with alternative fuel vehicles charge station location problem and flow-refuelling location problem.

3.1. Alternative Fuel Vehicles Charging Station Location Problem

With increasing global warming concerns, alternative fuel vehicles has gained popularity in research areas. One of the most important problem of alternative vehicles is determining charge stations. There are several different solution methods for the problem.

Gavranovic et. al (2014) designed electric charge station network in Turkey by using capacitated p-median location model. The model aims to maximize company managers' preference scores. The capacity data is gathered from managers through maximum number of districts and maximum possible customer queue of the location as constraints. Chung and Kwon (2015) proposed three methods for determining locations of Korean Expressways; a multi-period optimization model based on flow-refueling location model and two myopic methods. They considered multi-period plan for Korean Expressways as a case study. Performance analysis was made by comparing the results of these methods. Zhu et. al (2016) first proposed a mathematical model for locating the charging stations with the aim of minimizing the total cost and extended genetic algorithm based heuristic methodology for larger problems. In their research, the authors defined criteria for EVCS locating and ranked the alternatives in Beijing, China. Zhao and Li (2016) implemented multi-criteria decision-making structure for locating charge stations. Criteria were selected by extended sustainability theory and by using fuzzy Delphi method which were found taking into account the economy, society, environment and technology.

Awasthi et. al (2017) aimed to solve the optimal siting of charging stations problem in Allahabad, India. For solving the mentioned problem, the authors implemented a hybrid algorithm based on a genetic and particle swarm optimization algorithm. After gathering the results, the infrastructure was tested in simulation by real time system. Xylia et. al (2017), proposed bus network of Stockholm is considered for solving the location selection problem of charging stations for electric buses. The authors presented a model of MILP for solving the problem. The model aimed to minimize transportation cost of bus network. Polimeni et al. (2017) implemented two-step model by using the data of the flow of EVs and the road network. First, the model calculated the required number of charging stations and located the stations by considering road network of EVs. This method was tested in an Italian highway network. Another multi-criteria method was implemented by Csonka et. al (2017) for solving the problem in Hungary. Weighted multi-criteria decision making model considered the existing stations and installed new stations for meeting the demands. The criteria were selected as demographic, economic, environmental and transportation-related attributes. In 2017, Atılgan et. al investigated the situation of recharging stations in Istanbul. The author created an integer linear program for locating the recharging stations. For the need of Istanbul's recharging stations, different market scenarios were considered among the candidate districts.

Moh et. al (2018) implemented a predictive algorithm for predicting the average charging rate and time of multiple charging requests of each vehicles. Simulations were designed for comparing the results of benchmark cases. Genevois and Kocaman (2018), in the traditional approach, Analytic Hierarchy Process was used to determine level 2 charging stations location in Kadıköy and Ataşehir, Istanbul. After determining the weights of shopping malls in two districts, a mathematical model was defined for locating the stations by maximizing user utility with consideration of budget and capacity. Kong et. al (2019) proposed an optimization algorithm for EVCS by considering economy of operators, drivers' charging satisfactory, power loss of EVs, traffic efficiency and safety of power grid. Dynamic real-time data were used for better solution. A case study was conducted for comparing the efficiency of algorithm in Beijing, China.

3.2. Flow-Refuelling Location Problem

In their seminal paper of 1996 Hodgson et. al, proposed a flow capturing location-allocation model. MILP model and greedy algorithm were compared in a case study which aimed to solve the morning traffic in Canada. In their article, Kuby and Lim (2007) developed a flow refuelling location model in order to locate charge stations on a network by maximizing the refuelling level of destinations. Three methods were used for solving the problem such a MILP, mid-path segment algorithm and added-node dispersion problem which is upgraded version of maximin and minimax methods. Kuby et. al (2009) also used flow refueling location model for maximizing the flow volumes for refueling and maximum driving range between refueling stations and number of stations. For gathering the data geographic information systems and heuristic algorithms are used. The proposed algorithm was tested in the case study in Florida. Yao et. al (2014) considered minimizing annual cost of investment and energy losses maximizing captured traffic flow on their multi-objective planning method. The user equilibrium based traffic assignment model was combined with the planning method in order to cover maximall traffic flow capturing problem. The proposed methodology was tested on well-known benchmark instances.

Riemann et. al (2015), conducted a flow-refuelling location model for a specific case study. The model aimed to maximize the traffic flow by obtaining optimal locations for the wireless power transfer facilities of electric vehicles. The authors also implemented a heuristic algorithm in order to solve NP-hard problem policies. Brey et. al (2016) implemented a flow-refuelling model in order to determining hydrogen refueling stations for alternative fuel vehicles in Seville, Spain. The aim of the article was to maximize the traffic covered by the charging stations and minimize hydrogen refueling stations number by considering average distance of the city's residents. Hong and Kuby (2016) extended a flow-refuelling location model with threshold coverage in Florida for alternative fuel vehicles' station locating problem. The model focused on the percentage of zone's that can be completed with the driving range of vehicles and station locations.

Markovic et. al (2017) proposed a two-stage stochastic model which can solve a multi-stage, mixed-integer stochastic flow-refuelling problem. For solving larger problems, a Lagrangian relaxation algorithm was implemented. Proposed solution methodologies were tested on the road networks of Nevada and Vermont, USA. Since both proposed methodologies were considered

stochastic, multiple time points and different traffic flows were used for better solutions for locating charge stations of electric vehicles.

Wu and Sioshansi (2017) improved the flow based refuelling station algorithm with stochastic data. Stochastic data was gathered and calculated from the uncertain demand of charging the EVs. MILP solution and heuristic algorithm results were tested and compared in a case study in Ohio, USA. Zhang et. al (2017) proposed a multi-period capacitated flow refueling location problem for EVCS. A case study was implemented in order to create a charging station network in Waschington D.C., New York and Boston. The proposed model determined fast charging stations (level 3) by considering facility capacity and flow demands coverage. For more accurate results, the authors claimed that realistic demand forecast models could be used. He et. al, 2018 used a bi-level programming model based on flow-refuelling location model was implemented in order to find the optimal locations of charging stations considering EV's driving range. The model aimed to maximize the flow. For larger problems, a heuristic model was built and results and efficiency of both models were tested on well-known benchmark problems.

Abdalrahman and Zhuang (2019) proposed an extended version of flow capturing model by inserting dynamic traffic flows into the model. All feasible routes were taken into consideration and the model gave opportunity to the traveler by letting them choose the minimum travel time possible. The contribution of the research was that the model can implement different types of charging stations by Gaussian mixture model-based clustering algorithm. Jochem et. al (2019) also implemented flow-refuelling location model for a specific case of European highway. A network was designed for plug-in electric vehicles in selected countries such as France, Germany, the Benelux countries, Switzerland, Austria, Denmark, the Czech Republic, and Poland. Implemented methodology aimed to find number of fast charging stations that was needed for a driving range of 150 km.

Honma and Kuby (2019) compared two refueling station location models minimizing total travel time and covering demands with the same number of refueling stations perspectives. For this purpose, a path-based well-known algorithm flow-refuelling location model and a well-known node-based algorithm p-median model were used. Both models were extended for locating the Hydrogen refueling stations in Florida, USA.

The above given literature survey's solution methods are summarized in Table 3.1.

Table 3.1 : Solution Methods.

Author	Exact				Heuristic					MCDM
	MILP	P - Median	FRLM	MISM	Prediction Model	Genetic Algorithm	Particle Swarm	Heuristic Algorithm		
Abdalrahman et. al (2019)	✓							✓		
Awasthi et. al (2017)						✓	✓			
Brey et. al (2016)	✓									
Chung et. al (2015)	✓									
Csonka et. al (2017)	✓									
Gavranovic et. al (2014)		✓								
Genevois et. al (2018)										✓
He et. al (2019)			✓							
Hodgson et. al (1996)			✓					✓		
Hong et. al (2016)	✓									
Honma et. al (2019)	✓	✓								
Jochem et. al (2019)	✓		✓							
Kong et. al (2019)	✓									
Kuby et. al (2009)	✓							✓		
Kuby et. al (2017)	✓		✓							
Markovic et. al (2017)				✓						
Moh et. al (2018)					✓					
Polimeni et. al (2017)	✓									
Riemann et. al (2015)	✓							✓		
Wu et. al (2017)										✓
Xylia et. al (2017)	✓									
Yao et. al (2014)	✓									
Zhang et. al (2017)	✓		✓							
Zhao et. al (2016)										✓
Zhu et. al (2016)	✓					✓				

Previous three works made in Istanbul have only focused on districts of Istanbul. Gavranovic et. al (2014) considered all districts of Istanbul and implemented a maximum coverage problem solving methodology. As a result, 15 districts are selected for recharging stations. Atılgan et. al (2017) considered 10 districts from both parts of Istanbul since Istanbul is a big city with total 39 districts and 2 parts, which are Anatolian and Europe. It is not quite right to consider districts from both parts and the distance between districts and taking into consideration that people are not willing to switch parts more often. It is thought that it is better to consider only one part of Istanbul for gathering more valid results. Genevois et. al (2018) considered two districts of Istanbul in Anatolian part, Kadıköy and Ataşehir. The study was about locating charge stations in shopping centers of stations.

Our contribution to literature is focusing all the districts in Anatolian part of Istanbul. The methodology can be applied to European part of Istanbul. Another contribution is that I implemented flow-refuelling station location problem, which was never used for Istanbul before.

Table 3.2 shows the application areas of article's mentioned before.

