MSc Program
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Current Challenges on E-Mobility Applicability Perspectives: An analysis of different market models

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

supervised by
Dipl.- Ing. Dr. Amela Ajanovic

Dragos Mosu

1227678

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Affidavit

I, Dragos Mosu, hereby declare

1. That I am the sole Author of the present Master Thesis "Current Challenges on E-mobility applicability perspectives: An analysis of different market models", 102 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
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Abstract

In the spotting light of an intensive climate policy and an evolving dependency on imported fossil fuels in the mobility sector, electric vehicles receive a lot of attention. The deployment of electric vehicles is regarded as an effective policy strategy to meet emissions (CO2) reduction targets. Sustainable and climate friendly policies should encourage innovation as this can stimulate efficiency when using the natural capital and thus foster new economic opportunities. The innovations, regarded as new technologies, should be properly directed towards a beneficial diffusion that would include social, economic and environmental improvements, by enabling win-win synergies between market components like government, industry and consumer.

Following the need of identifying proper models for integrating the electric mobility in a common market, it became clear that solely market forces cannot facilitate such a transition alone. Thus, the market remains just a catalyzer for the electric mobility in the case when the policy, the relevant industries and the consumer are decisively committed to such a technological change. Functioning market models rely on synergetic and productive relationships and interaction between the participants. Moreover the participants activities, considered as specific business models, should be viable in the long term in order to consolidate the market positions. Exactly such strategy is adopted by most of existing players; however, the pace of deployment is relatively slow but has a stable up-trend.

In the end, the deployment of E-mobility will mostly depend not on the way that technologies will be developed and promoted, but predominantly on the capability to organize and administer the operations of sophisticated terrain of market actors

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List of Acronyms

CO2………..Carbon Dioxide
WACC……..Weighted Average Cost of Capital
NPV……......Net Present Value
IRR…………Internal Rate of Return
MIRR………Modified Rate of Return
EVs…………Electric Vehicles
R&D………..Research and Development
EU…………..European Union
ICE………….Internal Combustion Engine vehicles
AC/DC……...Alternative Current/Direct Current
TSO………....Transmission System Operator
DSO………....Distribution System Operator
CSO………....Charging Station Operator
TCO…………Total Cost of Ownership
EMS………....Electric Mobility Service
B2C………….Business to Costumer
B2B………….Business to Business
DCF………….Discounted Cash Flow

1 Introduction

Through the discovery and implementation of large scale energy use in form of fossils the mankind has been able to develop and evolve into a modern society with new levels of life quality. Nevertheless this trajectory is not able to last to infinite. Thus implementing a low carbon economy paired with sustainable development concepts should replace a big part of the used energy mix in all involved economic structures. One of the most intense part of energy usage, is the transportation sector. The electrification would switch the core fuel element and thus would reduce the aggregated mobility emission factor. It is mainly a technological change that bears difficulties in the beginning but promise socio-economic benefits in the long term. It is known that innovation is a driver of economic and thus social progress on both micro and macro levels. Thus, new approaches toward climate friendly market life and self-awareness are the new challenges in our century. However, during the history, technological innovations were actively supported by policy makers due to the fact that these emerging innovations remained uncompetitive till the maturity. In nowadays the low carbon target requires new concepts and thus smart governing in order to successfully substitute old resource oriented approaches. Moreover it is crucial to stimulate natural market attractiveness for the new products. Knowing that the business world`s decision making process is driven by a few parameters such as profit and risk, the projected task continues to face a lot of barriers, not mentioning the technical unevenness and consumer change inflexibility.

A successful initiation of electric mobility requires feasible business cases, which is one of the crucial challenges to be achieved in order to enable the development of a future mass market. Electric mobility is still situated in an introductory stage where costs are high, sales are low, and competition is missing. In other words there is no natural demand and thus no related supply. It is just a new target for the society. Thus the governments across the world, following the climate task, are the main architects of the new industry. In the current introductory stage the demand has to be created, and consumers have to be persuaded to try the new product. An intrinsic characteristic of this market stage is the temporary lack of economic benefits. Filling the gap between the current technology demonstration and the market uptake seems to be the main challenge at the moment.

The purchase of an electrical vehicle implies a substantial investment and a behavioral change. Today, it is widely known that the performance of electric vehicles is lower than that of conventional internal combustion engine vehicles. Improving the performance and thus the cost-benefit factor of electric vehicles is therefore a primordial aspect in the development of electric mobility and should be approached from the cost side as well as from the benefits side. Moreover, costs could be reduced by technological improvements, scale effects, or diversification of risks by redistribution of financial burdens, for instance by innovative business models like battery leasing, car-sharing or other models. This would also create more visibility for the electric vehicles and thus could foster demand and acceptance.

1.1 Core Objective

The objective of this report is the analysis of different possible market model and therefore necessary business cases for electric vehicles, which are per se an important part of the preliminary market stage. The market models that are reviewed in this paper describe the possible interactive “state of being” between different electric mobility actors like car manufacturers, utilities or new entrants. However, besides the way how these actors will be linked with each other on the market, it is also necessary to assess the business attractiveness of their implied products. Thus the market in terms of independent or integrated models will include the assessment of business cases that in this paper are considered the business solutions (models) in regard to the EVs (Fleet Management, E-Taxi, car-sharing) and infrastructure (Charging Station Network). Without identifiable business models (considered as cases in this paper as it contains own assumptions) a general market model does not make sense. Therefore the market models and business models are strongly correlated in this paper.

A quick step from the market preliminary stage into the market growth stage is desirable, and, hence, the identification of effective and cost-efficient implementation scenarios is advisable.

Thus relevant emerging business models in the electric mobility field (EV Fleet, E-Taxi, Car Sharing and E-Stations) are described and their outcome assessed. The assumptions correspond to the average existent information. The goal is not to identify the exact metrics but to vastly light out the differences between the cases and thus emphasize the barriers and the future development probability as well as the sector investment attractiveness according to possible entrance players. It remains interesting to investigate whatever these electric mobility solutions can become viable businesses and how they will help the mobility industry achieve better market shares. A better understanding of how this sector is naturally expanding and what expectations do investors have, can offer valuable information about the whole innovative mobility trend. This would enable access to reliable and maneuverable development measures. The purpose of this analysis is to help read the electric mobility market as it evolves, and also provide an initial assessment of the risks and rewards it presents.

1.2 Methodology

The paper provides an analysis of current e-mobility business models and it tries to investigate how the market is dissolving the new technologies emphasizing the cost-benefits principles. A comparison between real promoted concepts would give vital information about the market openness. Through assumptions and existent data the paper will try to identify the profitmaking center and though its efficiency, trends, risks and reliability.

The analysis in this report was based on two types of desk research:

- Web research: analysis of official websites from governments, institutions, companies, and other websites, press-releases, stakeholders, etc.;
- Literature study: analysis of reports, research studies, documents and scientific papers.
- Case study analysis including:
  - Assumptions of market situation: growth rate, existent electric vehicles number in a specific market (city), targeted market share assumed by the business cases
  - Assumptions of input elements as: electric car purchase price, Operation & Maintenance costs, fuel price, depreciation, Discount Rate (WACC), Investment Horizon

- Presentation of results: Net Present Value, Internal Rate of Return, Modified Internal Rate of Return, Operational Margin, Return on Invested Capital, Profit Index.

Considering the Electric mobility a new research field, the web research has been more extensive than the study of literature, in order to gain an overview of current developments as up-to-date as possible.

1.3 Structure of work

The Master Thesis is fundamentally divided into four parts:

- The first part describes the key drivers of electric mobility, its components and the policy related measures toward the proposed target of the Climate Change Task. These topics are mainly based on literature research.
- The second part includes the detailed aspects of the current electric mobility market, its players, interference actions, relationships characteristics and possible development concepts.
- The third part invokes a practical approach in the purpose of reaching some hard facts over the analyzed sector. It will take in consideration a market scenario, general input assumptions and thus present the appraisal of discussed business cases. Business Cases are considered the assessed business models that are close to enter the market or already did.
- The fourth part combines the results of the third part with the perspective of the second one and offers a trajectory for the further development opportunities.

2 E-Mobility Current State of Affairs

Electric vehicles (EVs) are presently being discussed all over the world and are considered a promising mean to increase the energy-efficiency targets, reducing petroleum dependence and promoting transportation sustainability. In order to successfully diffuse EVs, it is vital to point out its key driving forces and constraints and thus identify the initiatives regarding early adopters in order to address development policy measures towards these factors. Electric mobility is not a new concept. EVs emerged in the 19th century, when they seemed to overcome steam and fossil cars for some time.

However, environmental concerns have provided a new stimulus to the progress of electric mobility. As a result, numerous initiatives to stimulate electric mobility are being supported by governments, companies, universities, and private individuals.[1] Production magnitude must be created, and technology cost and infrastructure hurdles must be addressed in order to reach scale market penetration while generating workplaces and economic growth. To achieve these benefits and reach the goal, it is proposed a new effort that supports advanced technology vehicle adoption through improvements to tax credits in current law, investments in R&D and competitive programs to encourage communities to invest in infrastructure supporting these vehicles[2]

2.1 Drivers and Constraints

2.1.1 Environmental Challenges

The environmental situation today is alarming. Following facts emphasize the necessity to take action in regard to the environment[3]:

- Greenhouse gases like CO2 emissions lead to climate change
- Mobility sector is responsible for up to 30% of global energy consumption
- Around 18% of global carbon dioxide emissions are associated with mobility, 75% of them caused by road traffic

[1] Electric mobility policies in the North Sea Region countries, August 2012, NSR Electric Mobility Network
[2] One Million Electric Vehicles By 2015, February 2011 Status Report, US Department of Energy
[3] OECD Transport Outlook 2012

- CO_2 emissions in emerging countries (including BRIC) are expected to double till 2030
- Emissions in OECD countries will still grow by about 25%
- Global CO_2 emissions related do mobility are expected to grow by almost 2.4 times till 2050

Directing the work on reducing the world's carbon footprint has become a global aim. Environmental and thus climate protection are societal challenges and part of ongoing governmental agendas. Related policies have been enacted by many national and international institutions. Increasing emissions restrictions for passenger cars have pushed further developments of low or zero technologies, in this case electric vehicles.

According to "Umwelt- und Prognoseinstitut e.V.", avoiding the climate catastrophe can only go along with a turnaround in the transport policy. It is expected that the number of cars worldwide to increase by a factor of 4.5 until the year 2030. Therefore a turnaround in the transport policy seems hardly possible without the reduction of traffic-caused CO_2 emissions. E-mobility in combination with improvements in the mix of electricity generation may make that possible or at least play an important role in this process.

2.1.2 Growing population and urbanization

The growth in population and its economic development during the last decades leads to an increase in the mobility metrics and thus, at current technological availability, a drastic increase in emissions and fuel demand over time. This natural human development trend assists, through urbanization, to a further increase in mobility concentration in specific geographical regions. The OECD predicts:[4]

- By 2050, all modes of mobility in emerging countries (including BRIC) will have experienced considerable growth (from 2.5x to 5.7x multiples according to different transportation means)
- In 2050, the world population is expected to reach 9.3 billion people
- In 2020, an additional 800 million people will achieve middle class status in BRIC countries

[4] OECD Transport Outlook 2012

Nevertheless, this as natural as it appears is not the main factor that needs to be taken in consideration. The urbanization trend implies the concentration of emissions in highly populous region thus endangering the health of the urban population. Following trends are being considered:

- Rising global rate of urbanization from 53% in 2010 to 67% in 2050
- While industrialized countries still rank as the most urbanized in the world, developing countries are rapidly catching up
- Number of megacities expected to increase from 22 in 2011 to as many as 100 in 2050[5]

Resulting urban challenges that will need to be addressed are:

- Greater air and noise pollution
- Increasing traffic congestions
- Existing infrastructure pushed beyond its intended capacity

The world's population is increasingly city-based with 53% of the population currently lives in urban areas and by 2050 this number is expected to reach 67%.[6] Today, 64% of all travel made is within urban environments and the total amount of urban kilometers travelled is expected to triple by 2050.[7] Thus, to cope with this increasing demand the urban mobility will need massive investment in the future. Furthermore, due to progressing customer expectations mobility services will have to broaden their business model in order to transform. Hence, the main challenge is to facilitate continuous and sustainable growth. While knowing future development trends it is important to stimulate electric mobility clusters in the developed countries (EU) in order to achieve scale and matured knowledge and thus technology. This could make the development countries (EU) the frontrunners in E-Technologies that will need to be deployed in the emerging world.

2.1.3 Economic challenges

Economic growth is known to trigger the demand for energy. However, if mentioning the E-mobility distribution infrastructure, it might prove to be unable to cover further inelastic demands.

[5] Global Transport Scenarios 2050 - World Energy Council
[6] The Future of Urban Mobility 2.0, Arthur D. Little future Lab, 2013
[7] The Future of Urban Mobility 2.0, Arthur D. Little future Lab, 2013

Moreover the estimated declining natural resources provide an additional solid argument.

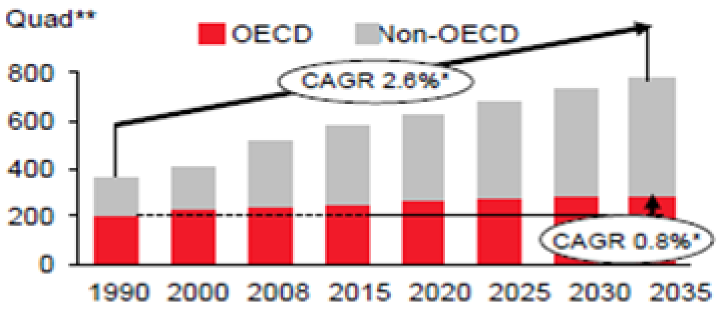

Figure 1: Growing energy demand especially in non-OECD countries (Source: International Energy Outlook, 2011)

However, the geopolitical importance of oil can cause a dangerous volatility of energy prices that is still not properly diversified. It can be the right time to think ahead of our perceivable future. The developed economies are facing growing energy dependency. This happens since the demand for energy is rising and a large part of it is imported. For example 73% of oil in the EU is consumed by the transport sector.[8] Mobility solutions based on electricity would make other primary energy sources accessible thus contributing to the energy security and diversifying the dependence risk. Therefore, the electrification of transport can be regarded as an achievable opportunity for a sustainable mobility.

2.1.4 Consumer demand

In order to attract more customers the prices of electric vehicles have to become competitive. Next, clients will need to cope with the idea of being able to go a limited distance at once. However, the possibility to cover almost unlimited distances is important for people although this does not happen often in reality. Thus changing the mobility patterns and the customer needs become an important challenge. Though, with a constant growth in population density it becomes questionable whether the concept of car ownership is feasible. A changing ownership relation from individually owned vehicles to shared vehicles that are linked to further multimodal transportation services could make a contribution to improving the future

[8] European Roadmap Electrification of Road Transport 2nd Edition; June 2012; ERTRAC

traffic situation.[9] This, complemented with more public transport use and maybe a multi-mobility approach suggest a behavioral change of the consumer regarding their way of reaching desired destinations.

For a successful diffusion of new technologies it is also required to consider the demand side which implies changes in behavioral samples that rely on individual consumers decisions. Numerous studies in psychology have addressed environmental decision-making at the level of individual mind but these studies often neglect the complex interactions with broader societal development and the role of other peoples' experiences and decisions when individuals making decisions.[10] Nevertheless the main barrier remains the user acceptance.

- 503 potential users (age range18-70) were asked if they would purchase an EV instead of an ICE vehicle. For 81% of all this was not an option. The main criteria were high initial investments and unfavorable performance characteristics. Only 9% of the interviewees stated to have deep knowledge about electric mobility.[11]
- 700 potential buyers. For 70% of them purchasing an EV was no option. The main reasons were first the limited range, second the high price of electric vehicles, and third the less developed charging infrastructure. However two thirds of the interviewees knew about EVs.[12]
- In Germany, USA, France and China the price of electric vehicles is the main barrier. Furthermore, in Germany other concerns are the range anxiety and charging infrastructure. However, the charging infrastructure was of less importance in USA, China and France. Here, more attention was paid to security and technology features.[13]
- 6,000 interviewees (age18 years and upwards) showed that customers change their attitude and objections against electric vehicles if they gain more knowledge about electric vehicles. The expansion of information

[9] Analysis of Different Implementation Business Cases; November 2012; This document is a deliverable of the Coordination Action ICT4FEV funded by the European Union in the framework of the European Green Cars Initiative under the FP7 Grant Agreement Number 260116

[10] "Changing minds about electric cars: An empirically grounded agent-based modeling approach" Ingo Wolf1, Tobias Schröder, Jochen Neumann, Gerhard de Haan; Freie Universität Berlin, Germany Potsdam University of Applied Sciences, Germany

[11] Price Waterhouse Cooper Study (2010)

[12] Frankfurter Markeninstitut BrandControl (2011)

[13] The international "Continental-Mobility study" (2011)

campaigns for the public at large represent important tasks to increase the user acceptance.[14]

In the end, the main constrains perceived by the customers are high investment costs (due to battery), range limit, missing infrastructure and adaptation need. Nevertheless, a more informative approach to present the new product might show positive results. This is an argument supporting the need of more visibility for electric mobility. This might be done through promoting new mobility solutions and offering them as a demonstration. Thus new business models shall be developed and encouraged by electric mobility task architects.

2.2 E-Mobility Policy trends and State Support

During the recent years a number of state policy initiatives tried to encourage the introduction of EVs. The industry can expand production with the support of policies that encourage investment in manufacturing facilities and provide incentives to promote adoption and drive consumer demand.[15] Such an attempt will provide important operational data on vehicle usage, charging patterns and possible impacts on the electrical grid. The demonstrations will document lessons learned that help streamline infrastructure permitting processes and make data available that can alleviate consumer uncertainty and help transition EVs from clusters of early adopters to national, mainstream use.[16] On the other hand there is a need to educate the human infrastructure required for electric mobility deployment and acceptance.

However, the main vector of policy support is directed toward rewards (user, investor) and innovations (R&D). Costs and performance are key factors for electric mobility success. Therefore, efficient regulation and incentives are essential for the implementation of the EVs.[17]

There can be many reasons why the adoption of new innovative technology can be slow and fail, especially in the beginning. Usually this happens due to many existing uncertainties and associated anxieties about commercial robustness and risk with

[14] Empirical study conducted by the Fraunhofer Systemforschung Elektromobilität
[15] One Million Electric Vehicles By 2015; February 2011 Status Report; U.S Department of Energy
[16] The Future of Urban Mobility 2.0; Imperatives to shape extended mobility ecosystems of tomorrow; Arthur D. Little; January 2014
[17] Electric Vehicles in Urban Europe; Madrid Network Meeting and Study Visit; URBACT; November 2010

many remembering well some of the high profile and relatively recent examples of marketplace winners and losers.[18]

The Kyoto protocol sets binding target values for the reduction of CO2 emissions thus several climate change packages are mandatory. The European Commission was determined to respond to this challenge. After voluntary agreements with automotive manufacturers failed the European Commission set CO2 emissions limits of 130g/km for 2012 till 2015.

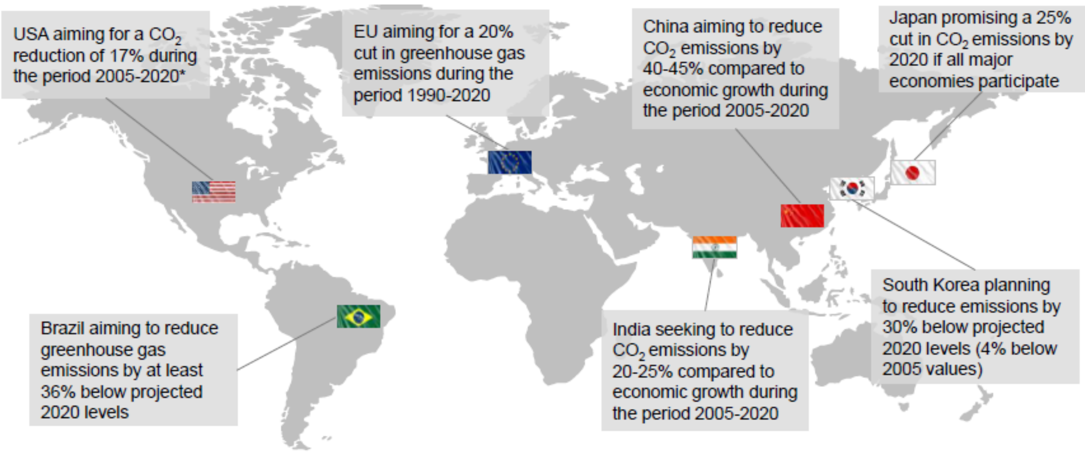

Figure 2: Climate targets across the globe (*Source: Arthur D. Little 2011)*

Until the year 2020 newly produced automobiles are required not to eject more than 95 g/km of CO2.[19] This means that some market players need to reduce emissions up to 50 % compared to the present situation in order to comply with the demanding regulatory requirement. The mentioned emission cuts are based on the overall CO2 targets, presented in the Figure 2.

Besides legal requests the policy passes incentives to the market players. The aid money is essential as long as the e-mobility market does not deliver sufficient revenues for involved companies. The targets as well as subsidy amounts differ among countries. In several countries premiums for buyers of e-cars are paid out by the government or tax advantages are granted.[20]

As mentioned, the key advantage of EVs diffusion is the provided occasion to decarbonize the road transport sector. Of course this also depends on electricity and

[18] The solution for electric vehicles in commercial fleets; Bosch & Vodafone; November 2012
[19] European Commission; Regulation No 333/2014 from April 2014.
[20] McKinsey (2012)

policy frameworks are already in place to increase renewable generation capacity, replace nuclear capacity and trial carbon capture and storage technology.[21]

However, electric mobility competes with alternative drive technologies in terms of R&D funding, regulation and the construction of supporting infrastructure.[22]

Correspondingly, governments and institutions stimulate their economies to become leading suppliers and leading markets of EVs. Big investment programs have been organized for R&D, technology demonstration, and market introduction:[23] The listed countries were not selected under specific criteria. The main aim is to provide an informative overview on more active countries that promote the electric mobility matter and do commit large investments.

- Germany is investing about 1 billion Euros in R&D projects (alternative fuels, alternative drive train technologies, infrastructure, battery recycling)
- France under 2009 Pacte Automobile invests about 400 million Euros in the development of EVs and about 2.5 billion Euros within 10 years to create an infrastructure for EVs.(research, develop and install)
- Spain, Italy, Portugal, Denmark and Ireland offer apart from investments in R&D, subsidies and tax reductions for EVs.
- The EU has started the “European Green Cars Initiative” in 2008 and invests together with the industry app. 5 bill. Euro in different R&D projects and credit packages.
- China invested app. 3 billion USD for technological innovations between 2009 and 2011. Additionally, subsidies for purchasing EVs are paid.
- The USA invested app. 2.4 billion USD in projects affiliated to battery and electric drive technologies and subsidies for their production. Furthermore, tax reductions are offered. The US government plans to increase their investments significantly until 2020.
- Japan invested 200mil. Euros in a five year campaign for batteries and incentives for the purchase of EVs.

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[21] Green Tourism: Bringing the Energy, Environmental and Tourism Sectors Together, 27th October, Gateshead; Richard Kotter Electric Cars & Charging Points; Northumbria University; E-mobility NSR

[22] M. Hülsmann and D. Fornahl (eds.); Evolutionary Paths Towards the Mobility Patterns of the Future; Lecture Notes in Mobility; Springer-Verlag Berlin Heidelberg 2014

[23] Analysis of Different Implementation Business Cases; Coordination Action ICT4FEV; European Green Cars Initiative; November 2012

- Finally, a good example is Norway. However there is no information available that states that Norway has overtaken such big investments programs in R&D and market comparable with those stated above. Nevertheless the Government achieved a high EVs market share of 6.1% in 2013 through a good mix of financial and non-financial incentives, that positioned Norway as the biggest and the most successful EV market. Availability of free public charging stations as well as toll-free roads, ferries and the ability to use bus lanes and high tax (also fuel) regime for conventional vehicles are important factor to consider if evaluating the Norway success. This success is considered to be the result of a consensus between top-down regulation and bottom-up local support measures.

A lack of coordination between initiatives leads to a poor results in terms of electric mobility performance. Thus there is a need for a more holistic modus operandi. In that context, there is required a better alignment of international, national and regional mobility strategies while respecting liabilities and making sure solutions are adapted to specific contexts.

2.3 Main components of electric mobility

The main components of electric mobility are the type of vehicles, the batteries and the infrastructure for charging.

2.3.1 Involved Vehicles

E-mobility refers to the usage of electric vehicles in the traffic sector. While the concept is quite established in the railway industry it is questionable whether it can compete with the combustion engine as a type of drive for transportation or not.

The first question is whether the traditional engine can cope with the challenging environmental and political surroundings. At first, consider the fact that energy efficiency of combustion engines is at about 20 %.[24] It is hard to believe that conventional actions like downsizing or turbo charging of traditional cars will be sufficient to ensure that CO2 emissions stay below the 95 g/km limit in Europe. Thus, an extensive electrification is most likely going to fulfill the legal and environmental requirements. Despite all these facts it is questionable whether the life

[24] according to Wikipedia

cycle costs of electric cars will be able to compete against those of traditional cars. According to an index created by Oliver Wyman (2009), differences in manufacturing costs will become lower within the next 15 years but remain significant.

