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Investigating Turkey's EV Technology Adoption Level: How Would Turkey Cross the Chasm Through Policies?

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Abstract

The demand for oil has been booming as more developing countries start integrating into the global economy. Volatility in the oil price and energy costs coerce governments and industries to seek alternative energy sources. Furthermore, the negative impact of carbon emissions on the environment along with pressure from governmental and social organizations' compel automotive manufacturing industries to gradually shift to these alternative energy sources. Enacted legislations and proposed economy bills (to promote green technologies) have especially had an impact on industry practices. Governments additionally give certain incentives, (such as tax breaks,) to encourage the adoption of green technologies by both consumers and manufacturers. Corporations invest in research and development to bring forth innovative technologies for a number of reasons: to find the most cost effective technology that works with sustainable energy, to keep up with the ever-changing industry conditions, and (thereby) gain a competitive advantage in the market. Electric Vehicles (EV), which claim to reduce the carbon emissions, are offered at a competitive price and performance, and, therefore, one of the strongest green technology alternatives. Thus, throughout the world, many corporations are focused on developing and manufacturing EV models in order to take lead in the market. As of September 2013, the United States had the largest fleet of plug-in electric vehicles in the world by annual sales - over 450,000 plug-in electric cars. The United States has taken a dominant role in adopting this new innovative green technology and many of its states have taken up the incentives and adapted to its regulations. Overseas, Turkey took lead among the developing countries and already launched its first EV model; it aims to become an important EV manufacturer for Europe. In this paper, the financial, psychological, and infrastructural barriers to cross the chasm in EV technology are investigated and suggestions for betterment through policies for the future are made.

Keywords: Green Technologies, Electric Vehicle, Turkey's EV Policy, Chasm

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Introduction

In 1890, "*La JamaisContente*," the first EV, was invented. It was able to reach speeds up to 100 km/h. In contrast, the internal combustion engines (ICEs) were much slower and problematic. However, EVs have not received the expected interest and satisfactory sales figures so far (Midler & Beaume, 2009). They failed to replace the ICE technology, as did the steam car, which was another promising technology of time. EV did not pick up enough attention from final consumers and manufacturers back then, and although it reappeared in the market from time to time, it was never been able to be a favored or comparable alternative to ICE. The core of the EV is the battery. Technological development on batteries' capacity did not improve much since the 1890s. Dramatic improvements took place in the first decade: going from 10Wh/kg to 18Wh/kg in 1901, and then to 25Wh/kg in 1911. Afterwards, its technological evolution reached a slowdown; it took 80 years to double battery life and capacity (Soares, Almeida, Lopes, Garsia-Valle, & Marra, 2013).

The volatility in the oil prices forced multinational corporations to seek price competitive technologies for the automotive industry (Ustaoğlu & Yıldız, 2011). Moreover, the upcoming danger, Green Gas Emissions (GHG) is expected to increase in the following 20 years by up to 45% (Bretschger, 2011). As a result of GHG and other negative factors, concerns about climate change arose and together with energy security came renewed interest in EV. This coerced certain states to enact certain regulations for zero-carbon-emissions standards in the United States. The first state to lead the effort was California. Due to severe air pollution in the Los Angeles metropolitan area (caused by motor vehicles), California had a special exemption from the federal government to update its own automobile emission standards (Mom, 2004). Then, other states, (including New Jersey, New York, Connecticut, Oregon, Washington,) referred to as the "CARB" states followed in the same fashion and adopted California's emission standards (Matthew, 2008).

The Environmental Protection Agency (EPA) also took California's emission standards and set it to be the national standard of 2016. This accelerated the adoption of green technologies by corporations (USEPA, 2011). The Obama administration contributed to the adoption of EV by setting a goal of one million plug-in vehicles by 2015, and enacted legislation and policies accordingly (Hidrue, Parsons, Kempton, & Gardner, 2010).

Additionally, the US Department of Defense is investing about $20 million to demonstrate the concept of using a fleet of electric vehicles with hopes that the EV will offset the high purchasing costs (Knowles, 2013). Furthermore, thanks to increasing awareness of environmental issues such as eco-efficiency, consumer demand toward green technologies is increasing (Noci & Verganti, 1999). The demand prompted production of EVs by several manufacturers. Between 2008 and 2013, approximately 140,000 EV have been sold in the United States (Voelcker, 2013; Cobb, 2013). Chevrolet Volt, Nissan Leaf, and Tesla Model S are the top selling EV models as of September 2013 (Cobb, 2013; Voelcker, 2010).

During the evolution of EV, it has taken so long for EV to take the lead in green technologies in the automotive industry due to several reasons. The main concern was the perception of poor cost/performance charts that are aided also by the negative media attention (Voelcker, 2010; Carroll, 2011). EVs had to alter the misconception in the media and in the markets by offering a competitive advantage over ICE in three categories: drivability, braking behavior, and practical design. Drivability should ideally be based on realistic driving conditions rather than standard patterns since the former will produce test cycles more fitting to real world use. When it comes to braking behavior, electric cars possess the same feature of hybrid electric cars called *regenerative braking*. Regenerative braking utilizes the electric motor as a generator during braking; its output is supplied to an electrical load where the transfer of energy to the load creates the braking effect. Although regenerative braking methods are a great means to support electric battery, its technology has its own limitations. For example, at lower speeds, the braking effect drops thus requiring reinforcement by friction brakes for a vehicle's complete halt. Moreover, regenerative braking can only occur when no other electrical component on the same supply system is drawing power. Under emergency brake conditions, the power required to be dissipated could be many times the maximum power delivered under acceleration - that is why the friction brakes are again required as supplementary support (Musk, 2013). Practical design is also another issue that needs to be addressed in order for EVs to offer a competitive advantage over ICE (Knowles, 2013).