Table 3.2: Applications.

	Case Study				
Author	America	Asia	Europe	Turkey (Istanbul)	Benchmark
Abdalrahman et. al (2019)	✓				
Awasthi et. al (2017)		✓			
Brey et. al (2016)			✓		
Chung et. al (2015)		✓			
Csonka et. al (2017)			✓		
Gavranovic et. al (2014)				✓	
Genevois et. al (2018)				✓	
He et. al (2019)	✓				
Hodgson et. al (1996)	✓				
Hong et. al (2016)	✓				
Honma et. al (2019)	✓				
Jochem et. al (2019)			✓		
Kong et. al (2019)		✓			
Kuby et. al (2009)	✓				
Kuby et. al (2017)					✓
Markovic et. al (2017)	✓				
Moh et. al (2018)					✓

Polimeni et. al (2017)			✓		
Riemann et. al (2015)		✓			
Wu et. al (2017)		✓			
Xylia et. al (2017)			✓		
Yao et. al (2014)					✓
Zhang et. al (2017)	✓				
Zhao et. al (2016)		✓			

4. THE MODEL

4.1. The Problem Formulation

In this section, flow-refuelling location model is explained. The flow refuelling problem is originally designed and used for facility location problem and it is one of the most important discrete location theory problems. This model aims to determine facility or station locations. In our situation the model locates one or more stations considering the flow of the paths' between districts that are determined.

q: index of OD pairs (the shortest paths for each pair)
Q: set of all OD pairs
f_q*:* flow volume on the OD pair q
k: index of station locations
K: set of all potential station locations
p: the number of stations to be located
h: index of station combinations
H: set of all potential station combinations

$$y_q = \begin{cases} 1, & \text{if } f_q \text{ is captured} \\ 0, & \text{otherwise} \end{cases}$$

$$x_k = \begin{cases} 1, & \text{if a station is located at k} \\ 0, & \text{otherwise} \end{cases}$$

$$v_h = \begin{cases} 1, & \text{if all stations in combination h are open} \\ 0, & \text{otherwise} \end{cases}$$

$$a_{hk} = \begin{cases} 1, & \text{if station k is in combination h} \\ 0, & \text{otherwise} \end{cases}$$

$$b_{qh} = \begin{cases} 1, & \text{if station combination h can refuel OD pair q} \\ 0, & \text{otherwise} \end{cases}$$

$$max\, Z = \sum_{q \in Q} f_q y_q \tag{3.1}$$

$$\sum_{h \in H} b_{qh} v_h \geq y_q \qquad \forall\, q \in Q \tag{3.2}$$

$$a_{hk} x_k \geq v_h \qquad \forall\, h \in H; k \in K \tag{3.3}$$

$$\sum_{k \in K} x_k = p \tag{3.4}$$

$$x_k, v_h, y_q \in \{0,1\} \qquad \forall k, h, q \tag{3.5}$$

Objective function (3.1) aims to maximize the flow volume that can be refuelled. Constraint (3.2) prevents the capturing of path *q*, unless a suitable combination of stations is selected. Constraint (3.3) ensures the opening of all stations in a selected station combination *h*. Constraint (3.4) ensures that the number of opened stations equals to *p*. Constraint (3.5) provides the binary constraints

4.2. Data Collection

The suggested approach is applied on nine different policies considering number of charge station locations 2 to 10. Table 4.2.1 shows the potential station locations (*k*), Table 4.2.2 shows the combination of facilites (*h*). The objective of the research is to determine the locations of electric charge stations. Optimum locations of the districts of Asian side of Istanbul are obtained by a flow refuelling method based on the flows between locations and possible electric station locations.

Table 4.2.1: Potential Station Locations.

No.	*K*: Set of Potential Stations
1	Ataşehir
2	Beykoz
3	Çekmeköy
4	Kadıköy
5	Kartal
6	Maltepe
7	Pendik
8	Sancaktepe
9	Ümraniye
10	Üsküdar

Table 4.2.2 : Combination of Stations.

No.	*H*: Set of All Potential Station Combinations
1	Ataşehir - Kadıköy
2	Ataşehir - Maltepe
3	Ataşehir - Ümraniye
4	Ataşehir - Üsküdar
5	Beykoz - Çekmeköy
6	Beykoz - Sancaktepe
7	Beykoz - Ümraniye
8	Beykoz - Üsküdar
9	Çekmeköy - Sancaktepe
10	Çekmeköy - Şile
11	Çekmeköy - Ümraniye
12	Kadıköy - Üsküdar
13	Kadıköy - Maltepe
14	Kartal - Maltepe
15	Kartal - Pendik
16	Kartal - Sancaktepe
17	Kartal - Sultanbeyli
18	Maltepe - Sancaktepe
19	Maltepe - Sultanbeyli
20	Sancaktepe - Sultanbeyli
21	Sancaktepe - Tuzla
22	Ataşehir - Ümraniye - Üsküdar
23	Beykoz - Çekmeköy - Sancaktepe
24	Kadıköy - Maltepe - Kartal
25	Ataşehir - Ümraniye - Üsküdar - Kadıköy
26	Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli

Paths are created with the minimum driving range that a vehicle can travel with low electric load. Minimum driving range of a typical electric vehicle is 40 kilometres. In table 4.2.3 the distance matrix of districts are shown for Asian part of Istanbul. The data is gathered from General Directorate for the Highways department (https://www.kgm.gov.tr).

Table 4.2.3 : Distance Matrix (Km).

District	Ataşehir	Beykoz	Çekmeköy	Kadıköy	Kartal	Maltepe	Pendik	Sancaktepe	Sultanbeyli	Şile	Tuzla	Ümraniye	Üsküdar
Ataşehir	-	24	34	9	17	11	33	29	14	63	26	7	14

Beykoz	24	-	24	29	37	34	60	35	34	73	47	22	26
Çekmeköy	34	24	-	38	33	27	43	14	21	36	33	29	36
Kadıköy	9	29	38	-	19	13	20	24	18	63	30	12	11
Kartal	17	37	33	19	-	13	7	21	18	60	17	22	27
Maltepe	11	34	27	13	13	-	16	16	11	56	27	19	20
Pendik	33	60	43	20	7	16	-	29	23	71	16	27	29
Sancaktepe	29	35	14	24	21	16	29	-	10	41	21	19	28
Sultanbeyli	14	34	21	18	18	11	23	10	-	50	16	20	25
Şile	63	73	36	63	60	56	71	41	50	-	63	57	63
Tuzla	26	47	33	30	17	27	16	21	16	63	-	32	36
Ümraniye	7	22	29	12	22	19	27	19	20	57	32	-	12
Üsküdar	14	26	36	11	27	20	29	28	25	63	36	12	-

Table 4.2.4 shows the paths of OD pairs and flow values of the paths. The flows are assumed to be proportional with the number of gas stations on the paths. Hence, relative path flow scores are obtained based on the path having the minimum number of gas stations.

Table 4.2.4: OD Pairs and Flow Values.

No.	Paths	Path Flow Value
1	Ataşehir - Ümraniye	9
2	Beykoz - Çekmeköy	6
3	Çekmeköy - Şile	5
4	Kadıköy - Üsküdar	6
5	Kartal - Pendik	10
6	Maltepe - Sultanbeyli	8
7	Sancaktepe - Tuzla	10
8	Ataşehir - Ümraniye - Üsküdar	13
9	Beykoz - Çekmeköy - Sancaktepe	11
10	Kadıköy - Maltepe - Kartal	10
11	Pendik - Tuzla - Sultanbeyli	14
12	Ataşehir - Ümraniye - Üsküdar - Kadıköy	21
13	Üsküdar - Ümraniye - Çekmeköy - Şile	14
14	Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli	15
15	Maltepe - Kartal - Pendik - Tuzla	25
16	Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe	23
17	Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla	20
18	Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli	27

19	Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla	28
20	Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal	31
21	Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik	36
22	Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla	39

Figure 4.2.1 shows the path of Ataşehir - Ümraniye on the map. The flow score of this path (9) is obtained by getting the number of gas stations between its nodes which is given as follows:
Ataşehir – Ümraniye : 9

Figure 4.2.1 : The path of route 1.

Figure 4.2.2 shows the path of Beykoz – Çekmeköy on the map. The flow score of this path (6) is obtained by getting the number of gas stations between its nodes which is given as follows:
Beykoz – Çekmeköy: 6

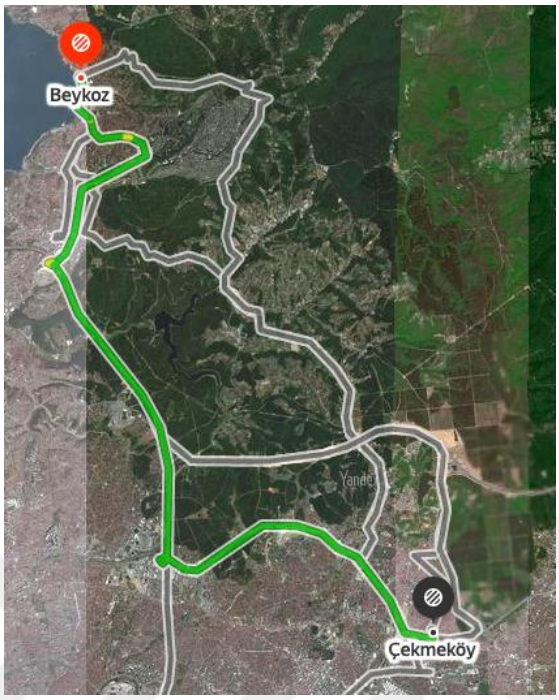

Figure 4.2.2 : The path of route 2.

