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Title: ELECTROMOBILITY IN GERMANY – STATUS QUO IN INTERNATIONAL COMPARISON AND FUTURE PERSPECTIVES

HFU Business School

IMM Research Project report

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Keywords: *e-mobility, electric car industry, Germany*

Abstract: Germany is one of the leading countries in automotive industry as it houses many big automakers of the world. Since electromobility is becoming popular worldwide, the country also follows the trend to reduce pollution and climate change which have long been a serious environmental problem. This paper researches on the current situation of e-mobility in Germany and suggests solutions to overcome obstacles which this country is facing when promoting electric vehicles. Several countries which are leading in e-mobility race are chosen to analyze in order to select suitable solutions to apply in Germany given its own context. All countries included in the research are graded based on the most important indicators of e-mobility. Particularly, three biggest challenges which slow down the e-mobility process in Germany are charging infrastructure, high electricity price and lack of investment in R&D. Therefore, solutions have been made to help Germany overcome those above-mentioned challenges.

Highlights of the paper: The paper finds out the major challenges in electric car industry in Germany. Other countries which are also promising in term of e-mobility are thoughtfully selected and included to be analyzed based on important e-mobility criteria. Finally, the most appropriate solutions are suggested for Germany.

INTRODUCTION

In the context of increasingly scarce resources, global climate change and alarming air pollution in many big cities around the world, leading countries in term of electromobility have been continuously making efforts to reduce the dependence on fossil fuel and move to a more sustainable way of transportation. Germany is not an exception. With the ambitious goal of having one million electric vehicles (EVs) on the road by 2020, the country aims to take the lead in the trend of replacing traditional gas-powered vehicles with highly efficient ones that can be driven by alternative energy. To meet this goal, German Government has invested a large amount of money in building charging infrastructure for EVs in some pilot cities. Non-monetary incentives have also been taken into effect, for example free parking fee and exclusive roads for electric cars.

However, despite above mentioned attempts, this goal is considered illusory as German customers still hesitate to purchase EVs. The challenges posed by electromobility in Germany lie in the whole supply chain which ranges from raw materials for batteries; components for electric drives; new vehicle designs; energy supply systems to new infrastructure construction and develop supply capacity and business models. For this reason, the development of electromobility in Germany requires multi-sectoral measures, the involvement of new actors and new mode of cooperation (German Federal Government n.d).

This topic is hence chosen since it is suitable with the new trend of sustainable development in transportation in Germany. The purpose of our research is to find out current challenges in EVs consumption in Germany and propose possible solutions to overcome those challenges. We begin our report by defining what it means by "electromobility". We select five other countries and areas, specifically the United States, China, the Netherlands, Israel and Nordic Area to analyze solutions which have been implemented in those countries. We then consider the applicability of those solutions into Germany scenario. In the final sector, we make preliminary recommendations to increase the usage of EVs in Germany.

CHAPTER 1: LITERATURE REVIEW AND THEORETICAL BACKGROUND

The present section provides an overview of electromobility as well as a description of the advances in e-mobility in selected countries. The review begins with an explanation on e-mobility, then a brief history and the current progress together with general challenges.

I. What is meant by electric mobility?

The main propose of electric mobility is to foster and establish a sustainable mobility, represented as a solution to achieve substantial CO2 reductions towards a more efficient and cleaner transport sector (Netherlands Enterprise Agency 2016).

According to the definition of the German government and the National Development Plan for Electric Mobility (NEP), the term refers to all street vehicles which are powered by any electric motor and their energy is providedprimarily from the power grid which means that the conveyance vehicles can be externally recharged (NEP,2015). There are two major types of electric vehicles: the battery electric vehicles which work merely with chemical energy stored in rechargeable electric battery lump. The second type includes plug-in hybrid vehicles which are a combination of electric motor and a fuel engine, whose batteries are recharged by connecting a plug to an electric source (Lee, Lovellette 2011). Nevertheless, electric mobility is specifically characterized by the battery-electric vehicle encompassing all road vehicles with at least three wheels, such as private cars, commercial vehicles, and buses (Sauter-Servaes 2011; Weider, Rammler2011). Furthermore, it embraces the overall system. It includes the energy supply, the charging system, micro and macro infrastructure (NEP 2015). Therefore, electric mobility captures multi-faceted networks of innovation in terms of technological development, social and cultural changes (Servou 2016).

A contemporary concept integrates urban policy visions of new ways of mobilities services. In this way, electric mobility covers two principles of sustainable mobility, which are increasing engine and fuel efficiency, electric car-sharing modality, public transportation, smart mobility and autonomous mobility, where ICT applications are used for the development of framework conditions for specific mobility patterns evolving around electric vehicles (Augenstein 2014). Hence, in this industry two important developments will affect E-mobility: 1): the growth in renewable energy technologies and 2) the emergence of smart grid systems. Because of the nature of almost all renewable energies which requires electricity storage, smart grid-based systems of electricity management will help to overcome the situation by using the storage of batteries and reserving power during low energy usage of BEVs times (Dijk et al. 2013).

II. Brief history of electric mobility and general developments

Even though electric mobility has gained popularity during the last years, was during the late 19th and early 20th century the first prototypes of battery electric vehicles emerged. Electric vehicles were forced out of the market because of the initiation of the mass-production of mass production of gasoline-powered vehicles by Henry Ford in 1913, which reduced the prices of gasoline-powered vehicles. Nevertheless, due to gasoline shortage during the first and the second World Wars, electric vehicles temporally came back, but almost disappeared during the economic crisis in the late 1920s (Servou 2016; Dijk et al. 2013).

During the 1960th and 1970th in the USA, due to a vast awareness of the negative effects of pollution and rising oil prices, electric vehicles re-emerged; but, the final outcomes of several types of research addressed by Clean Air Act triggered were insufficient in terms of technological performance and price compared to their gasoline counterparts (Dijk et al. 2013). In 1990's, another intent to revive electric vehicles took place once again with the possibility of mass production, regulatory norm established by the American State of California with the Californian Zero Emission Vehicle Mandate, which forced car manufacturers to develop and produced electric vehicles (Westbrook 2007) and, to an initial environmental policies and programs promoted across Europe to cope with environmental increasing issues (Dijk et al. 2013). However, the mandate was taken back in 2003 because of law due to lawsuits by the traditional automotive industry), and the industry slowed down again (Collantes 2006).

During the 1990s, the limited technological progress, particularly in batteries, discouraged the mass commercialization of electric vehicles. First, as the main cars were equipped with lead-acid batteries, they were limited lifetime and range. Second, when the focus changed to nickel metal hydrate and lithium-ion batteries, the outcome were highly expensive vehicles at low production chunk. Nevertheless, in the period 1995-2005 hybrid technology and Toya Prius marked an important breakthrough for the electric vehicles adaptation. Thanks to Prius, Toyota gained the reputation of the greenest volume car producers in the world and during 1997-2007: it is estimated that more than one million Prius were sold worldwide (Dijk et al. 2013).

Historically, some projects which fostered the adoption of electric vehicles have only achieved temporal success. To illustrate, in La Rochelle, France, one experiment with 2000 BVEs was addressed by the French electricity utility EDF in 2000. Apparently, the experiment was a success, due to the high public attention and great acceptance from the users. Relevant insights regarding consumer acceptance, preferences and special needs to final adaptation were obtained; notwithstanding, the demand was minimal and sales expectations were not accomplished outside the experiment (Dijk et al. 2013; Hoogma et al. 2002).

From 2005 onwards, concerns about climate change gave rise to governments worldwide to demand the car industry to decrease seriously vehicle CO2 emissions. The transportation sector is one of the main responsible of CO2 worldwide, with 23% of all CO2 emissions in 2013 and second only to the energy industry with 42%. As a result, governments are both investing, supporting researchers and entrepreneurs in specific areas of interest in electric mobility, and establishing robust policies against fuel vehicles (Bernhart et al. 2016).

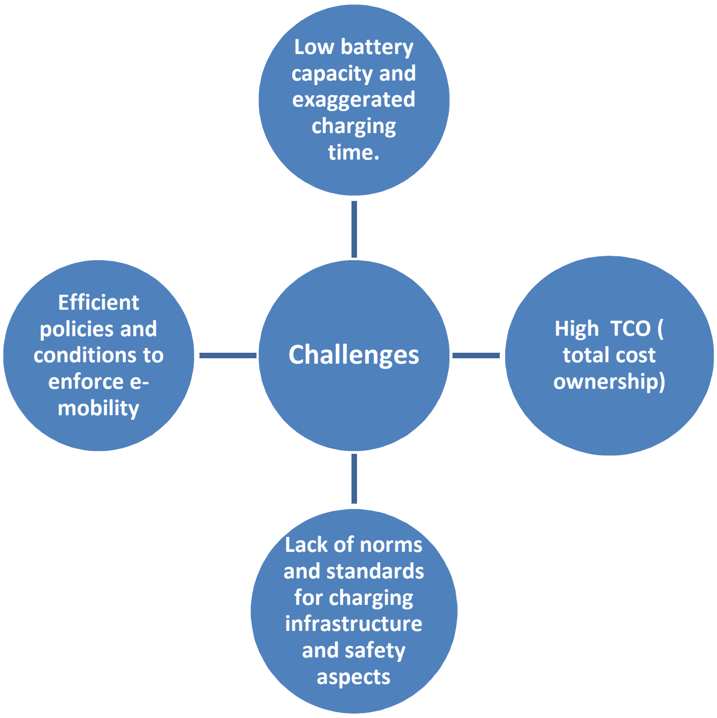
Finally, according to Dijk et al. (2013) the future success of electric mobility basically depends on improvements in (1) infrastructure, (2) changes in mobility patterns, (3) developments in the global car manufacturing regime, (4) optimization of energy efficiency for affordable prices, and (5) in the electricity sector. All these developments do not work in isolation but together with Government policy and regulations.

III. General challenges of e-mobility

There are several major challenges existing which is illustrated in Figure 1. Firstly, the energy container - "The Battery" - operating the electric cars still does not provide the same range that could be achieved using a fossil fuel operated car. Because of that problem, the attractiveness to electric cars still did not reach the level to be appealing for the consumers. In accordance with the environmental concerns, the manufacturing and the disposal processes of the batteries are still not clean. Additionally, the energy chain might not be 100% green, thus, it is hard to prove that the electric car industry and its operation are environmental friendly, especially if the electricity used is not generated from renewable sources (Kotzab et al. 2015). Western Europe in general and Germany privately, are old communities established in old cities that already have complex and deeply integrated infrastructure systems. Now, depending on the technology that will be dominating the market, introducing infrastructure to serve the transition might be complex. If simple battery-motor system is considered, it is easy to integrate charging stations into the existing electricity grid. But, if the hydrogen-fuel-cell technology is to be considered for the market, taking into account that Germany is one of the pioneers and most advanced countries in this technology, a hydrogen gas delivery infrastructure needs to be established to support this technology.

Figure 1: General challenges in e-mobility transition (Own illustration)

(Source of information: Kotzab et al. 2015; Fontes, COMSOL 2014)



The current majority customers of electric cars, especially Tesla customers, are rich society members that would like to highlight that they are concerned about the environment. Electric cars are much more expensive than the normal cars, even if the operating (including maintenance) costs might be less than combustion engine operated cars, the total cost of ownership (TCO) over the average ownership period of the cars which is 5 years, is still not attractive for the majority of the consumers (Fontes, COMSOL 2014). This might be the major challenge, which is to convince the consumers in conducting this transition. Solutions for other challenges can be easily triggered if consumers invest in the shift to electric cars.

