MSc Program
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Political, legal and economic factors influencing the development of e-mobility

Master Thesis zur Erlangung des akademischen Grades
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Wien, 11.09.2013

Affidavit

I, **MAG. ALFRED MELAMED**, hereby declare

1. that I am the sole author of the present Master's Thesis, "Political, legal and economic factors influencing the development of e-mobility", 80 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted this Master's Thesis as an examination paper in any form in Austria or abroad.

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Abstract

The technological progress in the last decades caused a huge jump in the level of transport services. Due to this development and the dominant use of fossil fuels, the transport sector contributes to a large extent to worldwide greenhouse gas emissions causing global warming.

In order to fight global warming it is therefore obvious, that a change towards sustainable transport solutions has to take place. As a result of the higher efficiency of their engines, electric vehicles are deemed to be the key technology for sustainable transport in the future.

Due to higher cost of ownership, technological limitations such as the limited range and the missing charging infrastructure, however, the annual sales of electric vehicles are far below 1%. Considering the even lower stock of electric vehicles the ecological impact is still almost not measurable.

The global scenarios and roadmaps show the potential development of electric vehicles. In order to reach these targets countries have to make a huge effort in providing an optimal framework for the development of this new technology.

Beside the technical limitations, political, legal and economic barriers have to be overcome. Within this paper the political, legal and economic key factors to be considered when developing strategies for e-mobility are analysed.

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List of abbreviations and symbols

AIT .... *Austrian Institute of Technology*
aws .... *Austria Wirtschaftsservice*
BCG .... *Boston Consulting Group*
BEV .... *battery electric vehicle*
BMF .... *Ministry of Finance*
BMLFUW .... *Ministry for Agriculture, Forestry, Environment and Water Management.*
BMVIT .... *Ministry for Transport, Innovation and Technology*
BMW_F .... *Ministry of Science and Research*
BMWFJ .... *Ministry of Economy, Family and Youth*
CCS .... *carbon capture and storage*
CDM .... *Clean Development Mechanism*
CO .... *carbon monoxide*
CO2 .... *carbon dioxide*
CV .... *Commercial Vehicles*
CWP .... *Commission work program*
DG .... *Directorates-General*
EACI .... *Executive Agency for Competitiveness and Innovation*
EC .... *European Commission*
EDGAR .... *Emission Database for Global Atmospheric Research*
EERP .... *European Economic Recovery Plan*
EIB .... *European Investment Bank*
EMPORA .... *E-Mobile Power Austria*
EPoSS .... *European Technology Platform on Smart Systems Integration*
ERTRAC .... *European Road Transport Research Advisory Council*
ETP .... *European Technology Platforms*
EU .... *European Union*
EV .... *electric vehicle*
EVI .... *Electric Vehicles Initiative*
FFE .... *Forschungsstelle für Energiewirtschaft*
FFG .... *Forschungsförderungsgesellschaft*
FWF .... *Fonds zur Förderung der wissenschaftlichen Forschung*
GBER .... *General Block Exemptions Regulations*
GDP .... *Gross domestic product*
GHG .... *Greenhouse Gas*
ICEV .... *internal combustion engine vehicle*

ICT .... *information and communication technology*
IEA .... *International Energy Agency*
IFA .... *Institut für Automobilwirtschaft*
IPCC .... *Intergovernmental Panel on Climate Change*
JI .... *Joint Implementation*
KLIEN .... *Klima und Energiefonds*
KPC .... *Kommunalkredit Public Consulting*
L .... *daily driving range*
LCA .... *Life cycle assessment*
LDV .... *light-duty vehicles*
M&R .... *maintenance and repair*
MFF .... *multiannual financial framework*
MS .... *Member States*
MVEG .... *Motor Vehicle Emissions Group*
NMHC .... *non-methane hydrocarbons*
NOVA .... *Normverbrauchsabgabe*
NOx .... *nitrogen oxides*
NPE .... *National Platform for Electromobility*
OEM .... *Original Equipment Manufacturer*
OICA .... *International Organization of Motor Vehicle Manufacturers*
PHEV .... *plug-in hybrid electric vehicles*
PM .... *particulate matter*
PPP .... *Public Private Partnership*
REN .... *renewable energy*
SME .... *small and medium-sized enterprises*
SUV .... *Sport Utility Vehicle*
TCO .... *total cost of ownership*
TEN .... *Trans-European transport and energy networks*
TEU .... *Treaty on the European Union*
TFEU .... *Treaty on the Functioning of the EU*
THC .... *total hydrocarbon*
WTW .... *Well to Wheel*

History

No.	Date	Version	Change
1.	9.6.2013	V1.0	Initial Version
2.	9.7.2013	V2.0	Final Version
3.	9.9.2013	V3.0	Formal Corrections

1 INTRODUCTION

1.1 Objective

The core objective of this thesis is to identify the political, legal and economic key factors to be considered when developing strategies for e-mobility. Although the paper will focus on Austria global and/or European aspects and inputs will be reflected wherever possible and necessary.

The results of this paper should help individuals, entrepreneurs, inventors, investors and policy makers to find appropriate individual and global strategies in order to reach the common goal of mitigating global warming.

1.2 Major questions

Within this thesis the following topics shall be analysed:

- The importance of the transport sector and especially EVs in respect of climate targets
- The advantages and disadvantages of EVs in comparison to ICEVs
- The actual and projected share of EVs
- The identification of political players (EU and Austria) and an analysis of their decision making process
- The identification of the legal and economic key drivers
- A comparison of total cost of ownership between EVs vs. ICEVs
- Main legal and economic barriers

1.3 Method of approach

This master thesis is divided into two sections.

The first part of this thesis starts with an analysis of the impact of e-mobility in respect of climate targets. In order to evaluate this impact, the development of the anthropogenic greenhouse gas (GHG) emissions over the last decades is shown and the responsible industry sectors are identified. The transport sector will then be focused on identifying the emission drivers and the technological options to reduce GHG especially CO2. To understand these options a comparison of the advantages and disadvantages of EVs in comparison to ICEVs is made, with a special focus on the efficiency of the engine.

An analysis of the current deployment status of EVs followed by the examination of the scenarios for the expected development of EVs is crucial to understand the high effort to be undertaken by the different stakeholders in order to reach the ambitious targets.

Within the second part of this thesis the political, legal and economic factors influencing the development of e-mobility are examined.

As incentive measures and programs are often valid for only a very short term, the intention of this thesis is not to give a detailed insight into each single national and EU initiative program in the area of e-mobility but to give a comprehensive overview of the political framework, the strategies, the main involved authorities and the decision making process. This should help individuals get a good overview how to travel through the jungle of the involved public institutions and to understand their motivation.

Within the legal aspects a focus is given to state-aid, however, due to the same reason as for the political aspects, just the framework is described under which institutions apply incentives such as grants or favourable loans.

The economic factors are analysed by means of the comprehensive tool of the total cost of ownership analysis (TCO). By doing so all major economic influence factors for decision making of individuals and enterprises are covered.

The information for this paper was gathered through an intensive desk research in combination with expert interviews. The literature comprises scenario papers, legal documents, political roadmaps, strategy papers, program information, technical evaluations and webpages published by the main players involved in the development of e-mobility and related cross sectional topics. Whenever possible, discussions with experts from industry, ministries and public agencies were held.

2 Analysis of the existing framework

2.1 Transport sector

Natural and anthropogenic GHG emissions are the drivers for climate change. In order to stop the heating up of the planet, policymakers try to implement strategies to reduce GHG caused by mankind. Carbon dioxide (CO2) is the most important anthropogenic GHG. CO2 emissions have grown from 1970 to 2004 by about 80% from 21 gigatonnes (Gt) per year to 39 Gt. The CO2 “production” by the combustion of fossil fuels contributed in 2004 to 56.6% of total GHG emissions. The largest growth in GHG emissions between 1970 and 2004 has come from energy supply, transport and industry. In 2004 the transport sector was responsible for 13.1% of worldwide GHG emissions. (IPCC, 2007)

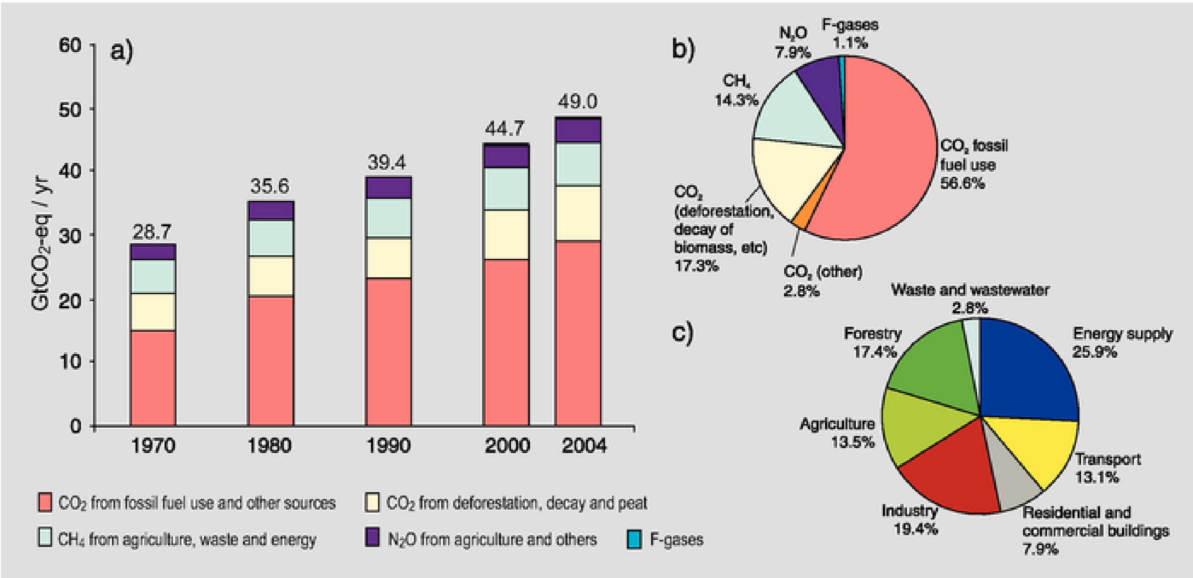


Figure 1: (a) Global anthropogenic GHG emissions (b) Share of different anthropogenic GHGs in total emissions in 2004 (c) Share of different sectors in total anthropogenic GHG emissions in 2004 (IPCC, 2007)

According the European Commission Emission Database for Global Atmospheric Research (EDGAR) the worldwide GHG emissions increased from 47.3 Gt CO2-eq in 2005 to 50.1 Gt CO2-eq in 2010 (European Commission Joint Research Centre & Netherlands Environmental Assessment Agency, 2011).

Figure 2 shows that the share of GHG emissions of the transport sector in the EU accounted in 2007 25%. However, in comparison with the other large contributing sectors as the energy sector, the industry or the residential sector the transport sector was the only one with an increasing trend. Within the transport sector, road transport (trucks, passenger cars and busses) is responsible for the major part of the pollution as it is to a large amount dominated by fossil fuels. Therefore it plays a major role in the EU-policy and strategies to combat climate change (Ajanovic A., Haas R., & et al., 2011).

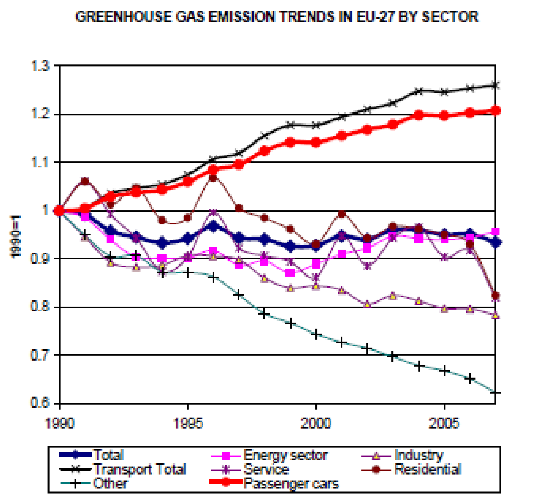


Figure 2a. Greenhouse gas emission trends in EU-27 by sector (EU, 2010)

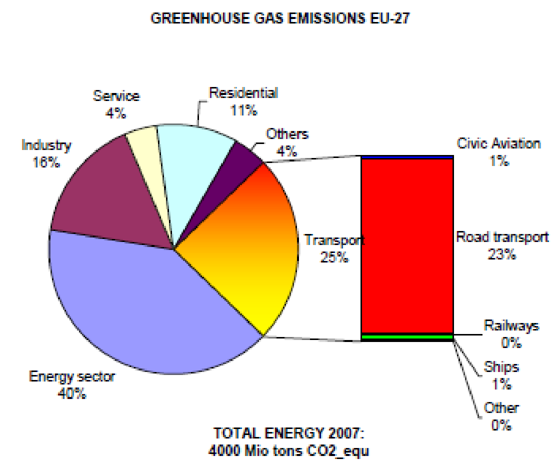


Figure 2b. Share of Greenhouse gas emissions in EU-27 by sector in 2007 (only domestic transport considered) (EU, 2010)

Figure 2: Trends and share of Greenhouse gas emissions in the EU (Ajanovic A., Haas R., & et al., 2011) figures from (EU, 2010b)

Within the transport sector the technological progress was the driver that led to a steep increase in the level of transport service in the last decades. With the breakthrough of the steam engine an increasing amount of energy was covered by fossil non renewable energy sources, due to the higher energy density (see figure 3).

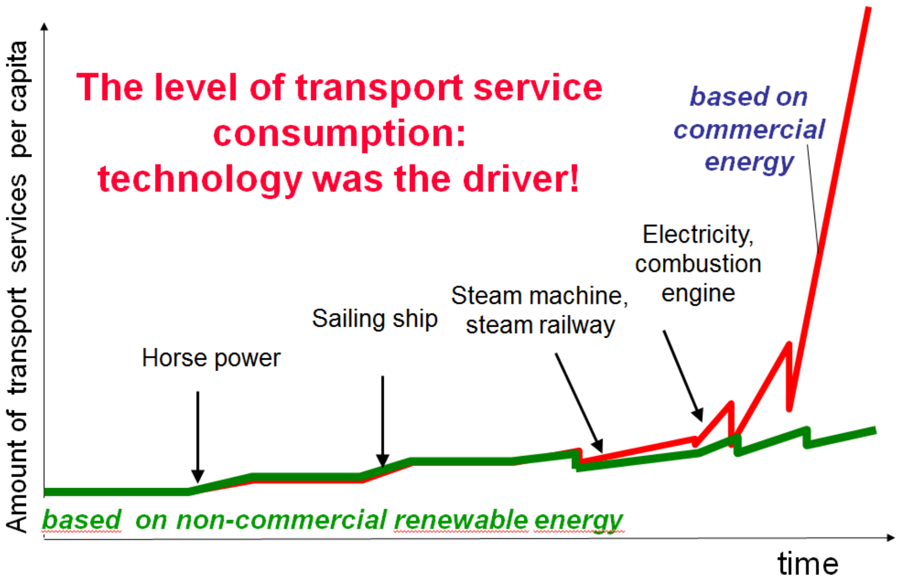


Figure 3: Level of Transport service (Ajanovic, 2012)

In addition to the higher amount of transport service consumed per capita, the growth of the population and the increase in the gross domestic product (GDP) in developing countries (entailing an increase in mobility) are further factors influencing GHG emissions of the transport sector. Figure 4 shows how much industrialized countries contribute with their energy consumption per capita to global warming, assuming that a large portion of the energy is based on fossil fuels.

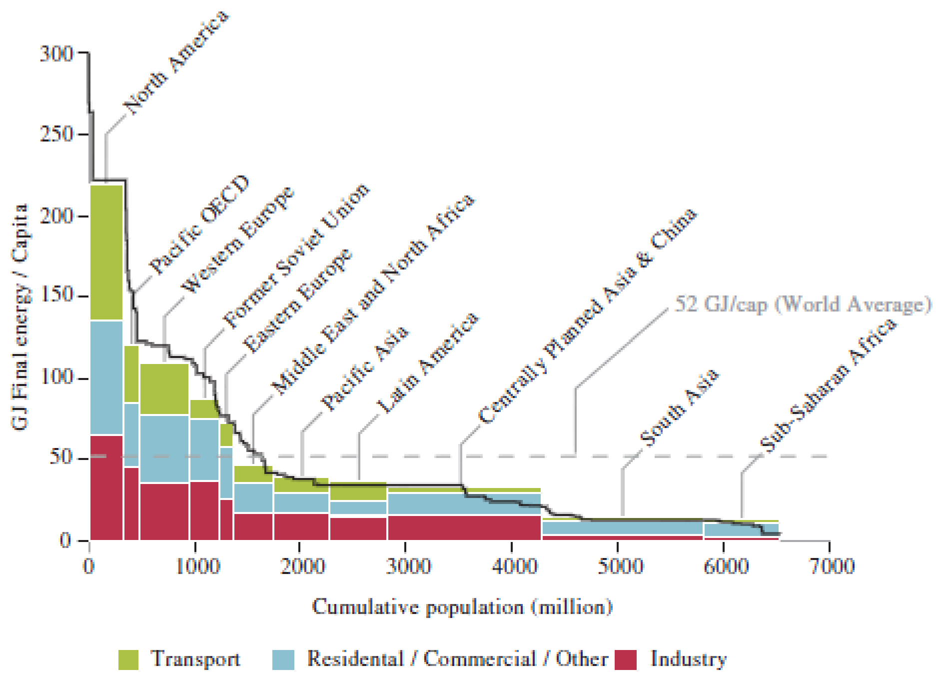


Figure 4: Final energy (GJ) per capita versus cumulative population for 11 world regions sorted by declining per capita energy use (GEA, 2012)

In order to reduce GHG emissions caused by the transport sector, several technological options for efficient low-CO2 emitting powertrains are currently in development. The options can be classified into three groups:

- alternative fuels (e.g. biofuels, hydrogen, etc.)
- advanced internal combustions engines and
- electric vehicles

All three technological options contributing to GHG reduction are currently investigated simultaneously, thus many technological developments and concepts fall into more than one of the identified groups. The final target of the path shown in figure 5 is the highly efficient electric engine powered by clean energy sources (BCG, 2009).

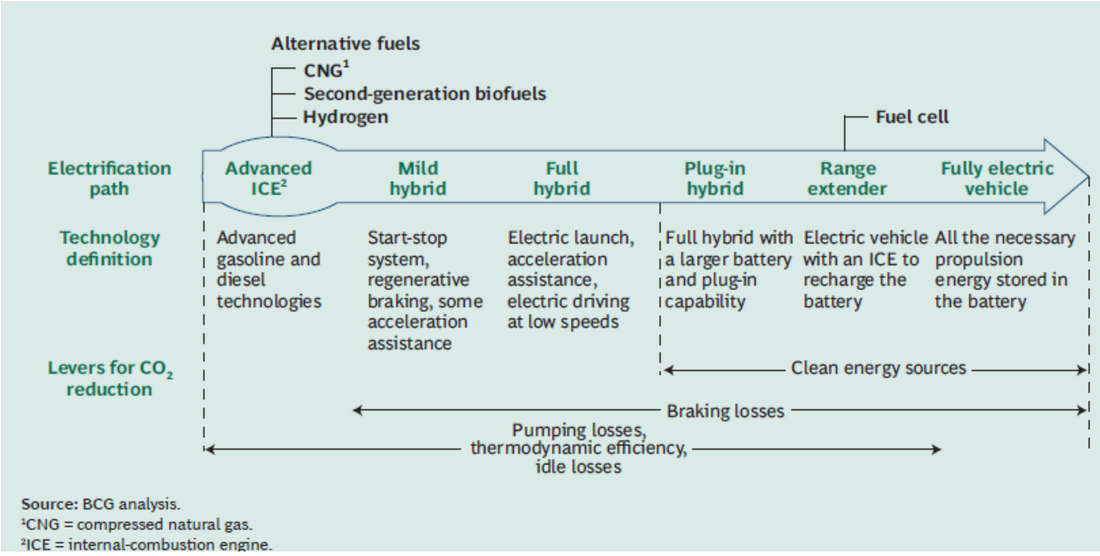


Figure 5: The Electrification Path (BCG, 2009)

2.2 BEV vs. ICEV

Mobility is nowadays covered by a wide range of vehicle types providing transport services. They can be classified according to their powertrain concept as shown in figure 6. On the one hand there is the conventional internal combustion engine vehicle (ICEV) powered mainly by fossil fuel and on the other hand there is the electric vehicle (EV) powered by electricity. In-between there are all kinds of combinations called “hybrids” The focus of this paper is mainly on EVs for passenger transport.

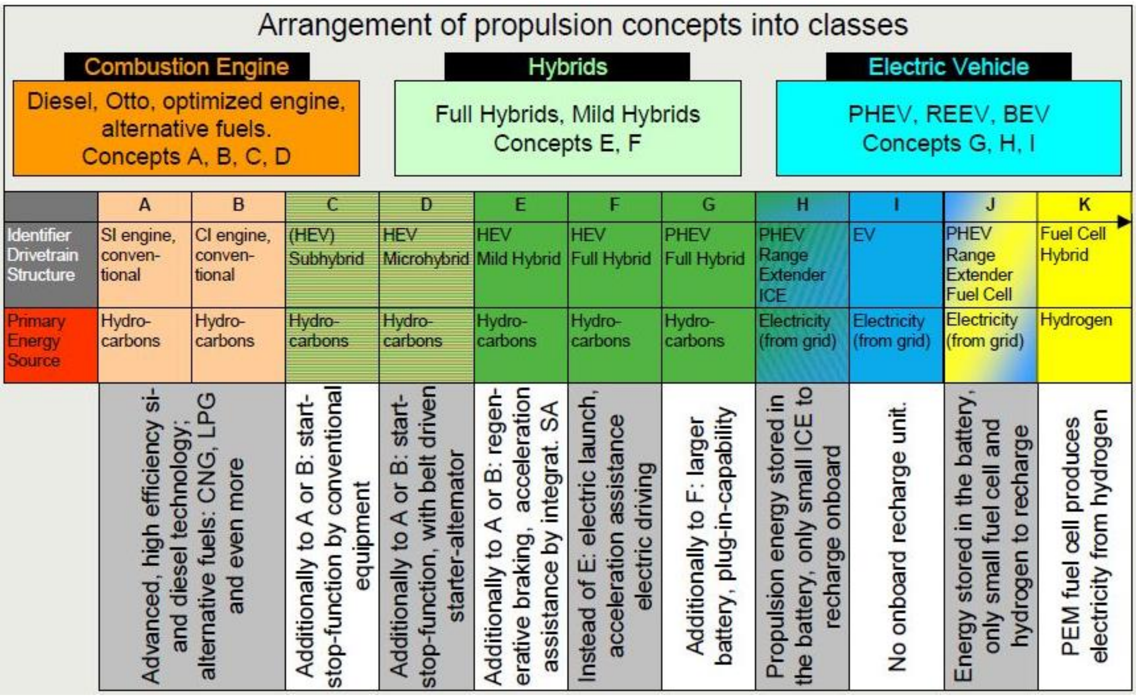


Figure 6: Schematic classification of alternative powertrains (Wikipedia, 2010)

Apart from the glider (or platform = vehicle without main technical components such as engine etc.) the main components of a battery electric vehicle (BEV) are the battery, the electric motor, a motor controller and a charger. An ICEV consists of a combustion engine a starting system including a battery, a fuel-, exhaust- and lubrication system, a gearbox and a cooling system. From the technical point of view a BEV is therefore much simpler than an ICEV (Larminie & Lowry, 2003).