Figure 4.2.3 shows the path of Çekmeköy - Şile on the map. The flow score of this path (5) is obtained by getting the number of gas stations between its nodes which is given as follows:

Çekmeköy – Şile : 5

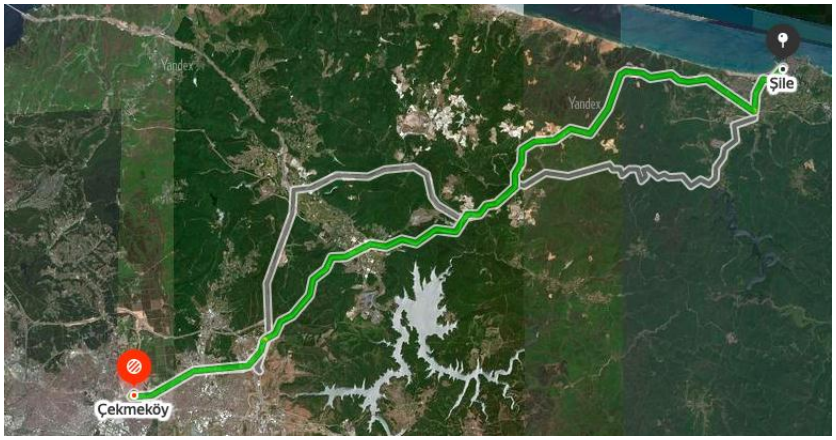

Figure 4.2.3 : The path of route 3.

Figure 4.2.4 shows the path of Kadıköy - Üsküdar on the map. The flow score of this path (8) is obtained by getting the number of gas stations between its nodes which is given as follows:

Kadıköy - Üsküdar : 8

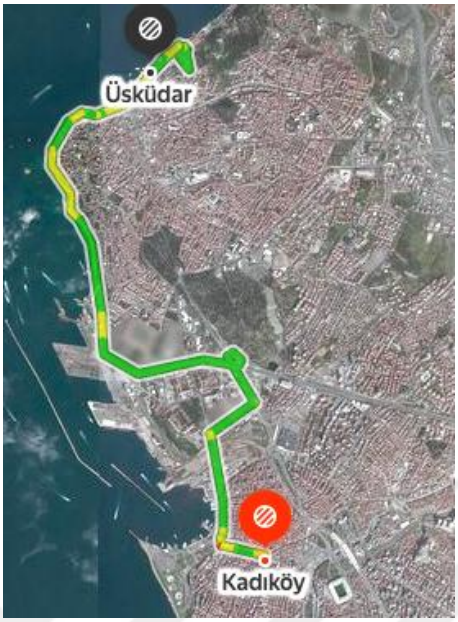

Figure 4.2.4 : The path of route 4.

Figure 4.2.5 shows the path of Kartal – Pendik on the map. The flow score of this path (10) is obtained by getting the number of gas stations between its nodes which is given as follows:
Kartal – Pendik: 10

Figure 4.2.5 : The path of route 5.

Figure 4.2.6 shows the path of Maltepe - Sultanbeyli on the map. The flow score of this path (8) is obtained by getting the number of gas stations between its nodes which is given as follows:
Maltepe – Sultanbeyli : 8

Figure 4.2.6 : The path of route 6.

Figure 4.2.7 shows the path of Sancaktepe - Tuzla on the map. The flow score of this path (10) is obtained by getting the number of gas stations between its nodes which is given as follows:

Sancaktepe - Tuzla : 10

Figure 4.2.7 : The path of route 7.

Figure 4.2.8 shows the path of Ataşehir – Ümraniye - Üsküdar on the map. The flow score of this path (13) is obtained by getting the sum of the flow scores between its nodes which are given as follows:

Ataşehir – Ümraniye : 9

Ümraniye - Üsküdar : 4

Figure 4.2.8 : The path of route 8.

Figure 4.2.9 shows the path of Beykoz – Çekmeköy - Sancaktepe on the map. The flow score of this path (11) is obtained by getting the sum of the flow scores between its nodes which are given as follows:

Beykoz – Çekmeköy: 6

Çekmeköy – Sancaktepe: 5

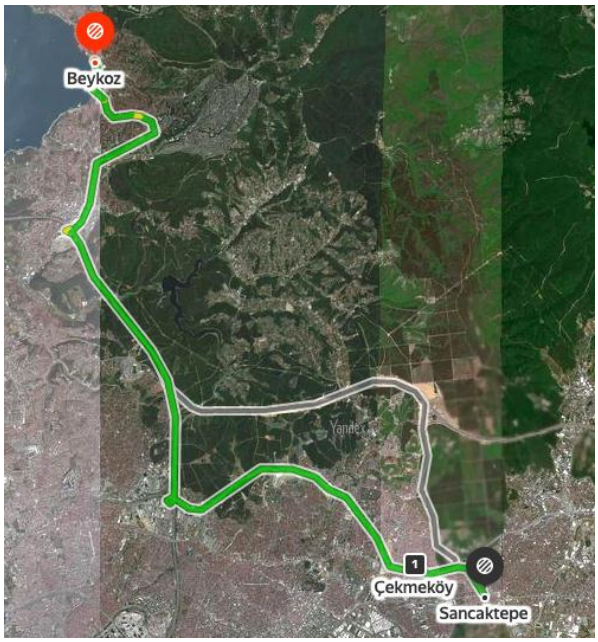

Figure 4.2.9 : The path of route 9.

Figure 4.2.10 shows the path of Kadıköy - Maltepe - Kartal on the map. The flow score of this path (10) is obtained by getting the sum of the flow scores between its nodes which are given as follows:

Kadıköy – Maltepe: 4

Maltepe – Kartal: 6

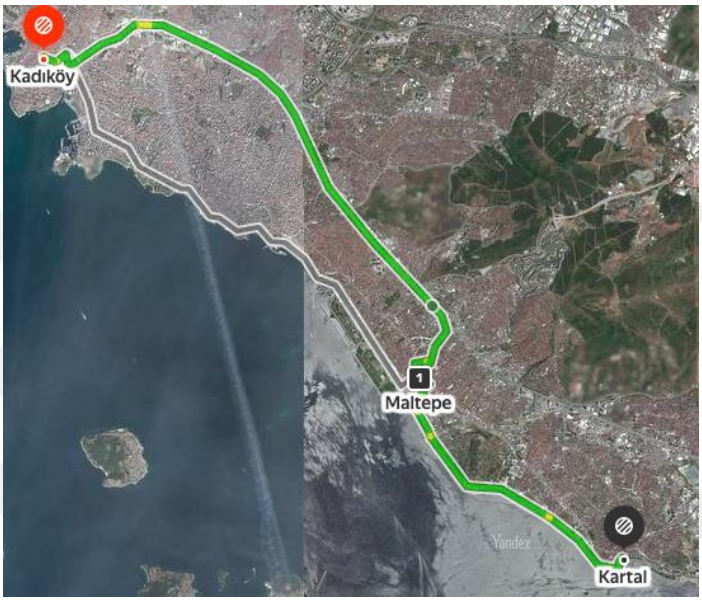

Figure 4.2.10 : The path of route 10.

Figure 4.2.11 shows the path of Pendik - Tuzla - Sultanbeyli on the map. The flow score of this path (14) is obtained by getting the sum of the flow scores between its nodes which are given as follows:

Pendik – Tuzla: 9

Tuzla - Sultanbeyli: 5

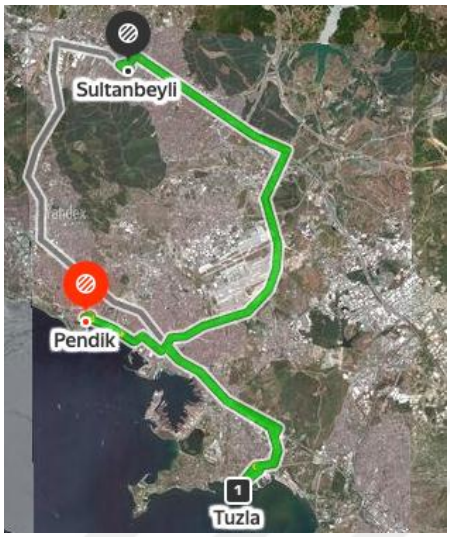

Figure 4.2.11 : The path of route 11.

Figure 4.2.12 shows the path of Ataşehir - Ümraniye - Üsküdar - Kadıköy on the map. The flow score of this path (21) is obtained by getting the sum of the flow scores between its nodes which are given as follows:

Ataşehir – Ümraniye: 9
Ümraniye – Üsküdar: 4
Üsküdar - Kadıköy : 8

Figure 4.2.12 : The path of route 12.

Figure 4.2.13 shows the path of Üsküdar - Ümraniye - Çekmeköy - Şile on the map. The flow score of this path (14) is obtained by getting the sum of the flow scores between its nodes which are given as follows:

Üsküdar – Ümraniye: 4

Ümraniye – Çekmeköy: 5
Çekmeköy - Şile : 5

Figure 4.2.13 : The path of route 13.