IV. Country Profiles

In this session, we explain why certain selected countries are included in the research.

1. ***The United States of America***

The United States (the U.S) is one of three biggest energy-consumption nations in the world (Lee, Lovellette 2011). This country has great effect on global environmental condition through its energy production and consumption.

For many years, United States Presidents have called for a reduction in the country's dependence on fossil fuels in general and foreign oil specifically. Even though higher fuels tax have been implemented, to achieve the greater reduction in oil consumption, it is required that Americans change the way they power their transportation system (Lee, Lovellette 2011).

Over the last decade, the U.S EV industry has posted impressive growth, with hundreds of companies now entering the EV market (Gordon et al. 2012). The country has put strong focus on policies regarding tax exemption and government subsidy for EV owners. However, in term of investments for infrastructure and R&D, the U.S seems to be left behind smaller countries such as the Netherlands or Israel. Obviously, to further the transition to electric-drive vehicles, it will take a sophisticated set of policies and local actions to spur both manufacturers and consumers.
The U.S is included to analyze in this research since the situation of EV industry in this country is quite similar to that in Germany. Specifically, there are many auto makers who are ready to jump into EV market while customers still have doubts to replace their conventional vehicle with an electric one. Moreover, the number of EV polices is abundant while infrastructure investments seem to be neglected.

2. *The Netherlands*

The Netherlands is the European runner-up with nearly 10% of new car sales falling into the EV category in 2015 (International Energy Agency 2016b). In line with European and global initiatives, the Netherlands has set the goal to reduce CO2 emissions. To reach this target, besides the efforts have been made by the electricity production sector to use more renewable sources, the country has emphasized the importance of adopting more EVs for the transport sector (Bellekom et al. 2012). Trailing only after Norway in term of e-mobility in Europe, the Netherlands intends to phase out all fossil fuel-powered automobiles by 2025 (Staufenberg 2016). The adoption of EVs is actively supported by the Dutch government through the exemption of the registration fee and road taxes. Considering the potential of EVs in the country due to its relative small size and geography, the government set a target of 15,000 to

20,000 EVs on the roads in 2015 but this target was already achieved in 2013 (Bolier 2013), two years earlier compared to the original plan.

Dutch companies, social institutions, knowledge centers and public authorities are working in national and international partnership to accelerate the growth of electric driving and to capitalize on the associated economic opportunities. The e-mobility areas in which Dutch companies operate include charging infrastructure, charging services, parts manufacturing and the production of light electric vehicles (Netherlands Enterprise Agency 2016b).

Achievements in electromobility in Netherlands signal commitment and support from the national government. This country was chosen due to its good combination of government incentives and strong investment in infrastructure and research. Furthermore, the focus of the Netherlands in generating energy for EVs from renewable sources is expected to be a good example for electricity production sector in Germany.

3. ***The State of Israel***

The State of Israel is a country in the Middle which total area under Israeli law, including East Jerusalem and the Golan Heights, is 22,072 square kilometers while the total area under Israeli control, including the military-controlled and partially Palestinian-governed territory of the West Bank, is 27,799 square kilometers. The country contains geographically diverse features within its relatively small area with a population in 2017 defined by the Israel Central Bureau of Statistics of 8,700 480 people (Central Bureau of Statistics 2017). Israel is home to more than 5,000 startups and 750 venture-capital-backed companies. The country created 1,400 new technology startups in 2015, making it the world leader in terms of startups per capita.

This country has been named as a highly suited location for electric mobility because its major urban centers are located less than 150km apart, and more than 90% of the population drive less than 70 km/day. Moreover, according to Andersen et al (2009), Israel was the first country to adopt the Electric Recharge Grid Operator energy introducing the first prototype electric vehicle in Tel Aviv in 2008, which is a business model that creates a market for the coordinated production and consumption of renewable (Perdiguero , Jiménez 2012)

The Israeli automotive and smart mobility industry is becoming an innovation lab and pulse generator for the advances connected with electric, autonomous and smart mobility. Close of 500 startups in the industry haven been created and have been operating during the last two decades. Over the last four years, the investment in the Israeli smart mobility sector reached USD 1.6 billion. Companies are investing in the country through bilateral R&D partnerships, M&As, strategic ventures, and setting up innovation labs. Among the principal foreign investors are automotive players like GM, VW, Daimler, Ford, Renault-Nissan, Bosch, Samsung; furthermore, during the first quarter of 2016, Sony snapped up chip developer Altair for USD 212 million, Oracle bought Israeli cloud computing specialist Ravello for USD 500 million, and Cisco disbursed USD 320 million on Leaba, another chip design startup (Bernhart et al. 2016).

4. ***China***

China is the world's most populous country with population nearly 1.5 billion, equivalent to 18.47% of the total world population (worldometersn.d). Recently China has the world's fastest-growing economy and is under the second industrial revolution. Such a fast economic development has required China to consume huge amount of resources and energy. Taking electricity and heat sector as an example, energy structure of each country is decided by its own possession of energy resource. In China, electricity is dominantly generated by coal-fired power (Zhang et al. 2014b). Since natural resources are finite, unlimited exploitation may lead to unsustainable development. Besides, coal-fired usage will contribute to greenhouse gas emissions and air pollution which worsen global warming. Among others, energy and transport sectors are two main sources of CO2 emissions due to the burning of fossil fuels (Sierzchula et al. 2014). In 2013, the energy and transport sector account for 50.14% and 22.43% to the world's total CO2 emissions respectively. China has the second highest total CO2 emissions which are 41.84% emissions from energy sector and 30.98% emissions from transport sector (Zhang et al. 2014b). The potential to reduce CO2 emissions in electricity sector is limited although China has tried its best to adjust the energy structure (Zhang et al. 2014b). In transport sector, with the development of urbanization, the CO_2 emissions coming from internal combustion engine (ICE) will increase more rapidly (Zhang et al. 2014a).

However, electric vehicles (EVs) provide a more promising solution to solve the issue of CO_2 emissions and air pollution (Yabe et al. 2012). Therefore, it is indispensable for China to introduce the adoption of EVs as its sustainable development goal (Zhang et al. 2014b) and make China leading position in automotive industry (Du, Ouyang 2017). New energy vehicles development has been listed as a national strategy and EVs industry has become a newly emergent industry in which Chinese government has invested great efforts to support for its development (Du, Ouyang 2017). China has numerous strategies for EVs development and has obtained several achievements. Taking this course into account, China has been chosen to look into its strategies and policies as possible models which may be applicable for the purpose of this research.

5. ***Nordic Area***

Nordic Area is also considered to be investigated for feasible application to Germany's EVs policy. Nordic countries consisting of Denmark, Finland, Norway and Sweden which have great potential of renewable energy development (Graabak et al. 2016). Although each country has different characteristics, they have much common in economy. Foreign trade has great economic significance in these small, open economies countries. Nordic countries have also lately but rapidly developed into industrialized economies with large public sectors, including welfare services and high taxation. Recently, economic structure of Nordic countries has significant change, switching into service sector and high-tech industries. They have also relatively similar development patterns, such as the important role of the state and the public sector in these countries. They have mainly invested in infrastructure, education and research as well as social welfare. Nevertheless, these countries have exploited their rich natural resources for early phase of industrialization. In Finland and Sweden, forest was the primary source whereas Norway has used waterfalls to produce power as well as explored oil in the North Sea. Food industry is the key industry in Danish economy and its economic development was largely based on agricultural land (Hoydaln.d).

In order to solve the puzzle of energy security and climate change, Nordic countries have tried to minimize the overall energy consumption and replace by renewable energy. Indeed, the Danish power system has gradually transmitted from centralized fossil based energy to decentralized renewable energy sources (Ekman, Jensen 2010). While Finland has the choice of substitution low-carbon fuels for high-carbon fuels, such as substitution of wood for fossil fuels (Linden et al. 2013), the European Union Directive on energy efficiency in buildings and technical regulations have showed how Norway can reduce its greenhouse gas emissions by 2020. Norway has also its own legislation and regulation to commit with the Directive. Energy efficiency requirements in new building were stricter, such as installation of fuel oil boilers is no longer permitted, or energy labeling of dwellings is required when a dwelling is sold or rent (Sandberg, Brattebø 2012). In addition, the strategic focus on biomass and biofuels from agricultural lands and forests of the "Oil Commission" has been a key strategy of how Sweden would comply with sustainable energy policy (Eriksson 2015). In general, they have ambitions and plans to develop low carbon energy supply by 2050 (Graabak et al. 2016).

With such identical goals, these countries may increase the adoption of EVs as a mean to tackle the matter of climate change since electric cars can help to reduce CO2 emissions in both energy and transport sectors. On one hand, electric vehicles can replace conventional vehicles with internal combustion engines which generated mechanical energy from fossil fuels. On the other hand, they can solve the problem of energy consumption as a storing device (Zhang et al. 2014b)which has absorptive capacity of renewable energy such as wind power or solar power (Bellekom et al. 2012). As a result, countries in Nordic Area should be observed for the present paper.

V. Country analysis

In the below section, we mention what has been done in each country to increase the usage of EVs as well as their achievements, outgoing plans and e-mobility trends (if any).

1. Germany

In Germany, the adoption of EVs is actively supported by the German Federal

Government. EVs are exempted from the annual circulation tax for a period of five years from registration date (European Automobile Manufacturers' Association 2014). Besides, as part of the package of financial incentives approved in 2016, private owners of EVs that charge their cars in their employer premises are exempted from declaring this perk as a cash benefit in their income tax return (Grimm 2016).In August 2014, the federal government introduced non-monetary incentives through new legislation which includes granting the authority to local governments to allow EVs into bus lanes as well as to offer free parking and reserved parking spaces in locations with charging points (Taefi et al. 2016). The law also provides special license plates for EV owners to allow proper identification to avoid abuses of these privileges. However, most municipalities, including Hamburg and Munich, are not willing to allow EVs in bus lanes (Hirte, Tscharaktschiew 2013).

Concerning purchase incentives, a scheme to promote EVs was approved in April 2016 with a budget of €1 billion. A total of €600 million is reserved for the purchase subsidies, another €300 million are to finance the deployment of charging stations while another €100 million would go toward purchasing EVs for federal government fleets (Bellon 2016).

In term of charging infrastructure, several pilot projects have been implemented based on partnerships of carmakers and utility companies. The joint program of EV and charging station test in Berlin called "E-Mobility Berlin" by Daimler and RWE set up 500 charging stations in the German capital (Hirte, Tscharaktschiew 2013). Carmaker BMW and Vattenfall have run a project with mini EVs in Berlin and Munich since 2009 (Taefi et al. 2016), these two companies are in the process of expanding their project to Hamburg. Similarly, Volkswagen and E.ON also run an EV project in Berlin and Wolfsburg which is called "Electric Mobility Fleet Test". This is a research project with mostly partners in German universities using the Volkswagen EVs to be tested (Hirte, Tscharaktschiew 2013). Daimler, together with the utility company EnBW and the government of Baden-Württemberg have run the project that includes erecting charging stations in the states (Taefi et al. 2016).

Thanks to above mentioned efforts, by the end of 2015, there were 49,221 EVs on the roads of Germany. 23,193 vehicles were registered in that year, which accounted for more than 47% of total EVs (Netherlands Enterprise Agency 2016b). This number reflects a positive result from the efforts that the federal government and automakers have made since the introduction of "National Electromobility Development Plan" in 2009. Germany has deployed 5,572 public charging stations (Netherlands Enterprise Agency 2016b), making it about 0.11 charging point for each EV. As of December 2016, Germany ranked as the 8th largest EV market in the world and the 5th largest in Europe (International Energy Agency 2016b). The market share of EVs in Germany reached close to 1% in 2015, also the year-on-year sales growth in this year exceeded 75% (International Energy Agency 2016b).