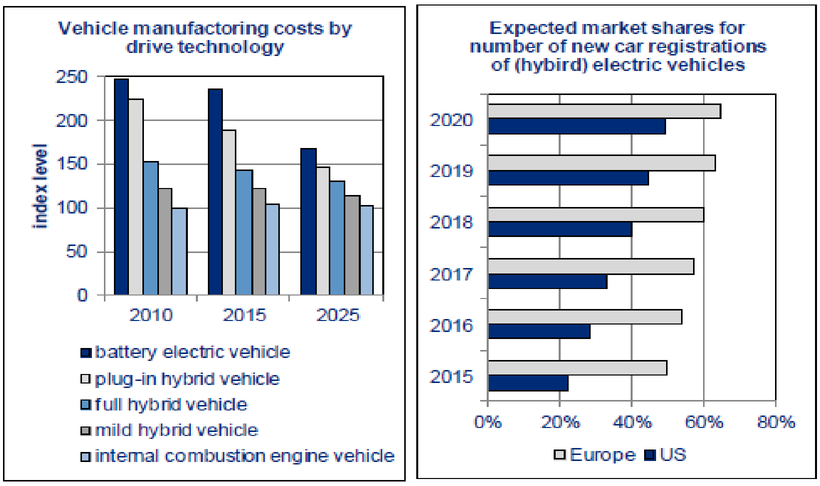

Figure 3: Manufacturing costs and expected market share (*Source: Deutsche Bank 2011)*

Currently, EVs are far away from being a mass market product, its production being still not profitable due to the small number of produced units. On the other hand, market potential is expected to be high by many experts. Deutsche Bank expects a considerable increase in market share for new electric cars in US in 2020. There is also expected that the costs technologies tend to fall. (Figure 3) Thus the price of EVs could become competitive during the next decades. Electric vehicles that can be found on the market are: hybrid electric vehicle (HEV), plug-in hybrid electric vehicle (PHEV), battery electric vehicle (EV). An operating scheme of each car has been presented in Figure 4. In order to better understand how these cars can be diffused, by owning them or by using them as a service, some aspects of these vehicles shall be described.

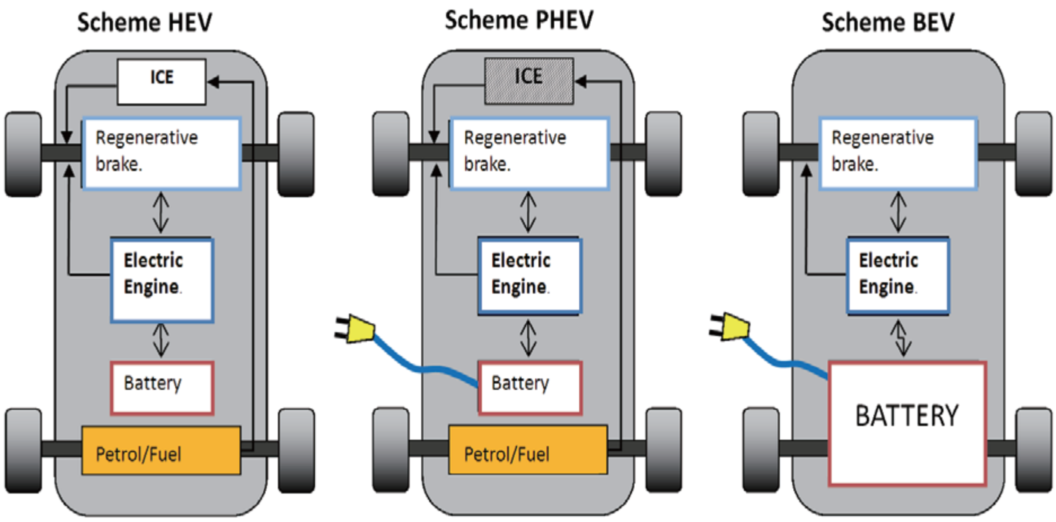

Figure 4: Electric vehicle types (*Source: CSCanada*[25])

- ***Pure Electric Vehicle* (EV)**: are vehicles which are fully powered by electricity from batteries that can be recharged via a connection with the electricity grid. EVs are driven only by an electric motor and do not rely on petroleum. Their fuel supply comes from electricity which is stored in a battery. Purely electric vehicles are far from a mass market, despite their environmental advantages. Such EVs are more efficient than conventional internal combustion engines (ICE). They release almost no air pollutants and less noise than ICE vehicles. Also, as part of smart grids, they have the potential to contribute to levelling the fluctuations of renewable electricity generation from wind turbines and photovoltaic panels.[26]

However the autonomy offered by the battery is lower than in a conventional vehicle and the current network has still considerable limits for charging. This makes the user feel uncomfortable with such an uncertainty. Nevertheless, the most critical component in the price of EVs is still the battery.

- ***Plug-in Hybrid Electric Vehicle* (PHEV):** are hybrid vehicles having petrol or diesel engine and an electric motor, plus a battery pack, which can be recharged via an electric socket. PHEVs are powered only from the battery for the first trip portion. Once the battery has been wasted, the engine propels the vehicle for the rest

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[25] Sergio Valero Verdú, Carolina Senabre Blanes, Demetrio López Sánchez (2013). Feasibility of Recharging Electric Vehicles with Photovoltaic Solar Panels. *Energy Science and Technology*, *6*(2), 24-30.

[26] 4-174 Praetorius **886;** ECEEE 2011 SUMMER STUDY Energy efficiency first : The foundation of a low-carbon society; PAN EL 4: TRANSPORT AND MOBILI TY

of the trip. Such hybrid vehicles have appeared as an alternative to replace a considerable fraction of fossil fuel consumption with electricity. However quantifying the expected benefit is more challenging than with other vehicle technologies because pf the energy from two distinct sources. The fuel consumption varies on the distance and drive cycle. Finally, PHEVs are attractive because they combine the positive attributes of HEVs and pure EVs while in the same time softening the disadvantages of each. As a result, PHEVs have the greatest potential to penetrate the market and reach significant petroleum displacement.

- ***Hybrid Electric Vehicle*** **(HEV)**: combines a conventional petrol or diesel engine with an electric motor. The batteries that fuel the electric motor are recharged however by regenerative braking or by converting energy from gasoline. Also, due to the low range offered by batteries available today, hybrid electric vehicles are now the most common form of electric vehicles. Yet in contrast to pure EVs, HEVs mostly focuses on increasing the efficiency of internal combustion motors, not on developing electric vehicles.

Vehicle components that influence the car fuel consumption and CO2 emissions are of external (driving resistance) and internal nature (fuel type and constructional factors).[27] These factors should be addressed in order to increase fuel efficiency and thus obtain an emission cut. Following measures will definitely improve the efficiency metrics of an electric car, which desperately needs a range extension.

- *Cars need to lose weight*

  Reducing weight does reduce driving resistance, thus lowering fuel consumption and CO2 emissions. This could be obtained by using lightweight materials as steel alternatives.

- *Aerodynamic improvements*

  Aerodynamic improvements in the design of the bodywork help to drop off the air resistance, which can reduce the fuel consumption and thus increase the range.

- *Optimizing driving styles*

[27] Green Mobility Fact Book; Lanxees

Up to 30% of fuel consumption is related to the way a vehicle is used. Adding electronic assistance systems might enable a more efficient driving style.

These improvements demand close cooperation between car manufacturers and suppliers. Moreover, it remains important to consider the driving patterns of existent vehicles, including the electric one.

Most cars in the cities are used only for short and medium distances. There are for sure exceptions, but considering the average consumer car usage, most people drive only short distances each day.

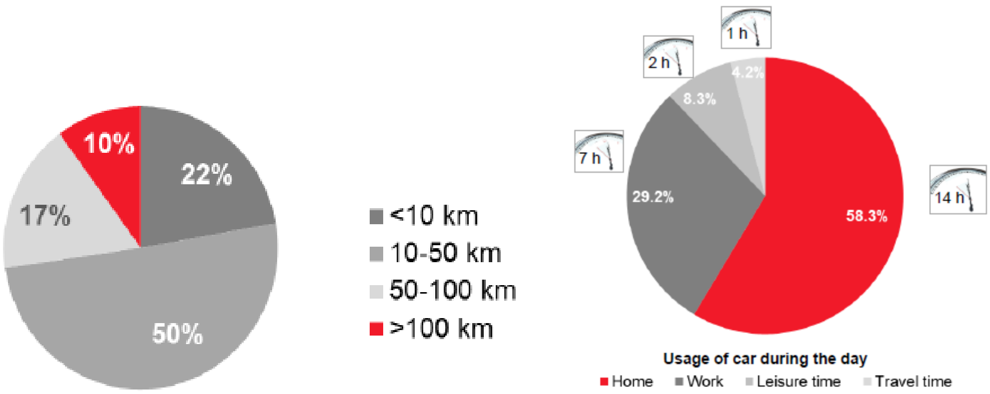

Figure 5: Average Car usage (*Source: Lanxess E-Mobility Fact Book)*

Only 10 % of vehicles are driven more than 100 km per day (see Figure 5). Moreover as presented in Figure 5, 58% of time the car is stationed at home and 29% at work. This means that the car of an average user is used mostly for driving to work and then back home.

Drivetrain type	**Ideal driving distance**
EV	0-40 km
PHEV	0-120 km
HEV	0-120 km
ICE	> 120 km

Table 1: Ideal driving distance (Source: Author)

Thus EVs are a preferably options only for a distance less than 40 km. Even if the range can reach 150km, the anxiety due to the missing infrastructure and the charging time poses a big barrier. In short distance cases, the EV can substitute the usual internal combustion engine, which shall remain the suitable option for ranges bigger than 120 km. The preferable driving ranges are resumed in Table 1.

EVs are seen as an encouraging technology to reduce CO2 emissions and as a driver of the transition to more sustainable transportation. Comprehensive investment in research and development, e.g. in battery technology, is essential to achieve these goals, but technological development alone will not ensure the large-scale diffusion of such innovations.[28]

2.3.2 Batteries

In this part it is examined whether there are or will be battery technologies ready for mass production. It is interesting to investigate wherever there are any battery technologies that provide a large amount of energy, are cost effective, long lasting and abuse tolerant.

Several studies by Deutsches CleanTech Institut (2010), show that lithium ion batteries are most likely to meet these requirements. Deutsche Bank (2008) estimated that lithium ion batteries will make up 70 % of the automotive battery market in 2020.

The main question is how steep the batteries price decrease will be in the future. The cost components for a battery are presented in Figure 6.

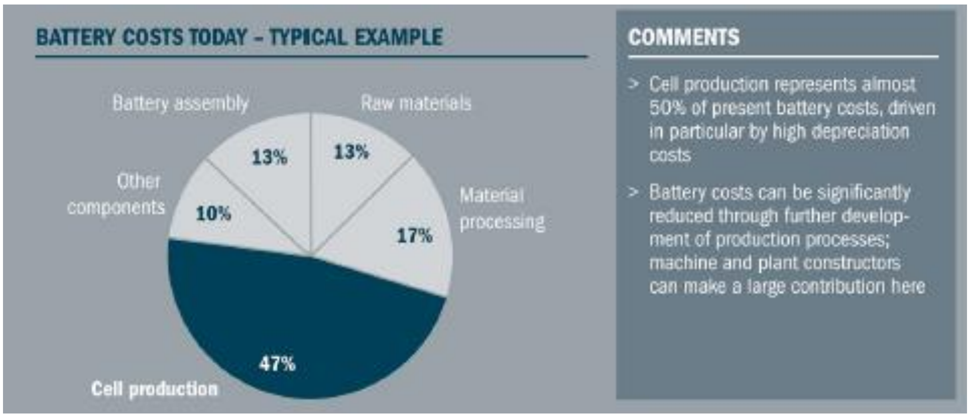

Figure 6: Battery cost structure (*Source: Roland Berger Study 2011)*

Note that only 15 % of today's battery costs are caused by raw materials. Moreover almost 50% of the battery cost is related to cell production and its high depreciation rates. At the point in time when mass production develops economies of scale will become evident.

[28] "Changing minds about electric cars: An empirically grounded agent-based modeling approach" Ingo Wolf1, Tobias Schröder, Jochen Neumann, Gerhard de Haan; Freie Universität Berlin, Germany

Hence, technologies which convert chemicals into electric energy can certainly enhance the deployment of EVs However, at this stage the batteries show a poor result due to the innovative aspect.

Nevertheless, the electricity as a fuel has a lower energy density when compared to traditional fuels. (Figure 7) The energy density of electricity constitutes app. 1/50 of gasoline. An additional problem is that electricity cannot be stored.

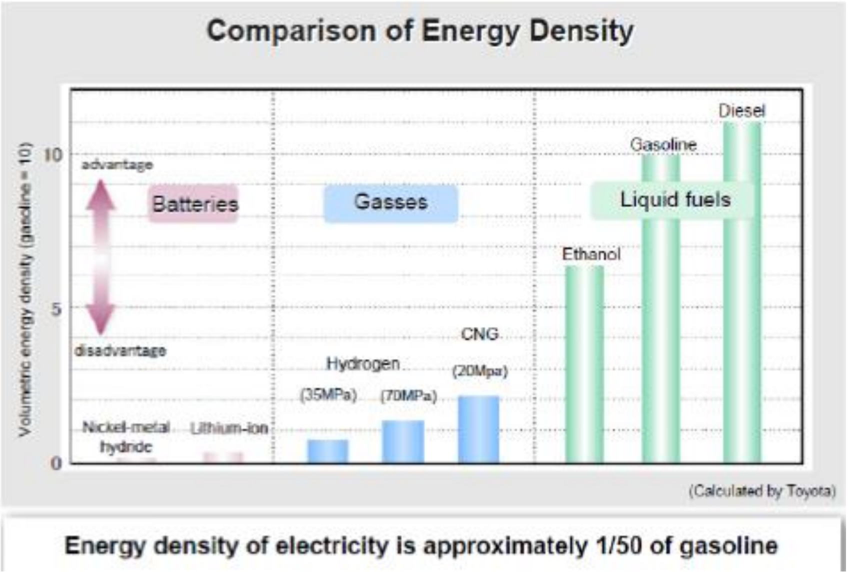

Figure 7: Energy density for different fuels (*Source: Toyota Motors*[29])

However, the technology of batteries is advancing. Highway EVs require batteries that contain a large amount of energy and can provide sufficient power for acceleration. On the other hand, the weight and volume should remain low. The Table 2 below gives a summary of the properties of the different battery technologies.

	Pb-acid	NiCd	NiMH	Li-ion	Zebra
Specific Energy (Wh/kg)	30-35	50-60	60-70	60-150	125
Specific Power (W/kg)	80-300	200-500	200-1500	80-2000	150

Table 2: Specific Energy and Power of Battery Technologies (*Source: Norwegian University of Science and Technology, Nina Wahl Gunderson, 2010)*

- **Lead-acid (Pb-acid)**

  Lead acid is one of the oldest technologies having a low cost and specific energy, about 30Wh/kg. Lead is toxic, making batteries vulnerable to explosion

[29] Toyota's Approach to Sustainable Mobility And Fuel Cell Vehicle Development

during overcharging. Hydrogen gas is emitted during charging and ventilation is needed when the battery is charged indoors.

- **Nickel-Cadmium (NiCd)**

  The specific energy is higher, around 50Wh/kg and the specific power is within good metrics. The cost is quite high, but the battery is still vastly used in EVs today. The batteries steadily lose their energy capacity if they are constantly recharged after being only partially discharged. Cadmium is a toxic heavy metal, and needs to be handled carefully during recycling.

- **Nickel-Metal-Hydride (NiMH)**

  This battery has many analogies to the NiCd battery, but the performance is better. The battery has high specific power and suits well with hybrid electric vehicles. The battery is used in many EVs and PHEVs. However, the battery is affected by high self-discharge when not in use.

- **Sodium-Nickel-Chloride (Zebra)**

  The Zebra battery employs a molten electrode and needs a high temperature around 300°C. The specific energy is high. The battery is situated in an isolated container, and requires energy supply during standstill to for heating.

- **Lithium-ion (Li-ion)**

  Lithium-ion batteries are considered to be the next generation battery technology. The specific energy and power are very high. It has no memory effect and little self-discharge. The resources of material in the battery are generally considered plentiful and not dangerous. Li-ion batteries are vastly used in electronics like computers and mobile phones. The current challenge is scaling up the size of the batteries while lowering the cost. Being initially more cost expensive, Li ion provides greater range and shorter charging time. These new battery technologies offer four times the storage capacity of traditional lead-acid batteries enabling the use of regular sized vehicles.[30]

Thus the batteries for electric drive vehicles are presented and alingned in time according to utilizability in Figure 8 below.

[30] A Guide to Electric Vehicles, Sustainable Energy Authority of Ireland

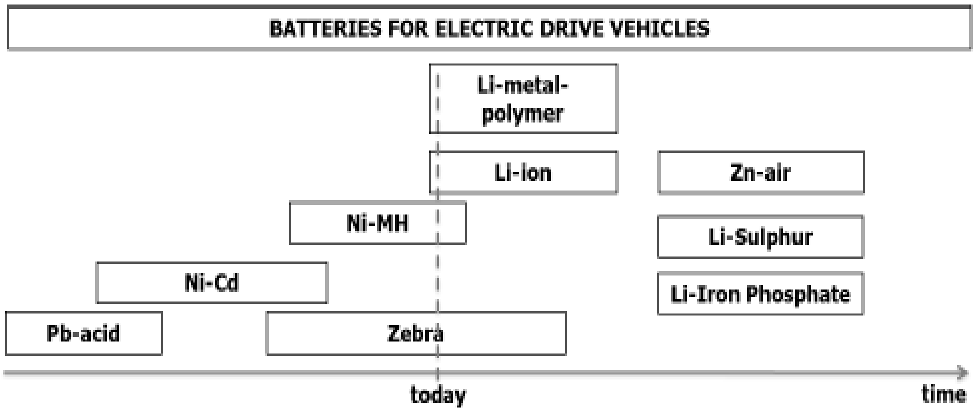

Figure 8: Batteries for electric vehicles (*Source: Norwegian University of Science and Technology, Nina Wahl Gunderson, 2010)*

According to Figure 9, most of experts tend to believe that batteries are considered to become the most used in the production of electric cars.

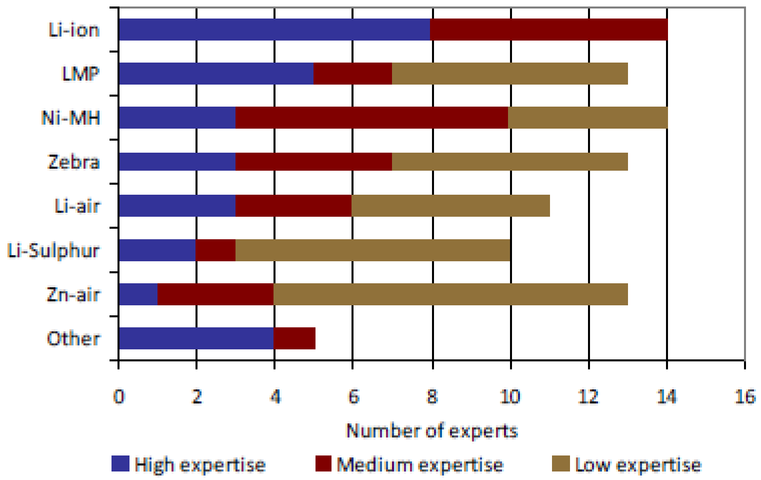

Figure 9: Expertise on batteries (*Source: Eni Enrico Mattei Foundation*[31]*)*

Furthermore, the raw material of lithium which is vastly used for most batteries is still available for decades, but is located only in a few global regions which usually are known as (politically) less stable and reliable regions.[32] Thus, in order to secure raw materials it should be investigated how such batteries can be recycled.

Moreover, the diversity of vehicles can cause additional difficulties for the battery manufacturers. This also may add barriers to the battery standardization adopters.

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[31] Going Electric: Expert survey on the Future of Battery Technologies for Electric Vehicles; Eni Enrico Mattei Foundation; 2012

[32] M. Hülsmann and D. Fornahl (eds.); Evolutionary Paths Towards the Mobility Patterns of the Future; Lecture Notes in Mobility; Springer-Verlag Berlin Heidelberg 2014

There are no identified European funding schemes with a clear target description as presented for the USA and Japan. Nevertheless, the European Green Car Initiative supports R&D project for Batteries and set objectives based on studies, resumed in the Figure 10 here below:

Batteriesfor EVs	2012	2016	2020
Energy Density(cells)	220Wh/kg(140-300)	300 Wh/kg(150-500)	450 Wh/kg(250-700)>1000 (LiO2)
Lifetime(calendar life)	9 yrs(8-10)	11 yrs.(10-12)	17 yrs.(10-20 yrs)
Cost(cells)	500 Euro/kWh(350-600)	400 Euro/ kWh(250-500)	250 Euro /kWh(200-300)100 (LiO2)

Figure 10: Battery roadmap (*Source: The European Green Car Initiative, European Commission)*

It is truly expected to reach a cost reduction of 50% and also double the energy efficiency of the cells. Moreover, the batteries lifetime is also expected to increase, also at double metrics. Additionally the mass of the battery is also expected to visibly reduce. Thus, concluding, the main problematic aspects of the battery manufacture should considerably reduce till 2030, with 70% to costs and 45% in mass, as seen in Figure 11.

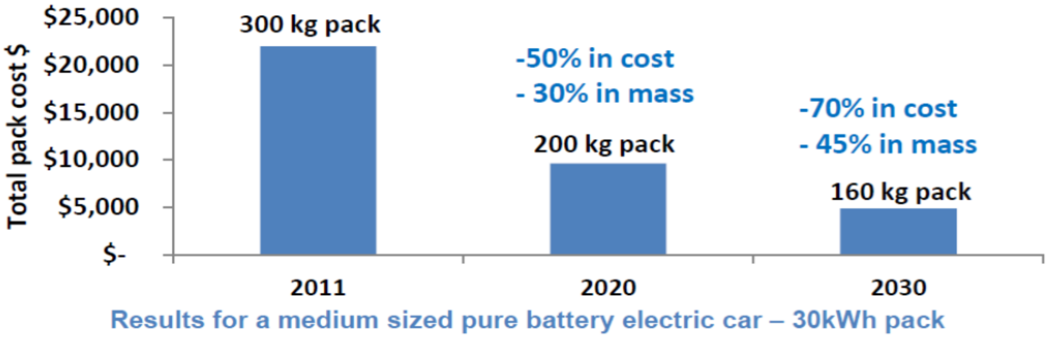

Figure 11: Battery development expectations (*Source: Element Energy, 2012)*

There are fundamental technical challenges to master before these technologies can be diffused. The cost related benefits obtained by high volumes of batteries production are mostly dependent on the development of EV market.

To support these risks associated with the battery, there is a need for the Battery industry to have market access and financial backing. In this field, the model of a Joint Venture between the battery industry and the automotive industry has not been widely considered in Europe.[33] It is still not clear if the European auto industry will prefer such a joint venture, or an approach of standard battery supply. In the second case, there will be a strong competition from Asian and American markets, which

[33] E-mobility Roadmap for the EU battery industry; RECHARGE; July 2013

have a larger production capacity. There is a major risk that the EU can't set decisions to invest until the market becomes a reality.

Thus the development of battery technologies is expected to forgo through more market stages till reaching expected feasible results. The "y" axe contains the battery price and its development according to mentioned market development phases, as presented in Figure 12.

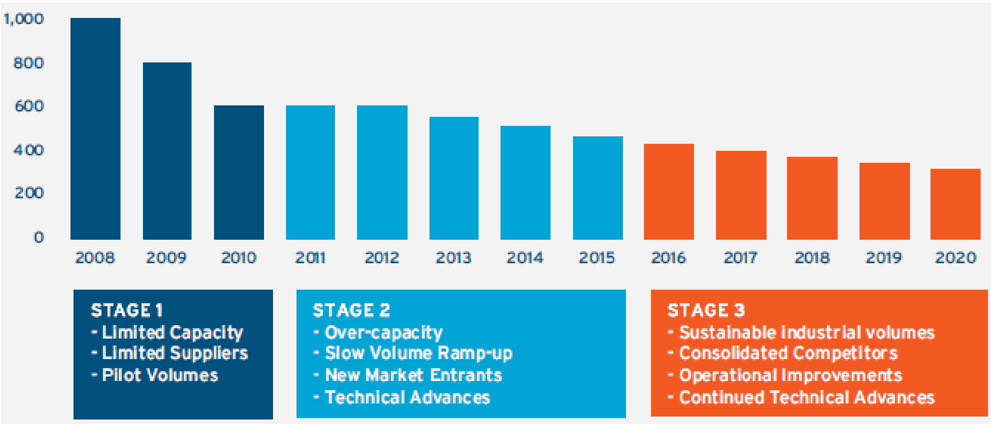

Figure 12: Market development phases (*Source: PWC 2012)*

Finally, the major risk associated with EVs is, owning the battery:

- The batteries are expensive to replace so if they fail prematurely the owner could be left with a sizeable bill.
- It is not clear how the residual value of the battery would be priced, given that battery performance (with most battery chemistries) degrades with use.
- Batteries are still new to the market, especially for a vehicle application, which generate fear to some consumers.
- The performance of a battery is less than that of fossil fuels. More cells have to be installed, which increases weight and costs.
- Batteries lose capacity due to frequent charging as well as environmental factors
- Regular charging is necessary
- Global production of lithium-ion batteries cannot meet the projected demand for e-cars in 2020 Production capacity must grow 125 times in order to supply the predicted 100 million cars. [34]

[34] Market outlook to 2022 for battery electric vehicles and plug-in hybrid electric Vehicles; Final report to the Committee on Climate Change; AEA; June 2009

2.3.3 Infrastructure

Vehicle electrification is currently being widely promoted in order to help improve urban air quality, to support efforts to reduce carbon emissions, and to limit reliance on fossil fuels.[35] There are mainly two possible charging possibilities, home charging or public charging. Optimistic technology developments in this area could provide considerably faster loading mechanisms in the future.[36] However it requires very high infrastructure investments.[37] One main challenge is the establishment of standards for the connectors. Thus unification and interconnectivity of system is a necessity.[38]

Another important characteristic of the charging infrastructure is of the electrical nature. Usually connected within an electric grid infrastructure EV Charging stations can be divided in three types of charging levels, presented in Table3.