Figure 4.2.14 shows a sample path of Beykoz – Çekmeköy – Sancaktepe – Sultanbeyli on the map. The flow score of this path (15) is obtained by getting the sum of the flow scores between its nodes which are given as follows:

Beykoz – Çekmeköy: 6

Çekmeköy – Sancaktepe: 5

Sancaktepe – Sultanbeyli :4

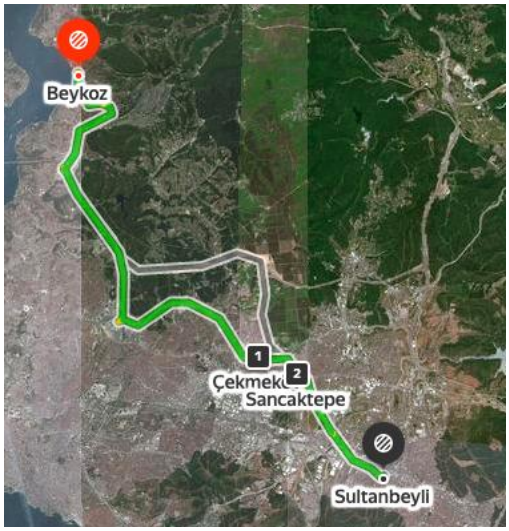

Figure 4.2.14 : The path of route 14.

Figure 4.2.15 shows the path of Maltepe - Kartal - Pendik - Tuzla on the map. The flow score of this path (25) is obtained by getting the sum of the flow scores between its nodes which are given as follows:

Maltepe – Kartal: 6

Kartal – Pendik: 10

Pendik – Tuzla: 9

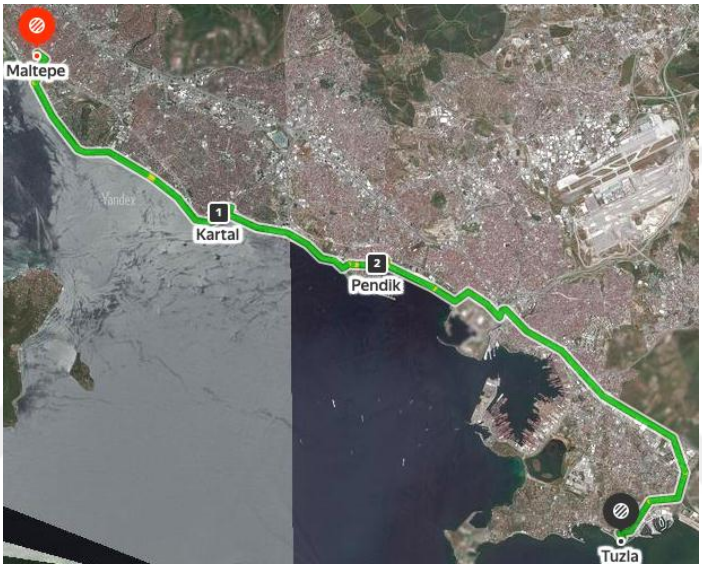

Figure 4.2.15 : The path of route 15.

Figure 4.2.16 shows the path of Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe on the map. The flow score of this path (23) is obtained by getting the sum of the flow scores between its nodes which are given as follows:

Ataşehir – Ümraniye: 9

Ümraniye – Üsküdar: 4

Üsküdar – Kadıköy: 6

Kadıköy – Maltepe: 4

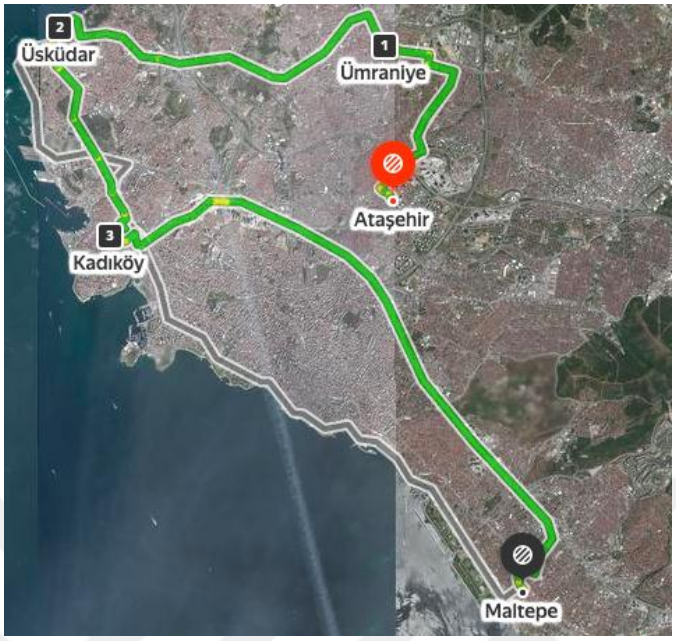

Figure 4.2.16 : The path of route 16.

Figure 4.2.17 shows the path of Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla on the map. The flow score of this path (20) is obtained by getting the sum of the flow scores between its nodes which are given as follows:

Beykoz – Çekmeköy: 6

Çekmeköy – Sancaktepe: 5

Sancaktepe – Sultanbeyli: 4

Sultanbeyli – Tuzla: 5

Figure 4.2.17 : The path of route 17.

Figure 4.2.18 shows the path of Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli on the map. The flow score of this path (27) is obtained by getting the sum of the flow scores between its nodes which are given as follows:

Ataşehir – Ümraniye: 9

Ümraniye – Üsküdar: 4

Üsküdar – Kadıköy: 6

Kadıköy – Maltepe: 4

Maltepe – Sultanbeyli: 4

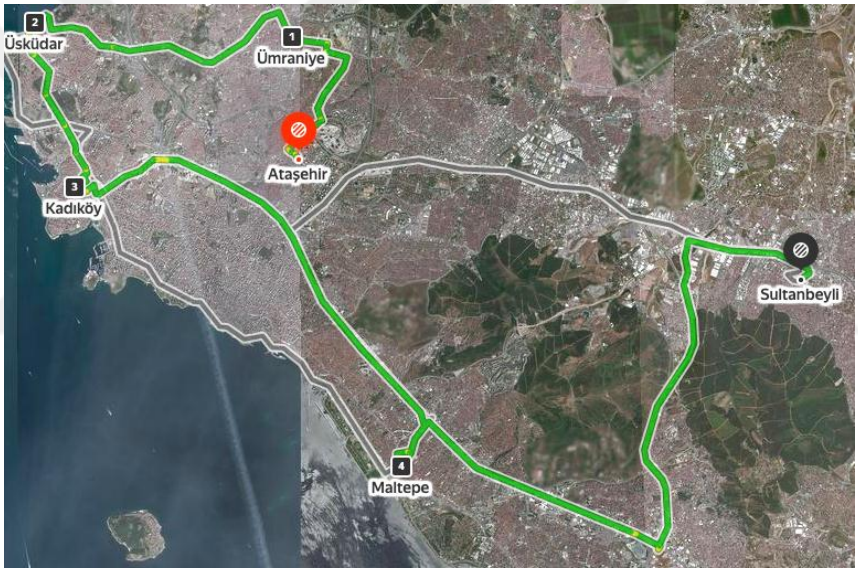

Figure 4.2.18 : The path of route 18.

Figure 4.2.19 shows the path of Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla on the map. The flow score of this path (28) is obtained by getting the sum of the flow scores between its nodes which are given as follows:

Beykoz – Çekmeköy: 6

Çekmeköy – Sancaktepe: 5

Sancaktepe – Sultanbeyli: 4

Sultanbeyli – Pendik: 4

Pendik - Tuzla: 9

Figure 4.2.19 : The path of route 19.

Figure 4.2.20 shows the path of Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe – Kartal on the map. The flow score of this path (31) is obtained by getting the sum of the flow scores between its nodes which are given as follows:

Beykoz – Üsküdar: 4
Üsküdar – Ümraniye: 4
Ümraniye – Ataşehir: 9
Ataşehir – Kadıköy: 4
Kadıköy – Maltepe: 4
Maltepe – Kartal: 6

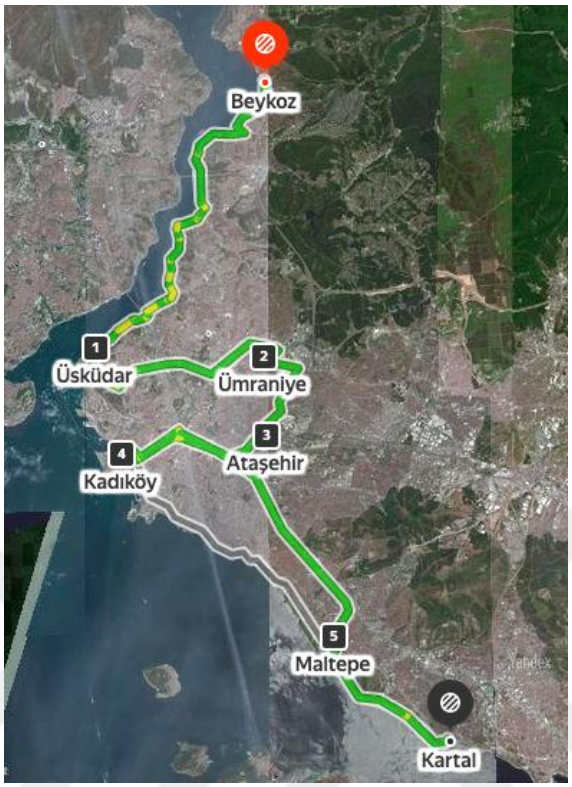

Figure 4.2.20 : The path of route 20.