In spite of several achievements, at the moment, the German Government is under pressure to further promote EVs given the discrepancy between the goal of 1 million EVs in 2020 and the figure of only about 75,000 cars in 2016 (Cobb 2017). As current promotions have not shown significant results, the country is now focusing on more expensive and public-orientated solutions. In particular, plans for a buyer's premium subsidy of approximately EUR 4,000 to EUR 5,000 per car were discussed (Vietor 2016). Such a buyer's premium should be borne by national subsidies and partly by the automotive industry. The Minister of Transport has called for car manufacturers to contribute to incentives and buyer's premiums in order to decrease the purchase prices for EVs (Vietor 2016). Additionally, Germany also plans to invest further EUR 300 million in building 15,000 new charging stations which will be operated by private investors, supermarket chains, shopping centers and stores (Vietor 2016).

Regarding e-mobility trend in the future, despite currently low usage rates, a market survey by McKinsey found that a third of Germany's urban population is a prospective user of car-sharing services. Nearly 40% of young Germans (18 to 39 years old) living in cities with more than 100,000 inhabitants indicated that ten years from now they will use sharing cars more (Amsterdam Roundtable Foundations 2014).

2. ***<u>The United States of America</u>***

Solutions to increase the usage of EVs in the U.S are classified into four categories which are monetary incentives, emission test exemption, parking incentives and charging station investments.

Firstly, in term of monetary incentives, the government has exempted charging station tax and federal tax for EV owners. Particularly, for federal tax, a credit of $2,500 or $7,500 (depends on the battery capacity) is given to EV owner since 2010. This tax exemption will be faded out after the given manufacturer had sold 200,000 qualified EVs (Lee, Lovellette 2011). Furthermore, a system called "Car Allowance Rebate" has also introduced, through this system, people would get $3,500 or $4,500 if they exchange less fuel-efficient vehicle for a higher fuel-efficiency one, which includes EVs (Zhang et al. 2014b). Apart from stimulating consumers to purchase and use EVs, the government also has encouraged manufacturers to promote the development of EVs. Some policies on tax reduction, low loan interest and R&D investment have been proposed by the government. For instance, three loans of more than $2.4 billion have been distributed to three firms (Nissan, Tesla and Fisker) for EV manufacturing. The Advanced Technology Vehicle Manufacturing program retains approximately $4 billion in appropriated subsidies to help leverage further loan guarantees (Gordon et al. 2012). Concerning stimulus-funded grants for advanced battery manufacturers, direct loans were granted to manufacturers of up to 30% of the cost to re-equip, expand, or establish manufacturing facilities(Gordon et al. 2012).

Secondly, many states in the U.S such as Maryland, Michigan, Nevada, New Jersey, Oregon and Washington have waved vehicle testing requirements or offered alternative fuel-vehicle emission inspection for EVs(Gordon et al. 2012).

Thirdly, even though in the U.S, parking incentives are not as popular as in European countries, some states including California, Connecticut and Hawaii provide free parking spaces for qualified EVs registered in corresponding state(Gordon et al. 2012). New York has been developing infrastructure deployment plans for light duty vehicles in New York City, focusing primarily on parking lots located in both the central business district and key residential neighborhoods(Gordon et al. 2012). It also addresses solutions for regional travel to and from regional destination hubs.

Finally, the number of charging stations cannot satisfy charging demand for EVs in the U.S, specifically, by the end of 2015, there were about 404,000 EVs but only 32,000 public charging points, approximately 0.079 charging point for each EV (Netherlands Enterprise Agency 2016b). Therefore, the country is trying its best to build more charging stations in key regions. California has spent $1 million to create a unified state-wide approach to planning and implementation of critical charging infrastructure activities in order to support and expand the market for EVs. Similarly, New York has also granted $1 million to accelerate the introduction of a network of charging stations throughout the Northeast and Mid-Atlantic regions of the U.S(Gordon et al. 2012).

In 2015, there were 404,093 EVs in the U.S (including 113, 869 EVs newly registered) (Netherlands Enterprise Agency 2016b). The U.S alone accounted for 45% the total number of EVs worldwide. It is also the second largest EV market in the world, after China. The market share of EVs in 2015 was 0.7% (International Energy Agency 2016b). Technology learning, R&D and mass production led to rapid cost declines and performance improvements in the past decade. The battery cost fell from $1,000/kWh in 2008 to $268/kWh in 2015 (International Energy Agency 2016b), which represents a 73% reduction in seven years. Additionally, improvements in the energy density of batteries allowed a larger electric range, making significant progress to address range anxiety issues. In 2008, the energy density of batteries was at 60Wh/L. In 2015, it attained 295Wh/L, improving by almost 400% (International Energy Agency 2016b).

To promote the usage of EVs further, in the short term, the U.S government still puts attention on tax policies which stimulate the purchasing of EVs. Federal EV programs will be extended and expanded to provide direct financial incentives to EV manufacturers. In addition, auto dealer leading the way in EV sales will also be rewarded. States leading in EVs usage such as California and New York are planning to move away from fuel taxes and toward carbon pricing to compensate governments for their lost revenue(Gordon et al. 2012). The federal government will also target EV policies at those regions where cleaner, renewable electricity is already generated(Gordon et al. 2012)since expanded EV use in those regions will reduce carbon emissions. Last but not least, utility providers will be encouraged to revisit their electricity rate designs, invest strategically in charging infrastructure and investigate the effectiveness of decoupling regulations (Gordon et al. 2012).

3. ***The Netherlands***

Tax incentives have dramatically increased the number of EVs in the Netherlands. In

2015, the fiscal incentive package included an exemption from purchase tax and from monthly road tax for EVs, 4% to 7% addition to taxable income for lease-car drivers of EVs plus an environmental investment allowance up to 36% of a maximum investment of 50,000 Euro (Netherlands Enterprise Agency 2016b). Subsidies are available in municipalities including Amsterdam, Rotterdam, Utrecht and Tilburg for the purchase of a personal or company electric passenger car, light commercial vehicle or taxi. In addition, several municipalities made subsidies available for charging points and the disposal of polluting passenger and delivery vehicles (Netherlands Enterprise Agency 2016b).

Since 2008, the municipalities of important cities in the Netherlands have been investing in charging points to encourage electric driving. The charging network makes the Netherlands a world leader in promoting electric driving. In 2014, Noord-Brabant Province installed 100 innovative public charging points for EVs in the province's five largest cities (Netherlands Enterprise Agency 2015). This is part of the "Smart Charging, Brabant Style" pilot project. According to this project, distribution system operator and other market players developed a charging point that is 50% cheaper than existing stations. This station smart charges electric cars, thereby distributing local clean energy effectively and safely. Moreover, the electric-car driver can choose whether to use power provided by the charging point's supplier or by his own service provider. This free choice of supplier is unique in the Netherlands.

Brabant has also launched a pilot program in 2015 for flexible charging rates (Netherlands Enterprise Agency 2016b). It is believed that cheaper charging can be achieved by enabling e-drivers to choose from among the rates of multiple suppliers at the charging point. In the pilot, service providers offer e-drivers the option to delay their charging session until the price of electricity is low. In 2015, the municipality of Amsterdam, together with that of Rotterdam, the Hague and Utrecht, signed a collaboration agreement on the user-friendliness of the charging points, the use of an open communication protocol and connecting with European standardization (Schumann 2015).

Besides infrastructure investments, car-sharing is a practical business model which has gained popularity in the Netherlands in recent years. By the end of 2014, Car2Go expanded its fleet of electric cars in Amsterdam to 350 vehicles. In three years' time, the original fleet drove 8 million electric kilometers (Netherlands Enterprise Agency 2015). In the near future, the number of sharing-cars in this country is expected to increase substantially. By the end of 2050, together with autonomous driving, car-sharing would reduce the number of cars needed in the Netherlands up to 50% (Amsterdam Roundtable Foundations 2014).

The Dutch government is helping local authorities, citizens, companies, and organizations to achieve environmental initiatives that are difficult to get off the ground. One way it does that is to make a Green Deal with the initiators of sustainable projects and ideas. One outstanding deal is the "The SME Innovation Acceleration" with the objective is to strengthen the innovative capacity of the Dutch economy and SMS's economic potential by stimulating cross-pollination between the SME community and knowledge center (Netherlands Enterprise Agency 2015).

Electromobility has been bringing many economic opportunities for Dutch enterprises. One example is the business project called "East Coast Electric" launched in 2013. This project helps Dutch companies setting up a local partner network, conducting market research, exchanging knowledge, and implementing initial business development in the U.S (Netherlands Enterprise Agency 2014). In return, the program's local presence ensures that American EV frontrunners look to the Netherlands when choosing a location for pilot programs or regional headquarters.

In recent years, many universities and vocational schools pay enormous attention to electric driving (Netherlands Enterprise Agency 2014). Their efforts address technical, commercial, and social aspects of the technology, and student teams are able to turn theory into practice in international competitions.

According to the country report developed by the Netherlands Enterprise Agency (2016), the major achievements the nation has achieved can be reflected in three statements named as "Netherlands is ready to load and go". 1) The country has a sound and solid e-infrastructure. The infrastructure for the energy supply has a high quality and superior performance, it comes across every dwelling and building of the country. Moreover, the load Infrastructure For electric vehicles, after seven years since the initiative started, is now well organized, and more importantly, power plants have enough capacity to easily provide the necessary power for EVs's owners who charge them at home or at public places. 2) A unified charging infrastructure, the country has announced national agreements on interoperability, corresponding to European standards. It adopted the Mennekes Type 2 plug as its national charging interface standard. Currently, 28 414 publicly accessible chargingpoints have been implemented accordingly with the standard regulations (EAFO 2017; Fuel Choices and smart mobility Initiative, Netherlands Enterprise Agency 2016). Finally,3) A fast-charging network, which represents one of the main concerns among consumers, has been rolled out along Dutch highways. A number 680 fast recharging points have been installed till 2017 throughout the Netherlands (European Alternative Fuels Observatory 2017).

In addition to the three main achievements mentioned above, table 1 summarizes and compares the total number of electric vehicles currently in circulation with the settled goal in each period (European Alternative Fuels Observatory2017).).

Table 1: Total number of electric vehicles currently in circulation with the settled goal in each period (European Alternative Fuels Observatory 2017)

Time frame	Market development (stage)	Objective	Actual figures
2009-2012	demonstration projects (start-up)	2,500-3,000 EV's	1,579 EV's (End-2011)
2012-2015	up-scaling (implementation)	15,000-20,000 EV's	90,275 EV's (December 31, 2015)
2015-2020	continued roll-out (consolidation)	200,000 EV's	115,223 EV's (December 31, 2016)
> 2020	mature market (scale back)	1,000,000 EV's in 2025	

With reference to research contributions, Netherland's National Knowledge Platform for Electric Vehicle Charging Infrastructure (NKL) has developed in 2016 a digital database to support municipalities in their endeavours for accurate and independent information to set their policy on electric transport. Moreover, a research conducted in 2016 by Decision and APPM Management Consultants for the Netherlands Enterprise Agency (RVO n.d) has confirmed that the number of charging points has a positive impact on the number of electric cars in a municipality. Moreover, the study reveals that using a subsidy scheme for the purchase of electric cars has a positive impact on the number of fully electric cars within a given municipality. Additionally, the guide "Sustainable solar charging" commissioned by the Netherlands Enterprise Agency describes how the charging of electric cars can be combined with solar energy from solar panels (Netherlands Enterprise Agency 2017; CBS 2016).

