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Renewable Energy in Central and Eastern Europe

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Who supports the electric car? Analysis and comparison of case studies and support schemes in selected countries

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

supervised by
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5th December 2011, Vienna

Affidavit

I, **Gernot Prettenthaler** hereby declare

1. that I am the sole author of the present Master Thesis, "Who supports the electric car? Analysis and comparison of case studies and support schemes in selected countries“,
   91 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

Electric mobility is a very current and fashionable topic at the moment and the hype among all players in the automotive and energy sector, among scientists and activists and in particular among politicians. But which approach is the best for the implementation of electric mobility for a country and which country can serve as a role model for all the others? This thesis attempts to solve these two questions with the help of sound research of available literature. The strategy concerning electric mobility of selected countries is analysed as well as the tools which are used to support the implementation. A comparison of the different strategies shall show how effective the tools are and identify the most successful country in implementing electric mobility. The results indicate that an overall ranking of the countries is rather premature, as all country have only recently started their programs and the projects are more or less up and running for a short period of time. The comparison also shows that none of the countries have neither the perfect solution nor standing too far behind the others. The tools are very similar and even the number of electric vehicles registered are similar compared to the overall number of newly registered vehicles of each country.

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1 Introduction

After 100 years of development of combustion engines a significant change in technology is fuelled by the threats of climate change caused by enormous CO_2 emissions due to increasing number of vehicles, the ongoing debate about the oil peak and simply as a new hype for the devastated economies in the Western world after the world economic crisis in the year 2008. The electrification of the power train is supposed to be the symbol of future mobility. Although the existing power trains running on fossil fuels will further keep their important position, the first important steps towards an innovative future and for a sound transition into new technologies in mobility have to be taken right now.

1.1 Motivation

Electric mobility is a highly interesting topic, because it can be interpreted at the moment in two very controversial ways: On the one hand it is supposed to solve the CO_2 problem, and ensure the individual mobility people are used to but it also opens the way for an intermodal split of transport and an enforcement of public transport. On the other hand the purchase prices of electric vehicles (EVs) are generally twice as high compared to those of ordinary internal combustion engine vehicles, yet the range is limited to 140 kilometres and the big question is how and where to charge the vehicle, if you are living in the 3rd floor of an apartment area without garage. Between these two general opinions of people lies the reality of electric mobility. The task is to attract customers for a car which is almost twice as expensive as a comparable car of the same size, which has a fewer range, a need for a charging infrastructure and no security concerning reselling and lifetime of the batteries.

1.2 Core objective / the core question

The different approaches of six countries, namely Austria, Germany, Portugal, Denmark, China and the United States of America, are analyzed concerning the implementation of electric vehicles in each country. Also, the different degree of involvement of each country is going to be analyzed. The strategies of the six analyzed countries are screened concerning the projects, the number of vehicles on the road and the status in the charging infrastructure. In the last part of this master thesis a comparison of the different approaches is made on order to evaluate the existing outputs and perhaps find an answer to the question: Which approach is the most promising for the implementation of electric mobility and which of the countries is the most advanced in the field of electric mobility concerning number of vehicles on the road, operation of the overall system or mobility provider and the number of charging points installed?

1.3 Main literature

The main literature is based on political programs, strategy papers and project descriptions submitted by the government or other authorities, project companies, and companies in the automotive or energy sector of each of the six countries. Comments, newspaper articles and reports of journalists and interested groups are also a fundamental backbone of this thesis.

1.4 Structure of work

This master thesis is principally divided into three major parts:

- The first part describes the historic development of the electric vehicle, the reasons of its failure in the past, the circumstances of its return and political strategies on a supranational level. These topics are mainly based on literature research.
- The second part is the detailed description of the strategies of the six countries and is based on literature as well. The strategy of each country is analyzed concerning the overall strategic approach towards electric mobility, the R&D projects for electric mobility, the show cases for an implementation of electric mobility and, if existing, other activities of the government e.g. public relations.
- The third part combines the findings of the 2nd part, analyzes the differences and similarities and tries to identify the best approach towards electric mobility.

2 Historic Development of the Electric Vehicle

2.1 Period from 1881 until 1940

Vehicles powered with energy are not a novelty of the last 20 years but have been part of the automotive history and even held a dominate position at the early days of cars. The first official electric car was invented by Mr. Gustave Trouvé in 1881. It was a vehicle with three wheels and a maximum speed of 12 km/h.[1] ‘Even though the electric vehicles were even prior to the invention of the first cars with combustion engines by Mr. Gottlieb Daimler in 1886.[2] Despite the existence of fossil fuels cars it was an electric vehicle called “La Jamais Contente” (Figure 1), which broke the barrier of 100 km/h for the first time on 29th of April 1899.[3]

Figure 1: La Jamais Contente[4]

Around the turn of the 19th to the 20th century the statistics of vehicles in the United States were dominated by steam engines with 40%, followed by electric engines with 38% and gasoline vehicles were the clear minority with only 22% of all registered vehicles.[5] Another technical highlight was the “Lohner Porsche” constructed by Ferdinand Porsche which was presented at the world exhibition in Paris in the year 1899. The car had two electric engines

[1] www.buch-der-synergie.de (translated)
[2] www.elektroauto-tipp.de (translated)
[3] www.buch-der-synergie.de (translated)
[4] www.buch-der-synergie.de (translated)
[5] www.elektroauto-tipp.de (translated)

in the hubs of the two front wheels and a maximum speed of 58 km/h and a driving range of 50 kilometres with the help of a lead accumulator with 80V.[6]

Figure 2: Lohner Porsche[7]

Since 1905 the famous model "Victoria" was manufactured at the Siemens-Schuckert factories in Germany and was at that time announced as the first electric vehicle of the world. The vehicle was first introduced in Berlin and used with its maximum speed of 30 km/h as a taxi for hotels and as a transporting vehicle.[8]

Figure 3: Siemens Victoria[9]

In the United States the popular model "Detroit" started its production in 1907 by the Anderson Carriage company. The car was rated at 80 miles per charge and was continuously produced by different production companies until 1938 which makes the "Detroit" the EV with the longest period of production so far. [10]

6 www.buch-der-synergie.de (translated)
7 www.buch-der-synergie.de (translated)
8 www.siemens.com (translated)
9 www.siemens.com (translated)
10 www.detroitelectric.org

Figure 4: Electric Detroit[11]

2.2 The 1990ies

In the 1990ies the electric vehicles gained increased attention again due to the debate on reduction of CO_2 emissions. For example, in Southern California 80% of the CO_2 emissions were caused by traffic which was suspected to be responsible for25% of the young population between 15 and 25 years suffering from asthma and in the year 1990 41 smog alarms were triggered in the Southern Californian region only.[12]

Inspired by General Motors' (GM) announcement of an electric car prototype the California Air Resources Board (CARB) identified the car exhaust as its biggest opponent and introduced the Zero Emissions Mandate in the year 1996 with the target of 2% of the new cars sold in 1998 having to be zero emission vehicles (ZEV), 5% in 2001 and 10% in 2003.[13] Within one year 9 other states followed the example of California and introduced the same commitment.[14]

In the year 1996 the EV-1 by GM was introduced to the American market and quickly found many customers, especially in California due to the above mentioned restrictions. The EV-1 had an engine power of 102 kW and a range of up to 150 kilometres. As its development costs were significantly high, the vehicles were only available on a 3-years leasing basis with costs of 400 up to 500 USD per month. Three years afterwards, in 1999, the cars were recalled by GM with the official reason that demand was low and the product no longer

[11] www.detroitelectric.org
[12] Paine, C. (2006): Who killed the electric car? (sequence in the movie)
[13] www.whokilledtheelectriccarmovie.com
[14] Fraunhofer IAO & PWC: Elektromobilität (2010), p.13 (translated)

profitable. The withdrawal caused a lot of negative feedback from satisfied clients who could not understand why GM simply forced the clients to return the vehicles. Rumours emerged that even the promotion of the vehicles was done in a way not to attract too many clients. All these happenings were described in the documentary “Who killed the electric car?” in 2006.[15]

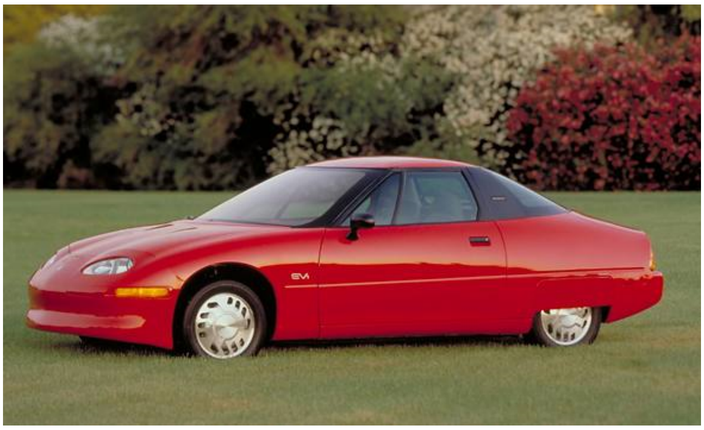

Figure 5: GM EV-1[16]

In Europe the main activities in the field of EVs were launched in France, Germany and Switzerland. On the German island Rügen 60 EVs from different brands were tested between 1992 and 1996.[17] All relevant German car producers like Volkswagen, Mercedes, Opel and BMW took part in the project and vehicles such as the Mercedes 190, the VW Caravelle, the BMW 3 or the Opel Astra were equipped with different accumulators and electric engines and all together around 1.3 millions of kilometres were driven. The daily ranges of the vehicles varied from 80 up to 150 kilometres and in combination with a “fast charging of around 30 minutes” some test vehicles made up to 300 kilometres per day. [18]

In Mendrisio (Switzerland), around 400 different EVs were tested between 1994 and 2001. The project was carried out by the Swiss company named Protoscar and supported by the municipality and co-financed by the Swiss government. Main target customers were private clients and the whole project was supervised with statistic research in user behaviour.[19]

The development of the EVs in the 1990ies was definitely led by the automotive industry in the United States of America, in Europe and to a smaller extent in Japan. China was not part

[15] www.whokilledtheelectriccarmovie.com
[16] www.focus.de (translated)
[17] Fraunhofer IAO & PWC: Elektromobilität (2010), p.13 (translated)
[18] www.spiegel.de (translated)
[19] Protoscar (2009): Mendrisio project, lessons learned and experience with private users, presentation at Klima Fonds conference 2009 (translated)

of the automotive sector at that time and for this reason there were also no initiatives in electric mobility.

2.3 Reasons for failure of the electric vehicles

In the early days of the 20th century the electric vehicle lost its dominant position due to three developments: [20]

- *Low Fuel Prices*: Oil was very cheap at that time and prices even declined as further oil sources were found in the United States

- *Technological and Economical Fallback behind Combustion Engine*: Henry Ford started his business in 1903 and from the very beginning he focused on the production of combustion engines which experienced several technological leaps at that time. Mr. Ford also invented the assembly line production which gave him the possibilities of economies of scale in his production. The Ford cars had a price range between 500 and 1,000 USD while the EVs had an average price of almost 2,000 USD.

- *Missing Infrastructure and Standards*: Despite the fact that the first petrol station was established not before 1913, the petrol station network still grew faster than the grid network for energy as there were no standards in energy production due to the famous fight between Edison and Tesla about alternating current (AC) and direct current (DC).

In the 1990ies the following reasons were identified for the failure of the EVs:

- *Lobbying and altered political focus*: Shortly after the introduction of the ZEV (zero emission vehicles) commitment the American Automobile Manufacturing Association started with campaigns against the political decision and achieved a more flexible target value for the year 1998. After further lobbying activities over the following years the commitment was further diluted by alternative measures such as a fuel cell programme introduced by U.S. president George W. Bush. In parallel, also the GM strategy was completely changed: After the purchase of Hummer, the automotive

[20] www.buch-der-synergie.de (translated)

group started to invest into fuel demanding SUVs and despite heavy protests of customers pulled the EV-1 out of the market.[21]

- *Bad eco-balance due to energy mix:* Although more than 60 million of German Mark was invested of the automotive sector was not very happy with the bad eco-balance related to the German energy mix, which was dominated by energy from coal-fired power plants. The well-to-wheel calculations showed even worse results for the EVs compared to fuel saving petrol and diesel vehicles. The project was stopped and the results were safely stored with the argument that both the technique and the clients were not yet prepared for electric vehicles.[22]

The stated reasons for failure for the past waves of introduction of electric vehicles are anything but outdated and are still significant for all present initiatives. They clearly show that mid-term strategy of implementation combined with an increase of regenerative energy production and a stable political support scheme are the most important preconditions.

[21] www.whokilledtheelectriccarmovie.com
[22] www.spiegel.de (translated)

3 Reasons for the Renaissance of the Electric Vehicle

The return of the idea of electrification of the power train of vehicles has three reasons: First and most important of all there are significant threats due to vehicles with combustion engines, the major among them is the increasing CO_2 emissions and the upcoming consequences for our climate. This leads us to alternative scenarios of our daily mobility, which allows us to keep up our standard of coming quite easy from point A to point B. And last but not least, the politicians also realized that an urgent change in our personal transportation modes has to be made.

3.1 Three obstacles for combustion engines

Regarding electric mobility three key indicators can be identified which will be the catalyst for future forms of mobility. The three key indicators are the increasing CO_2 emissions in the transport sector, the ultimate dependence of the transport sector on limited oil reserves and the increasing demand for mobility worldwide.

3.1.1 Increasing CO_2 emissions caused by transport

Air pollution and climate change have already been key arguments for the implementation of EVs in California in the early 1990ies. While the arguments were maybe too weak at that time, they gained political importance due to the Kyoto Protocol and, unfortunately, topical significance due to recent climate change catastrophes. Beyond all other emissions CO_2 from fossil fuel is the biggest problem we are facing. The splitting of the CO_2 emissions world wide on the different fuels is shown in Figure 6.

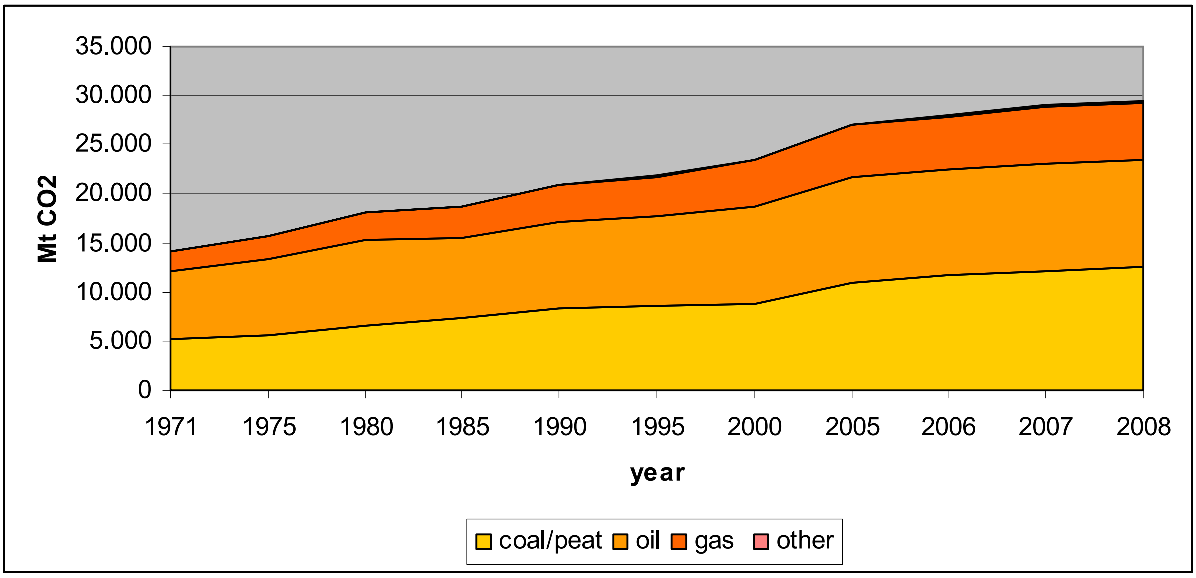

Figure 6: World total CO_2 emissions by fuels from 1971 until 2008[23]

In 2008 43% of the CO_2 emissions were caused by coil and peat and 37% by oil. The trend in the years from 2005 to 2008 show that the emissions coming from oil stay constant, while the emissions coming from coal and peat were slightly rising with 3% over the three years. Reason for this increase is the growing demand for energy especially in the developing countries China and India, with huge coal reserves.[24]

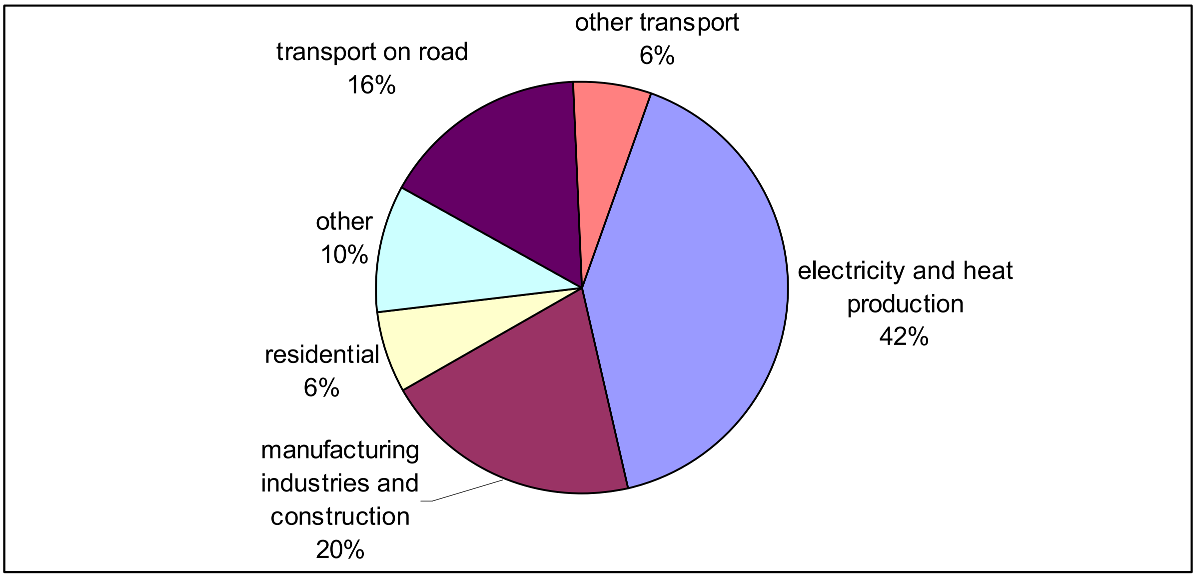

Figure 7: World total CO_2 emissions by sectors in 2008[25]