Figure 4.2.21 shows the path of Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik on the map. The flow score of this path (36) is obtained by getting the sum of the flow scores between its nodes which are given as follows:

Beykoz – Çekmeköy: 6

Çekmeköy – Sancaktepe: 5

Sancaktepe – Sultanbeyli: 4

Sultanbeyli – Maltepe: 5

Maltepe – Kartal: 6

Kartal – Pendik: 10

Figure 4.2.21 : The path of route 21.

Figure 4.2.22 shows the path of Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla on the map. The flow score of this path (39) is obtained by getting the sum of the flow scores between its nodes which are given as follows:

Beykoz – Çekmeköy: 6

Çekmeköy – Sancaktepe: 5

Sancaktepe – Sultanbeyli: 4

Sultanbeyli – Maltepe: 5

Maltepe – Kartal: 6

Kartal – Tuzla: 5

Figure 4.2.22 : The path of route 22.

4.3. Computational Results

The mathematical model is run for the nine different *p* values and the optimum solutions are obtained. The results of the applied model are shown in Appendix 1 – Table 1. The gap ratio (GR) is computed considering the deviation from the maximum captured flow score among the solutions of all *p* values. The GR for $p = 2$ is obtained via the following calculations.

GR (p = 2) = (358 – 165) / 358 = 53.91%

When the GR values are analyzed, it is concluded that there is no significant improvement for the *p* value bigger than 6. Hence, it does not seem reasonable to establish the system with more than 6 electric charging stations in the initial stage.

Considering the result of $p=2$ case, the map of one of the two selected stations, Kartal, and the captured paths are shown in Figure 4.3.1.

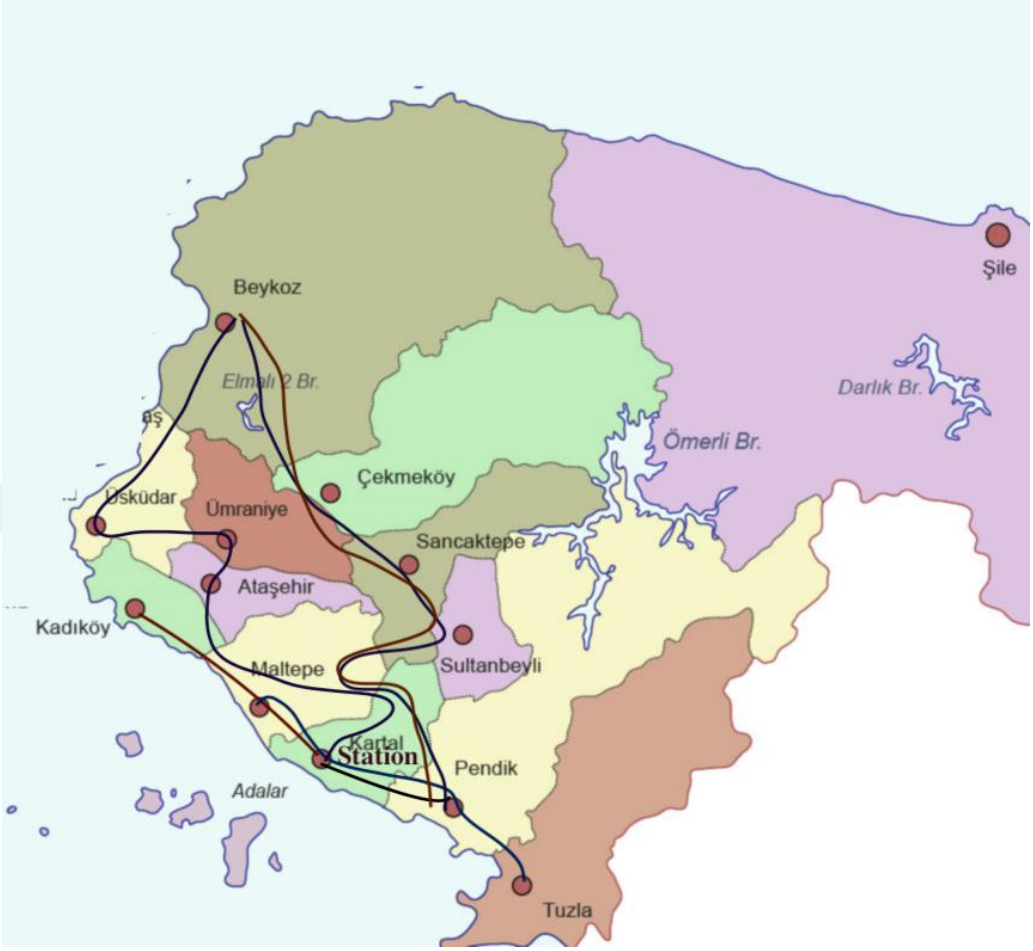

Figure 4.3.1 : A sample path of selected station Kartal and covered paths.

4.4. Sensitivity Analysis

4.4.1. Impact of Driving Range

To understand the impact of the driving range, driving range is increased from 40 km to 50 km and the flow values are kept the same. The mathematical model is run for the seven different *p* values since there where no change after *p*=8 and the optimum solutions are obtained. With the change in driving range the set of potential stations (*K*), the set of all potential station combinations (*H*), the OD pairs tables are changed. The tables mentioned and results table is given respectively in Appendix 2 – Table 2, Table 3, Table 4 and Table 5.

The GR for p = 2 is increased up to %24,6.

GR (p = 2) = (376 – 266) / 276 = 29,25%

When the GR values are analyzed, it is concluded that there is no significant improvement for the p value bigger than 5. Hence, it does not seem reasonable to establish the system with more than 5 electric charging stations in the initial stage.

Considering the result of p=2 case, the map of one of the two selected stations, Ataşehir, and the captured paths are shown in Figure 4.4.1.1.

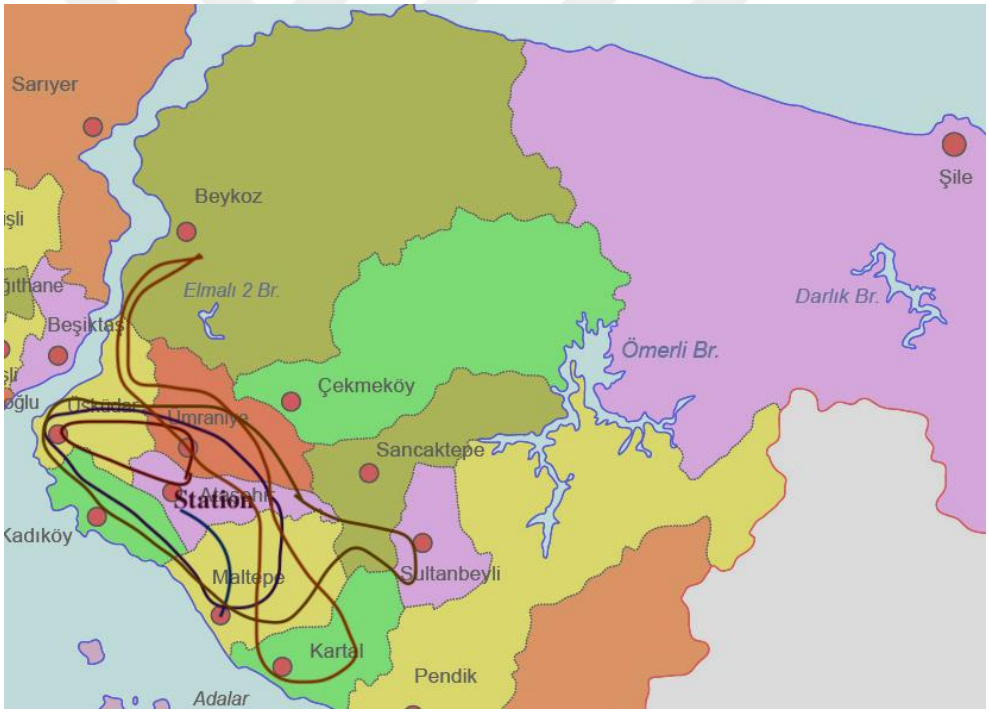

Figure 4.4.1.1 : A sample path of selected station Ataşehir and covered paths.

4.4.2. Impact of Flow Values

EVCS can be installed in gas stations and shopping centers. To see the impact of flow values of the paths on system performance, I calculated the flow values according to the number of shopping centers in districts instead of total gas station numbers between districts. Driving range

was kept 40 km.

The mathematical model is run for the nine different *p* values and the optimum solutions are obtained. With the change in flow values only the OD pairs tables and results are changed. The tables mentioned and results table is given respectively in Appendix 3 – Table 6 and Table 7.

The GR for *p* = 2 is decreased up to %3,51.

GR (p = 2) = (256 – 127) / 256 = 50,4%

When the GR values are analyzed, it is concluded that there is no significant improvement for the *p* value bigger than 3. Hence, it does not seem reasonable to establish the system with more than 3 electric charging stations in the initial stage.

Considering the result of *p*=2 case, the map of one of the two selected stations, Ümraniye, and the captured paths are shown in Figure 4.4.2.1.