What are termed "truly discontinuous innovations" are what cause the consumer and the market to alter existing behaviors (Knowles, 2012). However, before a disruptive technology can be assimilated into a mainstream marketplace, it must pass through multiple phases of adoption during which the market behaves differently in each phase.

Moore (1991) studied these phases in his work of technological adoption lifecycle and identified five subdivisions of consumers. The major barrier before new technologies are finally adopted - which Moore (1991) defined as *chasm* - is being used to explain Turkey's current position of EV technology in the market. Moore also notes that what prevents the majority of consumers from adopting the technology are the *pragmatist* consumers, (i.e., those who do not adopt a product until it becomes a *whole product* which offers performance, convenience, and price competitiveness against the old technology.) The psychological barriers which prevent EVs extend within domestic and global markets include the final consumer doubts and expectations axis with manufacturers' achievements. To identify the possible barriers to EV approbation, we have used consumer's concerns documented in a survey conducted in Turkey. Central and municipal governments' roles will be investigated. Also, the political efforts and government policies' effectiveness will be examined under current circumstances. The growth opportunities for electric vehicles will be illustrated and the current position of Turkey will be discussed. Finally, in the light of the study of Philip &Wiederer (2010), which matches the policy levers with the barriers in the cities of Climate Leadership Group (C40) which includes Istanbul, the writers have put forth suggestions policy levers should take into consideration in order for Turkey to increase EV use and cross the chasm.

1. Literature Review & Hypothesis

1.1. Crossing the Chasm in the New Technology Adoption Cycle

Although the first EV was developed almost as early as the ICE, for several reasons it did not gain enough recognition in the automotive market. Nevertheless, EV offers a great deal of competitive advantage over ICE due to a number of reasons determined from the surveys. However, it still is not at a level to discontinue its prior technology. Ever since the first penetration of EV to the Turkish automotive market, EV was similarly not embraced by the masses of consumers. The survey results that are conducted in Turkey reveal that EV technology is still at a point that calls for improvement in several aspects to fulfill the expectations of the great majority.

The current production plans and the demand for EV indicate that the technology is still at a very early stage in its lifecycle. As all disruptive technologies experience the certain stages of technology adoption lifecycle, the authors examine the current stand of EV in these stages, and suggest what could be done for EV to gain competitive advantage and crossover the so-called *chasm*.

To further explain the EV's position in the current market and the possible solutions for consumer adoption, the concepts in Moore's study (1991) titled, "Crossing the Chasm," are used.

Discontinuous innovations are defined as new products or services that cause the consumer and market to alter their existing behavioral trends (Knowles, 2012). However, before a disruptive technology can be absorbed into a mainstream marketplace, it has to pass through multiple phases of adoption. In each phase, the market behaves differently. The end goal of all these transformations is to create a sustainable value chain that can transform the new technology into reliable, usable contributions. In other words, the goal is to raise the so called *main street* state of business maturity in which technology-enabled businesses resemble most other sectors of the economy (Moore, 2002). Technology adoption life cycle models the response of any given population to the offer of a discontinuous innovation - one that forces abandonment of traditional infrastructure and systems for the potential of previously unavailable sets of benefits. According to Moore (1991) the bell-curve in Graphic 1 represents the five subpopulations and the market phases during the technology adoption life cycle (Moore, 1991).Moore (1991) divided the consumer types into five categories: *innovators, early adopters, early majority, late majority* and *laggards*.

These are also recognized in different terms in literature such as *technology enthusiasts, visionaries, pragmatists, conservatives* and *skeptics*, respectively (Moore, 1991; Moore, 2002). The authors will be using the latter categorization in our study. Although one can go into detail and explain all five subcategories of consumers, our study focuses on the *chasm* that is caused by the different characteristics of visionaries and pragmatists. According to Moore (1991), the market should focus on one group of customers at a time, using each group as a base for marketing to the next group. The most difficult step is making the transition between early adopters of the product (technology enthusiasts and visionaries) and pragmatists (early majority). The difficulty in going toward the segment of pragmatists is what *chasm* is referred to (Moore, 1991).

Moore further explains the characteristics of pragmatists and what they want more than anything else is a 100% solution to their problems, i.e. what can also be referred as the *whole product.* Pragmatists would only buy the product when it is whole product.

Very few innovative products reach the whole product stage and crossover the chasm. It is an obvious high pay-off challenge for companies to crossover the chasm to reach the mainstream market. The pragmatists and conservatives form the mainstream market where technology is widely adopted and companies make substantial revenue (Knowles, 2012).

