MSc Program
Renewable Energy in Central and Eastern Europe

Support Measures on Electric Mobility Sector: Socio Economic Analysis of Best Practices

A Master's Thesis submitted for the degree of
"Master of Science"

supervised by
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29.04.2015, Vienna

Affidavit

I, ION URSU, hereby declare

1. that I am the sole author of the present Master Thesis, "Support Measures on Electric Mobility Sector: Socio Economic Analysis of Best Practices", 107 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
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Abstract

The fossil fuel dependency and the desire to reduce pollution levels mean that the electric vehicle has set off as an attractive mobility alternative in recent years. The purpose of this study is to review the main barriers that electric vehicle must curb if it is to become an acceptable mode of transport and to review the main public policies that governments might put in action to help in dealing these obstacles. Public policies have been projected for four basic issues of the electric vehicle: the infrastructure; triggering demand for these vehicles; research and development programs; and the introduction of electric vehicles in sustainable mobility agendas. The effect of different implemented measures is however scarce and monitored through comparable valuations on the environment, economics and society.

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1 Introduction

Electric cars are not a concept for the future, it is happening now. The growing share of electric cars in the transportation segment is due to good strategies policies implemented by many countries in different ways. Still, several factors are influencing the development of electric mobility. Thus, in order to effectively support and successfully deploy Electric Vehicles (EVs), it is vital to identify the initiatives including early adopters and to aim the measures towards these segments. As a result, a multitude of initiatives to foster electric mobility is being reinforced by governments, universities, and private companies. Moreover, the electric-mobility term includes mostly electric vehicles, the infrastructure needed and the consumption related aspects of transportation, all this sustainable. Being and energy related sector it is important to note that each energy sub-sector would have been impossible to be developed without government support. It is however interesting to investigate how the current policies plan the sector development, through what measures, incentives, addressed to whom, in what way, with what expectations, and if cost effective. In order to create a more accurate conclusion about the current state of being, first of all the paper will deal with general issues of electric mobility sector, in the aim of main catalyzer identification. It is evident that the technology is not mature and need a place to start the mass introduction process. However, the most important driver of electric vehicles promotion is the environmental impact according to the climate warming concerns. Thus, it is useful to analyze the effect of increasing the share of electric vehicles in the transportation. However, the valuation of climate benefits on the society is hard to be assessed and it is based on market values. In the end, as a main purpose, the cost of the emissions reductions from the electric mobility sector would show how efficient this technology addresses the climate impact.

1.1 Objectives

The main questions to be investigated in this paper include:

- rationale for EVs diffusion initiative
- advantages and disadvantages of EVs

- an analysis of policies concerning initiatives such as strategies, action plans and financial and non-financial incentives aiming to stimulate and promote electric mobility;
- International progress on electric mobility. Barriers to cooperation.
- main stakeholders and their interests involved in the electric mobility initiative
- What effect would have the formulated EVs stock targets of main frontrunner countries on climate task, energy dependence and socio-economic endeavor
- Expected trends and infrastructural changes

The aim of this paper is to review the broad range of measures that the public sector might implement to promote the electric vehicle and investigate the environmental and socio-economic effect in cases when the EVs market share increases and the proposed EVs stock targets are to be reached.

1.2 Approach

Sizeable portions of these stimulus packages are directed at environmental goals, particularly the reduction of GHG emissions. Thus after reviewing the electric mobility components, drivers, benefits and risks this thesis addresses the impact of EVs on the reduction of GHG emissions. Here the main influent component is CO2, which emissions the governments are targeting to reduce through different incentives and regulations.

Incentive measures are often implemented for a short term, thus the intention of this thesis is not to provide a detailed insight in each national initiative regarding the electric mobility but to present an informative overview of policy frameworks and strategies. This should help individuals to have a closer understanding on what the policy pays more attention and where and how public institution find motivation to promote innovations. The attractiveness conditions of electric mobility to potential consumer are discussed. Moreover the stakeholders of the policy framework are addressed.

Due to the high diversity of scenarios and predictions in the literature, the paper includes a case calculation concerning the EVs market diffusion (taking in consideration the formulated EVs stock targets) and its impact on CO2 emissions mainly. The calculations rely on existent researches and estimations. Following steps are considered:

- Identification of most successful countries in terms of EV stocks and their formulated targets. This approach is considered adequate but still might not address the reality and has the purpose of stimulating general results in order to see what outcomes would be achieved if the targets are to be reached.

- The time trajectory is 2015-2020 as farther timeframes seem too futuristic and lose accuracy in estimations. However, the obtained results from using the aggregated targets of front-running countries shall give a feeling of EVs importance, if projected for a later deployment as 2020-2050.

- According to the overall EVs stock targets, the number of future EVs is derived. This approach was selected due to the diversity of policies, plans and targets at the global level. Moreover, there are still a lot of unknowns concerning the future number of EVs. This is the reason why this paper takes in consideration the formulated targets by Governments. It is considered important, apart from identifying best working practices, to see what outcome these can bring. Therefore, it is considered appropriate to aggregate the Governments targets in order to assess the overall impact on climate. Due to the fact, that the climate is a global issue, such an approach is considered suitable.

- Considering the EVs components and characteristics improvements over time, the CO2 emission savings are assessed. Moreover the used fuel lifecycle is included.

- The saved CO2 emissions are valued according to the current ETS carbon price and the social cost of carbon SCC parameter. The valuation of carbon savings is being performed due to the fact that the EVs diffusion is planed primarily with the aim of reducing GHG emission and thus keeping the global warming at 2 degrees Celsius.

- No data for policy spending toward electric mobility support was available on global level. Thus, the efficiency and the cost benefit of establishing a EVs market share is hard to be calculated. However, the paper uses a bottom-top approach. This means, it identifies the possible savings, evaluate them and thus sets the cap limit to the public spending. In this way, the result would suggest the cost of externality.

- On the literature basis, the paper identifies the countries that spend more on electric mobility. Next, according to current EVs sales, the efficiency of EVs measures is discussed.

The information in this paper was collected through a rigorous desk research. The literature includes legal documents, strategy papers, technical evaluations, main Stakeholder's web pages, scenarios researches, roadmaps for industries and policies, Project and program information. Discussions on the topic were held with experts form the industry.

1.4 Structure of Work

This paper is divided in following parts:

- The first part addresses the issues related to electric mobility context. Climate problems are put in frontline and electric vehicles are identified as a possible reliable solution. Thus the current developments of electric vehicles are presented. Moreover the main drivers and barriers are identified.
- The second part has the purpose of presenting the policy implication. Thus the directions, stakeholders and strategies of policy frameworks are discussed. Stimulus measures and Incentives are described and analyzed. In the end, the international progress is reviewed.

- The third part relies on a combination of literature assumptions and estimations and an own calculation case. This has the purpose of estimating a conditional EVs situation and build tangents with the supporting instruments and outcome effects.

2. E-Mobility Context and strategic assessment

2.1 The climate Change context

The climate change is triggered by the rising of greenhouse gases (GHGs) levels in the atmosphere. This is a serious danger to the physical and economic livelihoods of individuals around the globe and could negatively affect ecosystems by putting 20-30% of plant and animal species at an increasingly high risk of extinction.[1] This is expressed by the Intergovernmental Panel in Climate Change with confidence under the situation when global temperatures go 2-3°C above pre-industrial levels. Without further actions, the earth warming is unavoidable. This would bear knowable and unknowable consequences. (See Figure 1) The main Task is to avoid letting the temperatures grow above these levels. The main influencing factor is the greenhouse gas emission (GHGs), such as CO2 and N2 that primarily come from the burning of fossil fuels during activities including electricity production and operating internal combustion engines. However the main focus in this paper is directed toward emission reduction from operating internal combustion engines. This means, allowing more technologies that are efficient to switch to electric mobility. In this, case however, the electricity still poses an emission threat, due to the fact that it is the fuel of electric vehicles (EVs).

EVs have been around in various guises since the early 1900's and have found niche markets in low power, low range applications such as milt floats and golf buggies.[2] However, despite previous failures to set off the technology, EVs have once again appeared as an option for mainstream sustainable transportation. This happened largely due to climate change's rapid rise on the political agendas. Policy makers realized the difficulties in reducing GHG emissions from the transport sector, especially given the close ties between transport consumption and economic growth.

[1] Intergovernmental Panel on Climate Change (IPCC) 2012
[2] Committee on Climate Change; AEA (2009)

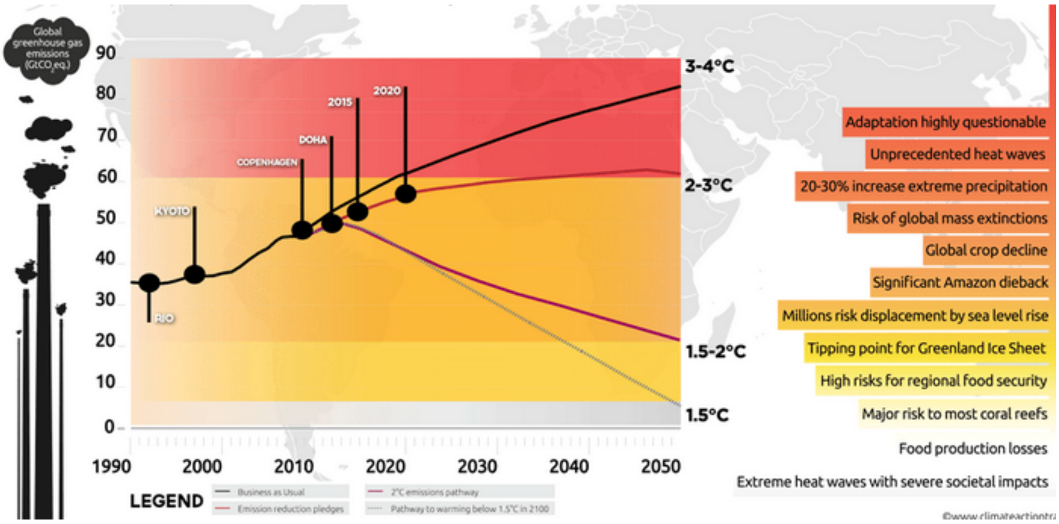

Figure 1: Climate Change trajectories ***(Source: Ecofys Consultancy 2014)***

The European Commission was eager to address this challenge. Voluntary agreements with automotive industry failed to deliver rapid reduction in CO2 emissions. Thus, European Commission enforced average CO2 emissions limits for new cars. The limits were fixes at 130g/km and will implemented between 2012 and 2015. The EC plans to strengthen the limit to 95g/km by 2020. Road transport is the second biggest emitter of greenhouse effect gases, causing 24.4% of total GHG national emissions (EU 27 -19%)[3] Thus, the CO2 emission in the EU transport sector are presented in the Figure 2 below.

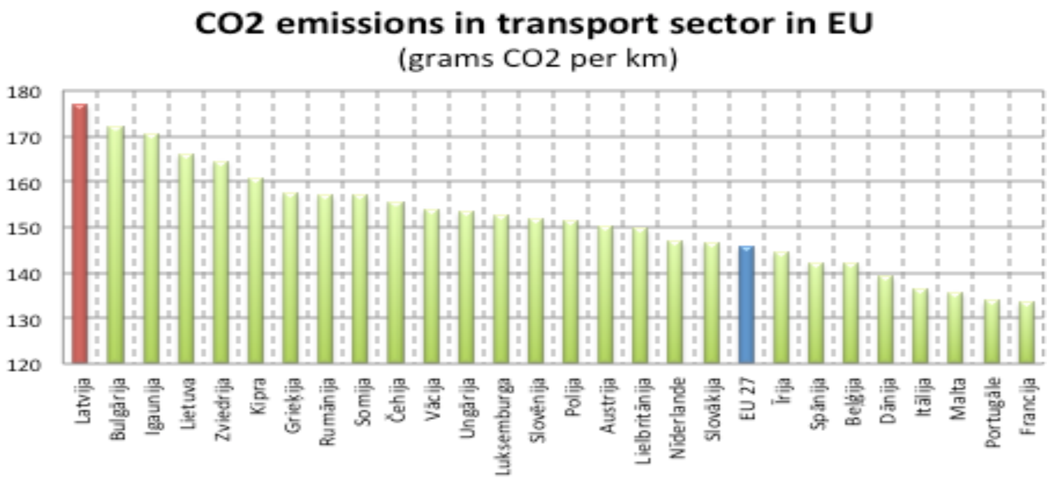

Figure 2: CO2 emissions in EU transport Sector (*Source: MEPRD 2013*[4])

[3] 05/04/2014 - Regulation (EU) No 333/2014 of the European Parliament and of the Council of 11 March 2014 amending Regulation (EC) No 443/2009 to define the modalities for reaching the 2020 target to reduce CO_2 emissions from new passenger cars

[4] Facilitation of use of green transport – electromobility, Ministry of Transport ; Ministry of environmental protection and regional development of the republic of Latvia; April 2013

In the long-term, EVs are important to those countries seeking to decarbonize the transport sector. Figure 3 illustrates the key role of transport CO2 reductions in the 2°C Scenario, which describes a future energy system that would limit average global temperature increases to 2°C by 2050.[5] In this scenario, the potential share of CO2 emissions reduction will be 21% by 2050 in the transport sector. In order to achieve this share, 3/4 of all car sales would need to be of some electric type by2050.

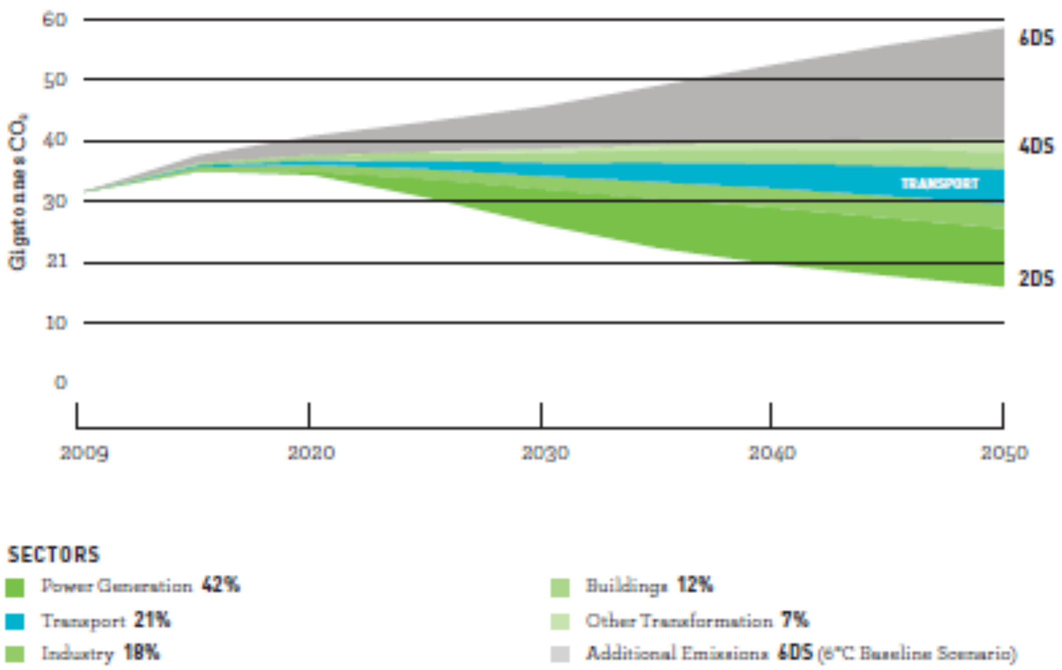

Figure 3: Role of Transport in CO2 Reduction; IEA, ETP 2012[6]

Thus, transport or mobility will play a vital role in cutting CO2 emissions needed to achieve global political climate change targets. The world's car fleet is expected to triple by 2050, with 80% of the growth in rapidly developing economies.[7]

2.2 Electric mobility

It is clear that Mobility is an essential part of today's life, representing an urgent and necessary element for the modern society. This need for more mobility confronts like natural resources and environmental barriers and requires new sustainable mobility concepts. Electric Mobility plays a primary role in handling these problems, in the

[5] Global EV Outlook, International Energy Agency's (IEA) 2013
[6] Sector percentages represent aggregated contributions to emissions reductions relative to the 4°C Scenario, which is based on currently proposed policies.
[7] FIA Foundation for Automobiles and Society

form of decreasing fossil dependency or de-carbonization policy. Adopting E-mobility implies a sizable change in existing systems. While generating a basis for new possibilities, new challenges occur and create a considerable impact on the value chain. As shown in Figure 4 new actors access the value chain increasing its complexity and thus creating new interdependences. This explains the requirement of introducing new ways to process and exchange information.

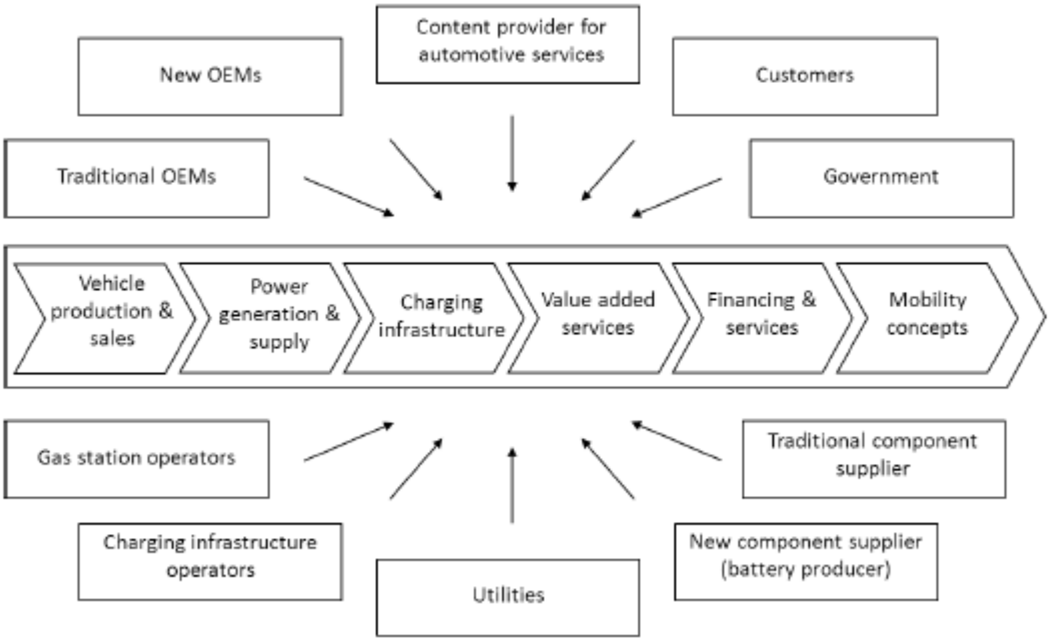

Figure 4: Electric Mobility Value Chain[8]

It has been however clear that in this industry it will not be a single type of engine to ensure individual mobility in a cost-efficient and climate friendly way. Thus, cars will still remain powered by classic internal combustion and hybrid engines, biofuels, natural gas and hydrogen, along with electricity. Purely electric vehicles are far from a mass production, despite their advantages. Electric vehicles are more efficient than conventional engines, thus allowing the use of a broad energy resource base for mobility purposes like renewable sources. Moreover these cars release almost no air pollutants and less noise. Also, they have the potential to level the fluctuations of renewable electricity generation.

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[8] Analysis and Discussion of Critical Success Factors of E-mobility Interconnected IS Infrastructure; Johanna Mählmann, Patrick-Oliver, Groß Michael H. Breitner; Published in: Multikonferenz Wirtschaftsinformatik 2012 Tagungsband der MKWI 2012

Up to now, research into electric vehicles has a strong focus on the technical components, in particular on battery issues. Current battery costs need to come down to a range of EUR 200 to EUR 300 per kWh in order to generate mass market appeal and acceptance.[9] This is a 40% to 60% cut from the current battery prices, assumed by McKinsey to be in the area of 500 EUR per KWh. Moreover according to overall research results, such a price decrease trajectory has a real potential as the battery prices were 1000 EUR/kWh in 2007. Thus a span of 40% to 60% price cut is still possible to be achieved till 2020, a fact that will make the things look better for the electric mobility sector. (See also Figure 6)

The drivers behind this are environmental concerns at local and global levels, but also peak oil. Given the potential sustainability advantages of EVs, but also the early stage of development, many governments worldwide have recently implemented EV policies, including Japan, China, France, Norway, Austria and Germany, to name just a few. On the EU level, a research initiative called “Green Cars Initiative” has been launched with a focus on sustainable forms of transport and mobility. Grants from the European Commission for scientific research, and loans from the European Investment Bank will be available for research into electric vehicles and infrastructures.

In the last years the world has again considered vehicle electrification in light of increasing and volatile oil prices, deteriorating urban air quality, and climate change. This renewed interest represents a “third age” of electric vehicles, starting with the mass-market introduction of EVs in 2010[10]

- Governments (as mentioned like U.S, Japan, China and EU countries) are now developing clear diffusion goals for EVs. Such a commitment in following climate goals has been met by most of the developed countries. Nevertheless, it is important to identify the frontrunners in order to assess their position and their means that contributed to such an achievement.

- Automobile manufacturers and consumers are embracing this technological switch

[9] Electromobility in Germany: Vision 2020 and Beyond; Germany Trade Invest, Issue 2013/2014
[10] Tali Trigg, “Third Age of Electric Vehicles,” *IEA Energy*, Issue 2, Spring 2012.

- EVs Sales growth rates in major markets new car models, a variety of manufacturers and batteries cost reductions are help the upheaval up EV market. The major markets are U.S, China, Japan, and EU countries like France, Norway, Germany and Netherlands. Thus, the U.S. more than doubles its EVs stock, reaching 291 332 units that accounts for nearly three-sevenths of the total global stock of EVs.[11] Japan ranks second with about 108 000 units sold since 2009, with 15% of global sales, followed by China with more than 83 000 plug-in passenger cars sold since 2008 (12%).[12] Since 2010, over 228000 light-duty plug-in electric vehicles have been registered in the European market as of December 2014, representing 32% of global sales.[13] As of December 2014, European sales are led by the Netherlands with 45 020 registered plug-in EVs registered is followed by France (43 605 all-electric cars and light utility vans sold since 2010) and Norway (43 442 registered plug-in EVs). Norway is however the country with the highest market penetration per capita in the world, having overpassed the 5% market share level.
- Innovative business models such are contributing to further mobility electrification. Governments are supporting this market transformation by offering investments in R&D and consumer incentives.

According to the up-stated, the greatest developments of electric mobility in terms of EVs market penetration are seen in U.S, Japan, Netherlands and Norway. Nevertheless China, France, Germany, Austria and other developed countries are also pursuing the aim of raising the EVs share and thus decarbonize the transport sector. However, the stated 5 countries (U.S, Japan, China, Norway and Netherlands) will be considered as "first runners". Furthermore, such a country selection allows gain an overview on the biggest world regions like North America, Europe and Asia. Putting them together will also improve the perspective look on the electric mobility global sector.

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[11] Jeff Cobb (2015-02-18); Top 6 Plug-In Vehicle Adopting Countries – 2014; hybridcars.com
[12] International Energy Agency, Clean Energy Ministerial, and Electric Vehicles Initiative (EVI) (March 2015); "Global EV Outlook 2015"; Clean Energy Ministerial.
[13] European Automobile Manufacturers Association (ACEA) (February 2015). "New Electric Vehicles Registrations In The European Union". ACEA.

Nevertheless, the electric mobility deployment is not considered an easy task. It includes a need for new infrastructure and new driving behavior. These however should not hinder the taken initiative to move toward a sustainable mobility option.

2.2.1 Sustainable electric mobility

A shift to ultralow carbon cars should achieve the required emission reductions from road transport in order to meet climate goals. Thus, it is essential to start developing the market for a range of alternatives. The question of whether a shift to electric mobility can deliver a sustainable solution stimulates fierce discussion between those that view e-mobility as a panacea for sustainability and those who argue that it perpetuates a car-dominated society with inadequate environmental benefits.[14] Both arguments are plausible, as this is a way to switch to electric vehicles (EVs), that will influence how sustainable the eventual outcomes will be. The Figure 5 below illustrates the challenge the Electro-mobility sector has to face, including thus potential benefits and risks.