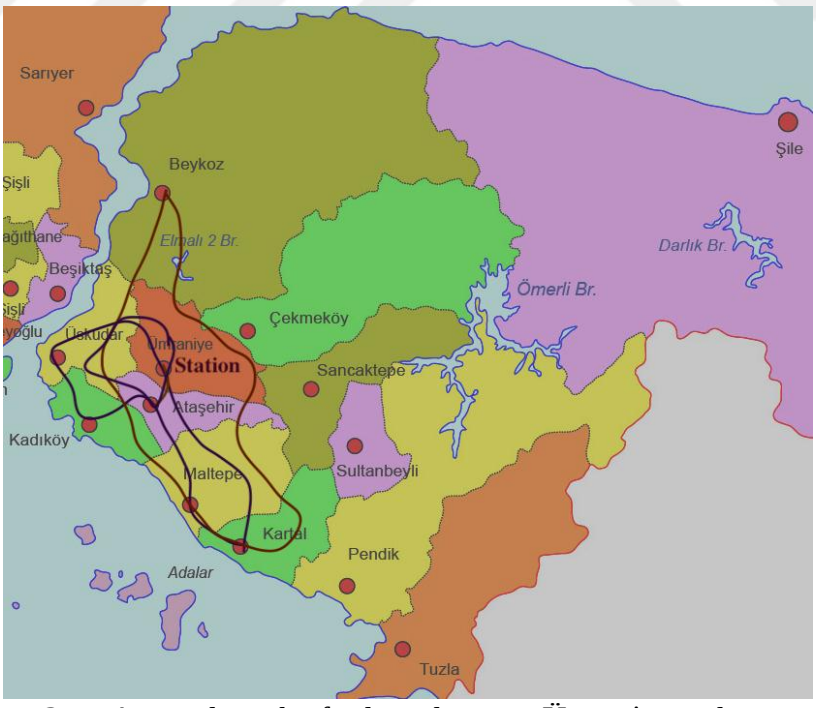

Figure 4.4.2.1 : A sample path of selected station Ümraniye and covered paths.

5. CONCLUSIONS

Nowadays the main problem in this research area is about reducing the global warming in industry. Researchers are mainly focused on all stages of manufacturing a product from its production to service processes by considering green thinking concept. Transportation sector is one of the most harmful sector for greenhouse emission and environmental concerns. Turkey is the 15th country that has the most carbon emissions all around the World.

Deficient number of refuelling stations in Istanbul are the biggest obstacle in development of EV usage. A driver living in Istanbul is not able to drive long distances in the city. In order to solve this problem, I studied the determining electric charge stations in Asian part of Istanbul by flow-refuelling station location approach. Firstly, the paths between districts are found then flow values of districts are found by considering the gas station values in between the paths. Secondly, the stations and locations connected to stations are found by flow-refuelling location model for different *p* values and the results are compared by refractive flow rate and summarized. The best solution considering optimum GR value is gathered when *p* value is equal to 6.

For this study, the problem is considered in a general way. For further studies, other methodologies may be developed and applied to the same problem and results may be compared by the proposed methodology. Additional constraints may be considered such as the capacity of stations, other parameters, etc. Different station types may be considered by adding more constraints. Also, the study can be extended with considering both parts of Istanbul.

REFERENCES

Abdalrahman A., Zhuang W. (2019) PEV Charging Infrastructure Siting Based on Spatial-Temporal Traffic Flow Distribution. IEEE Transactions on Smart Grid, 10(6), 6115 – 6125.

Adderly S.A., Manukian D., Sullivan T.D., Son M. (2018) Electric Vehicles and Natural Disaster Policy Implications. Energy Policy, 112, 437-448.

Atılgan B., Uşaklı Y.M., Baraçlı E.M., Onat N.C., Küçükvar M. (2017) Investigation of Optimal Charging Locations for Electric Vehicles in Istaanbul. International Conference on Industrial Engineering and Operations Management, Colombia.

Awasthi, A., K. Venkitusamy, S. Padmanaban, R. Selvamuthukumaran, F.

Brey J.J., Brey R., Carazo A.F., Montero M.J.R., Tejada M. (2016) Incorporating Refuelling Behaviour And Drivers' Preferences In The Design Of Alternative Fuels Infrastructure In A City. Transportation Research, Part C(65), 144-155.

Chung S.H. & C. Kwon (2015). Multi-period planning for electric car charging station locations: A case of Korean Expressways. European Journal of Operational Research 242, pp.677-687.

Csonka, Balint & C. Csiszar (2017). Determination of charging infrastructure location for electric vehicles. Transportation Research Procedia 27: 768-775.

Gavranovic, H., A. Barut, G. Ertek, O.B. Yüzbaşıoğlu, O. Pekpostalcı & Ö. Tombuş (2014). Optimizing the electric charge station network of EŞARJ. Procedia Computer Science 31: 15-21.

Genevois M.E, Kocaman H. (2018) Locating Electric Vehicle Charging Stations in Istanbul with AHP Based Mathematical Modelling. International Journal of Transportation Systems, 3, 1-10.

Hakimi S.L (1964) Optimum Locations of Switching Centers and the Absolute Centers and Medians of a Graph. Operations Research, 12 (3), 450-459.

He J., Yang H., Tang T.Q., Huang H.J. (2018) An Optimal Charging Station Location Model With The Consideration Of Electric Vehicle's Driving Range. Transportation Research, Part C (86), 641-654.

Hodgson M.J. (1990) A Flow-Capturing Location-Allocation Model. Geographical Analysis, 22 (3), 270-279.

Hodgson M.J., Rosing K.E., Storrier A.L.G.M. (1996) Applying The Flow-Capturing Location-Allocation Model To An Authentic Network: Edmonton, Canada. European Journal of Operational Research, 90, 427-443.

Hong S., Kuby M. (2016) A Threshold Covering Flow-Based Location Model To Build A Critical Mass Of Alternative-Fuel Stations. Journal of Transport Geography, 56, 128-137.

Honma Y., Kuby M. (2019) Node-Based Vs. Path-Based Location Models For Urban Hydrogen Refueling Stations: Comparing Convenience And Coverage Abilities. International Journal Of Hydrogen Energy, 44, 15246-15261.

https://afdc.energy.gov/vehicles/, 01.12.2019.

https://autowise.com, 01.12.2019.

https://commons.wikimedia.org/wiki/File:Plugin_hybrid_electric_vehicle_(PHEV)_diagram.jpg, 01.12.2019.

https://edgar.jrc.ec.europa.eu/, 10.11.2019.

https://www.energy.gov/articles/history-electric-car, 01.12.2019.

https://www.energy.gov/, 01.12.2019.

https://www.epri.com, 28.12.2019.

https://www.ergon.com.au, 01.12.2019.

https://www.europarl.europa.eu/RegData/etudes/BRIE/2019/631047/IPOL_BRI(2019)631047_EN.pdf, 01.12.2019.

https://ev.hedeffilo.com/elektrikli-arac-tarihcesi, 01.12.2019.

https://www.fueleconomy.gov/feg/hybridtech.shtml, 01.12.2019.

https://www.globalcarbonproject.org , 10.11.2019.

https://www.iea.org, 01.12.2019.

http://www.ieahev.org, 01.12.2019.

https://www.jato.com, 10.11.2019.

https://www.kgm.gov.tr , 10.11.2019.

https://oli.cmu.edu/, 01.12.2019.

http://tehad.org, 10.11.2019.

https://www.zap-map.com/charge-points/, 10.11.2019.

Jochem P., Szimba E., Reuter-Oppermann M. (2019) How Many Fast-Charging Stations Do We Need Along European Highways? Transportation Research, Part D (73), 120-129.

Kong W., Luo Y., Feng G., Li K. Peng H. (2019) Optimal Location Planning Method Of Fast Charging Station For Electric Vehicles Considering Operators, Drivers, Vehicles, Traffic Flow And Power Grid. Energy, 186.

Kuby M.J., Lim S. (2007) Location of Alternative-Fuel Stations Using the Flow-Refueling Location Model and Dispersion of Candidate Sites on Arcs. Networks and Spatial Economics, 7(2), 129-152.

Kuby M., Lines L., Schultz R., Xie Z., Kim J.G., Lim S. (2009) Optimization Of Hydrogen Stations In Florida Using The Flow-Refueling Location Model. International Journal Of Hydrogen Energy, 34, 6045-6064.

Markovic N., Ryzhov I.O., Schonfeld P. (2017) Evasive Flow Capture: A Multi-Period Stochastic Facility Location Problem With Independent Demand. European Journal of Operational Research, 257, 687-703.

Moh A.N.S., Ruzmetov A., Bakhouya M., Naitmalek Y., Gaber J. (2018) A Prediction Model of Electric Vehicle Charging Requests. Procedia Computer Science, 141, 127-134.

Polimeni, A., G. Napoli, L. Andaloro & V. Antonucci (2017). Electric vehicle charging infrastructure planning in a road network. Renewable and Sustainable Energy Reviews 80: 98-108.

Riemann R., Wang D.Z.W., Busch F. (2015) Optimal Location of Wireless Charging Facilities For Electric Vehicles: Flow-Capturing Location Model With Stochastic User Equilibrium. Transportation Research, Part C (58), 1-12.

Wu F., Sioshansi R. (2017) A Stochastic Flow-Capturing Model to Optimize the Location of Fast-Charging Stations with Uncertain Electric Vehicle Flows. Transportation Research, Part D (53), 354-376.

Xylia, M., S. Leduc, P. Patrizio, F. Kraxner & S. Silveria (2017). Locating charging infrastructure for electric buses in Stockholm. Transportation Research Part C 78: 183-200.

Yao W., Zhao J. Wen F., Dong Z. (2014) "A Multi-Objective Collaborative Planning Strategy for Integrated Power Distribution and Electric Vehicle Charging Systems". IEEE Transactions on Power Systems, 29(4).

Zhang A., Kang J.E., Kwon C. (2017) Incorporating Demand Dynamics In Multi-Period Capacitated Fast-Charging Location Planning For Electric Vehicles. Transportation Research, Part B (103), 5-29.