4. The State of Israel

The country believes that business entrepreneurs need access to both new markets and the necessary political resources with incentives and regulations governing these markets. Hence, Israeli government regulations go beyond tax policy but embrace a complete supportive system between the government that provides financial resources, infrastructure, regulation and leadership, and the market and the human capital (Rosner 2017).

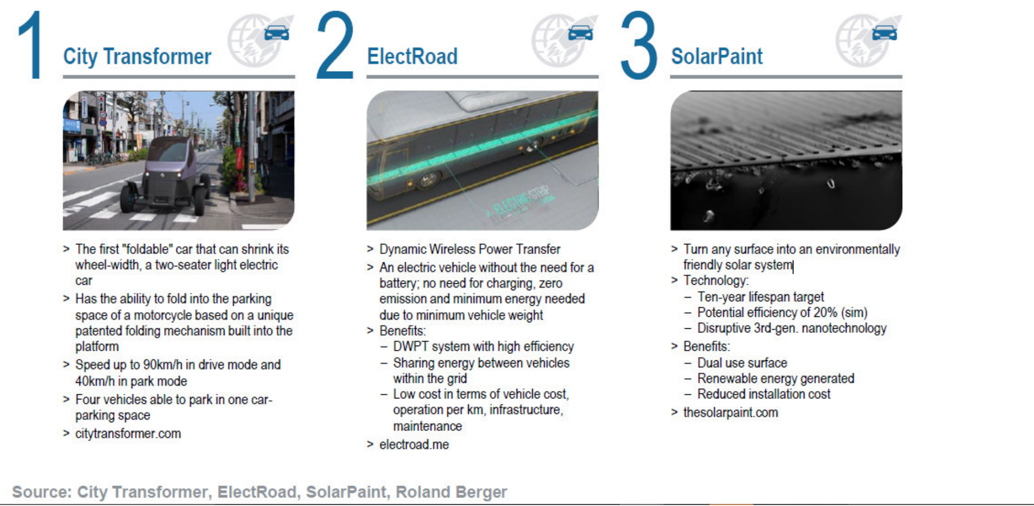
In Israel, the necessity to reduce air pollution is supported by a politic plan, implemented specifically to reduce the country's dependence on oil, a national mission which requires harnessing national resources and given top priority. For this reason, the Fuel Choices and Smart Mobility Initiative was launched in 2011 as Israel's national program for alternative fuels and means of transportation, The Initiative aims to establish Israel as a centre of know-how and industry in alternative fuels and smart mobility, serving as a showcase to the world (Cohen, Naor 2013; Rosner 2017) One of the outstanding regulations is the green tax reform, which result was a remarkable reduction of the media pollution level. Before the reform, in 2008, the measure was 10: for 2012, the media level was 4 (Roshal, Tovias 2016).Among the incentives for adopting and electric car, there is a complete charging infrastructure and charging infrastructure deployment subsidies (National Research Council (U.S.) 2015).

In 2015, Israeli startups raised USD 2.6 billion in fresh venture capital, compared to the USD 2.9 billion raised in Germany (with ten times the population) and just USD 1.9 billion raised in France (Perdiguero, Jiménez 2012).

The electric mobility sector comprises around 80 businesses founded in the past 20 years. Since Israel has no access to major natural resources, Israelis have always sought to use energy efficiently.

The smart mobility startup scene is continuously searching for inefficiencies in the daily lives of millions of people, the system often utilizes a Big Data or community-based approach to collect information and build new services. Companies focus on infotainment, navigation, shared mobility offers, smart navigation including parking management, and complete fleet management with logistics optimization have tested their developments in the Israeli market, whose size is manageable and later brought it to the full-size markets. Two enterprises: Innoviz Technologies and Mobileye are improving 3D imaging and mapping around vehicles to enhance their ability to sense and react to the environment. "The more sensitive vehicles become to their environments, the greater their capability to advance beyond human perception" (Shalev 2017; Bernhart et al. 2016).

Figure 2: Several current e-mobility startups in Israel (Bernhart et al. 2016)



Among the important contributions, Israel has delivered solutions in terms of Hardware needs of finals integration into the vehicle, scaling of software production with partners and licenses, and software demand to adaptation to installed hardware and pilot frameworks.

Furthermore, local companies have improved components for electric drivetrains from electric machines, power electronics and batteries to full vehicles. Their contributions go from "foldable" electric cars to Electro roads with dynamic Wireless Power Transfer with lower costs of vehicle cost, operation per km, infrastructure, maintenance, and solar paint which can turn any surface into an environmentally friendly solar system. Figure 2 describes some current startups (Bernhart et al. 2016)

For Israel, three key technological and commercial trends for electric mobility are detected: 1) Electronic mobility, 2) autonomous mobility, and 3) smart mobility.

First electronic vehicles technology and efficiency, due to worldwide political regulation concerning the current C02 emission regime, especially in Europe where for 2020, 95 percent of all vehicles will be allowed to emit just 95g/ km (26% less than in 2015), OEMs have improved or set off specific components to foster the development of electric vehicles. By 2030, Plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs) will represent the majority of new car registrations. Therefore, new architectures adapted to PHEVs for larger production volumes will enable initial economies of scale to be generated for electric traction. Manufacturers will develop and introduce special modular PHEV architectures before 2025 as a cost-effective solution.

Under this approach, the country believes that electrification of individual mobility is a key topic for sustainable transportation and in order to achieve it, four areas in R&D are a priority: electric powertrain, power electronics, batteries and charging infrastructure.

The second trend, autonomous mobility, which main focus is to increase safer transportation, intends that vehicles drive themselves during off-peak hours to car washes and parking structures where they will be fast charged. “Safer transportation” refers to features that help to avoid and reduce the implications of an accident. The key areas of progress searching are Vehicle location and environment, prediction and decision-making algorithms, real-time learning and highly accurate mapping, and Vehicle-driver interface.

Finally, smart mobility, which according to the industry Structure of the Israeli automotive and mobility industry (Bernhart et al. 2016), is concerned with infotainment and connected car, sharing mobility, navigation, and ITS, parking solutions to improve performance, eco-friendly efficiency, safety, as well as user’s facilities. The focus points for smart mobility include mobility platforms and apps, booking and payment processes, robocars, and autonomous taxi services. Nevertheless, to successfully adopt smart mobility, Israel have described three overarching trends driving have been identified around the concept: alternative propulsion systems, driverless and connected cars, and the shared economy (Bernhart et al. 2016; Shalev 2017).

5. ***China***

Although the core technologies associated with EVs are less competitive in the world market place, China had become the world's largest plug-in electric vehicle market by the end of 2015 (Du, Ouyang 2017). This phenomenon has raised the question of what strategies China had planned to increasingly develop its EVs market and how it has implemented those strategies. Article has indicated four main points accordingly. First, China's subsidy policy has significantly influenced on its new energy vehicle market penetration. Second, the future optimal roadmap for Chinese EVs market is associated with plug-in hybrid electric sports utility. Third, micro-electric cars are dominant in the market. Finally, the charging infrastructure construction may be more concentrated and there should be a consideration regarding the post market of electric vehicles (Du, Ouyang 2017). Hence, it will be very important to review Chinese new energy vehicles national programs to understand its strategy during the transit phase.

Since 2006, new energy vehicle development has been assigned as the country's long-term development plan (2006-2020) and become a national strategy of China. EVs are divided into two categories: cars and commercial vehicles which comprise buses and other commercial vehicles (Du, Ouyang 2017). Hao et al. has estimated the impacts of China's electric vehicle Subsidy 2.0 on its market penetration and found that technological improvement and battery cost reduction play an important role in China's new energy vehicle market (2014). The government has developed electric vehicle technology and its industrialization by promoting state science and technology projects, implementing demonstration projects and subsidizing EVs purchase (Du, Ouyang 2017).To support electric vehicle technologies state projects and promote market penetration, China has been funding 880 million, 1.1 billion, 2.8 billion and 3.0 billion RMB based on 10th, 11th, 12th, 13th five-year plan respectively (Du, Ouyang 2017). Chinese EVs industry under the government support has moved from a niche market to a developing stage. It offers new opportunities for the country in the e-mobility (Meyer et al. 2016).

China has also very clear scheme for EVs development and market penetration. Chinese new energy vehicles development process from 2003 to 2015 includes 3 stages, which are Industrial exploration (2006-2009), Industrialization preparation (2010-2012), and Industrialization development (2013-2015) (Du, Ouyang 2017). In each stage, government subsidy is the core of its incentive policy (Du, Ouyang 2017) and results are measured by market share of each stage. The differences among 3 phases are the exclusion of types of electric vehicles which cannot receive national subsidy in each stage with the purpose to narrow down the scope of new energy vehicles to include only plug-in electric vehicles. It has some Programs to support technological research and development, testing and verification, such as the National Basic Research Program of China (973), National High-tech R&D Program (863 Program), and National Science and Technology Infrastructure Program. From 2009, the country has some demonstration programs for new energy vehicles to obtain the target of 1% market share penetration (Du, Ouyang 2017). The largest pilot program is the demonstration project in 2008 Beijing Olympic Games, in which 585 new energy vehicles are put on road, covering 371.4 million km, carrying 441.7 million passengers (Du, Ouyang 2017)

In 2015, 565,000 plug-in electric vehicles are sold worldwide(U.S. DOE), accounting for 67% of China's global market share. Globally, the ownership of electric cars is close to 1.3 million(ZSW). China's accumulative sales of plug-in electric vehicles surged dramatically to 343% in 2015. This has promised its ambition to reach 5 million electric cars on road by 2020 (Wang et al. 2017). China has announced official purchase subsidy for EVs for the first 13 national experiment cities, following by 6 cities as private purchasing demonstration in 2010(Du, Ouyang 2017). This is the so-called "national subsidy policy 1.0". In the third stage, the "national subsidy 2.0" was implemented. The subsidy is phased out by 5% and 10% in 2014 and 2015 respectively. The central government provided consumers with $8.4 billion plug-in electric vehicles incentives in 2015, 10% sales tax exemption on EVs and homeowners in several cities receive subsidies for home chargers (Wang et al. 2017). During this period, EVs were put into operation in total 39 demonstration cities clusters with 88 cities (Du, Ouyang 2017). In general, subsidies were up to $27,600 (171,000 RMB) per vehicle in some regions (Wan et al. 2015). Beside national subsidy policy, the government also implemented non-monetary incentives, such as exemption from restrictions on vehicle ownership (Wang et al. 2017), mainly in urban cities like Beijing, Shanghai and elsewhere. Yet the core actor is still the national subsidy policy, which not only supports technological and research development, but also consumers and local automakers, such as SAIC in Shanghai, BYD in Shenzhen and BAIC in Beijing (Wang et al. 2017). Its government has proposed a clear development plan for charging infrastructure by different regions with system includes charging pricing regulation, charging infrastructure establishment incentive policy, incentive policy for electric vehicle purchase for office use, and exemption from sales and travel taxes. Though, the progress of infrastructure construction was very slow (Du, Ouyang 2017), encumbering the market penetration of new energy vehicles. Particularly, demonstration cities are eligible for receiving subsidies up to 120 million RMB for charging points construction in 2014. Electric vehicle charging infrastructure is integrated into metropolitan regions in 2015. Moreover, China has guidance scheme for infrastructure construction and has planned to put 12,000 charging stations with 4.8 million distributed charging poles into operation by 2020 (Du, Ouyang 2017).