Charging level	Specification	Typical use	Time to charge battery
Level 1 (slow)	120V / 13 A	Charging at home / office	7- 8 hours
Level 2 (Fast)	240V / 32 A	Charging at supermarket , gym	3 – 4 hours
Level 3 (Rapid)	Up to 500V / 200 A	Like a normal gas station	30 minutes

Table 3: Charging levels and its specifications *(Source: University of Barcelona Research 2012) 2012)*

Level 1 charging is simply a standard 120-volt AC outlet with installation costs as little as a few hundred dollars, having the slowest charge rate, capable of filling a battery in 7 to 8 hours. Such charging stations are most suitable for locations where EVs are parked for longer periods of time, such as homes and office parking areas.

Level 2 charging utilizes a 208 or 240-volt dedicated circuit and a typical power delivery with either 3,300 or 6,600 Watts.[39] The cost of installing ranges from a few to many thousands of dollars. The charging is much faster than Level 1 thus being able to fully recharge a battery in 3 to 4 hours, depending on the equipment. Level 2 charging suits mostly with locations where the EVs are parked for a shorter period.

[35] Progress In Electromagnetics Research Symposium Proceedings, Stockholm, Sweden, Aug. 12-15, 2013
[36] Structured Solutions AG, Report from 2011
[37] RWE (2009) estimated the costs for wide coverage of Germany with charging stations at €3 bn
[38] According to Deutsches CleanTech Institut (2010) unification across Europe is planned for 2017
[39] HAWAII EV READY Guidebook for Commercial Electric Vehicle Charging Station Installations; Plug In America; 2012

(Restaurant or shopping) Such a publicly positioning should be perceived by EV drivers as an opportunity to extend the range of the vehicle.

Level 3 charging (DC Fast Charging) can charge an EV battery from 20% capacity to 80% in under 30 minutes. Such Chargers can supply power from 25kW to 240kW. Some companies are seeing fast charging as a business opportunity, comparable to running a gas station.

Casual users might rely on using a DC Station if they are willing to extend their range for that day or do not own a charger at home. Moreover, fleets need DC charging to cover their higher daily distance requirements.

There are two methods of fast charging. The first is to use a three phase AC current and to convert DC inside the car. Second, is to transfer DC current to the car with a suitable voltage level for the battery. The fast charging demand can be expected to develop based on various benefits, such as "security" for EV-owner's fear that the battery energy is limited ("range anxiety"), efficient charging solutions for commercial fleet operators, "inter-city travelling" and for heavy vehicles (buses and trucks).[40] Some of the fast charger products also have options with additional AC charging connections as shown in Figure 13.

Figure 13: Fast chargers *(Source: ABB and Schneider Electric)*

Generally speaking, three distinguishable charging scenarios are possible:**[41]**

- Private: charging at home (e.g. garage, carport)
- Semi-public: charging at work and commercial locations (e.g. parking decks, supermarkets)
- Public: charging at public parking sites, existent stations etc.

[40] Fast Charging Stations – Market situation and Installation guidelines; Vattenfall, Asset Development, E-mobility R&D Program 2011; Lennart Spante, Vattenfall Research and Development
[41] Green Mobility Fact Book; Lanxees

Most users are able to charge their batteries at home or at work which can be done with usual 220V connectors. This lowers the infrastructure requirements significantly. Thus, the private charging is preferred since cars can be easily recharged overnight. Nonetheless, private parking lot with an electric outlet is a precondition so semi-public and public charging stations are as well very important to consider. Finally, the main infrastructure components are presented in Figure 14.

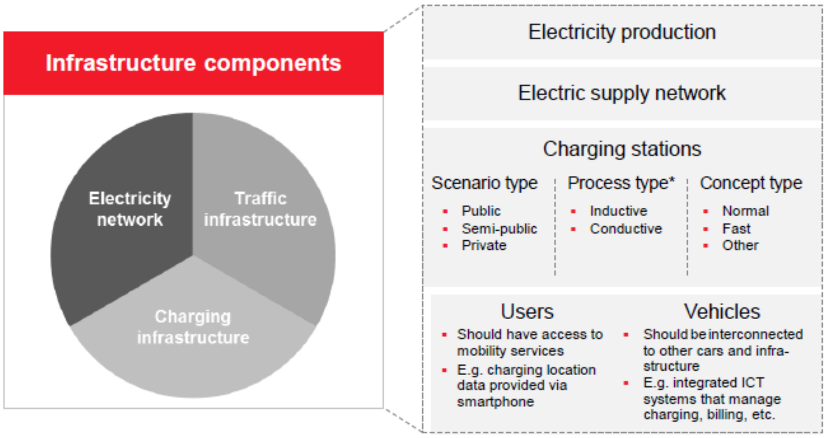

Figure 14: Infrastructure components (*Source: Lanxees Green Mobility Fact Book)*

Currently the charging solution is available with different options, such as personal identification via card prepaid systems management and monitoring software, smart charging with electrical protection and anti-theft security, etc.[42]

The first point to keep in mind is the need of information to EV drivers regarding the location of these charging points. Thus, GPS technology is very helpful for informing users about the nearest available charging points. Such information would drop off driver uncertainty, raising the utility of EVs and reducing the number of optimal charging points. Another important issue is the need for standardized charging systems. The main features that would need to be standardized are:[43] 1) Plug-in types; 2) Recharging protocols; 3) Communication protocols between cars and recharging systems; 4) Regulations for public recharging that ensure safety with minimal administrative barriers; 5) Battery recycling standards and regulations; and 6) Utility regulations. The last element to consider is the cost of charging stations,

[42] Sergio Valero Verdú, Carolina Senabre Blanes, Demetrio López Sánchez (2013). Feasibility of Recharging Electric Vehicles with Photovoltaic Solar Panels. *Energy Science and Technology*, *6*(2), 24-30.

[43] "Policy options for the promotion of electric vehicles: a review"; Jordi Perdiguero and Juan Luis Jiménez; Research Institute of Applied Economics; University of Barcelona, 2012

and wherever there should be a tariff for recovering investments, which are till now not clear.

Indeed, as the electric mobility market is strongly linked to the electricity market which has different regulations. Thus the interface between markets should be streamlined if and where necessary. The distribution network operators (DSOs) activate in a highly regulated environment while the electricity suppliers work in a competitive market. Additionally, DSOs must not discriminate against any network users, e-mobility being one of them, having to reflect, objectively and transparently, specific costs and constraints within their contractual relationship.[44] Such an un-discriminatory attitude towards all network users is a vital base for the development of a new market with new players.

Furthermore convenient access and user-friendly usage is crucial for commercial success. To enable this, the interoperability of communication and data protocols is an absolute precondition.

Electrifying transportation adds an increase in load to the existing electrical grid. Many locations may not be able to accommodate this new load with current infrastructure.[45] However, studies show that electrification of the entire car fleet would result in an increase of around 10 % in total electricity demand, and this can be met with the existing generation capacity.[46]

Thus, only a situation with multiple fast-loading operations at the same time of the day may cause a challenge to the security of the electricity grid. Though, controlling these peaks is a question of smart metering and proper support, not of fundamental change. However, studying these impacts is beyond the scope of this work. Equivalently, the consequence on electricity prices considering EVs large scale adoption is beyond the scope of this work.

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[44] Deploying publicly accessible charging infrastructure for electric vehicles: how to organise the market?; A EURELECTRIC concept paper; July 2013

[45] The Return On Investment for Taxi Companies Transitioning to Electric Vehicles; A Case Study in San Francisco; University of Waterloo Technical Report CS-2011-20

[46] E-Mobility in Germany: A research agenda for studying the diffusion of innovative mobility concepts; German Institute for Economic Research (DIW Berlin); Dr. Barbara Praetorius; ECEEE 2011 SUMMER STUDY

3 Market Models: Roles, Players, Concepts and Fields

The focus is split between the electric mobility market models and its implied actors business solutions. The way how the market is organized and how potential electric mobility actors interact is the first component. However it is also important to assess market actor's activity in terms of business operation. Due to the fact that Electric mobility solutions are a new business field, the attractiveness of potential business models should be also considered. Without viable and feasible business models (presented in up-coming Chapter as business cases) no reasonable market model constellation will be able to arise.

The move towards new mobility concepts requires a comprehensive understanding of all involved elements. The pollution criteria of fossil fuel led to the development of alternative fuels. These, however, need a covering infrastructure, that is still undeveloped. Moreover the downstream energy chain is not useful in any form to the current initiatives. This happens to be a part of the nature. The electricity is a fully other form of energy when comparing it to liquid fuels. Thus, another segment of the energy market enters on the stage, mainly the electricity industry, which is known to be competing with the oil and gas branches. This part invokes additional interest into the matter. With this being said, the electric mobility erodes a different value chain, which is presented bellow in the Figure 15.

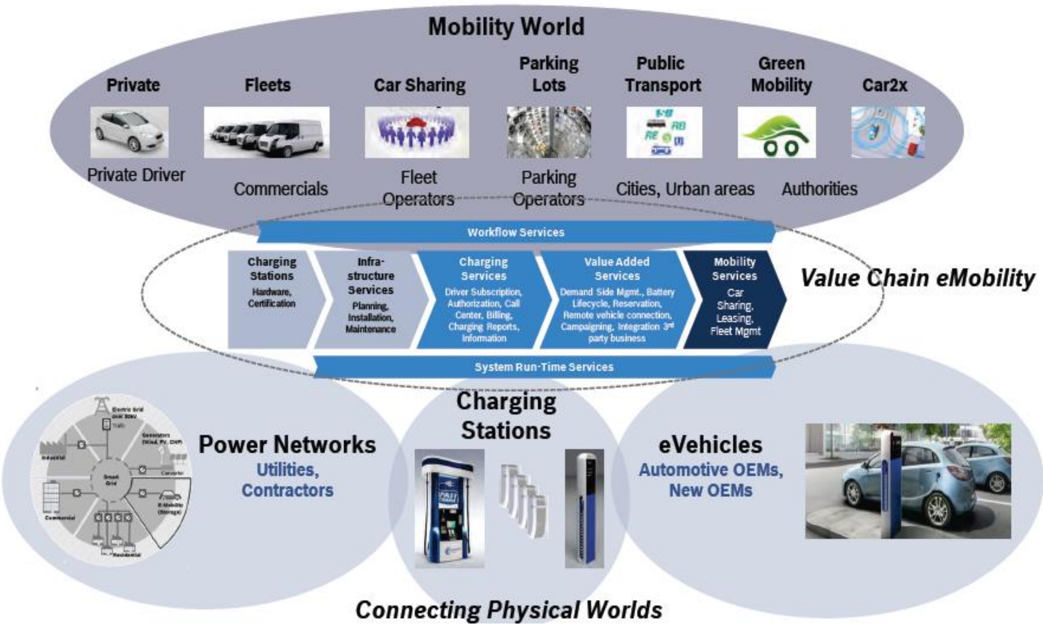

Figure 15: Electric Mobility value chain (*Source: Bosch E-mobility Solution Report 2012)*

Through connecting relevant systems and parties to one comprehensive system can ensure a reliable utilization of electric mobility solutions. Further on, the components are separately described for the purpose of clarifying the market structure.

3.1 Market model components

A generic market model portrays the minimal requirements and agreements between relevant market players that are required in order to form a functioning market where players can naturally thus fostering the mass penetration of electric mobility services. Such a market model illustrates the roles of the players in the market, their liabilities, relationships and interactions. It offers an overview on interrelationships between the actors and their functions in the electric mobility value chain. All sides involved have to endorse some agreements (for example between providers and electricity suppliers) in order to support a customer-oriented market. A market model is not a business model. It does not describe business strategies form individual players, nor does it provide a revenue stream and risk analysis. A market model that has the purpose of enabling a competitive habitat for electric mobility must allow for:

- Access to new entrants, with a vast range of services;
- A reliable long-term investment climate;
- Transparency in services and prices;
- Revenue that reflects value creation

Due to the alternative fuel, electric mobility will advance on top of the existing electricity market models. A distinction between market roles is made:

- **Primary roles** are essential roles that have to be addressed in any functioning market, apart from the market size. (Automotive and Electricity Sector)
- **Secondary roles** are roles that may arise once market scales up but are not vital for the basic functioning of the EVs market.(IT and Communications, Battery Industry, OEM and other add value service sectors)

Thus, a business actor may opt for one role, or a combination of roles, as long as regulations allow for this. Thus different possibilities erode in following business model types, as presented in Figure 16.

In order to confront future challenges the adoption of new technologies and business models is often required. In its 2011 study, Arthur D. Little identified three long-term sustainable business models for the future of urban mobility, which it dubbed the "Amazon", "Apple" and "Dell" models of electric mobility (see Figure 16).[47]

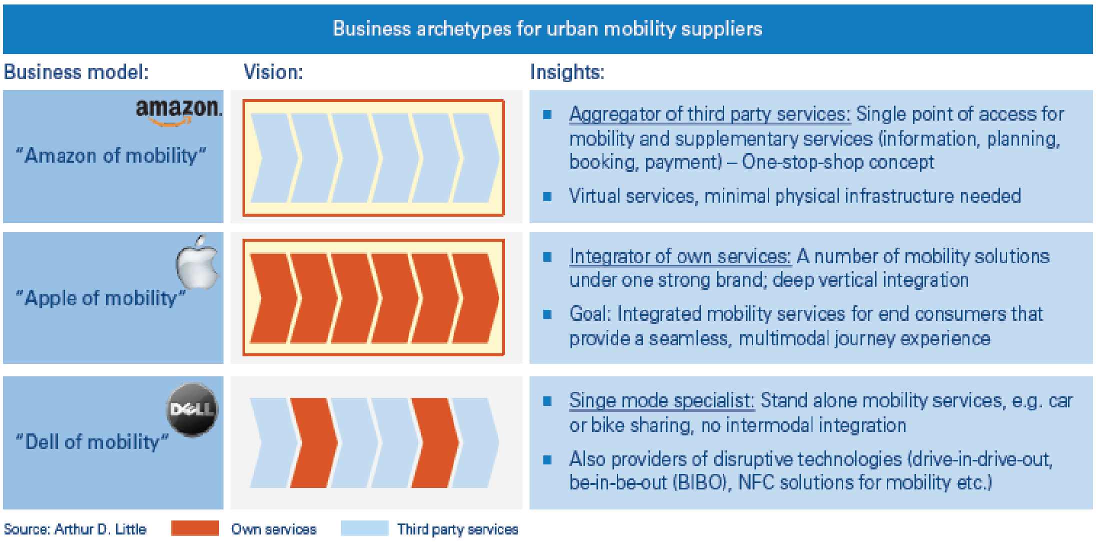

Figure 16: Business model types for electric mobility (*Source: Arthur D. Little, 2011)*

- **The Amazon model:** like the online retailer it is an aggregator of third-party services. Its service relies on a single point of access like information, planning, booking and payment functions. These are typically virtual services, with little physical infrastructure needed, which line up a so called one-stop shop. (Examples: Qixxit, Moovel, SMILE, Check 24) Nonetheless, according to market research there is presently no truly consolidated intermodal routing of travel chains. Such an integrated service has however a great potential to attract substantial volume. In the case of EVs, such a business model can operate like intermediators bringing additional value to users. However such a model needs an already developed electric mobility concepts and products in order to be able to link the efficiency between them.
- **The Apple model:** Like the original name, the key aspect of this model is its deep vertical integration of services. The goal here to offer the user an exclusive experience. (For example ZipCar, MyDriver, DriveNow)
- **The Dell model:** As background, Dell increased its presence by focusing on online sales and supply chain excellence. In the electric mobility context, this alludes to single mode specialists such as public transport, taxi, car sharing,

[47] Arthur D. Little, "The Future of Urban Mobility – Towards networked, multimodal cities of 2050, 2011

carpooling services and limo services. All these services are expected to expand over the next years.

These models do not need to stand alone. For example the Amazon and Apple types can be combined. Thus an electric mobility provider could integrate its services with those of third parties and offer ‘’one face’’ services to the user. Figure 17 shows how this could work from the perspective of the automotive sector and a public transport organization. However, these solutions and business models are currently not being broadly applied and only a few actors have succeeded to integrate them at full business potential. Moreover a combination of these models is also likely to find a presence in the market when considering stable growth and preferable conditions.

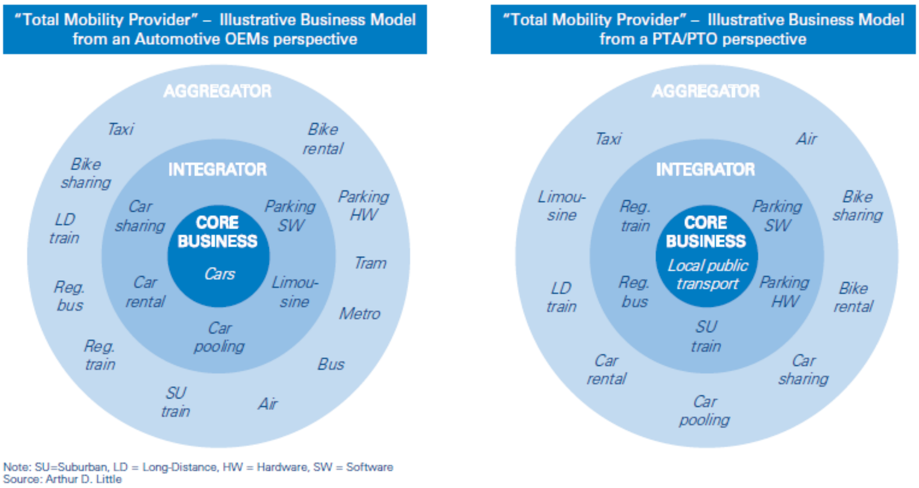

Figure 17: Combined business models (Integrated E-Mobility Provider) *Source: Arthur D. Little (2011)*

Furthermore it is important to outline the main sectors that are closer to the e-mobility.. Thus the main products of e-mobility are identified: it is the electric vehicle, the fuel in form of electricity and the needed infrastructure. Secondary service like telematics, which is supposed to act mostly as an integrator or connector of these main components, remains also a vital part of the success formula. However, these services depend mostly on how the primary one will develop. Thus, apart from the discussed possibilities of business types, there is an opportunity for the electric mobility sector to create Total Providers. Total Providers have their own core business component, like cars or charging solution (including or not electricity) and could also expand through acquiring or partnering other primary players and thus creating an all-in ready to use solution. Like presented, in Figure 17, the automotive sector and the Public transport sector could provide a large diversity of electric mobility services. However, in this case, the infrastructure will have to be incorporated or outsourced.

On the other hand, due to the high electrification aspect, utilities have also a potential to develop large charging networks. The possession of the needed know-how and the access to electricity market makes them more competitive in comparison with charging equipment suppliers. In this case, the strategy directed towards a network mass development seems appropriate. However, there is still a high risk as it is pointless to invest such an effort and not to be sure of if and how many EVs will appear on the market. Nevertheless these two branches depend on each other and have a potential to become very vertical in their structure, with an optimistic assumption of electric mobility future presence. Nevertheless, if incorrectly sizing the situation, there might appear a risk of allowing new players in this segment of the market. The energy market liberalization can trigger this risk into an opportunity for the others, if considering a tight specialization and market optimistic perception. Further on, the Figure 18 presents the main sectors, actors and their focus in regard to electric mobility market.

Sector	Mobility	Energy	Added Value
Actors	Car Manufacturers Components Suppliers Battery manufacturers Specialized Tuning	Electricity Supplier Retailer/Producer Transmission System Operator (TSO) Distribution System Operator (DSO) Balance Responsible Party, Balance supplier and Metering Operator	IT companies Communication companies Other
Focus	Vehicle	Fuel and infrastructure	Clearance and Integration

Figure 18: Main actor of electric mobility sector (*Source: Author)*

Mobility related business cases include the production of the EVs with all its specific components and the battery; EVs distribution; and electric mobility as a service.

The first two business cases are similar to existing value chain elements of traditional vehicles. The main goal of these points is to cut the large gap of the purchaser price of EVs and ICE vehicles. This issue is already being addressed by existing offers.

One implementation like battery leasing reduces the price and the risks due to the unpredictable residual value.

However, more interesting for a wide electric mobility implementation are ideas to use electric mobility as a service, for example car-sharing, which benefit is at least.

Firstly, the acquisition of pricey EVs is not required, thus removing one of the major constraints of EVs. Secondly, a shared EV is supposed to reach higher annual mileages than privately owned cars. This reduces the TCO due to the significant lower EVs operation costs. A further advantage is the high visibility of the shared vehicles. Moreover, car sharing market has a clear upward trend, which could be used to accelerate the diffusion of EVs.

Despite this, most of the present car-sharing companies manage fleets of mainly ICE vehicles. However, the introduction of EVs is either being developed or planned by almost all car-sharing entities. A general business case for car-sharing and fleet management will follow up. However, in this case, the car-sharing segment is being implemented by existing car manufacturers and has a lower risk of being challenged by new entrants.[48] A main challenge for such concepts is the connection of the vehicles to charging stations. Thus companies should collect and recharge the EV fleet, offer incentives to the users if doing that or outsource this task.

The availability of energy is a basic precondition for an operational mobility system. In the case of ICE vehicles, energy is delivered by a small number of oil companies and distributed via fueling stations. For electric mobility, however, the value chain is not as simple structured, not even considering the difficulty to store electricity.

First of all electric energy can be generated in numerous ways by utilities. The energy distribution is organized by network operators. Network operators and utilities may be the same company, hanging on the specifics of national regulations. Though the business cases for electric energy generation and distribution are established and will not be part of the following considerations. Their actors are however also important catalysts in the implementation of charging infrastructures.

Relevant business cases have a clear concentration on the development, distribution and operation of charging infrastructures and networks. The operators of charging stations could also be private. However, a big part of charging network operators, are currently, utility companies. Utilities, as energy providers, play a vital role in the market development of services related to electric mobility. Because of having the

[48] Car2go (Daimler), DriveNow (BMW), Quicar (Volkswagen), ZebraMobil (Audi), Mu by Peugeot, TwizyWay (Renault), and Multicity (Citroën).

experience with networked energy structures they have a significant know-how lead. Following attributions can be distinguished:[49]

- Electricity Supply Retailer. These are entities that hold licenses or are active on the electricity market by producing themselves or trading.
- Transmission System Operator (TSO) is responsible for the stability of the power system operation through a transmission grid in a geographical area.
- Distribution System Operator (DSO) currently manages the assets for low, medium and high voltage distribution networks. It is also responsible for connecting all loads of the electric system and keeping a solid safe and reliable network for the supply of electricity to all users. (EURELECTRIC Market Models paper, p. 16)
- Balance Responsible Party, Balance supplier and Metering Operator. A party that has a contract proving financial security and identifying balance responsibility and markets the difference between actual metered energy consumption and the energy bought with firm energy contracts by the Party Connected to the Grid. (ENTSO-E; The Harmonizer Electricity market role model, p.13).
- Metering Point Operator is responsible for metering duties. In most cases this position is managed by the DSO. The metering information is vital in order to enable pay-per-use or pre-paid billing models for e-mobility business cases.

This description identifies all the roles for given segments of the electricity market, including both electricity wholesale and retail markets. Considering a mass use of EVs, the main responsible role will have the charging infrastructure providers. Therefore, each presented attribution might develop into a specialized service, thus business model. However, mass initiation of EVs will still require some time and utilities are well positioned to benefit greatly from this development.[50]

Analyzing the EVs impact on the grid infrastructure, supporting pilot projects in developing charging networks and electric fleets, educating the consumers and lunching proactive researches and demonstration campaigns will cement their

[49] The definitions have been aligned as much as possible with other publications. For the electricity market, they have been taken from the ENTSO-E harmonized electricity market role model.
[50] Bosch E-Mobility Solution; Anuj Jain; Bosch software innovations, 2012

opportunistic position. Nevertheless, changes in infrastructure, operational activity, pricing and regulation are still barriers to overcome.

Finally, added services can improve the EVs functionality or simply increase the convenience of electric mobility. Hence, solutions concerning navigation, booking, payment and multi-modality use combats range anxiety. Examples of such successful business cases are rare because most actions are still on the research and development level. The bankruptcy of the Silicon Valley developer "BetterPlace" was a signal of market immaturity of the added value sector. There is still too much revenue dependency on EVs number, and on the way how the consumer charges them. However, the impact of added services is considered to be very important for the acceptance and also the improved functionality of electric mobility.

Accordingly, their development and evolution is a key aspect of future business cases but will not meaningfully contribute to the expansion of charging infrastructure or to the reduction of EVs TCO in the near-term.