Moore (1991) further explains his theory on understanding pragmatists introduces strategic solutions to crossover the chasm. As pragmatists feel comfortable in moving in herds, they evaluate the entire value chain, and not just the specific product offer. Because value chains form around herds, there has to be enough repeatable business in the pipeline to reward an investment (Moore, 2002). As mentioned, low resale figures are one of the major drawbacks of EV. Since pragmatists are unlikely to take risks, this is a major concern that has to be addressed before their adoption of the EV technology.

2. Adoption of Ev Technologies

2.1. Psychological Barriers on Global Consumer Demand

Manufacturers' production strategies are based on consumers' preferences and interests. The consumers are the ones who tell the market suppliers what and how to produce. In this case, this translates into less expensive, greener, performance quality, and generally more developed EVs technologies. The research surveys focused on EVs technologies at a point where they do not meet the market expectation at present time. The general expectations are that they should be able to go farther, on less charge time, for a cheaper price than auto manufacturers are currently offer (Deloitte, 2011). Due to the manufacturer's inability to meet market expectations', government policies still play a key role in influencing first mover's motivation to purchase EV technologies (Diamond, 2008). Policy makers believe that several factors such as monetary incentives, gas prices, and travel distance have a direct impact on consumers. However, incentive policies have a limited vision and focus mainly on these factors; this gives leeway for criticism of the effectiveness of these policies.

In many instances, it has been seen that consumer demand could not be swayed by these kinds of policies. The differences in technology accumulation, advantages of ICEs, and disadvantages of EVs create psychological barriers on final consumers.

Contrasting both technologies further would help to offer a better understanding of the current situation. ICE has dominated the transportation market for over a century and offers more to final consumers. So it has obviously come a long way. Another simple core fact which explains final consumers' demand of ICEs is power. Lead-acid technology is the most developed battery technology used on EV so far. It has a nominal specific energy of 30 Wh/kg, while gasoline is about ninety-three times more than that (Soares, Almeida, Lopes, Garsia-Valle, & Marra, 2013). Manufacturers are focused on battery density to increase the capacity to 200-250Wh/kg by the year 2020. On the other hand, according to survey studies, the cost of "power" for environment and economy is much higher than renewable energy sources offer.

According to J.D. Power and Associates (2008) report, covering US consumers, many first movers stated sensitivities towards environmental issues, however, only eleven percent of them were willing to purchase EV-based technology. The demographic backgrounds of EV purchasers are mostly female and highly educated. The EV consumer could be characterized with the following features: highly educated, high household income, and being four years younger than the average new vehicle buyer profile. European and developing countries' markets, (such as Turkey, Brazil, India, China, and Argentina,) seem more interested than developed nations, such as Japan, U.S.A., Germany, and France (Diamond, 2008; J.D. Power Associates, 2008). On the other end, power, performance, convenience, safety, stylishness, and good value are still very important key factors for male buyers.

According to Deloitte's survey (2011), more than eighty-five percent of the respondents stated that the extremely important issues are range, convenience to charge, cost to charge, and the resale market, and meeting current expectations. Manufacturers come up with different technologies and ideas to solve the range issue. For example, Chevrolet's EV model, *Volt*, has a built-in generator that expands to a range distance of up to 500 km. BMW offers to its customers an ICE vehicle for long distance travels. Range, however, is still a psychological barrier, even with manufactories' different solutions to meet consumers' expectations.

U.S., UK, and Japanese governments' subsidize EVs premium sales price in order to make them more attractive in the market and help manufacturers go for mass production in order to reach the level of economies of scale.

An EV's battery cost is approximately $16k and is equal to almost fifty percent of the vehicle's manufacturing cost; this is estimated to decrease by forty percent by the year 2020. Battery manufacturers are key providers and they expect to expand their battery production units from 172k to 1.51 million by 2015. This is hoped to reduce the manufacturing costs. Battery cost structure is mostly based on labor cost, (which are high,) electronic parts, and volatility of key metals' price that prevents manufacturing cost to decrease. With these high production costs, the effectiveness of governments' direct price subsidizing policies is debatable. It clearly does not remove the psychological barrier for the final consumer. Another key issue, which creates psychological barriers for final consumers, is battery-charging time. The manufactures, such as Renault, offer different solutions to shorten the charging time. Renault does not sell the battery to its customers instead it leases it for 83€ per mount. Therefore, the battery is replaceable at charging stations in two minutes; however, this idea has its downsides as well. The charging stations are very limited in almost every country. So long charging time and insufficient amount of charging stations are other key factors that keep final consumers from deciding to purchase an EV.

Fossil fuels are limited energy sources and cause a variety of problems for modern economies including, but not limited to: environmental issues, crude oil price volatility, increasing demand, etc. EVs operating costs are lower compared to other transportation options, and mostly subsidized by governments. This still has not attracted the final consumers' attention, though EVs were generally seen as a promising popular alternative to ICEs from the beginning. By 2050, expected annual sales estimates are over 100 million units worldwide (Soares, Almeida, Lopes, Garsia-Valle, & Marra, 2013). Needless to say, this is far behind today's sales. The studies and surveys, which examine the demand for EVs, mostly conclude that they are a temporary solution for metropolitan cities CO_2 emission problem. They are suitable for daily use in metropolitan cities, however, cost related problems and psychological barriers again keep drivers away from this technology. Markets' offering simply does not meet the consumers' expectation for range, charge time, and purchase price, globally.