Regarding the sectors in Figure 7, three sectors are sharing 64% of the total amount of CO_2 emissions, namely electricity and heat production and transport on the road and other

[23] IEA Statistics (2010): CO_2 emissions from fuel combustion, p.44 following
[24] IEA Statistics (2010): CO_2 emissions from fuel combustion, p.8
[25] IEA Statistics (2010): CO_2 emissions from fuel combustion, p.9

transport. The energy sector worldwide depends largely on coal, which is the most carbon-intensive fossil fuel. Countries like Australia, China, India, Poland or South Africa have a share of coal of 69% up to 94% in their energy production mix. This is of course a huge problem but compared to the energy sector which has at least alternative sources like renewable energy or nuclear power the transport sector, in particular transportation on the road, is heavily dependent on one type of fuel, namely oil.[26]

3.1.2 Depending on limited oil reserves

Despite a slight drop of its share from 33% in 2008 down to 28% in 2010 due to governmental measures to promote fuel efficiency, oil remains the dominant fuel in the primary energy mix and according to the IEA reference scenario; oil will keep its major share even for the year 2030.[27]

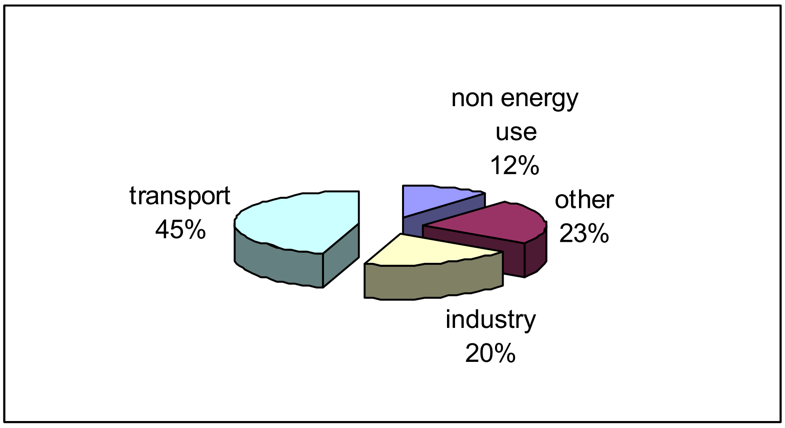

Figure 8: Sector share of world oil consumption in 1973[28]

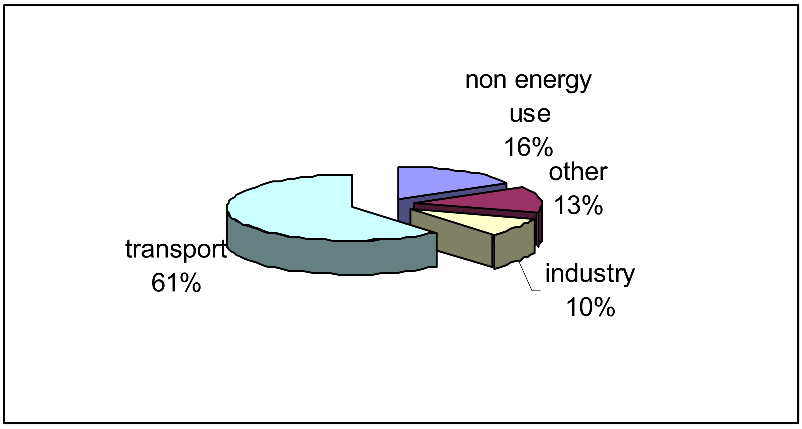

Figure 9: Sector share of world oil consumption in 2008[29]

[26] IEA Statistics (2010): CO_2 emissions from fuel combustion, p.8 following
[27] IEA World Energy Outlook 2010 (2010): Executive Summary, p.5
[28] IEA: Key World Energy Statistics 2010 (2010), p.33
[29] IEA: Key World Energy Statistics 2010 (2010), p.33

As Figures 8 and 9 clearly show the transportation sector is highly depending on oil and its dependency is growing from 45% in 1973 to 61% in 2008. What is even worse in this context is that the total consumption also increased from 2,250 Million tonnes of oil equivalent (Mtoe) in 1973 to 3,502 Mtoe in 2008.[30]

Looking at the regions where the crude oil is produced the obvious number one area is the Middle East region with a share of 30%, followed by the OECD countries with a share of 22.3% and the Former Soviet Union with 16.7% share in the year 2009. The biggest countries of production are the Russian Federation, followed by Saudi Arabia and the United States of America which have together a total share of 33% of the overall production. The biggest oil exporting country is by far Saudi Arabia and the biggest importers by far are the United States of America.[31]

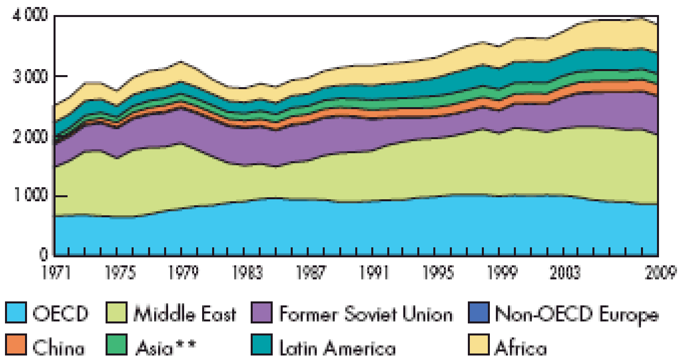

Figure 10: Production of crude oil in Million tonnes (Mt) by region between 1971 and 2009[32]

The dominating position of the fuel oil combined with the fact that major oil sources are concentrated in the Middle East region, which used to be very vulnerable to political crises in the past decades had a major influence on the pricing of the oil. Basically, the oil price is regulated by the forces of free markets, but it is strongly influenced by the Organization of the Petroleum Exporting Countries, which is a syndicate of countries worldwide, which together control 80% of all known crude oil reserves in 2009.

The crude oil price development is a complex combination of world demand (depending on the world economies) and the production and supply mainly dominated by the OPEC countries. A high crude oil price slows down economic growth on the one hand, but a low oil price is decreasing the earnings of the oil exporting countries.

[30] IEA: Key World Energy Statistics 2010 (2010), p.33
[31] IEA: Key World Energy Statistics 2010 (2010), p.10 following
[32] IEA: Key World Energy Statistics 2010 (2010), p.10

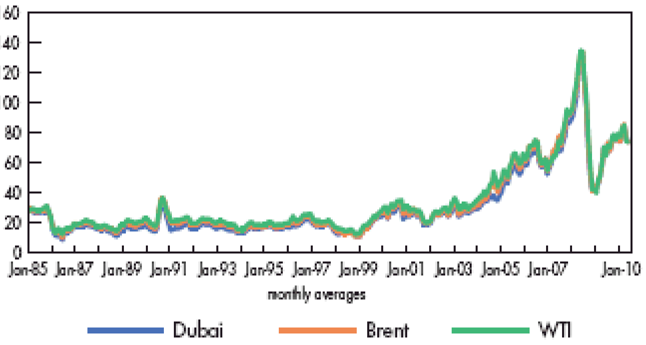

Figure 11: Key crude oil spot prices in USD/barrel[33]

According to the International Energy Agency (IEA) the oil price will steadily increase to the level of USD 113 per barrel in 2035 due to the high oil demand reaching about 99 million barrels per day (mb/d), which is 15 mb/d higher than in 2009. Half of the net growth is coming from China alone, mainly driven by rising use of transport fuels. Almost two thirds of this additional demand per day is satisfied with unconventional oil production, which means output will rise from 2.3 mb/d in 2009 up to 9.5 mb/d in 2035. The unconventional oil production mainly consists of Canadian oil sands and Venezuelan extra-heavy oil and emits between 5% and 15% higher CO_2 emissions on a well-to-wheels basis compared to conventional crude oils. The current simulations of the IEA show a scenario with very high oil prices but do not consider peak oil production but already a slightly decreasing demand for oil due to efficiency policies of several governments.[34]

Of course an increasing oil price also affects the electricity price to a certain extent but the main fossil fuels in the generation of electricity are coal and natural gas with a share in total generation of 68% in 2008 and a projected share of 55% in 2035, as renewable energies will expand over the period.

3.1.3 Increasing Demand for Mobility

As already stated, transport is a key trigger for reducing the greenhouse gases in particular CO_2 emissions. In the year 2008 22% of the CO_2 emissions are caused by transport, meaning road, rail, air and sea.[35] The future development of transport is mainly defined by two major indicators: growth of the world population and development of the GDP, as growing economies have increased demand for transportation of people and goods.

[33] IEA: Key World Energy Statistics 2010 (2010), p.40
[34] IEA World Energy Outlook 2010 (2010): Executive Summary, p.6 and 7
[35] Greenpeace (2008): Energy [r]evolution, p.161

According to the U.S. Energy Information Administration the total world population will rise from 6.6 billions in the year 2007 up to 8.5 billions in the year 2035. The world's largest population will be China together with India and the African continent. The strong tendencies of increasing population in the Asian region and decreasing population in the Western OECD regions will continue.[36]

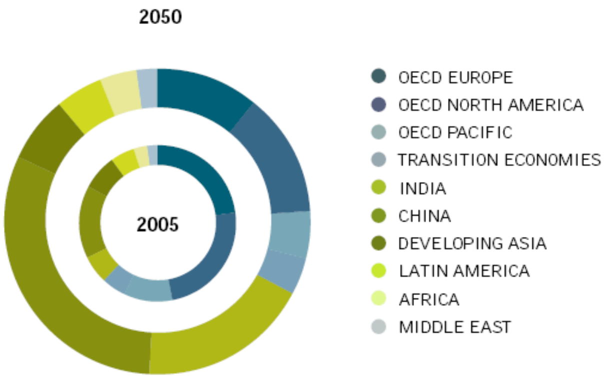

Figure 12: Development of world GDP by region[37]

While the OECD countries together hold almost 2/3 of the world GDP in 2005, the change in world population will also switch the majority of GDP to the Asian region including China and India, which will then have almost a share of 2/3.

Despite the trends in population and GDP, the final energy use per region will continue to be dominated by the OECD countries and the developing Asian countries, China and India, will increase their share but still will not have a significant participation in the transport final energy use in 2050 as it is shown in Figure 13. The possible explanation could be found in Figure 14, as the major part of final energy is used in light duty vehicles and heavy trucks and this transport mode will keep its dominant position until the year 2050. Both transport modes are used, to an extremely high extend, in the Western OECD countries e.g. the United States of America have the highest level of passenger travel per capita in the world (more than 25,000 km per person per year).[38] With respect to this fact it is clear that the automotive sector is still looking forward into a prospering future as the analysis of PricewaterhouseCoopers (PWC) shows in Figure 15.

[36] U.S. Energy Information Administration: International Energy Outlook, p. 145
[37] Greenpeace: Energy [r]evolution, p.161
[38] IEA: Key World Energy Statistics 2010, p.10

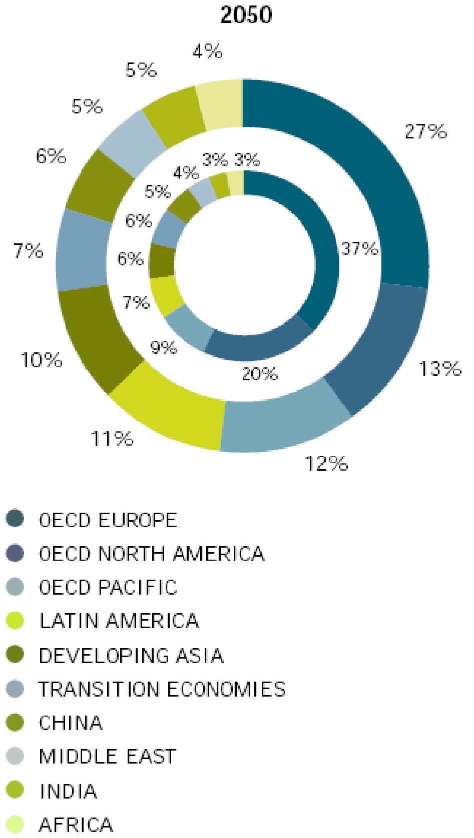

Figure 13: World transport final energy use per region 2005/2050[39]

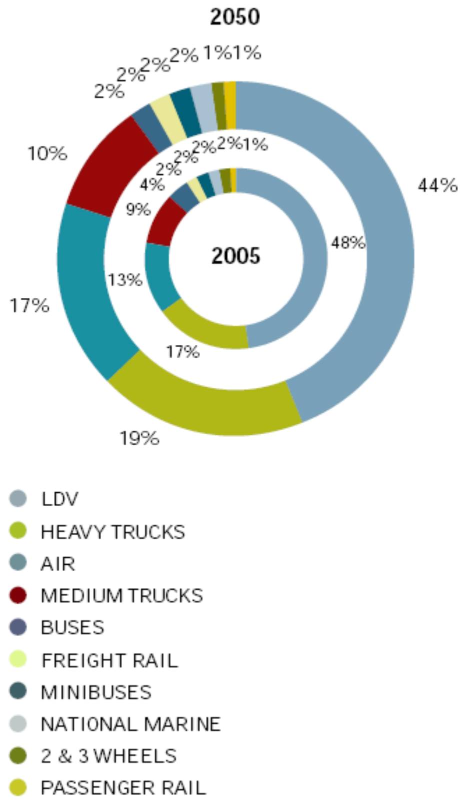

Figure 14: World final energy use per transport mode 2005/2050[40]

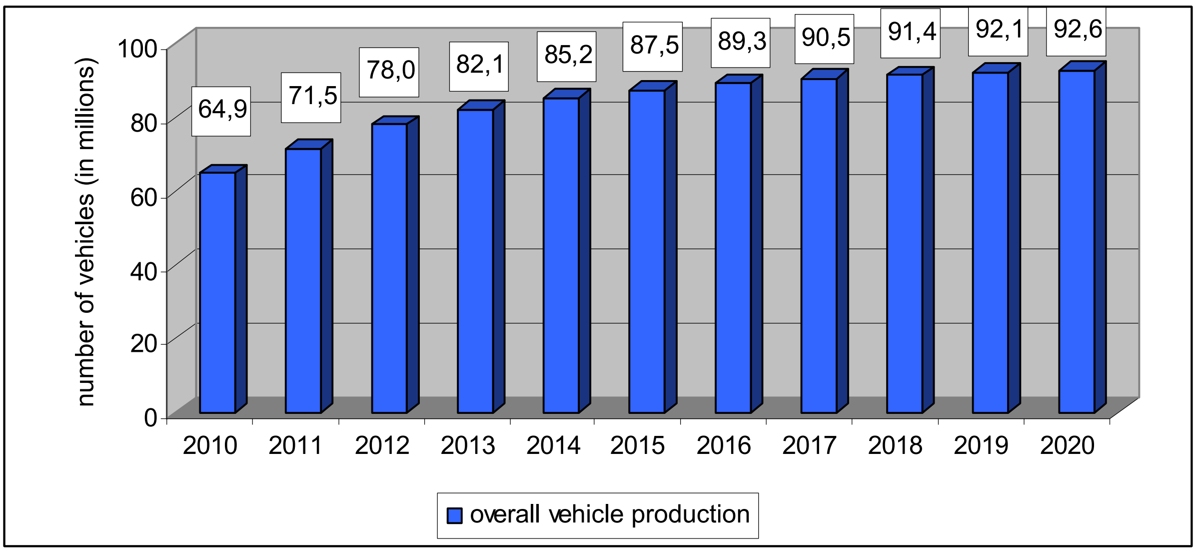

Figure 15: Production forecast for vehicles[41]

[39] Greenpeace: Energy [r]evolution, p.161
[40] Greenpeace: Energy [r]evolution, p.162
[41] PwC (2010): PwC Autofacts 2010, 2nd quarter

3.2 Innovative Alternatives

In the view of these threats the need for change is without question. A lot of different concepts and technologies are waiting to show their practical relevance.

3.2.1 Alternative Fuels and Power trains

To achieve a significant reduction of emissions, several fuel alternatives are entering the market. They can be differentiated by the fuel which they are running on and they reach from biodiesel, biogas and bio- methanol to compressed natural gas (CNG) or liquefied natural gas (LNG) vehicles to hybridisation of the vehicles including the battery electric vehicles (BEV) and fuel cell electric vehicles (FCEV).