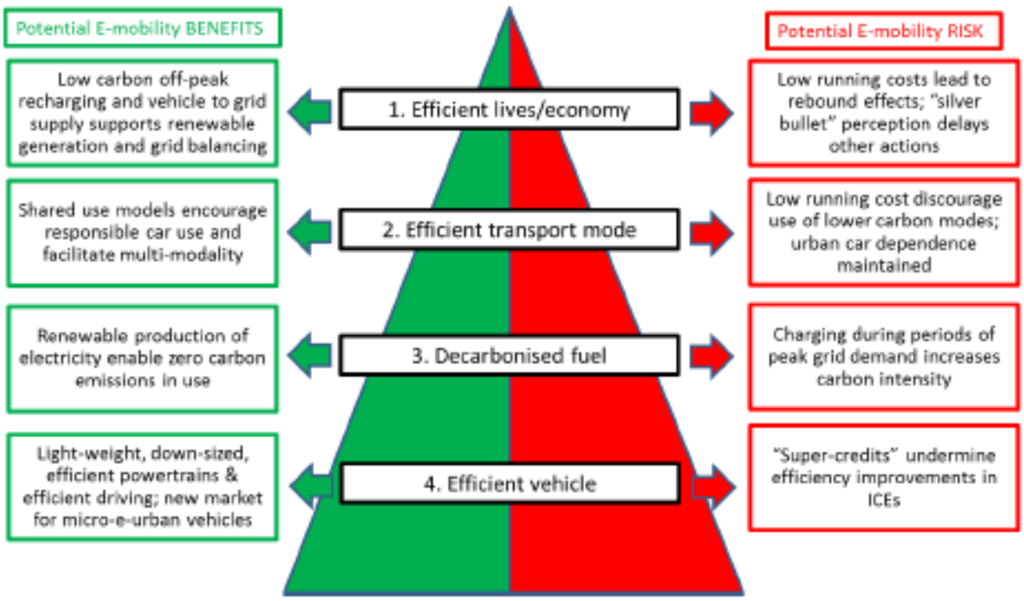

Figure 5: Potential benefits and risks of electric mobility (Source: Transport and Environment 2014)

[14] Electric Vehicles in 2013: A Progress Report, Published in July 2014 by Transport and Environment

Where and how EVs are driven, how the fuel is generated and when the car is charged will all decide if electric mobility will become a sustainable transport solution. The more adapted electric vehicles are:

- **Battery Electric Vehicles**, which are pure electric vehicles with all of their power derived from electricity. This is supplied to the battery, which then drives an electric motor. These vehicles produce no emissions, although they will still indirectly affect emissions if the power that they use comes from fossil fuelled power plants.
- **Plug-in Hybrid Electric Vehicles** powered mainly by electricity, can operate similar to an EV, but in addition, they have a small conventional internal combustion engine, which extend the available range. These vehicles do produce emissions while the ICE is in operation, but typically at a lower level.
- **Hybrid Electric Vehicles** combines an ICE with an electric system. The presence of the electric powertrain has the purpose of achieving better fuel economy and higher efficiency through technologies such as regenerative braking. Some hybrid vehicles use their ICE to generate electricity to recharge batteries to power the electric motors. However, these cars use the electricity in order drive more efficiently and are therefore not a truly innovative solution for a mass emission reduction.

The first important aspect of electric cars has a technical issue. It is the battery that makes the electric vehicle such a low performer in comparison with the normal car. If examining the EVs technical aspects from the available data, battery capacity is directly correlated with battery mass. Thus, more battery capacity implies a heavier and larger car. This is still the main challenge to battery manufacturers, to compress the cells performance without increasing the mass.

Moreover, ranges are still much limited (in average 150 km) and pure electric driving are limited to short and medium range applications. In terms of maximum speed and acceleration, EVs are not expected to differ significantly from usual cars. Nevertheless, due to overheating issues, EVs have a limited top speed range. Despite all this, their performance will increase over time and thus allow EVs to be used beyond urban regions.

The main problem associated with EVs is the battery cost, which represents almost the half of the vehicle price. Nevertheless, the costs of batteries are decreasing as long there is a high activity in the research sector. (See Figure 6) The reduction in battery cost shows how targeted R&D can improve technology development and thus the EVs market deployment. Battery costs are not just coming down in absolute terms, but in the near term, battery costs may be less than half the cost of an EV.[15] Apart from batteries, the R&D should be diversified in order to decrease overall EV costs.

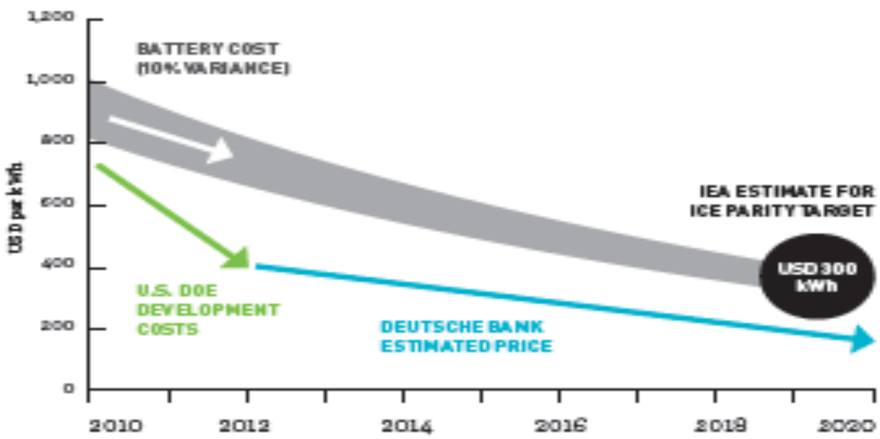

Figure 6: Batteries price trajectory (IEA 2012)

Another problematic issue of EVs is the charging process. Despite the fact that the electricity is cheaper than gasoline or diesel, the charging provides an inconvenience due to the electricity physical property. Charging an electric vehicle requires more time and is from this point of view very unattractive to costumers biased with quick fueling patterns. The lack of suitable infrastructure causes another inconvenience. However, the supply equipment installation is taking place across different locations (home, office, street, retail etc.) and by different charging modes. These modes can be generally grouped into the categories:

- **Slow Charging** is the most common type of charging that has the function to provide alternating current (AC) to the battery in 4 to 12 hours timespan for a complete charge.

[15] Impacts of Electric Vehicles – Summary report, Commissioned by: European Commission, Delft, CE Delft, April 2011.

- **Fast Charging** (DC charging) supplies the battery with Direct Current (DC) in a range (0.5 to 2 hours) for a full charge.

The next issue with EVs is the user acceptance. Despite the self-perception of being climate friendly, people tend to make decisions on preferences and provided utilities. Many studies show an increased willingness to pay more for an electric vehicle, but the way the people think and the way they act are not identical in most of the times. An increased purchasing price, limited range, longer charging, unknown safety issues and residual value seem to be serious disadvantages when deciding to buy a new car. All these elements determine the total cost a car ownership (TCO). This is considered an important indicator that most of people use when confronting decision to buy a car.

The difference in price between a conventional car and an electric car is often perceived as a loss. Thus policy makers are trying to fill the TCO value gap by offering up-front payments, tax exemptions and other benefits in order to make the users to lose the sense of loss.

The introduction of EVs is complicated because of the containing elements as, additional infrastructure, consumer new behavior and innovative technology. Attractive cars might be technologically rather complicated. Thus putting it under competitive conditions is a challenge. Many already available prototypes are proof that the technological obstacles have been addressed. The real complexity lies in something else. To introduce EVs on a large scale, different elements need to be present. The answer to what need to happen and who will pay for it is unclear and highly debated. Charging stations will need to be installed, that is clear. However it is still unclear what technology is more suitable, which electrical characteristics to use and how to implement the payment/billing system. The technology is still developing and many options are still floating around.

Electric driving is a new domain and new opportunities are showing themselves. Nevertheless, it is not clear what they can achieve.

2.2.2 Electric vehicles sale developments

The EU is accountable for a quarter of global EVs sales (See Figure 7). The US and Japan represent the largest national markets, with California in particular having achieved a 4% market share, largely driven by a mandate requiring manufacturers to sell EVs. [16] In the next years, China is expected to develop a big share in this branch. There is a wide differentiation in EVs sales in EU countries like Norway and the Netherlands that reached a market share of 5%, in contrast to almost 1% in other member countries. In these two countries, generous fiscal incentives stimulated the market in 2013; in the Netherlands some of the incentives ended on 31 December spurring last-minute purchases late 2013.[17]

However, it remains essential for the future policy to encourage EVs beyond 2020.

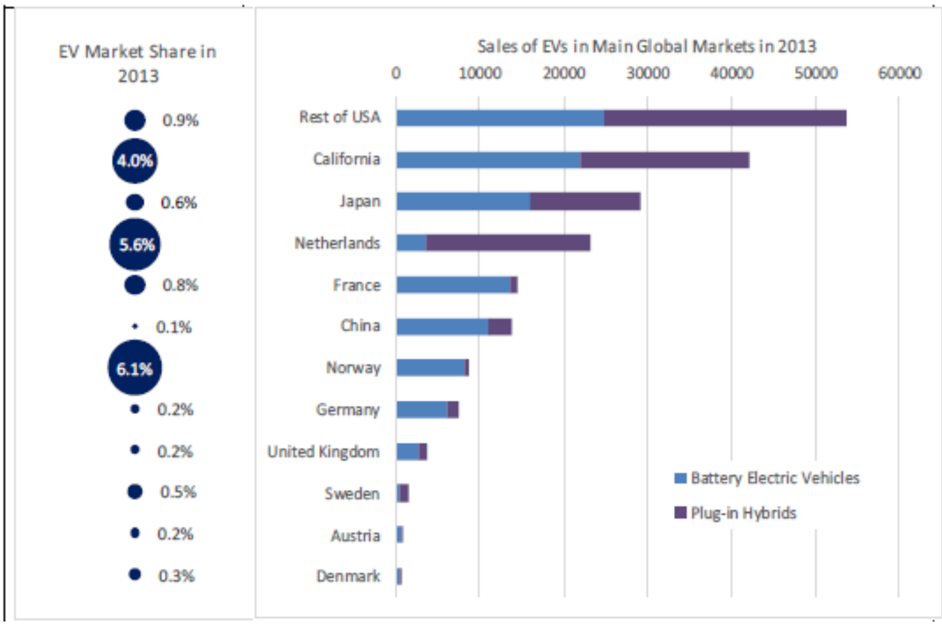

Figure 7: Electric Vehicles sales in main global markets (ICCT Data 2013)

The high sale figures from USA are understandable due to the high population and motorization ratio. Moreover, an important factor is that the U.S energy policy subsidized the EVs purchase with 7500USD. California added up an additional 3000USD summing up a total of 10500USD.[18] Japan is historically known to focus on innovation. However, more interesting is the difference between Netherlands and Denmark as both of them have overall similarities. Despite this, Denmark has a much low share of EVs thank Netherlands. To say that Denmark was unfriendly to cars would be an understatement as a 180% tax along with the 25%VAT charge

[16] DRIVING ELECTRIFICATION A GLOBAL COMPARISON OF FISCAL INCENTIVE POLICY FOR ELECTRIC VEHICLES; Peter Mock and Zifei Yang; ICCT, 2014

[17] Electric Vehicles in 2013: A Progress Report, Published in July 2014 by Transport and Environment

[18] Hidrue, M.K., et al., Willingness to pay for electric vehicles and their attributes. Resource Energy Econ. (2011), doi:10.1016/j.reseneeco.2011.02.002

and the yearly road tax on new car ownership makes new car ownership a challenge to most Danes. Denmark has a goal of 200,000 EVs by 2020, recently reduced from 400,000. However, 2014 and 2015 will definitely show a better result, because all EVs are now not a subject of the 180% tax and yearly fee. It seems that Denmark concentrated more on the deployment of the renewable energy supply. It might be now the right time to focus on the transport sector as it has a high potential to be correlated with renewable electricity as a main fuel for the vehicles. On the other side, Netherlands achieved far better results, however the majority of clean vehicles are hybrid plug-ins and solely a tinier part of the market is filled with pure EVs. The reason for higher sales in Netherlands is the better policy that includes the Discount on or exemption of vehicle circulation tax, favorable fiscal treatment of leased cars, subsidies for the installation of charging points and subsidies for R&D higher stimulation. All these are not present in Denmark and thus provide a higher stimulus for the market uptake, a fact that is already registered.

The future trajectory of EVs sales is highly uncertain but seems likely to continue the uptrend. This steady growth is more likely to last longer than a sudden transformation could happen.

EVs can perform an important role in the switch to more sustainable mobility but are not a universal remedy. Specifically, the question how the EVs appearance will evolve will determine how sustainable the eventual outcome becomes. For example: unless vehicles are fueled by clean energy, the benefits from CO2 savings will be limited. Next, unless EVs are suitably used in combination with other sustainable mobility models, excessive vehicle use will continue to impose big costs and to reduce the quality of life. Therefore the focus of future policy must not target only increased sales but also the way electric vehicles are used in order to encourage electric mobility where it makes the most economic and environmental sense.

2.2.3 Rationale, Drivers and Barriers of Electric Vehicles diffusion

It should be stated that it is very difficult for alternative vehicles to break into the long-established and over-sophisticated market of ICEVs because of the numerous barriers to entry that they face. However, the EVs technology is being supported not without reasons but because it has a fundamental advantage. The EVs advantages include the potential to reduce the usage of fossil fuels for meeting vehicle requirements.

A key reason for supporting EVs is that they utilize more energy efficient technology than ICEVs do. This also results in a reduction of greenhouse gas emissions, although the size of these reductions depends heavily on the technology used to generate the electricity. This is subject of the provided example in the following chapters. A further advantage of the electric vehicle is that it should lead to an improvement in city air quality and noise levels.

There are however several barriers that will need to be prevailed before the market mass diffusion. These barriers include:

- **Costs**. Even though the EVs long-term total costs are less than those of ICEVs, (lower maintenance and fuel costs), the acquisition cost remains higher because of battery. Thus, a competitive purchase price will mainly depend on the advancement of battery costs. Currently there are evolving some solutions for spreading the cost of battery like offering grants or leasing. Moreover, the purchase cost has led the public sector to intervene via acquisition incentives and R&D support measures for battery developments.
- **Infrastructure for recharging**. Despite the existent of small networks in some cities, their spread of them is still slow. Charging stations installed at homes are slow and relatively inexpensive, while quick charging needs a higher investment. The failure to extend recharging networks can provoke range anxiety, the fear of not finding a charging point before the battery goes down. A further point concerning the chargers is their compatibility. The homogeneity of systems is therefore essential for the diffusion of EVs. Here, there is an obvious role for public regulation.
- **Consumer acceptance**. Pike Research (2009) concludes that consumers would be willing to make the switch if the EV reduced their energy costs. However, the presented figures show that consumers are faced with under-performance issues and consequently do not easily, switch. Moreover, consumer conservatism, unawareness, risk-aversion and misinformation seem to be the main challenge here.

- **The evolution of other technologies**. The existence of vehicles using other technology like fuel cell, biofuels, ethanol, hydrogen and the imposing presence of ICEVs represent obvious competitors for electric vehicles.

In attempts to overcome these barriers, various factors will come into play. These can be classified as endogenous (government and industry support) or exogenous (fuel prices volatility, economic break downs, etc.) The involvement of Public Authorities is plainly vital as far as it concerns regulations that directly and indirectly encourage the use of EVs. Thus it is important to support the growth of the current niche market in order to:

- Stimulate manufacturers to enlarge the range of available products thus reaching a wider span of potential buyers;
- Stimulate innovation and competition to accelerate the technological improvements;
- Cut prices, through both innovation and economies of scale;
- Increase the visibility of EVs on the road;
- Increase the use and installation of public recharging infrastructure, enabling the use of an EV on a wider range.

Therefore, it should be stated that whilst EVs contribute in reducing CO2 emissions in the short and medium term, the main emissions reduction benefits of this technology will be experienced in the long term (beyond 2020), when costs have been brought down and performance pushed up, adequately to enable a mass market uptake.

The many EVs advantage can be summed up in overall greater energy efficiency. This probably is the key motive causing public authorities to put into action a number of measures to assist the EVs at a range of official levels (state, regional and local).

3 Electric Mobility Support actions and strategies

3.1 Public policies directions

There are various government and industry support and investment programs for EVs. The majority of the investments from have been initiated in the developed regions like North America and the Europe. However, big industrial countries like Japan, China and South Korea have also kept the pace. The initiatives for electric mobility (target sales, pilot projects, infrastructure, urban rights, etc.) vary from country to country. The EVs infrastructure is mostly installed and developed in collaboration with private entities, showing that there is also economic potential apart from public interest. Research activities are abundant in the USA and the EU, but also in Japan and China.[19] Research activities at national level within the EU often make use of huge incentives packages. However, most developments are pilot and demonstration projects that involve private companies, universities, research institutes, and public institutions.

Policy frameworks have embraced four essential EVs features: charging network; fostering demand for EVs; industrial and R&D support; and the introduction of electric vehicles in programs of sustainable mobility.

In most cases, strong government backing on the demand and supply side, have led to rising market penetration. Well-designed financial incentives for consumers at the national and local levels are lowering upfront costs for EVs and EVSE, quickening sales and infrastructure deployment in a number of global markets.[20] Such subsidies give an advantage to early adopters and offer EVs manufacturers and consumer the conviction in the market further development.

Non-financial incentives are however also effective. On the supply side, R&D on technologies (batteries and vehicle components) has a positive impact on the market. Thus as stated the main policy implication targets the following directions:

[19] Impacts of Electric Vehicles – Summary report, Commissioned by: European Commission, Delft, CE Delft, April 2011.

[20] Global EV Outlook: Understanding the Electric Vehicle Landscape to 2020; Clean Ministerial, Electric Vehicle Initiative, International Energy Association; April 2013

3.1.1 Supporting citizens and businesses

When it comes to supporting citizens and business, three major options are available. First of all governments can provide up-front subsidies for individuals when they purchase an electric vehicle. However, these subsidies are very costly and are not that effective, as the cars remain too expensive for individual citizens. Moreover, such subsidies might enable car manufacturers to profit from these subsidies, a fact that might keep them from reducing prices.

Second, governments can support firms in the case they want to make use of EVs in their operations. Direct subsidies are an option, but it is also suggested that indirect implication like consulting and cost-of-ownership calculations might help in understanding the business better. Additionally, there are marketing benefits for the first companies that are using EVs and a city/government could help them in collecting and materializing those benefits by forms of co-branding.

Third, many cities enjoy a car sharing, a particularly interesting concept with respect to electric cars. EVs are typically well suited for use in cities due to size and range. Furthermore, such a concept allows people to gain experience with driving an EV and this could become very powerful in terms of public education.

3.1.2 Supporting charging-infrastructure development

All institutions recognize that the development and the installation of a recharging infrastructure are necessary to make the EVs market introduction successful. However this task is taken mostly by City Administrations. Although a national directive would trigger the municipal authorities to get involved. There are different approaches to this however. The most proactive promoters invest in a number of on-street charging that are placed on strategic locations such as shopping malls, railway stations and public parking facilities. Another strategy is to place the points close to EV owners' homes. Cities can opt for co-financing options in which a private entity, invests in the infrastructure with combining funding from the municipality. However, such a solution is able to succeed only when the private party is truly interested in investing in such a project.

Nevertheless, the business model for public recharging is still risky as the profit margins on electricity are marginal. Especially in the early phase when drivers count on low energy costs to payback the initial vehicle investments, higher charging costs are theoretically unacceptable. Additional to this consideration the lack of billing solutions motivate many cities to offer either free electricity or to implement flat fees and prepaid systems

3.1.3 Regulatory measures

Whereas the most measures need direct financial involvement of public institutions, there are also regulatory means that have less impact on public budgets. The most popular measure is to offer free parking for EVs. Often the parking occurs at public charging stations that might be occupied by EVs that are already fully charged. How to solve this problem remains unclear but some parking time limits might be effective. Moreover, free parking is a temporary measure that is suitable as long as the number of EVs is limited.

However, the regulatory measures should not only stimulate EVs demand but also reduce car use in general, which seems contradictory. According to this issue, it is arguably if parking should be completely free because the top goal should be to reduce the use of cars and to support cycling and public transport. Cities with bus lanes can let EVs to make use of them. Moreover, actions that hamper EV drivers from spending time in traffic might be very powerful in persuading businesses.

Another measure is to force property builders to include charging infrastructure in the parking slots of their projects.

3.1.4 Raising awareness

Most people lack the experience of driving an EV. As a result, there is no knowledge about the technology itself. Thus, governments may be able to provide such information during all sorts of events or whenever people ask. Especially for the second case, a one-stop-shop could concentrate all the information and thus provide an important role in rising consumer awareness. However, such means of communication reaches only those citizens that already have an interest in the topic. To increase visibility and attract people interest, charging points and EVs should be visible to the public.

Offering a possibility of driving an EV is very important in persuading people that EVs are worthy vehicles to drive. This, however, do not force public administrations to buy these demonstration EVs, but they can try to co-organize events in collaboration with car manufacturers or dealers. Alternatively, they can set-up an EV center where people can test and drive EVs throughout the year. As mentioned before, car-sharing models including EVs are also effective in having many people obtain the experience of electric driving.

3.1.5 Public procurement

For a number of reasons it is worth to reflect on buying EVs for the government vehicle fleets. It is a way of showing the public and businesses that the public administration is not just talking about EVs but is also taking action. Finally, this is also a way of presenting that EVs is a reasonable technology and makes sense from a monetary perspective. Nevertheless, the process of picking the right EV for is difficult and if procurement regulations are applied, the process becomes more complex. The acquisition costs are higher than those of conventional cars are and it is still difficult to fully assess the total costs of ownership. However, subsidy schemes may lower the costs, but the hurdle to do more than purchasing a small flee of demo vehicles remains. Moreover, companies are discouraged by public procurement regulations and consumers have their own specific preferences, thus the true effect of public procurement is highly debated.

3.1.6 Governing the transition with other levels of government

Public Authorities cannot run the alteration towards electric mobility without cooperation on national and international level. Thus, national collaboration with cities, regions, and central government could lead to standardized billing systems, integrated and centralized information about infrastructure availability. However, each municipality has own regulations concerning parking spots and certifications for charging points. Thus, an integration approach would provide clarity to citizens and interested parties that aim to build-up charging networks.

On the other hand, international cooperation is essential to lobby for general standards for connectors and sockets. This is necessary because nowadays, different connectors are in use and people must take multiple cables with them.

Setting a standard for each region or city is thus not a solution, as consumers must have the possibility to move between cities and countries nations, so international cooperation is without doubt required.

In the end, the governments are in charge of setting the targets and regulate the activity but as recognized, the EVs are also an important subject for cities and municipalities as the range suits mostly within the urban capacity. Moreover, only 16 cities and regions together held about 30% of worldwide EV stock and represent the early leaders who are identifying challenges and best practices.[21]

- The experiences of urban drivers and the pilot policies of local governments are fastening the transition to sustainable mobility. (*Low Emission Zone (LEZ) in UK[22], Netherlands[23], Germany[24], Norway[25] , Grønn Bil in Norway[26])*

- Car sharing models are offering an experience with electric driving, which afterward help to make informed decisions about EVs acquisition. Also, car sharing is emerging as a demonstrable solution for innovative mobility, reducing traffic intensity, GHG emissions and noise (*DriveNow, Car2Go, Flinkster, Cambio)*

- Fleets including buses, freight and taxi can boost the public ability to electrify the passenger vehicle stock. (The *Bus Service Operators Grant* (BSOG) in UK[27]

- Cities act as laboratories for EV deployment initiatives and can provide valuable lessons to help in understanding the functionalities of this technology. (*Metropoolregio Amsterdam Elektrisch* (MRA-E))[28]

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[21] Global EV Outlook: Understanding the Electric Vehicle Landscape to 2020; Clean Ministerial, Electric Vehicle Initiative, International Energy Association; April 2013

[22] The most polluting vehicles - that do not meet the LEZ emissions standards - are not allowed driving in the area and will need to pay a daily charge if used within the LEZ.
http://www.lowemissionzones.eu/countries-mainmenu-147/united-kingdom-mainmenu-205

[23] http://www.lowemissionzones.eu/countries-mainmenu-147/netherlands-mainmenu-88.

[24] http://www.lowemissionzones.eu/countries-mainmenu-147/germany-mainmenu-61

[25] Low Emission Zone (NO): http://www.lowemissionzones.eu/countries-mainmenu-147/norway-mainmenu-197, http://www.nordicroads.com/website/index.asp?pageID=369

[26] http://gronnbil.no/

[27] The Department for Transport has modified BSOG in April 2009 to provide greener buses through rewarding gains in fuel efficiency and the introduction of low carbon buses. A new call with a budget of £15 million (green bus fund) was launched in July 2010 by the UK's Department of Transport.
http://www.dft.gov.uk/publications/bus-service-operators-grant-bsog-for-community-transport/

- Support measures need to be designed to best fit the needs of a given region. (The *Community Challenge in UK*[29], *Hertogenbosch Electric Mobility in Netherlands*[30]*,ENEVATE for the EU, Joule I, II Program for EU)*

- Financial incentives have been successful in some markets (Norway), though other non-financial measures as special traffic rights have proved to be suitable as well. (*Fuel Economy label in UK*[31]*, Ecoscore in Belgium*[32]*)*

- Most municipalities use a mix of incentives to foster demand for EVs and necessary infrastructure. These include financial and non-financial subsidies as upfront reward, tax exemptions and traffic special rights.

- A number of cities (countries) are leading by example by having already included EVs to public fleets (Spain, Norway, Netherlands,Japan). The charging stations are installed at public buildings and the electricity is in some cases offered at discount prices.

However, municipalities are learning from their own experience and from each other. As a result, other cities intending to electrify the mobility markets do not need to cover the high costs of a first-mover. Instead, they can learn from early leaders.

Nevertheless, the rationale trigger for policies towards innovation lies in several market failures. First, if the negative externalities of environmental challenges are not collectively paid the society is unlikely to use the resources efficiently. This market failure suggests that policies should adjust this externality, through CO2 taxes, tradable certificates or other market instruments.