Despite huge subsidies from central and local authorities, EVs sales are limited by lack of charging poles and high price (Sathaye, Kelley 2013) and consumer's conservative purchasing behavior (Bjerkan et al. 2016). This problem requires a business model to overcome these obstacles. In fact, many Chinese automakers establish car-leasing and shared mobility business model as a new market for electric vehicles and as a method to expose new energy vehicles to potential buyers. The most successful innovator is Kandi who launched a car sharing service in Hangzhou city from September 2013. Their cars are parked mostly near business centers, hotels and residential communities, providing convenience for passengers to use flexibly. This innovation of Kandi obtained subsidies from government up to 120,000 RMB, opening a new trend helpful for EVs adoption (Wang et al. 2017). Together with new business model of car sharing, non-monetary incentives turn out to be more effective as Chinese car makers are too dependent on subsidies. License plates assurance seems to be effective to stimulate electric cars consumption in urban cities such as Beijing or Shanghai, where conventional vehicles are limited due to space scarcity and traffic congestion (Wang et al. 2017). Therefore, Chinese government is considering how to phase out its monetary incentive policies and accelerate the purchase and usage of new energy vehicles employing other non-monetary incentive policies.

6. ***Nordic area***

Due to their concerns about the climate change and energy efficiency, Nordic countries have focused on numerous policies to lower carbon energy supply by 2050. Specifically, the Danish parliament has targeted to supply half of electricity consumption by wind power by 2020, 100% electricity and heat supplied by renewable energy by 2035 and 100% sustainable based energy system by 2050. Finish government has set a target to reduce its greenhouse gas emission at least 80% by 2050 in 2009. Together with Denmark and Finland, Norway and Sweden have also planned to decrease greenhouse gas emission by 30% by 2020 and zero net emission by 2050 in Norway and Sweden respectively (Graabak et al. 2016). Whereas in electricity sector, non-fossil electricity production has gradually emerged as solution for climate change, electrical and hybrid vehicles development has been seen as a potential answer to the transport sector dilemma (Eriksson 2015). High mobility in Nordic area together with high share of renewable energy resources have increased the possibility of an integration of sustainable electricity supply into electric cars' power system (Graabak et al. 2016). This is the reason why Nordic governments have tried to integrate their green energy policies into EVs development policies. Each country's policies will be discussed as follows.

a. Sweden

Among others, Sweden has a different policy to subsidy 40,000 SEK from 2012 for the purchase of renewable based energy cars. Still it has annual circulation tax exemption for private electric car owners (Graabak et al. 2016).In 2004, Sweden has started to decarbonizes the road transport system. Regulation is promoted to stimulate 85% of government agencies' car purchases or leasing contract to be eco-friendly vehicles. It has also national target to be fossil-fuel independent by 2030. In addition, Swedish government has introduced national demand-side measure in 2012 to increase the purchase of plug-in electric cars. The policy has focused on fleet vehicles as this sector can maximize benefit with low operational costs and represent significant buying group vehicles. One of its policies, the Clean Vehicle Directive governs and formulates technical specifications in public procurement processes to all public transport services and road transport vehicle acquisition. There is also demonstration project of numbers of hybrid ethanol buses for the potential of electrification of public transportation (Wikström 2015). In general, Sweden's strategies to promote EVs are surrounding public transportation with taxes exemption and moderate subsidy. As a result of this, sales continued to increase in 2015 with total number of plug-in electric vehicles up to 12,496 in which 80% of that accounted for fleet vehicles or company cars. Swedish road transport system has constituted 94% of the total energy use in transportation with renewable fuels share surpassed 10% in 2014 (Wikström 2015).

b. Norway

While Sweden accounted for the fourth largest market share of electric vehicles in 2014, amounted to 1.4% with 7,928 electric cars put into operation, Norway stood out with a market share of 12.5% in the same year, and increase EVs usage to 50,000 in April 2015 (Wikström 2015), and had 22% market share in Norway in 2015. Its electric vehicle market has doubled from 2011 to 2014 and there is still room to develop. By end of 2015, there were 75,000 battery electric cars and 12,000 plug-in hybrid electric vehicles registered in Norway. 82% of petrol or diesel cars have been replaced by electric vehicles (Haugneland et al. 2016). To achieve such remarkable performance, Norway has implemented prominent policies. The Norwegian government has launched some package of incentives to promote hydrogen and zero emission electric cars, such as no purchase or import taxes, low annual road tax, free municipal parking, and some other taxes exemption policies. The nation has also charging network plan for longer distance trips. In order to satisfy such goal, they have launched finance assistance to the establishment of at least two multi standard fast charging poles every 50km on all main roads by 2017. In 2015, the nation possesses 1,350 charging stations and has planned to reach 25,000 charging points by 2020 (Haugneland et al. 2016). Due to high petrol price, Norwegians are attractive by the free charging stations supplied by government(Zhang et al. 2014b). In 2007, Norway reformed its car registration tax so that electric cars and hydrogen fuel cell cars are excluded from registration and annual taxes. There are also free parking fees for new energy vehicles in public parking lots and EVs have certain priority on bus lanes (Graabak et al. 2016). EVs adoption policies are long-term strategy, therefore Norway's government has continued to put into effect further actions. From 2017, local authorities will inform more benefits for electric cars to bus lanes and free toll roads (Haugneland et al. 2016). On top of that, EVs owners who have short commutes do not require public charging stations. However, there is barrier for those who live in shared apartment buildings. Thus, Oslo and some other cities authorities have a grant system to set up charging poles in those buildings to lift up the barrier (Haugneland et al. 2016). This has proved that Norwegian government aims to carry out a comprehensive approach to foster EVs practices.

c. Finland

In 2009, the Ministry of Employment and Economy has appointed a working group to examine the business opportunities for electric vehicle technology. In conclusion, there are crucial export chances with targeting net sales from 1 to 2 billion Euros in 2020 (Wu et al. 2013). Its strategy was primarily to use transport sector to resolve the problem of heat and energy sector. In Finland, car registration tax is based on CO2 emissions. EVs owners pay only 5% for the registration tax and this tax policy was expended to annual tax on cars from 2010 (Graabak et al. 2016). Moreover, the collaborative program TransEco from 2009-2013, with the participation of Technical Research Center of Finland (VTT), intended to provide tools for the adaptation of transport system to the goal of climate change (Wu et al. 2013). Government also takes part in some other related institutions to promote usage of electric vehicles. For instance, TEKES (Development Center for Technology and Innovation) is a Finnish institution assisting innovative businesses, which is governed by the Ministry of Employment and the Economy, has financed research and development EVs projects such as supporting factories manufacturing batteries for electric cars (Wu et al. 2013). One of those is EVE – Electric Vehicle Systems program 2011-2015, which resulted in 80 different projects with more than 100 participants from enterprises, universities and research institutes, public authorities, to promote a comprehensive approach of electric cars development. The program would accommodate multiple aspects such as research, testing and validation, demonstration, advancing the markets as well as infrastructure and services. EVs stock in Finland in 2013 was eventually 253 battery electric car and 290 plug-in hybrid electric vehicles (TEKES 2014) despite the fact that there were no electric car used in Finland in 2010 (Vuori, N. Huy 2016). Those facts have demonstrated that

Finland has the potential to obtain more success on its aim to lift up electric car adoption in the future.

d. *Denmark*

Denmark agreed on greener transport system policy which excluded car registration tax for electric cars. In Denmark, the registration tax for conventional cars is more than 100% of their sales value (Graabak et al. 2016).In particular, it taxes cars at 180%. Though, only electric cars are exempted from this heavy tax, hybrid electric vehicles owners still have to pay those taxes (Pappas 2014). This policy is to foster the growth of only electric vehicles. The country also received $2.8 million funding from European Commission as a support for its effort to boost incentives for the purchase of EVs in order to reach European Union's purpose of cutting greenhouse gas emissions (Pappas 2014). Furthermore, they plan to offer free parking for electric car to encourage EVs development. Thus, the mechanism that Denmark government is using to promote usage of electric cars is relying on tax exemptions, free parking and public funding (Pappas 2014). There is also certain attainment of charging infrastructure in Demark. A venture startup company called Better Place has worked with Denmark and Renault SA to install battery switching poles in Denmark, Israel and Australia. Though, its bankruptcy was announced in 2013, 770 charging stations set up by the company were acquired by E.ON - a German holding company and large electric utility - and still under operation (Pappas 2014). The project was strongly supported by Danish government. Despite of the company's bankruptcy afterwards, the installation of charging infrastructure has probably spurred Danish electric cars development. Yet Denmark should put more effort to spread wider usage of EVs.

After analyzing selected countries in detail, in the next chapter the research method and the country selection arebeing discussed in more detail. This is followed by the evaluation and comparison of the chosen countries regarding selected relevant e-mobility criteria. Based on this evaluation, a list of suggestions will beformulated for Germany.

CHAPTER 2: METHODOLOGY

I. Data collection

Secondary data is used for this paper. In order to satisfy the research purpose, general literature review about electric vehicles has been used to analyze the current thinking, policies and facts concerning the development of electric vehicles. The review was mainly sourced from academic journal databases such as EBSCO and Science Direct.

The approach of this paper is based on deductive technique. Data collection will be descriptive qualitative data regarding policies and strategies of each chosen nation. Comparative method will be used to analyze current investigation. Since the purpose of the paper is to discover possible policies for electric vehicles adoption in Germany, different policies and strategies from chosen countries will be weighted and analyzed to identify applicable approaches.

II. Data analysis

In this session, all selected countries are analyzed and graded based on important e-mobility indicators.

1. __Energy sources__

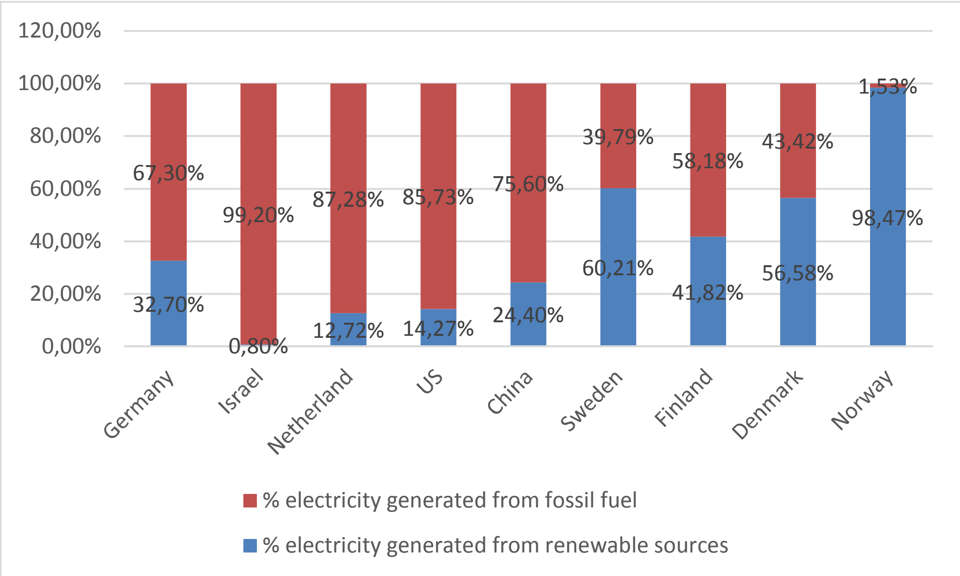
The ultimate goal of any countries promoting e-mobility is to reduce the environmental impact. In fact, to solve the global environmental problems such as climate change, air pollution, etc., it is required to combine the usage of EVs and the clean energy sources used to generate electricity for charging EVs. If one country increases the number of EVs on the street yet still depends only on fossil fuel to generate electricity, the impact on the environment would be even worse due to the emission from electricity plants. For this reason, energy source criterion is included as an indicator to identify which countries would be environmentally beneficial when replacing conventional vehicles with electric ones.