The assessment of market actors and their roles is crucial in order to enable a playing ground for business initiatives. So, at this moment, having identified the most viable components of the electric mobility services, it is still important to address the issue of their connection. Considering that the automotive sector concentrates on providing efficient EVs and developing usage concepts for them and the energy/utility focuses more on assuring a functioning infrastructure and developing attracting charging models, the gap between them will create opportunity for added value services. For example, universal costumers (Roaming Customers) will need a standardized data exchange between the e-mobility service provider and the charging infrastructure operator. This can be achieved either with a bilateral contract or through a "Clearing House" or via a combination of both that ensures interoperability.[51] Another example can be considered a global platform that will bridge Charging Station Operators and e-mobility operators and thus process and exchange data in order to enable fluid access to any charging stations by e-mobility customers of any e-mobility service provider. The following roles are secondary, meaning that their apparition relies on the market scale-up. Their usefulness becomes important under substantial market

[51] Deploying publicly accessible charging infrastructure for electric vehicles: how to organise the market?; A EURELECTRIC concept paper, July 2013

shares that unfortunately do not exist today due to the limited market development of electric mobility services.

3.2 Generic picture of market relations

This section has the aim to provide a generic picture of how the primary market actors and their roles interfere with each other. Thus, the main focus of market relationships is based on how the electric mobility service interacts with the fuel supply, in this case the electricity market. To have a clear insight on the link between the electricity market and the charging infrastructure, Figure 20 below provides a general overview of both of them. It has to be considered that the electricity retail market is not integrated and thus specific regulations and contractual structures with TSOs and DSOs are set within each Member State. However the regulatory connectivity issues are not a part of the paper topic.

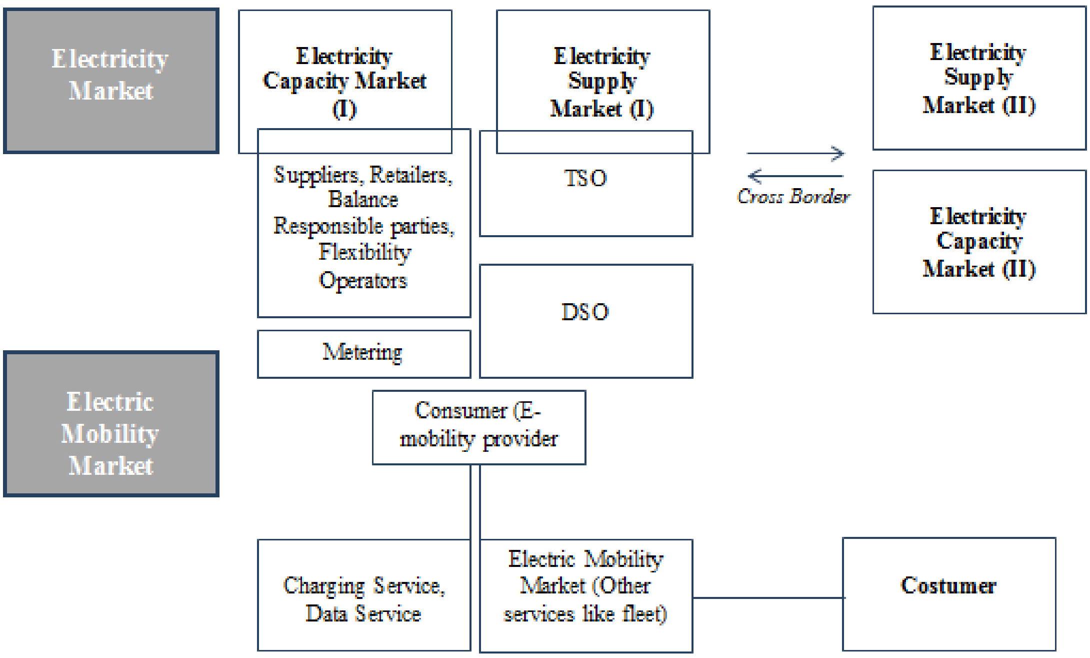

Figure 19: Overview of the electricity and the electric mobility markets
(Source: Author)

As mentioned above, the electric mobility market is tightly linked to the electricity market. The Figure 19 shows the point where the electricity market connects with the electric mobility market. Of course, some actors may carry out their tasks within the electricity market only (TSO, Supply) while others might have a stronger contact, and thus a more direct effect on the electric mobility market (DSOs, metering and retail)

Figure 21 illustrates a general starting point where no business-to-business (B2B) relations are being recognized. However, there are presented existing B2B relationships in the electricity market including its connection to the Charging Stations. Nevertheless, the e-mobility provider can also integrate the function of the Charging Operator, thus becoming a Total Service Provider. This is less probable to happen as it requires massive investments and integration efforts, that even the opened eyes see its unfeasibility. However this might arise in market maturity stages where already the diffusion achieved considerable levels. Nevertheless, in this situation, the apparition of a Total Service Provider would forgo through financial acquisitions and might however present a monopolistic threat.

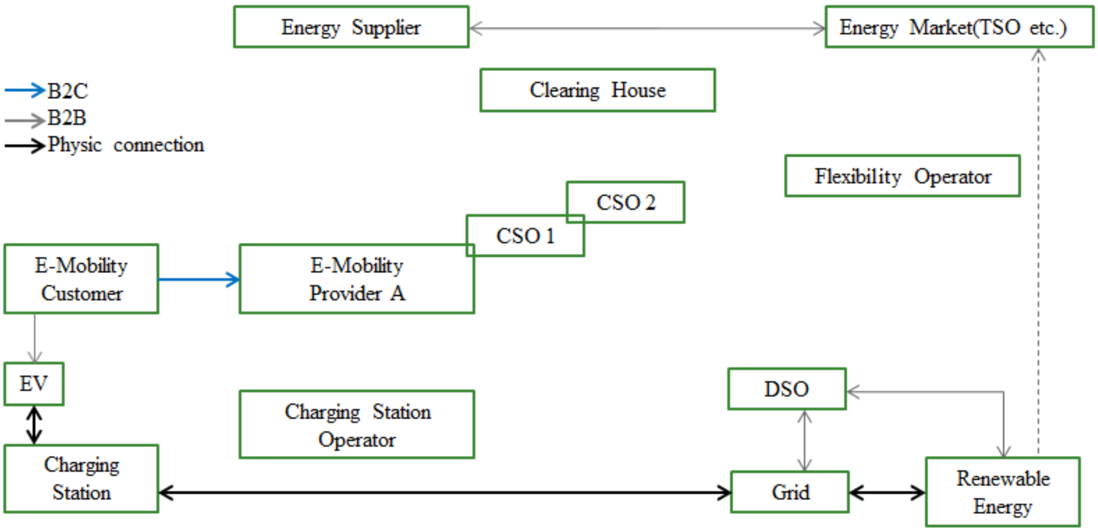

Figure 20: General market starting point *(Source: Author)*

According to the Figure 20, following components are presented:

The electricity grid roles:

- Renewable energy sources
- DSO
- Flexibility aggregator (capacity market)
- Energy market (Supply, retail, TSO etc.)

Electric e-mobility roles:

- The customer
- Charging Stations
- Electric Mobility Service Provider
- The Charging Operators
- Clearing House

Further on, it should be noted that customer point of access to electric mobility services plays an important role, which can be also considered as a point of sale for the above mentioned business cases.

Though, the customer has mainly two possibilities to have access to electric mobility services, direct payment and roaming. Please note that the market constellation of electric mobility services depends more on the way the fuel is supplied be it for electric fleet companies or for individual contractors.

The direct payment of the own customers is not difficult. But, to use public charging points that are not operated by the own Provider is a more delicate situation to confront. Thus, two possible roaming situations are discussed below.

3.2.1 Charging Service Roaming

Considering a customer that has a contract with an E-Mobility Service Provider (EMS), he can recharge at a public stations that are not operated by his own Provider. This is done via a B2B roaming agreement between his Service Provider and the relevant Charging Station Operator (CSO), which choses the desired Electricity Supplier or and sells the charging service (including electricity) at specific price and contractual conditions to the electric mobility Service Provider. This means that the Station Operator has a B2B contract to the electricity supplier, which service is fixed at the station entrance. This is shown in Figure 21 below illustrated by the grey arrow.

The EMS bills his customers for a package service that includes electricity and infrastructure fee. This is done via the B2C contract and takes in considerations parameters like time, power, energy etc. Additionally it may include other services like parking or it can optimize offer through different price marketing approaches.

As mentioned, the E-mobility provider might render the use of vehicles, just the charging solution or integrate both of them, including also added value services. This part is not about what service is offered, more is about how the provider of e-mobility service organizes its relationships with the electricity market, which is vital point for a proper functionality of the overall concept. However, considering the liberalized electricity market and the varying prices according to the time, the apparition of specialized entities in providing fixed graphs and maybe low prices due to fluctuation speculation and scale, might arise.

In this case the EMS provider will line up a B2C and a B2B approach. The B2C is covered through offer marketing concepts and tends to fulfill customer needs. On the other hand the B2B connection is more complex. Here, the EMS provider can organize its acquiring transaction through one general or a few multiple B2B relationships, directly with the electricity market actors (be it producers, traders, operators, distributors) or can outsource this to a Clearing House. Such a market constellation is illustrated in Figure 21 that shows the relationships between actors.

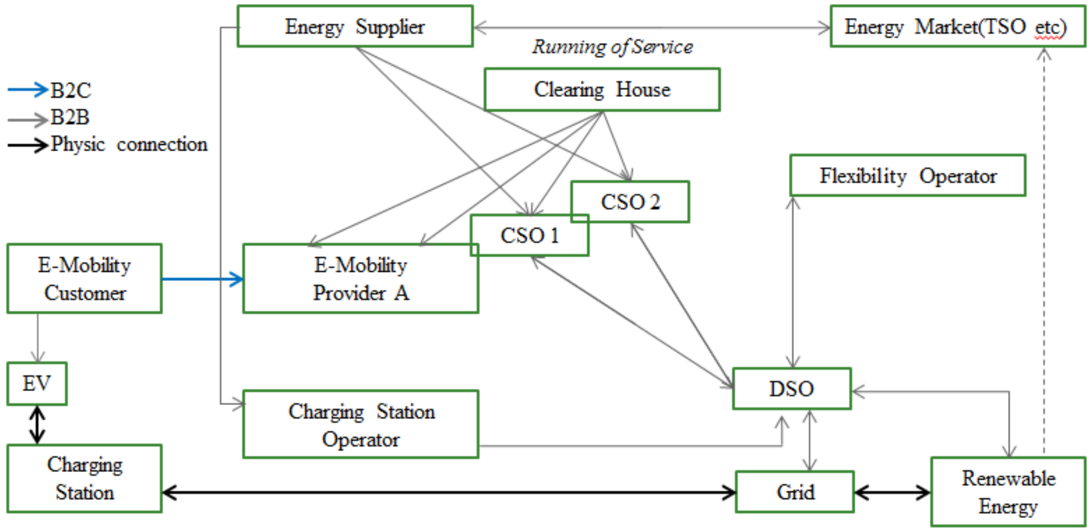

Figure 21: Charging service roaming (*Source: Author based on literature*)[52]

3.2.2 Electricity and service roaming

This implies a situation where a customer has a contract with an EMS provider for charging services and is also able to access public charging stations that are not operated by his EMS. This is enabled by a B2B roaming agreement between his EMS Provider and the other CSO. The used electricity is acquired from an ESR partner of the EMS. The B2B settlement does however not include the price of electricity and the EMS provider will charge his customer with an additional fee for roaming in using other public charging stations that do not belong to EMS. Thus, for the customer, electricity is part of the already initiated B2C contract with his EMS Provider.

Such a roaming scenario means that the EMS Provider gets the electricity from an Energy Supplier of its own choice for charging its clients at all available public

[52] Green e-Motion 2014; Plug-and-Charge und E-Roaming – Potentiale der ISO/IEC 15118 für die E-Mobilität, Mültin and Schmeck, 2014; Gunnar Lorenz, EURELECTRC, 2011; EURELECTRIC concept paper, July 2013 (valid also for other schemes in this chapter)

charging points. Thus, the CSO has the role of a neutral market player with a multi-vendor approach. This means that he is able to identify the EMS Provider that has a B2C contract with the specific customer that uses the public Charging Station and accordingly clears the transaction on the base of B2B agreements. Such an agreement bridges the Electricity Supplier with the EMS Provider. Hence, the customer cannot choose the electricity supplier because it is associated to the EMS Provider picked by the customer by his B2C tie.

The CSO however requires an agreement with the DSO for connecting and using the grid system. Moreover the CSO needs a contract with an Electricity Supplier for its own consumption and for non-roaming, thus offering a direct payment system at the charging point.

In order to not complicate the things, Figure 22 assumes that the CSO is also the network operator to which the charging stations are connected. In such a situation it is a private network operator that may take the forms like shopping malls, large estate owners etc. This is generally the case in public areas that can motivate property owners to become CSOs and thus improve the revenue stream. This might be a good solution for naturally fostering the infrastructure development. Nevertheless, presently, the complexity of operation and the not-defined policy, technical and economic support remain as significant barriers.

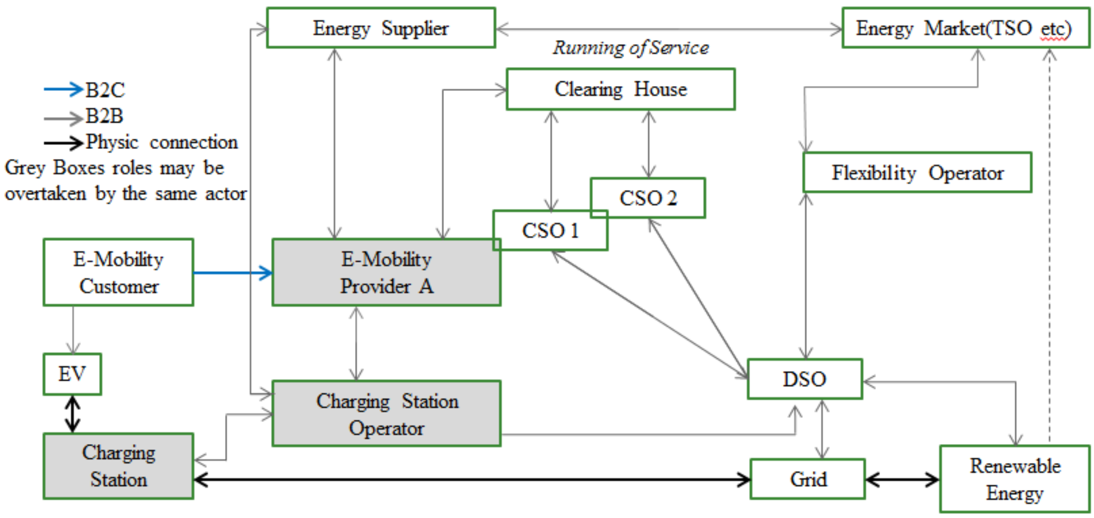

Figure 22: Charging service and electricity roaming (*Source: Author)*

In this theoretical portrayal of roaming solutions, the CSO has in most cases an agreement with the DSO for connecting and using the grid. The main difference between the two cases is outlined by who has a direct agreement with the Electricity

Supplier. Either the supplier is attached to the CSO charging point or it comes packed with the EVs via a B2C agreement with EMS Provider.

Furthermore, the data exchange for roaming customers is vital for both cases. However, in reality the cases described above are not being implemented in a clear form because of national market characteristics.

The following part below discusses national implementations of electric mobility market structures in some Member States that are planned or are already operated.

In practice, various roles can be managed by a single actor. The EMS Providers might also be CSOs, which role can also be played by a DSO. Or an Electricity Supplier might also operate as an EMS Provider. Many other combinations may exist, including also a Total E-Mobility service provider.

3.3 Possible use of electric mobility market models

3.3.1. The independent market model

An independent market model is presently being applied in Spain, France, Germany and Denmark. Of course there are some differences in the market organization but in general, the market structure suits to the charging service roaming case mentioned above. It goes along the following interactions. The public charging stations are installed autonomously from the regulated DSO/TSO grid business. The obtained provision from of installing, owning or operating charging stations comes from a competitive activity that can be performed by any interested party.

Furthermore, from a DSOs perspective, the new interconnection points for charging stations are treated as any other regular new interconnections to the grid. Thus, the DSO can provide a metering service of the network to the charging station operator. In the case of a liberalized market this task and other like clearance can be outsourced to a third party.

However, should specific limitations in regard to capacities arise in the distribution network then a smart charging process has to be developed. This depends on the national regulatory frameworks. Nevertheless two possibilities may be considered:

- The DSO searches for flexibility in market by finding an aggregator or balance operator that covers the variances.

- The DSO keeps a direct contract with the network owner to which the charging stations are affiliated. This allows the DSO to request reactionary actions like power reduction or increase, depending on the local network load.

Considering the fact that this market model has a competitive aspect, a single party can own charging stations, operate it and serve clients as an EMS. This is presented below in Figure 24. Thus, supplying the service through one entity may also cover the expenses that arise from maintaining a charging station. Currently such costs are still uncovered. The EMS supplier in this case is either operating a balance group or sub-balance group, or acquires electricity from the market. In such a case an electricity supply company may act as an EMS provider that will also own and operate the charging stations. Theoretically it could also offer EVs to costumers and become a Total Provider. However this case is less probable due to the high costs related to organizing an EV fleet. Moreover, CSOs must be neutral. This means that they should enable the use of their service to any EMS willing to develop a business.

In most relevant cases the EMS or the CSO is thus the final customer of the electricity that renders charging service that might include a kWh element or other price measures like time of charging or price per charge. This however will depend on each national electricity market model. The structure of an independent model is presented below in the Figure 23.

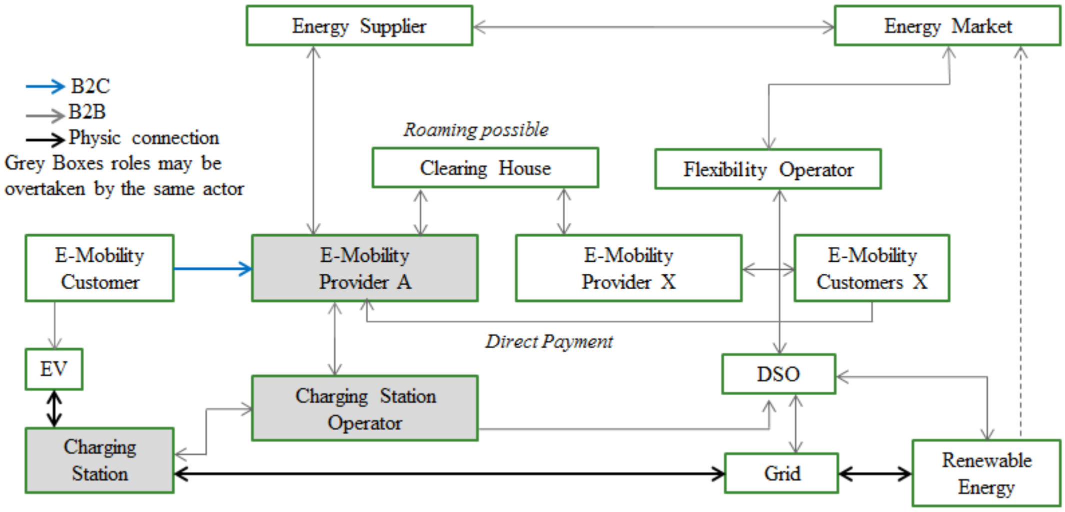

Figure 23: The independent market model (*Source: Author)*

Finally it is important to mention how costumers will access the electric mobility service that is in this part related more to the charging element. Thus, from the consumer perspective, following access points for charging may be considered:

- Costumers access stations operated by own EMS provider: In this case they have a contract, with their EMS, that takes the subscription form.
- Costumers access stations operated by different EMS provider: In this case the access is possible via a roaming agreement**.** Such an agreement is generally a contract that may be managed by a data clearing house, a bilateral agreement or a mixture of both. Moreover the clearing house[53] could have also a financial role that would authenticate the transactions.
- Customers access public stations using direct payment systems. This means that the costumer has to pay for the service at the charging point, by credit card, cash, SMS etc.

Due to the strong dependence of E-mobility service providers on the electricity, the overall market models takes more in consideration the network aspect.

3.3.2. The integrated market model

Such a market model is already established in Italy, Ireland and Luxembourg as an early market development phase. Thus its strategy is based on the electricity and service roaming case. This implies the establishment a multi-vendor principles that allows competition between EMS that request the access to the public charging infrastructure. Thus the DSO is playing an important role and is able to attach the customer to an EMS provider. The Figure 24 illustrates the main links in such an integrated market model.

Moreover, in a roaming situation it is important to consider whether the roaming customer becomes a customer of the new EMS or whether he stays with his old EMS that acts in this case as a service reseller for offshore charging stations.

[53] Such initiatives for a clearing house already exist today. For example the Green eMotion is acting like such a Clearing House on a European level and is founded by the EU Commission. Moreover national, commercial initiatives are also being developed like Hubject in Germany and Gireve in France.

Such an integrated model presumes that the market for charging services is running on the DSO business design. This means that the charging infrastructure is considered a component of a monitored and supervised business related to the administration of the grid. Hence, its development is included in the activities of the DSO, which in this case acts as the CSO. Thus the DSO is installing and operating the Charging points and permits all EMS providers to compete in B2C services.

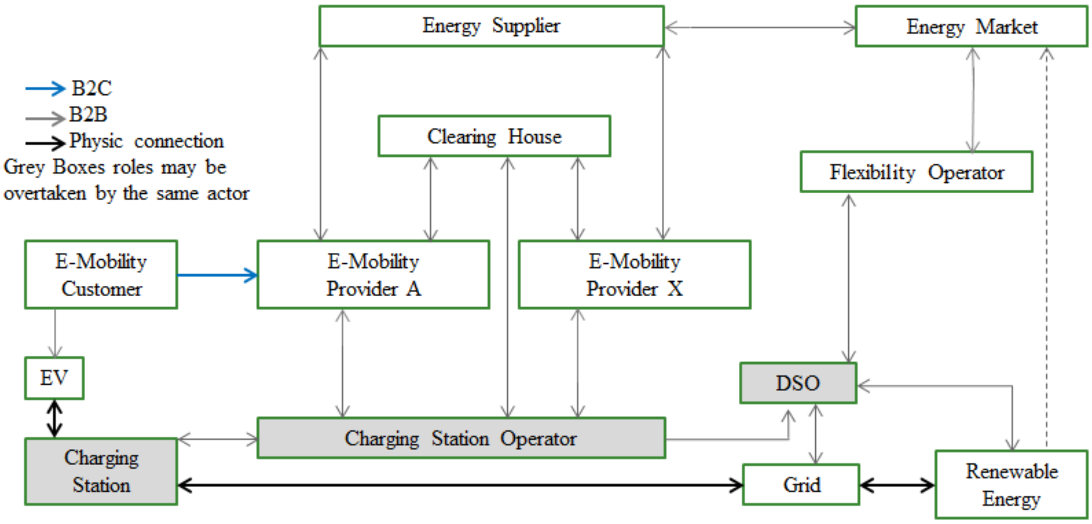

Figure 24: Integrated market model (*Source: Author)*

The customer may have an agreement with one or more EMS providers and can use any existent public charging station. Thus the DSO can run the clearing functionalities between different EMS providers. In such a case, if the market grows, the DSO might be motivated to outsource some services. This would create an opportunity for possible new adding value business models, like telematics in electricity markets. In situations where there are more DSOs in the market or the customer uses a foreign or international EMS, there is definitely a need for a Clearing House of a higher level that will be able to handle multiple DSOs and integrated infrastructures. In such a case the consumed electricity is not linked to the DSO contract with the supplier but should be additionally set like in the Communication industry

So, in this model implements the CSO (in this case the DSO) enables access to all EMSs and can spot their electricity supplier via the Clearing House that manages the B2B contact between the EMS and the Electricity Supplier. Therefore, the payment settlement is secured by the CSO/DSO. Thus the EMS organizes the transaction in its B2C contracts that includes the consumed electricity metrics. Furthermore, there might be included a fee for accessing the station, which can be traded as an administrative service by EMS to its customers in forms of pay per minute, per parking or flat rate. All this depends on the EMS contractual conditions and business model expectations. A further attribute of this model is the capability to use differentiated and incentivized tariffs.

It is important to note that the sale of electricity takes places through a relationship between the supplier, linked to an EMS or even act as one, and the final user. Further on, the DSO manages the billing by using a revenue-grade metering. Therefore the market model allows the sale of both electric mobility service and electricity to the final customer. Hence, the technology of charging stations is then a component of the DSO Assets and is recuperated by the infrastructure controlled return on investment, which means that the costs are spread among all grid users, as element of a grid fee. The components of a grid fee in such a model are presented below in Figure 25.

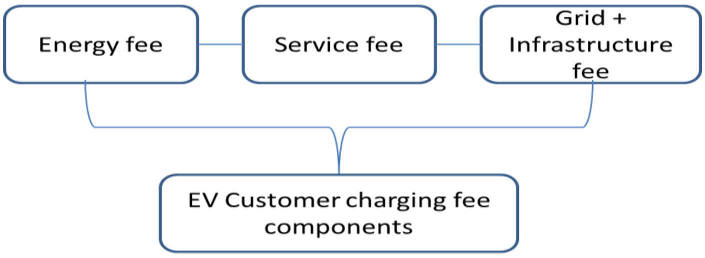

Figure 25: Components of integrated model electric mobility fee (*Source: Author)*

This makes possible to disperse the costly investments over the electricity network customers rather than over specific customers that use the electric mobility service. Such an approach might keep the costs and the outcomes at acceptable levels. Moreover, an overall increase in grid fees might act as an incentive for the deployment of electric mobility services.