Secondly, there are specific market failures in the market for innovations. The idea that market failure leads to under-investment in innovation, mainly due to difficulties

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[28] http://www.metropoolregioamsterdam.nl/20120509EV.html

[29] a yearly initiative, launched by the Low Carbon Vehicle Partnership and Energy Saving Trust, designed to "stimulate local action towards lower carbon journeys". The initiative offers prizes of up to £5,000 for community based projects promoting at least one of three categories: low carbon vehicles and fuels; smarter/ eco driving; reducing car use. Projects can deliver physical improvements, equipment or technological developments as well as providing information or setting up a scheme to promote sustainable transport (http://lowcvp.org.uk/assets/other/Community%20Challenge%20Brochure.pdf)

[30] http://www.s-hertogenbosch.nl/inwoner/milieu/luchtkwaliteit/maatregelen/

[31] This label is voluntary initiative for dealers and, helps car buyers easily assess the impact on climate change of different cars based on a colored scale http://www.dft.gov.uk/vca/accessibility/description-of-the-new-car-environmental-label.asp

[32] http://www.ecoscore.be/en

of firms to fully appropriate the returns to their investment, has been the principal rationale for public funding of R&D and public support for innovation for half a century.[33] Traditional responses to such market failures include policies that target the defense of intellectual rights, R&D subsidies to knowledge producers, and policies that can help in seizing externalities.

3.2 Policy stakeholders and market strategy

Theoretically, transformational changes, as the EVs are to the transport sector, need a deviation from the status quo. It cannot be assumed that the dependence upon dominant mobility solution providers will drive the switch away from fossil fuels. Thus, strong policies will need to dismantle market barriers to innovative technologies. It is primordial for policies to correctly account externalities and fairly assign responsibility to involved actors.

This section identifies the different stakeholders that need to be mobilized to successfully introduce the EV technology:

- **Governments and politicians** need to be convinced by the electric mobility and thus financially support necessary subsidies. Politicians can use EV in public showing a good example. Governments naturally play a central role in pilot projects since they can mobilize a number of useful instruments. National governments are traditionally in charge for legislation, taxation schemes and R&D funding. Supporting infrastructural measures such as installing public charging facilities, providing access to priority traffic lanes, or offering exemptions from road tolls may play an important part promoting the use of vehicles which are demonstrably less damaging to human health and the environment.[34]
- **City administration** should act as facilitator promoting EVs partnerships;
- **Citizens** should reduce and better plan their travel time. Customers can therefore be encouraged through financial incentives to choose the efficient solution.

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33 *THE FUTURE OF ECO-INNOVATION: The Role of Business Models in Green Transformation;* OECD/European Commission/Nordic Innovation Joint Workshop; January 2012

34 PLUGGED IN: THE END OF THE OIL AGE; Summary Report; WWF 2008

- **Service Providers** can create smart applications and thus integrate smart mobility functionality.
- **Public transport companies** can better inform their customers and for example provide a smart multi-mode travelling alternative, but they can also use electrified mobility in some cases.
- **Police or traffic supervisors** could better predict and control traffic flows.
- **Financial institutions** can support affordable financing to private entities and consumers to acquire sustainable means of transport.
- **Vehicle manufacturers** should improve the efficiency of their production process and end products. So far, the vehicle industry has played a minor role in the promotion of EVs. However, some car manufacturers are creating partnerships with utilities in order to overcome the 'chicken and egg' dilemma. Moreover, they often have a close contact with big fleet owners and can thus have a bigger role in promoting EVs in the market.
- **The supporting industries** (equipment producers) have a more proactive strategy, as their business depends on the increased use of their products.
- **Retailers and maintenance providers** play a key role in the EV market introduction since their commitment or hesitation in selling and servicing EVs do often affect the purchaser's decision.
- **Energy suppliers** (liquids, gases, or electricity) should decarbonize their energy generation lifecycle and bear responsibility in reducing their energy carbon content. For liquid and gaseous fuel suppliers, Low Carbon Fuels Standards can encourage the upheaval of biofuels. For electricity suppliers, more space is available. Thus including renewable resources, substitute coal with natural gas and carbon capture and storage technologies are possible solutions. However, big utilities are engaged in promoting the use of EVs, having provided charging solutions and sometime subsidized electricity.

In general, the chances of EVs successfully introducing improves with the number of stakeholders committed to the promotion plan. There is a variety of strategies for the involvement of additional stakeholders: persuasion, networking, mandates, voluntary agreements, public-private partnerships and leadership by example.[35]

A successful implementation of initiatives needs to have a flexible approach in cooperation with key-stakeholders. This approach involves flexibility in timing, adjusting size and the possibility to involve partners. Despite this, higher administration levels usually take a long-term perspective and thus develop uniform policy frameworks, thereby limiting flexibility. Thus, the challenge for upcoming subsidizing frameworks is to cover the gap between the need for flexibility and the aim for uniform policies.

However, circumstances points to the fact that there is no decisive pressure on EVs. This is not because involved elements impose barriers for electric driving, but because the interaction of elements makes the situation for many actors more attractive to wait that to act. Some actors are going for it, but many others are just pretending to do it. This is the current state of EVs. Doubts and uncertainties of different actors have led to complexities. However, actors face both advantages and disadvantages but, predominantly the disadvantages always come in first, being more compelling on the short term. Because it is relevant for the deployment of public resources, this dilemma gains more and more attention.

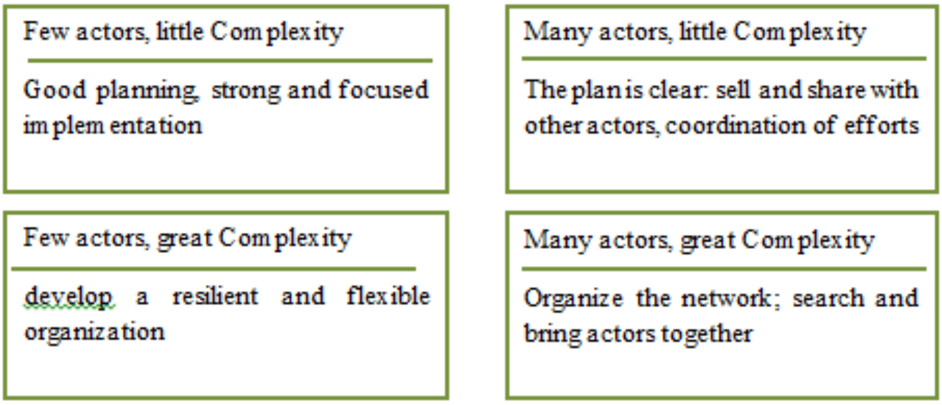

Figure 8: The arena of Electric Mobility (Author)

The arena of electric mobility (Figure 8) supposes the existence of many stakeholders and many interests. Electric mobility is not just a wicked policy problem and in order to make progress it must be developed in an arena full of actors and actions. However, it can cause different collective action problems.

[35] Hybrid Electric and Battery Electric Vehicles; Measures to Stimulate Uptake; AEA Energy Environment; 2008

If there is a simple complexity and only a few actors, the execution is relatively simple. In the case of a few actors and a higher complexity, a better process design and longer thinking could provide the apparition of the final strategy. Then simple execution could still be possible however just through a reasonable number of actors.

On the other hand, when there are many different actors, with different degree of commitment and involvement, possible strategies will change. Control focuses more on bringing interests of the various actors together than executing the plans. However, the complexity and multiplicity of actors is not necessarily restricted to the commercial players in the market.[36] It is also includes governmental authorities. For example, many regions are heavily invested in natural gas networks. They are stuck in this earlier strategy. How to solve this through governance remains a discussible dilemma.

When there is a situation of limited complexity and with different actors, the solution and end strategy lies in competent project management. However if the complexity is considerable, and the policy arena is filled diverse players, it remains impossible to elaborate preemptive solutions. Such situation requires collaborative interactions among actors in order create viable and sustainable strategies.

On the other side, EVs diffusion involves initial large investments benefits are expected to arise later on and can advantage those that contributed less in the beginning.

Policymakers face a similar free rider dilemma in the assessment of their strategic actions. They are opened for supports but it is still not clear whom and how much to help. Moreover, if exceeding to favor some actors, this might force the entrepreneurship stimulus decrease.

Every choice that governments make means they lose part of their freedom to act. Support, especially in the current era, is a zero sum game.[37] Incentivizing one initiative comes inevitably at the cost of resources for other projects. Moreover, the use of resources and political capital is risky.

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[36] Governing the transition to e-mobility: *small steps towards a giant leap;* Netherlands School of Public Administration, 2011

[37] Governing the transition to e-mobility: *small steps towards a giant leap;* Netherlands School of Public Administration, 2011

If the policymaker picks an inferior system, he might get locked by his commitment, which can inspire some market players to play strategically on this, asking for additional funding in order to strengthen an inevitably shrinking position.

The history of state aids is full with sad examples. Thus, this perspective applies to the current situation of carbon industry, which has good connections with governments. Therefore, if governments decided to kill the carbon industry, this would mean killing the interconnected areas of proper arranged businesses and government. However, if the governments may want create enough space for diversity and thus and ignore picking up a winner, which would delay the ultimate choice as long as possible. In this case, the winner is chosen by the market. If the government provides relatively equal support, the best alternative will stay on the surface, if the market is open and fair enough. (see Figure 9)

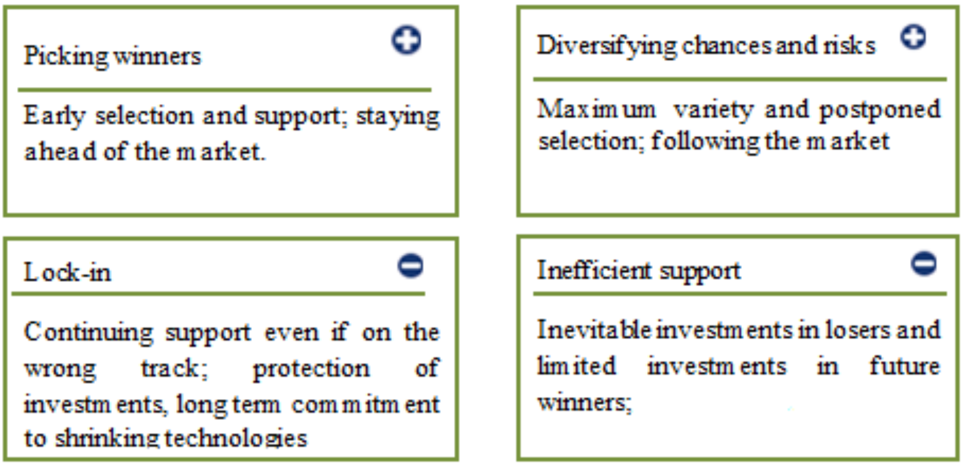

Figure 9: Supporting Innovations (Author)

Without intervention, there are limited chances for EVs mass introduction. The first dozen of cars will get on market without problems, thanks to policy incentives. What matters more are the steps that bring the EVs deployment upwards to mass acceptance.

Thus, this requires commitment from government, industry and society. It is still unclear how involved actors will find common agreements to follow suit.

The policy actions should be small, quick and simple to connect. It should represent a symbolic value and deliver a strong image with real content. It should be more than a suggestion of significant progress, something that truly matters.

3.3 Stimulus measures and Incentives

In many countries, financial incentives are already supporting the diffusion of energy efficient mobility means for consumers. However, adopting such incentives is in demand of careful consideration. The focus should be equally directed on supporting low emissions and energy efficient mobility in a technology neutral way. The risk of investing in a specific technology can miss the emerging favorite one. Even if there is a strong desire to stimulate the market in favor of EVs, the subsidies must perform in a way that does not decide in advance how EVs will emerge, charging arrangements function. Since the ultimate purpose is to reduce GHGs emissions in the case of transport fuels, the subsidies must be directed exactly to that. In this case, the performance in terms of CO2 reductions should rely on well-to-wheel emissions. Nevertheless in the long run is still preferably to rely on lifecycle emissions.

Stimulus actions are reactive policy frameworks, formed to mitigate an aggregate demand shock. Thus, such measures are characteristically short-termed and must stimulate aggregate demand in an economy. Policies on the other hand embrace mostly a long-term perspective and do not have the goal to directly stimulate the market. These differences makes clear that, stimulus actions express certain opportunities, while policies help anchoring the targets. In fact, such measures have been enacted during a crucial period, as governments around the world attempted to avert a global depression and at the same time attempted to reduce the environmental impact on the economy.[38]

3.3.1 Tax Instruments

Tax instruments are a popular indirect tool included in EVs mix of stimulus measures, having most often promoted for greater fuel efficiency in vehicles. Tax instruments enhance tax cuts and exemptions, tax credits and subsidies, and new environmental taxes.

Most tax incentives have been designed to act as stimulus, not to contribute to the environment or support the climate change task. However, since tax exemptions for

[38] Green Stimulus Measures ; EC-IILS JOINT DISCUSSION PAPER SERIES No. 15; INTERNATIONAL LABOUR ORGANIZATION, INTERNATIONAL INSTITUTE FOR LABOUR STUDIES

the acquisition of new cars contribute to a more fuel efficient vehicle fleet, it also has non-green elements.

Many EU Member States and other developed countries have implemented various tax related measures to support EVs. Following examples are known:

- Car registration tax reduction (Austria, U.S, Denmark, Norway, Netherlands)
- Personal income tax reduction (Belgium, U.S, Germany, Netherlands,
- Annual circulation tax exemption (UK, Germany, Netherlands, Portugal, UK)
- Incentives at the point of purchase (UK, Spain, Norway, Netherlands, Japan, U.S, China etc.)

Moreover, pushing up taxes on fuel consumption and downgrading those on electricity (produced primarily from renewable sources) would have an influence on the final price of these energy products, favoring the introduction EVs.

Additionally it is important to notice, that VAT has a significant effect on the EVs purchase price. Even if deducting the up-front bonus, EV owners due to the higher purchase price end up paying considerable VAT amounts. However, the only country that exempted EVs from this tax is Norway. This, along with high purchase subsidies and other non-financial incentives as privileged traffic rights seems to be a good practice in terms electric autos market penetration. In 2013 the car sales in Norway doubled.

3.3.2 General Government Spending

This government spending refers to a set of investment schemes that stirs up the R&D on innovation in clean technologies and support in parallel the infrastructure development. The Figure 10 below present the main directions targeted by policy keepers in order to promote innovations.

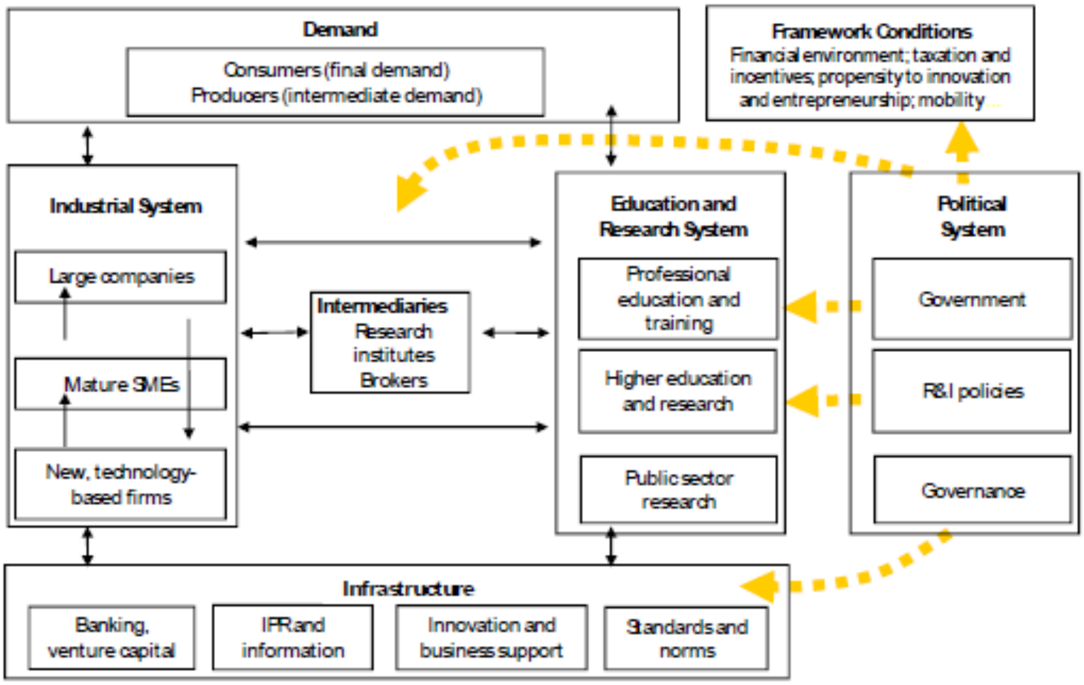

Figure 10: Market picture of a sectoral approach to innovations (JRC Scientific and Technical Reports, European Commission 2013)

3.3.2.1 Industrialization and R&D policies

The Automotive sector is one of the most promoted sectors in terms of governmental R&D spending. Figure 11 shows the sectors where Governments are mostly interested. As already mentioned, battery costs are the main factor that will decide upon the competitiveness of EVs.

It is therefore no wonder that most R&D actions are focused on technological upgrades of vehicle batteries. It thus recommended that governments provide assistance for most innovative battery producers in the sector.

Such assistance should empower the expansion of battery manufacturing factories ensuring that investment necessities are not an impediment to progress.

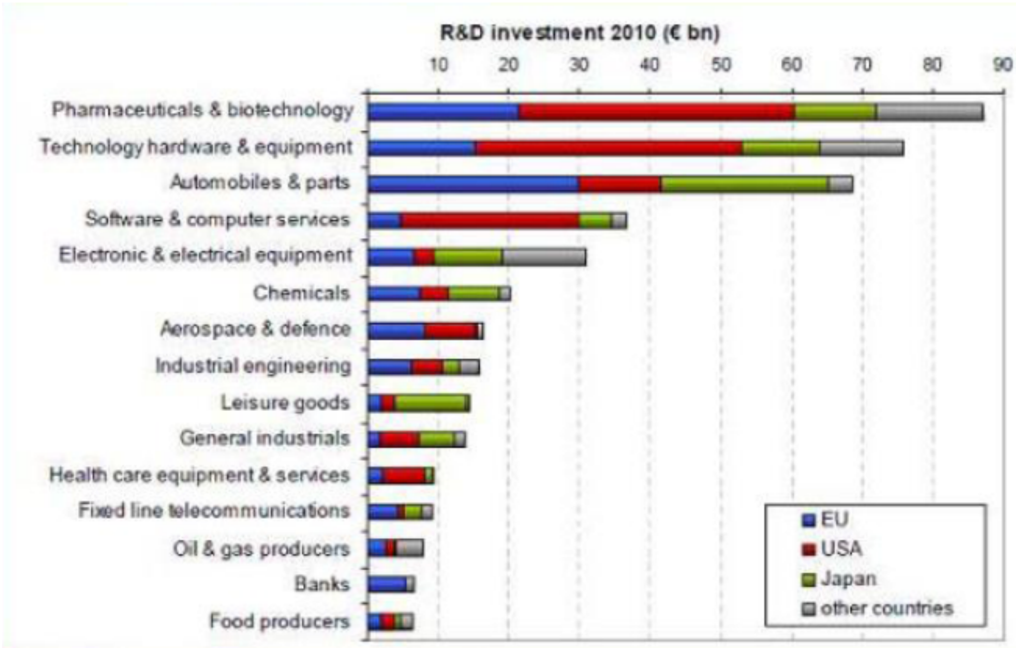

Figure 11: R&D investments in industries[39]

As an example, The European Commission has financed R&D projects via the JOULE I and II programs and under the European Economic Recovery Plan (EERP) via "European green cars initiative". Among the structures that received financial support are "European Electric Road Vehicle Association" (AVERE) and the "Association of Cities Interested in the Use of Electric Vehicles" (CITELEC).

Encouraging R&D in low-emission vehicles has the opportunity to achieve a breakthrough in the consumption of renewable and low emission energy sources. the European Economic Recovery Plan (EERP) proposed the "European green cars initiative".

In the end R&D are important activities for nations seeking to assist technological innovation achieve full market potential. The investments done in R&D in are diversified in different spheres. (See Figure 11) However, the transport sector is gaining much attention. This means that it is an important technologic sector being highly challenged by the need of innovation. Moreover when looking at Figure 12, there are presented the main components where the R&D funding for EVs flow. Thus as it is seen the highest investments are made in demonstration and public use

[39] Multiannual Roadmap for the Contractual Public Private Partnership European Green Vehicles Initiative; EPooSS, ERTRAC, Smart Grids; 2013

purposes. This emphasizes the primordial necessity of product visibility, public acceptance and the government desire to monitor and learn from the initial EVs market deployment.

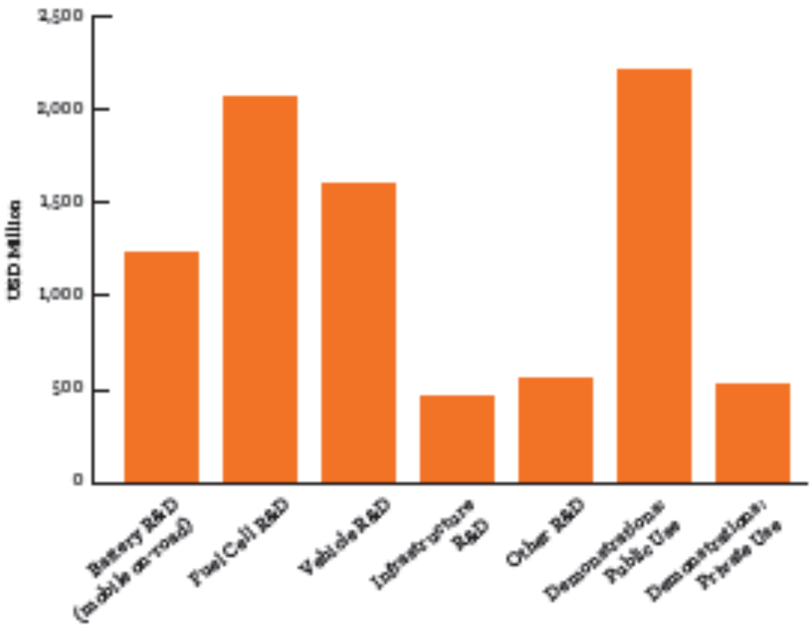

Figure 12: EVs R&D Investment spheres (IEA 2013)

However, there is also relatively more focus on battery and fuel cell R&D, which is a logical outcome especially when considering that these domains represent the largest cost of EVs.

The existent support will come eventually to an end, but in the short term they are of substantial importance to current fleet electrification efforts worldwide.

Other government spending refers to both direct and indirect labor market policies, investment in infrastructure and consumer subsidies.

In this area, the multiplier effect features prominently. The multiplier effect of government spending on general socio-economic outcome and private consumption can be significant, especially in the long run.

3.3.2.2 Funding Innovative companies and Collaborations

Viable and innovative projects in areas like electric transport usually require considerable financial backing in order to have an attractive appraisal. Accordingly, as a part of the new policies on industry is to organize an Innovation Fund, that will have the purpose to enable returns on investments. Consequently, entrepreneurs and

existent industries will have the opportunity to invest in profitable and sustainable projects. Such an Innovation Fund will improve the access to capital. Both governments and the business sector have to cooperate in funding innovations. This is the key to successful EVs market development.
In the end, improving the education and labor market quality would help realize the proposed targets.
Just as other industrial branches, the electric mobility sector has a structural need for qualified technical staff. Providing combined support and funding from governments and business world in order to create Centers of Excellence and Innovation would definitely payoff for both parties in the long term.

3.3.2.3 Infrastructure Support

As highlighted in a recent report by the European Electric Industry Association, many current regulatory frameworks do not sufficiently incentivize utilities to allocate their resources in order to embrace these paradigm changes.[40]

To date, governments and industry have to decide and how to cover these investment costs and how to recover these investment through charging fees. Moreover, both policy regulators and electricity industry must reach a common agreement on how to split the costs and collect the gains. The involvement of energy companies (mainly utilities) in the development of public charging networks will be far from simple. This is because a public charging network would generate only limited revenue flows and a questionable growth, while investment and risks are substantial.

The increase in demand for electricity created by the appearance of EVs on the market would not have a significant impact on the utilities earnings. However, these companies would have to invest charging networks in order to get in the market. Moreover, after such investments the charged electricity would have to be priced much higher than home residents are paying for. This could mean that most of consumers would have doubts in using these public charging stations. Thus, the

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[40] GRIDONOMICS: An Introduction to the Factors Shaping Electric Industry Transformation, Cisco 2011

involvement of power companies seems to be questionable without strong public subsidies. Following implication are seen at the level of European Union:

- supply a credit line to EVs owners for the positioning of private charging points and keep minimum requirements.
- supporting the installation of charging stations in new buildings. In this case the government provides subsidies covering up to 30%-40% of the investment.

3.3.3 Stimulating Demand for Electric Vehicles

As before mentioned EVs can generate significant environmental and price advantages over their utilization period, much greater than those by traditional ICEVs. However, EVs the hard fact is that these vehicles will remain unattractive unless the acquisition cost is incentivized. Such incentives for boosting consumer demand come in different ways and differ in magnitude. However, the future of these support measures is still unclear. As they benefit a limited number of people compared to a majority of consumers subject to the general taxation of conventional fleets, such incentives may not be sustainable as and when the numbers of electric vehicles increase substantially.[41]

Governments around the world have already set up financial support packages to foster consumer demand and increase EVs attractiveness. Thus, incentives were assigned with the intention to reduce the gap in price between EVs and ICEVs by reducing the extra upfront costs of electric vehicles. This is supposed to increase the affordability of EVs by diminishing the marginal capital cost. This is said be a necessary step for the overall attractiveness of EVS, if considerable sector growth is to be realized in the medium term. Nonetheless, there are a number of factors that may influence the decision of Governments to supply upfront subsidies and to determine an optimal level for these subsidies. The optimal level of subsidies is however hard to assess in time as well as how successful these are. This is because

[41] Towards E-Mobility: The Challenges AHEAD; International Automobile Federation, European Bureau, Brussel 2011

such schemes have not been in place for long time. A further reassessment of such measures is thus required.