According to analysts of the automotive sector, hybrids will have annual growth rates up to 20% and in the year 2015 11% of all new vehicles will be hybrids. The main field of usage will be the city centres and their suburbs. Hybrid technology is universal in its combinations and very similar to the fuel cell and electric vehicles technologies, so it is the starting point for the development of future electric vehicles (EV) for the automotive industries. Hybrids can be separated into full hybrids and micro hybrids which are both "ordinary" hybrids on the one hand and plug-in-hybrids on the other hand. [42] Full hybrids have the disadvantage of additional weight due to a 2nd engine and micro hybrids are working with start stop automatics and regenerative brakes. Plug-in-hybrids e.g. Toyota Plug-in-Prius or range extender hybrids e.g. Chevrolet Volt combine compulsion engines with small batteries and provide an extended range of the vehicle.[43]

[42] Oliver Wyman (2007): Automotive car innovation 2015, p.13 (translated)
[43] Bain & Company (2010): There is no alternative to electric vehicles, p. 13

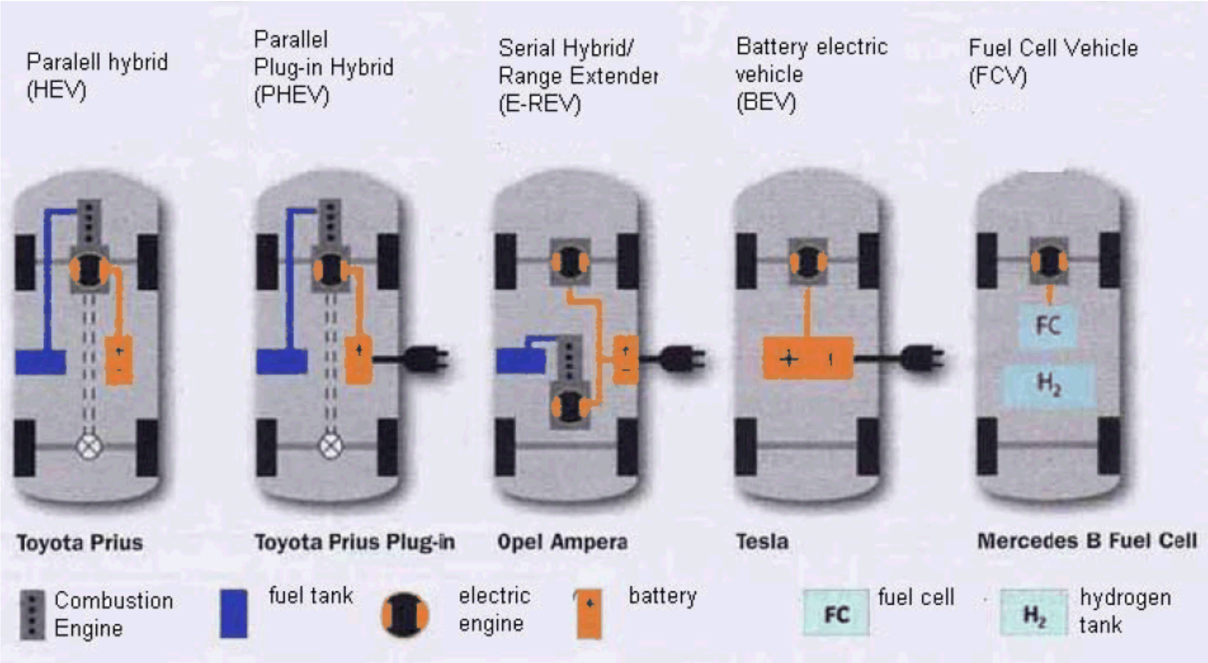

Figure 16: The different concepts from hybrid to electric and fuel cell vehicle[44]

All the described techniques have one thing in common. Their tank to wheel energy consumption is very competitive to the conventional combustion engine cars. Figure 17 shows that the hybridisation and electric vehicles are more efficient in their energy consumption than vehicles with internal combustion engines (ICE). The size of the vehicle starting from small (city cars with 2 seats e.g. Smart for 2 and city cars e.g. Peugeot 106) over medium (small family cars e.g. VW Golf and family cars e.g. BMW 3-series) to large (executive cars e.g. Audi Audi A6 and luxury cars e.g. Mercedes S class) is not affecting this trend.

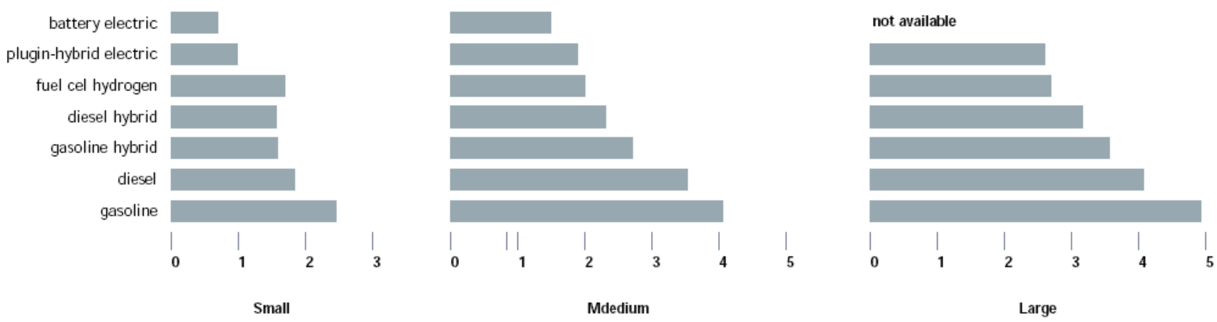

Figure 17: Energy consumption of reference target vehicles (Greenpeace reference scenario for 2050) for three size segments in litres of gasoline equivalent per 100 kilometres.[45]

[44] Dudenhöffer, F.: Electric mobility – a market for tomorrow, in: persönlich 5/2011, p. 20-23 translated
[45] Greenpeace: Energy [r]evolution, p.177

Even though the battery electric vehicles (BEV) are the “winner” of the comparison in Figure 17, the BEV comprises advantages and disadvantages as shown in Table 1.

advantages	disadvantages
• Lower pollution especially in cities due to emission-free driving if the energy is coming from renewable energy sources	• Higher purchase price compared to ICE vehicles due to smaller production capacities, high development expenses in battery technologies
• Lower driving noises and less vibration due to electric engine and the reduction of moving parts within the vehicle will create a more user friendly way of driving	• Lower ranges of the BEV due to the physical energy density in the batteries, e.g. about 130 kilometres maximum range with a Citroen C-Zero
• Lower dependency on fossil fuels, which could only be necessary in energy production	• The charging infrastructure for electric vehicles is still not fully developed and cannot be compared to the petrol stations network for ICE vehicles
• Electric mobility increases the intermodal mobility and supports public transport	• Need for additional energy sources could lead to increased use of nuclear power or energy from fossil fuels
• BEVs could serve as energy storages which can help to provide energy at peak times or which can store energy at times where renewable sources produce energy more energy than demanded (e.g. during night)	• Standardization of plugs and chargers is missing, which means different charging plugs and chargers coming from different automotive manufacturers

Table 1: Advantages and disadvantages of electric vehicles[46]

3.2.2 Alternative Driving Concepts

The threats of increasing CO_2 emissions and the increasing expenses for fossil fuels have created business models for people who do not want to own cars any more and instead try to use rental vehicles without any obligation of ownership or monthly payment. Car Sharing and public transportation are often mentioned in combination with electric vehicles and all three together are often described as intermodal operability. The customer does not own his or her car anymore but uses the different services of public transportation, bike rental, car rental or car sharing.

[46] Blanchet, M. (2011): Reinventing mobility, editorial in challenges magazine published on the 27th of January 2011

A modified version of car sharing is the car2go concept of Daimler, which is used in the German City of Ulm and in Austin, the capital of Texas. Compared to the car sharing systems in use, the car2go concept does not require fixed locations, times and reservations. The nucleus of the concept is as simple as possible: interested clients subscribe to the system and receive a chip card. With the help of the card, the clients can unlock one of the 200 cars which are available all around the city area. An upfront reservation is possible but not necessary; the renting of the Smart is not billed on a kilometre base but on minute base. One minute rent in Ulm is charged with 19 Cent, in Austin with 35 US- Cent per minute. With this concept, the 200 Smarts in Ulm are rented up to 1,000 times per day by the 18,000 subscribed clients who are, with a percentage of 66%, below 36 years of age. The concept is open and can be accompanied with smart applications for cell phones etc. The future of car2go and similar projects lies in the urban areas around the globe.[47]

3.3 Political Strategies of the European Union

The rolling plan of the European Commission with the name “A European Strategy for clean and energy efficient vehicles” clearly points out that the current sales of vehicles with alternative power trains can be qualified as a niche market but with the right regulations and initiative in combination with manufacturers´ production of EVs, the ground is prepared for rapid growth rates in the coming years.[48]

The rolling plan consists of 4 major fields of actions:

1. The regulatory framework should lead the way to a constant decrease of CO_2 emissions and has special focus on light commercial vehicles, heavy-duty vehicles and the sustainability criteria for bio-fuels. As a consequence, also the number of 15 directives will be reduced to 5 regulations, which should also simplify the registration of new types of vehicles within the European Union.[49]

2. The 2nd pillar of the European Union in the rolling plan is the support of research and innovation. This target should be reached with the European Green Cars Initiative. Two rounds of calls for proposal were already held since 2009 and, all in all, the Initiative have dedicated more than EUR 200 millions to projects in the field of electric

[47] Daimler Technicity (2010): Hyperlocal mobility, p 1 following (translated)
[48] The European Commission (2010):): A European strategy for clean and energy efficient vehicles, rolling plan, p.3
[49] The European Commission (2010): A European strategy for clean and energy efficient vehicles, rolling plan, p.3 following

vehicles technologies, including sustainable automotive electrochemical storage, logistics and co-modality and general research in hybrid and electric vehicles.[50]

The major focus of the roadmaps of the Green Cars Initiative is on hybrid cars (with 50 kilometres pure electric range) and electric vehicles with a range of 100 kilometres. With this key assumption three milestones were identified to be crucial for the implementation of electric vehicles and are stated in Figure 18.

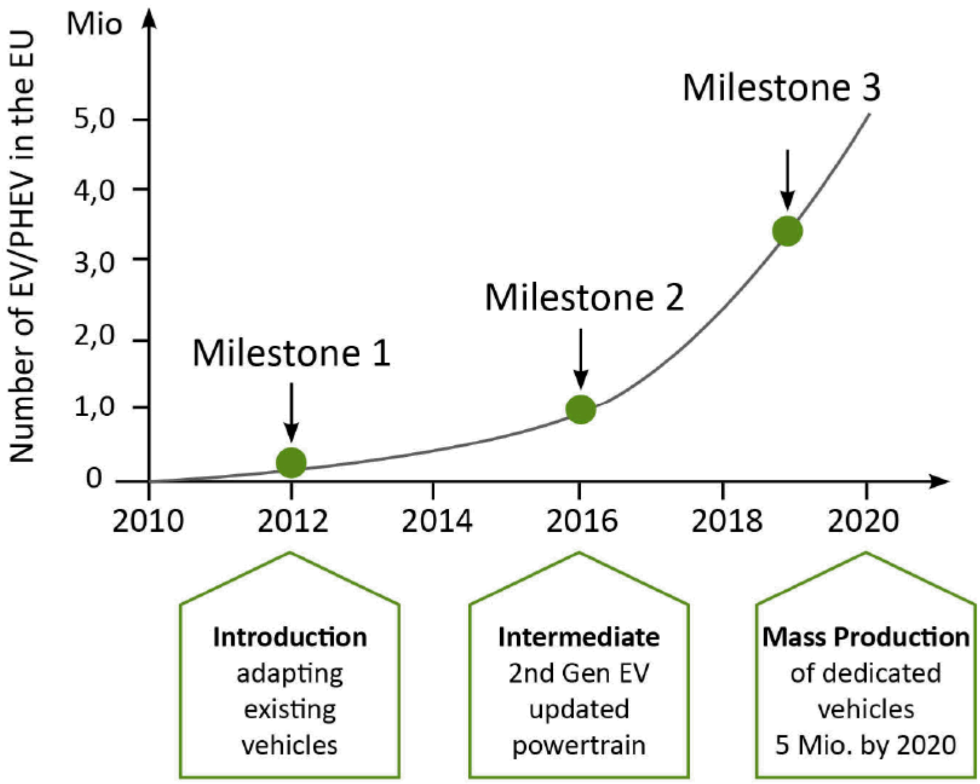

Figure 18: Milestones of the European Industry Roadmap for Electrification of Road Transport[51]

The first milestone describes the switch from conventional cars to hybrid and electric vehicles which will be used in demonstration projects and first fleets in niche application such as car sharing, taxi, delivery services and other fleets. The first phase is accompanied by efforts to increase public acceptance and the implementation of safety and billing standards. The second milestone from 2016 onwards will combine 2nd generation electric vehicles with advanced system integration and high performance energy storage systems and electric vehicles will be applicable for all types of customers. The roll-out of the charging infrastructure will

[50] The European Commission (2010): A European strategy for clean and energy efficient vehicles, rolling plan, p.6
[51] European Green Cars Initiative PPP (2010): Multi- annual roadmap and long- term strategy, p.19

start to spread from urban regions into rural areas. The mass production starting between 2018 and 2020 will mark the third milestone. The progress in battery technology will be visible in the tripled life time and energy density at about 30% of the actual price. The infrastructure will allow quick charging and bidirectional charging will give additional financial advantages for fleet applications.[52]

3. The European Commission is also working on demand side measures on financial incentives for consumers to encourage the purchase of alternative propulsion vehicles. In particular the revision of energy taxation directives targets on a framework for CO_2 taxation.

4. The European Commission also wants to establish and influence the development of international technical standards and for this reason cooperates closely with the United Nations Economic Commission for Europe (UNECE), which is organizing the technical harmonisation for vehicles. Among the topics which should be regulated are the post impact requirements to prevent electric shocks, the regenerative breaks and similar regulations which are not a 100% transferable from fossil fuel combustion vehicles.[53]

[52] European Green Cars Initiative PPP (2010): Multi- annual roadmap and long- term strategy, p.20
[53] Visvikis, C et al. (2010): Electric vehicles: Review of type-approval legislation and potential risks, p. vi

Table 2: Description of the milestones[54]

	Milestone 1	Milestone 2	Milestone 3
Energy Storage Systems	Full understanding and proper management of all relevant parameters for safety, performance, lifetime.	Manufacturing of long life, safe and cheap energy storage systems with advanced energy and power density.	Availability of batteries providing tripled energy density, tripled lifetime at 20-30% of 2009 cost and matching V2G.
Drive Train Technologies	Availability of drive train components optimized for efficient use and recovery of energy.	Manufacturing of range extenders & update of electric motors for optimized use of materials and functionality.	Implementation of power train systems providing unlimited range at sharply reduced emissions.
System Integration	Solutions for safe, robust and energy efficient interplay of power train and energy storage systems.	Optimized control of energy flows based on hard- and soft-ware for the electrical architecture.	Novel platform based in overall improved system integration.
Grid Integration	Charging adaptive to both user and grid needs.	Charging at enhanced speed.	Quick, convenient and smart charging with bi-directional capabilities.
Transport System	Road Infrastructures and communication tools encouraging the use of electric vehicles.	Full integration of electric vehicles with other modes of transport.	Automated driving based on active safety systems and car-to-x communication.
Safety	Electric vehicles (tested and inspected for) meeting (new) safety standards at same levels as conventional cars.	Implementation of solutions for all safety issues specific to mass use of the electric vehicle and road transport based on it.	Maximum exploitation of active safety measures for electric vehicles.

The first movers in the field of electric vehicles are countries such as China, the United States, Japan, South Korea and several countries of the European Union. These countries

[54] European Green Cars Initiative PPP (2010): Multi- annual roadmap and long- term strategy, p.21

are responsible for the technological development and progress on the one hand and also the first markets for EVs and charging infrastructure.

4 Countries and their approach

4.1 Austria

4.1.1 Overall Strategy of Austria

According to the Energy and Climate Agreement of the European Union from the year 2008, Austria is obliged to increase its shares of renewable energy sources up to 34% from gross energy consumption in the year 2020. In addition, Austria has to decrease its greenhouse gases by 16% compared to the reference year 2005 in the sectors which are not under the emission trading scheme (ETS). The energy efficiency should increase by 20% until 2020 compared with 2005. To achieve this goal, the ministry of environment and the ministry of economies have jointly set up an Energy Strategy for Austria in 2009. The three pillars of the strategy are a constant increase of energy efficiency, the ongoing enlargement of renewable energy sources and the long term securing of energy supply.[55]

The target of 250.000 electric vehicles (pure battery electric vehicles and plug-in hybrids without single track vehicles) is proposed as part of the strategy. This would be approx. 5% of the total number of passenger vehicles expected in 2020. To achieve this ambitious goal, a strategic roadmap is going to be rolled out.[56]

The implementation of electric mobility should strengthen the position of economy and technology in Austria, it should lead to sustainable and affordable mobility which is environmentally friendly and reduces the GHG emissions. Last but not least, the electric mobility has the positive side effect of reducing the dependency on fossil fuels.[57] The environmental and economical effects of the strategy and the target number of EVs in 2020 were calculated by PwC. The positions of the CO_2 reduction of approximately 15% are shown in Table 3.

[55] Federal Ministry of Environment & Federal Ministry of Economy (2009): Energy Strategy for Austria, p.7 (translated)
[56] Federal Ministry of Environment & Federal Ministry of Economy (2009): Energy Strategy for Austria, p.75 (translated)
[57] Federal Ministry of Traffic, Infrastructure and Technology (2010): Strategy, Tools and first use cases for the National Implementation Plan of Electric Mobility, p.25 following (translated)

Table 3: CO_2 emissions for road traffic before and after 20% coverage[58]

CO2 emissions			
without electric vehicles	**CO2**	**2020**	**2030**
Two-wheeled vehicles	mt	0.19	0.19
Light duty vehicles	mt	1.27	1.31
Passanger vehicles	mt	11.14	11.51
Total CO2 (without electric vehicles)	**mt**	**12.60**	**13.02**
with electric vehicles		**20%**	**20%**
Two-wheeled vehicles	mt	0.15	0.15
Light duty vehicles	mt	1.02	1.05
Passanger vehicles	mt	8.91	9.20
Total CO2 (with electric vehicles)	**mt**	**10.08**	**10.41**
Reduction due to changeover	mt	2.52	2.60
Battery charging	mt	(0.53)	(0.55)
Total reduction	**mt**	**1.99**	**2.06**
CO2 reduction with electric vehicles		16%	16%

PwC estimates the economic effect of the introduction of 250,000 electric vehicles until 2020 with a surplus of approx. EUR 1.4 billions for the Austrian government, as the increased investments in charging infrastructure and the reduced tax on fossil fuels are by far covered by the reduced import of fossil fuels. As a future additional benefit of 250,000 electric vehicles, there is the vision of smart grids which allows the utility companies to charge and empty the batteries of the EVs according to the demand for energy, which could replace expensive power plants for the generation of peak time energy and could support the further development of renewable energy sources such as wind and photovoltaic which cannot be connected to the peak hours of our energy consumption.[59]

[58] PwC(2009): The impact of electric vehicles on the energy industry, p.18
[59] PwC (2009): The impact of electric vehicles on the energy industry, p.19 following

4.1.2 Individual Support Scheme for Customers from the Klima:aktiv programme

Since 1st July, 2008 the Austrian Federal Ministry of Environment has implemented new tax regulations concerning the emissions of vehicles: The ministry is paying bonuses for vehicles, which have less than 120g/km CO_2 and fining vehicles which have higher values than 160g/km CO_2 with EUR 25 per gram on top since the beginning of 2011 (from 2008 until the end of 2010 the boundary value was 180g/km). Alternative propulsion vehicles like methane, CNG, LPG, E85 and hybrids are receiving a bonus of EUR 500 as tax reduction.[60]

The federal ministry for environment clearly attempts to strengthen the combination of green energy and electric mobility, as the full amount of the subsidy is only available if the necessary certificates for green energy products can be shown. So far, there is no financial support provided by the federal ministry for private customers to purchase electric vehicles or bicycles. Especially the single track vehicles for private customers are supported through financial aid coming from cities, districts and federal states in Austria.[61]