Additionally, such a model could reduce grid and service fees in the medium term because of quick evolving charging technologies and especially due to the synergies that may occur when the DSO is at the same time the CSO and its capability to properly allocate the load and integrate renewable energy sources.

From a technology point of view, using the DSO as the investment party provides a guarantee even if there is still no mass market activity in the electric mobility sector. This however happens due to the not-existent profit rationale. This strategic approach can help in overcoming “the chicken and egg” barrier of the electric mobility initiation phase for e-mobility.[54]

The establishment an integrated model depends on the Government decisions and can be put in action by mandating the local DSOs.

Finally, business opportunities arise for sectors like electricity distribution, data management, telecom, fleet etc. However, business models have to consider the fact that EVs dispose of lifecycle and long term uses. Hence, EVs due to its low performances need new vehicle models and architecture. Furthermore, there is a special need to harmonize EV and energy strategies in order to synchronize well the investments. Therefore, public private partnerships will be vital.

Most importantly, governments must allocate subventions to stakeholders, particularly to infrastructure initiatives and to consumers in order to facilitate the development of the necessary infrastructure and feasible business models.

The electric mobility developers are searching for business models that enhance products and services within the specific value chain. However, the main challenges persist:

- Where are the vehicles and the infrastructure?
- What is the business case?
- Where is the Return on Investment?

[54] In order to recover the investments in charging infrastructure, there is a need of an EV market. Contrary, the EV market cannot develop because of missing infrastructure.

4 Detailed economical comparison: Risks and Trends

The mobility is a vast and important segment of our society that keeps us moving and thus contributes with a big share in our socio-economic development. It is a well-established and integrated economic chain that has created specific relationships between the market participants. Electric mobility derived as a new service which includes the same old components but it lacks the know-how and the infrastructure. Mainly, the most important components are also the vehicles and the fuel. The up-mentioned infrastructure is one of the most difficult tasks to develop. It requires a lot of work but also it needs a natural demand. In our case, the need for new mobility appliances like the electrification, which is just one of solution, is created by the regulatory taskforce.

It is interesting to investigate if any of the current E-Mobility models has more potential, is more feasible or can assure structural growth. However the focus will stay on the most potential models. These enhance the core assets of E-mobility, which are vehicles and fuel. Accordingly, two main entrance strategies can be pointed out. Nevertheless, the third one will include a very risky approach, which will include a vertical integrated service, offering the E-mobility product.

Entrance	**Suitable Players**	**Product**
Fleet Operator	Automotive Industry	Mobility
Networker	Energy Distribution	Electriciy
All In Eservice	New Entrants	Electricity+Mobility

Figure 26: Investigating components (*Source: Author)*

The main point of this short research is to check this alignment from Figure 26 and to theoretically deduct the future role of the electric mobility. It is interesting to investigate how attractive is each entrance point and whom it could fit as suitable.

4.1 General Assumptions and Business Case presentation

In order to be able to compare the up-mentioned strategies it is necessary to line up the necessary input assumptions. The first thing to consider is the market deployment capacity and the growth rate. Following the regulatory targets, this paper assumes a ratio of electric cars per total of registered cars in a city. The city is chosen as the market because the electrification requires a developed infrastructure and a modern and aware demand side that will chose to follow the climate task. This section will investigate four case studies of business models that are being used could be used to support the market penetration of EVs:

- E-Taxi
- Fleet solutions
- Car Sharing
- Charging Network

Each case study will consider the following elements of each business model:

- The intensity of capital and asset allocation efficiency
- Financial health
- The scalability – is there anything that might prevent the business model being rolled out more widely?
- Assessment of the likely market impact including timescales for widespread adoption

These businesses were chosen due to current market development trends. All of them are oriented towards core e-mobility services. Other in-between related business opportunities like Equipment suppliers, IT and Communication, Electric Tuning, direct EV Sales and Information/Value related services are not considered. These are more likely to show growth when there will be already an established active E-mobility market. In this paper is more important to emphasize the possible first entrance opportunities and thus identify what driving and hindering forces are behind. However each of this approach needs an estimation basis.

In early 2012, there were almost 100,000 plug-in cars on the world's roads. A year later the report says, there were 200,000 vehicles and in late 2013 or early 2014 there were an estimated 405,000 electric cars globally.[55] Considering the data on worldwide vehicles in use being documented at roughly 865mio[56] passenger vehicles and 318mio commercial vehicles, the approximately EVs market share is considered to be 0.05%. This figure will be considered as the basic scenario for the upcoming assumptions. Continuing the trend from 2012 that states the doubling of EVs, it is

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[55] https://transportevolved.com/2014/04/16/number-electric-cars-world-doubled-past-year-say-academics/

[56] http://www.statista.com/statistics/281134/number-of-vehicles-in-use-worldwide/

assumed a 50.6% CAGR till 2025, resulting in 1% in 2020 and 3% in 2025 EVs market share. The CAGR rate also corresponds to the EVs sales growth rate, presented in Figure 27. Considering the fact that the Berlin is selected as the test city for the up-coming business models (cases) assessments, it is also relevant to include the data for Germany. According to Evobsession, the EVs share in Germany achieved 0.46% of the total market.[57] This rate can be attributed to the fast scenario and is based on a more optimistic development including the possible increase in EVs commercial fleets. The medium scenario is situated in the middle between the fast and slow (base) scenarios.

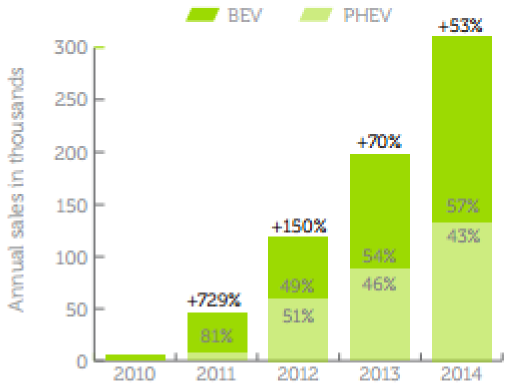

Figure 27: Global EVs annual sales *(Source: Global EV Outlook 2015, IEA)*

Below, in Table 4 the market share assumption figures are listed.

Market Share Assumption Scenarios			
	2015	2020	2025
Slow (Base)	0,05%	1,0%	3,0%
Medium	0,15%	1,5%	4,0%
Fast	0,50%	2,0%	5,0%

Table 4: EVs market share assumption figures *(Source: Author)*

57 http://evobsession.com/germany-electric-car-sales-doubling-charts/

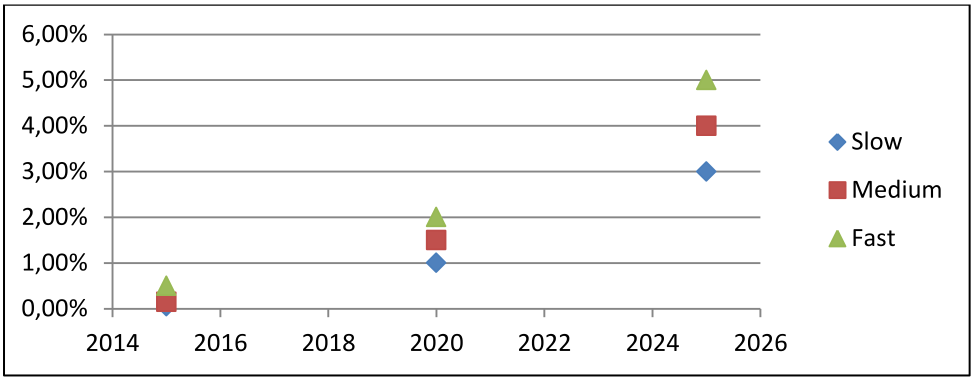

Figure 28: EVs market share assumptions *(Source: Author)*

Further on, the number of existent vehicles is required in order to obtain the calculation basis, which is the number of electric vehicles in a specific city. It is a small share from the existent combustion engine vehicles. This ratio is assumed and listed in Table 5. The following Table 5 includes the assumptions of registered cars and their growth rate:

Growth rate		*2015*	*2020*	*2025*
2%	Registered Cars	1000000[58]	1104080	1218994

Table 5: Registered Cars in Berlin *(Source: Author)*

Berlin was chosen as the case place as it suits the car registration number and it is an electric mobility friendly city. However, please note that the main aim is to obtain an overview on the business viability. Thus it is required to consider a specific location with a specific number. Berlin aims to become a frontrunner in electric mobility and thus to be recognized all over the world as leading city in electro-mobility development, testing and implementation.

EV Market Size			
Scenario	*2015*	*2020*	*2025*
Slow	500	11041	36570
Medium	1500	16561	**48760**
Fast	5000	22082	60950
Target Share	10%		

Table 6: EVs market size (*Source: author*)

[58] The assumed number is rounded up (actually 1.149.520) for calculation accuracy purposes. (in http://www.auto-motor-und-sport.de/news/pkw-bestand-2012-wer-hat-die-meisten-auf-der-strasse-6657528.html)

At this point the total number of estimated EVs is deducted (See Table 6, Figure 29 and Figure 30). Thus, when investigating the attractiveness of certain business model (case), it needs to take in consideration a target share to achieve in order to determine the purchase strategy of assets according to the market forecasted development. The assumption of 10% is chosen due to the big share of private autos procurement in the total EV size pie. Moreover it would not make a big difference what target share to choose. The main aim is to point out some comparable indicators of the chosen business cases in order to identify the healthiest one.

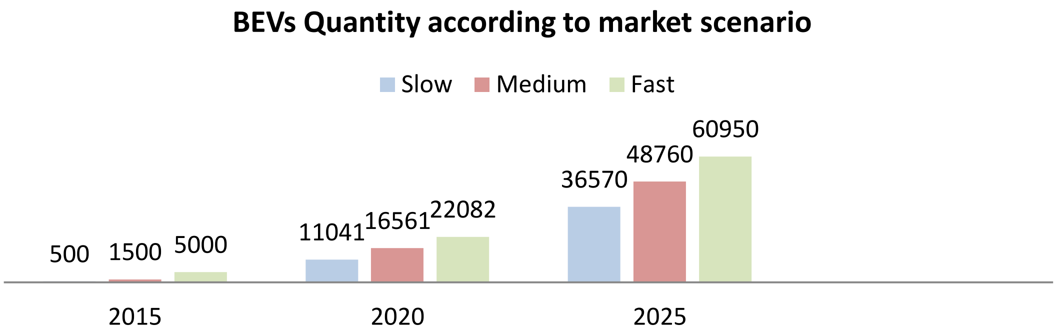

Figure 29: EVs quantity according to market scenario *(Source: Author)*

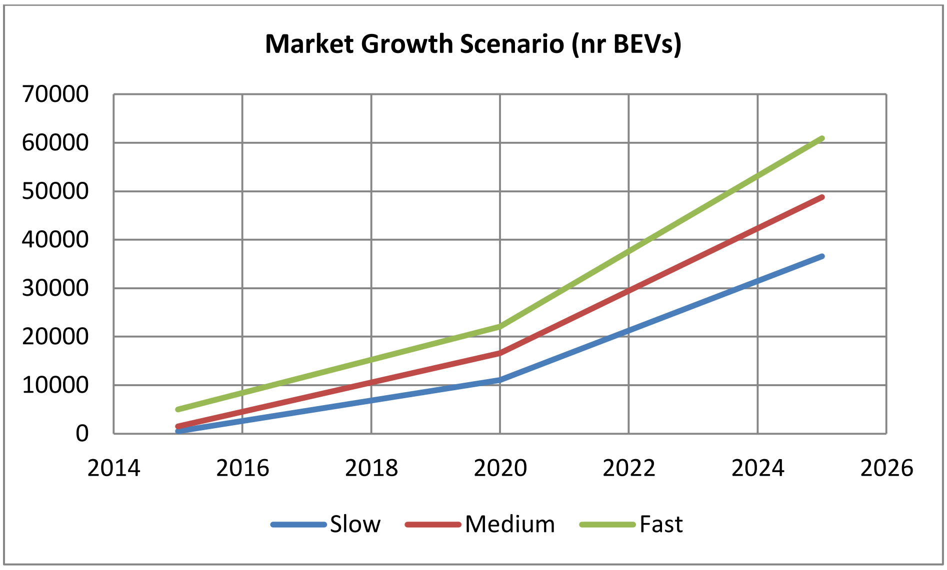

Figure 30: EVS quantity and growth trend according to market scenario *(Source: Author)*

When considering that the mentioned business models will chose their development trend according to the market share of electric vehicles, the following Table 7 shows the exact number of vehicles that should be acquired in order to keep pace with the growth. It represents the estimated target of 10% from the whole market share.

Scenario	2015	2020	2025
Slow	50	1104	3657
Medium	150	1656	4876
Fast	500	2208	6095

Table 7: 10% Market share according to estimated scenarios (*Source: Author)*

Nevertheless the exact number of acquired vehicles, which will be the main investments, is not necessary to correspond exactly to the figures in the Table 7. The probability of an error due to market failure or competition is taken in consideration. Thus each business model will assume different acquisitions, accordingly to the business specifics. However the investment is not the most important part of the investigation and thus the aim is to identify through some general assumption the most viable and economically healthy and capital attractive model. The selected business models (cases) are presented in the Table 8 below. These will serve as a basis for emphasizing the barriers and the development trends.

Business Models	Market Scenario	Target
E-Taxi	Slow(pilot projects)	Public
Fleet Services Car Sharing Station Operator	Medium(paralell development)	Corporate Public All
Emobility Corporation	Fast (aggressive specialization)	All

Table 8: Business Models adaption for market scenarios (*Source: Author)*

Further on, it is necessary to estimate the EVs number for each assumed business case. Thus, the electric taxi project is supposed to be started as a pilot project in a slow market scenario in order to boost public access to electric vehicles and keeping acquiring assets in a slow pace. Next, the Rental/Company Fleet project is assumed to be operating in a medium growth scenario, thus going with the strategy of buy and hold. The last project, Car Sharing is supposed to be developed by having optimistic development expectation and with the time keep the trajectory of the medium scenario. Moreover, private EVs are also expected to grow correspondently thus assuming a yearly growth rate of 40%. The results are presented in the Table 9. The year series from 1 to 10 represent the upcoming years and shall be considered the range 2015-2024, including the assumed EVs stock development for the selected market. Thus the section "All" sums up the total EVs stock, which presence in the Table 9 is mostly relevant to the electricity demand calculations.

In the end, the market data presented is the base for further business cases research. It corresponds with the initially estimated market size potential. It will also serve as an important metric in estimated the charging stations.

Year	1	2	3	4	5	6	7	8	9	10
All	1754	2454	3169	3957	4826	5389	6214	7175	7706	8346
Etaxi	50	150	250	400	600	450	500	600	650	700
Fleet	1104	1104	1104	1104	1104	1104	1104	1104	1104	1104
Sharing	500	1059	1619	2178	2738	3297	3857	4416	4476	4476
Private Auto Clients	100	140	196	274	384	538	753	1054	1476	2066
Market	4776	9552	14328	19104	23880	28656	33432	38208	42984	**47760**

Table 9: Assumed EVs fleet according to context *(Source: Author)*

Moving forward, in order to obtain analyzable results, the utilization of the EV fleet should be considered. Each investigated business case has its specifics, thus the EVs employed distance differ, being higher for taxis, medium for fleet management and lower for car sharing. However, according to the market scenarios, the business cases will lose their 10% initial market share due to forecasted natural competition.

These estimations are being based on web research. The operational period of EVs take in consideration maintenance delays and other unplanned time losses. The fuel price is estimated as the current average electricity prices of the top developed countries. Thus, the utilization metrics are presented in the Table 10.

Business	Taxi	Fleet	Sharing
km per day	200[59]	150[60]	100
Operational days	330		
Km/year	66000	49500	33000
Fuel Price	0,2 EUR/kVh[61]		

Table 10: Utilization metrics (*Source: Author)*

Moreover, business models integrate all the core elements of business strategies and operations that create and deliver value to the customers as well as to the company. The specific elements of business models include strategic actions on customer identification and partition, products and services to offer, business partners, resources to create and channels to deliver value, as well as the underlying cost structure and revenue streams to ensure economic viability of business (see Figure 31).

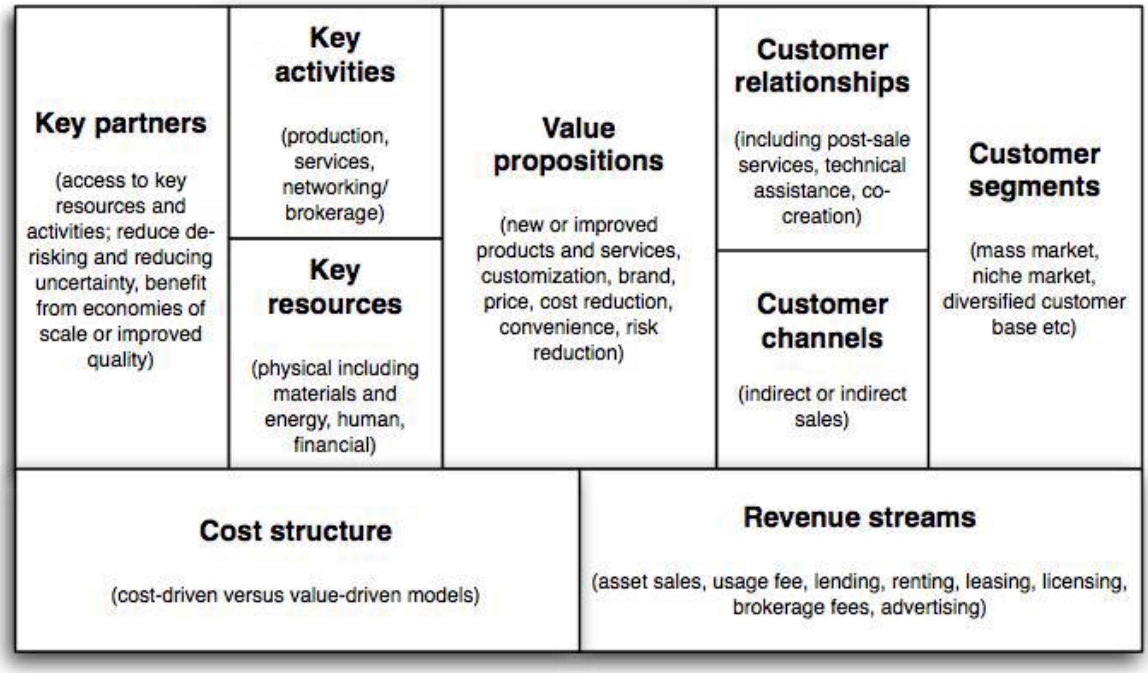

Figure 31: Main elements of a business model (*Source: Osterwalder and Pigneur 2010)*

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59 2014 Taxi Cab Fact Book, New York Taxi Commission, Bloomberg and Yaski; http://www.nyc.gov/html/tlc/downloads/pdf/2014_taxicab_fact_book.pdf

60 National Renewable Energy Laboratory Transportation Research (selected according to commercial fleets average daily mileage) http://www.nrel.gov/transportation/fleettest_fleet_dna.html?print

61 European Commission, EUROSTAT, 2014 http://ec.europa.eu/eurostat/statistics-explained/index.php/Energy_price_statistics

Value creation is the core motor of any business model, as it the most important factors behind the feasibility of a new product, service or technology introduced in the market. Traditionally, the value offered to the customer could include freshness, better performance, customization, convenience, functionality, design, better price, potential cost reduction and savings, risk reduction, higher accessibility.[62]
All the regarded models are assumed to provide competitive and professional service, including the mentioned characteristics above.

4.1.1 Case I: E-Fleet Management Services

The growth in EVs commercial and private fleet can enable scale economies to make EVs more cost effective and can also influence the development of a public charging infrastructure, thereby using the positive externalities and network effects to combat potential EVs acceptance barriers. From a commercial development and public policy perspective, fleets represent an attractive means of increasing EV adoption and reducing dependence on petroleum for transportation.[63] However, from a fleet operator's point of view, EVs represent just a partial solution. Thus, such alternative technologies should be seen as a part of a wider strategy for fleet sustainability that integrates other pivots like operating efficiencies and right sizing.
Three business cases were built:

- Public electric taxi
- Company fleet management or rental services
- Car sharing

Public Electric Taxi

This business case assumes a slow market penetration by electric vehicles and has a merely a demonstration purpose. The taxi company is assumed to increase the EVs acquisition year by year estimating a slow market development. Main case assumptions are presented in the Table 10 below:

[62] The Framework of Green Business Model for EcoInnovation; Jing, Hao, and Jiang, Bao S.; School of Economics and Management, Shenyang Aerospace University, Shenyang, PR China
[63] Fleet Sustainability How Fleets Can Help Jumpstart EV Adoption; PWC 2012

EVs Assets Range	**50-700**	**It is assumed to acquire 50 EVs in the first year and expand the fleet to 700 till the 2025**
Operational Costs	15%	It is estimated as a percentage of the EVs value which includes operational, maintenance and insurance costs
Fixed Costs	48 000	Per EV/year. Includes the administrative costs, wages, order system, fees, own charging stations etc. The main component is the salary which is estimated to have European standards.
Depreciation	20%	Due specific high mileage, the depreciation is set linearly for 5 years.
Battery Replacement	3 years	According to technical parameters, the battery will be replaced at the end of each 3 operational years. (Battery Capacity of 30kV) The replacement price is correlated to expected costs reductions.
Revenue	2 EUR/km	Estimated average value of taxi prices in Europe (adjusted with most promising development countries prices)
Electric Vehicle Cost	30 000 EUR	Based on price of Toyota Prius, Nissan Leaf and Ford Focus Electric. All of these cars have a good performance and proper dimensions for a Taxi.
Route Efficiency	50%	It is assumed that 50% of the routes will be tariffed. This means that an order is being fulfilled while the way back is empty.

Table 11: E-Taxi assumptions *(Source: Author)*

The E-Taxi model may consider its fleet serving initially the main transportation hubs, like Airports, Rail Stations, Bus Stations, crowded Malls and other demanding locations. The main route plan consists in boarding at the parking location, delivering the passenger to the desired location and returning to another stationary point. This happens due to the low available mileage, the EV has to its disposal. The 50% route efficiency assumes this route planning. Moreover, the taxi, being stationed and waiting for clients, can forgo the battery charging process. According to the 200 km average mileage per day, an E-Taxi is supposed to be charged twice per day. This implies possible two shifts per day, which results in high salary fixed costs.

Commercial Fleet/Renting

This business case supposes that the project company takes full charge on developing the fleet, covering the fuel, doing maintenance and providing all necessary support on the offered electric mobility service. It might have corporate clients by providing a bigger fleet to them and taking accountability of the service, thus making it attractive for firms in terms of lowering assets position and transferring the number to Expenses Accounts.

However, it should be price competitive with another market options and opportunities. In this case ICE vehicles seem a more viable solution. However, if a company sets emission targets, the EVs fleets might cover some of their needs, if they perform their trips locally.

Moreover the fleet company might offer their EVs as a rental service to the public. However, the consideration of starting such an EV fleet project includes an optimistic market acceptance scenario. Thus its follows a buy and hold asset strategy. Following the idea, the main input assumptions are stated below, in Table 12:

EVs Assets Range	**1104**	According to the Market Share Assumptions, 1104 EVs are to be acquired in the first year and respectively kept in operation till 2025
Operational Costs	15%	It is estimated as a percentage of the EVs value which includes operational, maintenance and insurance costs.
Fixed Costs	12000	Per EV/year. Includes the administrative costs, wages, IT system, fees, own charging stations etc. It is merely estimated to use 1000 in fixed costs per month for each EV.
Depreciation	10%	Depreciation is set linearly for 10 years, due to medium mileage per year.
Battery Replacement	3 years	According to technical parameters, the battery will be replaced at the end of each 3 operational years. (Battery Capacity of 30kV) It is considered that the second battery replacement will cost only the 75% of the first one and the third replacement will be 50% of the second one. This is assumed according to the Battery Cost heavily expected reductions.
Revenue	100 EUR/day	Estimated rental price per day according to Bloomberg analysis, Herz and Enterprice offerings. The price includes a high utilization rate (90%)
Electric Vehicle Cost	40 000 EUR	Based on price of VW E-Golf, Mercedes B electric and BMW I3. All of these cars are premium class and thus suitable and representative for commercial use and rental services.

Table 12: Fleet Service Company assumptions *(Source: Author)*

The key role of fleet services it to provide a wide range of vehicle and equipment services that embrace acquiring and using the fleet assets, maintaining and operating, licensing and inspecting all vehicles and equipment.

Car Sharing

The concept of car sharing is that users get the benefits of private cars without bearing the costs and liabilities of ownership. Thus, the fleet of vehicles can be accessed on an as-needed basis, thus considered an organized short-term car rental. Generally, participants pay a modest fixed amount plus a usage fee each time they use the car, its price depending mostly on time.

Continuing the idea, the Car Sharing case is projected to look similar to currently operating models on the market. Thus it includes a fleet of small EVs, an innovative order/billing IT platform and the relevant business administrative components. The model relies on positioning the vehicles over the city and keeping an eye on their status. All vehicle related costs (insurance, O&M, fuel), administrative and fixed expenses (legal, regulatory, building, service stations, staff etc.) are included in the price and thus offered as a full ready to use service. The main assumptions are labeled in Table 13 below.