Even so, the range constraints of electric driving would still exist. Anyway, by covering the price gap, this would definitely be a good motivation to choose EVs over ICEVs particularly concerning the reduced fuel costs. In spite of that, such measures would come at a high cost to the Governments and may be perceived as more than necessary for an increase in market presence. The Industry opinion on this is that the upfront support is one of the most influential considerations of the private consumer when deciding upon an acquisition. Less considered are the long-term running costs of EVs. Such affirmations have been also highlighted by previous researches.

Furthermore, while business and fleet buyers have broader perspective on vehicle ownership costs, they will analyze factors such as acquisition cost, O&M costs and CO2 emissions performance if needed. Moreover, they will still try to minimize their exposure to possible risks. Hence, commercial buyers are also in need of some upfront price support to get stimulated upon an EV purchase.

According to these factors, the higher the levels of support, the more likely it will be efficient in stimulating consumers and businesses to purchase EVs. However, experience from other countries show that the level of support for pure battery electric cars is typically around 20% to 27% of the total retail price of the vehicle.[42]

On the other hand, there is a debate over whether the level up-front support should remain constant over time, or whether it should decrease as the price gap between EVs and ICEVs shrinks due to learning effects and scale production.

If the Government decides to reduce the level of financial support over time, it will need to take in consideration the timing and the rate of subsidies reduction. Additional to this, governments will have to provide clear information to the public, to businesses about such attempts.

One of the main policy side benefits of structuring the incentive in this manner is that it allows the cost of the incentive to be estimated more readily than if an open ended commitment was made.

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[42] Market Outlook to 2022 for Battery Electric Restricted – Commercial and Plug-in Hybrid Electric Cars AEA/ED46299/Issue 1 AEA

Thus, strategies to influence consumer choices will need to be targeted and informative in order to stimulate consumers in choosing to use efficient vehicles. Good structured information is expected to have a key role in modeling consumer attitudes about electric vehicles.
Thus, demonstration projects would be helpful in bringing costumers in the reality of EVs. Consumers must be incorporated as an active part of the EVs deployment process, as their perceptions, beliefs and behaviors strongly affect the success of electric mobility. Consequently, consumers must be assured that EVs are affordable, reliable and suit their mobility needs. Negative preconceptions must be overwritten and renamed.

3.4 Review of main policy instruments

3.4.1 Command and control instruments

Such measures are usually the privilege of public authorities. Traditionally, they act as government's core strategy, being then complemented by other types of instruments. Examples of command and control instruments are presented below:

- **Standards** settle the general rules for stakeholders to follow when introducing EVs on the market. However, governments must be ready to adapt the standards systematically and be flexible as new technologies become available on the market. For example, environmental standards can be included in the licensing procedures for the different categories of vehicles. Moreover, CO_2 emissions standards are effective instruments to promote investing in fuel economy and sustainable mobility. The **United States** developed Corporate Average Fuel Economy (CAFE) standards in 1975 and recently adopted the EISA law that requires about 25% improvement in l/100km by 2020 (over 2007).[43] The **European Commission** has proposed improving efficiency around 18% over 6 years or more, setting an average standard of 130g/km that should be phased in between 2012 and

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[43] FIA Foundation, International Energy Agency, International Transport Forum and United Nations Environment Programme; 50 by 50: Global Fuel Economy Initiative

2015. The EC plans to tighten the limit to 95g/km by 2020. **Japan** used a "Top Runner" method for the development of fuel efficiency standards. Thus Standards are based on the best performer in the weight class and required a 19% improvement in fuel economy by 2010 (in L/100km). In 2007, additional standards were updated until 2015. These standards would increase the regulatory certainty in the case of manufacturers that do have long investment periods. This will also enable them to introduce the innovative technologies on the market.

- **Vehicle emission regulations** have become considerably tougher in most countries, mostly due to European regulation pressures. (See Standards)

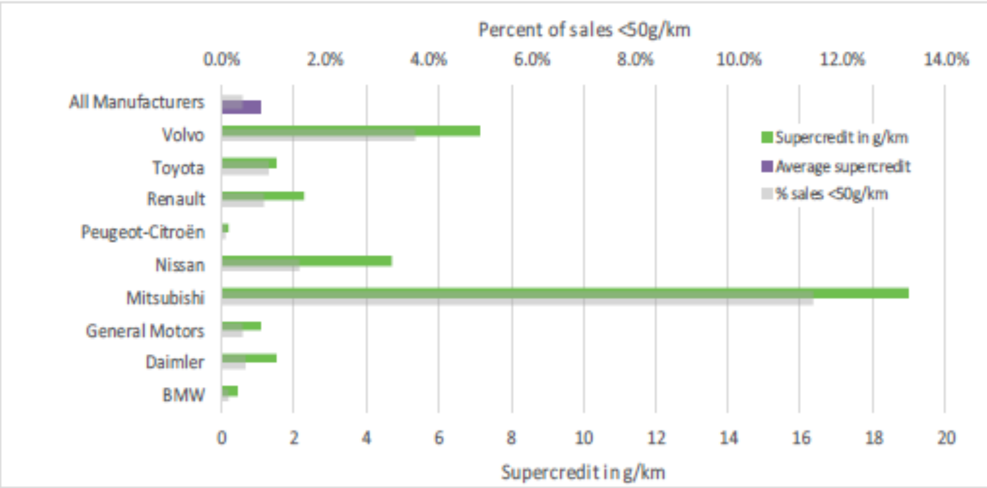

Figure 13: Super-credits overview (Electric Vehicles in 2013: A Progress Report; Published in July 2014 by Transport and Environment)

In 2013, according to Cars and CO_2 Regulation, EVs and other low-carbon vehicles can use additional incentive as counting 3.5 times towards the manufacturer's fleet average emissions through a super-credit mechanism.[44] These generous credits reduce the need for companies to improve the efficiency of conventional vehicles and have fortunately been capped for the 2020/1, 95g/km target.[45] The largest green credit recipients are shown in Figure 13. The super-credits are addressed to auto makers and have as subject

[44] REGULATION (EC) No 443/2009 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 April 2009 setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO2 emissions from light-duty vehicles

[45] REGULATION (EU) No 333/2014 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 March 2014 amending Regulation (EC) No 443/2009 to define the modalities for reaching the 2020 target to reduce CO2 emissions from new passenger cars

the registered cars in the European Union. For example the highest super-credit benefit was received by Mitsubishi, with a 19g/km and Volvo with a 7.1 g/km. For other manufacturers as Nissan and GM, super-credits brought them over the 2015 target already in 2013. Furthermore, other major beneficiaries have already reached the 2015 target and thus do not require such generous rewards.

- **Mandates** are the classic instruments used by the governments to force targeted stakeholders to change their behavior. Two types of mandates are mostly known in the case of EVs promotion: mandates for EVs procurement and mandates for EVs selling (California ZEV mandate for example)
- **Exemption from certain restrictive regulations** provides advantages to EVs regarding the access to particular traffic areas: public transport lane and restricted parking zones for example. However, these measures are usually implemented for a short term only, because as EVs become more demanded these actions would not be sustainable anymore. (Most of stated countries, Norway, US in some states, Japan etc)

3.4.2. Economic instruments

Economic instruments that target electric vehicles can help address the cost issue barriers, which blocks the market entrance of this technology. These instruments relate to the up-mentioned financial incentives. Such measures are considered of economic nature as they provide financial support in order to improve the economics of technology. Such instruments include:

- **Direct investments** provided by national and local authorities directed to R&D in infrastructure and in demonstration projects.
- **Targeted subsidies** are grants directed to stakeholders under different terms. The setting design of a subsidy is crucial to its success as inefficiency easily pops up if not properly designed. Popular types of subsidies were already discussed in this paper and have the aim in supporting the purchase, conversion, infrastructure and public transport areas of EVs.
- **Financing schemes and costs** are also important measures to successfully overcome the barriers of high investment cost. Such measures include

special financing rates and conditions. However, these instruments and all of them that were mentioned above must have a clear objective that can be estimated according to the input and output values so that an instrument get a rational, solid theoretical and practical reason.

Moreover, economic instruments are directed not only at EVs frontage but also at the general transportation sector. Such instruments rewards and punishes the carbon intensity in the car fleet lifecycle. This however advantages the use electric power vehicles. Such instruments use mostly taxation elements in order to reward EVs use or punish the use of carbon intensive vehicle. Taxation instruments cover following areas:

- Registration/purchase taxes
- Circulation taxes
- Fuel taxes
- Subsidies
- Taxation of benefit in use and parking charges

Table 1 bellow shows the impact of taxes on different sectors. However the tax impact is different in stated regions. If taking a look at Table 2, U.S has no special tax incentives. It is true that the fuel tax in US is much lower than in EU, so such mechanisms as tax incentives are more attractive and appropriate for EU.

	Private		Sole Trader			Company			
Vehicle Category	Private car	Private van	Company car	Public Service vehicle	Taxi	Company car	Other fleet car (e.g. rental leasing co.)	Light Commercial Vehicle	Public Service Vehicle Minibus/ bus
Registration/Purchase (lower carbon incentivised)	+++ ***		+++ ***		+++ ***	+++ ***	+++ ***		
Subsidies – purchase	+ **	+ **	+ **		+ **	+ **	+ **	+ **	
Potential Future Fiscal Measures									
Subsidies (including purchase and rebate)	+ *	+ *	+ *	+ *	+ *	+ *	+ *	+ *	+ *
Subsidies – research and development	+ ***	+ ***	+ ***	+ ***	+ ***	+ ***	+ ***	+ ***	+ ***
Circulation/ motor taxes	+ *	+ *	+ *		+ *	+ *	+ *	+ *	
Fuel taxes	+ *	+ *	+ *	+ *	+ *	+ *	+ *	+ *	+ *
Taxation of benefit in kind / and treatment of depreciation	++ *		++ *			++ *		++ *	
In use and parking charges[1]	+++ *	+++ *	+++ *		+++ *	+++ *	+++ *	+++ *	

+CO_2 reduction

* impact on market development

[1] takes into account reduced mileage

Table 1: Impact of Taxation on different sectors (AEA Energy & Environment 2007)

Moreover, according to Table 2, it is important to emphasize that Norway and Netherlands are the countries with the most relevant measures for the EVs uptake.

	Enhancing vehicle demand						Infra. Deployment		
	Purchase subsidies	Taxation incentives	Less insurance costs	Reduced/No parking fees	Use of public transport lanes	Free PT pass	Subsidies for infra uptake	Public funding for infra development	Tax deductions for infra uptake
DE		++							
UK	++	++		++*			++	++	
ES	++	+							
DK		+++		++					
FR	++			++*				++	++
NO		+++		++	++				
NL	+*	++		+++*			+*	+	++
IT	++	++	+	++*					
PT	+	++						++	
AT		++	+			++*			
US	++						++		
JP	+	++							
CN	++*	++*						++*	

*Policies on local level

Table 2: Overview of policy measures targeting vehicle demand and infrastructure deployment (Source: Leurent et al., 2011)

3.4.3 Procurement, collaborative and communication instruments

Procurement instruments supposes following commitments:

- EVs procurement by governments and involved stakeholders;
- Leadership by example;
- Common procurement;

On the other hand, collaborative instruments rely on the ideology that the governments apart from its power function should also use a collaborative managing role on the markets. Such instruments however deviate from traditional command and control government policy-making approach.

Taking into consideration the fact that the present vehicle market is dominated by a few big actors and the government usually does not dispose of enough resources to influence the action of those big players. In such a case, it seems more realistic for governments to take the role of a moderator, adopting a collaborative strategy and thus coordinating the actions of other stakeholders. A large range of collaborative instruments is available. Some of most used actions are:

- Certification and labels
- Voluntary agreements

- Public-private partnerships

However it is still not clear in what proportion to make use of such contradictory policies, commandment and collaboration. Anyway, every approach can be ranked as successful if it delivers the targeted results.

Further on, communication and diffusion instruments are relevant to all stakeholders and have the purpose to bring the public opinion on the need side, committing additional informative and educational efforts. Such a soft approach is usually considered weak but is in fact a must-do in order to ensure the success of the program. This is especially valid for the EV case as the public usually lacks quality information about such technologies. Following measures should be considered:

- Awareness campaigns
- Marketing activities
- Vehicle labeling and guiding the buyers
- Internal and external information
- Education and training
- Lobbying activities

All mentioned policy instruments have been examined independently. However, there are clearly connections between them that can include following constellations:

- Substitutability: Instrument I has an equal impact as instrument II, being able to replace it and unable to be added to it;
- Complementarity: the effect of combined instrument I and II is bigger than either of them alone, but is less in the case the instruments are summed.
- Additivity: the effect of combined instrument I and II is similar to the sum of their individual effects
- Synergy: the effect of combined instrument I and II is bigger than the sum of their individual effects. For example fuel taxes and subsidies for R&D close to be synergistic actions, while up-front costs incentives and fuel taxes will enhance additivity or complementary.

When analyzing several measures it is important to group them and evaluate the potential combined impacts. Wider issues must also be taken into consideration when examining the above instruments. For example, companies can compensate employer fuel costs and if the vehicle is predominantly used for work purposes, the impact of a fuel tax instrument on employer vehicle acquisition will reduce. In this case, the user is stimulated at all to choose the EVs. Thus, steps to address such issues should to be considered alongside the execution of policy instruments.

3.5 International progress

Although EVs exert a considerable amount of external benefits, it is still difficult for the market forces to accept them because no one is willing to pay for social benefits that do not directly benefit themselves in the short time. In order to mitigate this barrier governments initiate some attempts to convince the both parts of the market that EVs are not only environmentally-friendly, which is a collective problem, but also economical. It is further on interesting to look through the international arena of public involvement in the EVs promotion matter.

Thus, following a logical path, countries with most intensive CO2 emissions should lead the in terms of proactive efforts to cut emissions them down.

The main CO2 emitters at global level are the industrialized countries like U.S, China, Japan, Korea and European countries like Germany, U.K, France and Italy.

These industrialized countries have set targets concerning the electric vehicles market diffusion. These numerical targets are presented in the Table 3.

Countries	Targets	Deadline	Plan or Legislation
United States (U.S.)	1 million EVs	2015	EV Everywhere Grand Challenge Blueprint, 2012 [11]
United Kingdom (U.K.)	1.7 million EVs	2020	Committee on Climate Change, 2010 [12]
Germany	1 million EVs	2020	National Development Plan for Electric Mobility, 2009 [13]
France	2 million EVs	2020	French government (IA-HEV, 2014) [14]
Japan	EV market share reaches 50% in total vehicle sales	2020	Next-Generation Vehicle Strategy2010 [15]
China	0.5 million EVs 5 million EVs	2015 2020	Energy saving and energy automobile industry planning (2012–2020) [16]
Norway	0.05 million EVs	2018	The Norwegian government [17]

Table 3: Electric Vehicles targets in different countries (Source: Zhang et al., 2014)

Furthermore it is interesting to see how far the stated countries (frontrunners) are from the formulated targets. Thus, Figure 14 bellow states the targets in million vehicles per countries.

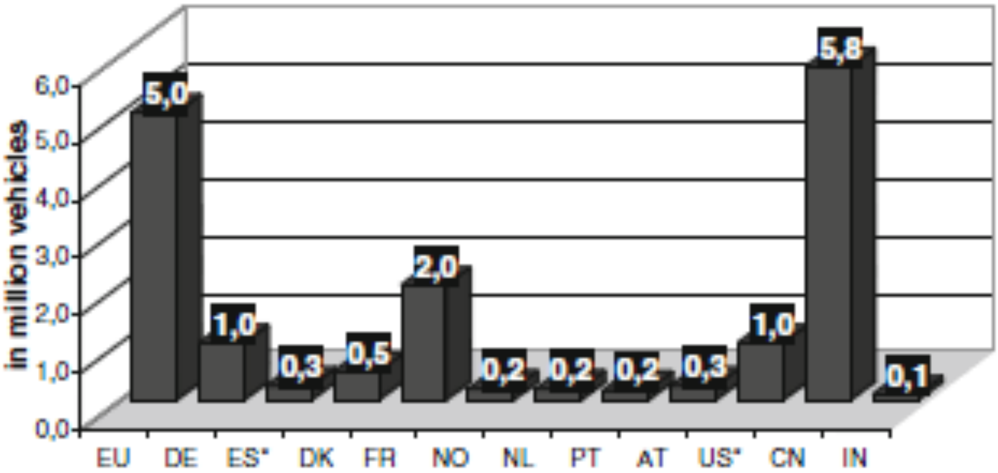

Figure 14: EVs targets by countries till 2020 (Source: Leurent, Windisch 2011)

Additionally the Figure 15 bellow shows the current achieved targed shareof EVs in the overall car fleet in different mentioned countries.

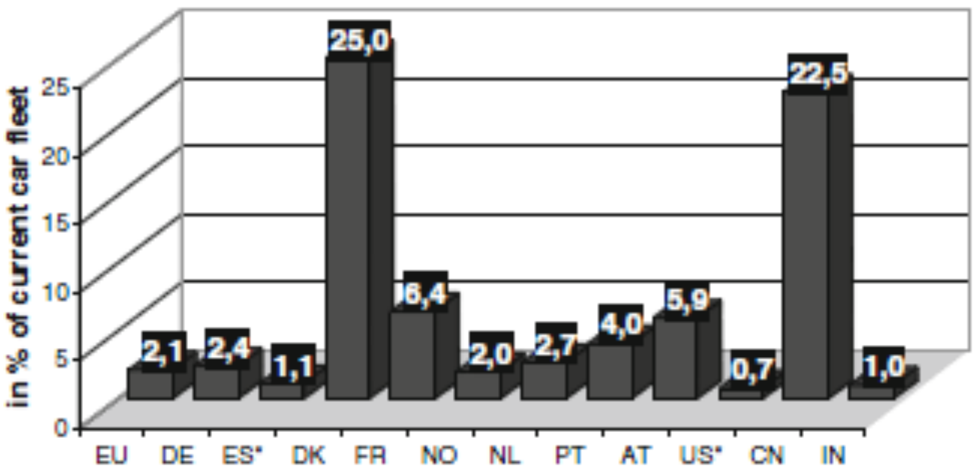

Figure 15: Target in % of current car fleet (Source: Leurent, Windisch 2011)[46]

Thus, none of the mentioned Countries achieved their targets. For example U.S had a goal in achieving 1 million EVs on road. However according to most actual EVs stock data, there were on the roads 224 000[47] EVs, which is almost one fourth of the proposed target. This also mostly happened due to Californian State active

[46] Fabien Leurent & Elisabeth Windisch ; Triggering the development of electric mobility: a review of public policies; Eur. Transp. Res. Rev. (2011) 3:221–235; DOI 10.1007/s12544-011-0064-3
[47] http://www.dw.de/the-global-climate-needs-greener-transport/a-18248083

involvement in promoting electric vehicles. Hence, the paper will consider the U.S goal to be prolonged until 2020. According to the same source, China has 29 000 EVs on the roads and is extremely far away from the target. Further on, Norway with its 26 000 EVs stock is on the half path of achieving its 50 000 EVs old target until 2018.
Downwards the paper, the actions adopted by most industrialized and thus carbon intensive countries are shortly discussed in attempt to gain an overview of the current global movements and to distinguish the diversity of effects.

3.5.1 United States

In addition, the "Energy Independence and Security Act of 2007" (EISA-2007) not only provided financial incentives, but also provided low loans for automobile manufacturers to develop EVs.[48] The American Recovery and Reinvestment Act of 2009 (ARRA) is however the most actual legislative decision that supports the deployment of alternative fueled vehicle technologies. It dedicated funds to EVs/PHEVs purchase ($2500-$7500) depending on weight and battery. The U.S EVs support can be divided in:

- **Direct Measures**
  - Subsidies (purchasing support, based on battery capacity or EV cost)
  - Tax reduction ((income tax credits and sales tax exemptions)
  - Free charging (most of the states) /parking (Hawaii, Nevada)
  - Emissions testing exceptions (Colorado and Pennsylvania)
- **Indirect Measures**
  - Carpool lane access
  - Infrastructure availability
- **Disincentives**
  - Annual electric vehicle fee (Nebraska, Virginia, Washington, Colorado)

However these measures are differently calculated in dependence from the implementation state. Furthermore, according the U.S emission standards, 54.5 miles per gallon fuel economy standard and 163 grams per mile of CO2e across the total vehicle fleet should be achieved until 2025.

[48] Energy Independence and Security Act of 2007; U.S. Department of Energy: Washington, DC, USA, 2007.

An infrastructure tax credit (30% of the costs, maximum $1000 for consumers and $30000 for entities)[49], support for federal fleet and a tax credit for manufacturer´s provision recovery is also offered. What is more, President Obama announced the plan of the next generation electric vehicle, which aimed to fund $1.5 billion to manufacturers to produce high efficiency batteries and their components. The plan was also to unlock $500 million to produce electric motors and other main EVs components. These financial packages for manufacturers are helpful for pledging one million EVs on the road by 2015. [50]

However, it is important to note that California has achieved a remarkable result, mostly due to its Zero Emission Vehicle (ZEV) program, which requires a rate of 10% from all vehicle sales in the state until 2025. Interestingly, it does not have the highest up-front price incentives.

Some U.S states provide incentives to businesses in order to encourage them in the manufacture of EVs. These incentives may take the form of tax credits for job creation, tax credits for produced EV unit and other grants for related equipment. Furthermore some states offer support for R&D purposes in form of grants and loans. (For example California Alternative and Renewable Fuel and Vehicle Technology Program) Additionally, an insurance discount is included in some places. (Farmers Insurance)

In 2012, the $268 million was allocated toward battery, vehicle, and infrastructure research and development; $360 million as allocated for infrastructure demonstration projects.[51]

Moreover, the US engages in joint projects on EVs roadmap with China and on technology development with Japan.

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[49] http://www.plugincars.com/breaking-electric-car-charging-station-tax-credit-extended-lower-30-pre-stimulus-levels-106580.html

[50] President Obama announces $2.4 Billion in Grants to Accelerate the Manufacturing and Deployment of the Next Generation of U.S. Batteries and Electric Vehicles: http://www.whitehouse.gov/the_press_office/2.4-Billion-in-Grants-to-Accelerate-the-Manufacturingand-Deployment-of-the-Next-Generation-of-US-Batteries-and-Electric-Vehicles (accessed on 13 June 2014).

[51] Electric Vehicles Initiative; *Global EV Outlook: Understanding the Electric Vehicle Landscape to 2020;* 2013.

3.5.2 China

China has recently striven to develop EVs, because it owns the largest CO2 emissions and car market[52] in the world. Thus, China has the largest market room for EVs.

The electric vehicle industry and its development have been addressed by Ministry of Science and Technology since 2001, with the adoption of “863 Electric-Drive Fuel Cell Vehicle Project”. The regulatory historic pathway can be presented as following:[53]

- **2001**: 863 Electric Fuel Cell Vehicles Project
- **2006**: 863 Energy-Saving and New Energy Vehicles Project
- **2008**: MOST, MOF, NDRC and MIIT[54] – Demonstration Projects
- **2009**: Plan on Adjusting and Revitalizing the Auto Industry
- **2010**: MOST, MIIT and MOF – Subsidy Standards for Private Purchase of New Energy Vehicle
- **2010**: 863 Key Technology and System Integration Project for Electric Vehicles/Development Plan for Fuel-efficient and New Energy Vehicles

In 2009, China announced a trial program to provide incentives for EVs, including up to RMB 60,000 for purchasing private EVs.[55] Currently the subsidy ranges between 4200 and 7200 EUR. Comparing this to the mechanisms of Europe, the subsidies are not an open for all EVs. The local protectionism is a serious case in the cities of China, which also acts as a barrier to the development of EVs. However, EVs will also be exempted from the 10% registration tax. Moreover, recently, the government, attempted to limit the acquisition of conventional cars via traffic controls, peak restrictions and registration lotteries.

Additionally the Government works on regulatory issues and invests massively in R&D, Infrastructure ($16 billion plan) and support measures towards the auto and battery industry. A big advantage detained is the fact that China is the world biggest producer of rare earths, which contains precious raw materials (neodymium) for EVs

[52] http://www.businessinsider.com/china-car-market-up-14-percent-20-million-sales-2014-1?IR=T
[53] Earley, R., Kang, L., An, F., ELECTRIC VEHICLES IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT IN CHINA; UN Department of Economic and Social Affairs; New York, 2-13 May 2011; Background Paper No.9 CSD19/2011/BP9
[54] MOST - Ministry of Science and Technology; MOF - Ministry of Finance; NDRC- National Development and Reform Commission; MIIT - Ministry of Industry and Information Technology
[55] Zhang, X.P.; Rao, R.; Xie, J.; Liang, Y.N.; The current dilemma and future path of China’s electric vehicles; Sustainability 2014, 6, 1567–1593.

production. On the other side, especially in the case of batteries, Chinas position is weak due to the low stock of patents it possesses. Finally according to “10 cities – 1000 vehicles” program, there are registered some successful demonstration projects in Beijing, Shanghai and Shenzhen including public transport, EVs and charging stations.