Comparing different transport technologies in respect of their ecological impact, three key aspects have to be taken into consideration:

- source of energy
- efficiency of the engine and
- energy required for production of the vehicle

The two main concepts evaluating the ecological footprint in terms of CO2 emissions are the Life Cycle Assessment (LCA) taking into consideration all three aspects and the Well to Wheel (WTW) analysis excluding emissions caused by the vehicle production. Although complicated to asses, the energy intensive battery production for BEVs, however, contributes to a considerable share of CO2 emissions as shown in figure 7 by Helm (Helms, Lambrecht, & Rettenmaier, 2011).

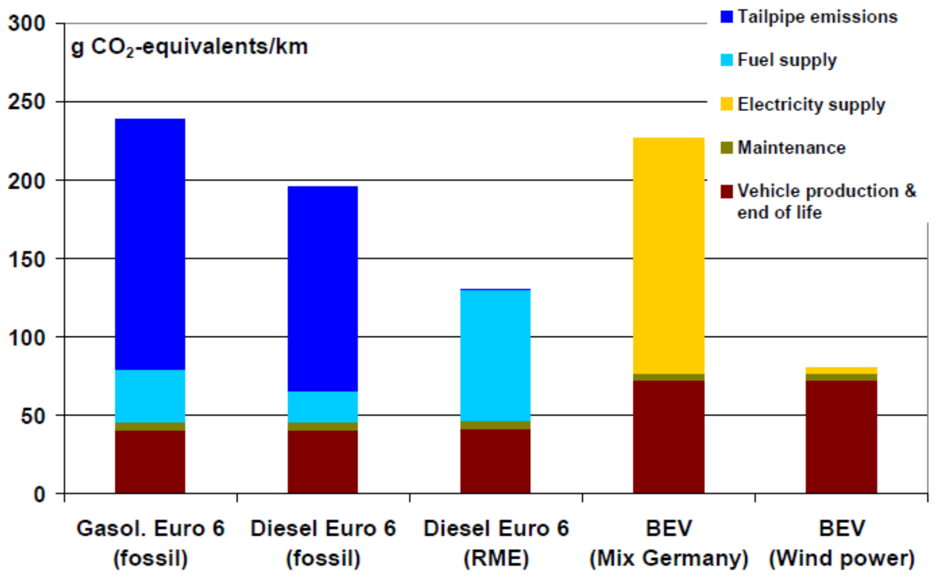


Figure 7: Greenhouse gas emissions per km (Helms, Lambrecht, & Rettenmaier, 2011)

Comparing an ICEV powered by fossil fuels with a BEV, the ecological advantage highly depends on the source of electricity supply. As the above figure shows, by using an almost completely renewable energy source the highly efficient electric engine shows a considerable advantage over combustion engines even when powered with biofuels (Helms, Lambrecht, & Rettenmaier, 2011).

Calculating the amount of CO2 emission for an ICEV is a quite simple formula. In the combustion process carbon (with a molecular weight of 12) takes up 2 oxygen atoms (each having a molecular weight of 16) and is converted into CO2 with a total molecular weight of 44. Thus 1kg of carbon produces trough combustion 3.67 kg of CO2. Due to the lower carbon content of fossil fuels the CO2 emission of 1l diesel is about 2.6 kg and of 1l gasoline about 2.3 kg (Schroedel, 2007).

For a BEV the emission has to be calculated indirectly via the electricity-mix that means by proportionally adding up all CO2 emissions of the fuels used in the electricity production process. This is far more complicated than for combustion engines and usually done by taking the available national data sources.

Based on a WTW-comparison between a Mini-D (Diesel) with a CO2 emission of 103 g/km (approx. 3,8l/100km) and a Mini-E (BEV) with a consumption of 14 kWh/100km, the BMW-Group calculated in 2010 the CO2 advantage of BEV considering the respective energy mix in different European countries. Figure 8 shows that with the EU-25 average electricity-mix, almost 50% of the CO2-emissions can be reduced without taking into consideration the production emissions (IFA, 2010).

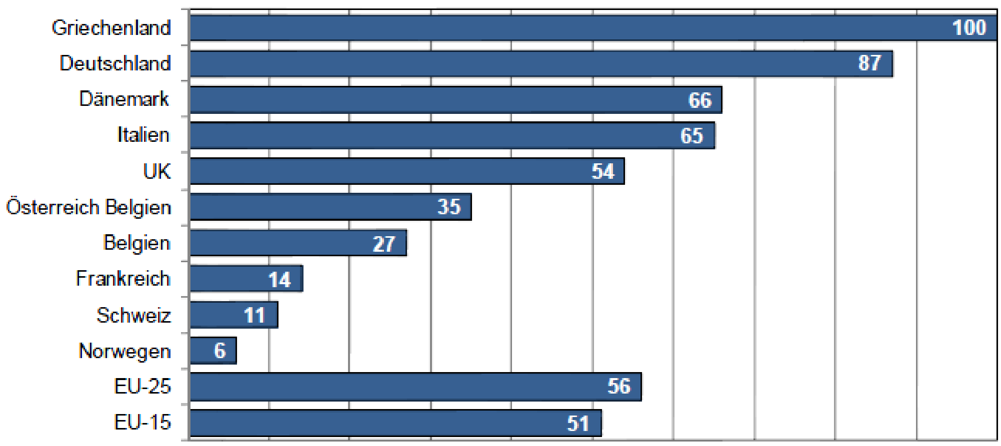


Figure 8: CO2 Emissions of BEV including energy-mix (in g/km) (IFA, 2010) based on a study by BMW

However low CO2 emissions are not only related to a higher proportion of renewables in the energy-mix, some countries as e.g. France produce a high amount of their electricity demand by nuclear power stations.

With a non-renewable energy mix the advantage of the engine efficiency is lost. Therefore from the ecological point of view an increasing share of BEV will have to be powered by an even larger amount of green energy such as wind-, solar- or hydropower in order to have a positive overall impact on global warming.

Thus a transport strategy cannot be developed independently of an overall energy concept.

As mentioned above the efficiency of the engine is one of the main drivers. Although the available data in different WTW studies widely differ due to the lack of unified testing and certifying methods, table 1 shows that the calculated WTW efficiency of the ICE ranges from 13% to 24% whereas electric engines can have efficiencies up to 77%. This gives a factor of 3 to 6 (Helmers E. & Marx P., 2012).

Propulsion technology	WTT (%)	TTW (%)	WTW (%)	WTW calculated (%)
ICE				
Petrol (gasoline)	79[a], 86[b]	16[a], 23[k]	10[o], 13[a], 12 to 14[p], 14[q], 20[r]	13 to 20
Petrol (gasoline) full electric hybrid	79[a], 86[b]	30[k], 37[a]	15[o], 17 to 22[p], 29[a,q]	24 to 32
Diesel	76[c], 82[a], 84[b]	23[a], 28[k]	13[o], 16 to 18[p], 19[a], 25[r]	18 to 24
LPG (propane + butane)	88[d], 93[e]	16[e]	11[o], 15[e]	14 to 20
		petrol ref. + 6[l]		
CNG (methane)	65 to 86[f], 85[e]	16[e]	12[o], 14[e], 21[r]	10 to 22
		petrol ref. + 9[m]		
FCV				
H_2 fuel cell (gaseous H_2 stored in pressure tanks)	37[g], 40[c], 53[h]	50[a], 56[k]	20 to 23[p], 22[a], 23[s], 29[q]	19 to 30
BEV				
Electric car (literature)		73[k], 80 to 90[n]	59 to 80[t], 74[k]	
Electric car minimum[i]	15[i]	73[k]		11
Electric car optimum[j]	59 to 85[j]	90[n]		53 to 77

WTW in the last column calculated from WTT and TTW literature as indicated. WWT, well-to-tank; TTW, tank-to-wheel; WTW, well-to-wheel; LPG, liquefied petroleum gas; CNG, compressed natural gas; ICE, internal combustion engine; FCV, fuel cell vehicle; BEV, battery electric vehicle. [a][7]. [b]Kavalov and Peteves [15]. [c]FfE [16]: H_2 made by steam reforming from natural gas (methane). [d]Calculated from Fritsche [17]. [e]Reviewed in [5]. [f]Depending on the length of the gas pipe, between 14% and 35% of the energy content can be used up in the chain (calculated for natural gas in the European market in [18]). [g][19]: H_2 made by electrolysis from water. [h]IAE [20]: Electrolysis from water including compression. [i]Coal mine to bunker 80%, coal to electricity 35%, grid to plug 90%, plug to battery 60%. [j]Wind energy transmission 97%, [storage power station (water) 70%], grid to plug 90%, plug to battery 97%. [k]Kloes [21]. [l]A compression optimized engine can increase efficiency by up to 6% (Heinze T, Saarbrücken THW, personal communication 2011). [m]In a single fuel engine, compression ratio can be optimized to achieve an energy efficiency increase of 9% over the patrol reference EU [22]. [n]Husain [23]. [o][24] (Light duty vehicles with curb weight 1.6 to 1.8 t evaluated). [p]Reviewed by An and Santini [25]. [q]Pelz N [26]. [r][27]. [s]Bossel [28]. [t]Reviewed by Hacker et al. [29].

Table 1: Energy efficiency of the propulsion technologies available to the market (in percentages) (Helmers E. & Marx P., 2012)

Although fuel efficiency of ICEVs improved through technological development during the last decades (see figure 9) the progress so far achieved is not sufficient to meet the emission targets considering the ongoing jump in transport service consumed per capita and in total (IFA, 2010).

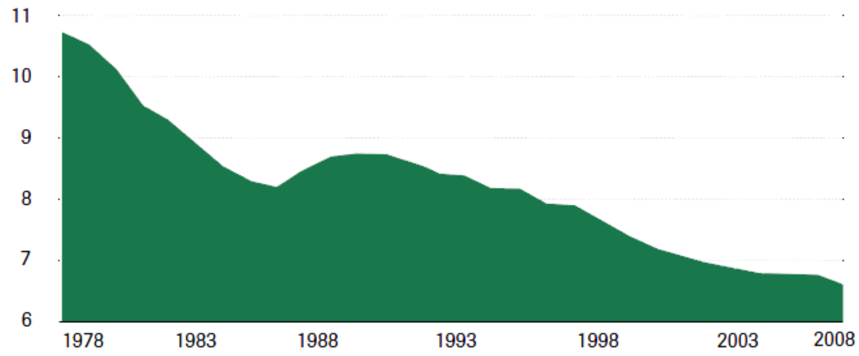


Figure 9: Development of fuel consumption l/100km from ICEV from German production (IFA, 2010)

However, comparisons of technologies depend on assumptions about many input parameters (e.g. size of cars, power of engine; driving cycle, etc.) and are therefore often difficult to accomplish. A practical approach would be to compare a vehicle that is currently sold in a diesel and in an electric version. According the consumption figures given by Daimler (Daimler, 2011) for the "smart for two", the following table 2 shows the calculated consumption in kWh/100km.

Car	Energy Content MJ/kg	Energy Content kWh/kg	Energy Content kWh/l	Consumption assumption l/100km	Consumption kWh/100km
ICEV (Diesel)	42,6	11,8	9,7	3,3	32,0
BEV					15,1
					factor 2,12
3,6	MJ/kWh	conversion MJ in kWh			
0,82	kg/l	specific weight			

Table 2: Efficiency of ICEV vs. BEV of a Smart fortwo (own calculation)

Given a diesel consumption of 3.3l/100km indicated by the manufacturer the diesel version consumes around 32 kWh/100 km. The consumption for the BEV indicated by the manufacturer was approx. 15 kWh/100 km. This gives an efficiency factor of approx. 2.1.

The reason for this low factor is that Daimler designed the 3rd generation Smart fortwo especially for urban mobility with a powerful 55 KW engine (greenmotorsblog.de, 2012). In comparison the available diesel engine of the Smart disposes of only a 40 kW engine with moderate consumption. However, according to different test reviews from automotive journals, if driven more sportively in urban regions the diesel engine consumes around 5l/100 km setting the efficiency factor to approx. 3.2. Here again one can see how the "certified" consumption figures indicated by the manufacturer differ from real data.

In comparison to other urban BEVs the consumption of the 3rd generation Smart electric drive is higher than of comparable electric vehicles. A Study from Geringer and Tober shows consumption figures for different BEVs (Geringer & Tober , 2012).

As shown in figure 10 Helmers and Marx carried out a LCA indicating CO2 emissions per 100.000km of different versions of the Smart. Comparing a petrol ICE, an electric Smart powered with the German grid-mix 2010, an electric Smart powered with 100% renewables and a used Smart with 106.000km driven (Helmers E. & Marx P., 2012).

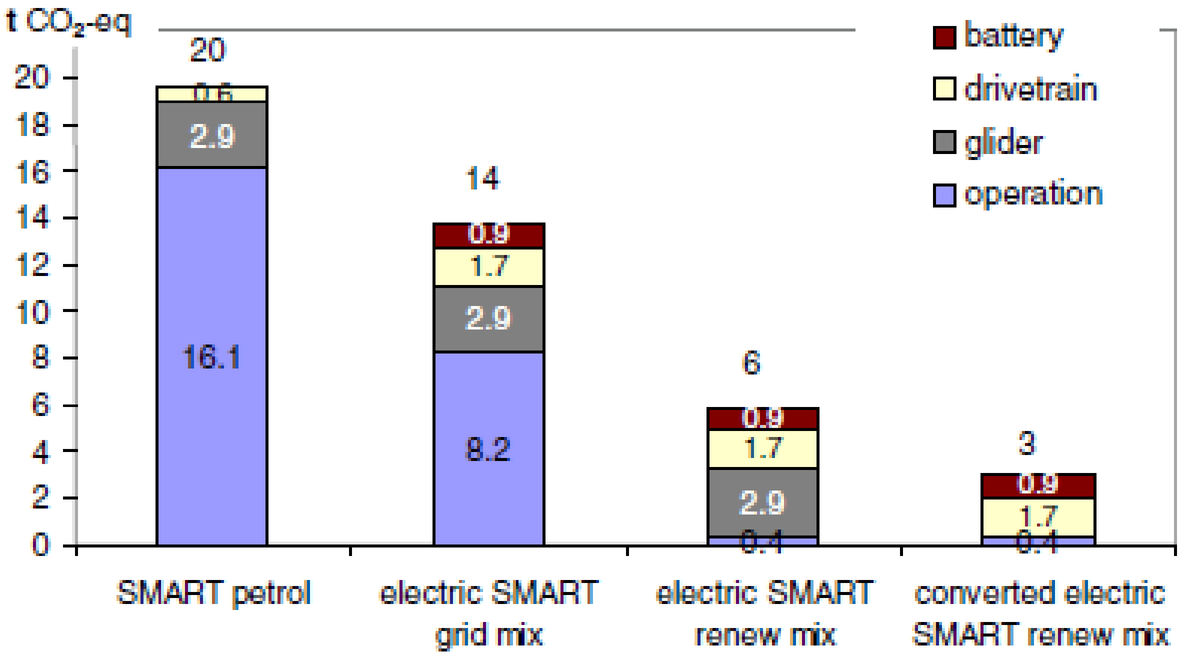


Figure 10: CO2 life cycle assessment based on a converted Smart car (Helmers E. & Marx P., 2012)

Comparing the Smart petrol with the electric Smart renew mix, the level of CO2 emissions is more than 3 times higher, thus the environmental impact is considerable.

2.3 Pros and cons of BEV

As BEVs offer many advantages they are deemed to be the key technology for sustainable transport in the future. However many problems still have to be solved until the electric engine will dominate the transport market:

Pros:

- **Efficiency**

  As in detail described in chapter 2.2., the electric engine is highly efficient in comparison to the combustion engine (about 3 to 4 times more efficient) thus less energy input is required for the same amount of transport service. The higher efficiency is mainly due to the lack of waste heat as produced in the combustion process. In addition kinetic energy can be recuperated from braking.

- **Emissions**

  The combination of an efficient engine with renewable energy source leads to a massive impact on GHG and other emissions caused by the combustion engines.

- **Noise pollution**

  At lower speeds the electric engine shows a huge advantage in respect of noise pollution against the combustion engine. Especially urban areas would benefit from that effect.

- **Vibration**

  Passengers of BEVs benefit due to the lack of the combustion process from a reduced level of vibration within the glider.

- **Better torque characteristics**

  As electric engines deliver almost no torque at lower speed and can accelerate without transmission or torque converter. They need no starter engine and can be attached directly to the drivetrain. By simply changing polarity of the electrical input the vehicle can reverse (Thermal-Fluids Central, 2013).

- **Low fuel cost**

  The fuel cost per km driven is lower than with fossil or biofuels.

- **Low maintenance cost**

  Due to the relative simple engine and conversion process, the maintenance and repair cost (M&R) of BEV can be reduced significantly in comparison to ICEV. In addition to the advantage of lower M&R cost the reduced wear and tear leads to an increase of the useful life.

- **Independency of fossil energy sources**

  A change towards locally generated renewable energy as a source for transport will reduce the dependency of the economy from the price for fossil fuels set by the fossil oil producing countries.

- **National added value and employment**

  Beside the independence locally produced renewable energy leads to higher added value in the region and has therefore a positive impact on GDP.

- **Energy storage**

  In case of a considerable amount of BEVs they could be used as temporary storage facilities in smart grids or smart cities environments in order to buffer fluctuations between volatile renewable energy production (e.g. wind or solar peaks) and consumption.

Cons:

- **Heat**

  Due to the lack of waste heat from combustion, BEVs have to provide heating in winter from the stored electricity thus converting the most valuable form of energy into heat with almost no exergy (Nakicenovic, Grübler, & Ishitani, 1996).

- **Energy density / driving range**

  The success story of ICEV was mainly due to the high energy density of the liquid fuels. One litre of diesel has an energy density of approx. 10 kWh. In comparison, for the same amount of energy a lead battery weights 333 kg, nickel–metal hydride battery 166 kg and a lithium-Ion battery 55 kg. Depending on the size of the battery the driving range of BEVs is limited to 150km to 200km. (Döring & Aigner-Walder, 2011). The higher efficiency of the engine is not able to recoup this disadvantage. The low energy density per kg of battery is the main reason for the restrictions of BEVs in respect of driving range. The poor driving range, beside the higher acquisition cost, is considered as one of the most crucial factors for the development of the BEVs.

- **Recharging**

  Given the restricted driving range the recharging process becomes of central importance. Whereas an ICE takes about 5 minutes to refuel the charging of a BEV ranges from 8-12 hours. Recharging is further limited due to the missing infrastructure and the long recharging time. As high-speed recharging systems are still very expensive and more or less still in experimental phase, alternatives have been developed such as battery exchange systems. However, none of the alternatives had a break through yet (Döring & Aigner-Walder, 2011).

- **Investment cost**

According to Helmers Lithium-Ion batteries cost, depending on the chemical components used, between 500 to 1000 EUR/kWh. Thus the cost of the battery system of a BEV consuming 15kWh/100km with 1 hour driving capacity amounts up to 15000 Euro. With two hours driving capacity the total cost of the BEV is almost double the one for ICEV (Helmers E. & Marx P., 2012).

- **Availability of raw materials**

Lithium is considered a scarce material when setting into relation the projected demand with today's production. Kleine-Möllhoff et al. analysed all relevant materials and could not find any critical bottleneck, arguing that an association of the situation between lithium and fossil fuels is not correct, as lithium can almost be completely recycled while fossil fuels are used up in the process (Kleine-Möllhoff, Benad, & et al., 2012).

- **Durability of battery**

Extreme temperatures have a significant impact on battery durability. A permanent thermal management of batteries is therefore essential (Kleine-Möllhoff, Benad, & et al., 2012). However durability of the batteries is far away from lasting the whole lifetime of the BEV itself. According to Tübke the durability ranges depending on the type of battery from 5 to 15 years (Tübke J., 2010). Considering the high investment respectively replacement cost, the durability is a major market barrier for the evolution of electro mobility. OEMs try to reduce this by extending the guarantee for the battery or to favour leasing systems. However a functioning 2nd hand market is not possible with the uncertainty of the durability in connection with battery cost of almost half of the price of a new vehicle.

- **Safety**

Modern battery materials, especially lithium, are critical in respect to their risk of explosion or fire as their materials are highly reactive. In addition to that the weight of the batteries is in case of accidents another critical factor for passengers.

- **Noise Emissions**

BEVs have the potential to reduce noise pollution in urban areas, however, the low noise emission level of BEVs is seen critically in respect to the risk of accidents. A mandatory minimum noise or artificial sounds and signals are being discussed.

- **Energy mix**

  As already described BEVs can only contribute to reduce GHG emissions when being powered by green energy. In order to meet the huge demand of energy from the transport sector the total share of renewable energy still has to increase significantly.