Zhao H. & N. Li (2016). Optimal siting of charging stations for electric vehicles based on fuzzy delphi and hybrid multi-criteria decision making approaches from an extended sustainability perspective. Energies.

Zhu Z.H., Gao Z.Y., Zheng J.F., Du H.M. (2016) Charging Station Location Problem Of Plug-In Electric Vehicles. Journal of Transport Geography, 52, 11-22.

APPENDIX

Appendix 1 – Table 1: Results.

p	Station	Covered Paths	Total Flow	GR (%)
2	Kartal	Kartal - Pendik; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla	165	53,91%
	Sancaktepe	Sancaktepe - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
3	Beykoz	Beykoz - Çekmeköy; Beykoz - Çekmeköy - Sancaktepe; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik - Tuzla; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla	258	27,93%
	Çekmeköy	Beykoz - Çekmeköy; Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe; Üsküdar - Ümraniye - Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Sancaktepe	Sancaktepe - Tuzla; Beykoz - Çekmeköy - Sancaktepe; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
4	Beykoz	Beykoz - Çekmeköy; Beykoz - Çekmeköy - Sancaktepe; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik - Tuzla; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz -	291	18,72%

	Sancaktepe	Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Beykoz - Çekmeköy; Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe; Üsküdar - Ümraniye - Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Kartal - Pendik; Maltepe - Kartal - Pendik - Tuzla; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Sancaktepe - Tuzla; Beykoz - Çekmeköy - Sancaktepe; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
5	Çekmeköy	Beykoz - Çekmeköy; Beykoz - Çekmeköy - Sancaktepe; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik - Tuzla; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Beykoz - Çekmeköy; Çekmeköy - Şile; Kartal - Pendik; Maltepe - Sultanbeyli; Sancaktepe - Tuzla; Beykoz - Çekmeköy - Sancaktepe; Kadıköy - Maltepe - Kartal; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Maltepe - Kartal - Pendik - Tuzla; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik - Tuzla; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla	311	13,13%
	Kartal	Kartal - Pendik; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik;		

	Maltepe	Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Maltepe - Sultanbeyli; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Sancaktepe	Sancaktepe - Tuzla; Beykoz - Çekmeköy - Sancaktepe; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
6	Ataşehir	Ataşehir - Ümraniye; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal	327	8,66%
	Çekmeköy	Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe; Üsküdar - Ümraniye - Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Kartal	Kartal - Pendik; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Maltepe	Maltepe - Sultanbeyli; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Sancaktepe	Sancaktepe - Tuzla; Beykoz - Çekmeköy - Sancaktepe; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe -		

	Ümraniye	Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Ataşehir - Ümraniye; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal		
7	Ataşehir Beykoz Çekmeköy Kartal Maltepe Sancaktepe	Ataşehir - Ümraniye; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal Beykoz - Çekmeköy; Beykoz - Çekmeköy - Sancaktepe; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik - Tuzla; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Beykoz - Çekmeköy; Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe; Üsküdar - Ümraniye - Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Kartal - Pendik; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Maltepe - Sultanbeyli; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Sancaktepe - Tuzla; Beykoz - Çekmeköy - Sancaktepe; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla; Beykoz -	333	6,98%

	Ümraniye	Çekmeköy - Sancaktepe - Sultanbeyli - Pendik - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Ataşehir - Ümraniye; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal		
8	Ataşehir Çekmeköy Kadıköy Kartal Maltepe Sancaktepe	Ataşehir - Ümraniye; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe; Üsküdar - Ümraniye - Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Maltepe - Kartal - Pendik - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Kadıköy - Üsküdar; Kadıköy - Maltepe - Kartal; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal Kartal - Pendik; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Maltepe - Sultanbeyli; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Sancaktepe - Tuzla; Beykoz - Çekmeköy - Sancaktepe; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik - Tuzla;	352	1,68%

	Ümraniye	Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Ataşehir - Ümraniye; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal		
	Üsküdar	Kadıköy - Üsküdar; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal		
9	Ataşehir	Ataşehir - Ümraniye; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal	358	0%
	Beykoz	Beykoz - Çekmeköy; Beykoz - Çekmeköy - Sancaktepe; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik - Tuzla; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Çekmeköy	Beykoz - Çekmeköy; Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe; Üsküdar - Ümraniye - Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Kadıköy	Kadıköy - Üsküdar; Kadıköy - Maltepe - Kartal; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal		
	Kartal	Kartal - Pendik; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik;		

	Maltepe	Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Maltepe - Sultanbeyli; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Sancaktepe	Sancaktepe - Tuzla; Beykoz - Çekmeköy - Sancaktepe; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Ümraniye	Ataşehir - Ümraniye; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal		
	Üsküdar	Kadıköy - Üsküdar; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal		
	Ataşehir	Ataşehir - Ümraniye; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal		
10	Beykoz	Beykoz - Çekmeköy; Beykoz - Çekmeköy - Sancaktepe; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik - Tuzla; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla	358	0%
	Çekmeköy	Beykoz - Çekmeköy; Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe; Üsküdar - Ümraniye - Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla;		

Kadıköy	Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Kadıköy - Üsküdar; Kadıköy - Maltepe - Kartal; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal
Kartal	Kartal - Pendik; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla
Maltepe	Maltepe - Sultanbeyli; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla
Pendik	Kartal - Pendik; Pendik - Tuzla - Sultanbeyli; Maltepe - Kartal - Pendik - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik
Sancaktepe	Sancaktepe - Tuzla; Beykoz - Çekmeköy - Sancaktepe; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla
Ümraniye	Ataşehir - Ümraniye; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal
Üsküdar	Kadıköy - Üsküdar; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar - Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal

Appendix 2 – Table 2: Potential Station Locations.

No.	*K*: Set of Potential Stations
1	Ataşehir
2	Çekmeköy
3	Kadıköy
4	Kartal
5	Maltepe
6	Pendik
7	Sultanbeyli
8	Tuzla
9	Ümraniye
10	Üsküdar

Appendix 2 – Table 3: Combination of Stations.

No.	*H*: Set of All Potential Station Combinations
1	Ataşehir - Sancaktepe
2	Çekmeköy - Beykoz
3	Çekmeköy - Sancaktepe
4	Çekmeköy - Şile
5	Kadıköy - Üsküdar
6	Kartal - Sancaktepe
7	Kartal - Sultanbeyli
8	Maltepe - Kartal
9	Maltepe - Sancaktepe
10	Pendik - Kartal
11	Pendik - Tuzla
12	Sultanbeyli - Sancaktepe
13	Tuzla - Kartal
14	Ümraniye - Beykoz
15	Üsküdar - Beykoz
16	Üsküdar - Şile
17	Ataşehir - Ümraniye - Üsküdar
18	Beykoz - Çekmeköy - Sancaktepe
19	Kadıköy - Maltepe - Kartal
20	Ataşehir - Ümraniye - Üsküdar - Kadıköy
21	Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli

Appendix 2 – Table 4: OD Pairs and Flow Values.

No.	Paths	Path Flow Value
1	Ataşehir - Maltepe	6
2	Çekmeköy- Beykoz	6
3	Çekmeköy - Sancaktepe	5
4	Çekmeköy - Şile	5
5	Kadıköy - Üsküdar	6
6	Kartal - Tuzla	5
7	Maltepe - Sancaktepe	7

8	Pendik - Tuzla	9
9	Ataşehir - Ümraniye - Üsküdar	13
10	Beykoz - Çekmeköy - Sancaktepe	11
11	Kadıköy - Maltepe - Kartal	10
12	Pendik - Tuzla - Sultanbeyli	14
13	Ataşehir - Ümraniye - Üsküdar - Kadıköy	21
14	Üsküdar - Ümraniye - Çekmeköy - Şile	14
15	Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli	15
16	Maltepe - Kartal - Pendik - Tuzla	25
17	Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe	23
18	Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla	20
19	Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli	27
20	Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla	28
21	Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal	31
22	Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik	36
23	Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla	39

Appendix 2 – Table 5: Results of Impact of Driving Range.

p	Station	Covered Paths	Total Flow	GR (%)
2	Ataşehir Çekmeköy	Ataşehir - Maltepe; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal Çekmeköy- Beykoz; Çekmeköy - Sancaktepe; Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe; Üsküdar - Ümraniye - Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla ; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla	266	29,25%
3	Çekmeköy Kartal	Çekmeköy- Beykoz; Çekmeköy - Sancaktepe; Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe; Üsküdar - Ümraniye - Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla ; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Kartal - Tuzla; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe -	294	21,80%

	Üsküdar	Sultanbeyli - Maltepe - Kartal - Tuzla Kadıköy - Üsküdar; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal		
4	Çekmeköy Kartal Maltepe Üsküdar	Çekmeköy- Beykoz; Çekmeköy - Sancaktepe; Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe; Üsküdar - Ümraniye - Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla ; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Kartal - Tuzla; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Ataşehir - Maltepe; Maltepe - Sancaktepe; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Kadıköy - Üsküdar; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal	329	12,50%
5	Çekmeköy Kartal	Çekmeköy - Beykoz; Çekmeköy - Sancaktepe; Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe; Üsküdar - Ümraniye - Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla ; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Kartal - Tuzla; Kadıköy - Maltepe - Kartal; Maltepe -	352	6,38%