EVs Asset Range	**500-4476**	According to the Market Share Assumptions, it follows a continuous asset buying strategy.
Operational Costs	15%	It is estimated as a percentage of the EVs value which includes operational, maintenance and insurance costs.
Fixed Costs	9000	Per EV/year. Includes the administrative costs, wages, IT system, fees, own charging stations etc.
Depreciation	10%	Depreciation is set linearly for 10 years, due to low mileage per year.
Battery Replacement	5 years	According to technical parameters, the battery will be replaced at the end of each 5 operational years. (Battery Capacity of

		30kV) The replacement price is correlated to expected costs reductions.
Revenue	0,4 EUR/min	Estimated rental price per min according to current Car Sharing companies like Car2Go, Drive Now, Autolib, Zipcar etc
Electric Vehicle Cost	30 000 EUR	Based on price of Smart Two, Renault Zoe, Chevy Spark, Fiat 500e and VW E-up. All of these cars are small class and thus suitable and practical for short distance renting in populous cities.

Table 13: Car-sharing assumptions (*Source: Author)*

Considering the estimated average distance per day, following metrics are further deducted in order to obtain the revenue metrics. According to other researches, the average short term car trip distance is 10 km per day.[64] Further on the speed is set up within the legal frameworks. Next, a 50% utilization ratio assumption implies the traffic jams and the waiting time. This figure also corresponds to older researches onto this topic.[65] Mentioned variables are presented in Table 14.

Average trip	10	km
Average speed	50	km/h
Average trip time	12	min
Stop time	50%	
Total drive time	18	min
Drive time/day	180	min
Price/min	0,4	

Table 14: Car Sharing Utilization (*Source: Author)*

Car sharing has the potential to cut off the costs of vehicle travel to the private users as well as the whole society. When an individual owns a car, the big part of the owning and operating of the vehicle is fixed. The variable cost of using it is comparably low hence the driver is motivated to drive over the economically rational

[64] JRC Scientific and Policy reports: Driving and Parking Patterns of European car drivers – a mobility survey, European Commission 2012

[65] Susan Shaheen, Daniel Sperling, and Conrad Wagner Printed in Transportation Quarterly (Summer 1998), Vol. 52, Number 3, pp. 35 -52

limits. Contrary, car sharing costs are closely linked to current car usage. Thus, car sharing has the tendency to enable the fixed costs to transform into variable costs. Car sharing is an efficient and attractive solution if seen as a mobility mode that can link the bridge between transit and private vehicles. However, for longer distances, one might choose a vehicle, plane, rail, bus and for shorter distances, one might prefer to have a walk, use a bicycle or a cab. But for in-between distances or activities, one might opt for using a shared vehicle.

4.1.2 Case II: E-Mobility Infrastructure Service

Most of the entities starting the business of charging infrastructure are certain that the business value is linked to the operating software rather than the infrastructure equipment. Thus, the electricity market specifics have a primordial importance in the model design of the charging stations.

One of the key properties of electricity is that it cannot be stored and thus has to be permanently balanced on the markets. Transmission and distribution network operators are doing this job by monitoring the supply and demand and adjust the load accordingly. Retail electricity users are usually shielded from intra-day fluctuations in the price of electricity, as their demand is properly planned and thus highly inelastic with respect to price.[66]

Shifting to the case, it is proposed to investigate a business, owning a network of charging stations. The main product is the full battery charge, thus the main economic component is the electricity. This case assumes the business owner to have the status of an electricity trader and thus installing charging equipment in suitable places. Such places are considered to be residential homes, parking lots, streets, crowded buildings, gas stations, stores, groceries etc. The potential clients range varies from including private owners to electric vehicles fleet companies (those mentioned above) thus rendering the service to the whole EV market. Therefore a mix from charging station equipment should be formed, according to each client category need. First of all it is necessary to estimate the demand for charging station. This can be assumed according to the forecasted EV market share when adjusted to the charging expectations. This case will consider the EV market situations, figured

[66] E-MOBILITY SERVICES New economic models for transport in the digital economy Case Study for Research Council UK Digital Economy Theme; University of Cambridge 2012

in Table 4 and the charging patterns of above mentioned business cases, including home charging. Next, the case assumptions are being listed in the Table 15.

Charging Station Price	**18000**[67]	Fast charging equipment planned to accomplish a Full Charge in 120 minutes (average)
Operational Costs	5%	It is estimated as a percentage of the equipment value which includes operational, maintenance and other costs.
Fixed Costs	100000	Per year for the whole activity, including electricity markets shortages and price differences, staff, station spot contracts and other administrative expenses.
Depreciation	10%	Depreciation is set linearly for 10 years
Utilization Rate	80%	Considering that the Stations are available 24/24
Max Charges per day	12	The number value derives by dividing the working hours (24 hours) to the average full charge time (2 hours)
Revenue	5 EUR	Per charge. This revenue model is selected due to its simplicity of use. Other revenues like advertising are not considered.

Table 15: Charging Station Network assumptions (*Source: Author)*

An interesting point in this case is that as a charging station operator, it is required to estimate the potential EVs market share in order to have an adequate allocation of installed equipment, which represents the main investment. This is the other way around of business planning in comparison to the fleet services mentioned above, where the main driver of investments is the share target of the EVs market.

[67] 1. Estimation range 15000-20000 **cited from**: eTec (2010), Electric Vehicle Charging Infrastructure Deployment Guidelines for the Oregon I-5 Metro Areas of Portland, Salem, Corvallis and Eugene. EV Project publication, www.theevproject.com/documents.php. **in** NREL; Plug-In Electric Vehicle Handbook for Public Charging Station Hosts; DOE/GO-102012-3275; April 2012
2.http://www.hmbreview.com/news/hmb-to-plug-in-first-ever-car-charger/article_6fd75760-9760-11e4-a88b-13f9d07e0fee.html

However in this case, it is assumed that the fleet services are being developed in parallel thus having enhanced the whole E-mobility market for a specific selected region, with estimated EVs market share on the basis of registered vehicles.

Thus, the charging needs, when referring to fleet services described above, includes charging demands of 1.5 per day for renting/commercial fleet products and 1 time per day for standard owners and car sharing companies. However, due to impossible estimation of human behavior, a 50% growth in charges per day is assumed. This enhances the optimistic vision that people will adapt and thus act more flexible in regard to the charging location. All this, makes the average charge per day raise to 1.4 per each estimated EV on the market.

At this moment, it is possible to estimate the demand for charging stations if taking into account the projected business cases and the market data. Thus by, dividing the total forecasted EVs number to maximal charges per day offered by the operator and then multiplying with the estimated ratio of each EV charge per day, the total demand for stations can be derived from this. (See Table 16)

Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
EVs Market *	4726	9452	14178	18904	23630	28356	33082	37808	42534	47260
Market Demand **	551	1103	1654	2205	2757	3308	3860	4411	4962	5514
Case 25%	138	276	414	551	689	827	965	1103	1241	1378

* According to current predictions and tailored accordingly to selected business models

** According to charging assumptions from previous Cases and EVs market

Table 16: Forecasted Charging Station market demand (*Source: Author)*

Having obtained the charging station development plan, the revenue metrics can already be calculated. It results by multiplying the number of deployed stations with maximal charges per day, utilization ratio and the price per charge. Further on by subtracting the costs elements the net result is ready to be used in the DCF model. The DCF model developed in this report employs a fixed cost of electricity based on a pre-determined pattern of charging time and a stable load graphic. Considering the average battery capacity (30kV) and the industrial cost of the fuel (0.12), an average charge cost lies by 3.6 per charge. So, in order to get the simplicity of use advantage, the revenue model considers the sale price per a charge to be 5.0 Euro, which is a 40% added value. The price per charge was selected according to current alternatives[68] and adjusted to the figures used in assessing this business model. Otherwise it can be considered that the price is built on a 40% added value on the top of the electricity price and one-charge battery capacity.

Thus, while the majority of EV charging will take place at home or the workplace, public charging stations can significantly increase the utility and comfort factor of EVs by extending the vehicle driving range.

4.2. Investment appraisal

Typical capital budgeting methods that are used to evaluate the investment include:

- Net present value (NPV)
- Internal rate of return (IRR)
- Modified internal rate of return (MIRR)
- Payback period
- Profitability Index

For the purpose of this paper, NPV and IRR analysis are used to assess the profitability of researched business cases. These methods are probably the most common metrics used to assess the investment appraisal.

The MIRR is also a deviation of the IRR that shows its inability to account for positive and negative cash flows during the project lifetime. Moreover, the payback period method is inappropriate for the purpose of this report. Since the payback period method simply calculates the time, required to recoup the investment of a project, it ignores any project cash flows generated beyond the payback period and neglects the time value of money. In the end, the profitability index shows the potential payoff of an investment compared to the initial cost of investing. It is a practical tool for rating projects because it enables to measure the created value per each investment unit. Additionally, following metrics will give a more detailed overview on the performance of analyzed business cases:

- Operational Margin (EBIT Margin)

[68] 1. http://www.plugincars.com/ultimate-guide-electric-car-charging-networks-126530.html
2. http://energy.hawaii.gov/testbeds-initiatives/ev-ready-program/electric-vehicle-ev-charging-stations-in-hawaii

- Cash Flow to Capital Expenditures (CF to CAPEX)
- Return on Assets (ROA/ROI)

These additional ratios are necessary for identifying specific performances of analyzed cases and will be expressed in median and average values for a 10 year horizon.

The Discounted Cash Flow Analysis is the main element of the current investment appraisal. It is a traditionally method used in finance to value a project, company, or asset. In and outgoing cash flows are estimated and then a discount rate is applied to those cash flows to obtain the present value. The sum of present values metrics is the Net Present Value or NPV. The DCF model considers the time value of money, which is means that money is more valuable in the present than the same amount in the future. This happens due to its characteristic to earn an interest.

The Internal Rate of Return or IRR, which is the rate of return that makes the NPV zero, will also be used to assess each charging scenario.

In order to make the formation of the DCF model easier, this paper tries to identify realistic spans for all components on revenue and cost side.

However government subsidies are not included in this paper. The main purpose is to identify the viability of existing and possible business cases and to see where support measures are mostly needed.

4.2.1 Capital Structuring Issues

Before committing to valuation of the investigated business cases, it is important to discuss the capital raising issues, like financing structure, interest rates and capital allocation in order to obtain an average cost of capital which will serve as a discount factor for the DCF valuation.

The financing will assume two possible allocation trajectories: a new project initiative performed by existent institutions and new entrants. Following financing structure are considered:

- Project Finance (80 Debt/20 Equity)
- Start-up (Financing Rounds)

Due to the Electric mobility main components, vehicle and electricity, it is highly believed that bigger projects will be started by existent automotive companies or electricity market actors. This is also confirmed by the currently operating electric mobility services. In this case, the financing is supposed to be backed up by the viability of existing relevant companies (for example, Drive Now by BMW, Car2Go by Daimler). However due to the innovative aspect of the E-Mobility service, which requires a close cooperation with new infrastructure elements like electricity, companies might tend to separate the electric mobility division form its core business. Thus it will act as a new project company, actively supported by the mother company. By the matter of fact, the electric mobility services depend heavily on the cooperation between involved sectors. The cooperation might be between Automotive-Energy sectors through a Special Purpose Vehicle (SPV) or between Public-Private sectors through a Public Private Partnership (PPP). This is also confirmed by existent cooperation initiatives like Daimler-Enel for Italy, Daimler-RWE for Germany, Volvo-ABB, Enel-Hubject.

Considering the fact that the analyzed cases require high investments, active cooperation and do not have a precedent log of activity, the project finance is considered to be the preferable option for financing the businesses. Project financing has mainly the functionality to diversify the risks in an equitable way between the different stakeholders. In Project Finance, the borrower (the Project Company) securities for the loan are the future cash flows of the project itself – it is ‘cash flow lending’, that is predicated on robust, long term and highly predictable financial modelling of forecast cash flows.[69] The project finance structure is presented in the Figure 32 below.

[69] Project Finance; David Gardner and James Wright; HSBC

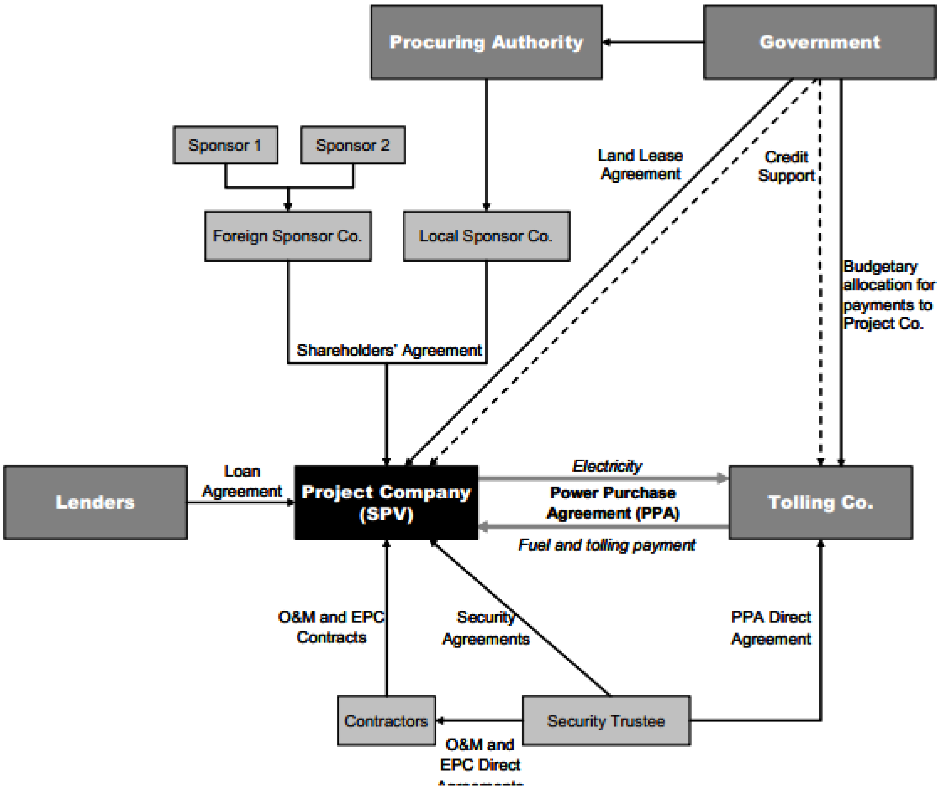

Figure 32: Project finance structure *(Source: HSBC)*

A good project offers many reasons for stakeholders to engage in project financing, mainly a method for infrastructure investment. In the case of an SPV, the liabilities and obligations associated with the project are limited. This provides structural benefits to the Sponsors (investors), which are presented in Table 17.

Sponsor Advantages under SPV	Public Authority under PPP
Limited Recourse	**Fiscal optimization**
High leverage	**Process efficiency**
Balance sheet treatment	**Process efficiency**
	Performance risk

Table 17: Project Finance advantages *(Source: HSBC[70])*

The limited liability protects the assets of the main company from an unforeseeable project default. Moreover the high leverage (typically 80% debt / 20% equity) lowers the average cost of capital therefore making the project a less risky investment. Additionally, the shareholders are allowed to book the debt off the balance sheets.

[70] HSBC , Project Finance, David Gardner and James Wright

This is a crucial issue if considering the financial hugeness for infrastructure investments that might be higher than the Sponsors company balance sheets. However, a public own company can also benefit from the advantages of undertaking a project finance method. By signing a PPP, the risks are transferred to the private sector, which boosts the efficiency.

Debt

Regarding the investigated business cases, the fleet services and the charging solution would require project financing. Thus is important to discuss about the debt and equity characteristics and values. It is estimated that the debt will have an 80% part of the project raised capital. Thus it is assumed that the interest for a long term senior loan is 3.20% according to the Europe Area bank lending rate.[71](See also Figure 33) An additional + 1.0% is being considered in order to enhance unexpected interest volatility.

As it is known, lenders expect a return according risk level, is the core motivation for any lending activity, indifferent form its form.

Furthermore, project financing creditors may also withdraw additional returns through different services like, having trustee function, offering hedging and consulting service, managing a Special Purpose Vehicle and Public Private Partnership accounts.

Figure 33: Euro Area Bank lending rate *(Source: European Central Bank)*

However, in such policy driven projects like electric mobility, development loans and grants are often accessible. Despite this, these financing options are not

[71] http://www.tradingeconomics.com/euro-area/bank-lending-rate

considered in this paper thus the main lending option remains the bank long term senior debt with an interest rate defined above.

Equity

Equity can be contributed in different structures:[72]

- Ordinary share capital;
- Shareholder loans,
- A bank-funded equity bridge loan

Supplying equity via loans can offer tax advantages and optimize the allocation of returns. Moreover, equity providers bear the primary risks and thus will demand a higher return than the debt providers.

Further on it is necessary to estimate the cost of equity. The CAPM (capital asset price model) is a traditional tool used in finance to assess the appropriate project discount rate. It enhances the investor compensation for non-diversifiable risk (the risk free rate and the additional market risk. Thus the next formula:

Cost of Equity = Risk free rate + Beta x (Market Risk Premium)

The cost of equity used in the DCF model is calculated using the betas of comparable companies publicly listed and active in the electric mobility industry. (See Figure 34)

Companies	Business Summary	Market Capitalization (million)	Debt (million)	Levered Beta	Asset Beta
A123	Develops, produces, and sells EV batteries and battery systems	$255.31	$203.55	2.41	1.62
Ecotality	Provides EVSE products and solutions	$29.88	$0.32	2.74	2.72
ZAP	Designs, manufactures, and sells EV and EV power systems	$50.02	$22.00	2.01	1.59
UQM	Develops and produces electric motors, generators, and power electronic controllers	$59.55	$0	2.24	2.24

Figure 34: Comparable of public listed EV companies (*Source: Yahoo Finance 2012)*

As this industry is more or less new, the number of comparable companies is limited. Due to this, the findings of other researches will be taken as assumptions in this paper. A very relevant research on this topic was made by the University of California. The Figure 36 was used in their research to determine the cost of equity. Thus, according to this, the average asset beta based on this set of comparables is

[72] HSBC , Project Finance, David Gardner and James Wright

2.04. Assuming a risk-free 10-year rate of 1.98% and a market risk premium of 5%, the unlevered cost of equity for an EVSE investment according to the Capital Asset Pricing Model or CAPM is determined to be 12.2%.[73]

Thus, this paper uses this 12.2% cost of equity and 4.20% cost of debt as the baseline for determining the WACC which will be used as the discount rate for the DCF valuation. The WACC is the weighted average cost of capital illustrated in Figure 35.

Figure: WACC calculation

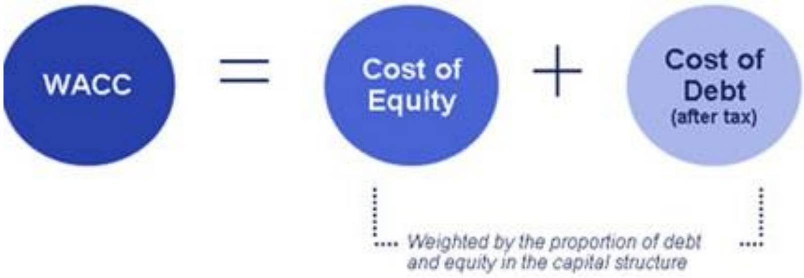

Figure 35: WAAC formula (*Source: accounting scholar[74]*)

Following the project finance estimated structure of 80% debt and 20% equity, and the debt and equity costs discussed above, the WACC is roughly 5.8%. This rate will be used as the discount factor in the valuation of the presented business cases.

However, due to the intensive innovational and technological demand, apart from project financing by existing companies, new entrants might penetrate the market with new products and services. These actors, lacking the financing advantages of the existing companies, are expected follow a start-up financing rounds pathway. The financing cycle of a typical startup is presented in the Figure 36.

[73] Financial Viability Of Non-Residential Electric Vehicle Charging Stations, University of California (UCLA) Anderson School of Management, UCLA Luskin School of Public Affairs. 2012

[74] http://www.accountingscholar.com/wacc.html

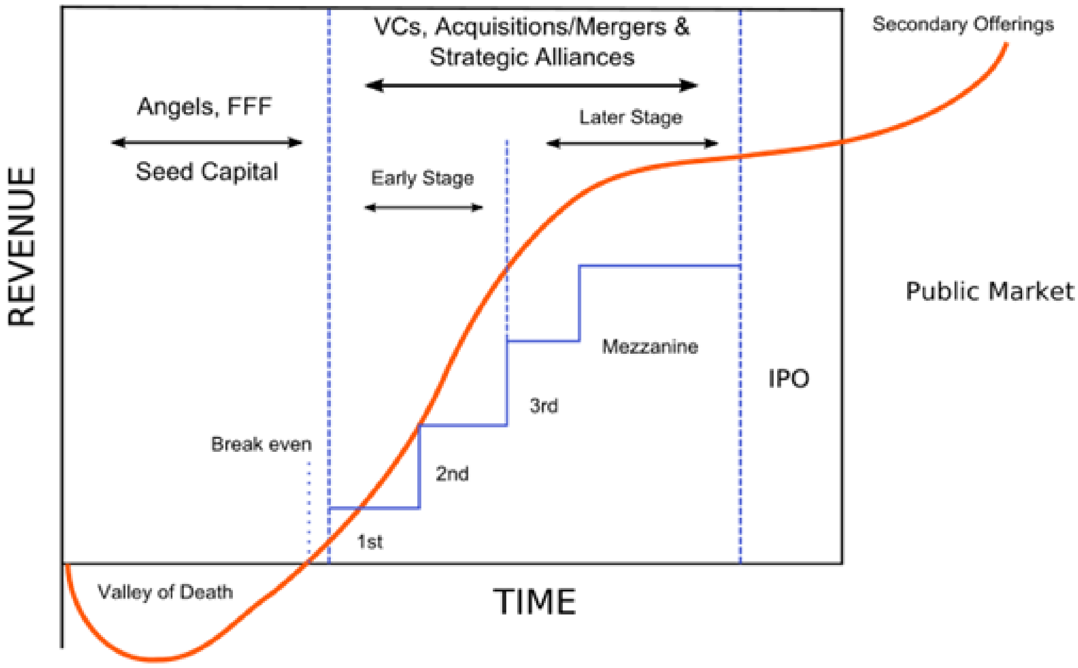

Figure 36: Financing rounds of a startup (*Source: Wikimedia)*

According to the Figure 36, the company has a lot of financing rounds until it can achieve maturity and can access the same financing conditions as the project finance company can. This gives the existent players a big competitive leverage over new entrants. Moreover the startup company will have to work with the equity components until achieving a proper debt possibility. In each of presented financing rounds, the company will attract new speculative investors and will thus decrease its initial equity shares. However, if the product is successful, the company will pursue inflationary valuations and strive to an Initial Public Offering (IPO) where the previous investors will exit the deal and the company will be listed on a stock exchange.

This is the main advantage and opportunity of the new entrants over the existent companies. It is not expected by a project finance structure to follow such a goal, when the sponsors are already listed companies. However this is not the case for the investigated fleet service and charging solution cases. It is merely an option for small binding (battery swap station) or integrated all covering electric mobility solutions (Total Electric Mobility provider) which is still inexistent and has a low probability of apparition.

4.2.2 Valuation

For the purpose of this paper, NPV and IRR analysis are used to measure the profitability of running the assumed business cases.

To conduct an NPV analysis, a DCF model was built. Cash flow statements and sample DCF inputs and outputs can be found in Appendixes. First, future cash flows generated by the each of the mentioned business case were estimated. These cash flows were then discounted by the WACC rate that represents the time value of money and risks and brings them into present values. In other words, future cash is worth less than present cash and uncertain cash flows are also worth less than cash flows that are more certain.

Summing the present values of future cash flows and subtracting from it any initial investments, the NPV of the investment is obtained. A NPV positive project shows a profitable investment because investors are sufficiently compensated for the risks they are taking on by investing in a project.

After conducting the calculations, the overall picture does not impress at all. Three of four analyzed cases have a negative NPV. However considering the entered general input assumptions the results should not define the whole sector appeal. It should instead present an overview on the electric mobility possible business cases. Some of the investigated models are currently operating in most of the developed countries. For example the solely positive position, the car sharing case is being actively promoted in several European and North American countries. Nevertheless it has a relatively low NPV of 6.8mil comparing to the invested amount of 183mil. According to the estimations it scored the best results and remains the best option in this report. However the assumptions estimated very optimistic operational parameters and excluded a lot of specific risks. Nevertheless, the positive results in comparison to other cases, motivates us to think that the car sharing developers also saw a good opportunity. The deployment of car sharing model is considered as a confirmation by the reality for the obtained result. Other presented models are not yet being as actively promoted.

The worst results are registered for the charging network case. The high negative NPV value reported to the lowest investment grade demonstrate the charging sector immaturity at this point. There is indeed a too big uncertainty in regard to the EV market share development and its need of a large charging network. At this stage the electric mobility service suppliers are covering the entirely charging need through their own solutions or by cooperating with equipment manufacturers. This is a natural apparition as they do control the supply of EVs and are thus able to tailor the charging demand. The electric fleet services and the electric taxi pilot project get also a negative NPV value, which suggest that the both models are not attractive for new profit-savvy investors. However, both of them get relative low values in comparison to the investment amount. Thus, an automotive company or a public authority could allocate the investments aiming in attaining a market share or boost brand visibility thus following not a profit making purpose. The results are presented in the Table 18.