- **Storage of electricity**

  In contrast to liquid fuels electricity generated by renewable forms such as wind and solar are difficult to store without high losses of efficiency. Beside the main method of storing large quantities of electricity via pump storage, power to gas, smart grids etc. are the recent but not yet sufficiently developed attempts to cope with this problem.

- **Support of renewables**

  As most of the renewables are not yet commercially competitive they still have to be supported by subsidies, tariffs, quotas, tax exemption etc. in order to initiate the necessary investment flow.

2.4 EV Status and Scenarios

2.4.1 EV Sales and Stock

According to the International Organization of Motor Vehicle Manufacturers (OICA) total global sales of all types of vehicles in 2012 amounted to 81.7 million as shown in table 3.

REGIONS/COUNTRIES	2009	2010	2011	2012
EUROPE	18.661.876	18.799.111	19.731.905	18.650.167
AMERICA	17.494.287	19.655.177	21.499.758	23.597.495
NAFTA	12.838.518	14.176.013	15.566.720	17.489.861
CANADA	1.482.232	1.583.388	1.620.221	1.716.178
MEXICO	754.918	820.406	905.886	987.747
UNITED STATES OF AMERICA	10.601.368	11.772.219	13.040.613	14.785.936
CENTRAL & SOUTH AMERICA	4.655.769	5.479.164	5.933.038	6.107.634
ASIA/OCEANIA/MIDDLE EAST	28.071.003	34.897.706	35.304.821	38.027.738
AFRICA	1.188.074	1.276.521	1.390.462	1.463.696
ALL COUNTRIES	65.415.240	74.628.515	77.926.946	81.739.096

Table 3: Development of global Vehicle Sales (OICA, 2013)

Figure 11 shows that Proff et al. calculated for passenger cars and Light Commercial Vehicles (LCV) total sales of about 51.1 million in 2011. Total sales of EVs were estimated for the same year with 40000 giving a market share of 0.06% (Proff H. & Kilian D., 2012).

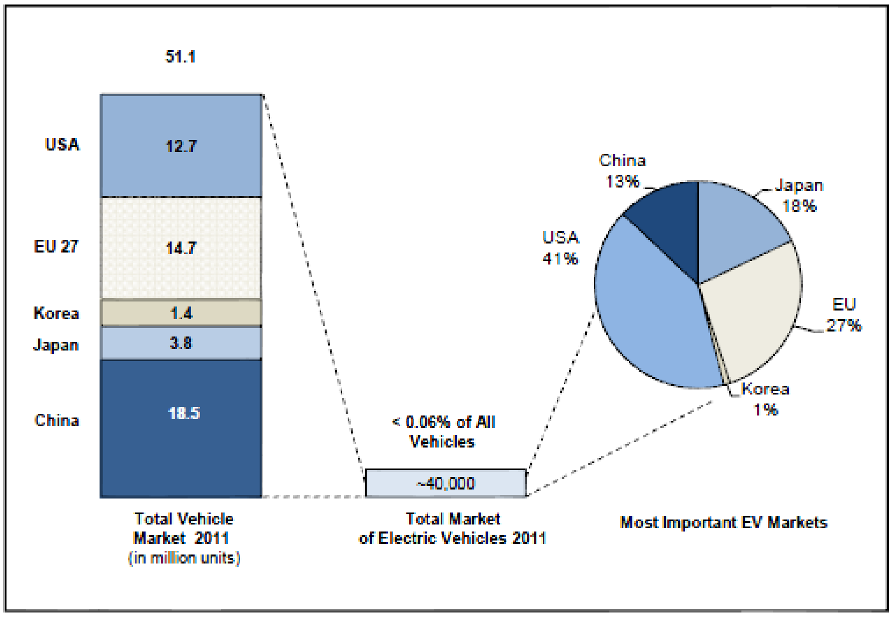


Figure 11: Sales of Electric Vehicles 2011 (Proff H. & Kilian D., 2012)

The main markets for EVs including plug-in hybrid electric vehicles (PHEV) are the USA, Japan, China, France, Germany and the UK. The figures from 2010, 2011 and half-year of 2012 show a considerable uptake in sales (see table 4).

	Total Sales (Passenger Cars * LCV)	Electric Vehicles (BEV, PHEV, REEV)			Hybrid (non-rechargeable)		
	2011	2012*	2011	2010	2012*	2011	2010
Germany	3,400,000	1,419	2,154	541	9,232	12,622	10,661
France	2,600,000	2,271	2,630	184	3,691	13,289	9,655
United Kingdom	2,200,000	559	1,082	138	12,720	23,373	22,148
Italy	1,900,000	286	346	72	2,725	5,125	4,845
Spain	910,000	202	377	69	5,160	10,350	8,500
EU (EU 15 + EFTA)	14,700,000	~11,000	11,563	n.a.	n.a.	103,400	n.a.
China	18,500,000	3,444	5,579	1,466	n.a.	2,713	n.a.
Japan	3,800,000	n.a.	n.a.	7,719	n.a.	n.a.	434,569
Korea	1,400,000	n.a.	335	66	na.	38,482	19,167
USA	12,700,000	17,530	17,813	345	217,701	268,807	274,763

n.a. = not available

* Figures include data from the first six months of 2012, Figures for EU 2012 are estimated based on Opel (2012) and Detroit new s (2012)

Table 4: Sales of Electric Vehicles (Proff H. & Kilian D., 2012)

According to figures by the Electric Vehicles Initiative (EVI) the United States had by the end of 2012 the highest stock of EVs worldwide, followed by Japan, France and China (see figure 12). This was mainly due to the predominance of the Chevrolet Volt (PHEV) (IEA, 2013)

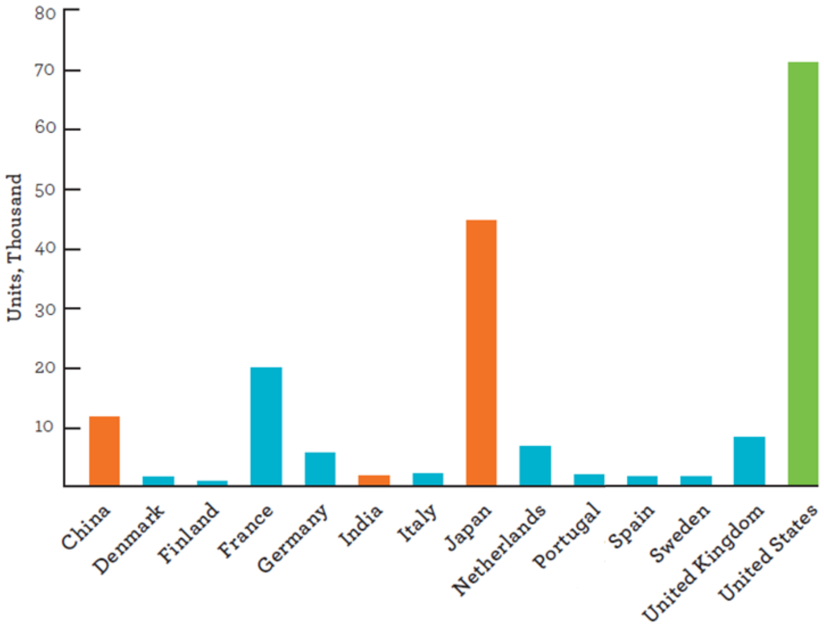


Figure 12: EV (PHEV and BEV) Stock in EVI-Countries in 2012 (IEA, 2013)

According the Austrian statistical agency the stock of EVs per 31.12.2012 was with 1389 units 0.03% of all passenger cars. Hybrid cars accounted for 8100 respectively 0.2% (see table 5).

Vehicle types	2012 Total	2012 % share	2011 Total	2011 % share	% change
Passenger cars cat. M1	4.584.202	72,8	4.513.421	72,9	1,6
thereof					
Petrol incl. flex-fuel	2.001.295	43,7	1.997.066	44,2	0,2
thereof Petrol	1.994.839	99,7	1.991.586	99,7	0,2
thereof flex-fuel	6.456	0,3	5.480	0,3	17,8
Diesel	2.570.124	56,1	2.506.511	55,5	2,5
Electric powered	1.389	0,0	989	0,0	40,4
Liquefied Gas	1	0,0	-	-	-
Natural Gas	1.826	0,0	1.572	0,0	16,2
Petrol/Liquefied Gas (bivalent)	184	0,0	125	0,0	47,2
Petrol/Natural Gas (bivalent)	1.283	0,0	1.098	0,0	16,8
Petrol/Electric powered (hybrid)	7.762	0,2	6.056	0,1	28,2
Diesel/Electric powered (hybrid)	338	0,0	4	0,0	8350,0

Table 5: Stock of vehicles on 31.12.2012 by vehicle types (Statistik Austria, 2013)

2.4.2 Scenarios

“The current trend of rising energy demand and rising emissions runs directly counter to the major emissions reductions that are required to prevent dangerous climate change. The United Nations Intergovernmental Panel on Climate Change (IPCC) has concluded in 2007 that reductions of 50% to 85% in global CO2 emissions compared to 2000 levels will need to be achieved by 2050 to limit the long-term global mean temperature rise to 2.0°C to 2.4°C” (IEA, 2010).

“In the BLUE Map scenario, CO2 emissions in 2050 are reduced to 14 Gt, around half the level emitted in 2005. This means emissions are 43 Gt lower in 2050 than the 57 Gt CO2 projected in the Baseline scenario. Achieving these CO2 emissions reductions will require the development and deployment of a wide range of energy-efficient and low-carbon technologies across every sector of the economy. End-use efficiency improvements in the use of fuels and electricity and power sector measures dominate the short- and medium-term emissions reductions. But to achieve the deeper emission cuts needed by 2050, these measures will need to be supplemented by the widespread introduction of new technologies such as electric vehicles (EVs) and carbon capture and storage (CCS) between 2030 and 2050” (IEA, 2010).

As described the transport sector contributes to a considerable extent to the total GHG emissions. It therefore has a high potential to contribute to CO2 reduction. Within the Blue Map Scenario of the IEA shown in figure 13, 37% of the reduction to be realized by 2050 shall result from the transport sector.

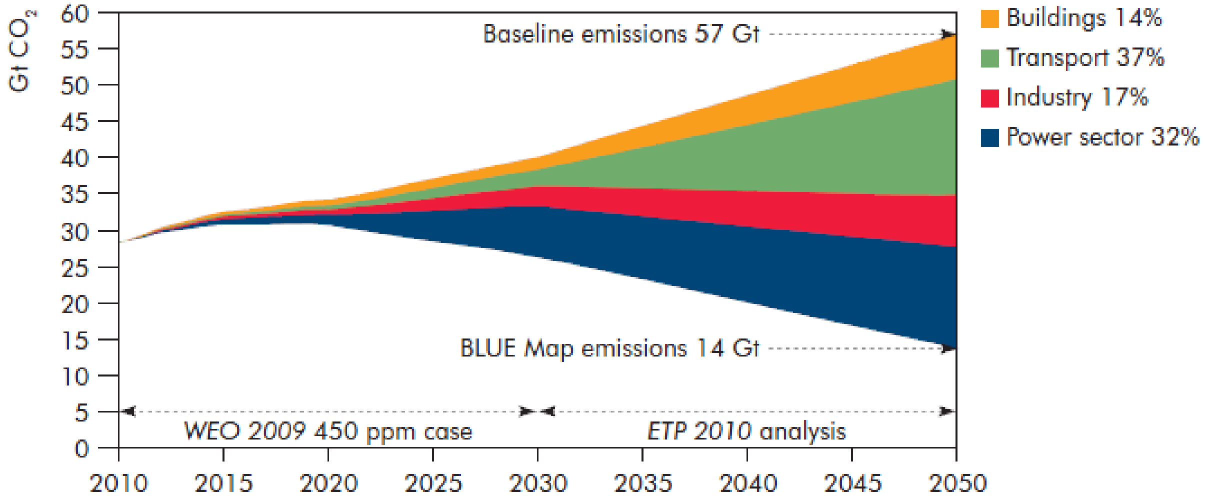


Figure 13: CO2 emissions reductions in the BLUE Map scenario by sector (IEA, 2010)

Figure 14 shows that according to the International Energy Agency (IEA) EVs and PHEVs are expected to play an important role in achieving a low-CO2 transport system in their BLUE Map scenario, particularly for light-duty vehicles (LDV). "The IEA EV/PHEV roadmap envisions that by 2050, EVs/PHEVs will reach combined sales of about 100 million vehicles per year worldwide, accounting for over half of all new LDV sales" (IEA, 2010).

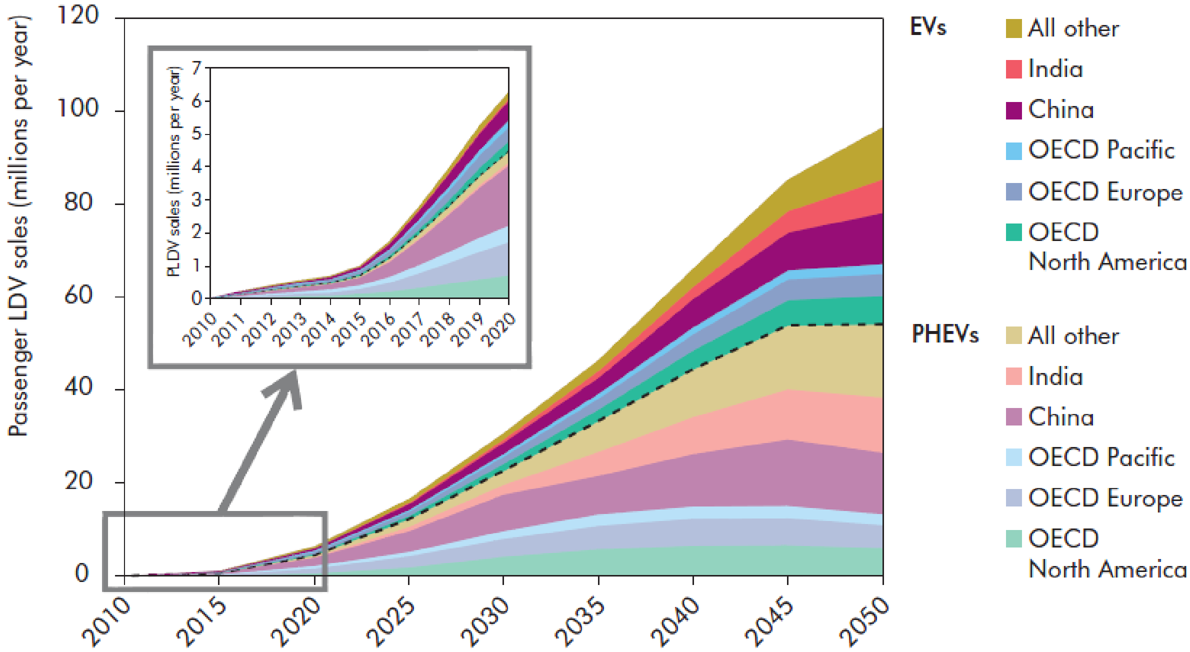


Figure 14: EV/PHEV roadmap vision for growth to 2050 (IEA, 2010)

A scenario analysis conducted by the German Institut für Automobilwirtschaft (IFA) calculates the potential market share of different drivetrain technologies until 2030 (IFA, 2010).

Scenario I: shows “business as usual” with no binding climate policy, a moderate increase in oil prices, gas as a accepted substitute for fossil fuel, expensive biofuels and moderate changes in mobility patters of individuals and OEM’s strategies.

Scenario II: assumes a stricter framework on CO2 limits combined with incentives and penalties, increased oil prices and changes in individual mobility patterns.

Scenario III: assumes a global agreement by 2015 on 50% CO2 cuts until 2030, substantial increased oil prices and the upcoming of new successful business models in transport sector (mobility providers) (Reiner R., Cartalos O., & et al., 2010).

The results of the study summarized in table 6 show that vehicles with alternative drivetrains dispose of a substantial market potential especially in scenario III where massive changes in the regulatory framework occur. In this case the market share of ICEVs will drop to 20% in 2030. In scenario II the total amount of EVs and PHEVs sold by 2020 accounts for 5.6 million. This scenario is thus in line with the roadmap vision by the IEA from 2010.

Anteile in %		Szenario I: Evolution		Szenario II: Zeitenwende		Szenario III: Strukturbruch	
	2010	2020	2030	2020	2030	2020	2030
ICE	95,0	79,0	65,0	77,0	59,0	67,0	20,0
HEV	5,0	15,0	20,0	15,0	13,0	20,0	28,0
PHEV	0,0	4,0	10,0	5,0	20,0	8,0	40,0
BEC /FCV	0,0	2,0	5,0	3,0	8,0	5,0	12,0
Weltmarkt Fahrzeuge (in Mio.)	54,34	74,09	87,40	70,40	78,66	66,68	70,00

Table 6: Scenarios of market share in % of volume for different drivetrain technologies (IFA, 2010)

As one of the dominant vehicle producer countries, Germany pursues a market focused strategic approach with the aim of becoming one of the leaders in e-mobility. Within the National Platform of Electromobility (NPE) representatives of industry, research, government, unions and society meet in order to develop a strategic plan with three phases, the market development phase until 2014, the ramp-up period until 2017 and the launch of mass production until 2020. The phases of the NPE plan mainly follow the milestones of the PPP European green cars initiative of the EU (see 3.1.4 EU Initiatives). The plan requires heavy investments by industry of about EU 17 bn that come along with substantial federal incentives. The target by 2020 is a stock of 1 million EVs on the road (see figure 15).

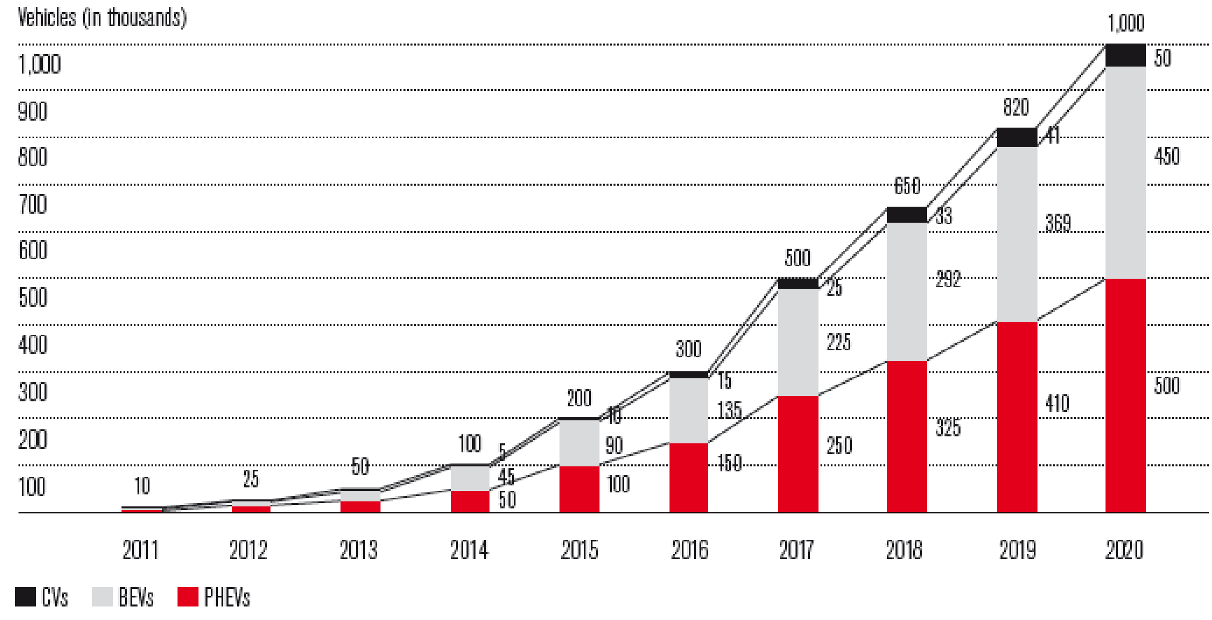


Figure 15: Market ramp-up curve (NPE, 2011)

Table 7 shows a scenario analysis published in 2010 by the Austrian “Umweltbundesamt” according to which the total stock of EVs and PHEVs in Austria will rise to about 4%.

year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Estimated stock of electric vehicles (EV & PHEV)	**365**	**1.392**	**3.157**	**5.831**	**9.426**	**20.761**	**38.224**	**66.022**	**104.100**	**152.874**	**209.333**
Stock: share of electric vehicles (EV & PHEV)	0,01 %	0,03 %	0,07 %	0,12 %	0,19 %	0,41 %	0,75 %	1,28 %	1,99 %	2,89 %	3,91 %
New registrations per year (EV & PHEV)	**365**	**1.027**	**1.765**	**2.673**	**3.595**	**11.335**	**17.463**	**27.797**	**38.079**	**48.773**	**56.459**
New registrations: share of electric vehicles (EV & PHEV)	0,12 %	0,34 %	0,57 %	0,86 %	1,14 %	3,55 %	5,40 %	8,49 %	11,50 %	14,55 %	16,65 %

Table 7: Scenario of the development of EV and PHEV stocks in Austria until 2020 (Pötscher F., Winter R., & Lichtblau G., 2010)

3 Factors influencing e-mobility

The first part of this thesis analysed the question why e-mobility is important, describing the impact and the trend of GHG emissions, the difference between combustion and electric engines in respect of their GHG contribution and the status and scenarios for the development of EVs.

Apart from technological barriers to be solved on the way to a sustainable future in the transport sector the focus of the second part of this thesis is to enlighten the legal and economic factors influencing e-mobility. However the legal and economic factors are very much dependent on the political environment setting the framework. For EU member states the political system of the Union, setting the strategic outline on important topics such as e-mobility, as well as national politics have to be taken into account.