This and adopted measures keeps China on track of transport electrification but the country remains to confront a lot of problems and define a clear strategy.

3.5.3 Japan

According to current data, in 2012 Japan registered 20% from worldwide EVs sales. Moreover the local car manufacturer, Nissan (Leaf) was able to obtain the status of the EV bestseller with Toyota (Prius) behind. A reason for such a positive development is the regulatory framework directed to consumers and industry.

The Industrial policy in Japan has attached to the battery development a great potential. Furthermore "The Next Generation Automobile Strategy 2010” considers the development of a large charging station network.

A government program (Green Vehicle Purchasing Promotion Measure) adopted since 2009 a purchase subsidy. The program was furtherly extended and adjusted so that it offers a purchase subsidy in order to reduce the price difference between conventional vehicles and EVs. The bonus has a maximal amount of 850,000 JPY (about 6,300 EUR).

In April 2010 Japan adopted the ‘Next Generation Vehicle Strategy 2010’ through alternative technologies for vehicles shall be supported until 2030.

By 2030 the target is to reach a new technology vehicle percentage (50–70%) of sold vehicles. In partnership with local actors (municipalities, automobile manufacturers, power-companies) the EV infrastructure is aimed to be intensively developed in different urban regions.

Moreover, Japan reliefs BEVs and PHEVs from acquisition tax (VAT – 5%) and annual tonnage tax and decreases the annual automobile tax for both.[56] With the

[56] Hosaka S (2010) Views and policies on Japan’s automotive industry’, ministry of economy, trade and industry, automobile division manufacturing board, presentation held at the EU-Japan centre for industrial cooperation at the seminar on making green cars a reality: policies and initiatives in the EU and Japan, 25 February, Tokyo, Japan

VAT tax and the provided purchase incentives the EVs TCO cost shall consequently reduce.

In regard to infrastructure, Japan offers a capped subsidy of 50% of costs. Next, the battery industry is considered as a world leader, Japan holding most of the patents. This is also the result of high R&D implication and support from the government and industry.

It remains unclear how Japan will continue to offer these subsidies and how the EVs market situation will look in the future. Despite this, Japan remains one of the most attractive markets in terms of EVs deployment because it has the car manufacturers, battery industry, the infrastructure (CHAdeMO) and also an already high EV market share.

3.5.4 Europe

The Financial Incentives in Europe considering the importance of emissions reductions, as well as energy security and supply, many countries in the Union perceive EVs as a solution to these problems and have accordingly made policy packages to stir up their development. Apart from support measures for the EVs use, Europe also concentrates on penalizations for high emission cars use. It offers credits to carmakers that produce vehicles with less than 50 g of CO2 per kilometer and provides additional incentives for the introduction of EVs.[57] The U.K. government modified the tax mechanism in the car property tax in 2007, and the tax is levied based on the CO2 emissions in grams per km (g·CO2/km).[58] In the new Ultra Low Emission Discount, the U.K. government gives a discount to electric vehicles that emit 75 g/km or less of CO2 and provides a 100% discount from the Congestion Charge for qualified vehicles. [59]The U.K. government pays more attention to low CO2 emissions. Therefore, the vehicles that are suitable with this are therefore permitted to enjoy the policies advantages, despite the fact that vehicles come from other countries, and localism protection diminishes. This, to some extent, can foster the marketization of EVs. Additionally, the U.K. adopted Plug-In Car Grant program

[57] Wilde, H.P.J.; Kroon, P. Policy options to reduce passenger cars CO2 emissions after 2020; ECN 2013

[58] Changes to the Congestion Charge; Transport for London

[59] London to Introduce New Ultra Low Emission Discount for Congestion Charge Scheme; Countering Dieselization; Green Car Congress 2013

that allows the consumers the purchase of clean vehicles. Under the program, qualified ultra-low emission cars will receive a grant towards their cost. This is 25% off the cost of a new electric car, but not to exceed £5000. [60]

From the point of the incentives financial mechanism, many countries in Europe often have proposed to use incentives on the base of CO2 emissions. (see Appendix for on overview of existing incentive around the world) Moreover, the majority of countries have not adopted any penalties. Especially in France, it adopts the bonus-malus system as the financial incentive.[61] Bonus is a discount in the premium, and malus is an increase in the premium. For example, vehicles that emit 20 g/km could benefit from a premium of €6300, and for vehicles that emit between 20 and 60 g/km, the premium is €4000.[62]Such a system is architected to reward the purchase of a new car emitting less CO2 through giving advantages to consumers and punishing those who decide upon a more carbon intensive model.

However, there are still some EU countries that have not based their policies on CO2 emissions, such as Germany, Demark and Norway. Interestingly, some of these countries have set generous rewards in form of up-front price support, being the leaders in this domain.

[60] Plug-in Car and Van Grants; U.K government website https://www.gov.uk/plug-in-car-van-grants/eligibility
[61] Overview of Purchase and Tax Incentives for Electric Vehicles in the EU; ACEA 2014
[62] Reducing CO2 Emissions from Passenger Cars; European Commission

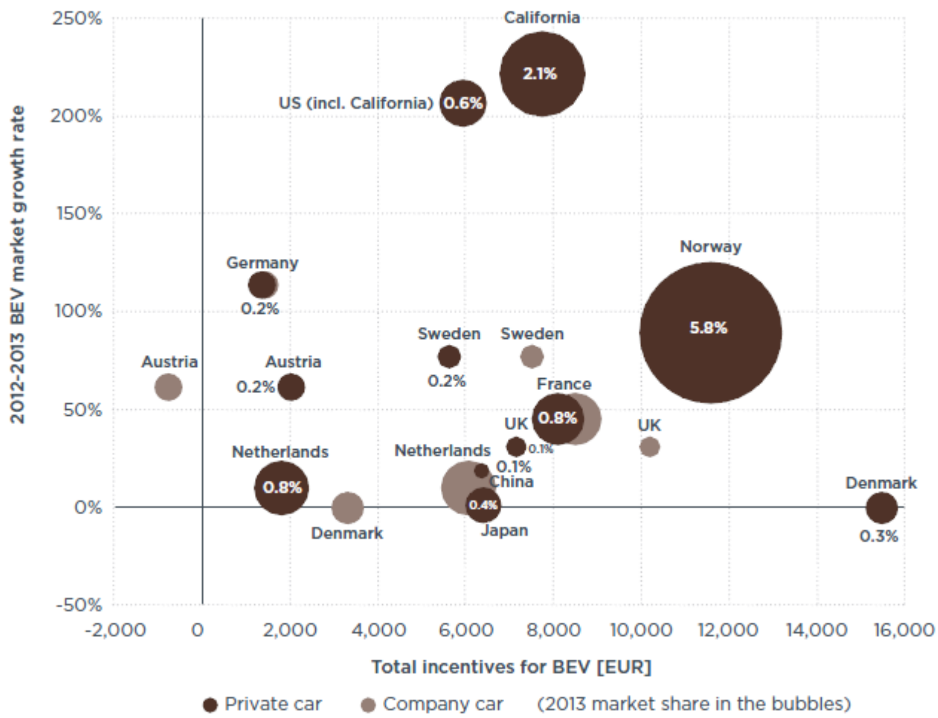

Figure 16: Total incentives and market share dynamics for EVs (Source: *MOCK P., YANG Z.* 2014)

As it is noticed in the Figure 16, the highest EVs market share was achieved by Norway, mostly due to high incentives for EV purchase. U.S, due to California has reached the second highest result, however with lower purchase incentives and a higher market share growth ratio, due to higher market potential. Another good result is provided by Netherlands. It reached the third place, however with much lower incentives with pure EVs and more generous to PHEVs.

Nevertheless, it is an outstanding characteristic European policy, mainly that financial incentives are proposed to rely on CO2 emissions, no matter of the incentives object. For example, consumers could benefit from such incentives if they buy the vehicles emitting less CO2. For manufacturers, in order to get the subsidies, they should build more efficient and environmentally friendly vehicles, such as EVs, which do almost produce no emissions. Such a policy approach shows that the governments are following a clear target of reducing CO2 emissions and do not want only to support a certain technology. May the best win, is the motto. As a result the competition is not cut down, thus offering free space to manufacturers to decide towards producing EVs or working on increasing ICEVs efficiency, or both of them.

This creates a so-called virtual pressure and still avoids heavy damages through radical bans as the case of nuclear power plants was.

3.5.4.1 Norway

As of 2014, Norway is the world leader in the EVs market share (5.9%). Such a large EVs stock is the result of high incentives. This successful achievement was reached during the last two years. The government strategy followed the strategy to facilitate the purchase and usage of EVs (now integrated as Climate Agreement among the parliamentary parties). However the car market is still low compared to other countries, and most of the cars are imported. Additionally, car ownership has medium values and almost 40% of the car sales are related to company activities.

Norway has high taxes on internal combustion engines vehicles. EVs however are largely exempt from these taxes, and also enjoy lower electricity costs. There is also no VAT (25%) for EVs and no road tolls. Moreover, EVs enjoy free parking, free charging and bus lines access. For companies, the mileage allowance is higher and they also benefit from a taxable benefit that is being reduced by 50%. [63]

Oslo can be considered as the EVs capital as Norway is enjoying the status of the highest EVs penetration rate per capita. Moreover Norway is the first country that achieved a nationwide charging network coverage, and thus having the cleanest vehicle fleet around the world, if considering that the electricity in Norway is 97% generated from renewable sources, mostly hydropower.

In addition to generous incentives, the success of Norway in fostering the EV market can be attached to pursued activism and resolute policy during the last two decades in this sector. The government also tried to support an EV manufacturing industry long time ago but failed (PIVCO and Pure Mobility). However this encouraged other more efficient measures. The EVs market in Norway is also benefiting from the high gas prices to consumers, which provides a stable source of income for the government (oil exports). Unlike other countries that extract oil reserves, Norway does not subsidize gas prices, which makes it expensive by the significant included federal taxes. Further, the Norwegian government has helped to support the installation of charging infrastructure throughout the country and in 2013 over 4,000

[63] Sandén, B.,Wallgren, P.: SYSTEMS PERSPECTIVES ON ELECTROMOBILITY 2014; Chalmers University of Technology; ISBN 978-91-980973-9-9

charging stations and 120 quick chargers had been installed.[64] Additionally, the government enabled the development of an informational platform on the chargers location and their availability. Such a development was able to the active government support that invested approximatively 6 million EUR and 1.25 million EUR in 2009/2010 and 2011/2012 in infrastructure campaigns.[65]

Finally, Transnova is a task force set up by the Norwegian Ministry of Transport aiming to reduce GHG emissions in the transport sector in Norway.[66] Transnova also finances demonstration projects. Furthermore it financially supported the participation of Norwegian communities in EU and ERANET projects.

3.5.4.2 Netherlands

By adopting the National Action Plan for Electric Driving, the Netherlands started its commitment towards the deployment of EVs. This plan included $89 million for the support of pilot demonstration projects, charging infrastructure and R&D.

The government has committed to develop 20,000 normal chargers and 100 quick chargers by 2015.[67] During 2012-2013, the total number of charge points increased from 3,600 to 5,770.[68]

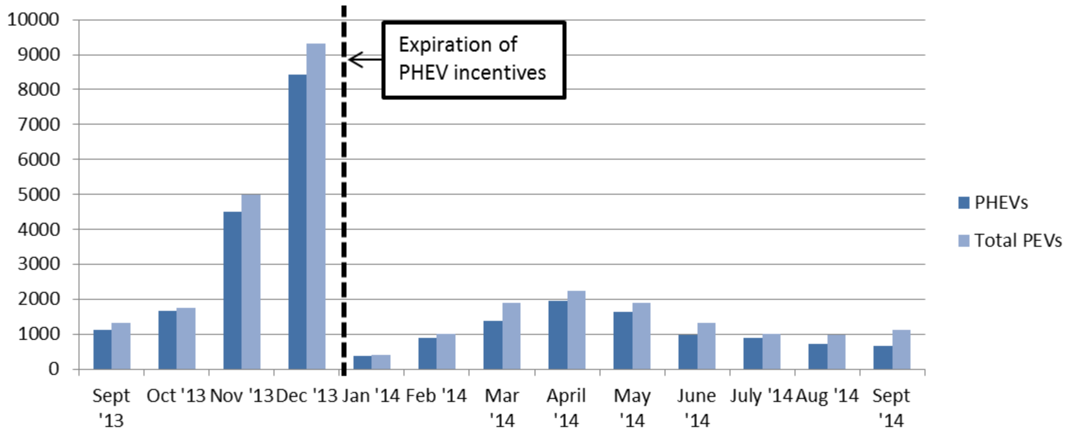

Figure 17: PHEVs and EVs sold in Netherlands 2013-2014 (Source: Pontes, Jose. *Monthly EV Sales.* s.l. : EV Sales, 2014)

[64] Vergis, S., Turrentine, T., Fulton, L., Fulton, E.; Plug-In Electric Vehicles: A Case Study of Seven Markets; Institute of Transportation Studies; University of California, Davis; 2012; Research Report – UCD-ITS-RR-14-17

[65] The European Association for Battery, Hybrid & Fuel Cell Electric Vehicles (2012)

[66] Holtsmark, B., Skonhoft, A.: The Norwegian support and subsidy policy of electric cars. Should it be adopted by other countries?; environmental science & policy 42(2014)160–168; www.elsevier.com/locate/envsci

[67] Electric Vehicles Initiative. *Global EV Outlook: Understanding the Electric Vehicle Landscape to 2020.* 2013.

[68] Project E-Load ended successful with 2500 Installed stations

According to Figure 17, the fall in EVs sale after the incentives for PHEVs expired (January 2014) emphasizes the correlation of strong policy incentives and high EVs sale rates, especially in small markets as Netherlands. The main incentives are presented in Figure 18.

Policy Instrument	Details
Subsidy scheme for low-emission taxis and vans	As of October 1, 2012, a subsidy of €3,000 (US$4,000) for battery electric vehicles (BEVs) is given. If living in the cities of Amsterdam, Arnhem, The Hague, Rotterdam, or Utrecht—or cities adjacent to these cities—an extra subsidy of €2,000 (US$2,600) is given for a BEV (to address specific urban sites for improved air quality).
Innovation vouchers electro-mobility	As of January 1, 2013, small- to medium-sized businesses are encouraged to make better use of existing knowledge of electro-mobility at universities and research institutes. For a maximum of €5,000 (US$6,500) a small- to medium-sized business can pose a research question to a university or research institute to answer in the field of electro-mobility.
Exemption of registration tax	Electric cars are exempt from paying registration tax until 2018. This tax is paid when the car is registered. The tax depends on the vehicle's CO_2 emissions and the catalog price. The exemption for clean vehicles gives a substantial fiscal advantage that can amount from €5,000 to €8,000 (US$6,500 to $10,500) for mid-size cars.
Exemption of road tax	Electric cars are exempt from road tax until at least 2014. This tax is paid for the usage of a motor vehicle, and the amount is dependent on the type of fuel, weight of the car, and regional circumstances. For a middle class petrol car, this is €400 to €700 (US$ 520 to 900) a year.
No surcharge on income taxes for private use of company cars	In the Netherlands, private use of company cars is subject to income tax. This is done by imposing a surcharge of 14 to 25% of the catalog value on the taxable income. Electric cars that are registered before 2014 are exempt from this surcharge for a period of 60 months. This gives a tax advantage of approximately €2,000 (US$2,600) a year compared to a regular company car.
Tax-deductible investments	The Netherlands has a system of facilitating investments in clean technology that implies these investments are made partially because they are deductible from corporate and income taxes. EVs have recently been added to the list of deductible investments. The MIA-VAMIL (tax relief for entrepreneurs willing to invest in environmentally friendly equipment) provides enterprises/ventures investing in EVs and recharging stations with an advantage of up to 19% of the investment.

Figure 18: Main incentives in Netherlands[69]

[69] International Energy Agency; Implementing Agreement for co-operation on Hybrid and Electric Vehicle Technologies and Programmes; Annual report of the Executive Committee and Task 1 over the year 2012; Hybrid and Electric Vehicles The Electric Drive Gains Traction

4 Electric mobility diffusion impact on economic-environmental endeavor: estimated overview

4.1 Electric Vehicles Stock

According to TransportEvolved research, in early 2012, there were almost 100,000 plug-in cars on the world's roads. A year later it was reported that there were 200,000 vehicles. To date, there are now an estimated 405,000 electric cars globally, with the magic 400,000 barrier crossed somewhere late in 2013 or early 2014[70] However there are many studies that try to estimate the future stock of electric vehicles. For example, Navigant predicts that sales of PEVs throughout North America, Western Europe, and Asia Pacific will grow from 352,000 annually in 2014 to 1.8 million in 2023. Other estimation comes from Clean Energy Ministerium and foresees almost 20 million EVs units in sales and 6 million in stocks the world by 2020. These estimations are presented in Figure 19.

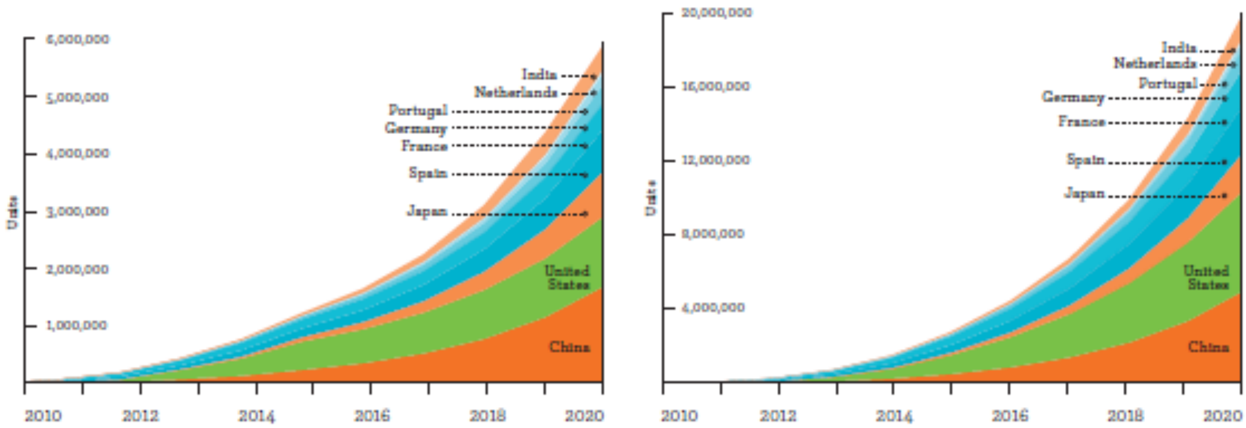

Figure 19: World EVs Stocks and Sales forecast (*Source: Clean Energy Ministerium 2013)*

However, it is hard to accurately estimate the numbers of electric cars on the roads by years beyond 2020. Due to different countries regulations, incentives and targets it remains almost impossible to find out a reliable figure. This is also confirmed by the results of conducted studies that show different numbers. That means that there is no accurate data to be collected. The data from Figure 20, as post-factum are close to those reported above. There were approximately 250 thousands EVs sales on the global markets, with a 25% share done in Europe. Other big markets are US and China.

[70] International Energy Association (2014)

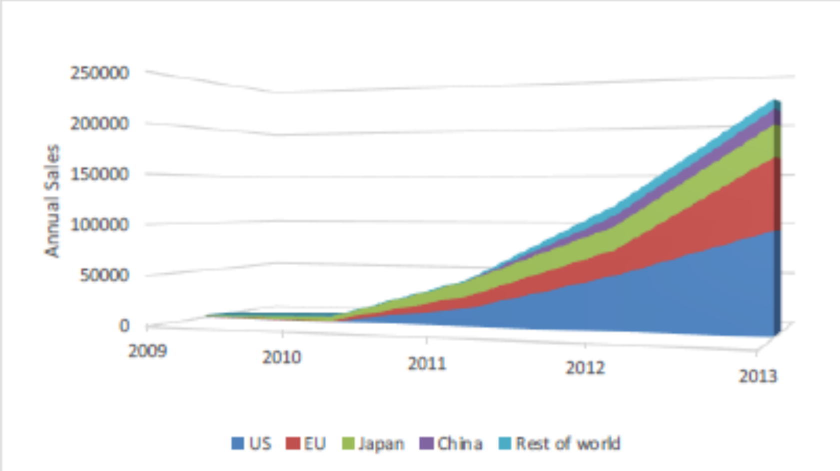

Figure 20: Global EVs sales (*Source: ICCT 2014)*

For a more accurate result it is proposed to investigate separate data in order to express an own conclusion. Therefore, this chapter will focus on a separate market share of EVs. There are currently 880 million vehicles on the roads with 98% gasoline powered contributing 40% of the planet's greenhouse gases.[71]

Next, according to presented findings, there are 400 thousands EVs on the road, which is 0.5% of the total existing vehicles worldwide. However, it is proposed to focus on the main frontrunners of the EVs deployment, more exactly on countries with the highest number of EVs stock (U.S, EU, Japan, and China). Thus in order to estimate a general impact of the future EVs market development it is proposed to aggregate the targets in order to obtain an overview of the future EVs stock. This will furtherly allow assessing the impact on the environment, energy dependence and economy. The targets formulated by the mentioned countries include the consideration of electric vehicles as PHEV and BEV. (See Table 4)

Such an assessment would quantify the impacts and thus valuate the supporting measures by necessity, result and best practice efficiency concerning the overall electric mobility fundamental goals. (Climate Task, Energy Dependency, Sustainable Mobility)

[71]Think Global Green report; http://www.thinkglobalgreen.org/ELECTRICVEHICLES.html

	Plug in Electric Vehicles		
Country	2014[72]	Target (2020)	
U.S	224000	1000000	
Japan	89000	1000000	*(Target 50% of sales)*
China	29000	5000000	
EU	-	5000000	
Norway	26000	200000	
France	37000	2000000	
Netherlands	38000	200000	
…	…	…	
Total EVs by 2020		**12000000**	

year	2015	2016	2017	2018	2019	2020
EVs target distribution (mln)	2	4	6	8	10	12

Table 4: Estimated EVs on road until 2020 according to formulated targets (Source: "The global climate needs greener transport" published by DW on 19.02.2015)

Thus, it is estimated to have 12 million EVs on roads up until 2020. Going beyond 2020 until 2050 requires a high accuracy and is therefore not considered. However, these figures will be selected from existing researches and compared to the short case study result. The EVs deployment is considered in this paper to have a linear distribution. The exactitude of the target series distribution does not matter because the 12 million global Target should be achieved until 2020 and can be slower or quicker in some specific years. Thus by the end of 2015, are expected to be 2 million EVs, which is five time more than the current EVs stock data. The probability of achieving these targets is not taken in consideration. Therefore the aim is to investigate what Governments expect to get as an output if achieving these targets.

Further on it is necessary to evaluate the car performances of electric cars to combustion cars in order to obtain the emissions and fuel savings. The assumed figures are presented in Table 5 below:

[72] http://www.dw.de/the-global-climate-needs-greener-transport/a-18248083

Parameter	
Km/per year	15000
CO2 g/km savings[73]	130
g/year/car	1950000
t/year/car	1.950

Table 5: EVs emissions savings (Source: Author)

The EVs emissions savings are calculated according to the equation below:

$$\text{CO2 t/year/car} = \text{km/year} \times \text{CO2g/km}$$

The average car traveled distances are presented bellow in the Figure 21.