In addition to the mentioned direct financial aid from federal side there is also indirect financial support coming from the relief of electric vehicles from the tax on emission for vehicles and the tax for insurance depending on the power range of the vehicle.[62]

Table 4: Austrian Subsidies for electric vehicles (as of March 2011)[63]

Austrian Subsidies in the klima:aktiv mobil programme			
focus	**target group**	**subsidised type of vehicle**	**amount of subsidy**
Electric Vehicles	Companies, public entitites, associations	**Up to 10 vehicles (below 3.5 tonnes)**	**Per vehicle**
		Multi track passenger vehicles	EUR 2.500/ EUR 5.000 if green energy is used
		Multi track small vehicles	EUR 1.250/ EUR 2.500 if green energy is used
		Small light weight vehicles or three wheelers	EUR 500/ EUR 1.000 if green energy is used
		Single track vehicle (e-scooter…)	EUR 250/ EUR 500 if green energy is used

60 Austrian federal office for environment (2008): CO_2 Monitor 2008,p.11 (translated)
61 Wolfsegger (2010): E-mobility – status quo of subsidies, p. 64 following (translated)
62 E-connected (2009): Final report, p. 43 (translated)
63 whttp://www.publicconsulting.at/uploads/20110401_informationsblatt_fahrzeugpauschalen.pdf (translated)

Electric bicycles	Companies, public entitites, associations	**Up to 50 e- bicycles**	EUR 200/ EUR 400 if green energy is used
Electric charging points	Companies, public entitites, associations	**Up to 50 charging points if green energy is used**	**Per charging point**
		Charging points for single track vehicles	EUR 250
		Charging points for multi track vehicles	EUR 500
Mobility management for cities, communities	Companies, public entitites, associations	Investments, running expenses, external immaterial expenses for implementation	50% of environmental relevant expenses for communities and NPOs/ 30% of environmental relevant expenses for companies

4.1.3 Support Scheme for Research and Development

4.1.3.1 A3Plus

This Austrian impulse programme supported by the federal ministry of traffic, infrastructure and technology (BMVIT) and the federal office for support of research (FFG) wants to shape the traffic of the future with R&D measures in the area of alternative propulsion technologies and alternative fuels. The goal is to initiate technology loops with innovation and is in line with the Green Car Initiative of the European Union.[64]

Together with the predecessor programmes, A3plus has supported 150 R&D projects with a total amount of EUR 43 million. The R&D topics which are supported are:[65]

- Alternative propulsion systems for road, rail or shipping traffic
- Vehicle electronics for energy efficient steering and system management
- Innovative storage technologies
- Alternative fuels
- Development of supply infrastructure for alternative propulsion vehicles

Within the first three rounds of A3plus projects for electric 3-wheelers, low cost electric utility vehicles, charging infrastructure were supported. The closing for the 4th round ended at the beginning of December 2010 for another volume of EUR 5 Mio.[66]

[64] Austrian Automotive Association (2010), Electric Mobility in Austria ,p.12
[65] Dorda/Panwinkler/Winter (2010): Alternative propulsion systems and national plan for implementation of electric mobility, p.56
[66] (Federal Ministry of Traffic, Infrastructure and Technology (2009): Results of 2nd call of programme A3plus, p. 4 following (translated)

4.1.3.2 New Energies 2020

From 2008 until 2010 already 4 calls of this supporting programme were held. The total volume of the subsidies granted is EUR 135 million which was split on 500 projects. The programme is the research and technology programme of the Austrian Climate and Energy Funds, which is a joint company of the federal ministry of environment and the federal ministry of traffic, infrastructure and technologies and has three major strategies: intelligent energy systems and grids, energy efficiency and renewable energies. With the help of the strategies the following targets should be fulfilled:[67]

- Reduction of fossil fuels and energy from nuclear power
- Increasing transition efficiency
- Signalling and leverage effect
- Cost efficiency through the reduction of greenhouse gases

For the 5th call of the programme EUR 30 million are available for the following focus points: smart energy R&D, energy efficiency, renewable energies, base for political decisions on technology/energy/climate and education.[68]

4.1.3.3 Electric Mobility Flagship Projects and Technological Beacons

Technical beacons should ensure the R&D competence of Austrian electric power train technologies and also have the goal to prepare a smooth technological change towards alternative mobility without fossil fuels. Last but not least the projects also connect the Austrian automotive suppliers with the energy sector and other innovation leaders in the field of electric mobility. The programme was set up for the first time in 2009 and had a budget of EUR 11 million, followed by EUR 8 million in 2010 and the tender for 2011 will have a budget of EUR 6 million. The biggest two projects are described in the following:[69]

4.1.3.3.1 EmporA

The EmporA project is run by the Austrian Mobile Power, which is a community of interest consisting of Austrian leading companies from the automotive sector, infrastructure technology, utility companies and research institutes. Target of the project is to develop an integrated system solution for electric mobility and to test it in a six months show case. Another target of the project is to establish integrated and standardized system architecture.

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[67] Austrian Climate and Energy Funds (2011): Annual Programme 2011, p.8 (translated)
[68] Austrian Climate and Energy Funds (2011): Annual Programme 2011, p.9 (translated)
[69] Austrian Climate and Energy Funds (2011): Annual Programme 2011, p.10 (translated)

All the findings are matched and checked with international developments and should support the introduction of electric mobility in the Austrian model regions. Cooperation partners of the project are AVL List, Infineon Technologies Austria AG, Magna E-Car Systems GmbH&Co OG, REWE, Siemens AG and Verbund AG. The total volume of the project is EUR 21 million, out of which EUR 8.8 million will be subsidized and will contain showcases with a total of 20 EVs. [70]

Figure 19: Trademark of the Austrian Mobile Power[71]

4.1.3.3.2 eMORAIL

Overall target of the project is the sustainable combination of EV car sharing for the first and last mile demand with public transport, in particular with railway services. The project is targeting commuters and the developed services will be tested in two rural regions in Styria and Lower Austria and to EV car sharing models in the cities of Vienna and Graz. The clients will be able to use mobility without having a car on their own with additional services to create an intelligent, innovative, affordable and environmentally friendly solution. To be able to have attractive pricing, the vehicles will be used by commercial clients during the day and will be returned to the commuters in the evening. The first show case was opened at the Vienna railway station west with 3 EVs for inter modular car sharing.[72]

Figure 20: Trademark of the eMORAIL[73]

4.1.4 Show Cases: The Austrian Climate & Energy Funds model regions

The Austrian Climate & Energy Funds model regions are the nucleus for the implementation of electric mobility and the source of first experiences for private and commercial clients. Model regions are the key issue for achieving the strategic goal of 250.000 EVs in the year

[70] Plunger, E.M. (2011): Summary of the emporA project, p.1
[71] www.austrianmobilepower.at/Initiative.1132.0.html (tranlated)
[72] www.emorail.at/projektbeschreibung.html (translated)
[73] www.emorail.at/projektbeschreibung.html (translated)

2020 in Austria. The operators of the programme have to comply with the following modules:[74]

- Development of a regional mobility concept including electric vehicles
- Development of intelligent charging infrastructure based on green energy
- Organization of suitable EVs
- Coverage of additional energy demand with new green energy sources
- Creation and market implementation of new business models e.g. car sharing, battery switch etc.
- Scientific monitoring during the project duration
- User education

At the first call, the model region in Vorarlberg was chosen; at the 2nd call the model region in Salzburg started its work. At the last call three model regions in Vienna, Graz and Eisenstadt were selected. All in all, 1/3 of the Austrian population is living now in one of the model regions. For 2011, the Austrian Climate & Energy Funds has prepared EUR 2.5 million for applications covering either commuters especially from the countryside into urban areas focusing on last mile solutions or urban logistics which introduce at least 200 vehicles consisting of pedelecs, scooters, light-weight vehicles and EVs.[75]

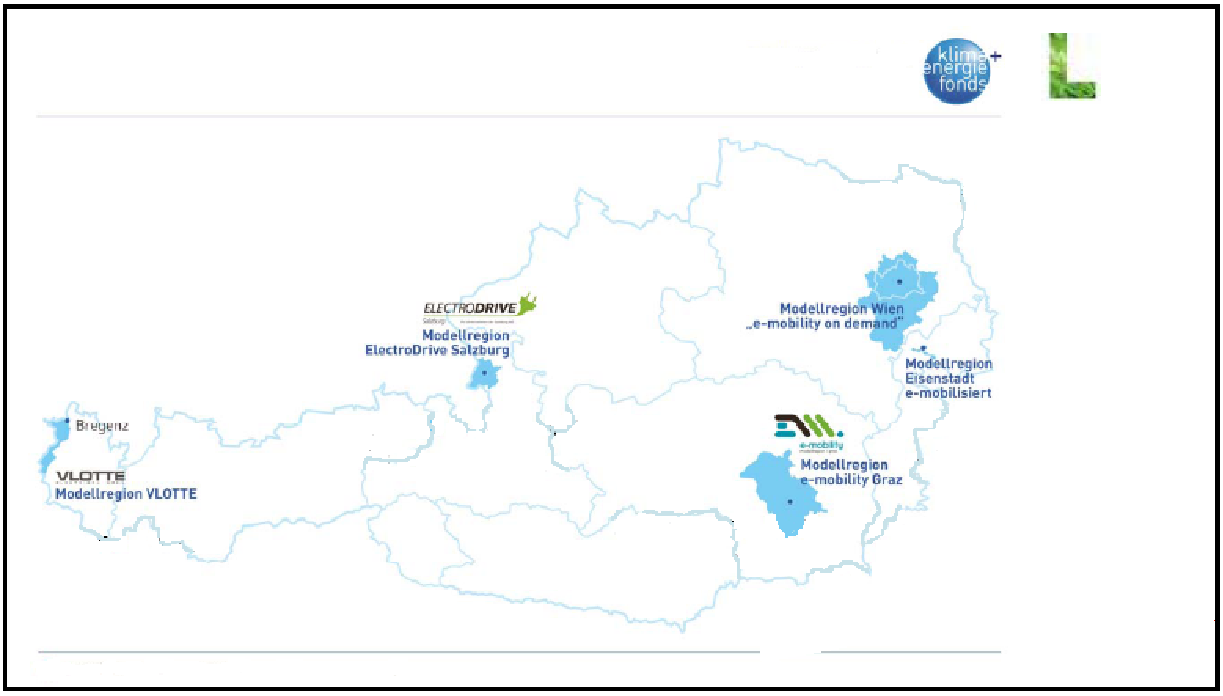

Figure 21: Austrian Climate & Energy Funds model regions[76]

[74] Austrian Climate and Energy Funds (2011): Annual Programme 2011, p.15 following (translated)
[75] Austrian Climate & Energy Funds (2011): Guideline for the Announcement of E- Mobility model regions, p.6 (translated)
[76] Raimund, W. (2011): First Implementation of Electric Mobility, p.13 (translated)

4.1.4.1 Vlotte

The first model region was established at the beginning of 2009 in the federal country of Vorarlberg. The project is managed by the local utility company VKW and accompanied by several partners including the Technical University of Vienna for scientific monitoring of the project. At the end of 2010, 77 EVs were sold on the basis of the mobility rate, which includes the financing of the vehicle, service, tyres, insurance and energy for free at the 57 charging points and annual tickets for public transport. At the end of the project in 2011 297 EVs and 100 pedelecs will be in use.[77]

Figure 22: Vlotte[78]

4.1.4.2 Electrodrive Salzburg

At the end of 2009 the city of Salzburg and the surrounding suburbs became the 2nd model region subsidised with EUR 1.9 million. The project name is called Electrodrive Salzburg and is managed mainly by the local utility company Salzburg AG and supported by The Advisory House AG and Raiffeisen- Leasing GmbH. At the same time, Salzburg AG also won a project for the integration of smart grids and received EUR 1.7 million for the establishment of an intelligent energy grid network.[79]

The business model of Electrodrive Salzburg is mobility on subscription: The client can rent or lease the vehicles and pays with one rate not only the bike, scooter, segway or car but also the energy, the access to the public charging points and, as an option, also fleet management services, vehicle insurance and an annual ticket for public transportation in the city of Salzburg.[80]

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[77] Eugster (2011): Vlotte Vorarlberg presentation, p.3 following (translated)
[78] www.vlotte.at/inhalt/at/80.htm
[79] Austrian Automotive Association (2010), Electric Mobility in Austria ,p.19 (translated)
[80] E-mobility model region Electrodrive Salzburg: key facts June 2011 (translated)

Figure 23: Electrodrive Salzburg[81]

The ambitious goal of the model region is to have 130 charging points, 1.000 EVs and 950 pedelecs running in the region. By June 2011 the project realized 792 e-bikes, 85 EVs and installed 50 public charging points and 20 non-public charging points.[82]

4.1.4.3 E-mobility Graz

At the end of 2010 the model region Graz, a syndicate of the city of Graz and the two utility companies Energie Graz and Energie Steiermark received EUR 1.6 million for realizing its e-mobility project goals. The target of the project is to have 500 EVs, 1.200 pedelecs, 140 public charging points and 950 non-public charging points in place. The business model will offer modality switches and smart mobility services and provides the additional energy through PV and hydro power plants in the area of Graz.[83]

In June 2011 already 430 pedelecs, 12 EVs and 10 public charging points have been installed. In addition to that 2 PV plants on roofs with a total installed capacity of 162 kW_{peak} have been realized.[84]

4.1.4.4 Mobility on demand – model region Vienna

Mobility on demand is a model region in the Austrian capital of Vienna, which is designed by the public utility company Vienna together with its subsidiaries, the utility company Wien Energie and public transport company Wiener Linien. The focus of the project lies on avoiding individual traffic with the help of hot spots which will allow an intermodal switch with smart applications and one mobility card. The project aims to reach 500 EVs and 1.000

[81] Schößwendter (2011): Electrodrive Salzburg presentation, p.4
[82] Status report June 2011 of model region Salzburg, p. 4 following
[83] E-mobility model region Graz: key facts June 2011
[84] Status report June 2011 of model region Graz, p. 4 following

charging points and receives EUR 1.3 million of subsidies. As of June 2011 the project realization is still under preparation.[85]

4.1.4.5 Model region Eisenstadt

The model region in Eisenstadt is the smallest of its kind so far as it covers an area with a population of roughly 20,000 inhabitants. The project is organized by a syndicate consisting of the city of Eisenstadt, the local utility company BEWAG and Raiffeisen- Leasing GmbH. Target of the project, which is subsidised with EUR 560.000 is to achieve 23 EVs, 10 light weight vehicles for transport and 69 pedelecs. The business model is to cheapen the rental fee with the help of multiple usages and to attract local companies to pay the costs out of their marketing budgets.[86]

As of June 2011 there are no vehicles in use so far. In September 2011 a test run for autonomous bicycle sharing system will start and at the beginning of 2012 the first EVs will be used for taxi transportation.[87]

4.1.5 Conclusion and Outlook

So far the model region programme of the Austrian Climate & Energy Funds is the most effective tool for a systematic implementation of electric mobility in Austria considering the amount of vehicles and the installed charging infrastructure. Even tough only 2 out of 5 are already active, there are already a significant number of vehicles on the road:

Table 5: Status of model regions (as of 30th June 2011)

Real/Planned Figure	EVs	Pedelecs	Charging Points
VLOTTE	297/300	100/100	70/70
Salzburg	85/1.000	792/950	50/130
Graz	12/500	430/1.200	10/140
Wien	0/500	-/-	-/160
Eisenstadt	0/33	0/69	-/-
TOTAL	**394/1.996**	**1.322/2.319**	**130/500**

[85] Vienna Public Services (2010): Application report of mobility on demand of model region Vienna, p.3 following
[86] E-mobility model region Eisenstadt: key facts June 2011
[87] Status report June 2011 of model region Eisenstadt, p. 4 following

In the first six months of 2011 326 electric vehicles were newly registered in Austria. This number is of course quite small compared to the overall number of newly registered vehicles, which is roughly 187,500 new vehicles, but it shows that the direct incentive plus the model regions' strategy at least has activated some early adopters.[88]

4.2 Germany

4.2.1 Overall Strategy of Germany

The national strategy for the development of electric mobility is a joint effort of politics, science and industry to cover the whole range from fundamental research until market introduction. The whole value creation chain comprising materials, components, cells, batteries until the total system integration is being considered. Furthermore, a concept for network integration will be established to cover the additional energy needs of electric vehicles with renewable energy sources with the help of an efficient handling of the energy peaks. The vision is to transform Germany into a leading market player for electric mobility, which will strengthen the competitiveness of the German automotive and automotive supplying industry.[89]

Table 6: The German way to a leading market in electric mobility[90]

	Phase 1 (2009-2011) Market preparation	Phase 2 (2011-2016) Market introduction	Phase 3 (2017-2020) Market penetration
R&D	R&D is crucial in all phases and for all topics ranging from automotive engineering, batteries/condensers, infrastructure to network integration		
Batteries & condenser	• Li-Ion batteries (1st generation) • R&D 2nd generation	• Showcases 1st generation • Mass production 1st generation • Start of production of 2nd generation • R&D 3rd & 4th generation	• Mass production 2nd generation • Start of production of 3rd generation • R&D of future storage technologies
Automotive engineering	• production of PHEV & BEV on existing platforms	• production of PHEV & BEV on existing platforms of all OEMs	• Mass production of 2nd generation PHEV & BEV

88 EURODAX statistics about new vehicle registration per June 2011
89 German Government (2009): National strategy for the development of electric mobility, p.4 (translated)
90 German Government (2009): National strategy for the development of electric mobility, p.45 following (translated)

		• 2nd generation platforms are close to start of production	
Infrastructure	• Simulations & tests • 1st public charging points • R&D about combination with renewable energies	• Charging infrastructure in several regions and cities • Testing of efficient handling of energy peaks • Combination with renewable energies	• Testing of smart grids • Complete coverage of network infrastructure • Smart grids in combination with fast charging and induction load
General conditions	• Safety standards • Legal frameworks • Standardisation	• Joined procurement of public companies • Examination of incentive scheme	
Market development	• Testing in fleets	• 1st private costumers • Business models for charging, recharging and batteries	• 1 million EVs in Germany • Germany is leading market for electric mobility

Based on this approach the German government sets the ambitious goal to have 1 million EVs in 2020, more than 5 millions EVs in 2030 and to have the majority of traffic covered with EVs in urban areas by 2050. The 1st phase is financed by the budget for economical cycle activations and the measures taken should support in particular the German automotive and supplying industry to prepare them for the challenges in electric mobility. In addition to the automotive sector, also the utility and research companies are targeted with this budget of EUR 500 million, which can be almost doubled due to investment participation of the industry.[91]

Two major pillars of the national strategy for the development of electric mobility are the national platform for electric mobility and the eight model regions, which should deliver the first feedback for the national strategy.