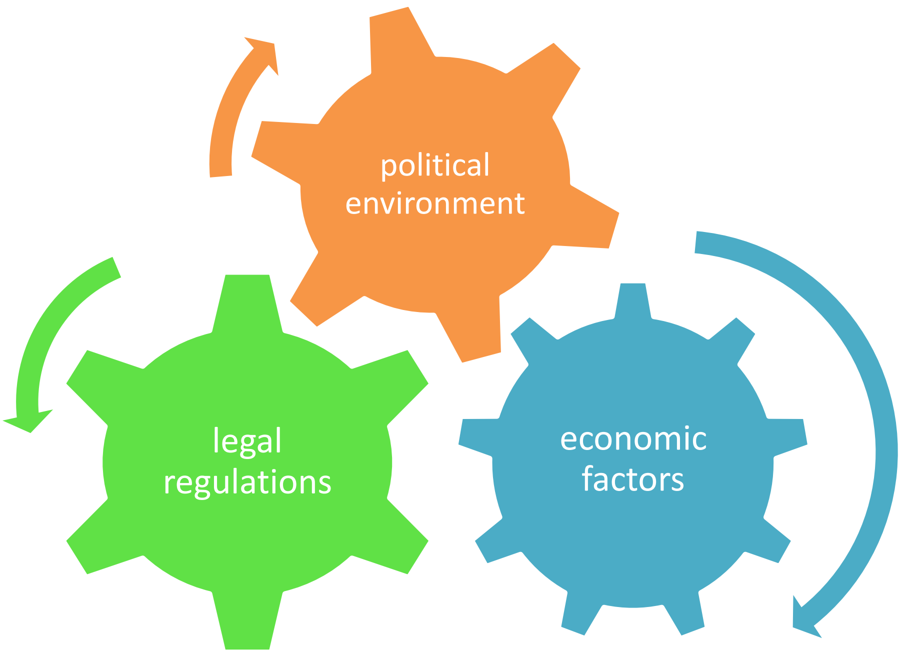


Figure 16: Interdependence of factors (own graphic)

3.1 Political Environment

The political environment setting the framework for the development of countries, regions and topics is maybe one of the most important factors influencing the progress of e-mobility. In addition it is equally complex as the technological problems to be solved.

More than many other topics regulated by political systems, issues related to sustainable development and climate change, such as development of renewable energy, e-mobility, energy efficiency etc., require a simultaneous approach in different disciplines and fields of responsibility. Therefore many multinational and national bodies are involved in the process. This makes the realisation of climate relevant strategies such a challenge.

When it comes to the realisation of a specific project or the development of an individual strategy it is not only essential to be aware of the existing regulations but also to understand the structure of the political system, the distribution of the competences, the goals and strategies and the relevant parties involved. This is especially true for investments in new technologies that might just become profitable in the long run.

3.1.1 Distribution of competence between EU and national authorities

The EU is based on a series of treaties. These treaties establish and empower institutions in order to implement the common policy goals. The two principal treaties are the Treaty of the European Union (TEU; also called Maastricht Treaty, effective since 1993) and the Treaty *on the Functioning of the European Union* (TFEU; also called Treaty of Rome, effective since 1958). These main treaties (plus their attached protocols and declarations) have been altered by amending treaties at least once a decade (Wikipedia, 2013d).

The TEU stipulated five main goals in order to unify Europe.

- strengthen the democratic legitimacy of the institutions;
- improve the effectiveness of the institutions
- establish economic and monetary union
- develop the community's social dimension
- establish a common foreign and security policy

In order to reach these goals, the TEU has various policies dealing with issues such as industry, education, and youth (EU, Treaty of Maastricht, 2013j).

The Treaty of Lisbon which came into force in 2009 was signed reforming existing treaties in in order to make the EU more democratic and efficient in dealing with climate change, national security and sustainable development.

The Treaty on the Functioning of the EU (TFEU) regulates the distribution of competences between individual member states (MS) and the EU. This topic is quite relevant when it comes to the question whether to lobby for renewable topics on the national or the EU level. Three types of competences can be distinguished (the areas of major relevance to e-mobility are highlighted in bold characters):

Exclusive competences:

When the Treaties confer on the Union exclusive competence in a specific area, only the Union may legislate and adapt legally binding acts, the MS being able to do so themselves only if so empowered by the Union or for the implementation of Union acts. The exclusive competences are listed in Article 3 (EU, 2010a).

- customs union
- the establishing of the **competition rules** necessary for the functioning of the internal market
- monetary policy for the Member States whose currency is the euro
- the conservation of marine biological resources under the common fisheries policy
- the common commercial policy

Shared competences:

EU and MS are authorised to adapt binding acts in these fields. The shared competences are listed in Article 4 (EU, 2013e).

In principal MS may exercise their competence only in so far as the EU has not exercised, or has decided not to exercise, its own competence.

- internal market
- social policy, for the aspects defined in this Treaty
- **economic, social and territorial cohesion**
- agriculture and fisheries, excluding the conservation of marine biological resources
- **environment**
- **consumer protection**
- **transport**
- trans-European networks
- **energy**
- area of freedom, security and justice
- common safety concerns in public health matters, for the aspects defined in this Treaty

In some areas the Union shall have competence to carry out activities, in particular to define and implement programs, set guidelines or conduct a common policy; however, the exercise of that competence shall not result in MS being prevented from exercising theirs.

- **research, technological development and space**
- development cooperation and humanitarian aid

In some important field a special coordination shall be ensured (Article 5).

- **economic policies**
- employment policies
- social policies

Supporting competences:

The EU can only intervene to support, coordinate or complement the action of MS. Consequently, it has no legislative power in these fields and may not interfere in the exercise of these competences reserved for Member States (Article 6).

- protection and improvement of human health
- **industry**
- culture
- tourism
- education, vocational training, youth and sport
- civil protection
- Administrative cooperation

3.1.2 Relevant EU Authorities

The EU has a broad institutional setup. This paper will focus just on the most relevant for the topic of e-mobility. The following figure 17 does not only show the main institutions on European level but also their institutional tasks as well as the interconnection to national authorities.

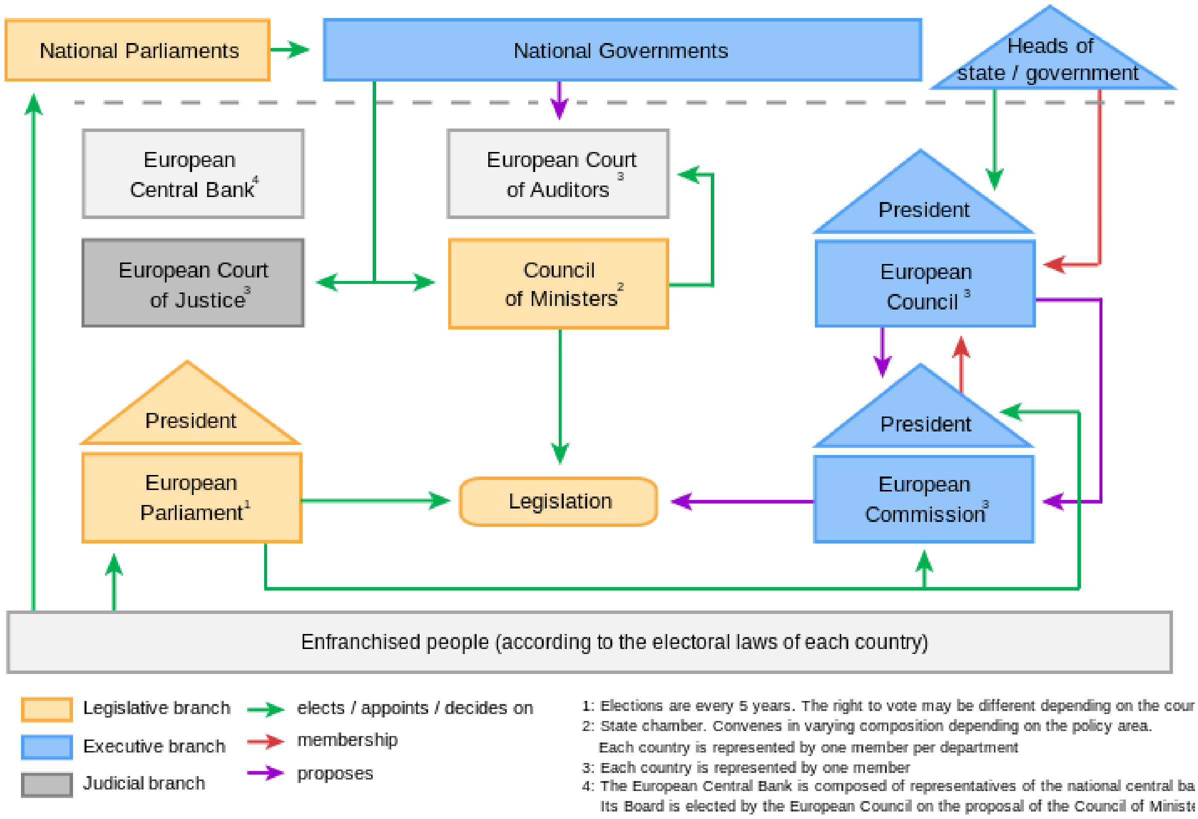


Figure 17: Political System of the European Union (Wikipedia, 2013c)

The **European Council** has no power to pass laws, however, it is composed of the national heads of government and the President of the EC. The council was charged by the Lisbon Treaty with defining the "the general political directions and priorities" of the Union. It is thus the Union's strategic (and crisis solving) body, acting as the collective presidency of the EU (Wikipedia, 2013b).

The **European Commission** (EC) is the main executive body of the EU responsible for proposing legislation, implementing decisions, upholding the Unions' Treaties and day-to-day running of the EU (Wikipedia, European Commission, 2013a). It is therefore the most important authority exercising the competences in the EU.

The EC is composed by 27 Commissioners nominated by the MS. Each commissioner is responsible for a specific field. Organisationally the EC is divided into departments called

Directorates-General (DG) classified according to the policy they are responsible for. In addition there are some service departments. The distribution of the individual responsibilities of the commissioners does not necessarily have to be in consistence with the responsibilities of the departments (EU, 2013d).

- Agriculture and Rural Development (AGRI)
- Budget (BUDG)
- Climate Action (CLIMA)
- Communication (COMM)
- **Communications Networks, Content and Technology (CNECT)**
- **Competition (COMP)**
- Economic and Financial Affairs (ECFIN)
- Education and Culture (EAC)
- Employment, Social Affairs and Inclusion (EMPL)
- **Energy (ENER)**
- Enlargement (ELARG)
- **Enterprise and Industry (ENTR)**
- **Environment (ENV)**
- EuropeAid Development & Cooperation (DEVCO)
- Eurostat (ESTAT)
- Health and Consumers (SANCO)
- Home Affairs (HOME)
- Humanitarian Aid (ECHO)
- Human Resources and Security (HR)
- Informatics (DIGIT)
- Internal Market and Services (MARKT)
- Interpretation (SCIC)
- **Joint Research Centre (JRC)**
- Justice (JUST)
- Maritime Affairs and Fisheries (MARE)
- **Mobility and Transport (MOVE)**
- Regional Policy (REGIO)
- **Research and Innovation (RTD)**
- Secretariat-General (SG)
- Service for Foreign Policy Instruments (FPI)

- Taxation and Customs Union (TAXUD)
- Trade (TRADE)
- Translation (DGT)

Some important DG’s for the development of e-mobility were highlighted in bold characters in the list above. From this organisational structure one can estimate how difficult it is to find agreement on relevant topics for the cross-sectional field of e-mobility.

The Commission's priorities are set out in the President's political guidelines which are transferred into annually updated work programs of the commission.

Main priorities for the 2013 Commission work program (CWP) are (EU, 2013c):

- Getting the foundations right: towards genuine Economic and Monetary Union
- Boosting competitiveness through the Single Market and industrial policy
- Connect to compete: building tomorrow's networks today
- Growth for jobs: inclusion and excellence
- Using Europe's resources to compete better
- Building a safe and secure Europe
- Pulling our weight: Europe as a global actor

Out of these priorities initiatives are elaborated. Major initiatives must be accompanied by impact assessments. Commission departments prepare "roadmaps" of planned impact assessment work.

Beside the main EU institutions involved in the legislative, executive or juridical process the EU has a number of other institutional bodies from which the **European Investment Bank** (EIB) financing EU investment projects and assisting small businesses through the European Investment Fund has to be pointed out in relation to e-mobility. It has of the following instruments:

- Loans for public and private sector
- Technical assistance by expert economists, engineers and specialists to complement EIB financing facilities.
- Guarantees available to a wide range of bodies
- Venture capital

The EIB has the following 6 priority objectives for lending (EU, 2013f):

- Cohesion and convergence
- Support for small and medium-sized enterprises (SMEs)

- Environmental sustainability
- Implementation of the Innovation 2010 Initiative
- Development of Trans-European transport and energy networks (TENs)
- Sustainable, competitive and secure energy

Furthermore some **agencies and decentralized bodies** have to be taken into account as influencing stakeholders in the development of e-mobility. EU agencies are independent legal entities under European public law distinct from EU institutions. They have special tasks of technical, scientific, operational and/or regulatory nature. This frees up the EU institutions, especially the Commission, to focus on policy-making (EU, Agencies and other EU Bodies, 2013a).

Some of the relevant agencies are:

- European Environment Agency (EEA)
- Executive Agency for Competitiveness and Innovation (EACI)
- Research Executive Agency (REA)
- Trans-European Transport Network Executive Agency (TEN-T EA)

Just to take out one example the, EACI was set up by the EC to deliver funding schemes and initiatives in the areas of energy, transport, environment, competitiveness and innovation. EACI is composed of European Commission officials and professionals, all specialists in energy, environment, business support, multi-modal transport, communication and finance. EACI was set up by the EC to manage on behalf of the respective DG's the following 5 initiatives whereby it fulfills its tasks in strong cooperation with four DGs (ENER, MOVE, ENTR and ENV) (EU, Agency for Competitiveness and Innovation, 2013b).

- Intelligent Energy – Europe (Program of DG ENER)
- Marco Polo (Program of DG MOVE)
- Enterprise Europe Network (Program of DG ENTR)
- Eco-innovation (Program of DG ENV)
- IPeuropAware Project (Program of DG ENTR)

3.1.3 EU strategy

The EU 2020 strategy aiming at a smart and sustainable growth was presented in 2009 and ratified by the EC mid-2010.

One of five targets of the strategy to be met by 2020 was related to climate change and energy sustainability:

- GHG emissions should be reduced by 20% (or even 30%, if the conditions are right) compared to 1990
- 20% of energy should be covered from renewables
- energy efficiency should be increased by 20%

Those consolidated targets were broken down to the individual MS. The Targets for Austria were a GHG reduction of 16%, a share of renewable energy (REN) of 34% and an efficiency increase by 7.15%.

As one measure to reach the EU 2020 climate relevant targets, the EU published 2010 an action plan encouraging the development of clean and efficient vehicles:

“Green vehicles, including those capable of using electricity, hydrogen, biogas and liquid biofuels in high blends, are likely to contribute significantly to the Europe 2020 priorities of developing an economy based on knowledge and innovation (smart growth) and promoting a more resource efficient, greener and more competitive economy (sustainable growth). The strategy is a vital part of the Europe 2020 flagship initiative ‘Resource-efficient Europe’, which seeks to promote new technologies to modernise and decarbonise the transport sector, thereby contributing to increase competitiveness. An assessment of the environmental, economic and social impacts will have to be taken into account in specific policy initiatives mentioned in the strategy. Actions at EU level will complement those taken at national and regional level and focus on areas where there is clear European added value, in line with the principle of subsidiarity” (European Commision, 2010).

The plan comprises medium to long term actions for the development of green vehicles that are capable of bringing down CO2 emissions considerably. The following vehicles were considered green (European Commision, 2010):

- Combustion vehicles using liquid biofuels and gaseous fuels (including LPG, CNG and biogas)
- BEV
- Hydrogen fuel cell vehicles

The rolling action plan comprises the following main elements (European Commision, 2010):

- Setting up a strong regularly reviewed regulatory framework in order to limit emissions
- Support research and innovation in green technologies
- Improve the market uptake by incentives and consumer information
- Standardisation measures
- Building up infrastructure
- Measures for power generation and distribution
- Promotion of the recycling of batteries

3.1.4 EU Initiatives

In November 2009 the EC published the European Economic Recovery Plan (EERP) that was designed to fight the prevailing financial and economic crisis by restoring the consumer and business confidence, restart lending and stimulate investment. One of the targets within the EERP was to develop clean technologies for cars and construction. For the realisation of this target three initiatives in form of Public Private Partnerships (PPP) were announced (European Commission , 2008):

One of these PPPs was the European green cars initiative, “involving research on a broad range of technologies and smart energy infrastructures essential to achieve a breakthrough in the use of renewable and non-polluting energy sources, safety and traffic fluidity. The partnership would be funded by the Community, the EIB, industry and Member States' contributions with a combined envelope of at least € 5 bn. In this context, the EIB would provide cost-based loans to car producers and suppliers to finance innovation, in particular in technologies improving the safety and the environmental performance of cars, e.g. electric vehicles. Demand side measures such as a reduction by Member States of their registration and circulation taxes for lower emission cars, as well as efforts to scrap old cars, should be integrated into the initiative. In addition, the Commission would support the development of a procurement network of regional and local authorities to pool demand for clean buses and other vehicles and speed up the implementation of the CARS21 initiative.” (European Commission , 2008):

Due to the cross-sectional topics the organizational structure of the initiative comprises public institutions as well as private parties that work closely together to reach a common goal.

The public side is represented by:

- DG Research and Innovation
- DG Information Society and Media
- DG Mobility and Transport
- DG Energy
- DG Environment
- DG Enterprise and Industry

The private sector is represented by industrial members directly as well as over the European Technology Platforms:

- European Road Transport Research Advisory Council (ERTRAC)
- European Technology Platform on Smart Systems Integration (EPoSS)
- SmartGrids

“European Technology Platforms (ETP) shown in figure 18 provide a framework for stakeholders, led by industry, to define research priorities and action plans on a number of technological areas where achieving EU growth, competitiveness and sustainability requires major research and technological advances in the medium to long term. Some European Technology Platforms are loose networks that come together in annual meetings, but others are establishing legal structures with membership fees. They work on developing and updating agendas of research priorities for their particular sector. These agendas constitute valuable input to define European research funding schemes. Since they are developed through dialogue among industrial and public researchers and national government representatives, they also contribute to create consensus and to improve alignment of investment efforts. ETPs foster effective public-private partnerships, contributing significantly to the development of a European Research Area of knowledge for growth” (EU, 2013i).

Energy	ICT	Bio-based economy	Production and processes	Transport
Biofuels	ARTEMIS	FABRE TP	ECTP	ACARE
SmartGrids	ENIAC	Food	ESTEP	ERRAC
TPWind	ISI	GAH	ETP SMR	ERTRAC
Photovoltaics	Net!Works	NanoMedicine	Manufuture	Waterborne
ZEP	NEM	Plants	FTC	ESTP
SNETP	NESSI	Forest-based	WSSTP	
RHC	EUROP		SusChem	
	EPoSS		EuMaT	
	Photonics21		IndustrialSafety	

Figure 18: European Technology Platforms (EU, 2013i)

The members of the technology platforms participating in the initiative prepared a roadmap for the electrification of road transport. This roadmap has regularly been revised since.

The identified portfolio of R&D projects is the result of an efficient continuous consultation process involving almost all relevant stakeholders (see figure 19). The commitment of the involved industries is reflected in collaborative research projects jointly funded with the EU (PPP European Green Cars, 2012).

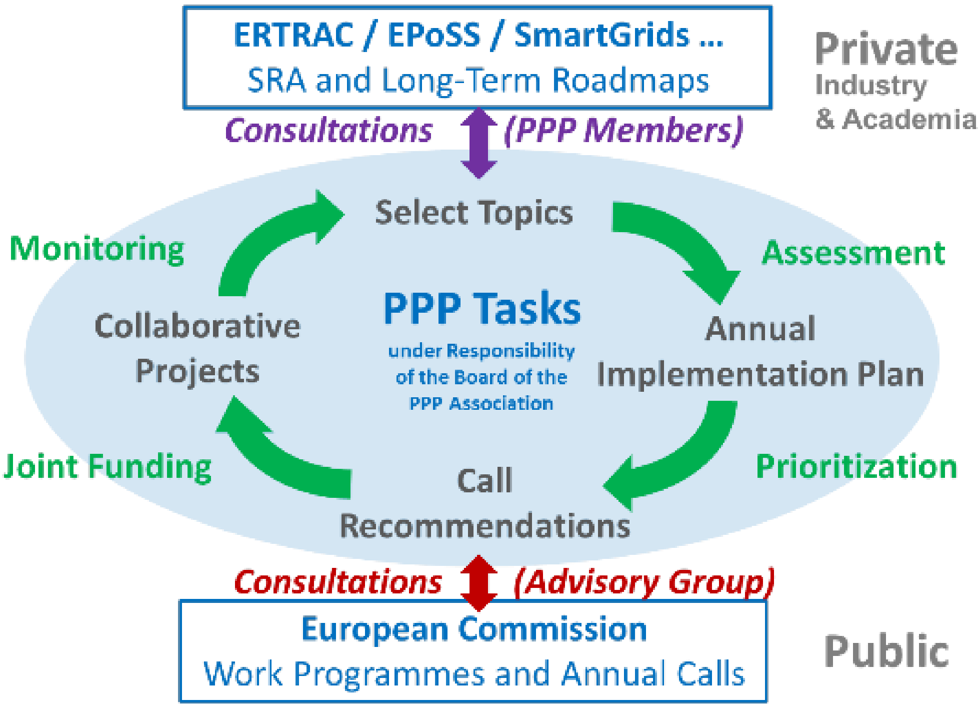


Figure 19: Stakeholder Consultation Process of the PPP European Green Cars Initiative (PPP European Green Cars, 2012)

With the most recent update of the roadmap including the extension to a 4th milestone scheduled for 2025 as shown in figure 20, the basis is provided for recommendations concerning the EU Framework Program for Research and Innovation 'Horizon 2020' (PPP European Green Cars, 2012).