	Investment (mil)	NPV (mil)	IRR	MIRR	Profit Index
E-Taxi	33	-1,8	3%	4%	-
Fleet Service/Rent	44	-2,2	4.8%	5.3%	0,9
Car Sharing	183	6,8	8,3%	7,5%	1,5
Charging Network	25	-7,2	-	-	-

Table 18: Capital budgeting investment appraisal (*Source: Author upon calculations)*

Further on according to Wikipedia the Profitability index (PI), also known as profit investment ratio (PIR) and value investment ratio (VIR), is the ratio of payoff to investment of a proposed project. In other words it is the present value of future cash flows divided to the initial investment amount. It allows quantify the value created per investment unit. A ratio of 1.0 is the lowest acceptable on the index and any lower value than this means that the project present value is less than the initial investment. On the other hand, the project financial attractiveness increases as this ratio goes over the 1.0 ratio. Thus, only two of the investigated cases deliver a discussible result. In the car sharing case shows a 1.5 ratio is expected to deliver 1.5 monetary units to each monetary unit invested. However the fleet services almost break evens the investment, which will be the case of 1.0 value of PI. Nevertheless, each euro invested in fleet services will get back only 0.9 at the end of the investment period. The rest cases provide a very low profitability index and thus are not mentioned due to unimportance.

Next, the internal rate of return, according to existent general definitions, is the discount rate at which the present value of all future cash flow is equal to the initial investment or in other words the rate at which an investment breaks even. IRR takes into consideration internal factors and does not calculate interest rates or inflation. It has the functionality to show the quality, efficiency and the yield of an investment. This is important to investors as it measures whether an investment result will be higher than the provided capital costs. However it does not take in consideration the reinvestment ratio. For a more accurate result the modified rate of return (MIRR) is desirable. While following the same logic, the MIRR takes into account the reinvestment of positive cash flows. The paper considers the financing rate and the reinvestment rate the same as WACC. Entities might decide to invest in projects with an IRR greater than the company rate of return target and cost of capital. Higher the IRR better is the project.

All the automotive related cases get a positive IRR and MIRR. This happens despite the negative NPV of some of the cases like E-taxi and Fleet services. This means that the sum of all future discounted cash flows is negative and do no break even the investment at the assumed cost of capital. However, a positive IRR means that the future value stays positive and the project does not run on negative incomes. So, all the cases apart from the charging network provide a positive future value but not sufficiently for being rated as an attractive investment. Nevertheless the car sharing model gets a MIRR of 7.5% which is higher than the cost of capital (WACC 5.8%) and is considered acceptable. However a difference of 1.7 percentage points of added value is definitely unimpressive for an invested amount of 183 monetary units.
The MIRR is commonly less than the IRR due to the reinvestment assumptions. Nevertheless it can also be higher, which is the case of the E-taxi mode. This presumes that the future reinvestments are more valuable at the reinvestment rate. However as it is assumed that these rates are identic, a higher MIRR means that the project produces more value within the time as it does at the beginning. This is the case for the E-Taxi and the Fleet Service.

As the matter of fact, the IRR and MIRR might be misleading. In other words it is the cost of capital that leads the NPV=0 not taking in consideration the residual value of the business. Accordingly, projects and businesses end value is either positive or negative but not zero. Hence, these return ratios show how high the cost of capital would have to be so that no value is created over the period. It indicates merely the cost of capital that makes the NPV breakeven over the assumed period.

Thus, another interesting point to analyze would be the sensibility of the business models to the cost of capital. This is presented by the NPV profile, which is presented below in the Figure 37. In the NPV profile, the NPV of the analyzed business models are arranged according to different capital costs.

The graphic in Figure 37 shows the elasticity of the NPV to the WACC. Thus just the Charging network remains negative and indifferent to the change of the discounted capital cost. Moreover it has an advantage of being the most resistant to external factor as the light blue line moves straight. Other cases get a positive NPV when the WACC is lower that assumed. The E-taxi model becomes unattractive starting with 2.5%, the Fleet Service at 5.1% and the Car sharing at almost 9% of WACC. Moreover and very interestingly both of the most attractive cases, the Fleet and Car sharing are way more risky than the E-Taxi and Charging Network as their NPV Profile line is very volatile and sensitive to the change in the capital cost value.

These cases become a true value destroyer when the discount factor rises more the 8.5% for Fleet and 12% for car sharing. In this case both projects get worse performance that the other two cases, the E-taxi and the Charging network.

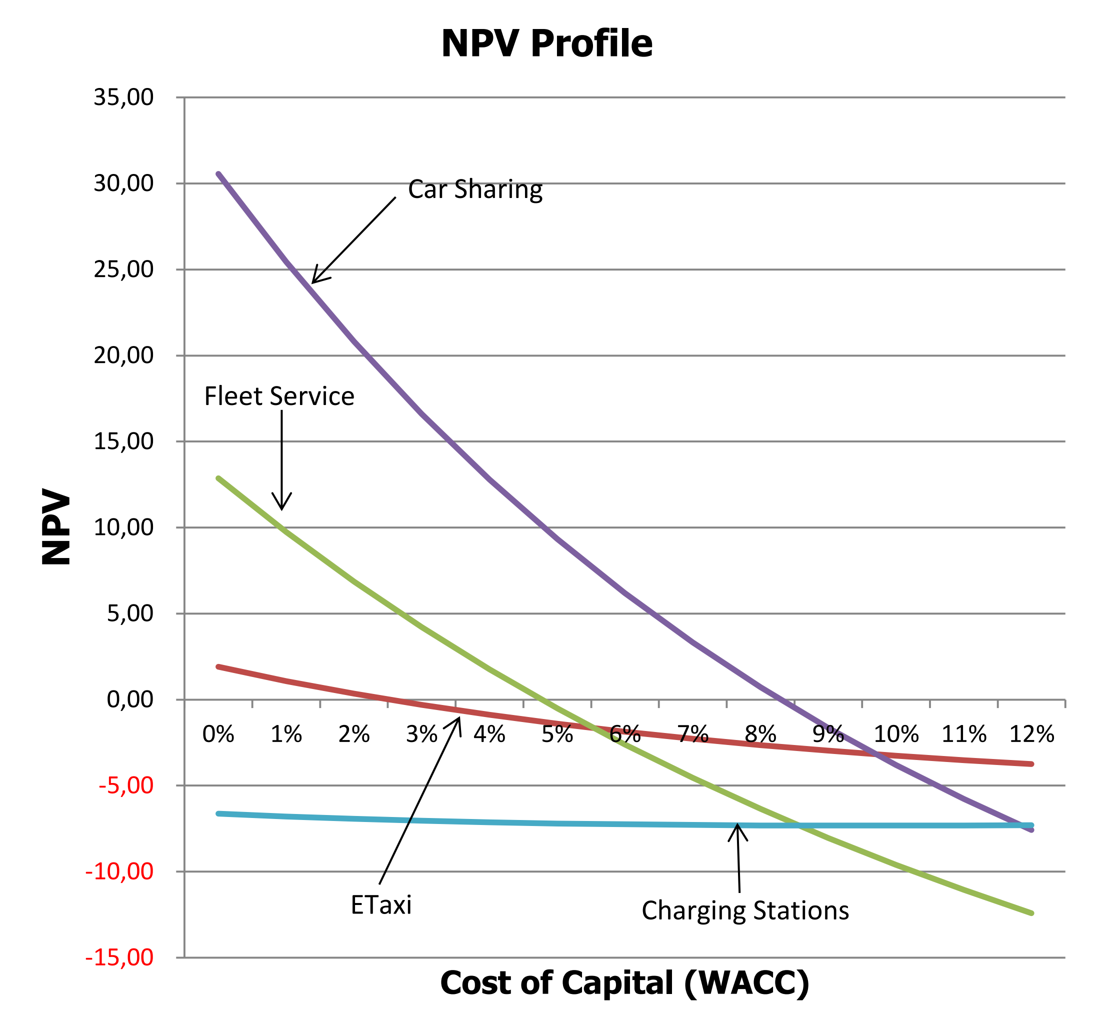

Figure 37: Capital budgeting investment appraisal (*Source: Author)*

However if the vehicle related projects can get a lower capital cost they might survive and be approved as successful. It is hard to guess how the WACC can have so low values. First of all it should not contain the equity cost which has the highest value due to investor`s expectations and opportunity cost. Another option would be considering public social projects, when the government will exclude the high return expectations. Thus the E-taxi might be considered a no-loss option if managed by the public authorities. In other cases the negative investment appraisal might be accepted with the strategic purpose of pushing the electric mobility sector, thus keeping the core business market share and locking the entrance in the electric mobility market. This would assure a strategic pole position for the moment if the companies are decisive and optimistic about the future of the electric vehicles.

Another point is that the capital budgeting model gives merely a time-value related appraisal and do not specify the business specific performances. In this case, a new set of ratios has been derived from the cash flow statement. The accounting results are presented in the Table 19.

	Investment (mln)	ROA/ROI Median	ROA/ROI Average	EBIT Margin	CF-CAPEX Median	CF-CAPEX Average
E-Taxi	33	9%	9%	14%	3%	-22%
Fleet Service/Rent	44	2,9%	4,4%	28%	18%	13%
Car Sharing	183	16%	15%	35%	6,1%	-6,7%
Charging Network	25	3,3%	2,6%	15%	-5,0%	-16%

Table 19: Accounting returns (*Source: Author)*

The term mean of a variable gives a focus on what happens on average. It should be considered an appropriate measure for a symmetrical distribution. In such a situation it takes the form of a middle value. In our case it supposes the middle of the cash flow sequence of ten years. However in the case that a distribution is skewed, then the average, in this case the mean, is usually not in the middle. Thus, a better measure would be the median. For this reason both of these attributions of numerical rows are examined.

The Return on Assets (ROA), in present analyzed cases can also be interpreted as Return on Investments (ROI) as the main investments are the assets. These parameters show how profitable a company is relative to its total assets or provided initial investment. It merely indicates how efficient the management is utilizing its assets in order to generate income. ROA is calculated on a percentage basis by dividing the annual income by its total assets. Moreover ROA is sometimes linked to the ROI because it barely illustrates the ratio between the net income and the effectuated investments. Hence, a higher ROA shows that a company or project is getting more money on less investment.

As all of the analyzed business cases have large investments amounts and the main product they offer is their assets, the link between these two ratios is considered appropriate. As it is presented in Table 18, all the models have positive results. However, these do not entirely correspond to the time-value results. The E-Taxi shows a better performance and this can be explained by the fact that the taxi fleet achieves a higher mileage per year and thus a solider revenue model which is linked directly to the revenue. Moreover, this mileage link to revenue explains also the good distribution of cash flows, where the average value is also the median value of ROA. In other cases, there are discrepancies regarding the income distribution. In the case of the fleet services, the assets are poorly managed despite the high price of rent. Additionally the fact that the average gives a higher value, which means that the income has higher value differences during the ten years, the median is lower. This implies that there are more low figures in the income structure, thus the middle is lower. In this case the median gives a more accurate result as the low values show that there are disproportional higher incomes which are not stable and might not even incur if the optimistic scenario fails.

In the next two cases, car sharing and charging network the median is higher and suggest the other way around, that higher income appear more often. This gives a more confident appraisal. However these findings might be related to the capital expenditure schedule. As noticed, three of the four cases suppose that new investments are being allocated regularly, in each year. But, the interesting fact is that the only case that invests the capital only once is the fleet service, and precisely this case provides a lower median value, when compared to the average ROE. So there is a small piece of evidence that the per-day renting is the less efficient asset allocation for electric vehicles.

The next indicator is the EBIT margin which shows the operational viability of the business. It is the ratio obtained when dividing the operational result (revenue minus main costs) to the revenue. It shows the commercial added value of the service. It neglects other outflows. This ratio shows higher values for the fleet services 28% and car sharing 35%. That means that both of them have a good revenue model and optimized costs. Interestingly the charging station has a higher margin than the taxi model, which the time-value DCF model did not show. This also shows that the electricity is a good commercial product for the vehicles. Moreover it is cheaper than the fossils. This however makes no changes in the overall attractiveness of the model. It is the only a remarkable element in the charging case.

In the end the proportion of cash flows to the capital expenditures shows what part of the allocated investments tends to become the available cash at the end of the year. It is almost the same method as the ROE however the free cash flow includes the CAPEX of each year and excludes the amortization and depreciation as these do not occur as real outflows. As the CF to CAPEX ratio increases, it is usually a positive sign. If a company has the financial ability to invest in itself through capital expenditures (CAPEX), then it is thought that the company will grow. It is important to note that this is an industry specific ratio, and should only be compared to a ratio derived from another company that has similar CAPEX requirements.

The charging station provides a negative cash flow as average, as median and in general. The business case is not healthy enough to achieve positive results. The reasons are discussed above. The taxi project has a very strange result, with high negative average ratio and a positive median. This implies that the middle of the distribution is positive, thus showing the company ability to recover and grow. The high negative value can be explained by the high negative cash flow in the first years of operation. This however happens due to the relative high capital expenditure at the same time. Nevertheless the fact that it continues to continually allocate investments it achieves a positive middle which is a good sign of model healthiness. Moreover when comparing the car sharing project, which recovers also from the negative area, it is impressive because of the CAPEX differences. However as stated the comparison of this ratio will give a more accurate result if the CAPEX has similar values. Continuing the though, the fleet service glorifies an impressive result. But, this is simply explainable by not have to invest in each year. In this case, the project gets a stable ratio due to the fact of having a solely initial investment. This high ratio might deceive and must not be interpreted with priority.

Adding to all that have been said, none of these findings should be separately used when making an investment decision. It is recommended to use a mix of them or to rank them according to objective and strategy.

Further on, after having a general picture on the attractiveness of some possible electric mobility business cases, it remains to investigate what current sectors could be interested in entering the electric mobility market.

4.3 Analysis of results

The basic elements of the emerging Electric Mobility main value chain components are clear. First of all there must be a market for electric vehicles, which includes a healthy demand and proper supply. Additionally there must be several operational models for enabling the use of EVs. Next, it must transfer energy from the network to a vehicle. It must also keep an eye on the information of the energy provider and the energy recipient. Moreover it must include a customer-friendly payment system that should also be easy for the energy distributor to integrate within its current sysze and finally it must fit government regulations and carmaker requirements. The following companies according to their industrial background are considered the most suitable for the electric mobility branch[75]:

- Automotive manufacturer
- Automotive components supplier
- Electric utility company
- Electrical components manufacturing
- Electrical security equipment manufacturer
- IT/software
- Power supply equipment manufacturing
- Startup companies focused on EV charging/services
- System integrator
- Telecom operator

However the core elements of the value chain are the EVs and the electricity, thus the most targeted companies have an automotive and electricity market related background. Other elements are considered binding elements which, when added to the core ones, provide an additional opportunity or value. Nevertheless, without a healthy appearance of the automotive sector and a viable infrastructure existence, none of the added value elements have a higher chance of success. For example, A123 and Betterplace, which tried to conquer the market, are bankrupt. Moving

[75] Finding value in the electric vehicle charging ecosystem; Ernst & Young

further, two possible market entrances are spotted: existent actors following a strategic horizontal expansion and new players aiming to achieve growth by specialization, through new revenue models.

New entrants are supposed to target the added value chain and will more likely appear as system integrators or IT/Software start-ups. However they require an already existent EVs market and a risk capacity. Because of the undeveloped EV market it is hard to estimate the success of these new entrants. Moreover the startups will have to go through a more complicated financing procedure. As shown in Figure 38, there are several rounds of financing and in order of being successful in each of them the company must provide evidences for the high hopes it has. Thus the cost of capital is higher, however the opportunity also persists. This makes the new entrance services hard to estimate. Therefore, a high exposure to the supply chain might cause a provider to be regarded as a competitor. Furthermore, a high CAPEX will be a significant burden for new entrants with low market capitalization.

However, even considering the existent players manufacture, know-how and capital advantages and looking at the analyzed cases, the electric mobility does not impress. For a better picture, the results were ranked according to performance. The ranking situation is presented in Table 20.

	Investment	NPV	ROA/ROI	EBIT Margin	IRR	MIRR	Profit Index	CF-CAPEX	Ranking
E-Taxi	3	2	2	4	3	3	3	3	**3**
Fleet Service/Rent	2	3	3	2	2	2	2	1	**2**
Car Sharing	1	1	1	1	1	1	1	2	**1**
Charging Network	4	4	4	3	4	4	4	4	**4**

Table 20: Case ranking (*Source: Author*)

As it is presented in the Table 20, the car sharing comes out as the winner and the charging station project as the big loser. This is somehow explainable and has not business related functions. Starting with the Taxi project, it has arguable points, a better NPV and ROE than the Fleet project. Despite this it has the worse commercial margin and here lies the biggest problem. Moreover a taxi is very exploitable and there are no evidences that EVs have the same durability as the traditional ICEs. It seems that the taxi gets better present value results and has also better asset efficiency than the fleet services does, all this with lower investments. This makes the number 2, the fleet project very arguable. There persists a high probability that if the fleet project will have to invest each year in new assets, it will get a poorer performance. Moreover the NPV profile shows a high risk and a big dependence on capital costs. On the other side the Taxi project delivers a more stable development and is less dependent on capital market risks. It is thus a medium-to-good solution to public authorities, if the emission target is followed. This is an important aspect as the taxi has the biggest mileage and thus the best CO2 reduction potential. Nevertheless it lacks the assurance that it can achieve the same mobility performance as the ICE does. Moreover it includes a lot of new adjustments to the status quo of taxi business. However, if considering the authorities implication and financial support it becomes a possible solution. The City of New York plans to develop a network of electric taxis. They already conducted a study and the Mayor Bloomberg seemed confident on this. This confirms the analyzed trajectory of results and has a sole potential investor, the Public Authority.

Even if the Fleet project gets the second rank, it is hard to imagine that the EVs will succeed through this business model. The main important factor is that rented cars are used for a longer range. This case fails from start. But corporate EV fleet services might deliver almost breakeven results. However it depends a lot on how big fleet users target their corporate ethics. Due to the high TCO, lower mobility performance and unknown residual value it has a low probability of acceptance. As presented in Figure 38, the EV production suffers from a margin shortfall, thus making the car manufacturers unable to realize the margins needed for a profitable EVs sale.

Notwithstanding, many companies adopt an ecological clean image and might diversify their fleet in order to deliver low emissions results. It must however be clear for them what advantages they will absorb from that. In this case an EV fleet outsourcing is supposed to have medium chances.

A proper adjustment to the company`s preferences and tailor made services can achieve the results deducted above. This is however not very attractive. Despite this, automotive manufacturers can fill the market with such service, as they decide to mass-produce EVs.

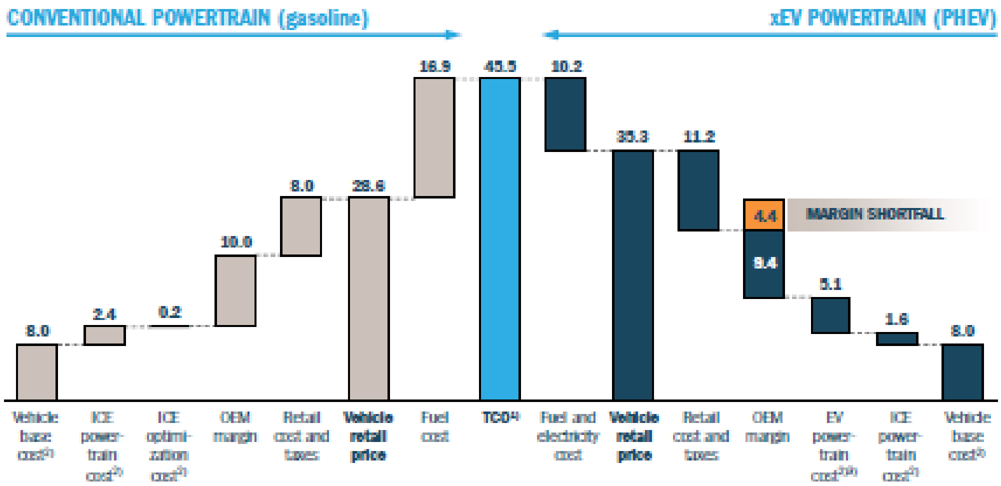

Figure 38: Total Cost of Ownership structure (*Source: Roland Berger 2013*)

This will ensure them visibility and strategic market shares. Additionally, it will improve the company image and will act like advertising. Thus the losses might be perceived as promotional and deducted in the corporate balance sheet. It is hard to believe that these losses will have any consequences on the overall financial results of the automotive manufacturer.

To this segment, it is also attributed the car sharing project. It has also tight affiliations with the automotive sector. It is also confirmed by reality that most of EVs are produced by existent companies. There are also exceptions, for example Tesla, the only successful one. However the model of this company differs completely from the others. It is solely specialized on EVs and therefore is not a subject of the analysis. Just for the information purpose, note that Tesla Motors announced its fourth quarter financial results, which show a loss of 107.6 million, or 86 cents per share. Moreover the founder said that the company won`t likely turn a profit until 2020. However the company still invests heavily in development. It is less probable that a lot of companies, especially new ones, would risk dealing with red figures for a longer period of time, just with the vision as the main driver.[76] Despite this, according to many analysts, there is a reasonable expectation that new EV manufacturers will appear. Nevertheless this will happen through unique technological discoveries and enormous dedication. Otherwise, the big car manufacturers will lead the market.

[76] “Tesla's loss wider than expected, sales fall short“, Marketwatch news, Published on Feb 11, 2015

The success of the car sharing can be explained through the intrinsic innovative mobility model. It has less attribution to EVs. It is barley a new mobility idea, and luckily is very suitable for EVs. It does not require big vehicles and long ranges. The results are positive, but not sufficient, considering the big investments. This makes the project very attractive for automotive manufactures offering them good operational results and more importantly, visibility. It has high chances to success in the big cities, offering a necessary product and also having a natural demand. The best point is that users of the service do not need to manage the EV different proprieties, like low range, charging habits, maintenance etc.

With the look on these cases, the main challenge for the automotive industry is the emergence of new value chains. Automobile manufacturers must prepare themselves technologically and organizationally for an increasing demand for green technologies, but otherwise it is also important that they focus on their competencies which are conventional drives.[77] It is suspected that too many OEMs are pursuing the "Mega-OEM" strategy at the moment, most of them risking heavy investment in proprietary solutions without a clear path for payback over the next 10 years.[78] Moreover, it is assumed that the value chain of the automotive industry will shift the share of the value added upstream segment. Therefore, new cars design is expected to be different around the power train. This however will affect the manufacturers and the supply industry. Especially in the area of battery development and production, European companies face major challenges, because appropriate technologies have been neglected for years and especially Asian manufacturers gained great experience and thus have strategic advantages.[79]

The main challenges are:

- Intense competition
- Lack of knowledge transfer from R&D to production
- High investment demand
- High economic risk
- Classic business models have to be developed from scratch.

[77] Evolutionary Paths Towards the Mobility Patterns of the Future; Michael Hülsmann, Dirk Fornahl
[78] Socio-Economic Aspects of Electric Vehicles: A Literature Review; Christian Hanke, Michael Hülsmann and Dirk Fornahl, 2009
[79] (Deutsche Bank Research 2011)

New and innovative business models are expected with the integration of EVs in the automotive market and if fleet operators become successful, the rules in the industry might change dramatically:[80]

- Pay for Use instead of Pay to Own
- New (aviation industry type) business models may come up: cars are built for Fleet Operators.
- Fleet operators will push the standardization of vehicle interfaces.
- Fleet operators might also influence the battery market.

The energy sector is also expected to encounter some changes, because an increase in the number of EVs leads to many questions regarding the network integration. However according to the estimated charging project, it is still a no-go business and will require a lot of time and market demand in order to gain profitability. However is has low investments and, as mentioned, should not scary the large utilities, in the case they position themselves strategically. The electricity system can theoretically absorb a high electrification ratio of mobility. However the main barriers at this stage are the regulation and the electricity sector itself. It is widely known that electricity cannot be stored as the gasoline does, and this needs adjustments in the upstream market.

A look at ongoing co-operations (EDF & TEPCO, Daimler & Enel etc) indicates that utilities are likely to cooperate with the automotive sector and authorities in order to offer sustainable mobility solutions. The power of such combinations is intriguing.

At this stage, suppliers are key actors in the value chain. Some of them shifted up within the value chain and through strategic partnering started to manufacture the charging infrastructure. Some of most suitable activities beyond the EVs production are stated below:

- Unbranded and Branded charging station manufacturer and retailing
- Installation, maintenance, operation and servicing of charging stations
- Car diagnostic
- Mobile/Web-based platform for general information
- Smart grid interface

[80] Accelerated Introduction of Electric Vehicles in North West Europe; Dr. Kord Pannkoke, Christian Ernst; ENEVATE 2012

- Smart charging, billing, metering and payment
- Management software for charging station network and energy grid
- Fleet management tools and engineering services
- Peripheral services: EV owners and battery related

This set of services can be adopted as core business product in different combinations. With regard to the energy sector, the position of a broker operator, grid-master or guardian fits optimally with the sector specifics. Thus, apart from the installation and maintenance of charging spots, the actors would have to administer and supervise the energy supply, use and billing. Thus, as a middleman such an entity could get higher margins, in the case of reaching scales. Hence, the key competence of such cases is the specialization.

However this is considered risky as car makers might develop comparable applications on board with the use of telematics.