[91] German Government (2009): National strategy for the development of electric mobility, p.46 following (translated); German ministries for Economy/ Traffic & Infrastructure/ Environment/ Education & Research/ Food, Agriculture & Customers (2009): Excerpt from the report about economic support action plan II concerning electric mobility, p. 3 following (translated)

4.2.2 Model regions

As part of the budget for economical cycle activations the concept of a restricted number of model regions was developed by the ministry of traffic and infrastructure. The principal idea is that electric mobility will develop out of certain clusters and will be influenced by the collaboration of global ideas and players with local circumstances and local partners such as communities and the local utility companies. All model regions will have their own regional project management and above them a centralized organisation is steering the communication between the model regions and the ministry and the interaction between the model regions.[92]

Model Regions
Electromobility

Figure 24: Trade mark of the German model regions for electro mobility[93]

The major topics are:

- Interaction between producer, user, service provider and provider of the infrastructure
- Observation of electric mobility under real conditions
- Wide range of vehicles from bicycles up to personal cars
- Combination of different mobility modes
- New mobility services like car sharing and new business models.[94]

From the 130 applications, the following eight model regions were chosen to receive approximately EUR 130 million between 2009 and 2011:[95]

1. Hamburg
   Hamburg was awarded with the price “environmental capital of Europe 2011”

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[92] German ministries for Economy/ Traffic & Infrastructure/ Environment/ Education & Research/ Food, Agriculture & Customers (2009): Excerpt from the report about economic support action plan II concerning electric mobility, p. 23 following (translated)
[93] http://www.now-gmbh.de/en/electric-mobility/downloads.html
[94] German ministries for Economy/ Traffic & Infrastructure/ Environment/ Education & Research/ Food, Agriculture & Customers (2009): Excerpt from the report about economic support action plan II concerning electric mobility, p. 23 (translated)
[95] Bonhoff (2010): everyday mobility in tomorrow’s cities, article in BEM magazine (10/2010): p. 72 (translated)

by the European Commission and wants to show the importance of alternative energy sources in the model region, a non discriminating access to charging infrastructure and last but not least the modal switch of individual to public transport. The three major pillars in mobility will be the up to 10 diesel hybrid busses, 50 smart electrics for fleets and car sharing, and 20 Fiat Fiorino and 15 Renault Kangoo Z.E. which will be used in public transport, logistics and in the harbour. Project partners are Vattenfall Europe, Daimler AG, Renault and the city of Hamburg with its own utility company Hamburg Energie GmbH and its public transport company Hamburg Hochbahn AG.[96]

2. Bremen/ Oldenburg

   The model region in Bremen and Oldenburg has three crucial advantages as a location: First, the whole area is largely producing alternative energy with its wind parks, second, it is an urban–rural area with a lot of commuters with small distances, and third, it has a very good scientific background in R&D. The two major partners in the model regions are the Fraunhofer institute for manufacturing and engineering and the German research centre for artificial intelligence. The two institutes have jointly founded the personal mobility centre PMC and offer electric mobility starting from pedelecs up to electric vehicles and combine it with public transportation and public charging infrastructure. The business models should attract both private and commercial customers and will be tracked and scientifically observed.[97]

3. Berlin/ Potsdam

   The main targets of the model region in the German capital are to gain experience with electric mobility and see its impact on traffic, energy consumption, construction and environment. The main directions of the initiative are the combination with public transport, the interaction of electric mobility and housing and the e-city-logistics. The project concerning the public transport is called BeMobility and contains up to 40 electric vehicles available at 20 stations and 50 pedelecs for inhabitants and tourists. The combination with housing is called WohnmobilE and should allow the inhabitants of certain housing areas to use car sharing offers. The e-city-logistics project contains

[96] Klingenberg, H. & Lindlahr, P. (2010): model region Hamburg, article in BEM magazine (10/2010), p. 78 (translated)
[97] www.personal-mobility-center.de (2011): information sheet of the model region (translated)

postal services as well as a fleet testing of around 100 Smart electric drives. All the projects are accompanied with scientific observations.[98]

4. Saxony

   The model region Saxony is run by Saena, the energy agency of Saxony together with public transportation companies in Dresden and Leipzig and other partners from the region such as Deutsche Telekom AG. The main focus of the project is called SaxHybrid and contains 10 serial hybrid buses which are running daily tours to gain experience concerning loading and charging on the different routes of the buses to optimize the usage of the hybrid vehicle. The 2nd major focus is put on the development and production of decentralized energy storage systems. This is a huge potential for the electric mobility as it tries to work out how the traction batteries can work for a 2nd life cycle at industrial storage systems. Last but not least, the 3rd project is called SaxMobility and tests electric mobility in real world situations of large company fleets. The project starts with the acquisition of the electric vehicles, the necessary charging infrastructure and the intelligent ITC systems for monitoring and steering. All in all, approx. EUR 9 million will be invested in the project.[99]

Figure 29: Serial hybrid bus on duty in the City of Dresden[100]

[98] Behrendt, F. (2010): model region Berlin-Potsdam, article in BEM magazine (10/2010), p. 74 following (translated)
[99] Kötzling, K. (2011): Electric mobility in Sachsen – information folder (translated)
[100] Kötzling, K. (2011): Electric mobility in Sachsen – information folder (translated)

5. Rhine - Ruhr

The German state of North Rhine-Westphalia has developed a master plan for the introduction of electric mobility in 2009. The master plan consists of three segments, which are battery technology, vehicle technology and infrastructure & grids.

The strategic goal of the government of North Rhine-Westphalia (NRW) is to have 250,000 vehicles with electric power trains on the road in the year 2020 and to increase the market share of the regional automotive industry significantly and to attract other automotive companies to establish factories in NRW. The first important step towards these goals was the creation of the model region Rhine-Ruhr, which is subsidized with EUR 115 millions of the German government. The following projects are part of the model region:

- CologneE-Mobil: The project is a collaboration of Ford, the University of Duisburg, the Rhein Energie AG and the city of Cologne. 25 electric vehicles of Ford will be tested in big company fleets.
- E-mobil NRW: This project is run by the utility company of the city of Dusseldorf and has the goal of integrating up to 20 electric vehicles, 26 scooter and 4 small utility vehicles and install up to 58 charging points.
- 21 hybrid buses will be tested in the whole area of the public transport network of Rhine- Ruhr.
- The project E-Aix is a joined project of 50 partners from economy and science under the coordination of the utility company Aachen.
- The project Stromschnelle is trying to establish electric mobility in the commuter traffic between the cities of Dortmund, Essen and Muehlheim. With the help of new business models up to 160 electric vehicles from Renault and Fiat (transformed Fiat Fiorino and Fiat 500).[101]

6. Rhine- Main

The model region Rhine- Main is situated in one of the most important regions for the German economy and is also an international and national traffic hot spot. The projects vary from scooter to pedelecs which are used in a sharing model in housing areas. In the city of Offenbach an electric bus is being tested and combined with pedelec and scooter sharing. The delivery company United Parcel Services Germany is testing 6 commercial vehicles for the delivery services in the city of Frankfurt/ Main. All in all, up to 65 electric vehicles, 10

[101] Cluster Nordrhein- Westfalen (2011): Master plan electric mobility, p. 3 following (translated)

commercial vehicles, 5 electric and hybrid buses and 140 are tested in the different projects. The model region is run by the regional utility company in Offenbach and is accompanied by several scientific studies. The model region is also working under the label of ZEBRA, which combines electric mobility with decentralized energy production and sustainable economic development of the region.[102]

7. Stuttgart

The public development agency of the region of Stuttgart is the project leader in the model region and coordinates all activities and sub-projects in the area. The vision of the model region is to make electric mobility visible, to show different approaches in electric mobility and to speed up the introduction of electric mobility. One big partner project is run by Daimler AG and includes 50 Mercedes Vito for small transport business of the company in the area of Stuttgart. Around 700 electric scooters are being tested over a period of one year by different users (500 are private users). This project is led by the utility company Energie Baden-Württemberg AG. And, last but not least, the public transportation company in Stuttgart is testing 5 hybrid diesel buses on selected routes.[103]

8. Munich

In the model region Munich players from the automotive sector, the energy sector and from science are joining forces to test electric vehicles and provide the necessary charging infrastructure in the area of Munich. One project is run by the public transportation company of Munich and compares the advantages and disadvantages of three different hybrid buses in practise. The sub project ‘drive e-charged’ is a joint venture of BMW, Siemens and the utility company of Munich and puts up to 40 electric vehicles of BMW Mini on the street. Target of this project is to gain experience of customers about fast charging, the acceptance of business models but also to increase the technical know how about components and systems for serial production. A third project is an energy sector joint venture of E.ON energy and the utility company of Munich which analyzes the charging behaviour of 20 Audi A1 e-tron users. For this

[102] Utility Company Offenbach (2010): flyer of the model region Rheine-Main (translated)
[103] Haag, H. (2010): press information of the model region Stuttgart, p1. following (translated)

purpose, the three companies obliged themselves to install an adequate number of charging points in and around the city area of Munich.[104]

4.2.3 National Platform for electric mobility (NPE) (show cases and flagship projects)

Based on the national strategy for the development of electric mobility the German chancellor founded the national platform for electric mobility on 3rd May, 2010. The mission of the platform is to establish Germany as a leading market and a leading industry for electric mobility. The set up of the national platform of electric mobility is for all important players from industry, politics, science and society in Germany to join forces for the realization of the mission. The shared targets of the NPE can be described as follows:

- Concentration of know how and necessary subsidies to achieve a competitive advantage in R&D
- Development of attractive and competitive products and solutions
- Development of a strong German market for the implementation of these products and solutions
- Stabilize and increase the German added value and employment
- Standardization on an international level
- Preparation of the education system on the demands of electric mobility
- Active contribution to the environmental protection in particular the climate[105]

The NPE proposes in its 2nd report in 2011 the following actions to achieve the German goals of being a leading industry and market of electric mobility:

- Implementation of technical beacons for battery, power train, information and communication technology, light weight construction and recycling. These technical beacons should be supported with one subsidy programme combining the action set by all ministries. In addition, the R&D in key technologies combining different technologies from different sectors and creating new services should be strongly enlarged. All in all, the NPE estimates a total volume of EUR 4 billion for these activities to prepare a market
- To increase the visibility of the potentials of the German industry and to stimulate demand by creating a certain number of show cases. The show cases allow politics and industry to focus their efforts on a small number of projects, but these projects

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[104] Speiser, I. (2010): model region Munich, article in BEM magazine (10/2010), p. 79 (translated)
[105] NPE (2010): interim report of the national platform for electric mobility, p. 14 (translated)

are designed to cover the whole system chain from the energy to the vehicle and, ultimately, to traffic systems

- To be able to achieve the target figure of 1 million electric vehicles by 2020, an intelligent incentive system has to be introduced otherwise the number of vehicles will be less than 50% of the plan. The NPE proposes different measures either monetary ones such as compensation for private users of electric company cars, extraordinary depreciation of EVs, tax deductions or non-monetary measures such as parking advantages or use of public transport lanes
- The NPE defines itself as a supervising body for model regions, show cases or technical beacons and will develop and lead an overall communications strategy for all players in the field of electric mobility. The evaluation of the progress will be documented in annual reports.[106]

4.2.4 Conclusion and Outlook

Germany has chosen a very strategic approach towards electric vehicles and divides the development towards electric mobility in three phases. In the current phase, R&D is dominating and only the eight model regions are trying to show electric mobility under real life conditions. As, so far, the government grants no additional subsidies, the number of vehicles outside the model regions is not significant. Compared to the 1.6 million newly registered ICE vehicles, the 1,162 (newly registered?) electric vehicles appear marginal. Of which, however, only approximately 770 vehicles are real serial vehicles, all the other vehicles like the Volkswagen, Mercedes or Smarts still hold a testing status, meaning that the cars can be used but must not be owned by the testing people. All in all, the success of the strategic approach of the German government is visible in registration numbers: Apart from some early adopters who are eager to make use of electric mobility, the larger part of customers can only be expected to follow suit as soon as the German car industry introduces its first serial models to the market.

Table 7: Overview of the German model regions[107]

	Hybrid vehicles (buses)	Electric vehicles	Single lane vehicles (pedelecs, scooters	Charging Points
Hamburg	5	100	0	100
Bremen/Oldenburg	2	77	25	160

[106] NPE (2011): 2nd report of the national platform for electric mobility, p. 43 following (translated)
[107] National Organisation for Technology of Hydrogen and Fuel cell (2011): status of implementation in the model regions, p. 16 following (translated)

Berlin/Potsdam	0	195	10	90
Rhine-Ruhr	21	140	140	340
Rhine-Main	6	61	471	95
Saxony	20	32	38	139
Region Stuttgart	5	91	712	190
München	1	60	0	150
TOTAL	**60**	**756**	**1,396**	**1,264**

In terms of number of vehicles the German approach will become interesting after the start of the first German serial production of electric vehicles from BMW, Audi, Mercedes and Volkswagen, which will be released in 2012/2013 according to the statements of these automotive companies. On arrival of these vehicles, the German government will maybe rethink its refusal of an individual support scheme and this could bring an additional boost to the number of electric vehicles sold. In the same timeline the charging infrastructure and the services for customers will be defined to profit from a then fast increasing market.

4.3 Denmark

4.3.1 Overall Strategy of Denmark

In February 2011 the Danish government published the Energy Strategy 2050 – from coal, oil and gas to green energy. The long term strategic goal is to be independent from fossil fuels by 2050. Among other targets of the strategy the transition to green energy in the transport sector sets the ambitious goal to have 10% share of renewable energy in the transport sector by 2020. A goal which is not going to be achieved solely with electric cars but also with bio fuels, nevertheless, it sounds utopian. Still, Denmark is a country with a long history of renewable energy and a current average share of 20% of wind energy in the grid network, which is supposed to further increase up to astonishing 50% by 2050. The current tax on the purchase of ICE cars in the range of almost 180% on the purchase price is a massive and brave statement of the government against the vehicles powered with fossil fuels and definitely pure utopia in any other country of the European Union or even of the world.[108]

With a population of 5.5 million and about 85% of people living in urban areas, Denmark is very well suited for the adoption of electric cars, furthermore, the topography of the country is

[108] The Danish Government (2011): Energy Strategy 2050 – from coal, oil and gas to green energy, p. 7 following

far less complex than the alpine areas of Central Europe. Also, every Dane travels a distance of less than 50km daily and today already approx. 40% of the Danish people claim to choose an electric vehicle when buying their next car.[109]

4.3.2 Individual Support Scheme

In early 2008 already, the Danish Energy Agency launched a programme to test and promote electric vehicles during the period of 2008 until 2012. The programme is subsidized with EUR 4.6 million. Since then, Denmark has adopted several tax exemptions to boost the demand for electric vehicles. The Danish government exempted the electric vehicles from registration tax of a staggering 180% and prolonged this tax free period until 2015. Electric cars are also exempted from ownership tax; vehicles excise duty, countervailing charges and road taxes. All these tax exemptions together are expected to reduce the prices of electric cars by more than 60% and make electric vehicles comparable to conventional cars in terms of pricing and pave the way for achieving the goal of 500.000 passenger cars in 2020, which is 25% of the total amount of registered passenger cars in Denmark.[110]

As a part of the energy strategy 2050 the Danish government is also providing EUR 3.4 million co-financing for the establishment of recharging stations for electric cars and clearly wants to push the promotion of electric cars through enhanced harmonisation and standardisation of technologies, in particular recharging infrastructure throughout the European Union.[111]

All these actions set by the Danish government are accompanied and strengthened by regional support schemes, for example in the Danish capital of Copenhagen. Within the area of the city, EVs can park free of charge and projects for implementing EVs can obtain a 10 years permission for approx. 500 parking lots to establish charging infrastructure. The city itself is currently in acquisition of 33 electric and hydrogen vehicles. The aim of the city is to have 85% of electric and hydrogen vehicles in its own fleet by 2015. By 2025 Copenhagen wants to become the world's first carbon neutral capital.[112]

[109] Shankar, B. (2010): Denmark's policy overdrive to boost electric cars, article on www.ibitimes.com
[110] Shankar, B. (2010): Denmark's policy overdrive to boost electric cars, article on www.ibitimes.com; O'Dwyer, G. (2010): Denmark's electric dreams, article on www.utilityweek.co.uk
[111] The Danish Government (2011): Energy Strategy 2050 – from coal, oil and gas to green energy, p.38
[112] Stehen, K. (2009): Green Growth in Copenhagen, p.1

4.3.3 Show Cases

In addition to the direct support from the public side, companies are setting initiatives in electric mobility in Denmark. One of the biggest players in this field is Dong, the 76.49% state owned utility company in Denmark, which is engaged in the EDISON project on the hand and is also a shareholder and partner of the start-up company Better Place in Denmark. Two other regional utility companies, Syd-Energi and SEAS-NVE, are joining forces with Sixt Car Rental and establish the joint venture company ChoosEV to become a nationwide electric vehicle operator.