Combinations of these factors create psychological barriers for final consumers. It does not seem to eliminate EVs technological limitations in the near future in the final consumer's mind; thus, the psychological barriers will remain.

2.2. Current Policies and Incentives in the United States

The U.S Energy Information Administration estimates that approximately two thirds of the oil consumption in the U.S. takes place in transportation throughout the country (USEIA, 2012). The increased oil consumption poses a threat to the environment and air quality. Since the upcoming threat of GHG is expected to increase up to forty-five percent in the following years, it forced certain states in the U.S. to pass regulations for a zero-carbon-emissions standard (Bretschger, 2011). Los Angeles, California, is the most intense metropolitan area in terms of car density, and was premier in seeking solutions for air pollution. Regulations for zero-carbon-emissions was first enacted by California State and subsequently by other states that are referred as CARB states. They adopted the same standards as California. CARB includes states in the major metropolitan areas such as New Jersey, New York, Connecticut, Oregon and Washington (Matthew, 2008).

After the wide adoption of these standards, the EPA finally adopted California's emission standards as the National Standard by 2016 (USEPA, 2011). This certainly added to the pace of green technology adoption by corporations because vehicles that are not dependent on gasoline reduce the gas emissions in comparison to ICE. According to the U.S Department of Energy's Alternative Fuels and Advanced Data Center, in most areas in the U.S., emissions are likely to be less than those of a conventional ICE (National Conferance of State Legislatures, 2013).As a new transportation technology, EV will have to overcome several barriers to gain widespread adoption. It needs assistance from the federal and state governments to overcome these barriers. To help overcome some of these barriers, the U.S. government has come up with a series of policies and incentives.

The Obama administration aimed to accelerate the adoption of EV through several legislations and policies. First of all, the government set a goal of one million plug-in EV being on the road by 2015. Subsequently, several legislations and incentives were taken in action in order to consolidate this goal (Hidrue, Parsons, Kempton, & Gardner, 2010).

The U.S. Department of Energy (DOE) announced that EV purchased in or after 2010 would be eligible for a federal income tax credit up to $7,500 (USDE, 2010).

DOE also partnered up with private companies to fund the EV project, which has facilitated the installation of over 8,000 residential and public charging stations in cities across the country (Salisbuly, 2013)[28].

IRS also announced that the qualified EV credit phases out for a manufacturer's vehicles over the one-year period beginning with the second calendar quarter in which at least 200,000 qualifying vehicles manufactured by that manufacturer have been sold for use in the U.S. The qualified EV that is manufactured by the manufacturer is eligible for up to 50% of the credit in the phase-out period (IRS, 2013). Furthermore, as of July 2013, 38 states have implemented incentives that would provide high occupancy vehicle (HOV) lane exemptions, monetary incentives, vehicle inspections or emissions test exemptions and parking incentives (National Conferance of State Legislatures, 2013). As an example, to accelerate EV adoption, California has ended free access of Hybrid EVs to HOVs and facilitated free access of EV to HOV through January 1, 2015 (Voelcker, 2010). States in metropolitan areas such as New Jersey and California facilitated purchase rebates, (in some cases, up to $3,000 for an EV.) Moreover, as charging stations are a strong barrier for vast EV adoption, state governments try to tackle this issue by facilitating permits. Some U.S. cities including Los Angeles, San Francisco, San Jose, and Oakland already started taking action (RMI Institue, 2013).

2.3. What are the Policy Options, Suggested in C40 Cities Including Istanbul?

Cities can mandate that EV charging equipment of a certain level is included in any new construction and can also influence where and how many charging stations can be installed in a particular area in order to increase the availability of charging stations. Governments can facilitate streamlining and expediting permitting processes, which are a means to establishing charging infrastructure to make it easier and cheaper for EV users and charging infrastructure providers (Philip & Wiederer, 2010). Philip&Wiederer (2010), conducted a policy analysis within C40 cities to identify the infrastructural and EV deployment barriers and suggested what policy levers can do to help mitigate or remove those barriers. A series of recommendations were also made. Since the study also includes Istanbul, it is critical to mention some of the recommendations in our study.

Cities with low levels of private off-street parking are likely to experience a lower EV uptake, thus subsidizing on-street parking would speed up the process of EV adoption.

Though municipal governments have limited sources to mitigate up-front EV cost, they, nevertheless, can utilize other policy levers to decrease the effect of it. Although the majority of the credit made is through federal and provincial governments in up-front costs, municipal governments can include waiving congestion charging and parking costs, providing free/discounted electricity for charging, preferred street access, and help reduce the lifetime costs. There are still barriers such as ambiguity in sale of electricity, regulations on EV investment by utilities, and technical standard for charging stations. Cities can or should use the regulatory influence to mitigate and remove the barriers to create a favorable environment for private investors.

2.4. Introducing EVs to Turkish Market and Domestic Production upon R&D

Turkey has been considered a promising emerging economy since the beginning of the 2000s; however, it struggles with its current budget deficit which is 54 billion USD (as of 2011) mostly due to oil imports, which are dependent upon energy demand. Transportation uses sixty-two percent of energy import which is equal to 33.6 billion USD. Increase in e-mobility will possibly decrease the dependence on oil imports. EVs charging will most likely be done during the night when the electricity tariffs would be lower; therefore, existing electrical structure would be protected from extra pressure. Turkish government's motivation is based on three key factors. First, Turkey has a strong automotive industry and needs to follow the technological developments taking place regarding intelligent vehicles and transport systems. Electric transportation technologies offer many strategic advantages for the country. Second, a considerable amount of carbon emissions from motor vehicles is a great concern in relation to climate change.