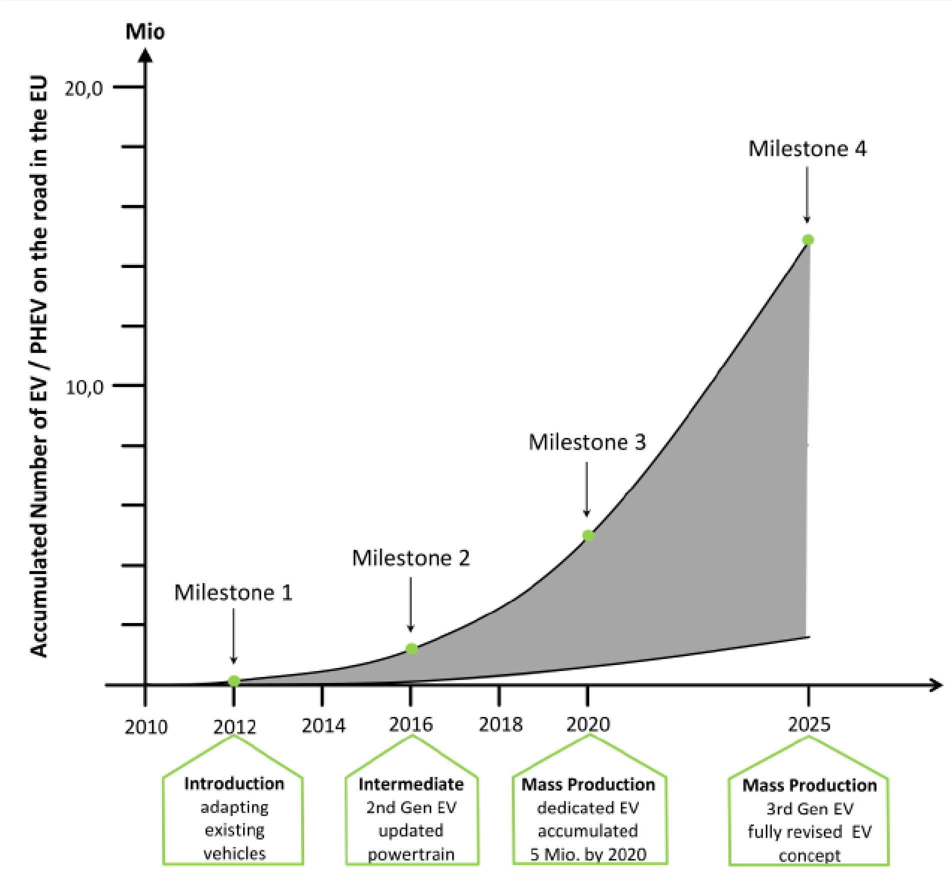


Figure 20: Milestones of the European Industry Roadmap for Electrification of Road Transport (PPP European Green Cars, 2012)

The milestones in this roadmap refer to passenger cars and consider six major technology fields:

- Energy Storage Systems
- Drive Train Technologies
- Vehicle System Integration
- Grid Integration
- Integration into the Transport System
- Safety

Beside the necessary R&D within these fields, the electrification of the vehicles requires a horizontal coordination across the various fields. Many of these topics are complex and require a high level of coordination with other fields. As some of the topics as Information & Communication Technologies, Grid Infrastructure and Materials are considered as crucial for the success of the electrification, they are therefore analysed in detail in separate roadmaps in order to reduce complexity (PPP European Green Cars, 2012).

The mass development of EVs will not only depend on the availability of vehicles as the primary object of the Green Cars Initiative but also on the simultaneous development of adequate infrastructure. Figure 21 shows that the adequate development of the infrastructure requires a coordination of various initiatives (PPP European Green Cars, 2012).

Figure 21: European Technological Initiatives dealing with EV development (PPP European Green Cars, 2012)

- EGCI (European Green Car Initiative)
  Dealing with topics in relation of the manufacturing of cars and necessary interfaces
- EEGI (European Electricity Grid Initiative)
  Topics in relation to the grid development
- ESCI (European Smart City Initiative)
  referring to the part that directly affects city mobility, planning and growth

3.1.5 EU expenditure

As the EU does not have disbursements like social security, defence or pensions like ordinary states, most of the budget is therefore dedicated for structural investments, subsidies and research. The EU's financial planning is carried out by two instruments: through a seven year plan called Multiannual Financial Framework (MFF) and through a budget, which is decided each year (Open Knowledge Foundation, 2013).

Within the MFF the limits for each category of expenditure for a determined period of time are laid down (see figure 22). The MMF actually in place expires by the end of 2013 (EU, 2013h).

Figure 22: MMF framework 2007-2013. (EU, 2013h)

Matching the EU strategies and policies, most of the money is spent for sustainable growth and natural resources. Within these two categories the major beneficiaries are the agricultural sector followed by regional policy instruments and R&D. Within the coming MMF period of 2014-20 agriculture and regional expenditure are supposed to slightly decline and R&D will benefit.

Ultimate responsibility for implementing the budget lies with the EC. But in reality, some 76% of the budget is spent under what is known as 'shared management', with individual EU countries actually distributing funds and managing expenditure on behalf of the EC (EU, 2013g).

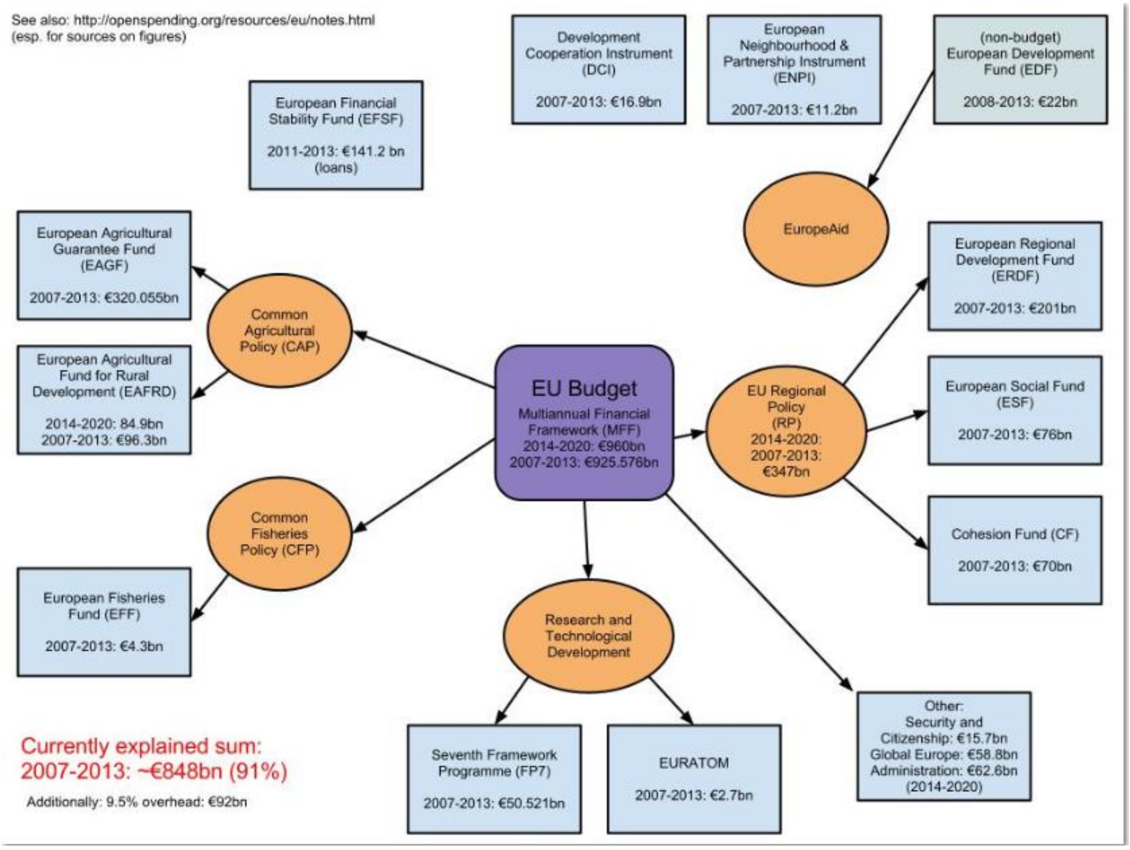


Figure 23: Overview of EU-Funds (Open Knowledge Foundation, 2013)

According to figure 23 the money allocated to initiatives or projects is distributed through dedicated funds that are part of the EU budget. The relevant issues for e-mobility are mainly covered under the MMF heading 1a and partly 1b (see table 8).

Heading	Period	Total amount in current prices (million EUR)
HEADING 1A — COMPETITIVENESS FOR GROWTH AND EMPLOYMENT		
Seventh research framework programmes	(07–13)	50 521.00
Trans-European Networks (TEN) Transport	(07–13)	8 013.00
Trans-European Networks (TEN) Energy	(07–13)	155.00
Egnos and Galileo (satellite radio navigation)	(07–13)	3 005.00
Marco Polo II (environmental performance of the freight transport system)	(07–13)	450.00
Lifelong Learning	(07–13)	6 970.00
Competitiveness and Innovation Framework Programme (CIP)	(07–13)	3 621.30
PROGRESS (Programme for Employment and Social Solidarity)	(07–13)	683.25
Custom 2008–13 (facilitating legitimate trade; preventing unfair and illegal trade)	(08–13)	323.80
Fiscalis 2008–13 (cooperation between tax authorities; fight against tax fraud)	(08–13)	156.90
Hercule II (protection of the EU's financial interests)	(07–13)	98.53
Nuclear decommissioning: (A) Ignalina; (B) Bohunice; (C) Kozloduy	(07–13)	1 560.00
Pericles (protection of the euro against counterfeiting)	(07–13)	7.00
Anti-pollution measures	(07–13)	154.00
Erasmus Mundus 2	(09–13)	493.69
HEADING 1B — COHESION FOR GROWTH AND EMPLOYMENT		
Total Structural Funds, including:		278 454.09
European Regional Development Fund (indicative)		*201 633.15*
European Social Fund (indicative)		*76 820.94*
Total Cohesion Fund		69 963.12

Table 8: Programs related to the Financial Framework 2007–13 (as in legal bases) (EU, 2012)

3.1.6 National Authorities

In Austria the equivalent to the DG's on EU level are the Ministries that, on federal level, are responsible for proposing legislation and implementing decisions and strategies.

- Federal Ministry for Agriculture, Forestry, Environment and Water Management (BMLFUW)
- Federal Ministry of Defence and Sports
- Federal Ministry of Economy, Family and Youth (BMWFJ)
- Federal Ministry for Education, Arts and Culture
- Federal Ministry for European and International Affairs
- Federal Ministry of Finance (BMF)
- Federal Ministry for Health
- Federal Ministry of the Interior
- Federal Ministry of Justice
- Federal Ministry of Labour, Social Affairs and Consumer Protection
- Federal Ministry for Transport, Innovation and Technology (BMVIT)
- Federal Ministry of Science and Research (BMW_F)

Like in the EU, Austrian Ministries use for some purposes specialized institutions and agencies to implement their strategies. These institutions and agencies are mainly financed by or report to one or two of the Ministries.

For the cross-sectional field of energy and mobility this ownership structure seems to be a disadvantage in comparison to the EU standards. As described above EU agencies are given specific tasks and depending on those tasks the involvement of the different DG's is composed. The cooperation between Austrian Agencies is restricted due to the competition between funding and competences of Ministries. For this reason not always the best suited institution will be charged with a specific task but the one belonging to the funding Ministry. A cooperation of those institutions is sometimes not wanted.

In addition, partially due to historical reasons, specific laws were passed defining a specific institution as sole agency of a funding scheme. This hinders other institutions, even having adequate instruments, to work or cooperate within the same legal framework.

The main federal institutions agencies dealing with e-mobility topics are:

- **Austria Wirtschaftsservice** (aws)

  (Controlled by: BMWFJ and BMVIT; partially funded and counter guaranteed by BMF)

The aws is the federal financing bank focusing on the promotion and financing of viable projects of companies. Similar to the EIB the aws disposes of various instruments such as grants, loans, guarantees, mezzanine and venture capital as well as consulting services. The core objective is to promote start-up and investment projects of Austrian companies in Austria or abroad, as well as later stage R&D projects (e.g. transfer to industrial mass production or even pilot plants in a bankable environment). There is almost no restriction to specific sectors (including renewable energy and automotive).

- **Forschungsförderungsgesellschaft** (FFG)

  (Controlled by: BMVIT and BMWFJ)

  The FFG is the national funding institution for applied research and development in Austria. It offers to Austrian companies, research institutions and scientists, instruments and services ranging from the provision funding to consulting services at all stages of technology development and innovation and support for integration into European research programs and networks (FFG, 2013).

- **Klima und Energiefonds** (KLIEN)

  (Controlled by: BMVIT and BMLFUW)

  The KLIEN promotes R&D, mobility, market entry and awareness concepts and projects of companies, individuals, municipalities and research institutions in the area of green and sustainable energy technologies.

- **Kommunalkredit Austria**

  (Controlled by: BMF)

  The Kommunalkredit was founded in order to provide municipalities with long term financing for infrastructure projects. Its subsidiary, the Kommunalkredit Public Consulting (KPC) was set up in order to process the environment promotion tasks laid down in the environment promotion law of 1993. In addition the KPC executes the Joint Implementation (JI) and Clean Development Mechanism (CDM) program for the Republic of Austria in order to reach the Kioto targets.

Whereby the aws and FFG have funds under own competence, the KLIEN and KPC just prepare decision papers for individual funding projects, which are then decided upon in external boards.

In fundamental and applied research fields the FFG and the KLIEN are the most important federal agencies promoting e-mobility topics. Figure 24 shows that in order to reach the strategy target not only the technology side has to be pushed but also the market side has to be stimulated in order to create a pull effect (BMVIT, 2009). Therefore financing and supporting instruments have to promote bankable projects in this field. This is the point where the aws steps in with its expertise and instruments. In this context bankable projects are not only deployable projects of mature technologies but also applied science projects of bankable companies independent whether SME or large. A good coordination between the agencies would be essential to assist companies to overcome the so called “Death Valley”.

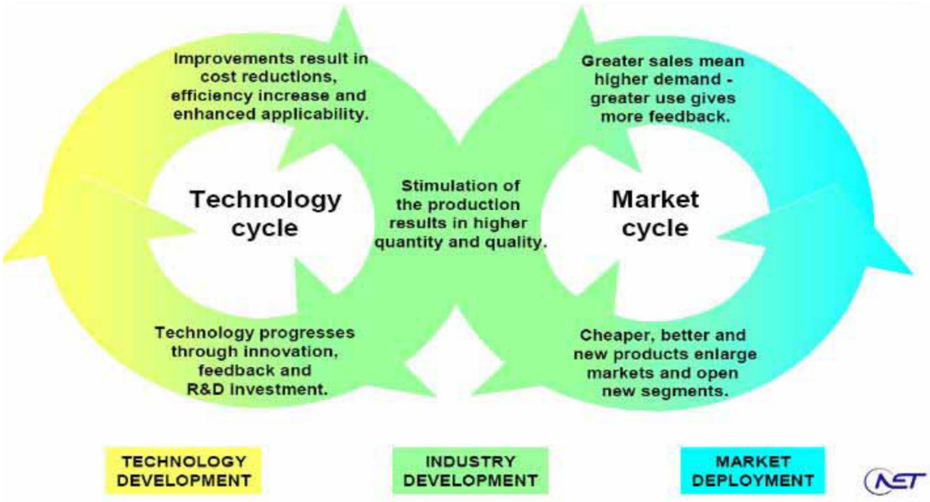


Figure 24: Technology Push und Demand Pull (BMVIT, 2009)

In addition to the federal institution various other institution are engaged within the field of e-mobility e.g.:

- **Austrian Institute of Technology (AIT)**

  The AIT is a non-university research institute and specialized in the key infrastructure issues. The AIT is a joint-venture between the BMVIT and industrial partners represented by the Federation of Austrian Industries.

- **Fonds zur Förderung der wissenschaftlichen Forschung (FWF)**

  The Austrian Science Fund is a legally independent organization funding basic research in Austria.

- **Nationalstiftung für Forschung, Technologie und Entwicklung (FTE-Stiftung)**

  The FTE-Stiftung is funded by the Austrian Central Bank and the ERP-Fund. Austrian Research Centers (ARC)

3.1.7 National Strategy

End of 2008 the newly elected Austrian government signed their program for the period until 2013 containing all major topics of the EU 2020 strategy.

2012 three Ministries (BMLFUW, BMVIT, BMWFJ) published together an action plan for e-mobility in and from Austria 'Elektromobilität in und aus Österreich'.

With the aim of strengthening the competitiveness of Austria as industry location the action plan focusses on the following measures:

- Integration of e-mobility in the overall mobility concept
- Adaption of the energy system and charging infrastructure
- Assisting market entry and developing adequate incentive systems
- Information and awareness measures
- Focusing on environmental effects and monitoring
- Strengthening the R&D competence of Austrian companies by an adequate support of the innovation process including the industrial mass production
- Improvement of the internationalization of Austrian companies by intensifying the cooperation, the information exchange and the adaption of national instruments
- Improvement of training, qualifications and expertise

The necessary measures will be initiated by the respective Ministries in charge, however, the implementation will be done in close cooperation with politics, administration, research, industry and economy (BMLFUW, BMVIT, & BMWFJ, 2012).

3.1.8 National Initiatives

Following the framework set by the EU the Austrian government and industry pays a high attention to the development of e-mobility.

The Federal Ministry of Transport, Innovation and Technology (BMVIT), responsible for setting the political framework for Technology, R&D, Infrastructure and mobility concepts in Austria, was given the lead in the development and implementation of the national plan for e-mobility. The BMVIT fulfils this task in close cooperation and coordination with other affected Ministries, industry, governmental institutions, regions, municipalities, media and the public via consultations (BMVIT, 2010).

The main initiatives comprise incentives for R&D, the establishment of flagship projects and the development of model regions.

In order to promote the innovation process the BMVIT disposes of a broad portfolio of instruments and programs. Total R&D funding from 2008 to 2010 under those programs accounted for approx. EUR 160 million (BMVIT, 2010).

- A3 and A3plus Technology program: funding cooperative R&D projects developing alternative propulsion systems and fuels
- Program Energy 2020: ICE-optimisation, light weight structures, electronics
- Lighthouse Projects: demonstration for market introduction
- FFG basic program: bottom-up product optimisation
- Headquarter program
- Research Infrastructure (e.g. Hydrogen Center Austria)
- Competence Centers (e.g. K2-Mobility)
- International Cooperation (FP7, ETPs, ERA-NETs, IEA)
- National agencies (FFG, Klimafonds, aws)
- Austrian Agency for Alternative Propulsion Systems (A3PS)

Some of the initiatives are organized in close cooperation with the industry in form of PPPs as e.g. the Austrian Agency for Alternative Propulsion Systems (A3PS). In other programs the cooperation with EU stakeholders is essential. Figure 25 shows a general overview of EU and national funds respectively programs in the area of research and technology development.

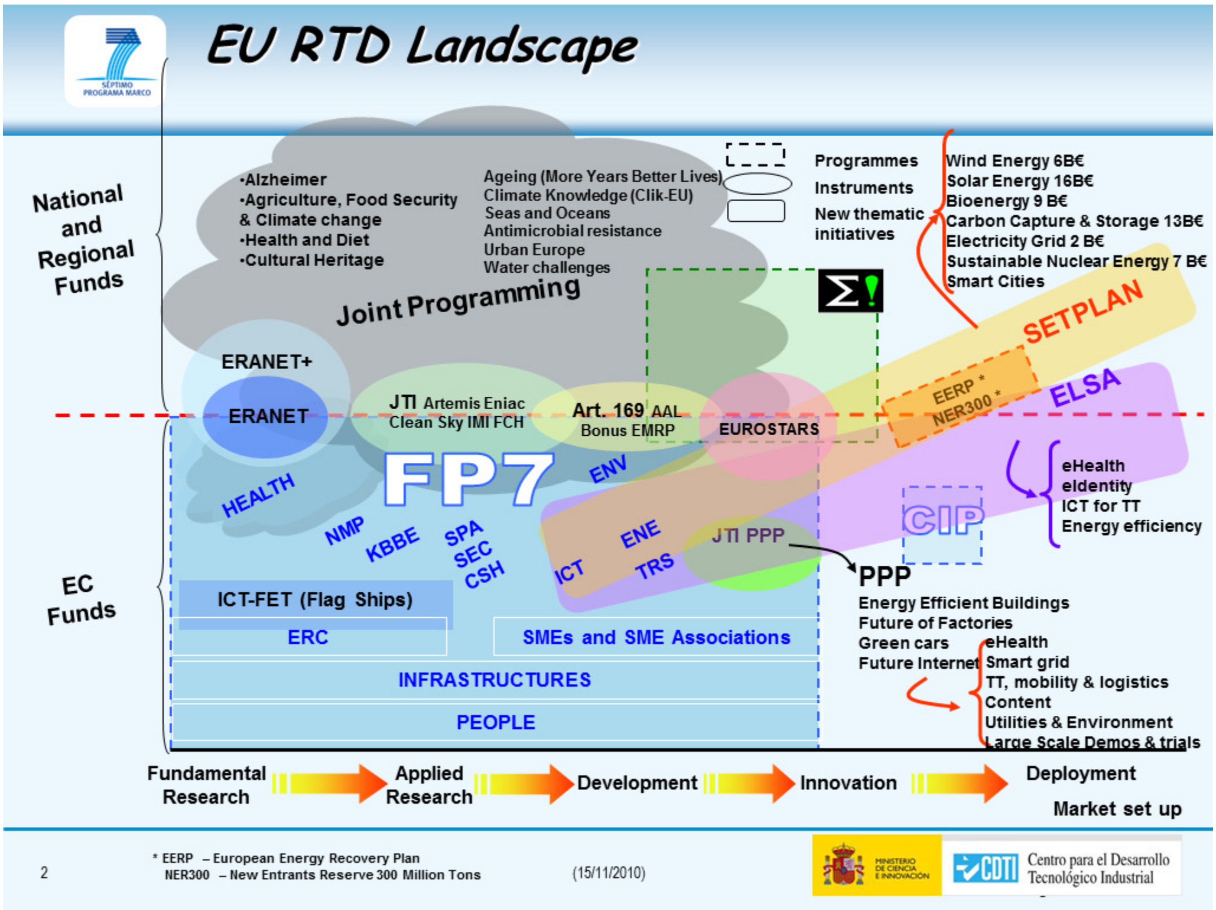


Figure 25: EU Technology Landscape (Rattenberger J., 2012)

Flagship initiatives (lighthouse projects of e-mobility) aim at supporting the market introduction of new technologies through demonstration. The program was set up in 2009 and the 4th call was closed by the end of 2012. So far almost EUR 30 million were attributed to projects. As an example E-Mobile Power Austria (EMPORA) (www.empora.eu) was funded within the first and the second call of the lighthouse program. The projects comprises 21 Austrian partners covering the entire value chain of e-mobility from the automotive sector, infrastructure partners, utility companies and research institutes in order to develop an integrated solution for e-mobility. With a total funding of approx. EUR 26 million it is one of the biggest research projects in Austria. The projects started in 2010 and will be finished in 2014 (Prettenthaler, 2011).