Segment	Private	Fleet vehicles	Company cars
Small	20,000 – 25,000 km	about 20,000 km	no window
Medium	18,000 – 35,000 km	about 20,000 km	no window
Large	15,000 – 40,000 km	18,000 – 25,000 km	no window

Figure 21: Average car travel distances (*Source: Frauenhofer Research Institute)*[74]

In the European, the emission target is 130 grams per km then by 2020 down to 95 grams per km.[75] An Emission decrease per km and a possible travel distance increase due to urbanization, is being taken in consideration. (See Figure 22)

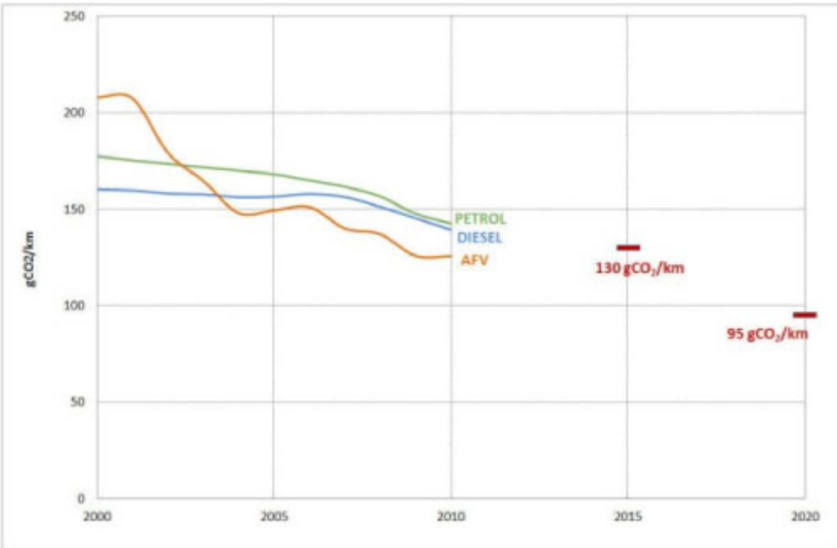

Figure 22: Emission Targets per km EU (*Source: European Commission)*

[73] Is considered as the emission level that is allowed by European Union (http://ec.europa.eu/clima/policies/transport/vehicles/cars/index_en.htm)
[74] WIETSCHEL,M., PLÖTZ, P., KÜHN, A., GNANN, T., Market evolution scenarios for electric vehicles; Karlsruhe 2013
[75] REPORT of European Commission (2012)

Thus, a modified emission savings base should be considered when assuming reduction in conventional vehicles emissions. Thus, the estimated emissions for the targeted aggregated EVs stock of selected regions are presented in the Table 6:

	2015	2016	2017	2018	2019	2020
Aggregated EVs targets	2	4	6	8	10	12
Km per year	15000	15000	15000	15000	15000	15000
CO2 g/km	130	123	116	109	102	95
Emissions per car mt/year	1,95	1,85	1,74	1,64	1,53	1,43
CO2 in million mt	4	7	10	13	15	17

Table 6: Emission impact of EVs (*Source: Author)*

The emissions are theoretically calculated according to the following equation:

Emission per car mt/year = km/year x CO2g/km : 100000

Thus when assuming a car travels 15 000 km per year and the emission efficiency improves from 130 CO2 g/km to 95 CO2 g/km, the “frontrunners” EVs target sums up 12 million electric vehicles on the roads, which means a total CO2 saving of 17 million metric tons in 2020. If aggregating the obtained results, a 68 million of CO2 metric tons could be saved till 2020 if considering all the formulated targets by the selected frontrunner regions and countries North America (U.S), EU (Norway, Netherlands, France, Germany, UK) and Asia (China, Japan)

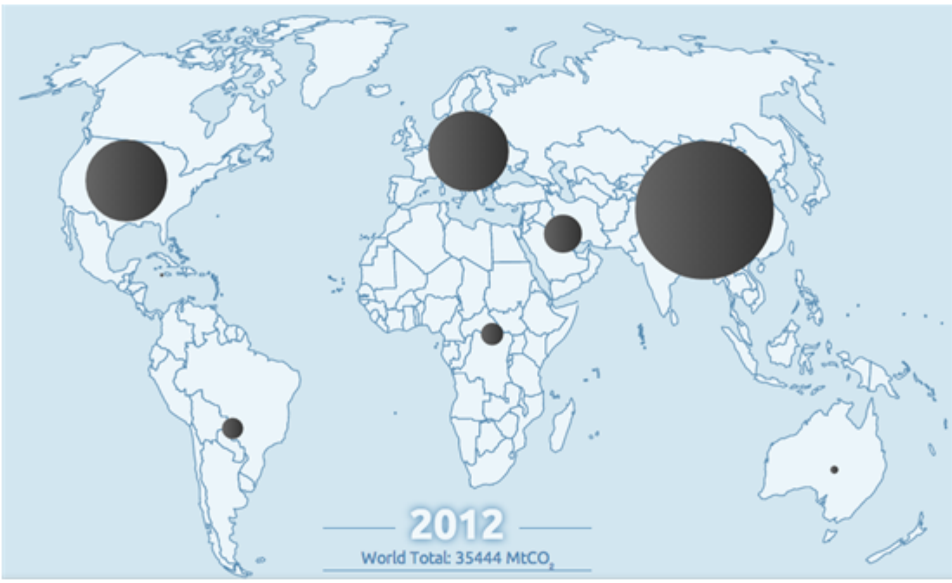

Figure 23: Global CO2 emissions (*Source: Carbon Atlas)*

The results on saved emission from above were calculated according to the following equation:

CO2 mil ton (Tank to Wheel A) = Emissions mt year/Car x Aggregated EVs targets

According to Figure 23, the total global emissions in 2012 were 35444 MtCO2. Concerning this, the aggregated EVs target in 2020 could solely reduce the global emissions with 0.2%. This is a relative small contribution, and does not take in consideration the emissions produced in electricity generation, which is the fuel of EVs. It does also not take in consideration the saved emissions from gasoline production. For a more accurate estimation, it is proposed to conduct a short analysis of CO2 emission caused by the electricity generation. This would allow quantify the effect of the well to wheel method. Thus, the 0.2% CO2 reduction in 2020 in comparison to 2012 level assumes that the targeted EVs stock is fueled by renewable electricity that produces no emissions. Moreover, according to the current carbon market price of 5 EUR/tCO2, which is listed at the European Emission Trading System (ETS), the total value of CO2 savings is 338 million Euros for 2015-2020. This figure, when compared to the invested amounts in the EVs deployment by the selected countries, shows how disproportionate the current situation in terms of value balance is.

4.2 Approaches in estimating CO2 emissions

In this case, due to the countries targets aggregation, it is just considered the CO2 emission factor of the global electricity generation mix. The emission from the manufacture process of vehicles is not considered. Thus, the global electricity generation mix is presented in Figure 24:

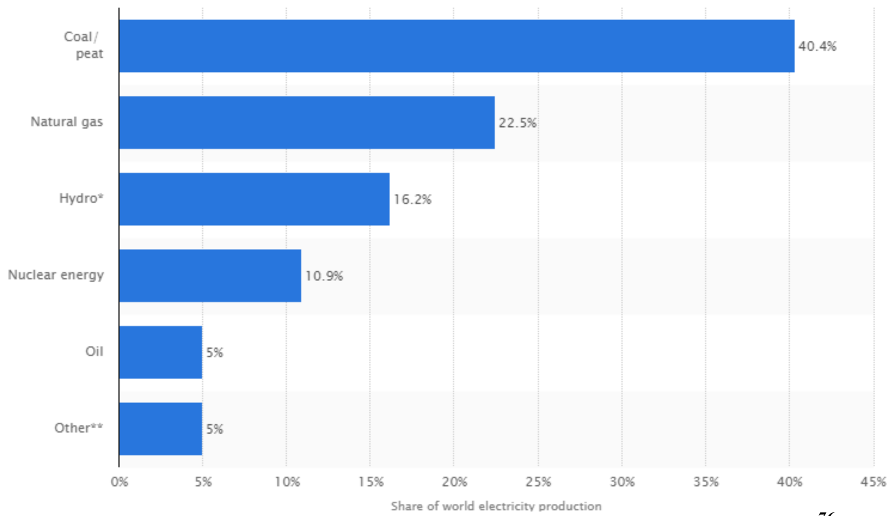

Figure 24: Global Electricity production mix (*Source: Statista 2012*[76])

It is therefore required to multiply the emission factor of each source used in the production of electricity with the share of its contribution to the global mix. Thus the emission factor for each fuel is presented in Figure 25.

Technology	Mean	Low	High
	tonnes CO_2e/GWh		
Lignite	**1,054**	790	1,372
Coal	**888**	756	1,310
Oil	**733**	547	935
Natural Gas	**499**	362	891
Solar PV	**85**	13	731
Biomass	**45**	10	101
Nuclear	**29**	2	130
Hydroelectric	**26**	2	237
Wind	**26**	6	124

Figure 25: CO2 emission factor according to electricity production technology[77]

However, in order to simplify the process and due to already existing data, the emission factor of the global electricity generating mix is published by IEA report and is calculated each year.(See Figure 26)

grammes CO_2 / kilowatt hour

	1990	1995	2000	2004	2005	2006	2007	2008	2009	2010	2011	average 09-11
World	524	526	528	539	542	543	546	539	533	529	536	533

Figure 26: CO2 emissions per kWh from electricity generation (*Source: IEA Statistics 2013)*

[76] http://www.statista.com/statistics/269811/world-electricity-production-by-energy-source/

[77] Comparison of Lifecycle Greenhouse Gas Emissions of Various Electricity Generation Sources; World Nuclear Organization, 2011

In regard to this, if considering the share of renewables, Norway has the biggest share, with 97% in electricity generation. On the other side, China has only 7% renewables share, however a much bigger EVs target. In this case, the efficiency of EVs deployment is higher in Norway, because it will drastically reduce the CO2 emissions solely by the fact of electricity generation emission "niveau", which is much lower than in China. However in this paper, for the sake of simplicity, the electricity generation footprint will be calculated on the existent data on the average CO2/kWh emissions in the world as presented in Figure 26. Thus following equations:

Electricity CO2 emissions *(Well A)* = CO2/kWh (world average) x Consumed Electricity

Consumed Electricity = EVs Stock Target x km/EV/year x kWh/km ratio (Figure 27)

Moving straight to the next step requires an assessment of the consumed electricity by the targeted EVs stock. Knowing the total required electricity for fueling the EVs and the fuel emission factor, the Emission from electricity generation will balance the first result. This means that CO2 saving caused by deploying an EV flee on the global roads is adjusted by including the emissions from the fuel production. However for a more detailed result it would be interesting to include the saved emission from gasoline production. This would compare the emissions from electricity and gasoline production and the difference will be attached to the savings incurred from driving an electric car instead of the conventional car.

Vehicle Category	Electricity (kWh/100km)
Passenger small	19.0
Passenger medium	16.5
Passenger large	21.5
LCV	18.5
Taxi	21.5

Figure 27: Average EV electricity consumption per 100 km (Source AECOM 2009)[78]

[78] Katie Feeney; Economic Viability of Electric Vehicles; AECOM for Department of Environment and Climate Change 4 September 2009; 60099409 (LCV –Light Commercial Vehicle)

According to UNEP, the average global fuel consumption for an average conventional vehicle is 8 l per 100 km.[79] However, it is planned to reduce this figure to 4 l per 100 km. Thus in order to calculate the emissions from the production of the gasoline, it is needed to assess the impact of producing and using the gasoline. Thus, it is assumed that the targeted EVs stock will substitute the equal numbers of conventional vehicles and will save the use of the fuel and the emitted gases for its production. Therefore, it is considered that the conventional autos are fueled only by gasoline. The gasoline proprieties are presented in Table 7.

Parameter	Value
Gasoline Energy Density g/kg	0,75
Gasoline Energy Content MJ/kg	42,40
Average CO2 Impact g/MJ	95

Table 7: Gasoline proprieties (*Source: Author)*

According to Wikipedia the density of gasoline ranges from 0.71 to 0.77 kg per liter. Nevertheless the paper uses the 0.75 kg/l number. The energy content of gasoline is 42.4 MJ per kg. This figure is also derived from Wikipedia. The GHG impact of petroleum ranges from 90 to 120 g CO2e/MJ (grams of CO2 equivalent emissions per mega joule (MJ) of gasoline fuel consumed) depending on the source of the petroleum and to what extent indirect emission impacts are included. The high end reflects unconventional resources and heavy oil, which can contribute to over 10% of current supplies.[80] The CO2 emissions during the petroleum life cycle are presented in Figure 28.

[79] Global Fuel Economy Initiative (GFEI); Plan of Action 2012-2015

[80] Assessment of Direct and Indirect GHG Emissions Associated with Petroleum Fuels for New Fuels Alliance, Life Cycle Associates LLC 2009

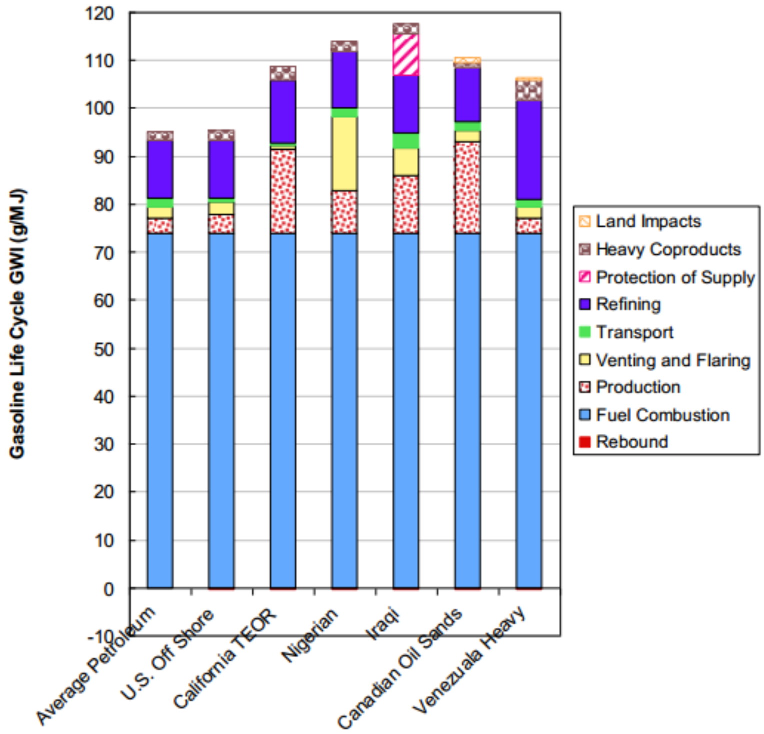

Figure 28: Summary of GHG Emissions for Different Crude Oil Production Scenarios (Source: Life Cycle Associates LLC 2009)

Thus, it is considered that the average CO2 impact of the petroleum (gasoline) life cycle process is 95 g/MJ. This number is taken in consideration for the calculation of CO2 emissions savings when substituting the conventional vehicles with targeted stock of electric ones. Comparing the well to wheel impact of the electricity and the petroleum production helps in obtaining a more accurate result.

Thus, in order to assess the emission savings from gasoline avoidance it is necessary to convert the estimated quantity of gasoline to kilograms in order to further obtain the energy content in Mega Joules. This will allow quantify the CO2 impact by multiplying with the average gasoline life cycle impact ration (95 g per MJ)[81]. On the other side, the total electricity required to fuel the estimated EVs stock is multiplied with the average global emission factor according to the electricity generation mix. This factor is provided by the International Energy Association. Thus following equation:

Gasoline lifecycle emissions *(Well B)* = Fuel consumption (l) **x** EVs Stock **x** Km/y **x** Gasoline energy density (MJ/kg) **x** Average CO2 impact (g/MJ)

[81] According to Figure 28 (Source: Life Cycle Associates LLC 2009) the average petroleum section is being considered.

After conducting these steps, the obtained results are presented in the Table 8 below.

	2015	2016	2017	2018	2019	2020	**Sum of 2015 - 2020 CO2 emissions**
Total EVs on Road	2	4	6	8	10	12	
Km per year	15000	15000	15000	15000	15000	15000	
CO2 g/km	130	123	116	109	102	95	
Emissions per car (Mt/year)	1,95	1,85	1,74	1,64	1,53	1,43	
CO2 (million Mt) *Tank to Wheel A*	4	7	10	13	15	17	**68**
Consumed Electricity (TWh)	6	11	17	23	29	34	
Electricity generation CO2 emissions (million MT) *Well A*	3	6	9	12	15	18	**64**
Net CO2 savings I without gasoline Life cycle (million MT) ***Well to Wheel I***	1	1,3	1,3	0,9	0,1	-1,1	**3.5**
Gasoline Life Cycle emissions (million MT) *Well B*	8	14	22	29	36	44	**153**
Gasoline Life cycle savings + Fuel savings (million Mt) *Tank to Wheel B*	13	22	32	42	52	61	**221**
Net CO2 Savings II (million MT) ***Well to Wheel II***	9	16	23	30	36	42	**157**
Clean Energy Use savings (million MT) **Well to Wheel III**	17	29	43	55	67	78	**288**

Table 8: Impact on global emission by covering a 5% of the auto market with electric cars (*Source: Author)*

Regarding the emissions, it can be stated that following implications are obtained from this table:

- Emissions saved by driving electric vehicles instead of conventional ones. In this case, there are 68 million tones saved at the end of 2020. The CO2 emissions from electricity production are not included. This figure is thus credible if the electricity is generated from renewable sources that do not produce any emissions. (Tank to Wheel A)
- Emissions generated by the production of required electricity quantity. The production of electricity emits 64 million tones till the end of 2020. (Well A)
- Emissions saved when considering the electricity carbon footprint (Well to Wheel I). In this case, when considering the produced emissions by electricity generation, these emissions are offset by the CO2 savings obtained

by driving electric cars. Thus there are 3.5 million of tones CO2 saved until 2020.

- Emissions caused by the petroleum lifecycle process. If the electricity carbon footprint is considered, the gasoline carbon footprint should also be included. If the conventional cars are substituted by electric cars, the gasoline is substituted by electricity. Thus, the CO2 savings from using the electric car includes the electricity carbon footprint and the avoided gasoline use and production. Therefore, the emissions from gasoline production that are avoided if on the roads (targeted EVs stock) were electric cars instead of conventional vehicles is 153 million of tones CO2. (Well B)
- Emissions avoided considering the gasoline lifecycle process and the emissions saved by driving the electric vehicles instead of the conventional ones. In this case, there are saved 221 million of tones CO2. (Tank to Wheel B)
- Emissions saved if considering the electricity generation carbon footprint. In this case, there are 157 million of tones of saved CO2. (Well to Wheel II)
- Emissions saved if considering that all deployed electric vehicles are fueled with clean energy form renewable sources. In this case – 288 million of saved CO2 (Well to Wheel III)

Following equations were considered:

Net CO2 savings without gasoline *(Well to Wheel I)* = EVs Stock **x** Emission factor (g/km) + Gasoline lifecycle emissions *(Well B)*

CO2 emissions (Tank to Wheel A) = EVs Stock **x** CO2 Emission factor (g/km)

An explication of how the further results were obtained is:

- Well to Wheel I = Tank to Wheel A – Well A
- Tank to Wheel B = Tank to Wheel A + Well B
- Well to Wheel II = (Well B - Well A) + Tank to Wheel A
- Well to Wheel III = Tank to Wheel A + Tank to Wheel B

The meaning of each presented terms are discussed in the Table 9.

Description	Explanation
Well A	CO2 from electricity production
Well B	CO2 from gasoline production
Tank to Wheel A	CO2 savings from driving electric instead of gasoline
Tank to Wheel B	CO2 savings from driving electric considering the gasoline life cycle carbon footprint
Well to Wheel I	CO2 savings form driving electric minus the electricity life cycle carbon footprint
Well to Wheel II	CO2 savings form driving electric, considering the electricity and the gasoline life cycle carbon footprint
Well to Wheel III	CO2 form driving electric, not considering both the electricity carbon footprint and including the savings by avoiding the gasoline life cycle carbon footprint. It is assumed that the fuel is provided by clean energy sources.

Table 9: Wheel to Wheel deciphered (*Source: Author)*

Considering the impact of discussed approaches, it is further on important to compare the savings with the total global emissions. According to Carbon Print, in 2012 there were 35444 million of tones emitted. Moreover, it was already stated above, that an aggregated EVs target from leading countries would reduce the total CO2 emission with 0.2%. However, this did not include the electricity and petroleum processing factors. Thus, a more accurate picture on the key finding is presented bellow in the Table 10.

Description	Savings 2020 to 2012	CO2 million MT
Tank to Wheel A	0,2%	68
Well to Wheel I	0,01%	3
Well to Wheel II	**0,4%**	**157**
Well to Wheel III	0,8%	288

Table 10: Impact on global CO2 emissions (*Source: Author)*

The results show a very insignificant emission saving when solely the electric care factor is considered. If the electricity generation emissions are considered then only a 0.01% reduction from the 2012 level is projected. This means that the energy-decarbonizing task is the most important element in the battle for reducing the global

CO_2 emissions. This is also confirmed by the fact that the well to wheel approach, that considers using 100% clean energy, estimates a 0.8% reduction compared to a 3.4% when the current electricity generation mix is included. In other words, an improvement in the energy life cycle will boost the impact of the electric vehicles on the overall emissions. Thus, if assuming the footprint of the current global electricity mix, the impact of diffusing the electric vehicles to the degree of the current countries targets (on aggregated basis 12 million), will reduce the overall CO2 emission by 0.4%. It is an insignificant result if stating that the emissions from the transport sector accounts just for 21% of the global emissions. The CO2 savings according to each approach are illustrated in Figure 29.

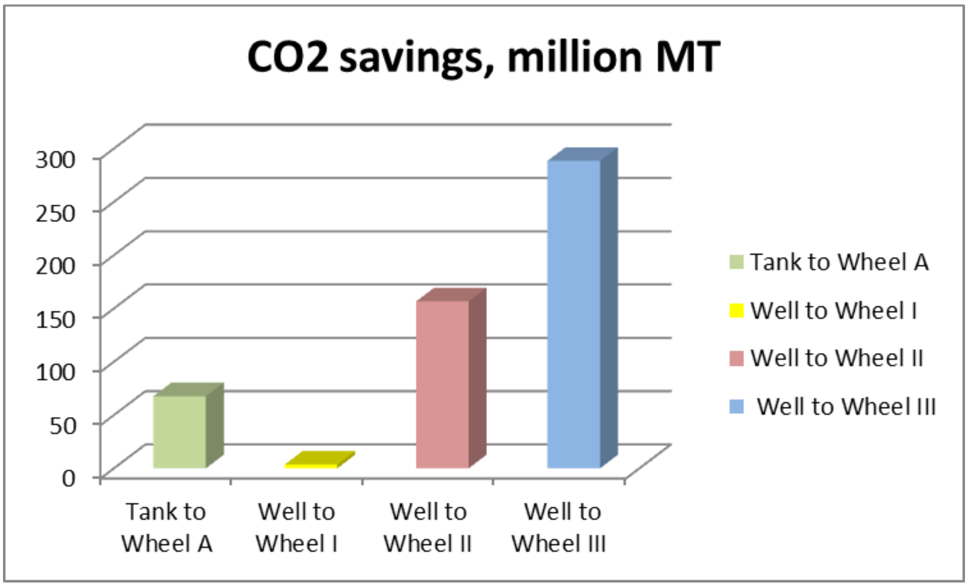

Figure 29: CO2 savings according to each approach

However as a small comment, countries like Norway and Netherlands will have better efficiency results when conducting the CO2 lifecycle calculations. Nevertheless due to the small targets when compared to U.S, Japan and EU, it is arguably if such countries do have a primordial importance in reducing the global CO2 levels. Despite this, Norway and Netherlands provide excellent examples of functioning policies and moreover renewable integration (Norway).

It is important to notice that the estimated reductions are compared to the 2012 global emission level. This is the actual existing data on overall emissions. Comparing the findings with an older emission level will give a better result.

However, the method that was used has the meaning of providing a short overview of the influence and importance of electric vehicles on the global emissions.
The main concluding remark is that the electric vehicle promotion is linked to the energy efficient improvement, both of them presenting a better result when promoted in parallel. Please note that the emissions figures from other sources and its evolution are not taken in consideration.

4.3 Valuation of CO2 impact

The range of CO2 reduction percentages are of a positive nature. However, the relative emissions reduction of 0.4% percent in comparison with the 2012 levels does not show us how efficient the sector was supported. Until nowadays, Governments across the world have worked toward positioning the electric vehicles closer to conventional ones, thus making them almost competitive. It is however hard to estimate the efficiency of utilized incentives and policies. The main policy instruments and its properties concerning CO2 emission reductions are presented in Figure 30.

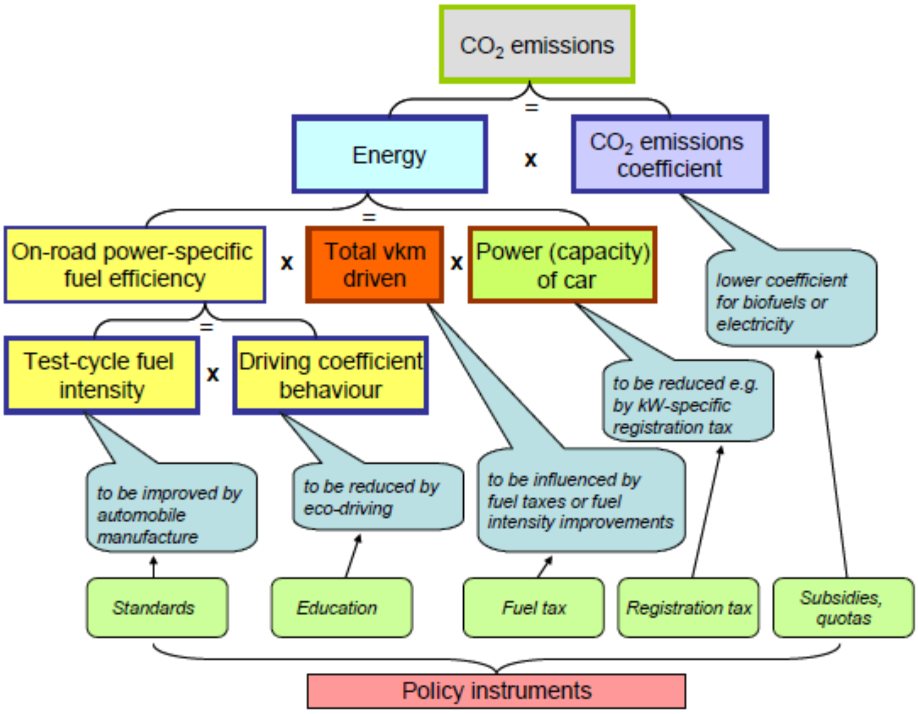

Figure 30: Impact factors on CO2 emission[82]

82 A LEAST-COST APPROACH TO REDUCE CO2-EMISSIONS IN

The monetary allocations in terms of spending, loan, grants or investments had the goal of reducing the greenhouse gas emissions. It is a very hard goal to be quantified in exact figures. Despite this, it is impossible to spend money and to not assess its value in terms of benefits or outcomes. The economics of money does not work like this even at the Government levels, where the driving force is not the profit making. However, there is a sophisticated market mechanism for the CO2 emissions, created by the European Emission Trading System.