Environmental issues are becoming a serious problem for developing economies. The governments' policies are focused on lowering GHG emission, especially in Turkey, given that the EU membership process sets a limit on emissions. EVs can be a remedy. Finally, EVs might be an alternative to lower oil import, and can lower the dependence upon it. As mentioned, imported oil has a negative influence on the current budget deficit (NL EVD Internationaal, 2013). The development strategy has been an export-oriented development model since 1980.

Therefore, foreign trade volume is one of the key elements for domestic economy.Science, technology, and innovation capacity has turned out to be one of the most prominent factors of competitiveness and sustainable development for economies. R&D and innovation activities are especially important to overcome the economic crisis and to take advantage of new opportunities (Tuncay-Celikel, 2010). The auto industry contributes significantly to the foreign trade volume by level of export-import in Turkey, the sixth largest producer among European countries.

However, EVs technologies face very low demand in domestic market and does not seem likely to dominate in near future. Approximately 190 EVs were sold in 2012 countrywide (Frost & Sullivan, 2013). The EV market is in its beginning phase according to International Energy Agency.

Twelve OEMs are expected to launch EV models in Turkey in next 5 years (Tuncay-Celikel, 2010; Frost & Sullivan, 2013). The Japanese joint ventures, Toyota and Honda, are the first manufacturers that introduced the Turkish market to EV based passenger vehicles. Toyota Prius and Honda Civic Hybrid were released recently in 2010. In 2012, another joint venture Renault started sell the first *fully electric* sedan EV model Fluence Z.E. with a sales price of approximately $26,000. Some domestic and foreign companies started to introduce their EV models on their websites. Electric two-wheelers have also appeared in the last few years, however, they have not achieved significant market penetration (Tuncay-Celikel, 2010).

It is estimated that 30k EVs will be sold in Turkey by the end of 2015, and ten percent of the total passenger vehicle sales will be EV technology by 2020. Worldwide estimated EV usage will reach up to 13 million in 2020, over a million in Germany and USA, and China aims to put more than 4 million vehicles on the road (IEA, 2013). Research topics relevant to EV technology are obviously a part of automotive R&D. Major auto manufacturers have devoted an increasing budget to develop competitive EVs in recent years (Tüccar, Tosun, Özcanlı, & Aydın, 2013). It is inevitable that scientific and industrial interest would sore upon public interest.

The major EV's R&D intuitions are respectively TUBITAK (Technical and Scientific Council of Turkey), MRC (Marmara Research Centre) Energy Institute, Istanbul Technical University OTAM (Automotive Technology Research and Development Centre), MEKAR (Mechatronics Research) and industry manufacturers like FORD, TOFAŞ (MEKATRO R&D), TEMSA, and OTOKAR.

The R&D work on the first domestically developed EV was conducted at TUBITAK Marmara Research Centre (MRC) Energy Institute. The model, TOFAŞ's FIAT Doblo, was introduced in 2002 featuring a battery power of 30kW. A small combustion engine was coupled with a generator, which supplies the electric motor that rotates the front wheels through differential. Later, Ford Otosan formed a research team within MRC, Istanbul Technical University OTAM and MEKAR in order to combine EV development projects. Hereat, this research yielded two prototypes, FOHEV 1 and FOHEV 2, for a light commercial vehicle called the Ford Transit Van.

The other efforts are respectively MEKATRO's direct hub drive development for FIAT, and Temsa and Otokar's hybrid projects for commercial buses. As far as full electric drive is Renault's Fluence ZE, prototype has developed in France and manufactured domestically, introduced to market in 2012(Tuncay-Celikel, 2010). Another important issue for EVs is charging station within the country. Along with the other two İstanbul Metropolitan Municipality associations, BELBİM (related to the information technologies) and ISPARK (related to the car parking services), İstanbul Enerji has been planning to install the required infrastructure for charging the electric vehicles in İstanbul, where the most of the new vehicle are sold. The first demonstration charging stations are planned for the parking lots and the social facilities of the municipality(IEA, 2013).

There are mainly five companies (EŞARJ, FULLCHARGER, YEŞİL GÜÇ, BD OTO and GERSAN) invested to charging stations in domestic market some of them supported by government and industry manufacturers. EŞARJ has installed around 300 charging station within the country and twenty-four of them are located in İstanbul. There are more charging stations in the country when compared to 200 registered EVs on the road. Three metropolitan governments (İstanbul, Ankara, and Gaziantep) are developing policies in order to encourage EV technologies to become widespread. Istanbul Enerji has started a project to establish charging infrastructures and signed protocol with charging companies to install charging units in public areas such as ISPARK and Public Buildings. The consumer demand and public interest is still very low to EV technologies despite government's and industry's efforts.