Since 2008 the KLIEN has promoted the implementation of eight e-mobility model regions in Austria (e-connected, 2013b):

- **VLOTTE** (Vorarlberg, Call 2008 and 2009)
- **ElectroDrive Salzburg** (Salzburg, Call 2009)
- **e-mobility on demand** (Vienna, Call 2010)

- **Großraum Graz** (Styria, Call 2010)
- **Eisenstadt e-mobilisiert** (Burgenland, Call 2010)
- **e-pendler niederösterreich** (Niederösterreich, Call 2011)
- **E-LOG Klagenfurt** (Carinthia, Call 2011)
- **E-Mobility Post** (Vienna, Call 2011)

Figure 26: Model regions for e-mobility in Austria (e-connected, 2013b)

The target of the program is to use the model regions for gaining experience and as a potential multiplier for the development of e-mobility in Austria. Therefore the program assists model regions in:

- acquiring charging infrastructure and EVs
- providing renewable energy and
- developing new business models

Beside the BMVIT the Federal Ministry for Agriculture, Forestry, Environment and Water Management (BMLFUW) initiated the e-connected initiative together with the KLIEN. The initiative aims at providing all relevant information concerning the public e-mobility topics (e-connected, 2013a):

- Education
- Business models
- Electric vehicles
- Charging stations
- Framework conditions

- System-integrated e-mobility
- Network integration (not active in the 2nd phase “e-connected II”)
- Energy storage (not active in the 2nd phase “e-connected II”)

3.2 Legal regulations

The change towards e-mobility faces new legal aspects to be regulated in order to foster the development and prevent unwanted side-effects. The regulations follow different motivation:

- Regulations to reduce the safety risks inherent in new technologies such as e-mobility
- Regulations to protect different market players from damage
- Regulations to provide a harmonized framework for development and innovation by setting standards and norms
- Regulations to ensure and promote the achievement of the strategic political goals

Another way to classify regulations is to distinguish between financial and non-financial ones, bringing the concepts together the following table can be drawn.

	Safety (technical risk)	Protection of market players	R&D Framework	Sale of BEV
Non Financial				
Standardization	x	x	x	
Environmental regulations		x	x	x
Parking regulations				x
Priority lanes				x
Low emission zones				x
Financial				
Loans			x	x
Subsidies			x	x
Taxation				x
Exemptions				x
Depreciation				x
Toll			x	x

Table 9: Type of instruments vs. motivation (own chart)

3.2.1 Environmental regulations

Given the EU 20 20 20 climate targets e-mobility is supposed to benefit from the continuously tightening of the national environmental regulations for vehicles with combustion engines.

Table 10 shows the development of average **CO_2 emissions** of cars licensed in Austria during the last decade. The negative trend in the years 2005 till 2007 was mainly due to the increasing share of highly powered Sport Utility Vehicle (SUV) (Pötscher F., 2012).

Year	Diesel	Gasoline	average of fleet (g CO_2/km)
2000	162	176	167,3
2001	161	175	165,8
2002	161	173	164,6
2003	161	170	163,6
2004	159	168	161,6
2005	161	165	162,4
2006	164	163	163,6
2007	164	161	162,8
2008	160	155	157,7
2009	153	148	150,3
2010	145	143	144,0
2011	140	137	138,7

Table 10: Average CO_2 emissions of new passenger cars in Austria (Pötscher F., 2012)

As the non-effective self-limitations of the industry lead to such negative consumer trends as the rapid increase of SUVs, the EU published 2009 the regulation 443/2009 for the reduction of CO_2 emission of new cars that came into force with the beginning of 2010. According to this regulation the OEMs have to obey certain CO_2-limits for their entire fleet. The targets in this regulation were set to 130 grams of CO_2 per kilometre (g/km) by 2015 and 95g/km in 2020 (EU, 2009). As the limits are connected to the average weight of the OEMs car fleet, different limits for different producers are valid. The limit for BMW would be approx. 138g CO_2/km and for Fiat approx. 120g CO_2/km (VCD, 2012).

In addition to the regulations for CO_2 emissions the European emission standards limiting toxic exhaust emissions of new vehicles sold in EU member states are in place.

Within this standards **toxic emissions** of

- nitrogen oxides (NO_x)
- total hydrocarbon (THC)
- non-methane hydrocarbons (NMHC), carbon monoxide (CO)
- particulate matter (PM)

are regulated for different vehicle type separately. Figure 27 shows the development of the limitations e.g. for diesel engines.

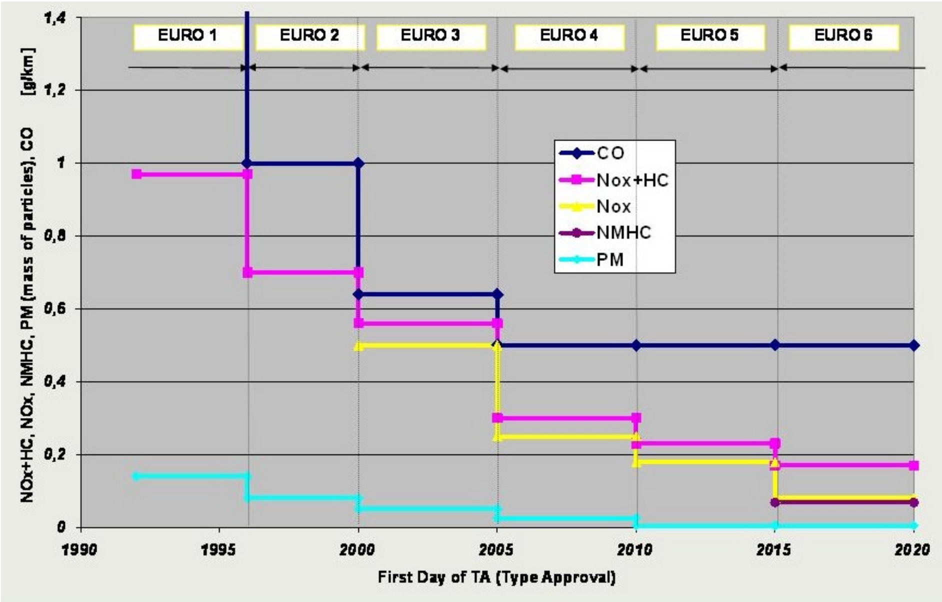


Figure 27: EU emission limits for diesel engines (Wikipedia, Abgasnorm, 2012)

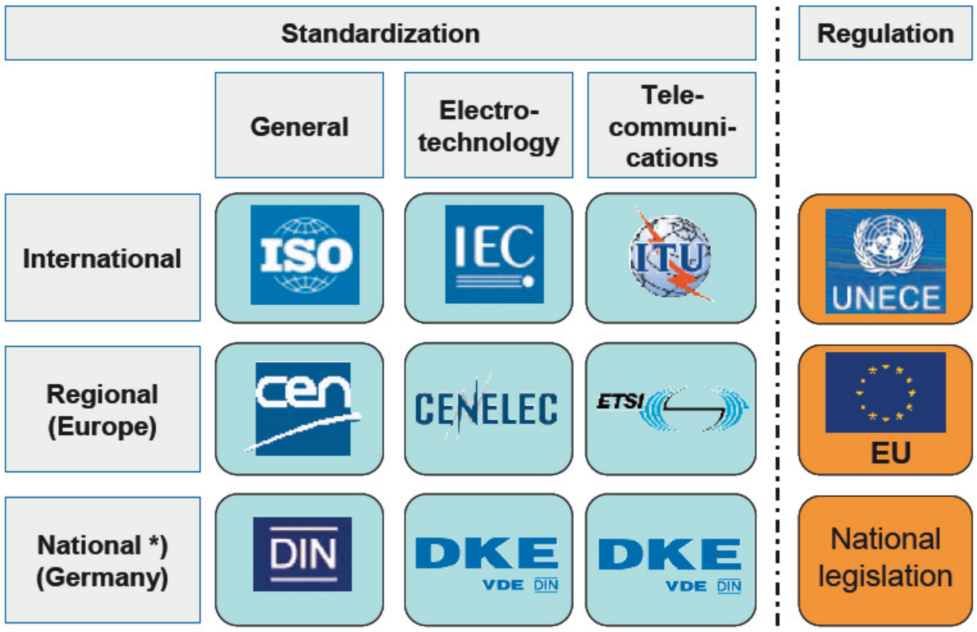
3.2.2 Standards and Norms

The large number national and international projects in the field of e-mobility that are currently under investigation or realisation require a systematic and transparent approach in order to prevent negative effects. Standardization is in this context an important and powerful tool in the process of market deployment as it offers main advantages in comparison to a non-harmonized process: (DIN, 2000)

- Consolidation of development skills of producers reduce R&D cost and accelerate development
- Formation of a reduced amount of variants leads to a transparent market for buyers thus preparing markets for new products
- Reducing the risk of a producer of investing in a non-competitive technology
- Economies of scale reduce production cost and total cost of final products
- Assuring a sufficient level of user safety

The development of the cross-sectional field of e-mobility requires a national and international integration of standardization efforts of different sectors and branches. It is deemed to be one of the key success factors for boosting the acceptance of EVs by customers (NPE, 2011).

Standardisation in the mobility field is manly driven by global industrial players together with national and international policy makers and regulatory bodies. Figure 28 gives an overview of the standardization landscape.



*) Other national organizations outside Germany include SAE, ANSI/UL International, etc.

Figure 28: Structure of the standardization landscape (NPE, 2010)

With the target of becoming the lead provider of e-mobility solutions, Germany, as one of the major producers of automobiles in Europe, developed the “German Standardization Roadmap” within the national plan of e-mobility in 2010. The main recommendations of this roadmap are (NPE, 2010):

- Coordinated and harmonized political action at European and international level
- Standards should be function related that means performance based rather than descriptive
- A uniform worldwide charging infrastructure is necessary
- Make primarily use of existing standards by adapting or expanding them rather than initiate new ones

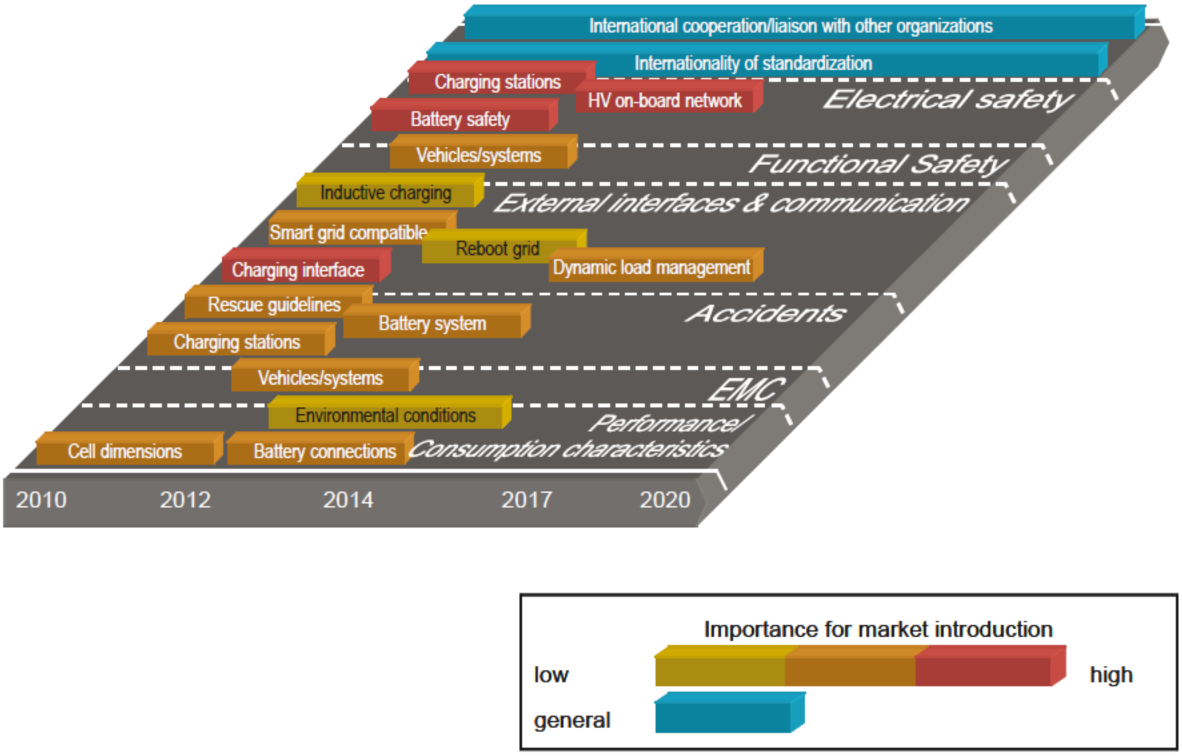


Figure 29: Schedule for implementing recommendations (NPE, 2010)

Figure 29 shows that, according to the findings of the roadmap the standardization, questions in relation to battery and charging should be given the highest attention.

3.2.3 Safety regulations

A new technology such as EVs bears new risks. The major part of the risks results from the battery unit. In order to increase the driving range materials with a high energy density such as lithium-ion are used for the production of batteries. These materials however are highly reactive and the right temperature management is essential for a safe operation. Especially during driving, charging or even in the event of a technical failure (e.g. short circuit) or an accident the battery has to be protected from overheating, burning or in the worst case exploding.

In order to protect consumers from damage, safety regulations are being adapted mainly through setting a high level of standards and norms. As shown in the standardization landscape above, the main responsible institutions are on EU level the European Committee for Electrotechnical Standardization (CENELEC) and in Germany the Verband der Elektrotechnik Elektronik Informationstechnik (VDE).

The following fields of risks related to the vehicle and the charging infrastructure have been identified:

- Electrical safety
- Functional safety
- Mechanical safety
- Chemical safety
- Acoustic safety

3.2.4 State Aid

Although the EU has a defined strategy in order to fight climate change, MS are limited by EC regulations when it comes to supporting renewable projects. Regardless if e.g. an R&D or an investment undertaking for e-mobility is planned, member states cannot freely decide whether and to which amount they will support the project. For this purpose it is essential to know the basics of state aid in order to get an idea under which conditions a project is eligible for state aid and to understand the requirements of national agencies such as the FFG, KPC, KLIEN or aws when it comes to the evaluation of applied projects. By respecting these laws and mechanisms in many cases projects can be adapted in order to fit into one of the eligible categories listed by the EU regulations.

According to the EU Treaty the competence regarding state aid provisions belongs to the EC (particularly to the DG Comp).

State aid in the sense of Article 107 has four characteristics (Department for Business Innovation & Skills, 2011):

- It is granted by a MS or through a MS resources
- It favours certain undertakings or the production of certain goods
- It distorts or threatens to distort competition
- It affects trade between MS

Examples for types of State Aid range from obvious ones

- State grants
- Interest rate relief
- Tax relief
- Tax credits
- State guarantees

- Direct subsidies
- Tax exemptions

to less obvious ones

- Free advertising on State owned TV
- Infrastructure projects benefiting specific users

(Department for Business Innovation & Skills, 2011)

In principle state aid is prohibited because of its distortion effect on competition between MS except (Art 107 TFEU) (EU, 2010a).

Due to existing market failures, however, State Aid may be considered to be compatible for certain purposes with the internal market (Art 107 (3):

- Areas with a low development level
- Aid to promote the execution of an important project of common European interest
- Aid to facilitate the development of certain economic activities or of certain economic areas
- Aid to promote culture and heritage conservation
- Other categories of aid as may be specified by decision of the Council on a proposal from the Commission (EU, 2010a)

Even being considered compatible, no state aid may be awarded before being notified and approved by the EC. This requirement can be fulfilled either by

- notifying the assistance itself related to the single project or by
- notifying the national assistance program (guideline) on the basis of which the single project should be assisted

Non-approved state aid is automatically considered to be ineligible (incompatible with the common market) and has to be recovered.

In order to simplify the notification procedure for certain sectors, the EC issued so-called „General Block Exemptions Regulations“ (GBER). Such block exemptions describe the conditions under which a certain state aid is considered to be compatible with the common market. State aid that fulfills all the conditions laid down in the GBER can be given aid to a certain determined amount without preliminary obligation of notification, however it has to be notified by the EC in a simplified form within the set deadlines (Department for Business Innovation & Skills, 2011).

The EC lists 26 categories of aid authorized under the GBER. The most important for the development of projects in the field of e-mobility are (EU, 2008):

- Aid to SME
- Aid for Research & Development & Innovation
- Environmental Aid

For all categories different maximum levels of state aid have to be respected. The cumulated state aid given to a specific project must not exceed the maximum level permitted.

In order to cumulate repayable state aid e.g. favourable loans or guarantees, the cash grant equivalent has to be calculated. This cash grant equivalent represents the real benefit the company gets and is calculated by discounting the amount of interests of the subsidised credit/loan in comparison with a credit according to market conditions.

Very important in this context is that state aid is only permitted if it has an "incentive effect". This means that the project would not have been undertaken or undertaken in a much reduced form if the aid would not have been granted. This is also the main reason why it is essential to apply for state aid before the project startes, this means before costs occur, orders are placed or advance payments are done.

Another simpler notification procedure is foreseen for state aid that does not exceed a certain ceiling, the so-called „De minimis" aid. The ceiling was set to EUR 200000 within three fiscal years. In contrast to the project related approach of the GBER the de minimis regulation cumulates all state aid given to a specific applicant over a specific period. The state aid is labelled with "de minimis" and the applicant has to declare to have respected the set ceiling within the defined period of time (Department for Business Innovation & Skills, 2011).

Although the numerous national state aid programs differ in detail from each other according to their target and are altered frequently over time, these two main concepts, the GBER with its categories and the de minimis regulation, can be found as legal basis in almost any national state aid programs.

As described above, state aid is a not only restricted to a financial measure however financial instruments are often in the focus of policy makers as adequate tools in order to stimulate the economic activity. Financial instruments in this context are e.g. subsidies, favourable loans or tax measures. The advantage of using financial instruments is their relatively simple impact assessment in terms of quantities and monetary effect and the fact that they can be budgeted.

In relation to the development of e-mobility financial state aid instruments can influence the demand or the supply side. Supply side financial instruments mainly focus on closing the financial gap for the development of technologies or financing their market entry. Addressees are individual companies, joint ventures or e.g. clusters. There are a broad range of EU and national instruments in this field. The funds are mainly administered and distributed by particular agencies as for example in Austria the FFG, aws, KLIEN, KPC etc. Demand side financial instruments stimulate the sales of BEVs by subsidising the acquisition or reducing the costs by giving tax advantages (Geringer B., Sihn W., & et al., 2011).

The main financial incentives available in Austria for pushing the demand side are:

Monthly vehicle tax

Vehicles powered exclusively by electricity are exempted from the monthly vehicle tax which is calculated e.g. for passenger cars as follows (KFzStG, 1992):

Vehicle tax in EUR = (Power of engine in kW – 24) × 0.6

NOVA

Exemption of the registration tax „Normverbrauchsabgabe“ (NOVA) for vehicles powered exclusively by electricity. For vehicles not exempted, the NOVA is generally based on the net purchase price and takes into account the consumption of the engine according the driving cycle measurements defined by the EU Motor Vehicle Emissions Group (MVEG) (NOVAG BGBl 595/1991, 1991).

The tax rate for vehicles powered by gasoline and other fuels is calculated:

Nova in EUR = net purchase price x 2 x (MVEG-consumption -3) /100

And for diesel vehicles:

Nova in EUR = net purchase price x 2 x (MVEG-consumption -2) / 100

Since 2008 there is an additional bonus or malus for low respectively higher CO_2 emissions.

The maximum NOVA is limited to 16%.

Fuel tax

In comparison to fossil fuels electricity for BEV generated by renewable forms of energy are, apart from VAT, not taxed. The tax for fossil fuels in Austria amounts to (MÖStG, 1995):

Gasoline EUR 0.482/l

Diesel EUR 0.397 /l

LGP EUR 0.261/kg

Subsidies

In Austria tax measures to promote e-mobility are dominant. Direct subsidies for the acquisition of BEVs especially by privates are very restricted or not available at all in certain regions.

At federal level the KPC offers a subsidy of max. EUR 4000 to companies or municipalities if the electricity consumed comes from renewable sources otherwise EUR 2000 (KPC, 2013). For private households there are currently no federal subsidies in Austria.

On regional level Salzburg is offering the highest amount subsidy with max. EUR 4000 in case the buyer can prove that he contributed in building up additional green energy capacities. If the buyer only uses green electricity the amount is reduced to EUR 3000 and without any restrictions to EUR 2000 (ÖAMTC, 2013).

3.2.5 Other regulations

In addition to financial incentives various other measures to promote e-mobility are under discussion or have been already implemented e.g.

- Reserved lanes (BEVs are allowed to make use of bus lanes)
- Environment or low emission zones where high emission vehicles are banned and BEVs have free access
- Reduced city toll for BEVs
- Free or subsidized parking and/or charging for BEVs

These measures mainly try to improve the quality of the transport service provided by a BEV in comparison to combustion engines in order to make electric cars more attractive from the user's point of view and to make up for the higher purchase price.

3.3 Economic Factors

The evaluation of the economic factors in this context comprise relevant topics to individuals, households, enterprises and the public having a major an impact or influence on e-mobility.