The data regarding the energy resources to generate the electricity in selected countries is collected. Then the data is compared and presented in Figure 3. The renewable sources in this research include biofuel, biomass, geothermal, hydropower, solar energy, tidal power, wave power and wind power. From figure 3, Germany is a middle-runner with 37.26% of the country's electricity generated from renewable sources. In can be seen that Germany is ranked higher than big countries such as the US or China yet compared to other European countries in Nordic area, Germany is left far behind.

Outstandingly is Norway with almost 100% of its electricity come from renewable sources. In Germany, wind power and biomass are two main sources for electricity generation (Lehr et al. 2012). The fact that nearly one third of Germany's electricity come from clean sources is worth encouraging nonetheless, with the ambitious goal of having one million EVs on the roads by 2020, the country must increase the proportion of clean electricity to avoid negative impact of electricity generation on the environment.

Figure 3: Percentage of electricity generated from different sources in selected countries in 2014 (Own illustration)

(Data source: Observer 2014)



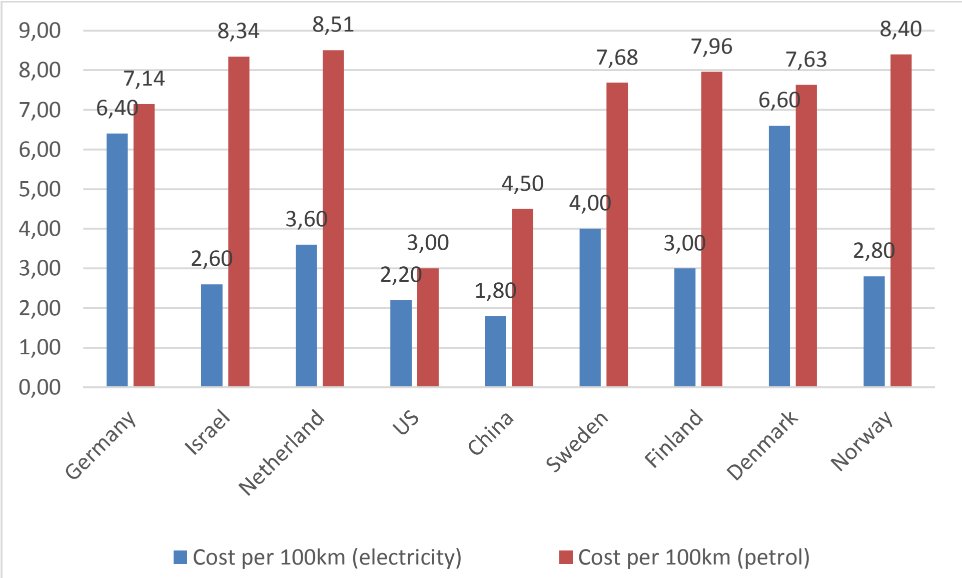
2. Electricity cost versus Gasoline cost

One of the factors that customers often take into consideration before buying an EV is the economic benefit gained from owning an EV compared to a conventional car. EVs run by electricity while conventional vehicles run by gasoline so the difference in prices of these two energy sources determine if it is worth replacing a conventional car with an electric one. If electricity price is lower than that of gasoline in one country, it is an important incentive to promote e-mobility. This criterion is mentioned and analyzed to give an idea of the contrast between two energies' prices in selected countries.

The price of electricity is measured by Euro per Kilowatt hour (Kwh) and that of gasoline is measured by Euro per gallon. The detailed prices in each country are presented in Table 6 in Appendix. To drive 100 kilometers (km), it takes an EV 20 Kwh of electricity and a conventional car 1.45 gallon of petroleum ((Wu et al. 2015). The cost of energy to drive 100km is calculated for two kinds of car and compared. The resulted is presented in Figure 4.

Figure 4: Energy cost in Euro per 100km for electric car and conventional car in selected countries (Own illustration)

(Data source: Deutsche Bank n.d; Numbeo 2017)

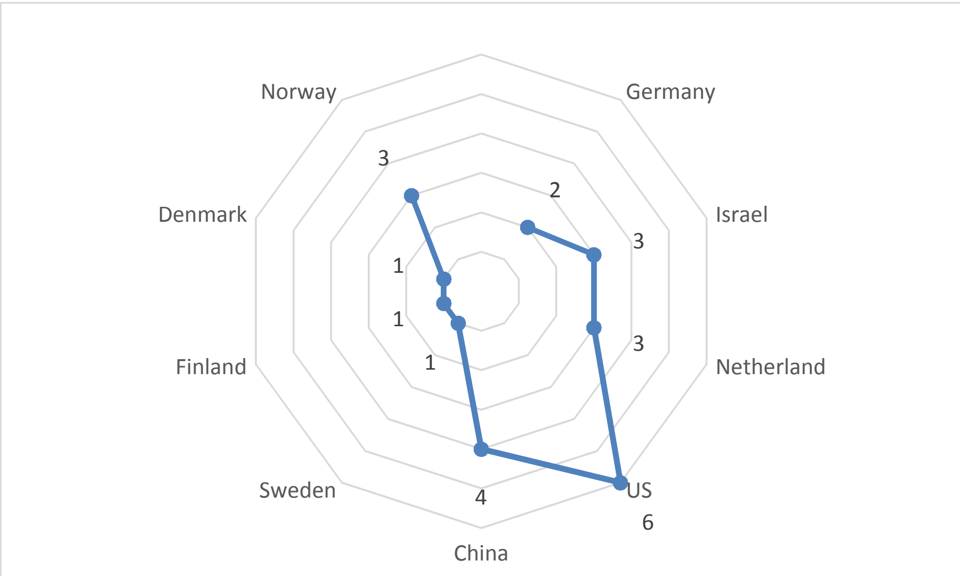


It can be seen from the Figure 4 that in all selected countries, it costs less to drive an electric car than to drive a traditional one. However, there are big differences in electric cost and gasoline cost in these countries. Particularly, Germany and Denmark are two countries that EV users get smaller economic benefit compared to those in other countries since electricity prices in these two countries are only a little bit lower than those of gasoline. On the other hand, in Israel and Norway, drivers may cut down energy cost by nearly 70% if they drive an EV. In China and US, both electricity and gasoline prices are considerably cheaper than those in European countries. In short, while gasoline price in Germany is similar to that in other European countries, the electricity price is too high (44% higher than the Netherland's, 62% higher than Norway's, etc.). Due to high electricity price, German customers hesitate to buy EVs despite of attractive tax incentives and purchase subsidy from the government. It is suggested that Germany should review the electricity price in order to boost EV purchase.

3. Plans in promoting e-mobility

Adopting e-mobility in any countries requires long-term efforts. From the literature review, it can be seen that each selected country has obtained achievements at some levels, however it is still a long way to reach the final goal in e-mobility. Therefore, continuous plans to promote EVs are necessary. The criterion of the number of outgoing plans is included since the number somehow reflects the commitment and effort of that country in increasing the usage of EVs. Nevertheless, the authors understand that more plans do not mean better plans. Additionally, since these plans are still being implemented, it's difficult to evaluate their effectiveness. For this reason, this criterion is not graded but the authors would like to discuss whether the plans in one country tackle the challenges in e-mobility which that country is facing.

Figure 5: The number of outgoing plans in e-mobility in selected countries (Own illustration)



As can be seen from Figure 5, the US is leading with six plans concerning e-mobility (Gordon et al. 2012). The country continues to put strong focus on tax incentives but besides EV users, automakers and car dealers will also enjoy favorable tax level as well. The US also realizes its weaknesses are the lack of both charging stations and clean electricity, that's why new plans focus on investing in building new charging points and increase the percentage of electricity generated from green sources. So far there is no plan mentioning the investment in R&D in the US.

Trailing after the US is China with 4 plans regarding infrastructure investment, new charging pricing regulation, new tax incentives and especially is the plan encouraging the purchase of EVs for office and government uses (Du, Ouyang 2017; Wang et al. 2017)

Israel and the Netherlands come up with three plans each for innovative e-mobility (Bernhart et al. 2016; Netherlands Enterprise Agency 2016b). As the Netherlands has already overcome first stages of adopting e-mobility, the country is now moving to promote car-sharing and develop smart grid (Netherlands Enterprise Agency 2016b). Israel, "the e-mobility lab", shows no intention to invest in charging infrastructure, the country decide to spend lots of money on projects such as autonomous or smart mobility (Bernhart et al. 2016).

All four countries in Nordic area agree that the increasing usage of EVs must combine with the increasing usage of clean electricity to reduce the pollution. For this reason, these four countries all have plans to generate more electricity for EVs from renewable sources (Graabak et al. 2016; Petter et al. 2016; Vuori, N. Huy 2016)

Lastly is Germany with two plans about premium subsidy for EV buyer and charging point investment (Vietor 2016). While infrastructure investment plan may be a good move of Germany, premium subsidy is highly doubted to be effective as former monetary incentives failed to attract customers to purchase EVs.

4. Density of charging points

An important criterion is the density of charging points over length of road. If conventional cars need gas station, electric cars need charging points to fill up energy for continuing driving. The density of charging poles can encourage people to consume more EVs because they will not purchase electric cars if there are not enough charging stations. This is the power source for EVs. Charging poles are divided into two categories: normal charging and fast charging. Some countries encourage private charging at home, yet there is limitation to collect this information, private charging is excluded out of this benchmark. Number of each type of charging points is divided by the total road length of each country to check the differences of density of charging stations over length of road among countries. The total density is the sum of density of each charging point type. To visualize this comparison, the density is graded from 1 to 3: density from 0 to 0.05 is graded as 1, from 0.06 to 0.1 is graded as 2, and as 3 if it is higher than 0.1. Respectively, there is one charging point at each 20km or higher for density from 0 to 0.05, each 10km to 16km for density from 0.06 to 0.1, and lower than 10km for density higher than 0.1.