2.5. Economies of Scale from Final Consumer Perspective

The total fleet of vehicles on Turkey's road is about 15 million, and only 200 of them EVs. The EV number is increasing by time; however, there are still uprising psychological barriers against EV based technologies. Manufacturers are not able to decrease cost, and final consumers are not willing to purchase an EV for many reasons but common ground for most of them is economies of scale. The key question is "Does EV suitable for individuals and small businesses?".There are some merits of using EVs for urban transportation due to quiet electric motor, higher efficiency at lower engines load that makes them advantageous in heavy traffic conditions where it is not possible to operate the vehicle at higher speeds, quicker and more accurate torque generation of electric motor, and finally, driving and braking force of an electric motor between tire and road surface (Tuncay-Celikel, 2010).

Table 2. Comparative cost analysis of Renault Fluence ZE and Fluence 1.5 dCi 105 HP

		Vehicle	
		Fluence 1.5 dCi 105 HP ($=USD)	Fluence Z.E. 95 b ($=USD)
Cost	Initial Cost	$21,867	$26,684
	PCT	$9547	$944
	VAT	$3936	$4803
Total Cost		$35,351	$32,432
Maintenance Expenditures		$590	$224
Wear and Tear Parts		$548	$631
Fuel Consumption per 100 km		5,3 liter	22 kW
Fuel Cost		$2/liter	Day: 13 ¢/kWh**
			Puant: 21 ¢/kWh
			Night: 8 ¢/kWh
MVT		$1661	$0
Fuel Expenditures per 100 km		$11	Day: $2,9
			Puant: $4.51
			Night: $1.94
Fuel Expenditures per 60000 km		$6616	Day: $1751
			Puant: $2711
			Night: $1167
Battery Expenditures		$0	$6468
Total		$44767	Day: $41,508
			Puant: $42,468
			Night: $40,924

Source:(Tüccar, Tosun, Özcanlı, & Aydın, 2013)

The operating advantages of EVs make them convenient for heavy traffic load metropolitan areas such as İstanbul, Ankara and Gaziantep. In order to test EVs comparative advantages with ICEs, Renault Fluence 1.5 dCi and Fluence ZE are suitable samples. Tüccar, Tosun, Özcanlı, & Aydın (2013) study measured final cost effectiveness of EVs by Turkeys operation costs and conditions. And they concluded that most important cost handicap of EVs, which creates drawback for final consumers, is their manufacturing cost.

The above calculations are based from 4 years of usage and 15k km per year. As final results EVs have slight cost advantages (almost 10% with night charge and 5% with day charge) compared to ICE vehicles for average consumers usage. However, for small businesses, which makes over 15k km per year, cost benefits increase. The maintenance expenditures calculated for same usage period below.

Table 3. Maintenance Expenditures

		Vehicle	
		Fluence 1.5 dCi 105 HP ($=USD)	Fluence Z.E. 95 b ($=USD)
Maintenance Expenditures	Labor	$138	$55
	Engine Oil	$203	$0
	Air Filter	$76	$92
	Oil Filter	$19	$0
	Cabin Filter	$91	$78
	Oil Bung Gasket	$1	$0
	Fuel Filter	$63	$0
Wear and Tear Parts	Front Brake Pads	$162	$162
	Front Brake Disc and Pads	$214	$286
	Rear Brake Pads	$77	$87
	Windscreen Wipers	$96	$96

Source: (Tüccar, Tosun, Özcanlı, & Aydın, 2013)

According to a study, comparative cost analysis is conducted to explore cost effectiveness of EVs and results show that EVs are slightly offer cost advantages compared to ICEs in heavy traffic load cities like İstanbul.

It is clearly stressed that governmental policies plays crucial role in order to spread EVs technologies broader markets.

3.1. Governmental Policies: Contrasting Domestic Efforts with Global Policies

Turkey has several policy instruments to support the "greening" of transportation, which could also help encourage the use of EVs. Turkey aims to fully cohere with EU legislation on transportation sector, and emission standards for all gasoline and diesel vehicles have matched the Euro IV standards since January 2009 (IEA, 2013).Government's EV technology policies' integrated from municipal and central government's policies combination and mostly focused on R&D in order to serve purpose of creating and supporting manufacturing industry in long term. Central government policies are limited to support R&D attempts and TAX breaks for final consumers, while municipal governments involve variety of developments. The main legal formation in order to support R&D on recent years are listed below (NL EVD Internationaal, 2013);

- Law Number 4691 on Technology Development Zones (2001): Aims at increasing cooperation between universities, R&D institutions and industry,
- Industrial Thesis Program: SAN-TEZ support (2007),
- Law Nr. 5746 regarding the Encouragement of R&D Activities (2008): Aims at developing the R&D infrastructure of Turkish industry,
- Pre-competition cooperation projects (2008): Refers to the cooperation among companies fordeveloping innovative products that are not yet introduced in the market,
- Techno-entrepreneur capital support (2009): Aims at entrepreneurs with prospective projects.

The efforts, to broaden EV technology usage, is not limited to legislative regulations. However, central government mostly detaches from rest of the world on this issue instead of subsidizing final consumers by price reduction make it look like more attractive. Central government's recommendations combined in two ministerial strategic documents that would impact the incentives for purchasing EVs when they appear in market. The first strategy document is energy efficiency, and the second document focuses on the automotive industry which includes an action plan for implementation [36].