3.3.1 Total cost of ownership

From the microeconomic point of view one of the main factors influencing investment decisions is certainly the comparison of the total cost of ownership (TCO) between available technologies. The TCO calculation model for BEVs is shown in figure 30.

According the Boston Consulting Group (BCG) consumers and enterprises are not willing to pay a substantial premium for BEVs unless they have an economic advantage in terms of TCO. Apart from monetary factors other factors such as availability of service, comfort of use, availability of charging infrastructure, environmental concerns, concerns about the development of fossil fuels price etc. influence microeconomic behavior. However, these factors will stimulate early adopters in niche segments while a TCO advantage is a prerequisite for the widespread success of the BEV (BCG, 2009).

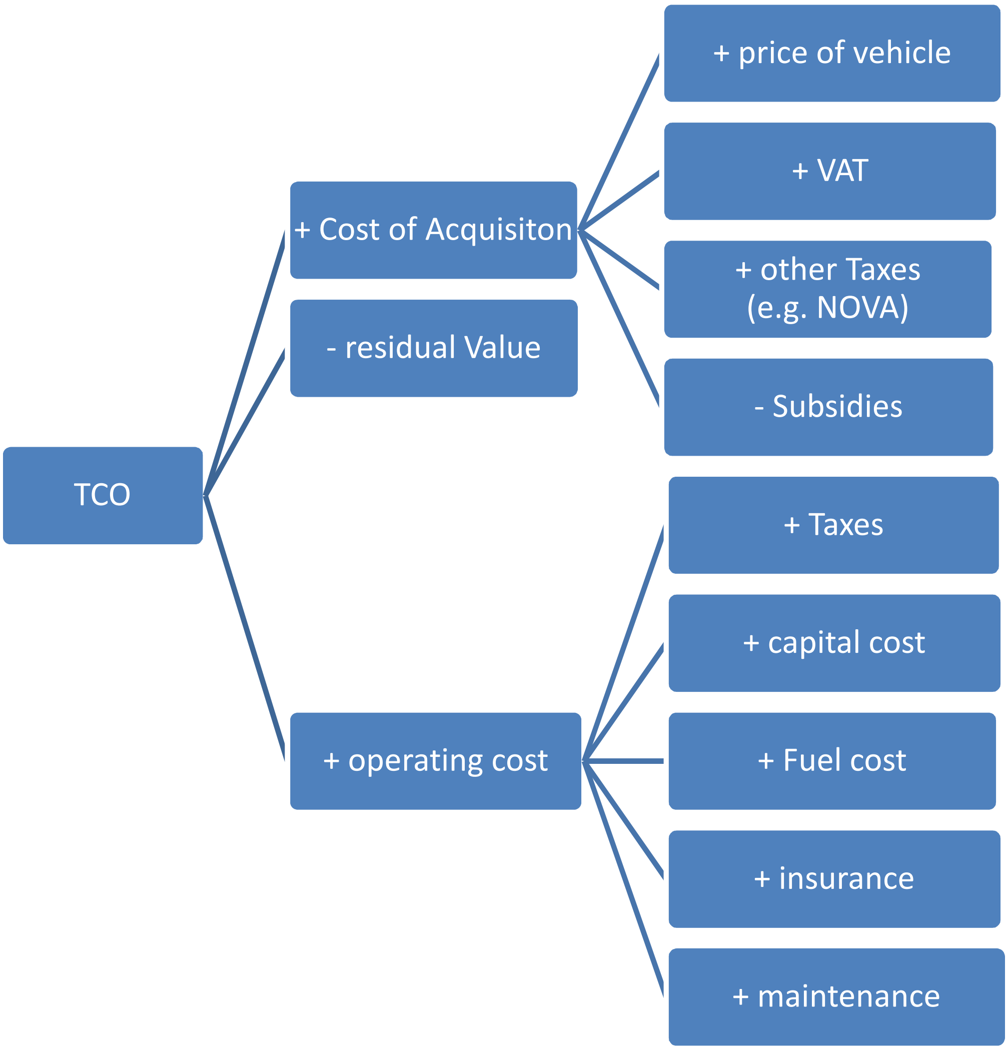


Figure 30: Total Cost of Ownership (NPE, 2011)

The main drivers of a TCO calculation are according the German National Platform for Electromobility (NPE) the higher cost of acquisition in connection with the lower residual value. Both values are mainly influenced by the price and the lifetime of the battery system.

This depreciation makes up to almost 75% of the TCO and is in comparison to conventional vehicles almost twice as high. (NPE, 2011)

According to the BCG the battery electric vehicle ist the last step on the electrification path. The use of the expensive but long during lithium ion batteries with a high energy density are the cost drivers. However the BCG forecasted in 2009 that battery costs will come down by 2020 to $500 to $700 per kWh. A BEV that is powered by a 20 kWh battery (providing energy for about 130km driving range) would then still cost additional $10000 to $14000 in comparison to a conventional ICEV. Figure 31 shows that setting these incremental costs into relation to the reduction of CO2 emission, every percentage point of reduction will cost approx. $280 by 2020 (BCG, 2009).

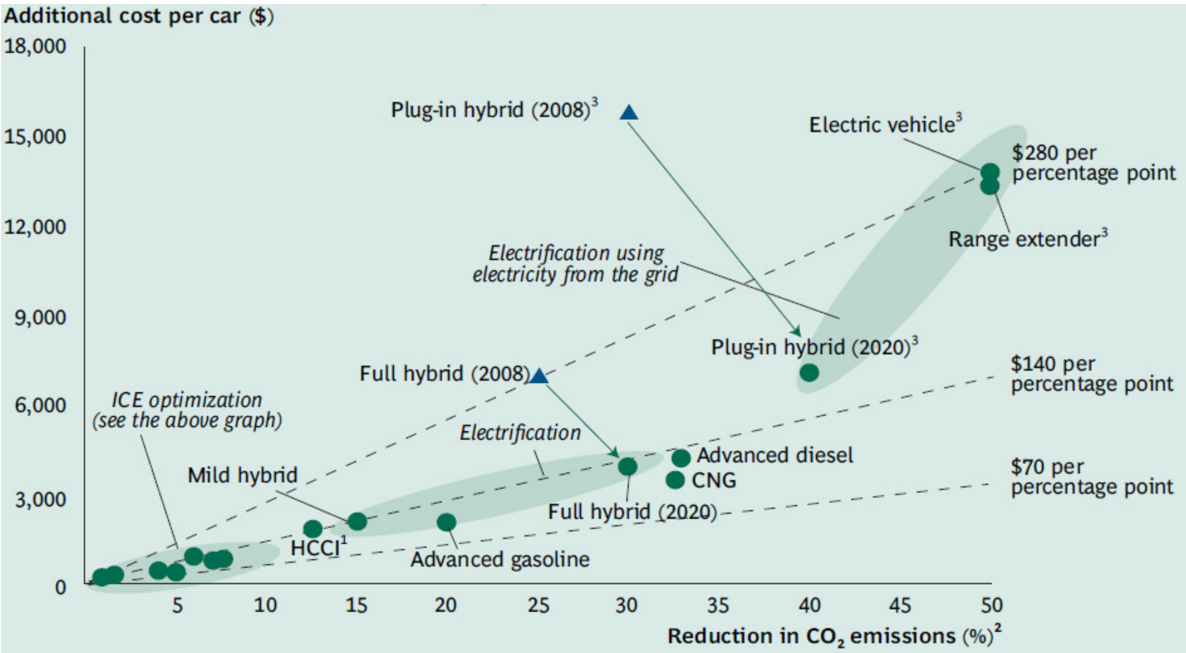


Figure 31: BEV costing $140 to $280 per percentage point of Co2 reduction (2020) (BCG, 2009)

However, figure 32 displays how much the latest forecasts for battery price for the years 2015, 2020, and 2030 can vary.

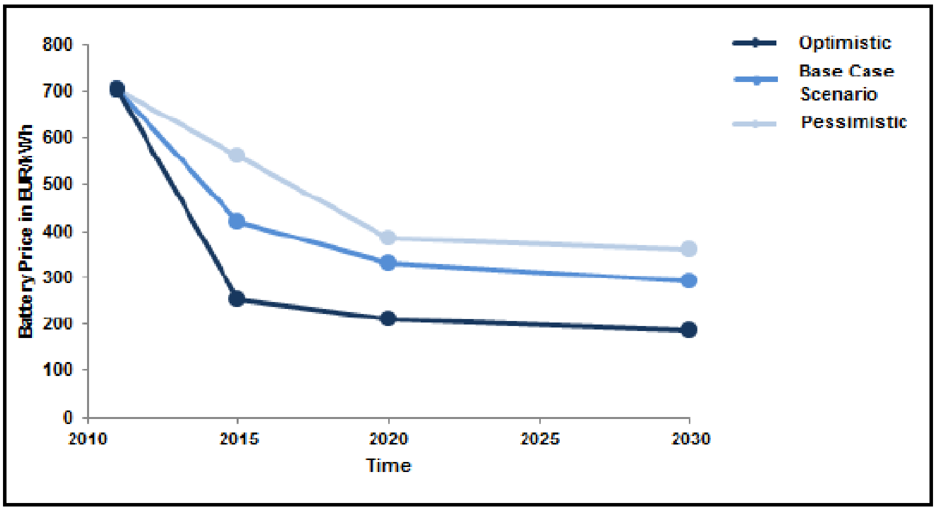


Figure 32: Development of the Battery Price for EVs in EUR/kWh over time (Proff H. & Kilian D., 2012)

As shown, the value of the BEV depends very much on the cost of the battery. However, lifetime of the battery can vary widely. This uncertainty has a negative impact on the 2nd hand market and thus the residual value as part of the TCO model. Existing formulas for residual value become very complex and can hardy reflect these uncertainties. In order to make up for this barrier new business models were invented. By separating the vehicle from the battery by offering leasing schemes the uncertainty of the battery lifetime is removed and traditional residual value calculation can be applied to BEVs (KPMG, 2012).

On the other hand BEVs benefit from lower operating costs due to cheaper fuel, lower cost for maintenance and repair (M&R), reduced tax and insurance premiums. Concerning the cost for M&R Propfe et al. analyzed and compared in 2012 different drivetrain technologies (see figure 33). According to their findings M&R cost of BEVs will be, due to the significantly reduced complexity for the drivetrain, by about 20% lower than for ICEVs (Propfe B., Redelbach M., Santini D., & Friedrich H., 2012).

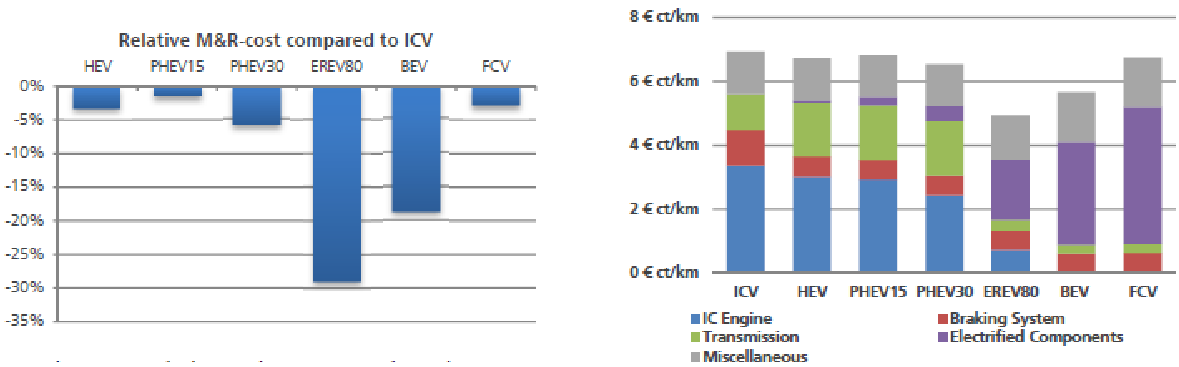


Figure 33: Relative M&R cost comparison & distribution of cost (Propfe B., Redelbach M., Santini D., & Friedrich H., 2012)

With rising units and increasing fossil fuel price the TCO gap can be significantly reduced in the long run. In the short run until 2018, however, the delta TCO between BEV and petrol powered ICEV will still remain between EUR 9000 and EUR 4000 (see figure 34). Given this relatively large gap monetary and non-monetary incentives are recommended by the NPE in order to reach the targeted one million EVs in Germany by 2020 (NPE, 2011).

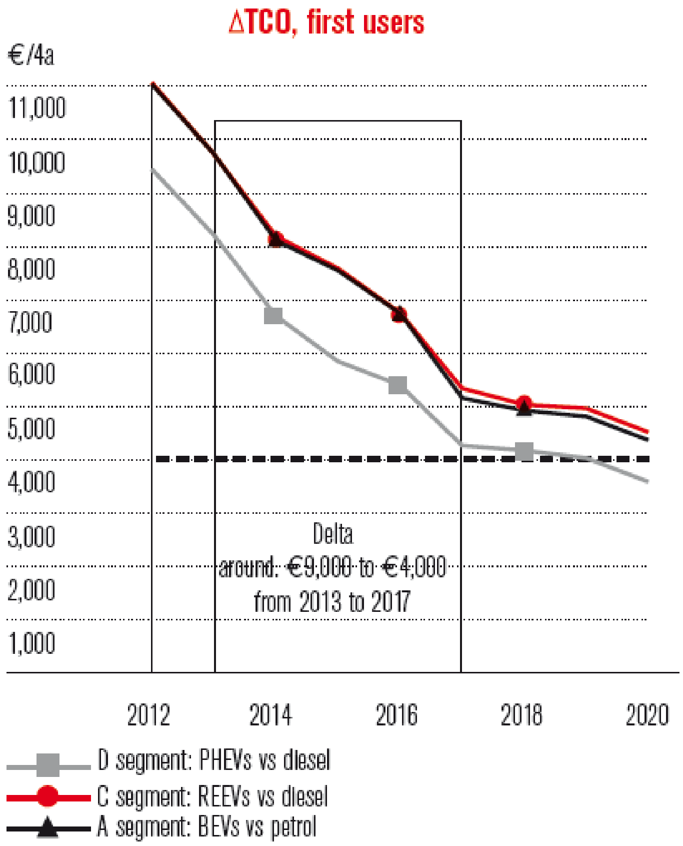


Figure 34: Delta TCO first Users (NPE, 2011)

The long run advantage of a BEV in comparison to an ICEV is confirmed by a study of Wyman of 2010 (see figure 35). According to Wyman the BEV will have lower TCO by 2025 than ICEV for an average mileage 15000km p.a.

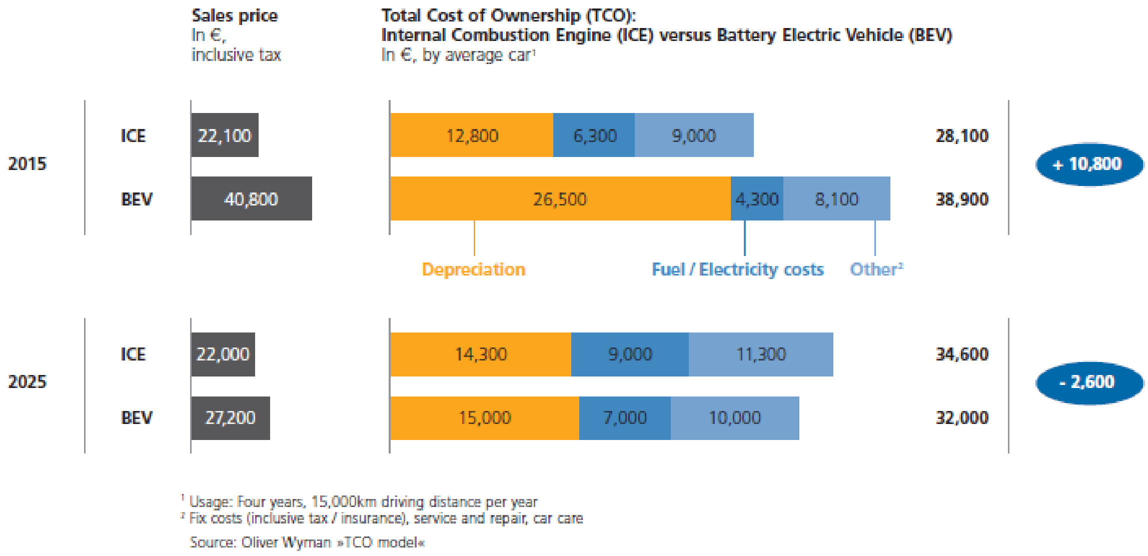


Figure 35: TCO Comparison ICE vs. BEV 2015 and 2025 (Wyman, 2010)

Plötz et al. (2012) computed and compared TCOs of four vehicle technologies until 2030. For easier reading TCO in figure 36 is shown on a daily basis as a function of daily driving range. The difference in consumption costs are reflected by different slopes. The higher initial costs of BEVs and PHEVs are reflected in the difference to ICEs and HEVs at L=0 (L= daily driving range). For this reason there is a minimum driving range required for BEVs and PHEVs to become cost effective in comparison to ICEs and HEVs. The figure shows that the TCO gap of BEVs of any size will be reduced over time due to falling initial costs of BEVs. By 2020 small and medium sized BEVs are competitive to conventional technologies at a daily driving range of 90-100km. By 2030 the TCO competitiveness can be reduced to a driving range of approx. 50km daily (Plötz P., Gnann T., & Wietschel M., 2012).

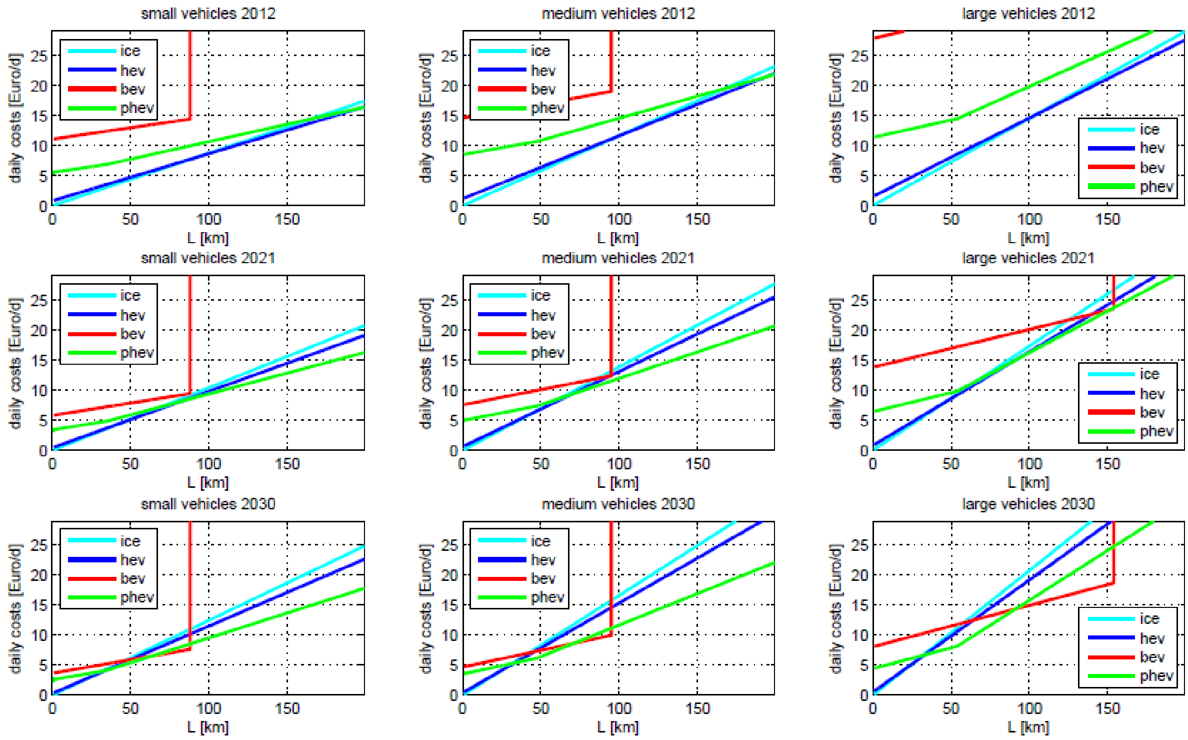


Figure 36: TCO projections by segment and technology as a function of the daily driving distance (Plötz P., Gnann T., & Wietschel M., 2012)

3.3.2 Profitability of charging infrastructure

Beside the TCO, the availability of the charging infrastructure will be probably one of the main success factors influencing the further development of e-mobility. Alongside technical questions to be solved as e.g. the charging time, the profitability of charging stations will determine the region wide availability. According a report by the *German Forschungsstelle für Energiewirtschaft* (FFE) in 2010 consumers will not be willing to pay considerably more for the electricity at a charging station than for home charging. According to their calculation the price for charging a compact BEV with a battery capacity of 35kWh would be EUR 7.44. Including all taxes and concession fees etc. and considering the lower input price for electricity, a margin of about EUR 0.27 for this charging procedure would remain for a commercial operator. It is obvious that with this margin it is impossible to recover the investment and operating costs (FFE, 2010).

The FFE believes that a solution to this dilemma could be increasing the electricity price to consumers for car charging. According the calculations and scenarios described in connection with the TCO evaluation before, the increase of electricity price would have a negative impact on the TCO of BEVs and shift the “break-even” of BEVs in comparison to

ICEVs more into the future. In order not to punish the early adopters and prevent the rising share of BEVs this strategy should only be implemented at a later stage. However it seems to be obvious that public intervention or completely new business models will be required in order to set up the required infrastructure.

- Charging in combination with shopping or eating
- Regulations for fossil fuel stations to provide electric charging
- Subsidies or tax benefits for operators

3.3.3 Profitability of business models

Whereas individuals focus on minimizing costs, private enterprises try to maximize profit and usually develop short-, medium and long-term strategies to achieve this target. The TCO comparison or other investment decision tools usually cover the short term sight of entrepreneurial decision making. In order to secure the profitability in the long run, companies try to continuously adapt their products and services to market developments. Due to the change towards sustainable forms of mobility, the whole automotive sector is in transition.