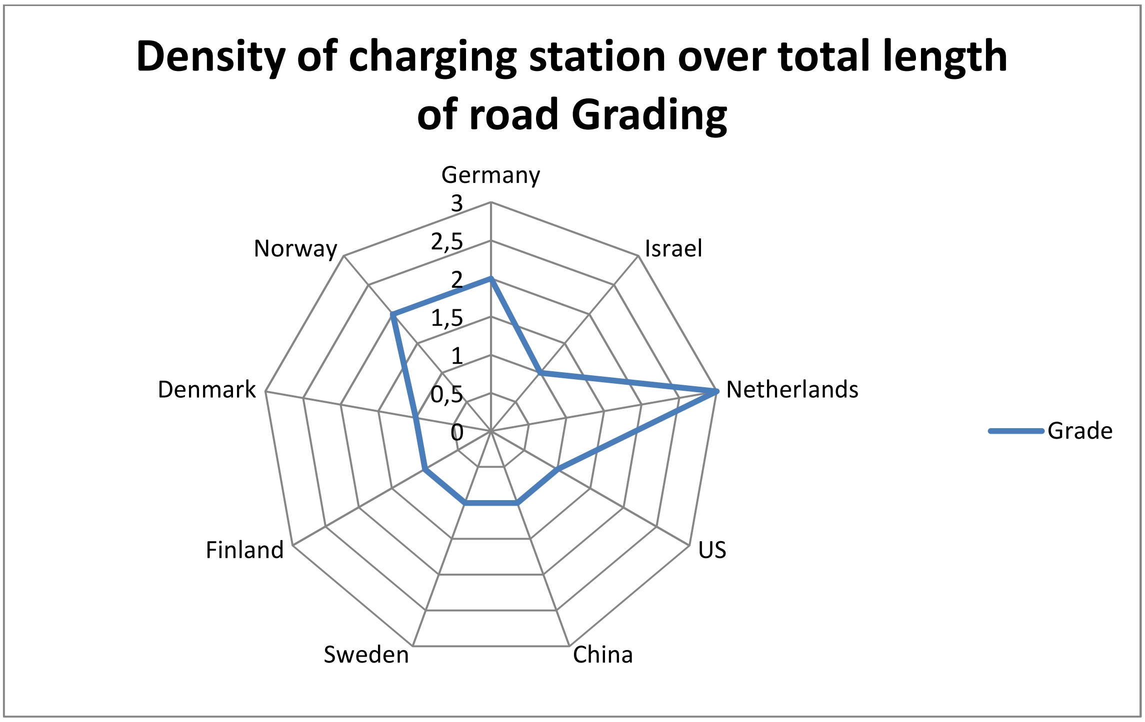
Table 2: Number of charging point over total road length in selected countries (Source: the detailed figures of charging points and length of road in each country are presented in Table 7 and Table 8 in Appendix)

Country	DE	US	CN	NL	IL	SE	FL	DM	NO
Charging point over total road length (point/km)	0.08	0.005	0.01	0.19	0.02	0.013	0.012	0.03	0.09

From Table 2 and Figure 6, it is obviously seen that Netherlands is outstanding in promoting charging stations with 0.19 charging point per km. Israel, the US, China, Sweden, Finland and Demark are graded least density of charging point, while Norway and Germany are graded at medium level. Though, Norway still has slightly higher density of charging station than Germany at 0.09. China and the US have lowest density of charging poles, which prove that these countries need to invest more in expanding their infrastructure for EVs development. Israel has also low charging point density because it has currently no fast charging stations. There are some countries in Nordic area which have lower density of charging points than Germany's. However, Nordic area has also notable development of EVs infrastructure. This may be because of their small land area leading to concrete charging poles growth. The same reason may be applied for the success of Netherlands as its size is very small in comparison with Germany's size. Germany has 357,121 km2 and is 9 times larger than Netherlands with only 41,543 km2. This condition makes it possible for Netherlands to implement their strategy concerning charging station construction.

Considering the importance of infrastructure development, specifically charging station expansion, Germany should review its plans to set up more charging poles. Netherlands has very successfully developed charging network with innovative charging points, and distribution system operator and other market players serve its citizen with cheaper charging price. The country allows for multiple suppliers at charging station so that consumers can choose which supplier they prefer with cheaper price. This flexible charging rates strategy has encouraged people to adopt more EVs. Therefore, Germany can refer charging station development strategy from Netherlands for its policy. Nevertheless, Germany potentially faces some difficulties. Because of its large size, Germany has some obstacles to be able to construct more charging stations for the whole country. High electricity price is another difficult for Germany to pursue a cheap charging rates strategy. Therefore, it requires Germany to have a long-term view to decrease electricity price by some means and gradually set up more charging poles, possibly in big cities first.

Figure 6: Grading of density of charging station over total length of road (Own illustration)



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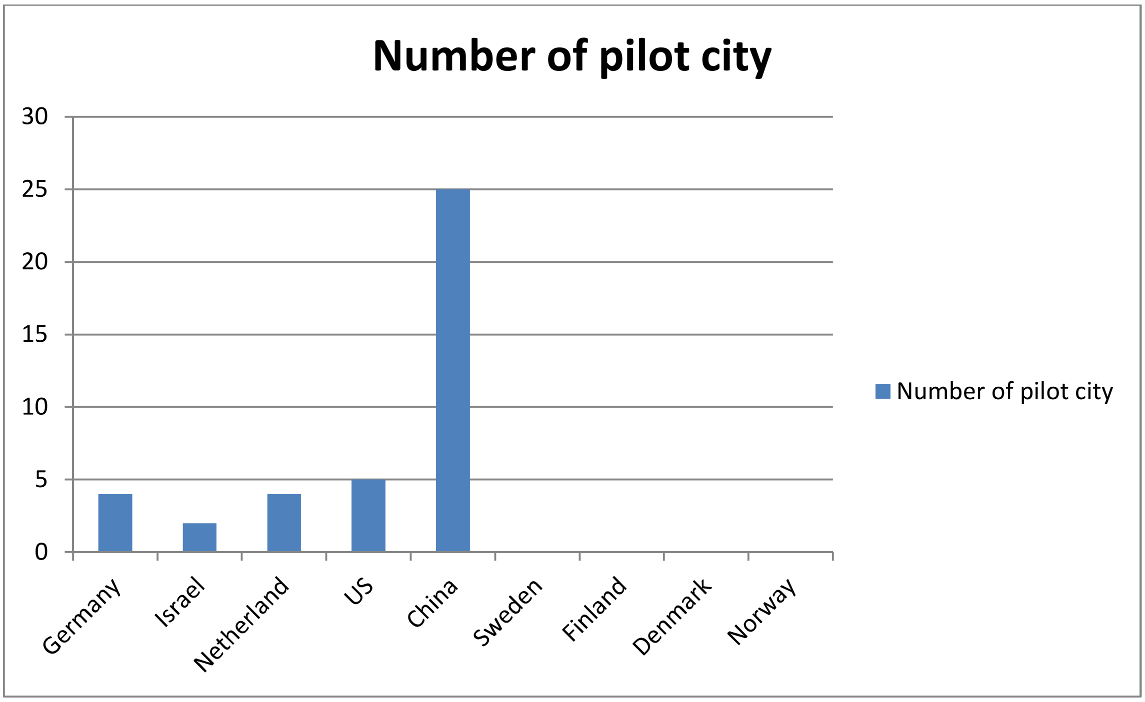
5. ***Pilot cities***

Pilot cities are considered as another criterion for comparing productivity of EVs development policies among countries. Since e-mobility is a new trend, pilot project may benefit governments to check the feasibility of a program at small-scale with experimental trials (Hulley 2007). The use of demonstration programs and projects in pilot cities can help governments learn how they might work in large-scale. In addition, for countries with large land area such as the United States or China, pilot programs are necessarily carried out before applying for the whole country. EVs development is a long-term progress, which needs time and extensive financial funding. Thus, those countries may not have enough financial support for promoting electric cars usage at once. Another reason is that, pilot cities are metropolises with specific development growth, residential zone, well-established infrastructure and other conditions which are convenient for advancing EVs adoption. This benchmark of pilot cities has evaluative value of how effective EVs development programs work in each nation.

Among five countries and one area, China has dominated in fostering EVs adoption with 25 pilot cities (Marquis et al. 2013), within which five main cities are Beijing, Shanghai, Shenzhen, Hangzhou and Chongqing. The US has 5 pilot cities (General

Services Administration (US)), following by Netherlands with 4 pilot cities (NL Enterprise Agency 2016) which are Amsterdam, Rotterdam, Brabant and Utretch. Germany has also 4 pilot cities (NPE 2015) focusing on big municipalities such as Berlin, Hamburg, Munich and Stuttgart. Israel is dissimilar because the country is very small and e-mobility has been developed in cities such as Tel Aviv and Haifa as a laboratory. Nordic area does not have pilot cities either. The four countries have similar plans applied for the whole nations. Capital cities and their vicinity's authorities have launched specific projects upon national policies. (Illustration of pilot cities in each country is presented in Figure 7).

Figure 7: Number of pilot cities in selected countries (Own illustration)



The commonality among these nations is each country has focused to develop EVs in big cities. Although this strategy is working effectively, yet they should gradually promote EVs adoptions within the whole country. Pilot cities can just be considered as an additional criterion because respective policies should be taken into account together with pilot cities. However, this benchmark should not be ignored. China has been leading in EVs market as its government attempted to motivate EVs development in many pilot cities, increasing from 12 to 25 pilot cities throughout years. While comparing with the size of the country, this number is not significant but it shows how this country has made an effort in EVs development. The US is a big country and its pilot cities are not enough for growing EVs in comparison with its size. Even though Nordic area does not have pilot cities, their policies have been applied for the whole country because their small land areas and low population allow them to implement such an approach. Germany has 357,121 km2 (European Alternative Fuels Observatory n.d) which is not much higher than Nordic area countries, but Germany has not promoted EVs for the entire country and there are also a few pilot cities. Netherlands has the same number of pilot cities as Germany does, however the country is small enough for easily controlling and developing EVs. Israel is also a small country and has put a lot of effort in innovative activities in EVs technologies and development. Altogether, Germany should expand its pilot cities in the future to be able to flourish EVs success. This requires a combination with approachable strategies for each city as well.

6. ***Policies in e-mobility***

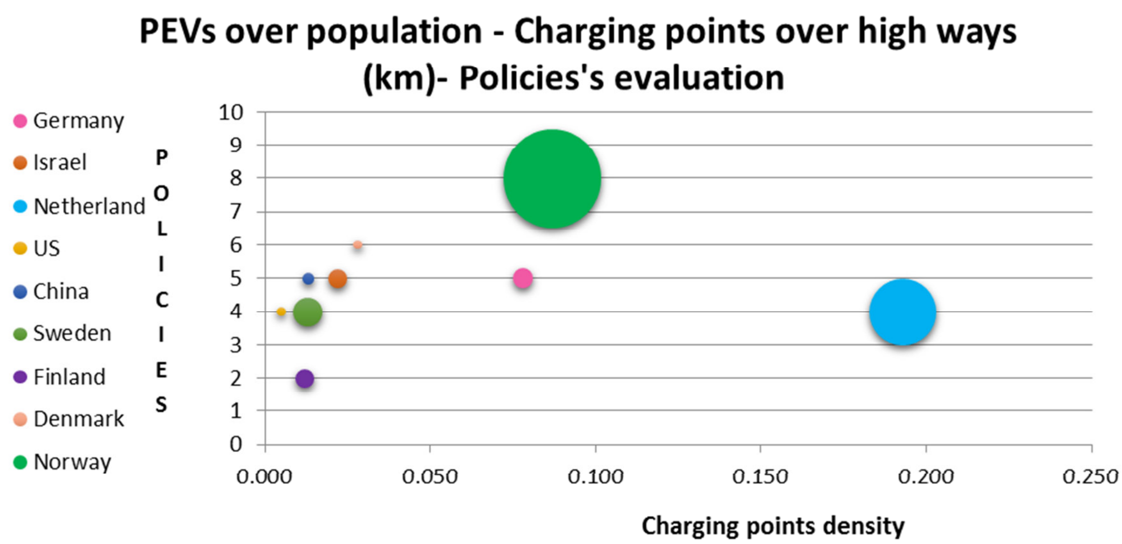
Policies were chosen according to the classification of the European Alternative Fuels Observatory association, which has identified the most relevant norms generated to enforce electromobility (European Alternative Fuels Observatory 2017). The types of policies were categorized as followed:

- Non-monetary incentives (research incentives, star ups incentives):
- Purchase Subsidies
- Registration Tax Benefits
- Ownership Tax Benefits
- Company Tax Benefits
- VAT Benefits
- Other Financial Benefits
- Local Incentives
- Infrastructure Incentives

Each country was graded according to the nature of its policies, each kind of policy add one point and at the end the grade obtained as a simple sum. For example, Finland is graded with 2 because the e-mobility incentives are related with Registration Tax Benefits and Company Tax Benefits. Germany was labeled as 5 since it fosters e-mobility with non-monetary incentives, especially for research purposes. It offers also purchase subsidies Registration Tax Benefits and Company Tax Benefits as well as local incentives. Yet its number of EVs over population is only 0.06. In this way, the nature of the policy plays a relevant role. Norway for example, has incentives for infrastructure. Moreover, in Nordic countries, Israel and Norway, electric mobility policies are more than incentives. They have established strict rules accompanied with all the facilities to implement electric mobility such as infrastructure, lower prices for electricity and renewable energy sources.