Nonetheless, the success relies on healthy partnerships with energy and telematics sector. Despite this, many of them have non-entrepreneurial cultures and might opt for winning market shares by themselves.

In such a case they have the necessary conditions, as they do generate the electricity and are deeply involved in the market. Such players must be able to handle the highest peak load times even if most of these spikes are infrequent, which is very relevant for renewable energy that has this problem as well in that the amount of energy created by the most popular renewables (solar, wind) vary tremendously, and they are not always in synch with usage peaks.[81]

Unfortunately, it is almost impossible to evaluate the practicality of this idea, because the smart grid software in not yet mature. The role at the utility level may help secure business immediately. Thus, the utilities are expected to lean toward the idea of investing in charging stations, as they will definitely want to compete on the market share with the petroleum suppliers. Moreover, there is a good change to combine renewable energy with mobility. This would be definitely highly supported from Government levels. Thus, the negative results from the charging station project should not deceive. This kind of projects will develop according to EVs market demands. Utilities are also more motivated to support the development of electric

[81] Finding value in the electric vehicle charging ecosystem; Ernst & Young

mobility as it boosts the revenues from its core product, electricity. On the other side, the automotive manufacturers consider this as a product switch and might not be willing to expand very fast, in order to win time for reorganizational issues. In other words they offer a substitute of their product, at a higher price, with lower margin, performance and acceptance. It is a challenging situation when comparing with utilities. That is why utilities should be more opened to offer cooperation as they tend to be more motivated in supporting the electrification of mobility. With all this being said, the market will be targeted mostly by existing companies. However innovative entrants have also a chance to succeed. In the end, the probability of a conglomeration in EM sector is almost zero. It is almost impossible to believe, that in the near future, an EM corporation will arise.

All involved sides as industry actors and governments emphasize the scale and the interoperability as vital elements to a successful development of electric mobility market and thus business models. Some analysts mention that a failure to successfully coordinate this system could slow the adoption process with 10 years. However, the most important element in fostering an EV market and a charging infrastructure is to create profitable industries where the economics are positive and self-sustaining to justify the investment as the market develops. According to the paper findings, this is not the case for the current reality as the market is in the preparatory development stage, aiming for recognition and questioning for acceptance.

5 E-mobility integration challenges

After having obtained some concluding findings, it is further necessary to align the main benefits and barriers in a short descriptive analysis. This will provide a basis for discussing future trends of electric mobility development.

5.1. Benefits and Barriers

Following an analysis of secondary literature in areas like users, economy, politics and legal, key subjects with regard to development of electric mobility have been developed and shortly described below. Main, related to topic, strengths have been identified:

- Acceptable overheads
- Low operating costs
- Cost stability and improved planning
- New working models
- Decarbonized travel and ecological labeling
- Quiet travel
- Feel good factor
- Compliance with Emissions legal requirements

On the other side of the table, the most significant barriers lie in technological challenges, market conditions, user acceptability and regulation. Following factors cause difficulties in the EVs diffusion:

- Range Limitation
- Other technologies (hydrogen, ethanol, fuel cell, biofuels)
- Safety
- Finance and costs
- Infrastructure

Considering the fact that this paper researches the attractiveness of electric mobility business models, it is necessary to emphasize the drivers that can influence the companies to move toward electric mobility acceptance and utilization. Thus, co-operation and corporate social responsibility are the crucial elements for developing large projects like industrial symbiosis and new transport systems.[82] The good news is that many companies have started to include social and environmental concerns in their core business models. Despite this, there are still a lot of internal barriers that hinder companies to efficiently adapt to innovational trends. The main of them are:

- Traditional mindset and lack of experience and know-how on sustainability topics;
- Insufficient experience and knowledge with new models and approaches;
- Lack of horizontality
- High production cost;
- R&D lack of competence.

Most actors are not ready to undertake crucial systemic changes. Additionally, the investment community perceives such systemic switches with skepticism. Moreover, there are also several external barriers:

- Lack of market forces
- Lack of capital for initial investment
- Difficulty of new business models to adapt in existing market environment
- Regulatory barriers
- Lack of consumer readiness and acceptance

The main responsibility to combat these barriers is attributed to Governments, support has always been vital in order to diffuse innovative technologies.

The analysis of business models also has potential implications for entrepreneurship policies. After conducting a general analysis on possible business models, it can be concluded that such policies are vital in order to create profitability. This will motivate investors to allocate the capital in this direction and create a necessary competition.

However after a public spending round for Renewable energy technologies and current global sensitive conditions, the governments seem to need a longer time to think out a proper strategy.

Another very important factor is the user acceptance to which the EVs usability is tightly related. Hence, a positive attitude to innovative technologies and actions

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

founded upon these, are vital for EVs market penetration. Acceptance is related to consumer advantages in using the EVs in comparison to other alternatives. The level of acceptance is influenced by hard facts like safety or range and soft facts such as design or image. Hence, perhaps in the future these factors will not be critical for the customer acceptance and a behavioral adaption will help it. However, many crucial questions remain unanswered[83]:

- When will take place a nationwide EVs introduction
- How will the customer change their vehicle
- Which charging standards will prevail and how the whole upstream infrastructure will look out
- Could the EV be used during long distances, which is very important preference
- How will the business world adapt, if at all.

5.2 Electric Mobility future trends

Energy, infrastructure and automotive industries are historically isolated from each other. However the electrification of mobility has an opportunity to cut the distance between these sectors. However as stated, there must be a common interest and a third party that would guarantee and support necessary intermediary measures.

In regard to the mentioned low EV performances and its dependence on the infrastructure, makes the EVs more suitable for urban use. Thus the near future is directed to the EVs use in urban regions. In this case, the main challenge is to develop suitable business models and create demand for it. Moreover the infrastructure must be redesigned in order to keep visionary ambitions of creating smart cities.

One futuristic solution would be the road electrification, so that EVs could recharge as they drive. ("Solar Roadways" project can be taken as example) Hence, there are two main ways in which the electricity could be transferred: conductively (through a direct metal-to-metal connection) or inductively (wirelessly via a magnetic field). Such innovative solutions require deep research and then commercial viability.

[83] Socio-Economic Aspects of Electric Vehicles: A Literature Review; Christian Hanke, Michael Hülsmann and Dirk Fornahl, 2009

Regardless of this, a mass deployment of electric vehicles will need city electrification and a super smart management of it. Moreover, a Smart City presumes the integration of different mobility services and actors:

- Public transport and taxi
- Car and Bike sharing
- Parking and Charging Infrastructure

The decision upon transport mode relies on the travel distance. Thus, the future of mobility supposes an intermodal use of different means of transport with simple, integrated and accessible platforms of use. Intermodal travel is the key to future mobility and electric mobility fits within its frameworks. The intermodal travel is presented below in the Figure 39.

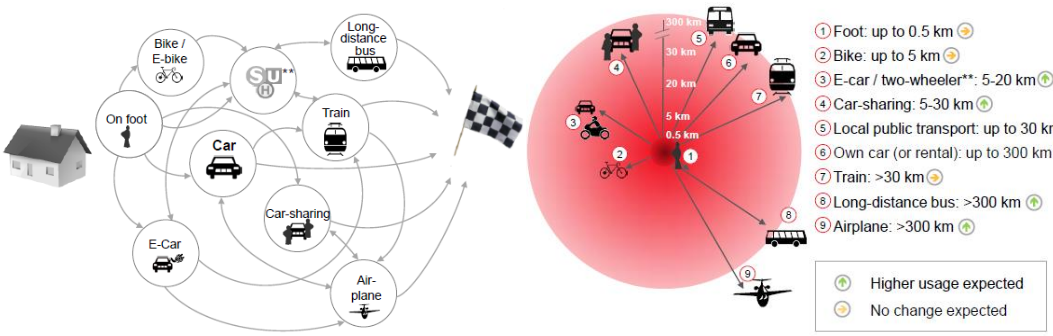

Figure 39: Intermodal travel (*Source: Green Mobility, Lanxess)*

Current technologies and the lack of cooperation restrain the potential of sustainable mobility solutions. Notwithstanding, the history give us the same lesson, that evolution is imminent and unavoidable. This refers also to the development of the vehicles in general. Reliable evidence is presented in Figure 40. It is impressive how innovations change our life.

Figure 40: Evolution of vehicles (*Source: Valeo, Klimacampus, Automotive Now (1/2011) - KPMG International)*

Cooperation between different players, not standalone solutions, leads to success. New ideas, materials and technologies will form the foundation for the future EVs development, infrastructure and business/market models which need to meet the potential increased demand for more sustainable mobility.

6 CONCLUSIONS

In the point of drawing a conclusion, the main drivers of the electrification of vehicles is the improved environmental stewardship by reducing the CO2 emissions through substituting the fuel, the decrease in petroleum dependence and the creation of new sustainable jobs and thus externalities-included economic growth. However, as the E-Mobility sector is considered positioned in an early market stage, there are significant barriers that hinder its market acceptance. As every new technology it must find its way out of basement and commit extraordinary efforts that involve more market actors, in order to succeed. Hence, a generalizing and conclusive description of the main important market pylons of this sector follows up.

Technology

From the technological perspective, patience and faith are the main soft attributions that describe a technological breakthrough. Thus in the case of electric vehicles, the performance for the first couple of models is not expected to compete with the long established conventional cars. Thus, the use of EVs provides higher costs, shorter range, a lack of sureness in regard to batteries, charging stations, residual value, standards, operational issues, all of these affecting the technology perception and acceptance. On the other hand, substantial improvements are observed during the last years, a fact that emphasizes the statement that more time is required for a higher diffusionary progress of this innovation. Nevertheless, the main benefit of using EVs is when refueled with renewable electricity. Thus, due to the electricity perpetuum modus characteristic and the underdeveloped battery industry, the EVs industry may encounter difficulties in achieving a mass rollout if other more accessible mobility technologies (hydrogen, fuel cell etc.) get a faster technological breakthrough. However even if conventional vehicles can improve its efficiency and reduce the emission capacity the risk of investing too much in R&D for EVs is persisting. Thus, a lack of decisive and clear commitment toward EVs from automotive and government side can be understandable due existent risks, which are left to the market to decide this through competition.

Infrastructure

The infrastructure issues come as a bonus to the up-mentioned statements. The electricity is however cheaper, partially more environmentally-friendly but impossible to store as the gasoline. However, the main fueling difference is the time it takes to charge and the range it affords. Both of this functional attributes cannot compete with the standardized petroleum fueling. However, the electricity market has a functional capability to cover a higher EVs share but can encounter operational rushes in the case of multiple fast charging demands. Thus, the infrastructure is considered the most important issue of the sector. Its active support and development will make users comfortable and thus will trigger the EVs use. However, there is a big reluctance to heavily invest in big infrastructure projects, all due to costly capital expenses and unfeasible results.

Consumer acceptance

Another very important component of a possible EVs mass deployment is the consumer demand and precisely consumer acceptance. This means that this EV technology should enhance a set of performance characteristics so that it could persuade the consumer preferences toward EVs acceptance. Despite this, at the moment the ownership of an EV may provide some adaption problems to the user, which might require a behavioral change. The biggest challenge is to facilitate and moderate this change in consumer behavior. This is being done by promoting EVs demonstration activities, offering cost incentives and traffic privileges. Thus, there are substantial steps done in order to persuade the user towards a more sustainable mobility mode. It is however difficult to predict the consumer choices and the sole thing that the market and governments can do on this matter is to actively monitor the process and learn the lesson from it in order to be able to design a more efficient regulation in regard to the electric mobility sector.

Market

This paper emphasizes the fact that strong alliances are crucial in order to allow the EVs to achieve bigger market shares. Such cooperative partnerships should create competitive advantages and thus open up new markets. Currently the market is artificially imposed to accept the EVs within its limits. Considering the fact that the EVs are just a new technology from the automotive manufacturers that uses another fuel for delivering the same service – mobility, the market value chain does not change drastically. It is merely a fuel substitution, form petroleum to electricity. This means that the biggest changes will be in the charging segment of the market, where the newness occurs. Due to the fact that it delivers the same service but with another technology, the market cannot facilitate this transition alone. Thus the market remains just a catalyzer for the electric mobility in the case when the policy, the relevant industries and the consumer are decisively committed to such a technological change.

Business

The early development of business cases, as generally analyzed in this pare, are not yet profitable. However this is an integral part of the current market preliminary stage that provide valuable experiences in regard to the capabilities and limitations of the EV technologies, and also indispensable information of user acceptance to possible business models. Thus, through collecting experience in understanding possible feasible business cases, important structural grounds for the needed technological improvements and future business developments can be created. This will help making the market more economically attractive and thus reach a profitable growth position. Moreover, as mentioned, the electric mobility market is expected to be entered by existent actors, with or without profitable business plans but more with a long term strategic decision.

- Automotive Manufacturers

This industry is responsible for the EV technological improvements. However from a business perspective there is no specific interest to heavily compete in the electric area of vehicles. It is barely a collective commitment to the policy regulations. From a cost perspective, the EVs may make sense in the long run due to the TCO aspect, but there is still unawareness of the future value.

Thus, the first analyzed business case is the E-Taxi, which is surely unfeasible but still strategically attractive for public companies that can herewith support the policy targets and boost visibility. The bad thing is that taxi fleets drive usually higher mileages and thus charging might be a problem. On the other hand a high mileage translates in high CO2 savings.

EV fleet servicing or renting, also being unprofitable yet, might make sense for automotive companies involved in renting with the purpose of assuring the market share and its position within the highly competitive sector. As customers, the target for the beginning is the corporate fleets that can gain image points without having big operational problems as they are getting the service rendered. Thus both of these cases, even if being not profitable might make sense for developers. Nevertheless, the investment decision making in the real world is tightly connected to risk assessment, a point that is significantly actual for these cases. This hinders an active investment involvement in such cases because of the fact that many risks are not addressed and there are no instruments on the market that can help in diversifying it.

Car-sharing is being classified as a feasible business model due to the fact that it provides additional value to the consumer and thus has a natural demand. Moreover, such a business model allows saving the costs relative to car ownership. In the reality, the existent car-sharing companies are running on operational losses, but under better conditions as assumed in the paper it has a potential to become feasible. Thus most of existent actors in the automotive industry have opted for investing in car-sharing models, which is a confirmation of the existent opportunity.

Finally the automotive industry and its suppliers should push for a stronger cooperation with engineering industries in the field of electric mobility. Moreover manufactures should not wait for customers but should direct the primarily focus on markets where they can better cover the customer needs. Thus, serving a selected pool of costumers will be a better strategy that to invest in many EVs segments in order to win clients. Hence, innovative business model are the solution for the success, pushing the automotive companies to do more than simply manufacture a new vehicle technology. However the existent uncertainties like the optimal market size, customer preferences and infrastructure require a clear and ambitious strategy in order to overcome these transitional barriers.

- Charging Infrastructure

A viable business model for public charging infrastructure is still not present on the market despite the significant progress during last years. Thus, the analyzed business case confirms this statement. There is no considerable EVs market, thus there is no scalable public station model available. From the electricity market perspective there are many unanswered questions. Moreover there is still some work to be done in order to integrate EVs in the electricity market. Thus, in this place, utilities or relevant energy actors are the best candidates for investing in charging stations. However they require some market size in order to commit to the work. There are discussions on the way how the billing and payment will forgo. In this case, the car fueling process will be similar to the telecommunication system. The stations in the city, home, in parking, malls should be easily to access and to use. Thus the public charging will be highly interconnected and incorporated in DSO functions, by allowing roaming and data clearance possibilities. Nevertheless, such a market can allow more actors, each managing its charging network or providing added value services for relevant processes in the charging business. As far as investments in the e-mobility sector are concerned there are still not many large and liquid companies closely focused on the sector. This makes it hard for investors to get a targeted e-mobility exposure via single stocks or index-linked products.

Government

It is not known even by Governments how long it will take to achieve this technological change. Probably it will take several years or more until the charging infrastructure develops, costs are driven down and the EV ranges increase. However, this process depends on the political and regulatory habitat which may support the electric mobility diffusion with financial and non-financial, direct or indirect measures. Many countries have already set in place incentive policies to support the EVs purchase and the infrastructure development or funding programs for R&D and demonstration activities. However there is a need of more determination in regard to this topic from the government across the world.

Even if there are today no viable business models on the market, electric is considered an important future market. Many companies are trying to develop active roles by implementing pilot business cases, building partnerships or simply seeking to benefit from a positive image offered by the use of electric mobility.

Moreover electric mobility investments might offer an exposure to a specific sector that enhances a number of different and unpredictable risks that may not even be affiliated to the electric mobility business. These risks are hard to assess as countries are approaching this topic individually.

In the end, the deployment of E-mobility will mostly depend not on the way that technologies will be developed and promoted, but predominantly on the capability to organize and administer the operations of sophisticated terrain of market actors. The demand will still rely on depend on oil prices volatility, fast charging networks, batteries cost and technology user-friendliness.

Hence, despite a long history full with disappointments, electric mobility keeps advancing in the direction of a better state of art and a more stable market presence. The current use of EVs privately or in different business models are targeting new consumer profiles that were not even considered possible in the past. A fundamental market penetration and infrastructure development will likely happen in a step-by-step mode over a number of years, thus being in need of high patience abilities for those that strive to achieve a new environmental clean transport era.

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APPENDICES

The Appendices (1-4) below contain the financial information in regard to the analyzed business plans. The calculation horizon is ten years and is presented in the range of 1 to 10 on the year section, assuming the investments to be done starting with 2015 till 2024. The metrics like Operational Result, Nominal Cash Flow, Free Cash Flow and Discounted Cash Flow are the most important and their calculation is shown in each Appendix by simple mathematical operations between the numerated financial positions (1 to 15).

Appendix 1: E-Taxi (Economic results in mln)

	Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
1	EVs		50	150	250	400	600	450	500	600	650	700
2	CAPEX	-1,5	-3	-3	-4,5	-6	-3	-3	-3	-3	-3	0
3	Revenue		3,3	9,9	16,5	26,4	39,6	29,7	33,0	39,6	42,9	46,2
4	Reinvestments				-0,5	-0,8	-0,7	-0,9	-0,6	-0,5	-0,8	-1,0
5	Fixed Costs		-2,4	-7,2	-12,0	-19,2	-28,8	-21,6	-24,0	-28,8	-31,2	-33,6
6	O&M		-0,2	-0,7	-1,1	-1,8	-2,7	-2,0	-2,3	-2,7	-2,9	-3,2
7	Fuel Costs		-0,2	-0,6	-1,0	-1,6	-2,4	-1,8	-2,0	-2,4	-2,6	-2,8
8	Operational Result (3+5+6+7)		0,5	1,4	2,4	3,8	5,7	4,3	4,8	5,7	6,2	6,7
9	EBIT (8+11)		0,2	0,5	0,8	1,2	1,7	1,7	1,8	2,6	2,6	2,7
10	Nominal Cash Flow (2+3+4+5+6+7		-2,5	-1,6	-2,6	-3,0	2,0	0,4	1,2	2,2	2,5	5,7
	Tax		0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
11	Amortization		-0,3	-0,9	-1,6	-2,7	-4,0	-2,6	-3,0	-3,1	-3,6	-4,0
12	Interest		0,0	-0,1	-0,1	-0,1	-0,2	-0,1	-0,1	-0,1	-0,1	-0,1
13	Net Earning (9+12)		0,1	0,5	0,7	1,0	1,6	1,6	1,7	2,5	2,5	2,6
14	Free Cash Flow (10+12)	-1,5	-2,6	-1,6	-2,7	-3,1	1,9	0,3	1,1	2,1	2,4	5,6
15	Discounted CashFlow	-1,5	-2,4	-1,5	-2,3	-2,5	1,4	0,2	0,7	1,4	1,4	3,2

Appendix 2: Fleet Services (Economic results in mln)

	Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
1	BEVs		1104	1104	1104	1104	1104	1104	1104	1104	1104	1104
2	CAPEX	-44										0
3	Revenue		32,1	32,1	32,1	32,1	32,1	32,1	32,1	32,1	32,1	32,1
4	Reinvestments				-11,0	0,0	0,0	-8,3	0,0	0,0	-5,5	0,0
5	Fixed Costs		-13,2	-13,2	-13,2	-13,2	-13,2	-13,2	-13,2	-13,2	-13,2	-13,2
6	O&M		-6,6	-6,6	-6,6	-6,6	-6,6	-6,6	-6,6	-6,6	-6,6	-6,6
7	Fuel Costs		-3,3	-3,3	-3,3	-3,3	-3,3	-3,3	-3,3	-3,3	-3,3	-3,3
8	Operational Result (3+5+6+7)		8,9	8,9	8,9	8,9	8,9	8,9	8,9	8,9	8,9	8,9
9	EBIT (8+11)		4,5	4,5	4,5	0,9	0,9	0,9	1,8	1,8	2,7	2,7
10	Nominal Cash Flow (2+3+4+5+6+7)		8,9	8,9	-2,1	8,9	8,9	0,6	8,9	8,9	3,4	8,9
	Tax		0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
11	Amortization		-4,4	-4,4	-4,4	-8,1	-8,1	-8,1	-7,1	-7,1	-6,2	-6,2
12	Interest		-1,1	-1,0	-0,9	-0,9	-0,8	-0,7	-0,6	-0,5	-0,4	-0,3
13	Net Earning		3,4	3,5	3,5	0,0	0,1	0,2	1,2	1,3	2,3	2,4
14	Free Cash Flow	-44	7,8	7,9	-3,1	8,1	8,1	0,0	8,3	8,4	3,0	8,6
15	Discounted CashFlow	-44	7,4	7,0	-2,6	6,4	6,1	0,0	5,6	5,4	1,8	4,9

Appendix 3: Car-sharing (Economic results in mln)

	Year	0	1	2	3	4	5	6	7	8	9	10
1	EVs		500	1059	1619	2178	2738	3297	3857	4416	4476	4476
2	CAPEX	-15	-17	-17	-17	-17	-17	-17	-17	-17	-17	-17
3	Revenue		11,9	25,2	38,5	51,8	65,1	78,3	91,6	104,9	106,3	106,3
4	Reinvestments							-4,3	-4,2	-3,7	-3,2	-2,8
5	Fixed Costs		-4,5	-9,5	-14,6	-19,6	-24,6	-29,7	-34,7	-39,7	-40,3	-40,3
6	O&M		-2,3	-4,8	-7,3	-9,8	-12,3	-14,8	-17,4	-19,9	-20,1	-20,1
7	Fuel Costs		-1,0	-2,1	-3,2	-4,3	-5,4	-6,5	-7,6	-8,7	-8,9	-8,9
8	Operational Result (3+5+6+7)		4,1	8,8	13,4	18,0	22,7	27,3	31,9	36,6	37,1	37,1
9	EBIT (8+11)		2,6	5,6	8,5	11,5	14,5	16,5	18,6	20,9	20,5	20,0
10	Nominal Cash Flow (2+3+4+5+6+7)	-15	-12,6	-8,0	-3,4	1,3	5,9	6,2	10,9	16,1	17,1	17,5
	Tax		0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
11	Amortization		-1,5	-3,2	-4,9	-6,5	-8,2	-10,8	-13,3	-15,7	-16,5	-17,1
12	Interest		-0,5	-0,5	-0,5	-0,5	-0,5	-0,5	-0,5	-0,5	-0,5	-0,5
13	Net Earning		2,2	5,1	8,0	11,0	13,9	16,0	18,1	20,3	20,0	19,4
14	Free Cash Flow	-15	-13,1	-8,5	-3,9	0,7	5,3	5,6	10,4	15,6	16,5	17,0
15	Discounted CashFlow	-15	-12,4	-7,6	-3,3	0,6	4,0	4,0	7,0	9,9	10,0	9,6

Appendix 4: Charging Stations (Economic results in mln)

	Year	0	1	2	3	4	5	6	7	8	9	10
1	Charging points		138	276	414	551	689	827	965	1103	1241	1378
2	CAPEX	-2,5	-2,5	-2,5	-2,5	-2,5	-2,5	-2,5	-2,5	-2,5	-2,5	0,0
3	Revenue		2,2	4,4	6,6	8,7	10,9	13,1	15,3	17,5	19,7	21,8
4	Reinvestments											
5	Fixed Costs		-0,1	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1
6	O&M		-0,2	-0,5	-0,7	-1,0	-1,2	-1,5	-1,7	-2,0	-2,2	-2,5
7	Fuel Costs		-1,6	-3,1	-4,7	-6,3	-7,9	-9,4	-11,0	-12,6	-14,1	-15,7
8	Operational Result (3+5+6+7)		0,3	0,6	1,0	1,4	1,7	2,1	2,4	2,8	3,2	3,5
9	EBIT (8+11)		0,0	0,1	0,2	0,4	0,5	0,6	0,7	0,8	0,9	1,1
10	Nominal Cash Flow (2+3+4+5+6+7)	-2	-2,2	-1,9	-1,5	-1,1	-0,8	-0,4	0,0	0,3	0,7	3,5
	Tax		0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
11	Amortization		-0,2	-0,5	-0,7	-1,0	-1,2	-1,5	-1,7	-2,0	-2,2	-2,5
12	Interest		-0,1	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1
13	Net Earning		-0,1	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,9	1,0
14	Free Cash Flow	-2	-2,3	-1,9	-1,6	-1,2	-0,8	-0,5	-0,1	0,2	0,6	3,5
15	Discounted CashFlow	-2	-2,2	-1,7	-1,3	-1,0	-0,6	-0,3	-0,1	0,2	0,4	2,0