4.3.3.1 EDISON

EDISON is an abbreviation for electric vehicles in a distributed and integrated market using sustainable energy and open networks. The project was initiated by Dansk Energi, the Danish energy association, which is a commercial and professional organization for Danish energy companies and the utility company DONG energy. Together with partners from industry (Siemens, IBM, Ostkraft Produktion) and science (Technical University of Denmark) the project was launched in August 2009 on the island of Bornholm, because with its isolated system, mainly powered with wind energy, the island is ideal for testing the interaction of renewable energies, the grid network and electric mobility. The total project budget is approx. EUR 6.6 million, which consist of EUR 4.4 million from FORSKEL, the research programme of the Danish transmission system operator Ernginet.dk, and EUR 2.2 millions of partner companies.[113]

Figure 25: EDISON demonstration site on island Bornholm[114]

[113] Christensen, J. (2010): 2nd flyer of EDISON project
[114] www.edison-net.dk/News/013_Edison_public_WS.aspx

The overall purpose of the EDISON project is to gather research institutions and major industry enterprises and to cover all stages from research, concept and technology development, to demonstration. The project is organized in seven working packages (WPs). Package 1 shall provide a knowledge platform for all partners. With the help of Package 2, system architecture design for EV systems shall be realized. The objective of WP 3 is to develop a technical system for intelligent system integration of distributed EVs connected in private homes, office parking lots etc. With the help of WP 4, the technologies for central fast charging stations and battery swapping stations, including control methods for optimal utilization of the battery capacity in the power system, shall be developed. The objective of WP 5 is to develop and test the EV power and communication interface for different architectures. This WP is lead by EURISCO. The WP 6 is divided into two parts: The 1st part is lead by DONG and should test the proof-of-concept of the EV charging control system and the battery models. The 2nd part is lead by Oestkraft and will be conducted with a few EVs and charging stations installed in the distribution grid on Bornholm. Last but not least, WP 7 is to steer the project and to disseminate the results of the other WPs.[115]

4.3.3.2 Better Place Denmark

The biggest Danish utility company has joined forces with the Silicon-Valley start-up Better Place to realize the vision of Better Place's CEO Shai Agassi: to develop and establish network and services to make the electric vehicle make sense. The decision of Better Place to start its European activities in Denmark are reasonable due to the mentioned topographic advantages and the political support as mentioned before, but still, the investment in the network which is necessary for a smooth start is enormous and when all the investments are made, the first clients have to be found and convinced. The concept of battery swap in special battery switching stations is as simple as Figure 26 shows.[116]

[115] Christensen, J. (2009): 1st flyer of EDISON project
[116] Bergman, J. (2010): Denmark leads Europe's electric-car race, article on www.time.com; www.betterplace.com/the-solution

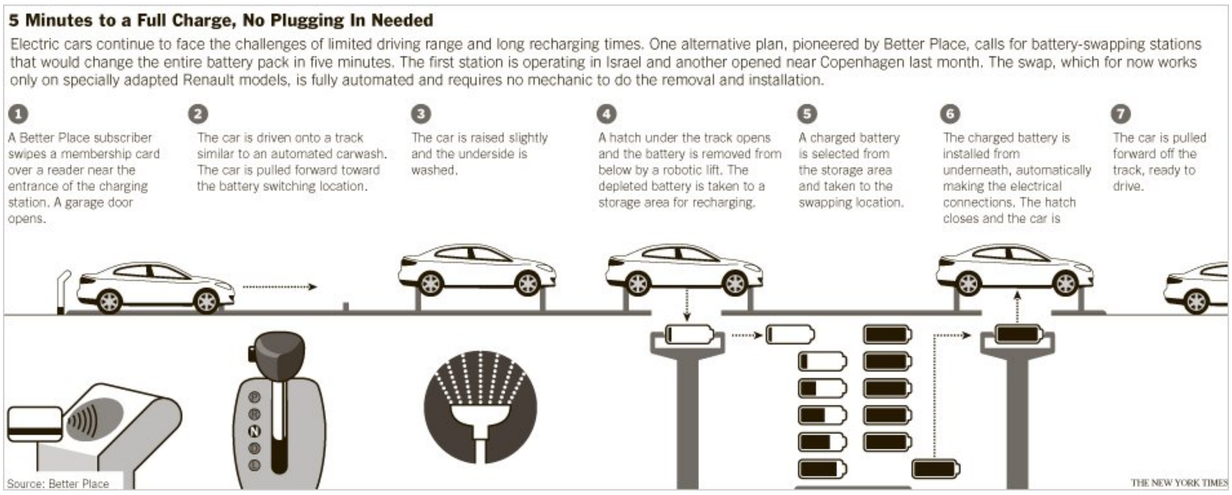

Figure 26: battery switch in the Better Place system[117]

The 5 minute battery switch is part of the better place package which includes the lease of the battery access, the charging point at home or at the office for overnight charging, and the energy for a fixed price of approx. EUR 250 per month. The vehicles will be sold or financed to the customer separately. At the moment, the only vehicle available for this system is the mid-size Renault Fluence Z.E., with the small Renault Zoe Z.E. to come in 2012. Better Place Denmark is expecting to sign on the first clients in the 2nd half of 2011 and to break the 1.000 clients limit within the first year of operation. The plans are as ambitious as the economics are challenging: One switching station is supposed to cost around EUR 3 million and for the coverage of the most densely populated areas of Denmark another 19 stations have to be erected. The total amount of investment of Better Place and Dong is supposed to be around EUR 103 millions.[118]

4.3.3.3 ChoosEV

ChoosEV was founded in 2009 as a joint venture of the two Danish utility companies Syd-Energi and SEAS-NVE together with Sixt Car Rental with a budget volume of approx. EUR 4 million. With its current 25 employees the start-up company wants to become a nationwide electric vehicle operator and sets its focus on the development of the charging infrastructure and the collection of testing data of electric vehicles. ChoosEV is hosting the project TestEnElbil.dk, which is a three year project subsidized by the Danish government. The target of the project is to get 300 EVs on the street, which are tested by 2.400 families and should generate 6 millions of supervised testing kilometres and more than 300.000 charging

[117] Berman, B. (2011): Plug-and-Play Batteries: Trying Out a Quick-Swap Station for EVs, article in the New York Times on 29th of July 2011

[118] Berman, B. (2011): Plug-and-Play Batteries: Trying Out a Quick-Swap Station for EVs, article in the New York Times on 29th of July 2011; Smole, E. (2011): international trends in electric mobility at the e-connected conference on the 19th January 2011, slide 9

cycles. The concept of the project is that ChoosEV works together with 30 municipalities and is supported financially by companies, which receive marketing benefits for their involvement through branding of the vehicles. ChoosEV together with the respective municipality is in charge for the setup of the necessary charging infrastructure. The testing family receives an intelligent charging module and a data collection module together with the vehicle.[119]

4.3.4 Conclusion and Outlook

The general framework in Denmark is very promising for the introduction of electric vehicles, as there are all types of subsidies ranging from individual support to parking free of charge. The collaboration with Better Place is definitely unique in Europe so far and will give the electric vehicle registration figure a real boost, if all the necessary steps in the setup of the switching stations and the charging infrastructure are properly made. So far, the registration figures for new electric vehicles in the 1st half of 2011 are 283.[120]

4.4 Portugal

4.4.1 Overall Strategy of Portugal

Since the beginning of the 21st century Portugal has put a lot of effort in its turn towards renewable energies. Between 2004 and 2009 Portugal increased its wind power capacity from 537 MW to 3,193 MW, which represents a sixfold increase, and in 2009, the largest wind farm in operation in Europe was situated in Portugal and the worldwide largest PV plant went into operation. Portugal's targets for 2020 were even more ambitious: first, to have 60% of the electricity consumption coming from renewable energies and second, with 7.6% ton CO_2 eq. /capita the most ambitious value of all European Union members.[121]

To be able to reach these goals the Portuguese government has already entered the electric mobility field in 2008, signing a "zero emission mobility" agreement with the Renault- Nissan alliance. In February 2009 the council of ministers established the resolution "Program for Electric Mobility in Portugal". The program foresees a total amount of 180.000 EVs in Portugal and an installed charging infrastructure of 20.000 slow and 600 fast charging spots. The ministers also promised to implement a share of 20% of electric vehicles at the annual

[119] ChoosEV (2011): presentation of the business model
[120] JATO statistics about new vehicle registration per June 2011
[121] Mobi.E (2009): Portuguese electric mobility programme, presentation file

change in public fleet and even purchased 20 electric vehicles for presentation purposes right away.[122]

4.4.2 Individual Support Scheme

The Program for Electric Mobility also includes incentives to stimulate the market demand of electric mobility. Tax incentives for private persons and companies together with tax exemptions for the purchase of EVs and road tax exceptions have been installed. On top of that, the Portuguese government is subsidizing the purchase of each EV with EUR 5,000 and another EUR 1,500 from "cash for clunkers" programme (for the first 5,000 EVs sold until the end of 2012). Furthermore, the Portuguese municipalities have agreed to exclude the EVs from charging for parking areas and allow them to use bus lanes all over the country.[123]

4.4.3 Mobi.E

Based on the Program for Electric Mobility the Portuguese government established the electric mobility platform MOBI.E, which is, on the hand, the unique brand for the customers and, on the other hand, the name of a consortium of companies and public entities to roll out electric mobility with all its services and infrastructure in Portugal.

Figure 27: Mobi.E trademark[124]

The fundamental principles for MOBI.E modules were defined as follows:

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[122] Mobi.E (2009): Portuguese electric mobility programme, presentation file
[123] Mobi.E (2009): Portugal – showcase to the world, presentation file
[124] Mobi.E (2009): Portugal – showcase to the world, presentation file

- Focus on the user who is at the end of the pipe of the introduction of electric mobility, i.e. each Portuguese citizen
- A fair, advantageous and competitive pricing when compared to ICE vehicles
- Establishment of an open system, which allows every automotive manufacturer, every utility company and to each operator to join
- Integration of information, energy and financial fluxes
- Attraction of private investors
- National scale, anticipating multiplication of EVs, which is also shown in the fact that mainly Portuguese companies and institutes are involved in the project. Only Siemens and lately Oracle joined the project so far.[125]

The main tasks of MOBI.E and the other important players in the Portuguese system can be identified in Figure 28.

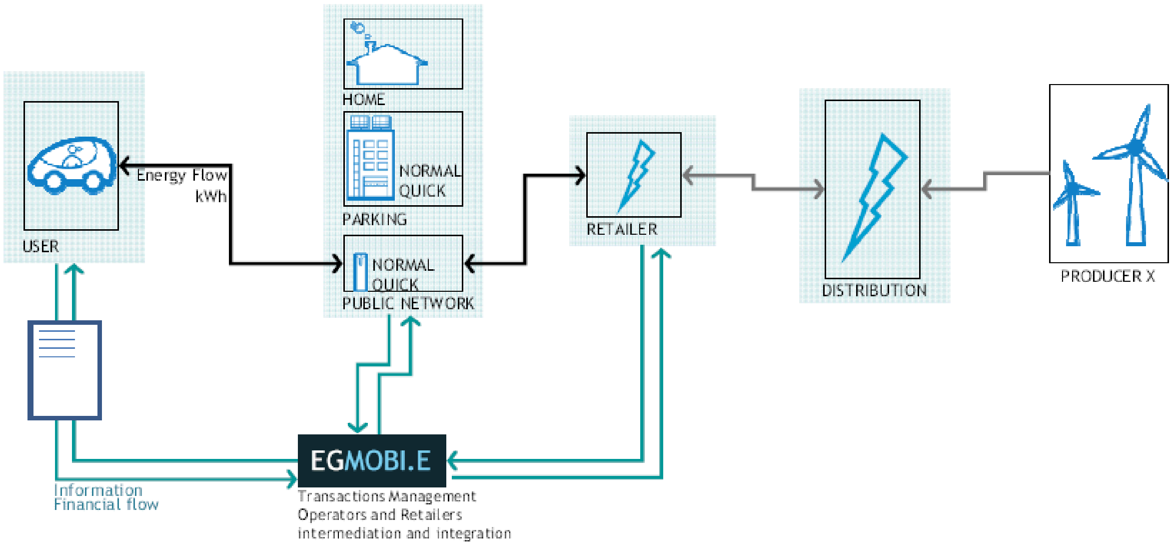

Figure 28: Who is Who in the Interoperable Model of MOBI.E[126]

As an operator, MOBI.E is obliged to establish the necessary charging infrastructure. It started this challenge in 2010 with a pilot infrastructure network which was rolled out in 25 municipalities (out of 300 nationwide) and the main highways. The pilot is financially supported by the National Strategic Framework and the charging points remain in the ownership of the municipalities to give them the chance to earn on concession contacts with other electric mobility operators. During 2011 the pilot areas are enlarged and in total 1,300

[125] Duarte Pacheco, F. (2009): Roadmap for electric mobility innovation in Portugal, presentation of Ministry of Economy and Innovation
[126] Dias, A. (2010): Portuguese Electric Mobility Program, presentation of Portuguese office for electric mobility (INTELI)

slow charge stations and 50 fast charge stations will be installed in streets, public parking lots, at service stations, airports, hotels and shopping centres.[127]

Other functionalities of MOBI.E to facilitate the clients´ use of the EVs are that the operator provides for the roaming between the electricity retailers, the service and billing including parking, public transport and domestic electricity, web based remotes for charging and real time management including status and vacancy information. In the evolution plan of MOBI.E more and more services and customized features will be introduced into the product portfolio supplemented by additional services related to vehicle-to-grid operations.[128]

4.4.4 Conclusion and Outlook

Portugal is the only country in Europe with direct involvement in the establishment of the charging infrastructure. The attempt with MOBI.E with a single brand, which is easy to recognize for the clients to create an open system which allows all electricity retailers, all car manufacturers and even other system operators to join is a very flexible approach, which at least gives a lot of opportunities to adopt the system in case of technological changes due to inventions. On the other hand, the roll-out of the infrastructure is for sure a huge investment, which is definitely a very controversial issue in times of increasing public debt especially in a country with huge debts like Portugal. The number of new registrations for the first half of 2011 with merely 93 electric vehicles, including 55 Nissan Leafs, shows that the investments of the government can still be defined as nothing more than strategic and the Portuguese public is, up to this point in time, not convinced by electric mobility.[129]

4.5 China

4.5.1 Overall Strategy of China

China, the country with the greatest population on earth and the fastest growing economy is also a leader in the development of electric mobility. Due to its enormous urbanization the demand for mobility in the cities is constantly growing and accompanied by increasing air pollution and enormous traffic congestion. Considering the fact that only two Chinese provinces have a density of cars per household higher than 20% and 29 out of 31 have less

[127] Dias, A. (2010): Portuguese Electric Mobility Program, presentation of Portuguese office for electric mobility (INTELI)
[128] Mobi.E (2009): Portuguese electric mobility programme, presentation file
[129] EURODAX statistics about new vehicle registration per June 2011

than 10%, the Chinese central government is getting more and more concerned about its ambitious goals for GHG decrease. The trend moves in a different direction: China has become - with a total amount of 14 million units sold - the world's number 1 car market and has overtaken the all time leader, the U.S.A.[130]

The concerns of the Chinese central government are not only caused by its environmental conscience but rather by economic reasons. Firstly, the country's oil consumption depends to more than 50% on oil imports, which could threaten the future economic growth rates. Secondly, the Chinese automotive sector is putting a lot of effort in the development of electric vehicles. The Chinese automotive sector produced 13.6 millions vehicles in 2009, which made China the largest car producing country worldwide. The by far biggest share of the produced vehicles is to satisfy domestic demand in China. And this demand has to be pleased despite all threats mentioned above, which means electric vehicles could be nice solution for the Chinese central government.[131]

Furthermore, the Chinese automotive industry is likely to profit from the shift from internal combustion engines towards electric propulsion, as there are a lot of barriers to overcome for Chinese manufacturers to produce high quality conventional vehicles to be able to compete on the global market. The situation in the production of EVs is slightly more favourable for the Chinese manufacturers. Surprisingly, it is not in particular the battery technology, which is the major advantage of Chinese producers: The Chinese battery manufacturers have set their focus on hand-made small batteries used in laptops or mobile phones but they cannot simply upscale to larger batteries used in vehicles, as manual production is not used in that segment anymore and the Chinese producers hold only 1% of the total patent registrations for lithium ion batteries. The major amount of patents is held by Japan, the US and South Korea, which are the countries with the largest budgets in R&D for this technology. The real advantage lies in the fact that China is the world's largest producer of rare earths. Rare earth materials, especially neodymium, contribute up to 30% to the material costs in the production of permanent magnet engines, which is the key motor type for EVs at the moment.[132]

[130] PwC Autofacts March 2011: China, PWC-report
[131] PRTM (2011): The China New Energy Vehicle programme, p. 12
[132] PRTM (2011): The China New Energy Vehicle programme, p. 12; Early, A. et al. (2011): Electric vehicles in the context of sustainable development in China, p. 2 following; Roland Berger Strategy Consultants (2009): Powertrain 2020, presentation p.22

Figure 29: BYD-E6-taxi-3 at EVS25 in Shenzhen[133]

Due to all these reasons the Chinese Central government started to think about the development of an electric bicycle and vehicle industry in 2001 when the "863 Electric-Drive Fuel Cell Vehicle Project" received an initial investment of approx EUR 93 millions. The name 863 is derived from the 3rd month of the year 1986, in which Deng Xiaoping launched the national high-tech development plan for the first time. As a consequence of this programme, China has become the largest producer and consumer of electric bicycles in the world. In 2009 China produced almost 24 million bicycles and had an overall number of 120 million bicycles driving on its street.[134]

In 2009 the central government of China enlarged its efforts for the implementation of electric vehicles with the "10 cities, 1.000 vehicles" program. The aim of the program was to stimulate the development with large-scale pilots in 10 major cities. The chosen cities were Beijing, Shenzhen, Shanghai, Jinan, Chongqing, Wuhan, Changchun, Hefei, Dalian and Hangzhou. The focus of the first introduction was on government fleet vehicles with predictable driving patterns such as buses, garbage trucks and taxis. Due to the promising results the program was quickly expanded to 10 other major Chinese cities. In June 2010 the program was finally extended from governmental fleets to include consumers in the cities of

[133] www.going-electric.org
[134] Early, A. et al. (2011): Electric vehicles in the context of sustainable development in China, p. 8 following

Shanghai, Changchun, Shenzhen, Hangzhou and Hefei. Initially the development of common national standards for charging infrastructure, vehicle charging methods, and charging network communication was not part of the 10 cities program and local approaches were developing. As a consequence, the different approaches were analyzed by the ministry of science and technology and a nationwide collaboration consisting of automotive sector and the infrastructure companies are now jointly developing a national standard for the charging method and connector both enabling AC and DC charging.[135]

Another strategic move of the Chinese central government is the enforcement of bilateral collaborations in the electric vehicle development. Together with the United States of America China has launched a Clean Energy Research Centre to collaborate on the introduction for standards in the electric vehicle development, on joint demonstration runs and a joint venture at the technological roadmap to identify common gaps in R&D. The Chinese government has also settled collaborations with several European countries in particular Germany, which can be seen at the show case in Beijing, where Volkswagen Golf-e are used or the Mini-e electric vehicle market research study carried out by BMW in China.[136]

All these strategic efforts combined with subsidies of approximately EUR 11 billion are expected to lead China to its strategic goal of having 500.000 EVs by 2012, 1 million by 2015 and 5 million by 2020.[137]

4.5.2 Individual Support Scheme

Out of the staggering amount of EUR 11 billion, approx. EUR 3.3 billion are dedicated to direct subsidies. The subsidy is based on the battery capacity, e.g. RMB 3,000 (EUR 350) per kWh. With this approach the Chinese central government allocates a maximum subsidy of EUR 7,000 for each purchase of a battery electric vehicle and EUR 5,800 for each plug-in hybrid electric vehicle. On the state level additional subsidies are possible, e.g. Beijing is granting the same amount like the national subsidy. Shanghai is subsidizing up to 20% of the purchase price with a maximum of EUR 2,300 for each plug-in hybrid and EUR 5,800 for each battery electric vehicle. Shenzhen is promoting plug-in hybrids with EUR 3,500 and battery vehicles with EUR 7,000 for each purchased unit. The only prerequisite for the subsidy of vehicles is local production.[138]

[135] PRTM (2011): The China New Energy Vehicle programme, p. 13
[136] Early, A. et al. (2011): Electric vehicles in the context of sustainable development in China, p. 10;
[137] Gissler, A. (2011): E-mobility in China – challenges and prerequisites, p.5
[138] Gissler, A. (2011): E-mobility in China – challenges and prerequisites, p.6

4.5.3 Show Cases

4.5.3.1 Beijing

The demonstration of electric vehicles in Beijing started as early as 2008, when the Olympic Games were held in the Chinese capital. The first vehicles were 50 buses with a battery exchange system and were able to run for a range of 130km with activated air conditions between the battery swaps. In 2010 another 50 buses with a capacity of 50 seats each produced by Zhongtong Bus Holding Co. Ltd. joined the fleet. These transit buses reach a maximum range of 200km and a maximum speed of 70kmh; the batteries are also exchanged with a battery swap system.