The next graphic illustrates a comparision between PEVs per capital, charging points and policies grade. The size of the bubble represents the amount of PEVs over population. While Norway has showed its leading position concerning with electric mobility implementation, other countries with much less polcies have also great results. This is the case of Sweden, Finland and Israel. Apparently, the number of policies is not a relevant key driver. Denmark, has a grade of 6 in terms of policies, but its PEVs per capital is only 0.013%.

Figure 8: PEVs over population – Charging points over high ways (km) – Policies' evaluation in selected countries (Own illustration)
(Data source: European Alternative Fuels Observatory 2017)



The following table summarizes the grading policies criteria.

Table 3: Grading of e-mobility in selected countries (Own illustration)

Tyoe of policy	Germany	Israel	Netherlan	US	China	Sweden	Finland	Denmark	Norway
Non-monetary incentives (research incentives, star ups)	1	1	1			1		1	1
Purchase Subsidies	1			1	1	1		1	
Registration Tax Benefits			1		1		1	1	1
Ownership Tax Benefits	1		1	1	1	1	1		1
Company Tax Benefits	1	1	1			1		1	1
VAT Benefits									1
Other Financial Benefits		1		1	1				1
Local Incentives	1	1						1	1
Infrastructure Incentives		1		1	1			1	1
Grade	5	5	4	4	5	4	2	6	8

7. ***Number of EVs over population***

The number of EVs over population was taken also from European Alternative Fuels Observatory. Nevertheless, for Israel, China and USA the data was extracted from the same papers used during the literature review. This indicator is calculated by dividing the amount of EVs registered in each country to their total populations respectively. It provides consistent information of the number of EVs relating to the country population size. Norway is leading with closely 100,000 EVs over 5 million people (0.44%). Following is Netherlands with 0.68%, Sweden 0.13% and Germany 0.68%.

Table 4: The percentage of EVs over population in selected countries (Own illustration) (Data source: European Alternative Fuels Observatory 2017)

Country	PEVs/Population
Norway	1.444%
Netherland	0.680%
Sweden	0.127%
Germany	0.061%
Finland	0.055%
Israel	0.050%
China	0.022%
US	0.015%
Denmark	0.013%

Stricter governmental policies must be carried out along with all the required facilities. To illustrate, if the German Government aims to increase the number of passenger electrical vehicles, it should execute better infrastructure and release policies to the car manufacturers enforcing standardization of charging components, batteries and other components which permit an easier PEVs ownership.

III. **Results**

After analyzing e-mobility relating criteria, there are several solutions that Germany can consider applying to increase the usage of EVs in this country.

Firstly, one of the determinants deciding the success of e-mobility in one country is the ease to charge the EV when the power runs low. In Germany, the number and density of charging point is still low, in some areas, drivers are even unable to find any points. Hence, this country needs to put great focus on building charging infrastructure to increase the number as well as the density of points in national charging network. Nonetheless, because of its large size, it is difficult for Germany to distribute charging poles equally along the country. Germany, therefore, may invest more in pilot city projects first before expanding to national scale.

Secondly, as concluded from data analysis, electricity price is too high, which discourages drivers to replace their conventional car with an EV. It is suggested that either Germany reviews its electricity rate or rises gasoline rate to boost EV purchase. Apart from electricity price, the sources which electricity is generated from also play a crucial part in reducing environmental impact from transportation and electricity manufacturing. At the moment, one third of Germany's electricity is generated from renewable sources. In the long term, the country must find a way to increase the percentage of clean electricity in order to maximize the environmental benefit brought by adopting e-mobility.

Thirdly, when looking at e-mobility policies and plans in Germany, it can be seen that the government has not realized the real challenges needed to tackle. The majority of policies and plans are too broad and go into the wrong direction. In short, it is important that the government considers three big weaknesses which are infrastructure, power source and R&D when making new plans or policies.

Last but not least, it may be too early for Germany at this stage to promote innovative e-mobility like in the Netherland or Israel. However, since smart e-mobility will soon be popular, this country should also pay attention to new trend such as autonomous driving or smart grid charger. Additionally, electric car-sharing is a business model that has been successful in many countries in the world. The model is not difficult to apply but the economic and environmental benefit it brought is huge, hence it can be a good idea to employ this model in main cities in Germany.

CONCLUSION

The goal of this research is to find out some applicable solutions for Germany to enhance more EVs adoption in the context of emerging e-mobility and its sustainable development. Based on some other countries' strategies, plans and policies, the investigation was conducted using qualitative data and comparative approach. Four countries the US, Netherlands, Israel, China, and one area (Nordic area including Sweden, Finland, Denmark and Norway) were examined with a broad scope of their EVs policies. Criteria defining EVs success were set up then compared among those countries and with the situation of Germany to draw out applicability for Germany.

The results indicated that Germany should take into account a holistic approach to increase more EVs consumption, referring from other leading countries' policies in e-mobility. Even though Germany is the 8th largest automaker in the world with a market share of EVs close to 1%, there are still some hindrances for its EVs development. German government is one of countries whose incentives embrace greater financial incentives like subsides, company and ownership tax benefits, its number of EVs over population is less than Netherlands, Sweden, and Norway. The nature of the policy and appropriate conditions have a crucial empowerment in the implementation of electro-mobility.

Possible solutions can be monetary incentives such as tax exemption, purchase subsidizes. Besides, the country should consider also non-monetary such as free parking lot, special lane for EVs, special license plate. Moreover, monetary incentives policies should be phased out after a period of time. The construction plan of charging stations should be reviewed to appeal its citizen to adopt more EVs. Besides, Germany should also intensify pilot projects based on partnerships with automakers and utility companies in varieties of pilot cities in order to amplify EVs usage. R&D in electric vehicles technologies should be continued as well, but must go parallel with reasonable and feasible implementation in practices. German government should not turn a blind eye to the electricity source generated for electric cars since this is also an important driver to encourage its citizen to purchase more EVs. In addition, high electricity price influences as well decision of consumers to buy or not an electric vehicle, leading to the necessity to lower this price.

The outcomes stemming from this paper can provide some relevant solutions in order to boost the usage of EVs in Germany. With a wide range of considerable countries being examined for their policies, applicable orientation based on comparison between studied countries and Germany have been suggested. Furthermore, this research has provided a comprehensive overview with respect to EVs in some leading nations and Germany itself. As a result, this paper has a certain value and salient results which can accommodate future research purposes.

LIMITATIONS AND OUTLOOK

It is important to note that there are several limitations involved in this research which may potentially impact our findings. Firstly, limited access to information in data collection processes might constrain our ability to include more criteria in the implementation of weighing respective figures and comparing each benchmark among countries. Besides, the weighing methodology is subjective to authors could reflect a limit to the assessment of the outcomes. As a result, this issue might hinder our capability to conduct a more thorough analysis of the results. However, discovery of this limitation can serve as a critical opportunity for further research which, by some means, can obtain more access to collect available data and comprise variety of criteria.

Secondly, although four countries and one area were covered, this study was unable to take into account all countries leading in e-mobility such as Japan, the United Kingdom or France. Notice that this paper consisted of those countries since we chose the representatives from various continents where the selected nations have been outstanding in adopting electric cars and been discussed in numbers of previous studies. For instance, in Asia, China has been considered to put into the research as it has become world's largest plug-in electric car market by the end of 2015 (Du, Ouyang 2017). The Netherlands and the Nordic area have pioneered and been very active to promote the usage of electric vehicles in Europe. The US has developed also strongly in e-mobility and Israel has emerged as a very innovative actor in this trend. Still is there room for future research to comprise more countries in order to acquire more information and facts.

Lastly, the study focused only on e-mobility for private sector and did not take into account the public sector. Moreover, most of the policies, incentives and solutions were based on the level of governments and authorities. This approach could provide an overview on how electric vehicles have been encouraged and adopted in several countries then suggest applicable solutions for Germany, but on governmental degree. Nevertheless, other actors such as automakers and especially consumers should not be neglected because they play also important role in electric car adoption beside the incentive policies from governments. Therefore, investigations to come should pay attention to auto manufacturers' strategies and customers' view as well as cover both private and public sector.

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APPENDIX

Table 5: Country Abbreviations

Country	Abbreviation
Germany	DE
The US	US
China	CN
Netherlands	NL
Israel	IL
Sweden	SE
Finland	FL
Denmark	DM
Norway	NO

Table 6: Price of electricity and petroleum in selected countries (Data source: Deutsche Bank n.d; Numbeo 2017)

	GE	US	CN	NL	IL	SE	FL	DM	NO
Electricity price (EUR/kWh)	0.32	0.11	0.09	0.18	0.13	0.2	0.15	0.33	0.14
Petrol price (EUR/gallon)	4.927	2.070	3.104	5.867	5.754	5.300	5.489	5.262	5.792

Table 7: Population and land area in selected countries

Country	Population and land area (km2)	Source
DE	81,276,000	(European Alternative Fuels Observatory)
	357,121 km2	(European Alternative Fuels Observatory)
US	326,474,013	(worldometers)
	9,144,930 km2	(worldometers)
CN	1,388,232,693	(worldometers)
	9,386,293 km2	(worldometers)

NL	16,933,000	(European Alternative Fuels Observatory)
	41,543 km2	(European Alternative Fuels Observatory)
IL	8,700,480	(Central Bureau of Statistics 2017a)
	22,072 km2	(Central Bureau of Statistics 2017a)
SE	9,816,000	(European Alternative Fuels Observatory)
	449,964 km2	(European Alternative Fuels Observatory)
FL	5,475,000	(European Alternative Fuels Observatory)
	338,155 km2	(European Alternative Fuels Observatory)
DM	5,673,000	(European Alternative Fuels Observatory)
	43,094 km2	(European Alternative Fuels Observatory)
NO	5,194,000	(European Alternative Fuels Observatory)
	323,802 km2	(European Alternative Fuels Observatory)

Table 8: Public normal charging and fast charging point, total length of road per country

	Country		**Source**
Public normal charging point	DE	16,266	(European Alternative Fuels Observatory)
	US	28,150	(International Energy Agency 2016)
	CN	46,657	(International Energy Agency 2016a)
	NL	26,088	(European Alternative Fuels Observatory)
	IL	400	(Better Place 3/23/2011)
	SE	1,654	(European Alternative Fuels Observatory)
	FL	706	(European Alternative Fuels Observatory)
	DM	1,675	(European Alternative Fuels Observatory)
	NO	7,040	(European Alternative Fuels Observatory)
Public fast charging point	DE	1,687	(European Alternative Fuels Observatory)
	US	3,524	(statista)
	CN	12,101	(International Energy Agency 2016a)

	NL	612	(European Alternative Fuels Observatory)
	IL	0	
	SE	1,084	(European Alternative Fuels Observatory)
	FL	205	(European Alternative Fuels Observatory)
	DM	421	(European Alternative Fuels Observatory)
	NO	1,117	(European Alternative Fuels Observatory)
Total length of road	DE	230,377 km	(statista)
	US	6,456,799 km	(statista)
	CN	4,360,000 km	(statista)
	NL	138,641 km	(statista)
	IL	18,566 km	(CIA)
	SE	216,976 km	(statista)
	FL	78,093 km	(statista)
	DM	74,130 km	(statista)
	NO	94,260 km	(statista)