The carbon pricing is the favored method by most economics for reducing global-warming emissions. It charges those who emit carbon dioxide for their emissions. According to Wikipedia this charge, called a carbon price, is the amount that must be paid for the right to emit one tone of CO2 into the atmosphere. Such carbon pricing is similar to a carbon tax or a requirement to purchase allowance certificates to pollute. Because such permits/certificates are tradable and their number is limited, this system is known as cap-and-trade.

Carbon pricing is advocated barely because CO2 is what economic theories call a negative externality, which is a harmful product that is not priced and charged for in any market. Consequently, too much CO2 is emitted. The possible solution to this paradigm, according to Pigou, and now following standard economics theories, is the need of governments to charge CO_2 emissions at a price equal to the monetary value of the damage caused by the emissions. This should be interpreted in the result as the value of socially optimal amount for CO2 emissions. However, the exact damage per ton of CO2 remains uncertain and thus hard to be quantified in monetary values.

The economics of carbon pricing is similar to those for taxes and cap-and-trade. Both prices are efficient, they have the same social cost and the same effect on profits if permits are auctioned.[83] Nonetheless, caps avert policies with no price, such as renewable energy incentives, from diminishing CO2 emissions, while carbon taxes do not.

The choice of pricing approach, a tax or cap-and-trade, has been controversial. A carbon tax is mostly preferred for its simplicity/stability on economic grounds, while

PASSENGER CAR TRANSPORT: THIS TIME ECONOMICS WILL KILL THE ELECTRIC CAR; Amela Ajanovic and Reinhard Haas, Vienna University of Technology, Energy Economics Group
[83] According to Wikipedia

caps are mostly preferred on political grounds. The market price of the CO2 is presented in the Figure 31.

According to Figure 31, the market collapse in 2011 and continued the downsize trend until recently. This is also an argument for nationalizing the climate friendly policies. However, the CO2 is priced at 5 Euro per ton. This number will be used in the valuation of the conducted estimations.

Figure 31: Europe ETS carbon spot price (*Source: Thomson Reuters Point Carbon)*

Valuating the CO2 impact at the current market prices eliminates the necessity to discount the values. It is not sure that the prices will remain at these levels or the market will exist until 2020 but it attaches a monetary present value to the CO2 savings estimated to occur until 2020. Considering the carbon price of 5 Euros per ton, the monetary value of achieving the EVs targets for the mentioned countries until 2020 is presented in Table 11.

Approach	Savings 2020 to 2012	EUR Billions Savings
Tank to Wheel A	0.2%	0,34
Well to Wheel I	0,01%	0,017
Well to Wheel II	**0,4%**	**0,78**
Well to Wheel III	0,8%	1,44

Table 11: CO2 savings at the current carbon market price (*Source: Author)*

The most optimal result which presumes a 0.4% reduction in emissions has the current market value of 0.78 billion Euros. However, these are future estimations and cannot rate the efficiency of existing incentives. Moreover, it is extremely hard to conduct a cost benefit analysis on the policy measures directed toward electric mobility support.

Use of auctioning revenues by Member States Under the Monitoring Mechanism Regulation, Member States were requested to report for the first time by 31 July 2014 on the amounts and use of the revenues generated by the auctioning of ETS allowances in the year 2013 The total revenues for the EU were € 3.6 billion.

4.3.1 Social Cost of Carbon

The Social Cost of Carbon estimates the benefit society will acquire, in monetary value, by avoiding the damage caused by each extra metric ton of carbon dioxide (CO2) released into the atmosphere. It is part of a larger exercise required by long-standing Executive Order of agencies of the Executive Branch of U.S. Government, including the Environmental Protection Agency.[84] When authorities prepare to provide regulations setting the laws, they must give grounds to the proposed regulations by assessing their costs and benefits. The SCC is practiced as the benefits side of the cost-benefit analysis. For a regulation that reduces emissions, the SCC represents the value of damage avoided by the regulation or in other words the benefits of such a regulation.

Cost-benefit analysis is a useful tool in government decision making. However, when using a cost-benefit analysis in assessing the climate change, sharp issues may arise. Thus, monetizing climate costs and benefits has been always a challenge when conducting such an analysis. Moreover, the analysis in estimating SCC supposes that assumptions go beyond the usual limits of science and economics. Such an exercise involves perceptions cloaked in sophisticated socio-economic models that may stay unseen by policymakers and stakeholders.

Economists use sophisticated economic models in order to simulate the real factors that may affect the costs and benefits factors a society is exposed to. The models used for SCC are called “integrated assessment models” (IAMs) because they attempt to incorporate knowledge from a number of fields of study, such as engineering, technology, behavior, and climate science, with the purpose of deciding

[84] World Resources Institute

whether particular climate change policies are economically efficient.[85] The IAM uses mathematical formulas to simulate the relationships between economic activity and measures to control emissions and the desired environmental outcomes.[86] Judgments are filtered into equations in order to capture interactions between different component parts.

An important variable used in calculating the SCC is the discount rate. The discount rate considers the challenge of sizing the time factor in climate policy. It includes three assumptions: humans prefer a gratification of benefits in the present that in the future, that future outcomes will be bigger and a dollar worth less to them as a result, and finally the opportunity cost of capital. In the calculation of cost-benefit and SCC, the choice of discount rate influences whether economists recommend investing in greenhouse gas reductions today or much later and thus, from this perspective, the higher the discount rate, the less significant future costs become.[87] The estimated social cost of carbon is presented in Figure 32.

Discount Rate Year	5.0% Avg	3.0% Avg	2.5% Avg	3.0% 95th
2010	11	32	51	89
2015	11	37	57	109
2020	12	43	64	128
2025	14	47	69	143
2030	16	52	75	159
2035	19	56	80	175
2040	21	61	86	191
2045	24	66	92	206
2050	26	71	97	220

Figure 32: Revised Social Cost of CO2, 2010 – 2050 (dollars per metric ton of CO2) ***Source: US Government***[88]

In regard to the conducted CO2 impact estimations it is interesting to use the SCC approach in order to value the emissions in monetary terms. According to a 5% discount rate the SCC value in 2015 is 11 $ per metric ton of CO2 and in 2020, 12 $.

[85] Michael C. MacCracken & L. Jeremy Richardson, Challenges to Providing Quantitative Estimates of the Environmental and Societal Impacts of Global Climate Change (May 2010)

[86] Frank Ackerman et al., Limitations Of Integrated Assessment Models Of Climate Change, 95 Climatic Change 297-315 (2009).

[87] The "Social Cost of Carbon" and Climate Change Policy, WSI, by Ruth Greenspan Bell - July 13, 2011

[88] Technical Support Document: - Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis - Under Executive Order 12866 - Interagency Working Group on Social Cost of Carbon, United States Government, May 2013

These figures are almost roughly the double value of the current carbon market price. Therefore, the result of targeted EVs stock deployment will have an approximate socio-economic value of 1.9 billion of Euro (at current 1,14 exchange rate). However a SCC cost (37$ in 2015 and 43$ in 2020) assumed in a 3% discount rate (which is more appropriate for such developments) will have a significantly higher social value. In this case, the Governments can allocate more money through initiatives and support measures toward climate friendly projects, including electric mobility promotion. The findings are presented in the Table 12.

Approach	Savings 2020 to 2012	CO2 Savings, Present Value (EUR)	CO2 Savings, 2020 Value (EUR)
Tank to Wheel A	0.2%	2,85	3,4
Well to Wheel I	0,01%	0,12	0,23
Well to Wheel II	**0,4%**	**6,6**	**7,6**
Well to Wheel III	0.8%	12	14

Table 12: SCC value of estimated CO2 savings in billions (*Source: Author*)

Due to the lack of accurate information on monetary figures allocated by Governments for the support of Climate Task, it is proposed to estimate the policy efficiency with a stop-limit approach. That means, if a national target (expressed in fixed or relative numbers) is achieved with less spending than the stop-limit (in this case expressed according to CO2 market price value or SCC value) it is considered efficient and acceptable. Considering targeted EVs stock, policy measures are allowed to budget their support spending in a range from 0.78 billion to 6.6 billion Euros for the 2015-2020 period, in dependence of the assessment method. This is the case of the basic result, which includes the adjustment of electricity and gasoline footprint. However if the Governments diversify their climate friendly programs and include other mechanisms for reducing the emissions from other sectors, the spending range gets higher. Thus if the total global spending for a 12 million EVs in the 2020 corresponds to the monetary range, then aggregated polices of frontrunner mentioned countries are considered efficient. Moreover, countries follow own goals and might decide up the climate commitment according to own national perception of benefit and cost. This however explains the current difficulties in organizing the work on an international basis.

4.3.2 Energy security impact

Global oil reserves rose by 31 billion barrels to 1,653 billion barrels in 2011. According to the targeted aim of EVs stock, the monetized value of avoided oil is 48 billion Euros, during 2015-2020. It can be saved from avoided imports or additional exports. Countries exporting oil could be motivated in deploying electric mobility. This could allow them to set free an additional amount of oil for the export. This would add value to the trade balance sheet and to the income from oil exports. A successful example for this is Norway, an oil exporter and a devoted climate friend. On the other hand, oil importers would save the additional value. If the targeted EVs stock will substitute a similar number of conventional cars, there is a potential to save 240 million of oil barrels. This accounts for 0.01% of the proven global oil reserved from 2013.

European transport is 94% dependent on oil, of which 84.3% is imported, and faces increasing fuel supply insecurity as oil comes from increasingly unstable regions of the world, and a high and rising oil import bill (€ 1 billion per day in 2011) which causes a deficit in the balance of trade (around 2.5% of GDP). It is clear that EU transport must diversify its energy sources. Additionally please note that U.S; China and Japan are also significantly exposed to oil dependence.

Energy efficiency in transport and effective transport management can substantially contribute to reducing emissions and oil consumption. However, they are not an alternative to oil substitution but a bridge to alternative fuels.[89] Alternative fuels are the final solution for the transport de-carbonization.

Electricity as a fuel for vehicles implies a substantial change in the transport energy supply, drastically reducing emission. Thus, electric vehicles are ideal for urban areas.

4.3.3 Policy measures spending overview

Upfront price (for example and average of 10 000 EUR per EV) – considering the cap limit of 6.6 EUR billion under SCC assumptions, will afford to support the deployment of approximately 660 000 electric cars, which accounts for 5.5 % of the estimated goal of 12 million EVs. Thus the use of up front pricing is seen as

[89] Report of the European Expert Group on Future Transport Fuels; Future Transport fuels; 2011

appealing but not efficient and it is recommended to be used in the initial promoting phase. Under the ETS carbon price levels, only 34 000 EVs could be supported with an up-front price.

Tax (Registration) Exemptions – has the same appraisal for the consumers as the Up-front price has, thus the Tax income is reduced and there is no need for public spending.

There is a higher need for structural measures (indirect) and thus public investments in infrastructure, R&D, industrial/manufacturing and business environment. The direct subventions must have the aim of attracting the demand. However the supply side is in a more acute need of support. It also has a bigger influence over the course of actions. Moreover it has a higher risk associated to the efficiency improvements. Without proper infrastructure, performant technology and functional market it is highly unlikely that the demand side would be convinced to switch to new products. This also explains the Governments spending, presented in Figure 33.

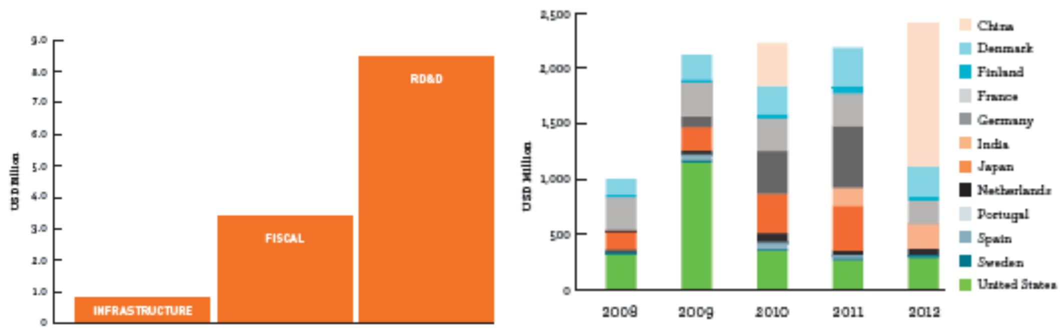

Figure 33: Figure EV Spending by EVI Countries, 2008-2102 (IEA 2013)

Most of the allocated money is directed toward research and development. The fiscal incentives are also high due to the need of attracting the demand in the initial E-mobility deployment stage. Most of fiscal incentives programs expired at the end of 2012. However, countries sitting bellow their CO2 targets, have updated their programs. For example, according to European Commission, total EU greenhouse gas emissions in 2013 fell by 1.8% compared to 2012, which brings them at around 19% below 1990 levels (scope of the 2009 Climate and Energy package). This keeps the EU on track to meet its 20% target by 2020. This might encourage the EU states to invest in core elements like technologies and acceptance, and not just spend the money with fiscal incentives that brings no innovative results.

There is less interest from the governments in budgeting the funds for the infrastructure. It is more or less understandable. Without an existing fleet of electric vehicles, there is no need to foster the infrastructure. As studies have reported, the current electricity grid could handle without a lot of problem the natural step by step integration of electric vehicles. Moreover, the infrastructure will be needed when a mass diffusion of EVs will be in sight.

Furthermore, it is stated that during the period 1990-2012, the combined GDP of the EU grew by 45 %, while total GHG decreased by 19 %. As a result, the greenhouse gas emissions' intensity of the EU was reduced by almost half between 1990 and 2012. Decoupling occurred in all Member States.[90]

In the end, it is interesting to review some developments in figures around the world. Such a review supposes a graphical analysis of public spending toward EVs promotion and market results of this technology. How it is important to keep in mind that each country differs in terms of conjuncture and market functionality, not even mentioning the cultures. Thus, according to the Figure 34 it is interesting to notice that countries are modifying the R&D spending during the years. This is an indicator that policy makers pay close attention on this matter. However China, U.S and Germany are the top spenders in this area. Nonetheless China is way ahead, a fact that can be understood by the grandeur of its market and population.

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[90] PROGRESS TOWARDS ACHIEVING THE KYOTO AND EU 2020 OBJECTIVES; REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL; (required under Article 21 of Regulation (EU) No 525/2013 of the European Parliament and of the Council of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC)

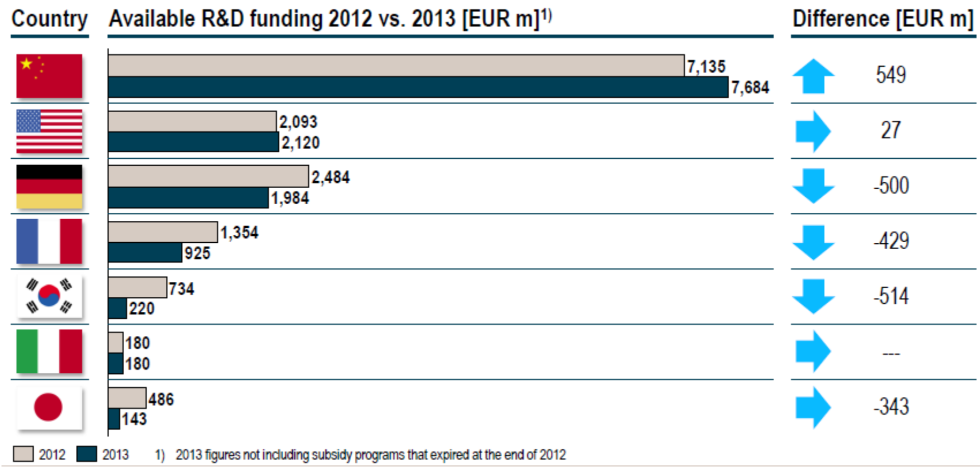

Figure 34: Available R&D funding (Roland Berger 2012)

Further, it is necessary to assess current developments in order to classify the results and get a clear picture on the global markets. Such an approach has been implemented by Roland Berger Consulting. They have built an Index for Electric Mobility, which construction elements are presented in Figure 35.

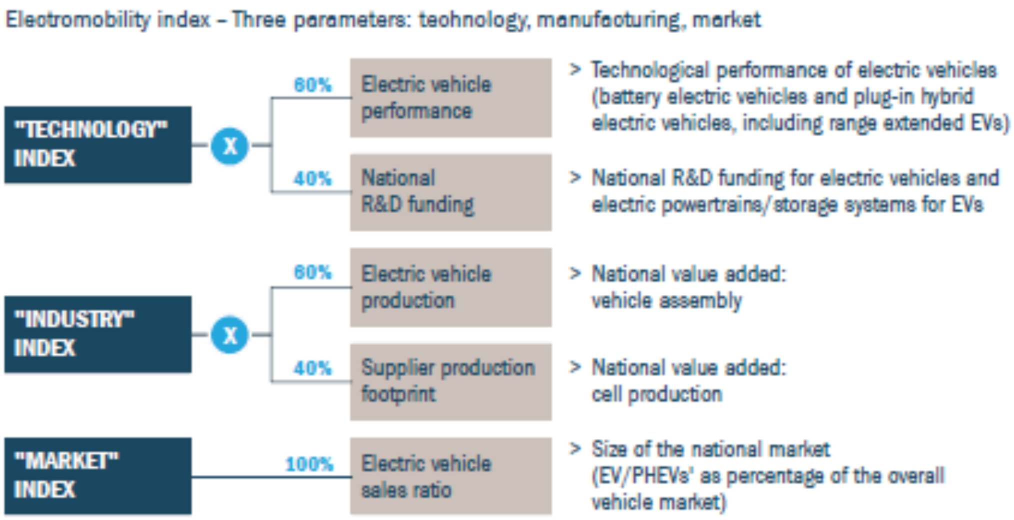

Figure 35: Electric Mobility Index (Roland Berger E-Mobility Index 2012)

As illustrated in Figure 35, such an E-Mobility Index includes the technologic, industry and market components in order to rank countries according to different characteristic and to identify who and where is better performing.

Thus, Figure 36 shows the rankings of most involved countries. Hence, Japan is the top achiever in industry and market developments. However, it should be noted that Japan has always been a very advanced technologic country and culture. Moreover, a dense market allows a good correlation of the actions among stakeholders.

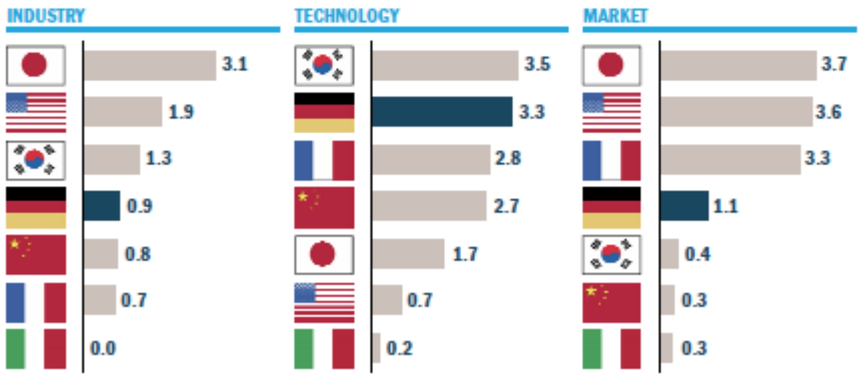

Figure 36: E-Mobility Index rankings (Roland Berger E-Mobility Index 2012)

It is however important to notice that in 2013 and 2014 Norway and Netherlands have witnessed an enormous growth of EVs thus, positioning them in the top of the rankings concerning the market share. Due to the fact that both these countries are comparable small if looking at the rest of the index members, such a modification in rankings is possible and does not make the results false. Additionally, china improved also its position. Nevertheless the Index ratings provide valuable information in regard to the overall electro-mobility development, classified per country focus.

However, in terms of technology, Korea is identified as a leader. This happens because of high research activity in the battery industry. This country has paid an increased attention to battery developments. Such an attitude has situated Korea in the top of the technology Index, being specialized mostly in battery production. Nevertheless, Germany is not letting go and due to a long history of technology success, hast the second position in the technology field.

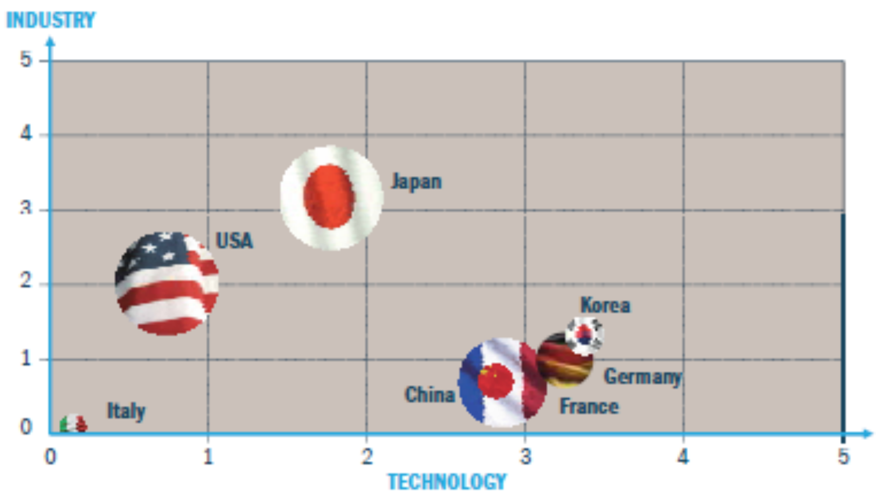

Figure 37: Overview of competitive positions (Roland Berger 2012)

A better illustration of the presented rankings is shown by Figure 37, which groups the countries according to relevant competitors. Thus, U.S and Japan compete in the industry, China, Korea, Germany and France in technology and Norway and Netherlands in market share achievements. (Not illustrated in Figure 37 due to remarkable performances in 2013 and 2014)

Further on it is necessary to assess the value of the technology development. This supposes the price of technology compared to its level and can be considered the maturity of the market. Thus, according to Figure 38, the most equilibrated positions are held by Germany, Korea and Japan, all countries with moderated EVs value for money.

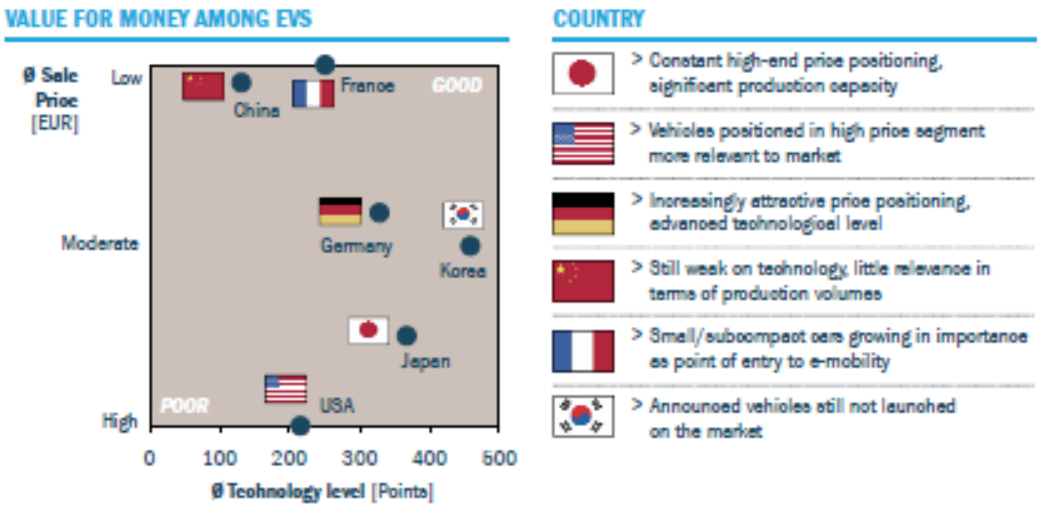

Figure 38: Value for money among EVs (Roland Berger 2012)

In the end, it can be restated that an increase in EVs number on the global markets will have a positive result in emission reduction, which has a substantial value in avoided damages. Despite this, the reduction is much more if considering the use of renewable electricity. Thus, solely the support of EVs does not seem to be appropriate without considering the fuel footprint. However the value assumption is still vague and theoretic. Moreover there is the abstract characteristic of climate impact as it cannot be properly understood and assessed by the mankind. This means giving a new value to the nature and embracing it in the usual functioning systems. How to do this is still a puzzle. Moreover, such initiatives, followed by substantial support packages, were able to reduce CO2 emissions and still not impact GDP growth. At this stage such an involvement does not affect the economies.

Importantly, the energy security issue is also in the positive sector of benefits. However the saving s of oil are minor, only 0.2% but more important is the reduced dependence. This is an important geopolitical aspect of global security in general. Nonetheless, policies directed only to EVs development are not enough. There is still the infrastructure and fuel matter. The emissions savings just from the use of EVs are not substantial enough to be classified as a success. Additionally, the energy lifecycle emissions, in this situation, electricity, must be reduced in parallel, by increasing efficiency and switching to renewable and low emission energy sources.

4.4 Arguments for future development

The EVs market is growing but is hard to predict how the future will look. However following the trend the new technologies, future scenarios have and optimistic character. As assumed in many studies, the electric mobility sector has just ended the first stage of market apparition. The description of such stages goes till 2030 and is illustrated in Figure 39.