Figure 30: Beijing EV bus[139]

By 2010 Beijing had approx. 1,800 electric vehicles including 200 buses on its streets which where provided with 19 public charging stations. The vision of the city majors is to have 23,000 electric vehicles, 100 recharging stations and 36,000 rechargers at home in place.[140]

4.5.3.2 Shanghai

The ambitious goal of the organizers of the EXPO 2010 was to establish a transfer with 100% zero emission vehicles with the EXPO Park and the surrounding areas. A temporary fleet of 160 electric cars and 340 electric buses was installed. The system runs with a fast charging system, which works while the passengers jump on or off the bus. The test is constantly growing and already includes more than 1,000 vehicles in different areas of the city. In addition to the mentioned subsidies for each purchased vehicle, the city of Shanghai

[139] PRTM (2011): The China New Energy Vehicle programme, p. 14
[140] Early, A. et al. (2011): Electric vehicles in the context of sustainable development in China, p. 26

is also supporting the installation of charging infrastructure with EUR 350.000 or maximum of 20% of the investment costs. All electric vehicles are also exempt from the city toll fee.[141]

4.5.3.3 Shenzhen

The city is the home of BYD and because of that not only a leading city for the implementation of electric vehicles in China but also worldwide. The city has committed itself in the '10 cities, 1,000 vehicles' program to have 24,000 vehicles on the street by 2015. This number consists of 4,000 buses, 2,500 taxi vehicle, 2,500 vehicles used by public companies and 15,000 consumer EVs. Within the same time range, the city wants to have installed 22,750 public and semi-public charging poles, 25 electric bus fast swapping stations and 200 public access fast charging stations.[142]

4.5.3.4 Conclusion and Outlook

China is putting a lot of effort in the development of electric vehicles and this effort ends up in an enormous speed of change towards electric mobility which cannot be found elsewhere in the world. The subsidies are very generous and the number of new electric vehicles is accordingly high. The investments in the infrastructure are both for fast charging and battery swapping and the only drawback in this context is the missing overall national standard for charging infrastructure. All in all, China will remain the power engine for the global trend towards electric mobility with a huge domestic market. However, considering that the power generation mix in China consists of energy from old coal power plants, the zero emission target of the electric vehicle can only be fulfilled if the energy mix is altered to renewable energies.

4.6 The USA

4.6.1 Overall Strategy of the USA

In March 2009, the aftermath of the global economic crisis caused by the bankruptcy of Lehman Brothers, president Obama declared the goal of putting 1 million plug-in hybrids on the street until 2015 and dedicated over USD 4 billion to the design, manufacture and purchase of these vehicles. This huge budget is embedded in the enormous amount of USD 25 billion which is dedicated to the Advanced Technology Vehicle Manufacturing Loan

[141] Gissler, A. (2011): E-mobility in China – challenges and prerequisites, p.8
[142] Early, R. et al. (2011): Electric vehicles in the context of sustainable development in China, p. 27

Program, authorized by Congress. The program is designed to support the development of vehicles and technologies that increase U.S. energy independence, create cleaner ways of transportation and support the American economy. The program has encouraged Nissan, Ford and GM to invest into battery technologies and alternative propulsion technologies. For example the Nissan assembly plant in Tennessee received a USD 1.4 billion loan and adopted its facilities to the production of the Nissan Leaf. The plant will start its production in 2012 and will have a capacity to build 150,000 electric cars and 200,000 lithium-ion battery packs per year and employ 1,300 people.[143]

Ten years after the controversial withdrawal of the EV-1 by General Motors, the Obama administration announced two electric vehicle programs as part of the American Recovery and Reinvestment Act, a program to stimulate the troubled American automotive industry after the crisis. The U.S. Department of Energy released USD 2.4 billion in grants for electric vehicle development and USD 400 million for demonstration projects and evaluation of plug-in hybrids. Another USD 54 million were prepared for tax credits on alternative refuelling property, including charging and USD 100 million grants were dedicated as a grant for the 5-City “EV Project” infrastructure installation, as described later on.[144]

13 years after the introduction of the still controversial Zero Emission Mandate by the CARB in California President Obama announced in May 2009 new standards for vehicle emissions and fuel economy. The expectations for new cars and light trucks sold in the U.S. by 2016, is that the vehicles are 30% cleaner and more fuel efficient. Several states have already followed the example of California and have introduced CARB regulations with fixed requirements for plug-in electric vehicles and combined with financial incentives. These states and their bigger cities, typically on the West and East coast, will see the first wave of vehicle electrification in America.[145]

The Obama administration is not only paving the way towards electric vehicles with dedicating budgets and setting up regulations but also going ahead as a role model: The U.S. General Services Administration bought the first 116 plug-in electric vehicles for federal fleet in May 2011. The 101 Chevrolet Volts, 10 Nissan Leafs and 5 Think City EVs will be leased to 20 agencies including the Energy Department, the Treasury Department and the Navy in five cities (Detroit, Washington, Los Angeles, San Diego and San Francisco. This is

[143] Roland Berger Strategy Consultants (2010): PEV Readiness Study, p.3; PRTM (2011): The China New Energy Vehicle programme, p. 17; Addison, J. (2010): Nissan Tennessee plant capacity = 150,000 electric cars per year, article on www.cleanfleetreport.com
[144] PRTM (2011): The China New Energy Vehicle programme, p. 17
[145] plaNYC (2010): Exploring electric vehicle adoption in New York City, p.7;Roland Berger Strategy Consultants (2010): PEV Readiness Study, p.5

the first step towards the ambitious goal of having only alternative fuels vehicles purchased by the federal government from 2015 onwards.[146]

Figure 31: The Chevrolet Volt[147]

4.6.2 Individual Support Schemes

The Federal government has also prepared a budget of USD 2 billion for different tax credits per type of electric vehicle:

Table 8: Federal tax credits for different vehicle types[148]

Type of vehicle	Tax credit in USD	
Electric vehicles	Battery size of 4 kWh	USD 2,500
	From 4 kWh up to 16 kWh	USD 417
	16 kWh and larger	USD 7,500
Electric 2- or 3-wheelers	10% of purchase price (max. USD 2,500)	
Conversion vehicles (PHEVs)	10% of purchase price (max. USD 4,000)	

In addition to the tax incentives for the vehicles the federal administration also grants tax credits on EV charge stations:

146 Roland, N. (2011): U.S. government to buy 101 Chevrolet Volts, 10 Nissan Leafs and 5 Think City EVs, article on www.autoweek.com
147 Picture from www.autoweek.com
148 U.S. Department of Energy (2009): Federal Incentives, published on www.afdc.energy.gov ; California Energy Centre (2011): The clean vehicle rebate project in California, published on www.energycenter.org

Table 9: Federal tax credits for EV charge station[149]

Applicant	tax credit for EV charge station in USD
consumer	30% of purchase price (max. USD 1,000)
businesses	30% of purchase price (max. USD 30,000)

In February 2011, the Obama administration proposed with its budget 2012 to transform the existing USD 7,500 tax credit for electric vehicles into a rebate that is available for all consumers immediately when purchasing the vehicle. It seems that in the United States of America the larger portion of incentives is done on a national level, but also several states have their own incentive regulations which are working on top of the national regulations.[150]

Table 10: Overview on state incentives (as of June 2011)[151]

STATE	incentive amount or rate	rebate or income tax benefit	sales tax exemption	conversions included	carpool lane access	infrastructure incentives
Arizona					yes	
California	up to USD 2,500				yes	yes
Colorado	up to USD 6,000	yes				
Connecticut			in progress			
District of Colombia		yes				
Florida				yes	yes	
Georgia	up to USD 5,000	yes			yes	
Hawaii	up to USD 4,500	yes			in progress	yes
Illinois	up to USD 4,000	yes		yes		yes
Louisiana	up to USD 3,000	yes		yes		yes
Maryland	up to USD 3,000	yes				yes
Massachusetts			in progress		in progress	
Montana	up to USD 500			yes		
Nebraska						
New Jersey	up to USD 4,000		yes		yes	
New York			in progress		in progress	

149 U.S. Department of Energy (2009): Federal Incentives, published on www.afdc.energy.gov
150 Article published on www.greencarcongress.com
151 Overview published on www.pluginamerica.org

Oregon	up to USD 5,000	yes		yes		
Pennsylvania			in progress			in progress
South Carolina	up to USD 1,500	yes				
Texas		in progress	in progress			
Utah	up to USD 2,500	yes		yes	yes	
Washington			yes			yes
West Virginia	up to USD 7,500	yes		yes		

In California, for example, the Clean Vehicle Rebate Project is funded with USD 15 million for the years 2011 and 2012 to promote electric, plug-in hybrid electric and fuel cell vehicles, depending on the range of the vehicle, with a rebate up to USD 2,500. The preconditions are that the vehicle is new and the applicant for the rebate keeps or leases the vehicle for a minimum of 36 months. The program is a successor to the alternative fuels program which is in force since 2008 in California and both programmes have in common that the funding is very well accepted and used by the Californian inhabitants.[152]

On the contrary, New York City is following a completely other direction. Despite its ambitious strategy to reduce the City's GHG emissions in 2030 by 30% from 2005 levels, which means a reduction of 44% for emissions coming from transportation, the administration is following the findings of a survey carried out by McKinsey & Company. The survey shows that there is a potential large group of early adopters in NYC, so the demand will outstrip the available vehicles and those early adopters will go for the purchase of an electric vehicle with or without a financial rebate or tax credit. Even a well established charging infrastructure is, at the first stage, not relevant for the early adopters as they will adjust their parking behaviour to the vehicle's demands. According to the survey the only thing which is important for the early adopters is that the vehicle is trendy and definitely recognizable as an electric vehicle.[153]

[152] California Energy Centre (2011): The clean vehicle rebate project in California, published on www.energycenter.org
[153] plaNYC (2010): Exploring electric vehicle adoption in New York City, p.4 following

4.6.3 Show cases

4.6.3.1 The EV Project

On 5th August, 2009 the project leading company ECOtality was awarded with a USD 100 million dollar grant from the U.S. Department of Energy. ECOtality is a San Francisco based company specialized in the research, development and testing of advanced transportation and energy systems for PHEV, FCEV and BEV. The project, which was officially launched in October 2009 is called “The EV Project” and is the largest deployment of electric vehicles and charge infrastructure in the U.S. In June 2010 the project received another USD 15 million from the U.S. Department of Energy and with the contribution of all the partners the total value of the project is approx. USD 230 million.[154]

Figure 32: The EV Project trademark[155]

ECOtality together with its more than 60 partners is installing approximately 14,000 Level 2 chargers and 400 DC chargers for fast charging in 18 major cities and metropolitan areas located in six states (California, Oregon, Washington, Arizona, Texas, Tennessee and in capital Washington in the district of Columbia. The infrastructure system will be installed in all bigger cities of the West Coast from Seattle to San Diego, in Dallas, Houston and Memphis. Chevrolet and Nissan North America are partners in the project and provide 5,700 Nissan Leafs and 2,600 Chevrolet Volts to the testing persons, who receive a residential charger and most of the installation for free.[156]

The driving and charging data of the test drivers are collected and analyzed to obtain an overall picture of the vehicles and the charging infrastructure during the project period of 36 months and the project also tries out different revenue systems for commercial and public charging infrastructure. The lessons learned from that project should enable an exact deployment of the infrastructure for the next 5 million EVs.[157]

[154] www.theevproject.com
[155] www.theevproject.com
[156] www.theevproject.com
[157] www.theevproject.com

4.6.3.2 The San Francisco Bay Initiative (part of "The EV Project")

The San Francisco Bay area with its already 8,000 electric vehicles can be defined as America's leading region in the deployment of electric vehicles. The area with its major cities San Francisco, Palo Alto, Berkeley and San Jose has approx. 7 million inhabitants and covers its energy demand to an extent of more than 20% from renewable sources such as wind, hydropower, solar or geothermal. Coal plants are not allowed in the Bay area. To provide the area's electric vehicle owners with an appropriate charging infrastructure, an additional 5,000 electric car charging stations from the EV Project will be installed in public and private areas and on top of that 50 fast chargers will be deployed along the highways.[158]

4.6.3.3 Charge Up L.A.!

Another partial spin-off project of "the EV Project has been realized in Los Angeles since May 2011. The Los Angeles Department of Water & Power (LADWP) has launched a pilot program that will provide rebates of up to USD 2,000 to the first 1,000 LADWP customers for home chargers (Level 2) and installation costs for their electric vehicles. The project is named Charge Up LA and should provide rebates for 3,000 to 5,000 EV home chargers. LADWP is also offering special tariffs "residential time-of-use rate" to their charger customers, which provides a significant discount for charging during "off-peak" hours during night and on weekends. The LADWP will track the EV charging patterns to get experience in the charging behaviour and of course to prevent an overstraining of the grid.[159]

Figure 33: Charge up L.A.! trademark[160]

[158] Addison, J. (2010): 5,050 electric car charging stations for SF bay, article on www.cleanfleetreport.com
[159] www.ladwp.com/ev
[160] www.ladwp.com/ev

The LADWP's EV strategy also includes collaboration with the major EV charger vendors such as "the EV project" to draw additional federal grant funds to the city. In addition to that the utility company will continuously upgrade the 86 existing public chargers in L.A. and install several new charging spots throughout the city area. It is also part of the project to inform the public with the help of a website and to start regional collaboration with agencies and industries to enforce the implementation of electric vehicles. Last but not least the city authorities have decided a new pilot program for the metropolitan transport authority to add 30 electric busses to the inner city bus fleet.[161]

4.6.3.4 Conclusion and Outlook

After the world economic crisis the Obama Administration has discovered renewable energies and the electrification of the vehicles as new technologies to stimulate the weakened American economy, especially the automotive sector. The budget released for the technological change in the automotive industry, the establishment of battery industry to serve both the PHEV and the BEV and last but not least budgets for charging infrastructure and pilot programs such as "the EV project". It can be expected that the front runner states like California with its CARB based zero emission mandate will continue their investments and as soon as electric mobility will become a trend, the United States will become of course dedicated followers of the new electric mobility.

[161] www.ladwp.com/ev

5 Comparison of the different approaches of the six analyzed countries

5.1 Overview of the actions of the six analyzed countries

As described in the previous chapter the countries have chosen their strategies for the implementation of electric vehicles. There are some similarities, but still each country has its individual approach. Table 11 shall outline these approaches and make them comparable on the first sight. The table discerns federal incentives for individuals and governmental initiatives and supports for projects, business models and last but not least a strategic support for a systematic implementation. While the individual support can be classified as a not very complex way of support, the projects are for sure more demanding in the setup. The most challenging action for a government is definitely the strategic support for a system implementation. This challenge can be eased a little by outsourcing the system implementation to an operator.

Table 11: CO_2 effect of the use of electric vehicles

Actions	support for individuals			support for projects and systematic		
Countries	**financial incentives for EVs**	**financial incentives for charging points**	**non-financial incentives for the use of EVs**	**show cases**	**R&D projects**	**business model or countrywide systematic approach**
Austria	***yes***	***yes***	***no***	***yes***	***yes***	***no***
comments:	*only for companies and public entities BUT exception from tax on emission and insurance tax on power range*	*only for companies and public entities*	*BUT: free of charge parking in Graz*	*5 model regions*	*mobility flagship projects*	*BUT: initiatives like e-connected and inter ministerial working groups*
Germany	***no***	***no***	***no***	***no***	***yes***	***yes***
comments:	*only small regional initiatives on project level*	*only small regional initiatives on project level*	*only small regional initiatives on project level*	*not started (5 show cases are supposed to start in 2012)*	*8 model regions*	*national platform for electric mobility is supporting the government in their actions*
Denmark	***yes***	***yes***	***yes***	***yes***	***yes***	***yes***
comments:	*registration tax, road taxes vehicle excise duty etc.*	*co-financing of recharging stations*	*regional initiatives e.g. free of charge parking in Copenhagen*	ChoosEV	*EDISON*	*support of business model BETTER PLACE*
Portugal	***yes***	***yes***	***yes***	***yes***	***no***	***yes***
comments:	*cash for clunkers program until 2012*	*within the scope of Mobi.E*	*free of charge parking and usage of bus lanes*	within the scope of Mobi.E	*partially within the scope of Mobi.E*	*government initiated business modell project Mobi.E*

Actions	support for individuals			support for projects and systematic		
Countries	financial incentives for EVs	financial incentives for charging points	non-financial incentives for the use of EVs	show cases	R&D projects	business model or countrywide systematic approach
China	***yes***	***yes***	***no***	***yes***	***no***	***yes***
comments	*on governmental and regional level*	*on governmental and regional level*	*BUT: free of city toll fee in Shanghai*	*10 cities - 1,000 vehicles program*	*partially within the scope of the show cases*	*program 863 & 10 cities - 1,000 vehicles projects, but also no standards in charging infrastructure*
USA	***yes***	***yes***	***no***	***yes***	***no***	***no***
comments	*on federal level and in several states*	*on federal level and in several states*	*BUT: car pool lane access in several states*	*The EV project and smaller regional projects*	*R&D funding but no visible projects*	*no visible initiative on top of the funding*

The only two countries in this comparison with a 100% in the range of activities are Denmark and Portugal, but the realization of their strategy is very time intensive. Germany is completely neglecting the support for individuals, but as the country is still in a market preparation phase it is not entirely important to have individual support. Austria and the United States share the position of not having a clear overall strategy for system implementation on a national level, but Austria has at least started a discussion about it and due to its size the country is depending on the developments on the European level. China is pushing in all directions to scale fast with the number of vehicles and charging points, but despite the centralized strategy development of an overall standard for the charging infrastructure is sill lacking (in particular the development of one Chinese charging plug has only just started). Currently a ranking out of the six analyzed countries based on the actions set cannot be made as the actions are still too young for correct conclusion.