	Maltepe	Kartal - Pendik - Tuzla; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Ataşehir - Maltepe; Maltepe - Sancaktepe; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Pendik	Pendik - Tuzla; Pendik - Tuzla - Sultanbeyli; Maltepe - Kartal - Pendik - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik		
	Üsküdar	Kadıköy - Üsküdar; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal		
6	Ataşehir	Ataşehir - Maltepe; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal	358	4,78%
	Çekmeköy	Çekmeköy- Beykoz; Çekmeköy - Sancaktepe; Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe; Üsküdar - Ümraniye - Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla ; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Kartal	Kartal - Tuzla; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Maltepe	Ataşehir - Maltepe; Maltepe - Sancaktepe; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe;		

	Pendik	Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Pendik - Tuzla; Pendik - Tuzla - Sultanbeyli; Maltepe - Kartal - Pendik - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik		
	Üsküdar	Kadıköy - Üsküdar; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal		
7	Ataşehir	Ataşehir - Maltepe; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal	371	1,33%
	Çekmeköy	Çekmeköy- Beykoz; Çekmeköy - Sancaktepe; Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe; Üsküdar - Ümraniye - Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla ; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Kartal	Kartal - Tuzla; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Maltepe	Ataşehir - Maltepe; Maltepe - Sancaktepe; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Pendik	Pendik - Tuzla; Pendik - Tuzla - Sultanbeyli; Maltepe - Kartal - Pendik - Tuzla; Beykoz - Çekmeköy -		

		Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik		
	Ümraniye	Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal		
	Üsküdar	Kadıköy - Üsküdar; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal		
	Ataşehir	Ataşehir - Maltepe; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal		
	Çekmeköy	Çekmeköy- Beykoz; Çekmeköy - Sancaktepe; Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe; Üsküdar - Ümraniye - Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla ; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
8	Kartal	Kartal - Tuzla; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla	376	0,00%
	Maltepe	Ataşehir - Maltepe; Maltepe - Sancaktepe; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Pendik	Pendik - Tuzla; Pendik - Tuzla - Sultanbeyli; Maltepe - Kartal - Pendik - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe -		

	Kartal - Pendik
Tuzla	Kartal - Tuzla; Pendik - Tuzla; Pendik - Tuzla - Sultanbeyli; Maltepe - Kartal - Pendik - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla ; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla
Ümraniye	Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal
Üsküdar	Kadıköy - Üsküdar; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal

Appendix 3 – Table 6: OD Pairs and Flow Values.

No.	Paths	Path Flow Value
1	Ataşehir - Ümraniye	14
2	Beykoz - Çekmeköy	3
3	Çekmeköy - Şile	2
4	Kadıköy - Üsküdar	7
5	Kartal - Pendik	6
6	Maltepe - Sultanbeyli	3
7	Sancaktepe - Tuzla	6
8	Ataşehir - Ümraniye - Üsküdar	17
9	Beykoz - Çekmeköy - Sancaktepe	5
10	Kadıköy - Maltepe - Kartal	8
11	Pendik - Tuzla - Sultanbeyli	9
12	Ataşehir - Ümraniye - Üsküdar - Kadıköy	21
13	Üsküdar - Ümraniye - Çekmeköy - Şile	10
14	Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli	6
15	Maltepe - Kartal - Pendik - Tuzla	12
16	Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe	23
17	Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla	10
18	Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli	24
19	Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla	14
20	Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal	28
21	Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik	14
22	Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla	14

Appendix 3 – Table 7: Results of Impact of Flow Values.

p	Station	Covered Paths	Total Flow	GR (%)
2	Ataşehir	Ataşehir - Ümraniye; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal	127	50,40%
	Ümraniye	Ataşehir - Ümraniye; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal		
3	Ataşehir	Ataşehir - Ümraniye; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal	191	25,40%
	Sancaktepe	Sancaktepe - Tuzla; Beykoz - Çekmeköy - Sancaktepe; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla ; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Ümraniye	Ataşehir - Ümraniye; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal		
4	Ataşehir	Ataşehir - Ümraniye; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal	209	18,35%
	Kartal	Kartal - Pendik; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Sancaktepe	Sancaktepe - Tuzla; Beykoz - Çekmeköy - Sancaktepe; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla ; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Ümraniye	Ataşehir - Ümraniye; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli;		

		Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal		
5	Ataşehir Çekmeköy Kartal Sancaktepe Ümraniye	Ataşehir - Ümraniye; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal Beykoz - Çekmeköy; Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe; Üsküdar - Ümraniye - Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla ; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Kartal - Pendik; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Sancaktepe - Tuzla; Beykoz - Çekmeköy - Sancaktepe; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla ; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Ataşehir - Ümraniye; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal	226	11,72%
6	Ataşehir Çekmeköy Kadıköy Kartal	Ataşehir - Ümraniye; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal Beykoz - Çekmeköy; Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe; Üsküdar - Ümraniye - Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla ; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Kadıköy - Üsküdar; Kadıköy - Maltepe - Kartal; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal Kartal - Pendik; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Beykoz - Üsküdar- Ümraniye - Ataşehir -	237	7,42%

	Sancaktepe	Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Sancaktepe - Tuzla; Beykoz - Çekmeköy - Sancaktepe; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla ; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Ümraniye	Ataşehir - Ümraniye; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal		
7	Ataşehir	Ataşehir - Ümraniye; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal	242	5,47%
	Çekmeköy	Beykoz - Çekmeköy; Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe; Üsküdar - Ümraniye - Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla ; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Kadıköy	Kadıköy - Üsküdar; Kadıköy - Maltepe - Kartal; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal		
	Kartal	Kartal - Pendik; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Sancaktepe	Sancaktepe - Tuzla; Beykoz - Çekmeköy - Sancaktepe; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla ; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Ümraniye	Ataşehir - Ümraniye; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal		
	Üsküdar	Kadıköy - Üsküdar; Ataşehir - Ümraniye - Üsküdar; Ataşehir -		

		Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal		
8	Ataşehir	Ataşehir - Ümraniye; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal	253	1,17%
	Çekmeköy	Beykoz - Çekmeköy; Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe; Üsküdar - Ümraniye - Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla ; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Kadıköy	Kadıköy - Üsküdar; Kadıköy - Maltepe - Kartal; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal		
	Kartal	Kartal - Pendik; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Maltepe	Maltepe - Sultanbeyli; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Sancaktepe	Sancaktepe - Tuzla; Beykoz - Çekmeköy - Sancaktepe; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla ; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Ümraniye	Ataşehir - Ümraniye; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal		
	Üsküdar	Kadıköy - Üsküdar; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli;		

		Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal		
9	Ataşehir	Ataşehir - Ümraniye; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal	256	0%
	Beykoz	Beykoz - Çekmeköy; Beykoz - Çekmeköy - Sancaktepe; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla ; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Çekmeköy	Beykoz - Çekmeköy; Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe; Üsküdar - Ümraniye - Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla ; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Kadıköy	Kadıköy - Üsküdar; Kadıköy - Maltepe - Kartal; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal		
	Kartal	Kartal - Pendik; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Maltepe	Maltepe - Sultanbeyli; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Sancaktepe	Sancaktepe - Tuzla; Beykoz - Çekmeköy - Sancaktepe; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla ; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Ümraniye	Ataşehir - Ümraniye; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe -		

	Üsküdar	Kartal Kadıköy - Üsküdar; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal		
s	Ataşehir	Ataşehir - Ümraniye; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal	256	0%
	Beykoz	Beykoz - Çekmeköy; Beykoz - Çekmeköy - Sancaktepe; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla ; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Çekmeköy	Beykoz - Çekmeköy; Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe; Üsküdar - Ümraniye - Çekmeköy - Şile; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Tuzla ; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Kadıköy	Kadıköy - Üsküdar; Kadıköy - Maltepe - Kartal; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal		
	Kartal	Kartal - Pendik; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Maltepe	Maltepe - Sultanbeyli; Kadıköy - Maltepe - Kartal; Maltepe - Kartal - Pendik - Tuzla; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla		
	Pendik	Kartal - Pendik; Pendik - Tuzla - Sultanbeyli; Maltepe - Kartal - Pendik - Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik		
	Sancaktepe	Sancaktepe - Tuzla; Beykoz - Çekmeköy - Sancaktepe; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli; Beykoz - Çekmeköy -		

Ümraniye	Sancaktepe - Sultanbeyli - Tuzla ; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Pendik -Tuzla; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Pendik; Beykoz - Çekmeköy - Sancaktepe - Sultanbeyli - Maltepe - Kartal - Tuzla Ataşehir - Ümraniye; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal
Üsküdar	Kadıköy - Üsküdar; Ataşehir - Ümraniye - Üsküdar; Ataşehir - Ümraniye - Üsküdar - Kadıköy; Üsküdar - Ümraniye - Çekmeköy - Şile; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe; Ataşehir - Ümraniye - Üsküdar - Kadıköy - Maltepe - Sultanbeyli; Beykoz - Üsküdar- Ümraniye - Ataşehir - Kadıköy - Maltepe - Kartal

BIOGRAPHY

Personal Information

Name, Surname	Büşra Gülnihan DAŞCIOĞLU
Birth Date	09/07/1993

Contact

E-Mail	busragdascioglu@gmail.com

Education Information

University	**Sakarya University** Industrial Engineering – 09/2012 – 10/2016
University	**Vienna Technical University – Erasmus+** Industrial Engineering – 09/2014 – 07/2015

Work Experience

08.2019 – still	Turkish Airlines - Expert

Foreign Language

English	Upper Intermediate
Turkish Sign Language	Upper Intermediate
German	Pre Intermediate
Icelandic	Beginner