The automotive industry has been identified as an area with a strong R&D and innovation potential; therefore, "National Science, Technology and Innovation Strategy 2011 - 2016" is a TÜBITAK's support project and aims at contributing to develop innovative technologies domestically. The Research and Support Programs are mainly for academics (*see appendix 1 for detailed list of supported programs*). ARDEB is responsible for the "1003 Priority Areas Research and Development Support Program", which also has started in 2012. Universities' R&D projects, regarding the electric and hybrid vehicles, are granted various supports under this program(NL EVD Internationaal, 2013).The central government's incentive program for final consumers is limited to tax breaks. In Turkey, motor vehicle taxes are one of the highest in the world for conventional vehicles, which dramatically increase cost of driving for final consumers. Therefore, tax reduction policies estimated as an effective way to support EVs sales. Two types of taxation measures are imposed on vehicles in Turkey(IEA, 2013);

- A tax on an initial new vehicle sale (special consumption tax, see below table)
- An annual vehicle tax, which is paid yearly and is currently based on the engine cylinder volume and the age of the vehicle, not the emission rates

Government's tax rates have been criticized by both consumers and manufacturers. However, there is no reduction expected on conventional vehicles tax rates in near future. Therefore, easiness on EVs tax rates might positively affect and promote sales. The special consumption tax rates on EVs are lower than conventional vehicles. On the other side sales tax reduction only applicable for battery electric vehicles and EV motorbikes.

Table 4. Turkish Government's Vehicle Taxation Rates (Conventional and EV)

	Conventional		**Electric Only**	
	Engine Cylinder Volume (cm3 cc)	Special Consumption Tax (%)	Electric Motor Power (kW)	Special Consumption Tax (%)
PASSENGER VEHICLE	<1600	37	<85	3
	1600-2000	60	85-120	7
	>2000	84	>120	15
MOTORBIKE	<250	8	<20	3
	>250	37	>20	37

Source: (IEA, 2013)

Municipal governments' interests on EV technology are wider than central government. İstanbul, Ankara and Gaziantep Metropolitan Municipalities encourages and develop different policies in order to promote technology. The aim of the policies could be categorized (IEA, 2013):

- Increasing the number of projects that could favor the use of EVs in cities by focusing on charging networks,
- Install and develop a network of charging stations for electric vehicles,
- Develop special projects for public fleets, public spaces,
- Developing projects to using EVs on public transportation which accounts only 25% of the registered vehicle and causes 30% of CO_2 emission.

Insufficient charging stations are most important barrier for final consumers, and it is not possible to extend them without municipalities' support. They should increase the number of the charging points and stations specifically at public parking and should regulate private parking; even though, there is more charging stations than registered EVs within the country at the moment. Another supportive effort to increase EV usage within to country is purchasing EVs for their own fleet in limited numbers. More than half of the registered EVs are owned by municipal government. The municipal government brings forth much more effort to support EV technologies within country; however, effectiveness of the policies is still questionable.

Conclusion

A good strategy to cross the chasm in new technologies is to create a value chain where there were no market and no value chain before. The conducted surveys clearly reveal that Environmental Concerns alone, are not the main motive to adopt EV technology because range, convenience to charge, cost to charge and resale market are significant barriers. The current technology of EV, still is very new and cannot meet market expectations in terms of performance and cost charts. Approximately 190 EVs sold in 2012 in Turkey. EV market is in its beginning phase according to International Energy Agency and 12 OEMs are expected to launch EV models in Turkey in next 5 years. Because of high up-front costs, EV does not bring a competitive advantage against its former technology ICEs and thus the main street consumers including pragmatists and conservatives do not adopt the EV technology.

The governments and do not have a big influence on technology part but central and municipal governments' policies can still play a key role in influencing first mover's motivation. Withoutsatisfying early adopters such as technology enthusiasts and visionaries, one cannot crossover the chasm and reach pragmatists. Therefore, it is essential for Turkish government to take extra steps through incentives and policies to better the infrastructure, cost, and resale problem that are concerning the substantial EV consumers. Istanbul has very limited off-street-parking due to its intense structure. The primary barrier that refrains EV from gaining competitive advantage over ICE is its upfront costs because almost 50% of EV's total cost is caused by battery technology.

Renault offers its customers to lease the battery to reduce the upfront cost, however the sale's price is still approximately $26,000. Recalling that in Turkey, motor vehicle taxes are one of the highest in the world for ICE, which dramatically increase cost of driving for final consumers, the central government's incentive program for final consumers is limited to tax breaks. Therefore, authors believe that tax reduction policies estimated as one of the most effective ways to support EVs sales. Moreover, better EV technology investment policies that will attract other EV manufacturers to penetrate to Turkish market, thus more competitiveness would speed up the solutions for cost/performance advancement. EŞARJ has installed around 300 charging station within the country and 24 of them located in İstanbul. Furthermore, insufficient charging stations is one of the most significant infrastructural barriers that hinders the productivity that of *pragmatists* require.

The Turkish government and Istanbul municipality government should bring forth more policies and incentives to increase the number of charging stations. Other incentives that would attract the consumer in a city like Istanbul, where parking is a major problem, would be that of offering free parking for EVs, following the fashion London municipality government offers eliminating parking fees in city center and toll exemption. With current central and municipal government policies, technological barriers, not enough competitiveness in the price, psychological barriers, EV does not seem to respond the expectations of the *main stream* consumers unless more effective policies and incentives brought forth for by the central and municipal governments.