According to Wyman “Innovative technology is the basis – but the better business design will be the critical factor of success.” Figure 37 by Oliver Wyman shows the value shifts that will occur along the entire value chain (Wyman, 2010).

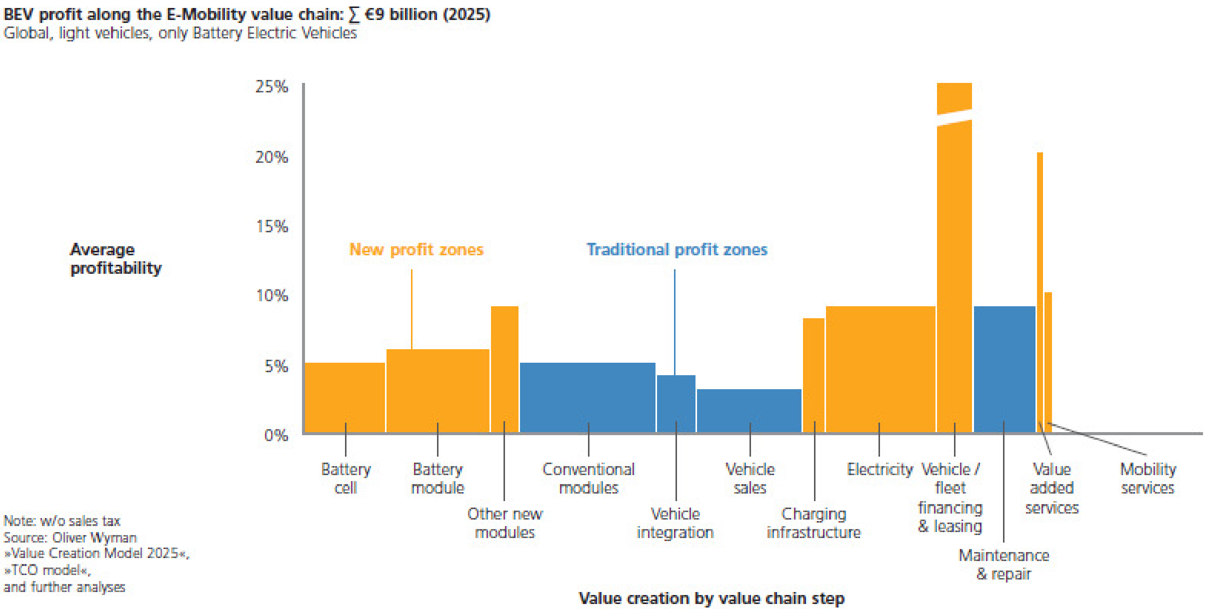


Figure 37: Value creation model (Wyman, 2010)

Wyman differentiates between traditional and new profit zones and up- and downstream steps, whereby downstream activities start with sales. According to the study “two-thirds of the approximately EUR 9 billion in profits (2025) generated by electric mobility will be produced »downstream« that is, by sales and in particular vehicle operation. Car manufacturers will be forced to tap these profit zones if they want to successfully offer electric cars in the years ahead. This includes both leasing and financing programs as well as services tailored to individual customer needs. A key profit driver will be the operation of electric vehicles – also arising from new business designs covering all facets of customers’ mobility needs, including leasing concepts and car sharing” (Wyman, 2010).

3.3.4 Macroeconomic

The macroeconomic pressures in the automotive industry will remain high in the coming years. This is mainly due to the high investment requirement for new technologies, the weaknesses of the financial markets and the economic crisis especially in Southern Europe (Portugal, Greece, Italy and Spain) bringing a high level of uncertainty. The lower purchasing power puts a high pressure on sales. Some countries such as France try to fight against weak private consumption by strategic public purchasing programs where state owned companies play the role of early adopters replacing part of their fleet by BEVs (Proff H. & Kilian D., 2012).

Almost any European country investigates potential growth markets and segments. From the macroeconomic point of view BEVs and high capacity batteries are capital- and know-how intensive in production. For this purpose highly industrialized countries such as Austria or Germany are likely to benefit from positive investment-, growth- and employment effects in these segments. The mid- or long-term break-through of BEVs, however, will depend on the technological progress, the development of raw-material costs and the availability of low cost renewable energy and charging stations (Döring & Aigner-Walder, 2011).

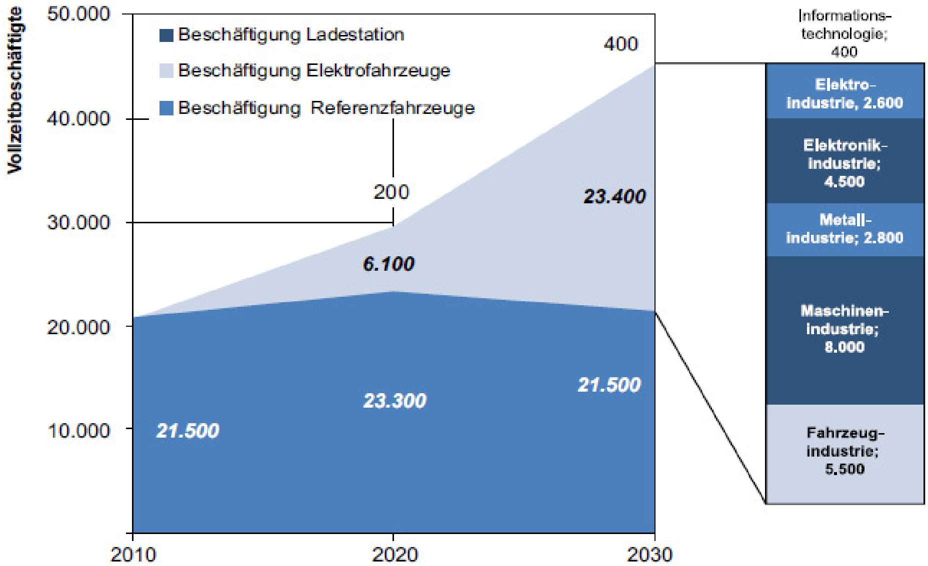


Figure 38: Direct employment (BEV and Charging stations) in the Austrian automotive Industry by 2030 (Best-case-scenario) (Fraunhofer Austria, 2011)

According to a study conducted by the Fraunhofer Austria Institute and the Vienna University of Technology the development of e-mobility has a maximum potential of additional value added of approx. EUR 4 billion and could create an additional employment of 57.000 over the next 20 years. In order to participate in this development companies have to adapt early to the new requirements by intensifying their R&D in order to create marketable products and invest in production capacities (Fraunhofer Austria, 2011).

In order to make up for the microeconomic disadvantage in terms of profitability, the provision of adequate aid programs for innovation and market entry will be a key driver to assist this macroeconomic development. In order to guarantee an efficient use of the limited available public funds, a focus on high potential multi-use segments is suggested. The two multi-use components with the highest estimated potential are the battery management and the chassis (lightweight and insulation) (Geringer B., Sihn W., & et al., 2011).

With a growing share of EVs the availability of the necessary raw-materials (mainly lithium) could be a further macroeconomic barrier. Although recent studies show, that even with growing demand natural reserves will last at least for more than 100 years, some critics fear, that the dependency on oil will be replaced by lithium, because the largest natural deposits of lithium are situated in geopolitical unsecure regions (Bolivia, Afghanistan and China). However, as lithium is not used up in the process (as it is fossil fuel) the early implementation of a functioning recycling system is deemed to be a necessary step to reduce this risk (Döring & Aigner-Walder, 2011).

4 SUMMARY

The technological progress in the last decades led to an increase in the level of transport service. Due to this trend and the dominant use of fossil fuels, the transport sector contributes to a large amount to the worldwide greenhouse gas emissions leading to global warming. The share of total greenhouse gas emission caused by the transport sector in the EU in 2007 accounted for almost 25%. Since 1990 the GHG emissions caused by the transport sector have increased by more than 20%. It was the only sector showing an increasing trend and is therefore given a great attention by policymakers in the EU and worldwide (Ajanovic A., Haas R., & et al., 2011).

As during the combustion process a large portion of the energy is converted into useless heat, the electric engine shows a much higher efficiency (about 3-6 times higher). Due to this reason EVs are deemed to be the key technology for sustainable transport in the future.

However it is important to always look at the whole life cycle when comparing different technologies. For BEVs especially the GHG contribution of the electricity production has to be taken into consideration. As long as the overall energy mix is not dominated by "green-technologies" such as wind-, solar- or hydropower the CO2 balance will be negative. In other words, only with renewables as primary energy source significant reduction of CO2 emissions can be achieved when shifting the transport sector to BEVs.

Until the electric engine will dominate the transport market many technical, legal and economic problems still have to be solved:

- storage & driving range
- weight & size of battery (energy density of battery)
- recharging time
- lifetime of battery
- costs of battery
- recharging infrastructure
- renewable electricity mix

The almost invisible number of EVs in relation to the total stock of motor vehicles and their low share in annual sales (<1%) reflect these deficits. Apart from technological problems, the market is, given the current framework (oil price, weak CO2 limits for ICEVs; high initial costs for BEVs), not yet prepared for mass deployment of EVs.

Due to the pressure to reduce anthropogenic GHG emission in order to stop climate change many scenarios have been developed. Some of the scenarios focus on the GHG reduction in terms of gigatonnes required to stabilize global warming and then look at the potential of different sectors to “absorb” this required reduction. In all of these studies the transport sector plays a major role. For example within the Blue Map Scenario of the IEA 37% of the reduction to be realized by 2050 shall result from the transport sector (IEA, 2010). Other studies have a more marked based approach. Starting with a projection of TCO for different drivetrains a cost gap in comparison to ICEVs is calculated and on this basis market shares are estimated.

In all scenarios BEVs will play a minor role until 2030. In the best case BEVs will account for around 10-12% of sales in 2030. However hybrid forms of vehicles will gain more and more market shares and pure ICEVs will lose significantly.

In order to reach these ambitious goals a huge amount of investment especially in R&D and market preparation is required. For this purpose the EU developed in 2009 the “2020 strategy” aiming at a smart and sustainable growth. Together with the strategy an action plan was published encouraging the development of clean and efficient vehicles.

The rolling action plan comprises the following main elements (European Commision, 2010):

- Setting up a strong regularly reviewed regulatory framework in order to limit emissions
- Support research and innovation in green technologies
- Improve the market uptake by incentives and consumer information
- Standardisation measures
- Building up infrastructure
- Measures for power generation and distribution
- Promotion of the recycling of batteries

As the EU was aware of that a successful implementation of the measures requires a cooperation of all stakeholder (industry, government, research and public) initiatives organized as Public Private Partnerships were installed. In addition the initiatives were closely linked to other initiatives with related topics. Especially the involvement of the industry was seen as a success factor. The industry benefits from this participation as it gets an insight into the long term strategy and decision making process of the EU and therefore can plan its R&D strategy following the future reglementation path. The politics on the other hand benefit from speeding up the intended transformation process by involving the implementing party from the beginning on.

This EU strategy was more or less immediately copied to national programs and roadmaps by the member states particularly by those having a substantial share of their industry engaged in the automotive sector.

In Austria the National Implementation Plan for e-mobility was introduced in 2010 and in 2012 three Ministries (BMLFUW, BMVIT, BMWFJ) published together an action plan for e-mobility. The provided funds are distributed through different programs administered by the main state owned promotion agencies (aws, FFG, KLIEN and KPC) each having their special focus. Comparable to the EU initiatives organized as PPPs also in Austria integrated platforms were established to involve all relevant local stakeholders (e.g. EMPORA).

From the legal aspects influencing the development of e-mobility the environmental regulations in respect to emissions, the definition of standards and norms and state aid reglementation have to be highlighted.

The success of the electric engine will very much depend on the restrictions that will be implemented for ICEVs in respect to emissions. The poor progress of emission reduction in the last decade has shown that self-limitations of the industry will not bring the desired impact. However not only the setting of emission limits will be essential but also a strictly defined and controllable method of calculation will be required. As a recent study by the ICCT has shown the average discrepancy of "real-world" calculations and manufacturers indications on CO2 emissions for vehicles has increased from 10% in the year 2000 to 25% in 2011 (Mock P., German J., & et al., 2013).

The development of standards and norms for e-mobility is deemed to be one of the key success factors for increasing the acceptance of EVs by the customers. As especially the automotive industry is known for its high standards in respect of safety and functionality, it seems to be taken for granted, that the same level will be respected for e-mobiltiy questions. This topic therefore seems to be underrepresented in risk evaluations.

State aid is a very much reglemented topic. On the one hand EU wants to incentivize strategic developments such as e-mobility on the other hand public funds for adequate projects can only be dispersed under very strict conditions set by the EU. On top of that the economic slowdown has led to budgetary cuts that also affect national state aid funds. Especially direct grants for the acquisition of EVs would be a powerful instrument to close the TCO gap and assist market entry. In Austria, however, such funds are almost not available.

Apart from non-monetary factors influencing investment decisions of individuals or companies a comparison of the cost of vehicles over their operating life is still the main selling argument. The mass of consumers is not yet willing to pay a substantial premium for the same or even a lower quality (e.g. due to range restrictions) of transport service. The NPE estimation of the TCO gap by 2020 between a BEV and an ICEV is around EUR 4000 (NPE, 2011). Therefore EVs are still and will be in the coming years products for niche markets and first movers. For a mass deployment which is expected to start in Europe by 2020 (PPP European Green Cars, 2012) the framework conditions have to change. Technological improvements especially in the field of batteries are expected to lead to a significant reduction of cost/kWh and to an increase of the durability which affects resale value.

According to Plötz et al. by 2020 small and medium sized BEVs will be competitive to ICEVs at a daily driving range of 90-100km. By 2030 the competitive advantage of BEVs is already given at a range of 50km daily. Connecting these findings with an analysis of the German driving behavior, with 70% of the vehicles driving less than 60km per day, BEVs with an operation range of 50-100km are not only well suited for driving patterns in urban areas but will become in reasonable time economically competitive to ICEVs (Plötz P., Gnann T., & Wietschel M., 2012).

The development of the oil price will be crucial for all TCO scenarios as the advantage over lifetime from BEV result from the lower fuel cost. The size of the gap will decide the game in the long run. However governments have to be careful influencing the oil-price by taxation as the share of EVs is still small and the energy mix is not yet prepared for the transformation. The negative side of the low electricity price is its barrier to the development of a region wide charging infrastructure as investments in “classical” charging stations equivalent to gas stations will not pay off. An increase of the electricity price for car charging, as a possible solution, would have the negative impact to shift the economic break-even of EVs to the future.

Therefore new business models will have to be developed. According to Wyman “Innovative technology is the basis – but the better business design will be the critical factor of success” (Wyman, 2010). Companies will have to adapt their strategies to the requirements of the new technologies. Some existing value chain steps will lose importance or be only profitable in combination with new or adapted ones (e.g. vehicle financing, vehicle operation schemes, mobility services, charging models, etc.).

Along the transformation process governments have to promote e-mobility by setting the right legal and economic framework in order to change behaviour and mobilize investments. Key measures comprise e.g.

- Tax advantages

- Priority driving regulations
- Priority parking solution
- Subsidies for R&D, market entry acquisition of EVs
- Awareness measures
- Emission regulations paths
- Strategic public purchasing

The macroeconomic benefits for governments result from positive investment, growth and employment effects in the new segments related to e-mobility. According to a study conducted by the Fraunhofer Austria Institute and the Vienna University of Technology the development of e-mobility has a maximum potential of additional value added of approx. EUR 4 billion (approx. 1.2% of GDP) and could create an additional employment of 57000 over the next 20 years (Fraunhofer Austria, 2011).

5 CONCLUSIONS

From the analysis of legal, political and economic factors influencing e-mobility are derived the following recommendations to stakeholders:

Recommendations for politics

- Development of an intelligent, dynamic and appropriate incentive system, in order to mobilize and award non-economic, but ecologic investments. Economic gaps shall be identified and temporarily closed when time is right. The amount of the incentive shall periodically be adapted to the economic gap in order to avoid over incentivizing certain sectors (as it happened e.g. with feed-in rates in some countries).
- A transparent short, mid, and long term strategy will help other market players to adapt their own compatible strategy and thus reducing risk, especially in R&D.
- In the introduction phase before mass production the focus should be on R&D in connection with the punctual development of demonstration projects (e.g. the model regions in Austria) in order to get the necessary market feedback. With an increasing maturity of the technology the focus shall shift to incentivizing the market entry by giving economic advantages to enterprises and consumers. This can be accompanied by non-monetary measures such as prioritization of EVs.
- Concerning the organization of public funds and the cooperation and interaction of state owned bodies, there is still a huge potential for improvement. In Austria it seems that not always the institution best suited for is given a specific task but the one whose owner (ministries) is funding. Although the agencies themselves are often interested in a closer cooperation in order to provide a maximum service to the industry, they remain political puppets. Due to this reason they sometimes try to act as economic oriented market players instead of joining forces. This makes it hard to assist mature technologies to overcome the “valley of death” and enter the market.
- Until new business models develop, the provision of charging infrastructure will – due to economic reasons – remain in the responsibility of the public sector. One idea to pass this responsibility over to other market players could be to enforce by law the installation of charging units at conventional gas stations. However this would not be as simple as obliging them to blend their petrol with biofuels and certainly would cause some disturbance. In order not to distort competition this could only be done EU-wide.
- The involvement of all stakeholders through projects and initiatives organized as PPP is an excellent method of efficient communication and should be applied where appropriate.

- For the success of strategies in the cross sectional area of e-mobility a cross-linking of the political decision makers and technical experts for energy, infrastructure, mobility, communication technology and economic aspects is essential. In addition a comprehensive information and marketing strategy is required to bring this complex topic to potential consumers.
- With only a small domestic market the Austrian players have to boost their internationalization and politics has to assist companies and research in this aspect (e.g. to help industry and research accessing international research networks)
- Depending on the strength of their industry, countries have to develop their own strategy for e-mobility in order to maximize the positive effect in value added.
- As the non-effective self-restrictions of the automotive industry in respect of emissions have shown, it is not recommendable to leave environmental protective measures to profit oriented organizations.
- In order to boost the presence of EVs the state should act as first mover and focus on EVs within innovative sustainable public procurement programs.
- As the new technology will partly require different skills than the ones for conventional transport, the education system should be adapted in time to have enough qualified experts when mass deployment starts.
- As e-mobility is still in the initial phase, state aid programs should be as technology neutral as possible in order to prevent discrimination of technologies or technical solutions, since it is not yet clear which technology will win the race.

Recommendations for industry and economy

- Companies working in the automotive sector shall start a new business line e.g. supplying parts for electric of hybrid vehicles in order to get the foot in the door to be prepared when the ramp-up starts. However, the combustion engine will still dominate the vehicle market for a considerable time and the cash-cow products for conventional engines still have a potential in respect of efficiency improvement.
- Almost any research, investigation or investment in relation to energy efficiency and e-mobility is eligible for state aid incentives. Some incentive schemes are easy to apply for, others more complicated, however, it is often advisable to apply for incentives directly instead of making use of an intermediary e.g. consultant. Almost all state aid agencies have qualified experts to evaluate projects within their program scope, and the personal contact is often essential for a positive decision. A participation in PPP initiatives will help to get into the topic of public incentives and in

addition provides first-hand information to participating companies. In such PPPs it is even possible to participate in the development of national and international strategies.

- The research strategy should take future market potentials into account. In order to reduce risk the research portfolio should comprise as many multi-use products and solutions as possible (e.g. products that can be used in hybrid and pure electric vehicles).
- Traditional profit zones will be complemented or replaced by new ones. New opportunities for business models arise in this respect. The combination of new profitable steps in value chain with solutions for special requirements from customers (e.g. availability of service against possession) will help to overcome economic gaps. Especially the enormous technological progress of information and communication technology (ICT) such as smartphones with integrated gps module will be a driver to this process.

Recommendations for research

- Research should not only focus on improving fuel efficiency but also on research efficiency. Investigation should not be done just for the sake of research but with a view to a potential market value and economic advantage. Successful inventions and innovations shall be pushed into the market with more consequence. The successful closing of a public funded research project should therefore not end with delivering a technological study or report but include a contribution to deployment into the market. Each research project, excluding fundamental research projects, should include an economic part. More and more public incentive funds focus on this aspect (e.g. the study2market program from KLIEN and aws).
- Participation in national and international inter disciplinary initiatives such as PPPs is recommendable. In this constellation research institutions can take over the role of initiators and “translators” between politics and economy. In addition an excellent network can be established.
- From involvement in demonstration and lighthouse projects a direct market feedback from outside laboratories can be obtained, that will add qualitative aspects to mainly quantitative research results.

Recommendations for consumers

- In order to contribute to energy efficiency consumers should in the first step reconsider their mobility behavior e.g. reducing average speed, anticipatory ecologic driving, change to public forms of transport, skip unnecessary trips, car-pooling and ride-sharing or the use of bikes or e-bikes for small distances. This would have two advantages, first a quick impact on emissions and second an immediate reduction of cost, however, personal comfort might suffer.
- When making investment decisions, consumers shall not only focus on initial cost of acquisition but take all relevant aspects into consideration e.g. operating cost and non-monetary aspects as privileges for EVs, especially in urban areas.
- Due to progress in battery technology and decrease in battery costs the price for EVs will continuously fall over the coming years so the market has to be observed closely to find the personal suitable point of entry. In parallel the range of available models on the market will increase, so customers will find it easier to find the best suited EV.
- Until battery technology is mature, buyers shall pay a maximum attention to exclude the technological risk e.g. replacement schemes or extended warranties.

It seems that industrialized countries have started to understand that the time has come to seriously start the fight against global warming. Some might be concerned by the rising impact of natural catastrophes or by the growing industrialization of developing countries other might pursue an economic approach and try to be among the leaders in promising new industries. The transport industry has been identified as one of the key drivers for sustainable future. The ordinary technological progress in the field of efficient transport systems, however, would be too slow to reduce GHG emission to the required level within the next decades. For this reason national and multinational “governments” try to generate a favorable economic, legal and political framework to foster the speed of technological development that is required for transition. The more people learn and care about changes in the environment the more it becomes clear to them – time is the most important driving factor.

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