5.2 Comparison of the charging infrastructure in the six analyzed countries

A comparison of the charging infrastructure of the six analysed countries is almost impossible as not enough reliable data is available. Nevertheless Table 12 tries to give an overview about the existing numbers of charging points in the projects described in chapter 4 and the target figures of these projects. In addition, the availability of advanced charging system like fast charging or battery switching stations is displayed. The last column outlines the standardization of the charging infrastructure, the possibility of roaming between the different infrastructures in use and the coverage of the country with sufficient charging points.

Table 12: Comparison of the charging infrastructure

Countries	charging points in projects		advanced charging systems	standardization & coverage
	existing	planned		
Austria	***130***	***150***	***no***	***no***
comments:	*figures from the model regions*	*figures from the model regions*		*no standards and roaming; coverage within project areas*
Germany	***1,264***	***n/a***	***no***	***no***

comments:	*figures from the model regions*			*no standards and roaming; coverage within project areas*
Denmark	***n/a***	***n/a***	***yes***	***yes***
comments:			*1 installed battery swapping station by Better Place; 19 more to be installed*	*standards, roaming and coverage within Better Place roll-out areas*
Portugal	***1,300***	***20,000***	***yes***	***yes***
comments:		*figures from the Mobi.E project*	*50 installed fast charging stations, 550 more to be installed*	*Mobi.E project is providing common standard, roaming and a good coverage*
China	***400***	***58,750***	***yes***	***no***
comments	*number of charging stations in Shanghai*	*plan figures for the cities Beijing and Shenzen*	*325 fast charging stations will be installed in Beijing and Shenzen*	*standardization is not yet available; coverage*
USA	***n/a***	***14,000***	***yes***	***yes***
comments		*in states participating at the EV project*	*400 DC fast charging stations will be installed in states participating at the EV project*	*no standards and roaming so far; the cities within the EV project are very well covered.*

This comparison shows the impressive numbers of planned charging points in China and the United States, but what is even more important on the long run is the availability of advanced charging system and roaming systems with a good coverage all over the country in Denmark and Portugal. The United States also have DC charging and a good coverage with one system, but only in the few states, which are already enrolling the EV project. In terms of infrastructure, the United States will, anyway, face the problem of weak grid network connections for a countrywide standardization. Austria and Germany are definitely standing at the end of the row in terms of infrastructure. Both countries have only good coverage of charging infrastructure in their model regions (in Austria only in the older projects in Vorarlberg and Salzburg). Although there are several regional initiatives to install charging points, there will be no roaming or standardization implemented in the short run. Both countries also have not decided about their strategy for advanced charging, but most likely it will be a fast charging system in both countries. China also has not yet decided which will be the advanced system all over the country, but at least there is a development visible concerning standardization and roaming for China.

5.3 Comparison of the amount of electric vehicles in the six analyzed countries

Concerning the EVs on the roads Table 13 outlines the number of EVs in the specific projects, the number of EVs registered in the first half of 2011 compared to the overall amount of newly registered vehicles in the same period. The target amounts announced by the governments of the countries analyzed are displayed as well.

Table 13: Comparison of electric vehicles

	Total number of EVs in projects	**number of EVs in projects**	**target amount of EVs**	**new registrations of EVs in 2011[162]**	**overall new registrations of vehicles in 2011[160]**	**in %**
Countries	**existing**	**planned**				
Austria	***394***	***2.019***	***250.000***	***326***	***187.267***	***0,2%***
comments:	*model regions*	*model regions & technical flagship projects*	*BEV & PHEV by the year 2020*			
Germany	***756***	***n/a***	***1.000.000***	***1.162***	***1.621.417***	***0,1%***
comments:	*in the 8 model regions*		*BEV by the year 2020*			
Denmark	***n/a***	***1.300***	***500.000***	***283***	***88.438***	***0,3%***
comments:		*300 EVs from ChoosEV & 1,000 for Better Place*	*BEV by the year 2020*			
Portugal	***n/a***	***n/a***	***180.000***	***93***	***91.822***	***0,1%***
comments:			*BEV by the year 2020*			
China	***2.800***	***47.000***	***5.000.000***	***n/a***	***9.218.300***	***n/a***
comments	*in the cities of Beijing & Shanghai*	*planned numbers for Beijing & Shenzen*	*BEV by the year 2020*			
USA	***n/a***	***8.400***	***1.000.000***	***n/a***	***8.464.450***	***n/a***

[162] EURODAX statistics about new vehicle registration per June 2011

comments		*planned numbers for the EV project*	*BEV & PHEV by the year 2015*			

In terms of vehicles, the existing model regions in Austria and Germany are really dominating the introduction of the EVs in both countries and if compared to the newly registered EVs it is obvious that apart from the model regions sales of EVs are not significant in both countries. In terms of ambitious projects, China and the US are clearly leading the pack; the same is true for the target figures announced by the governments.

Germany and Austria are leading the ranking for the newly registered EVs in the first half of 2011 which can be explained with the good established model regions. Denmark is following suit with the largest range of subsidies and non-financial incentives and Portugal is surprisingly at the end of the ranking. However, in relation to the overall newly registered personal vehicles, the amount of EVs is insignificant in all analyzed countries. The reason for this trend could be the high purchase prices and the known obstacles of EVs, which make the people doubt about the future of electric mobility.

5.4 Comparison of the expenditures in electric mobility of the six analyzed countries

Table 14 shows the budgets dedicated to electric mobility of the analyzed countries. As precise amounts cannot be stated there is a range of a minimum and maximum amount which is available in each of the countries. These amounts are compared to the countries´ GDP values and put into a relation to the GDP amount to draw further conclusions.

Table 14: Comparison of the expenditures in the electric mobility

Countries	**budget for electric mobility (in million EUR)**		**GDP per 2010 (in million EUR)[163]**	**in %**	**in %**
	minimum	**maximum**		**minimum**	**maximum**
Austria	***40***	***55***	***281.516***	***0,01%***	***0,02%***
comments:	*excluding subsidies*	*including subsidies*			
Germany	***130***	***1.000***	***2.476.926***	***0,01%***	***0,04%***

[163] www.data.worldbank.com

comments:	*budget of the model regions*	*budget dedicated to show cases for electric mobility*			
Denmark	***14***	***117***	***232.304***	***0,01%***	***0,05%***
comments:	*budget for subsidies and projects excluding BETTER PLACE*	*budget for subsidies and projects including BETTER PLACE*			
Portugal	***n/a***	***n/a***	***171.036***	***n/a***	***n/a***
comments:					
China	***11.000***	***11.000***	***4.399.513***	***0,25%***	***0,25%***
comments	*budget for electric mobility of the Chinese Central government*				
USA	***4.000***	***4.000***	***10.913.336***	***0,04%***	***0,04%***
comments	*budget of all federal subsidies and the EV Project*				

By far the largest budget is reserved by the Chinese Central government for the development of electric mobility. The budgets of the USA and Germany are also significant, but can be explained with the strong automotive sectors in both countries which need funding for R&D and projects for testing their products. The reason for the huge gap between the minimum and maximum amount in Germany is the budget of approx. EUR 1 billion which is supposed to be reserved for the implementation of the five show cases in 2012. A similar gap exists also in Denmark, but the reason is the budget for the Better Place implementation which is made by DONG, the state owned utility company. The Austrian budget is, compared to the other countries, smaller but it has a similar figure in relation to the Austrian GDP as the budgets of the other countries.

5.5 CO_2 effect of the use of electric vehicle in the six analyzed countries

In Table 15 the real CO_2 effects of a widespread implementation of electric mobility is shown. Table 15 compares the CO_2 emission of the best selling vehicles as published by the manufacturer or according to a public homepage for the CO_2 emissions of vehicles of each country with a Citroen C-Zero, an electric vehicle currently available worldwide. The CO_2 footprint of the electric vehicle is calculated with the energy mix of each country and the average energy consumption of the Citroen C-Zero per 100 kilometers (16 kWh per 100 kilometers). To make the amounts of the emissions more transparent the annual emissions of the conventional cars and the C-Zero are calculated based on an annual mileage of 15,000 kilometers for the ICE vehicle and the EV. The savings are coming from the difference between the ICE vehicle and the C-Zero.

For battery electric vehicle CO_2 emissions are calculated as:

$$CO_{2\_EV} = f_{conv\_ele} \cdot FI_{EV} \cdot vkm \qquad (1)$$

Where

CO_{2_EV}……CO_2 emissions of electric vehicle [gCO_2/yr]

f_{conv_ele}…….conversion factor [gCO_2/kWh]

FI_{EV}………..fuel intensity of electric vehicles [kWh]

vkm………vehicle kilometre driven per year [km/yr]

For ICE vehicle is calculated as follow:

$$CO_{2\_ICE} = f_{ICE} \cdot vkm \qquad (2)$$

f_{ICE}……CO_2 emissions of ICE vehicle per km driven [gCO_2/km]

CO_2 savings due to the switch to electric vehicle is calculated as:

$$CO_{2\_saving} = CO_{2\_ICE} - CO_{2\_EV} \qquad (3)$$

For example the calculation for Austria is as follows: 183 grams CO_2 per produced kWh multiplied with 16 kWh (energy consumption of the Citroen C-Zero per 100 kilometers) multiplied with 15,000 kilometers per year and divided with 100 (as the energy consumption of the EV is stated in 16 kWh per 100 kilometers). The result of 439,200 grams CO_2 emission per year is compared with the 1,770,000 grams CO_2 emission of the ICE vehicle (118 grams CO_2 emission multiplied with 15,000 annual mileage of the ICE) and results in a potential saving of 1,330,800 grams CO_2 emission per year (see also Table 15).

The country with the highest savings is Portugal, even though the bestselling conventional vehicle's CO_2 emissions are quite high, as the country has a favorable energy mix. The Austrian energy mix with a high percentage of hydro power also allows a very big saving effect compared to Germany. As both countries have the same best selling car with a quite good CO_2 emission rate, the savings are completely depending on the energy mixes of the two countries. The CO_2 savings of Denmark and the United States of America are very close to each other, but due to completely different reasons. While Denmark has a nice savings effect due to its high percentage of wind power and other renewable energies even tough the conventional car is the one car with the lowest emissions of the comparison, the United States is having these savings because of the conventional vehicle, which is a pick up with high emission values and despite its relatively high CO_2 emissions in the energy mix due to fossil fuels. Last and least country in this ranking is China which is even creating more CO_2 emissions with electric mobility due to its highly polluting energy mix. These results show very clearly, that the CO_2 savings of each country in electric mobility are closely linked to the energy mix and the future energy strategy of each country. As a consequence, the full effect of the electric mobility can only be achieved with a clear strategy for the enforcement of renewable energies.

Table 15: CO_2 effect of the use of electric vehicles

	bestselling personal vehicle in 2010	CO_2 emission (gram per kilometre)[164]	CO_2 emission per ICE vehicle per year (in grams)	CO_2 emission per produced kWh (in grams)[165]	CO_2 footprint per BEV per year (in grams)	CO_2 savings per vehicle & year (in grams)
Austria	***VW Golf VI***	***118***	***1.770.000***	***183***	***439.200***	***-1.330.800***
comments:	*source:www.datafact.com*					
Germany	***VW Golf VI***	***129***	***1.935.000***	***441***	***1.058.400***	***-876.600***
comments:	*source: www.autobild.de*					
Denmark	***Toyota Aygo***	***105***	***1.575.000***	***308***	***739.200***	***-835.800***
comments:	*source: http://bestsellingcarsblog.com/category/denmark*					
Portugal	***Renault Megane***	***159***	***2.385.000***	***384***	***921.600***	***-1.463.400***
comments:	*source: http://bestsellingcarsblog.com/category/portugal*					
China	***VW Lavida***	***109***	***1.635.000***	***745***	***1.788.000***	***153.000***
comments	*source: www.globaltimes.cn*					
USA	***Ford F-Series***	***140***	***2.100.000***	***535***	***1.284.000***	***-816.000***
comments	*source: http://blogs.cars.com/kickingtires/2011/01/top-10-best-selling-cars-of-2010.html*					

[164] www.autoverbrauch.at
[165] IEA: Key World Energy Statistics 2010, p.108 following

6 Conclusion

The analysis and the comparison of the six countries have shown that there are some efforts going on to support electric mobility in its progress. Regarding the hype which is generated around the topic of electric mobility, the actual figures in all six countries - which are nevertheless a very good sample for electric pioneers - are rather depressing. The following explanations can be put forward:

- The initiatives have just started or running just several months. The first movers have been activated and first learning lessons in the charging infrastructure are made. But in general it is still too early to make a serious conclusion which subvention program of which country is the most successful one. This fact is also visible in the big variety of different actions set by the government starting from R&D projects, show cases, partial subsidies for individuals and communications of strategies. All these actions are definitely necessary to get things started but also have the negative effect of losing the focus. At the end of the day the amounts invested in electric mobility of each country are huge but far away of being enormous so it can be argued that the governments also wait for the further development.

- The automotive sector on the other hand is waiting for the big subsidies and investment programs to allocate their electric vehicles in those markets with the highest probability of success. And those contingents are definitely high: The worldwide production of battery electric vehicles for 2011 is estimated to be approximately 100,000 units which represent not more than 0.14% of the overall vehicle production worldwide. This creates a vicious circle as the governments are waiting for clear statements and enough electric vehicles coming from the automotive sector and the automotive sector is waiting for governments to enable the infrastructure and fix the regulations to allow a mass market for electric vehicle, which means also significant production scales for the automotive sector. This situation is currently not stimulating the introduction of electric mobility, but it will be hopefully resolved within the next 2 years when more car manufacturers will enter the market.[166]

[166] Dudenhöffer, F. (2011): Electric mobility – a market for tomorrow, in: persönlich 5/2011, p. 20-23 translated

- Together with the bigger tickets in production the next steps in technology will be made. This means on the one hand that the vehicles will become easier to handle for the clients but on the other hand that the current available vehicles will be outdated quite fast. This situation is blocking the introduction too, as clients (in particular clients with large fleets) and also governments are waiting for further developments and are scared to invest into vehicles right now and create sunk costs. In this context it is easier for governments to subsidize R&D projects compared to show cases and individual support schemes which create public awareness.

- The fast development constraints also another field which is core business for governments. The electric mobility is still lacking standardization and the governments are overstrained with the information they are receiving from the different involved parties. As long as there are no standards for the charging plugs and the charging infrastructure all investments could run into the danger of being completely jeopardized by future developments. Investments such as the introduction of battery swapping stations invented by Better Place or fast charging stations are very costly and considering the missing standards it is clear that the initiatives will not leave prototype project status. At the end of the day the customer is paying the bill as he is not receiving the proper solution for his money: he will not be able to rely on a large charging infrastructure with simple payment modalities and roaming in an international context is not visible in the near future. This creates limitation for interested clients and reduces the interest into the new technology.

- The fist experiences from the show cases show that there is a need for a missing link between the automotive sector, the energy sector and the supporting governments for an appropriate implementation of electric mobility. This so called mobility provider is tested in Portugal with the Mobi.E project, the EV Project in the USA or The Mobility House in Austria, but the most prominent example is Better Place with its business concept. These and new players will be the real driving forces for the mass market in electric mobility. They will create products for the different needs of end clients with new value chains and stimulate new added values for clients, which is definitely missing right now. As long as there is no feasible product which accommodates the need of the clients and gives them an economical advantages the introduction of electric mobility will be restricted to test projects and prototype systems.

- Electric mobility is just one of the new technologies approaching the people right now. In earlier days there was the decision between gasoline and diesel as a fuel, but today due to alternative fuels there is a wide range of technologies entering the market starting from bio fuels, natural gas and the hybridization of the power train and the fuel cell based on hydrogen. These techniques are opens new ways apart from fossil fuels depending on oil. On the other hand the conventional ICE vehicles are being offered with new fuel saving engines and modes such as start-stop hybrids. This variety of possibilities could confuse the customer and could lead him to stay with the well known technologies. In reality several systems existing in parallel can be expected in the future and electric vehicles will be among them. Considering the political strategies for mobility in 2050 for example the White Paper on Transport by the European Commission the overall target is to reduce the overall GHG emission from transport with 60% compared to the level of 1990 and one of the action goals is to halve the use of conventional ICE vehicles in urban transport by 2030 and to have none of them by 2050.[167] To achieve this ambitious benchmark it is necessary to rely on all alternative propulsion systems in particular on electric engines. As a conclusion the alternative propulsion systems are not opposing each other, but are necessary to minimize the future share of fossil fuels in transport.

- Electric mobility is often seen in combination with public transportation and also as an integral part of intermodal switch in mobility. It is absolute justified to use electric vehicles as door opener for public transportation and to connect the vehicle with other upcoming trends like car sharing, but this means quite a big change in the mindset of people and this development will for sure need more time, maybe even one generation to erase the dogma of having an own car to stay flexible and individual.

Electric mobility is still in the beginning of its development. Countries which are already engaging themselves into the topic show at least the ambition to deal with one of the major problems of the near future. To keep the level of mobility for people high despite necessary CO_2 reductions will be a big issue for all countries. The next years will show which country has prepared itself best for the upcoming changes and if electric mobility will enter mass markets around 2017 or 2018 it will be clear which country has done its homework best.

[167] The European Commission (2011): White paper – roadmap to a single European transport area, p.9

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