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APPENDIX 1. Public Intuitions Responsibility Table

Objective	Institution in Charge	Institutions to cooperate with
1.1	MoSI&T	Ministry of Finance, Ministry of Environment &Urbanisation Ministry of Development , Ministry of Economy Turkish Standards Institute (TSE), NGOs
1.2	MoSI&T	Ministry of Education, Ministry of Development, Ministry of Economy, High Education Council (YOK), UniversitiesNGOs (Union of Chambers of Commerce & Industry (TOBB), Automotive Manufacturers' Association (OSD), Automotive Supplier Industry Association (TAYSAD)
1.3	Ministry of Finance	MoSI&T, Ministry of Development, Ministry of Economy The Scientific and Technological Research Council of Turkey (TUBITAK), Small and Medium Sized Enterprises Development Organization (KOSGEB), NGO's (TOBB, OSD, TAYSAD), Undersecretariat of Treasury
1.4	MoSI&T	Ministry of Finance, Ministry of Development, KOSGEB, TUBITAK, NGOs (OSD, TAYSAD)
1.5	KOSGEB	Ministry of Labor and Social Security, Ministry of Economy TUBITAK, Ministry of Development, Turkish Patent Institute, NGOs, (TOBB, OSD, TAYSAD)
2.1	MoSI&T	Ministry of Finance, Ministry of Economy, Ministry of Development TUBITAK, NGOs (TOBB, OSD, TAYSAD)

2.2	MoSI&T	Ministry of Finance, Ministry of Economy, KOSGEB, Undersecretariat of Treasury, Turkish Patent Institute
2.3	Ministry of Economy	MoIS&T, Ministry of Finance, Ministry of Energy and Natural Resources, Ministry of Environment &Urbanization Ministry of Development, KOSGEB, TUBITAK, Energy Market Regulatory Board, TSE
2.4	MoSI&T	Ministry of Development, Ministry of Economy, KOSGEB, NGOs (OSD, TAYSAD, Uludag Automotive Industry Exporters Union (OIB))
2.5	MoSI&T	Ministry of Development, Ministry of Economy, TUBITAK NGOs (TUSIAD, OSD, TAYSAD)
2.6	Ministry of Education	Ministry of Labor and Social Security, Vocational Qualification Authority (MYK) YOK,TSE Turkish LaborOrganization (ISKUR), KOSGEB, NGOs (TOBB, TUSIAD, Turkish Employers' Association of Metal Industries (MESS), OSD, TAYSAD, OIB)
2.7	MoSI&T	Ministry of Economy, Ministry of Development NGOs (TOBB, TUSIAD,OSD, TAYSAD, OIB)
3.1	MoSI&T	Ministry of Customs and Trade, NGOs (TOBB, OSD, TAYSAD, Automotive Ditributors Association (ODD), Association of Automotive Agents (OYDER))
3.2	Ministry of Economy	NGOs (OSD, TAYSAD, OIB, Turkish Exporters Assembly (TIM))
3.3	Ministry of Finance	MoSI&T, Ministry of Interior, Public Procurement Authority
3.4	Automotive Manufacturers Association (OSD)	MoSI&T, Ministry of Environment &Urbanisation, NGOs (OIB, TIM, ODD, OYDER)
3.5	Ministry of Transport, Maritime Affairs and	MoSI&T, Ministry of Finance,

	Communications	Ministry of Interior Ministry of Environment &Urbanisation
3.6	Ministry of Finance	MoSI&T, Ministry of Environment &Urbanisation, Ministry of Interior, Public Procurement Authority
4.1	Ministry of Finance	MoSI&T, Ministry of Environemnt&Urbanisation, Ministry of Development, NGOs (OSD, TAYSAD, ODD)
4.2	Ministry of Environment & Urbanisation	Ministry of Transport, Maritime Affairs and Communications Ministry of Economy, Ministry of Finance, Ministry of Development MoSI&T, Ministry of Interior, NGOs (OSD, TAYSAD, ODD)
4.3	MoSI&T	TSE, Technical Service Institutions, NGOs (OSD, TAYSAD, ODD)
4.4	MoSI&T	Ministry of Economy, Ministry of Transport, Maritime Affairs and Communications, Ministry of Customs and Trade, TSE, NGOs (TOBB, OSD, TAYSAD, ODD, OYDER)
4.5	MoSI&T	Ministry of Environment &Urbanisation, NGOs (OSD, TAYSAD)
5.1	MoSI&T	Ministry of Finance, Ministry of Development, Ministry of Economy
5.2	Ministry of Transport, Maritime Affairs and Communications	Ministry of Environment &Urbanisation, Ministry of Development Ministry of Economy, Ministry of Customs and Trade, Turkish State Railways (TCDD), NGOs (TOBB, OSD, TAYSAD, OIB, TIM, ODD)
5.3	MoSI&T	Ministry of Finance, Ministry of Transport, Maritime Afffairs& Communications, Ministry of Energy and Natural Resources Market Regulatory Authority (EMRA), TSE, NGOs (TOBB, OSD, TAYSAD)
5.4	MoSI&T	Ministry of Economy, KOSGEB, NGOs (TOBB, MESS,OSD,TAYSAD)