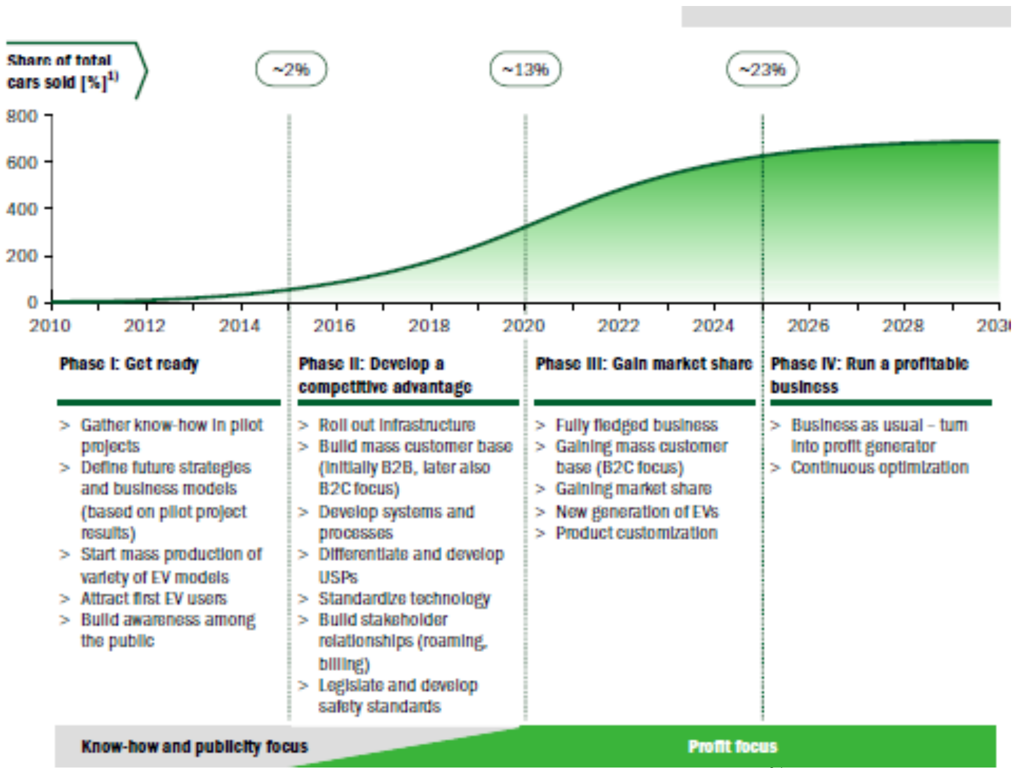

Figure 39: Electric Mobility development stages[91]

[91] Impacts of Electric Vehicles – Summary report commissioned by the European Commission; elaborated by CE Delft, 2011

New business opportunities in the private sector will likely emerge. Innovative business models that offer integrated mobility services will come afore as the sector takes distance from the traditional model. Electrical utilities and renewable energy suppliers will immediately identify the opportunities related with the electrification of transport sector, and not just from the viewpoint of boosting sales.

In geographic terms, the car transport sector electrification is attractive to any country or region which:

- is net importer of crude oil;
- strives to improve overall energy resources efficiency;
- has a big, growing road transport sector;
- has a big, growing automotive industry;
- intends to develop electricity infrastructure;
- is committed to reduce emissions.

Prime candidates include North America, the EU, Japan and China. As discussed above, these countries are the frontrunners in the desire to accomplish an ambitious target and enable the market existence of EVs.

Despite of the obvious benefits of transport electrification, possible negative consequences must not be forgotten. Sophisticated battery systems will encourage the extraction and processing of raw materials, which is associated with additional energy consumption. A mass production of batteries requires the development of a second hand industry for used batteries and also efficient waste management programs.

Another probable risk is that energy efficient applications may be consumed more often than their inefficient precursors, resulting in a net rise in energy consumption. Moreover, with almost a billion of vehicles in the world today, and considering the possible doubling of number by 2030, the fundamental dependency of the transport sector on liquid hydrocarbon fuels cannot be longer ignored. If however ignoring this, the world will be forced to confront additional challenges: coercion on governments to disclose protected areas for oil exploration, increasing geopolitical conflicts, human rights abuses and quick rising of CO_2 emissions with climacteric and possible catastrophic outcomes.

EVs can dramatically reduce the oil dependency of automotive transport in an efficient and sustainable manner. Nonetheless, an environmentally and economically sustainable transport sector cannot be achieved through electrification alone. Additional measures to reduce overall demand through smarter urban planning (Smart City), modal shift to mass transit, smart grid development, increased use of telecommunications technologies, and car sharing will make necessary and significant contributions. Automotive electrification can assist the needed transformation towards a highly efficient transport prototype, which is supposed to be also compatible with a sustainable renewable energy future.

5 CONCLUSIONS

The paper enumerated possible best practices in terms of policy measures concerning the deployment of EVs. However the general aspect of listed practices was correlated to the identified EVs market leaders. This had the purpose of showing that in some places, due to specific market conditions only some of the policy actions do deliver results that are still hard to be attributed to certain action.

The electrification of the global car fleet is surely a long-term ambition. EV market shares are still below 1% in most major markets. However in order to have more exact picture on the effects of future EVs development, this paper analyzed the overall impact if the EVs targets of main leading countries in terms of EVs deployment. The benefits can however not be properly assessed but the results obtained show that such a scenario would reduce the overall CO2 emission with 0.2% compared to the 2012 levels. This however takes in consideration the lifecycle of the fuel production. Moreover, such a scenario will save 0.01% of global oil reserves. Nonetheless these not the most representative results that redirect the focus to further structural issues and conclusions:

- Most of serious commitments of Governments initiatives have reached the end of the first introduction stage, which has a more demonstration function. The early adopters have been put in action, thus a range of EVs and infrastructure equipment reached the market thus the first learning actions are done. However, as it is the first deployment stage, it is not clear if it will reach maturity and if it is beneficial to do so. It is not excluded that other technologies or innovations will appear. Thus, in general, it is too early to formulate a serious conclusion on what policy strategy and support package of what country is the most successful one. Moreover, countries differ in terms of competitive advantages that it possesses. Thus, forcing to implement similar measures may disadvantage some countries more than others and there is a conflict of geopolitical interests in play. This is a too big risk for such a new topic. Therefore, it is also visible and understandable why most governments set different actions starting from R&D support projects, demonstration cases and subsidies for individuals. Such an approach does not bind the country to commit serious structural changes. It is just a confirmation that the governments provide awareness on the climate issues and take responsibility in this. Such introductory measures are definitely necessary to obtain a result, and undoubtedly, the result is there and will improve. However, the governments may lose the focus on the matter and concentrate to traditional issues that are proven by history to work. The Governments may hesitate in risking political and economic power in an unknown strategy. Such a bet is hard to be decisively taken, considering the complexity of collective commitments. Nonetheless, the invested amounts in Electric Mobility are impressing but not convincing so, it is also expected that governments may adopt a push and wait strategy that might not stimulate enough the uptake of EVs.

- The industrial sectors involved are not willing to disconnect from their traditional business, but understand the importance of innovation and dynamic evolution. Hence, the set of barriers and the market inexistence does not motivate them to take steps toward such actions. They are led by profit, and if there is not even a demand, such an initiative is not discussible from the business point of view. However, due close ties between business and governments, they cannot ignore such a public decision. Thus, they are waiting for big incentives and investment programs to open the market for their Electric Vehicles. They still want guarantees that such radical and innovative actions have a chance of success. This constellation creates an open-end problem, as governments are waiting for performant technologies and clear evolution statements and the industry expects for attractive conditions by the government side. Such a step and hold dance is therefore hindering the introduction of electric mobility solutions, but can be fixed if competition for the benefits pool is woken up.
- Another formal issue is the lack of proven solutions. This overwhelms the Governments with lots of differing information. Moreover, the lack of common standards for the needed infrastructure derives also from this. This is a considerable risk for investments as there is no guarantee that current systems won't get replaced by future developments. The market has

witnessed bankruptcies (Better Place, A123 etc.) of risk seeking companies that accepted the challenge and betted on a certain direction, like electric mobility solution. This however shows that there is still uncertainty about such a transport transformation. Even the successful Tesla Motors is running with red numbers. Moreover, it is necessary that the products, as public charging fees and EVs price keep in the range of the customers buying power. Without a feasible solution that accommodates with the costumer need and provides him an economic advantage, the EVs can remain just demo projects and thus restricted from mass adoption. Moreover, concepts in Electric Mobility, closer to present reality performances and habits, like fast charging including roaming and long range EVs are missing and are not even visible for the short future. This makes such innovative products limited in terms of customer attractiveness.

- In terms of targets, it is observable that none was achieved. However if conducting a final statement, the best practices among the best performers in terms of EVs market share were identified. Thus direct subsidies in form of up-front prices and tax reductions/cuts along with privileged traffic rights tend to be the most used measures. However they have different results because it targets the consumer. Thus without infrastructure, public acceptance even such generous subsidies can fail. Therefore another best practice is to foster R&D with the purpose of reducing the costs and infrastructure developments. This would reduce the consumer uncertainty and thus boost acceptance. However in terms of countries, if considering U.S with high car ownership and lower taxes, then a purchase subsidy or a tax relief would not improve the EVs TCO in the minds of consumer the way it will for smaller countries where the taxes are high and car ownership low. (Norway, Netherlands). As it was seen in Netherlands, when the subsidies expired, the EVs sales plumbed. Therefore there is also critic on the high subsidies. Of course they work but it is not visible that it helps EVs penetrate the market for long terms. Furthermore, if considering the fuel emission standards for conventional vehicles and the vast experience with their manufacture, it can be assumed that a radical reduction of conventional fuel emission levels will kill the EVs market as it is supposed to come through with less costs. In this case the deployment of EVs should be attached to a natural innovation path. Moreover such high subsidies like in Norway seem to incentivize the use of a new alternative rather than taxing the problem, the CO2 emissions. Additionally, the results of the calculation also show that the EVs deployment makes less sense without energy efficiency. A real example is China and Norway. China actively supports each part of EVs industry but fails to reduce emissions, due to the low share of clean energy in the country mix. On the other side, Norway generates its electricity almost fully from renewable sources. Thus, having fewer cars on roads and a clean fuel carbon footprint, enable Norway to get on the top and achieve the higher market share in terms of EVs numbers. This however does not suggest that the Norway policy measures should be implemented overall. It is also arguably that such subsidizing policies will achieve better results in long term and would not prove to be counterproductive.

The formulated barriers and current experiences presume that there is a fundamental gap between the industry interest, consumer acceptance and government support for a solid commitment in stirring up the diffusion of the electric mobility. This shows how complicated is for market actors to work together in achieve a common target as the Climate Change Task is.

Considering the general target, the reduction of GHG emission and thus combating climate warming, the most powerful governments around the world still failed to achieve a common understanding. (Kyoto Protocol) The fight against global warming was mostly filled with rhetorical commitments to reduce national emissions without engaging in creating trade, production and financing issues undoubtedly needed to affect a global energy transition.

On the other hand, states can participate and can chose not to participate in multilateral actions. A possible offering of global political reward to climate leaderships should be researched. Nevertheless, international obligations cannot be forces to states. Thus there is a need of a proper architecture of the global climate market so that it does not permit free riding and senseless spending.

In the end, the electric mobility faces an introduction period, which has the purpose of providing valuable lessons to all involved stakeholders.
The current situation invokes a flair filled with optimism as most governments and relevant industry players show their engagement and thus their ambition to deal with a major problem of humankind future. The next years will show if and how the world has learned and prepared itself for the upcoming changes and if electric mobility is a viable solution.

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APPENDICES

The appendices provide a collection of data of current EVs incentives, Charging Stations development and Collaborations for the development of future urban mobility. These data have an informative purpose and serve as an additional and supportive informational base.

Appendix 1: Collection of Data on Current Incentives for EVs (Global EV Outlook: Understanding the Electric Vehicle Landscape to 2020; Clean Ministerial, Electric Vehicle Initiative, International Energy Association; April 2013 and Market Outlook to 2022 for Battery Electric Restricted – Commercial and Plug-in Hybrid Electric Cars AEA/ED46299/Issue 1 AEA

Country/Vehicle Details	Value of support in currency of origin	Value of support in £ (approximate)	Value of support as a % of total vehicle price
Canada: (Federal rebates for vehicles 5.5l/km, e.g. Toyota Prius 1.5 l, Honda Civic Hybrid, 1.3l and additional provincial rebates for plug in electric and hybrid vehicles)	\$2,000 / \$3,000 (CAD)	£1,115 / £1,675	
Belgium: (vehicles with emissions up to 105 g CO_2/km)	€ 4,350	£4,000	20% to 40%
Ireland: (Hybrid and Flexi-Fuel - first registration)	€ 2,500	£2,300	Up to 15%
Sweden: (Hybrids with emissions less than 120g CO_2/km, electric cars - less than 37 kWh)	10,000 SEK	£850	Up to 5%
France: (Class A, vehicles under 100g CO_2/km)	€ 2,000	£1,850	Up to 15%
France: (Class A+, vehicles under 60g CO_2/km)	€ 5,000	£4,700	Up to 25%
USA: (Plug-in electric, batteries of at least 4kWh)	\$2500	£1,700	Up to 8%
USA: (Plug-in electric, gross vehicle weight up to 10,000 lbs)	\$7,500	£5,250	Up to 20%
USA: (Plug-in electric, gross vehicle weight up to 14,000 lbs)	\$10,000	£6,800	
USA: (Plug-in electric, gross vehicle weight between 14,000 lbs and 26,000 lbs)	\$12,500	£8,500	
USA: (Plug-in electric, gross vehicle weight up to 26,000 lbs)	\$15,000	£10,160	
Japan: (Nissan Hypermini - electric car)	940,000 JPY	£5,040	27%
Japan: (Mitsuoka CONVOY88 - electric car)	210,000 JPY	£1,125	24%
Japan: (Zero Sports Elexceed RS - Hybrid)	380,000 JPY	£2,040	19%
Japan: (Toyota Prius – hybrid)	210,000 JPY	£1,125	10%
Japan: (Honda Civic Hybrid)	230,000 JPY	£1,240	11%

Country	Up Front Price Support/Financial Incentives
USA	Up to US$7,500 tax rebate for purchasers of plug-in hybrid and electric passenger cars. Up to US$15,000 is available for purchasers of plug-in hybrid and electric heavy-duty trucks.
Canada	A range of incentives from federal and provincial governments, of up to CAN$5,000 rebate for new hybrid electric vehicles.
Japan	Incentives of up to $16,000 off the retail price of electric vehicles, and reductions in road tax and registration fees.
France	A French initiative named Eco-pastille, which began on January 1st 2008, sees that people who buy electric cars receive €5,000 back.
Spain	For an electric car bought in Spain €6,000 or 15% of the price of the vehicle will be returned to the customer.
Norway	Electric cars exempt from car registration tax. For a B class car the registration tax is around €7,500. VAT (25%) does not apply to electric cars.
Denmark	Electric cars do not pay registration tax.
Sweden	Low or zero carbon emission vehicles get a subsidy of 10,000 SEK, after owning the vehicle for 6 months. The Government has allocated SEK 250m for the rebate (50m in 207, 100m in 2008 and 100m in 2009).[40]
Ireland	Hybrid and flexible fuel vehicles are allowed a maximum remission of €2,500 on cars registered between 1st July 2008 and 31st December 2010. EVs are exempt from vehicle registration tax until December 31st 2015.
Netherlands	Electric cars in the Netherlands are exempted from car registration tax.
Switzerland	Individual cantons (sub-divisions of the country) provide their own EV incentives.
Greece	No road tax or car registration fees for electric cars.

EVI MEMBERS	FINANCIAL	INFRASTRUCTURE	RD&D
China	Purchase subsidies for vehicles of up to RMB 60,000.	—	RMB 6.95 billion for demonstration projects.
Denmark	Exemption from registration and road taxes.	DKK 70 million for development of charging infrastructure.	Focus on integrating EVs into the smart grid.
Finland	EUR 5 million reserved for vehicles participating in national EV development programme, ending in 2013.	EUR 5 million reserved for infrastructure as part of the national EV development programme, ending in 2013.	—
France	EUR 450 million in rebates given to consumers buying efficient vehicles, with 90% of that amount from fees on inefficient vehicles. Remaining 10% (EUR 45M) is a direct subsidy.	EUR 50 million to cover 50% of EVSE cost (equipment and installation).	EUR 140 million budget with focus on vehicle RD&D.
Germany	Exemption from road taxes.	Four regions nominated as showcase regions for BEVs and PHEVs.	Financial support granted for R&D for electric drivetrains, creation and optimisation of value chain, information and communications technology (ICT), and battery research.
India	INR 100,000 or 20% of cost of vehicle, whichever is less. Reduced excise duties on BEV/PHEVs.	The National Mission for Electric Mobility will facilitate installation of charging infrastructure.	Building R&D capability through joint efforts across government, industry, and academia. Focus on battery cells and management systems.
Italy	EUR 1.5 million for consumer incentives, ending in 2014.	—	—
Japan	Support to pay for 1/2 of the price gap between EV and corresponding ICE vehicles, up to YEN 1 million per vehicle.	Support to pay for 1/2 of the price of EVSE (up to YEN 1.5 million per charger).	Major focus on infrastructure RD&D.
Netherlands	Tax reduction on vehicles amounting to 10-12% net of the investment.	400 charging points supported through incentives.	Focus on battery RD&D (30% of 2012 spending).
Spain	Incentives up to 25% of vehicle purchase price before taxes, up to EUR 6,000. Additional incentives of up to EUR 2,000 per EV/PHEV also possible.	Public incentives for a pilot demonstration project. Incentives for charging infrastructure in collaboration between the national government and regional administrations.	Five major RD&D programmes are operational with incentives for specific projects.
Sweden	EUR 4,500 for vehicles with emissions of less than 50 grams of CO_2/km. EUR 20 million for 2012-2014 super car rebate.	No general support for charging points besides RD&D funding (EUR 1 million in 2012).	EUR 2.5 million for battery RD&D.
United Kingdom	—	GBP 37 million for thousands of charging points for residential, street, railway, and public sector locations. Available until 2015.	The UK Technology Strategy Board has identified 60 collaborative R&D projects for low-carbon vehicles.
United States	Up to USD 7,500 tax credit for vehicles, based on battery capacity. Phased out after 200,000 vehicles from qualified manufacturers.	A tax credit of 30% of the cost, not to exceed USD 30,000, for commercial EVSE installation; a tax credit of up to USD 1,000 for consumers who purchase qualified residential EVSE. USD 360 million for infrastructure	2012 budget of USD 268 million for battery, fuel cell, vehicle systems and infrastructure R&D.

Country	Other Incentives
Norway	Electric cars are not subject to the annual car tax of €345. EVs do not have to pay road tolls in Oslo. EVs qualify for free parking which can provide annual savings of around €2,000-€4,000. EVs are permitted to use bus lanes.
Denmark	Electric cars are exempt from annual car tax and qualify for free parking. It is thought that further incentives will be put in place to encourage the use of EVs to coincide with the introduction of Project Better Place in 2011.
Germany	Germany is currently considering inner circle parking and congestion charge incentives for EVs similar to those in London.
France	Free parking spaces for EVs (equipped with charging apparatus) are also being reviewed.
Greece	Electric cars are also free to drive in Athens when parts of it are restricted to other vehicles to reduce traffic congestion. There is also free charging on the street of some cities.
Italy	Certain cities in Italy have restricted driving within the city to EVs only. Some cities also allow free parking and charging for EVs.
Israel	The Israeli government is providing tax incentives to help Project Better Place achieve its goals. A 72% sales tax on gasoline-powered vehicles has been instituted, while electric cars are only taxed at 10%[41].

Appendix 2: Charging Stations Development (The development of e-mobility in global markets IAA 2013; Frankfurt, 2013)

CATEGORIE	UK	France	Norway	Italy
Number of charging stations 2012	> 3.000 > Thereof London: 1.300	> 1.250 > Thereof Paris: 1.000	> 3.700 > Thereof Oslo: 1.500	> 550 > Thereof Rom: 60
Dominant technology	> "Slow charging" > ~60 fast charg-ing stations[1)]	> "Slow charging" > ~10 fast char-ging stations[1)]	> "Slow charging" > ~70 fast char-ging stations[1)]	> "Slow charging" > ~5 fast charging stations[1)]
Financial assistance	> EUR 10 m	> EUR 1.5 bn	> EUR 9 m	> Requests bet-ween EUR 0.6-6.2 m
Operator	> Commercial operators	> Coop. OEMs/ industry/gov.	> Utilities	> Mostly utilities
Evaluation	> Fast network build-up, mostly by private operators	> Government as most relevant sponsor (pressure by local OEMs)	> Example for other markets	> Few sponsors, small steps forward

Appendix 3: Collaborations for electric urban mobility (TRANSPORT Action Plan Urban Electric Mobility Initiative; Climate Summit 2014)

Company	Products/Activities
BYD Company Limited	BYD specializes in IT, automobile and new energy. BYD is the largest supplier of rechargeable batteries in the globe and has the largest market share for Nickel-cadmium batteries, handset Li-ion batteries, cell-phone chargers and keypads worldwide. BYD has developed green products such as solar farm, battery energy storage station and an electric vehicle. The BYD E6 electric car has a driving range of 300 kilometres, far exceeding the driving range of most electric vehicles in the world which is around 160 kilometres.
Chery Automobile	The top selling pure electric car in China for 2012 was the Chery QQ3 with 5,305 units sold. As of October 2013, the QQ3 EV continued as the top selling plug-in car, with 4,207 units sold between January and October 2013. Accounting for new energy vehicle sales between 2011 and 2013, a total of 38,592 units were sold during these 3 years, of which 81.8% (31,558 units) were pure electric vehicles.
Beijing New Energy Vehicle Company	A subsidiary of the Beijing Automotive Industry Holding Corporation. Beijing New Energy Vehicle Company has plans to manufacture 150,000 EVs by 2015.
Beijing Pride Power System Technology Company	Another subsidiary of the Beijing Automotive Industry Holding Corporation. The company manufactures battery power systems. Along with other Chinese companies they are boosted by the fact that the country has been pursuing an ambitious EV pilot program that will be supported by about US$ 15 million in government investments.
General Motors	The number one selling EV in the US. Sales of the 2011 Chevrolet Volt near the end of 2010. As of mid-January 2014, the Volt has global sales of about 70,000 units. The U.S. is the leading market with sales of over 54,500 Chevrolet Volts.
Nissan-Renault Alliance	The Nissan Leaf is is the world's first mass-produced 100% electric vehicle and the world's best-selling EV. Since Nissan Leaf first went on sale in December 2010, about 70,000 units have been sold globally as of the end of June 2013. The company's second all- electric vehicle, the e-NV200 will be introduced by the city of Barcelona as a pure electric taxi. The company believes that other municipalities will be keen to replicate this example. Renault SA which is France's second-largest automaker owns 43% of Nissan, has sold about 40,000 of its line of four EVs since 2011, led by the Zoe five-door mini and the Kangoo van.
Mahindra Reva	Sold about 4,600 vehicles worldwide by late 2013, and India was its main market, accounting for 55% of global sales. The UK was one of the

	leading markets, and the REVA G-Wiz (as it was marketed in the country) was the top selling electric car in Britain for several years. The company targets to sell 30,000 battery-run cars a year by 2015-16. The firm will start with rolling out 6,000 cars a year from its newly commissioned plant near Bangalore. With exports contributing a major share, Mahindra-Reva expects to achieve full capacity realization of 30,000 cars annually by 2015-2016.
Tesla	Tesla sold 20,600 units of the Tesla Model S EV. Tesla is continuing to expand production and is now producing 550 cars per week. The company has recently began selling its cars in China and plan to start manufacturing the cars within mainland China. The company also plans to build the world's largest battery factory in the US and to open 30 new service centers and stores in Europe.
BMW	The BMW i3 boasts a range of up to 160 kilometres (100 miles) thanks to the high-voltage lithium ion battery. A newer version the BMW i3 Range Extender adds to the achievable range. BMW have entered agreements with governments and municipal authorities which include rebates for buyers and exemption from fees/taxes such as London's congestion charge.
Siemens	In the field of e-mobility, the company manufactures charging infrastructure and systems and are also providing innovative solutions for electricity based road freight traffic systems. Siemens has recently developed a cost-effective alternative to the use of fossil fuels in freight transport on the road via the electrification of freight traffic with eHighway. eHighway represents as an efficient and resource-saving alternative to reduce environmental damage.
Doppelmayr Cable Car GmbH & CO	Doppelmayr is a leading company providing aerial ropeway solutions. Operated solely by electric power, aerial ropeways are emerging as an urban mobility solution in many cities particularly when integrated into larger public transport networks.
Jiangsu Aima Manufacturing & Technology Co., Ltd.	China's largest manufacture of e-bikes, e-scooters and e-bicycles.
DHL	Leading Freight and Logistics Company. As a part of the group's climate protection program *GoGreen*, Worldwide DHL operates over 300 electric vehicles, more than 300 hybrids and almost 2,500 on bio fuel, gas, ethanol or dual fuel. A Recent project is implemented in Bonn/Germany: as the first in the industry, Deutsche Post DHL has set itself a CO2-efficiency target that aims to improve its companywide CO2-efficiency by 30 percent by 2020 on the basis of 2007. The company also invests in its network optimization, operations, and a sustainable use of energy in its buildings and business operations.
UPS	Leading Freight and Logistics company. The company has over 100 EVs operating in the USA.