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THE ROLE OF INFORMATION MANAGEMENT IN THE COMPLEX E-MOBILITY NETWORK

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ABSTRACT

Nowadays, electric vehicle is becoming more and more popular among public opinions, bestowing on this new transportation mean the best solution to move the energy consumption from fossil fuels to electricity, fundamental to decrease GHG emissions and the oil dependency.

In fact, the public reaction is significant, increasing electric vehicles (EVs) sales in Italy from 524 to 1306 and from 5453 to 25000 in the Netherlands between 2012 and 2013. These surprising figures are mainly due to the EVs low environmental impact, carried out by a CO2 reduction of 40%, an increase of energy produced by renewable sources of 72% and a decrease of dependency on fossil fuels of 70%.

On the counterpart the e-mobility world is characterised by a widespread uncertainty and complexity, which generate barriers for a consolidated market development. The main criticalities regard the battery technology which is in the early days of its development, contributing to a high purchasing price that still represents the most important psychological barrier for potential customers. Moreover, the battery technology constrains the driving range, generating the so-called "range anxiety", and exploits rare resources in the production such as lithium which need time and cost demanding processes to be recycled or disposed.

In this context, our research aims to reduce the complexity trying to overthrow the existing barriers through a creation of a new methodology which organizes, integrates and manages the information, addressing the following questions: what are the leading e-mobility stakeholders and the related interests and strategies? What are the information sources, types owned by different stakeholders? What are the information exchanged in the network? What are the critical network key performances in the e-mobility world? Is it possible to convince all the involved stakeholders to cooperate sharing information in an open data perspective?

The methodology is structured using the action research approach, because it has been considered the most appropriate method to support an innovative information management methodology and validate it in a work environment (Antea Group) in order to identify theoretical criticalities and misalignment with business purposes.

Key words: information management, stakeholder analysis, stakeholder clustering, e-mobility, Network accountability, inter-organizational accountability, network performance measurements, internet of things, open data, unstructured, structured and network data.

TABLE OF CONTENTS

INDEX OF FIGURES

INDEX OF TABLES

INDEX OF EQUATIONS

1. EXECUTIVE SUMMARY

The thesis research aims to develop a new methodology to manage the entire amount of information arisen from the e-mobility industry. This chapter is organised with the purpose to present a summary of the thesis research. The paragraph 1.1 provides an overview of the thesis objectives and the motivation behind the targeted output; the description of the methodology used is presented in the paragraph 1.2 in order to explain the steps conducted to reach the final results, explained in paragraph 1.3. Finally, a detailed description of the thesis structure is provided in paragraph 1.4.

1.1 Introduction and objectives

Nowadays, the propagation of electric vehicle as new transportation standard seems to be the best solution to move the energy consumption from fossil fuels to electricity, leading to several advantages.

First of all, the Hubbert peak reached in the last five years has shown that the society has consumed more oil that it has discovered, underlining the necessity to reduce the oil dependency.

The emissions of CO2 in 2010 has risen 5,9%, thus electric vehicle can reduce the overall GHG emissions cutting the consumption of liquid fuels by 70%, respect to traditional internal combustion engines: several governments are pushing on e-mobility in order to respect the international environmental agreements (Kyoto protocol, Europe 2020,…) which have defined ambitious environmental targets.

For these reasons, electric mobility is facing an important growing phase started less than 5 years ago, with different scenarios at European level: the electric vehicle sales in countries as Norway and Netherlands have increased annually by about four times, showing the huge potentiality of this business.

On the counter part many issues are connected to e-mobility world, arising the necessity to develop a comprehensive analysis of the main complexity and uncertainty drivers, in order to underline the crucial challenges and opportunities that so far have limited the electric vehicle propagation.

The main criticalities regard the battery technology, which actually weighs for 30% on the overall vehicle cost, contributing to a high purchasing price that still represents the main psychological barrier in potential customers. Moreover the battery technology still presents a limited driving range and the production is mainly developed by using rare materials, such as lithium, which need to be appropriately recycled and run the risk to be completely depleted in less than one decade.

In addition, the deployment of a widespread charging infrastructure is still limiting the propagation of electric vehicles, compromising the freedom of the drivers to charge the vehicle whenever they need.

The previous issues could be overcome in three ways:

- Challenging progresses in technology development, due to the necessity to improve the technology of the existing battery packs in order to assure a longer driving range and a lower charging time, without increasing the final purchasing price.
- Expensive governmental incentives systems, in order to overthrow the psychological barrier tied to the high purchasing price and support the development of a diffuse charging infrastructure.
- Improving the information management. The e-mobility is a fertile environment, where a huge amount of information, arisen from complexity drivers, is produced by different stakeholders, generating the necessity of collecting, analysing and integrating data, crucial to a large scale electric vehicle adoption.

Therefore, while the first two solutions are widely discussed by scientific scholars, the research object has focused the analysis on information management: field still not explored and rich of potential developments, without implying high implementation costs, differently from the first two solutions.

The analysis of the existing information, generated by different stakeholders, focuses on the data ownership: in fact, the e-mobility industry is characterised by several players with different goals and information sources. However in the e-mobility sector is not still presented a structured and defined methodology to collect, organize and integrate the huge amount of information coming from several stakeholders. The different players possess valuable data without sharing them in the network, constraining the cooperation among stakeholders, thus the propagation of the EV.

In this context, the thesis objective aims to fill the gaps in the e-mobility information management developing a methodology based on a first analysis on the e-mobility stakeholders' information management peculiarities: information strategy, needs, type of data (structured and unstructured), the data sources and the information exchanged in the e-mobility network.

Secondly, the stakeholder clustering represents the core of the framework reducing the network information management complexity and grouping the different players according to their informative and needs peculiarities. In fact, the e-mobility context is characterised by many stakeholders with different objectives and peculiarities, building different tight relationships to each other: thus, the stakeholder clustering contributes to the reduction of the complexity generated by a multi-stakeholder environment, reducing the number of players in few clusters, and underlines the relationship performances between clusters.

The methodology concludes proposing indicators, which monitor and underline the main network performances, no more linked to the single stakeholders but aligned with the complex e-mobility, focusing on the exchange of information among players in the network, underlining the potentialities and applications of a structured and organized information management method.

The analysis and the development of the methodology has been conducted in Netherlands, exploiting the opportunity to operate in the second country worldwide for electric vehicles sales penetration (*see pargraph 2.8.2*), in which the as-is information management situation is still presenting several challenges and gaps, being in "year zero". Instead, Italy has not invested in the electric mobility as a solution to improve the environmental conditions and the transportation sector bestowing on the information role a marginal challenge due to the absence of data and suitable background.

1.2 Methodology

The methodology exploited to support and accomplish the research results is based on the empirical analysis, driven by the methodology of action research, integrated with case studies (interviews). We've decided to co-create the research output with Antea Consulting Group, in order to improve the theoretical knowledge with the practical experience, underlining the gaps between the university research and real business cases.

In addition, with the purpose to test the framework of our research, we decided to exploit a Dutch governmental project (CINK) aligned with the overall thesis assumption and objectives. In this experimentation, our output has been tested, finding new weaknesses and discover further improvements mostly correlated on the governamental environment.

Qualitative research interviews have been developed both in Italy and Netherlands, during the Dutch stay from March to June 2014, meeting 20 e-mobility stakeholders, trying to cover all the main important roles in this sector, structuring the case studies in face-to-face interviews and Skype calls. The interviews have underlined the gaps between the two countries, showing as the Italian context is not suitable for our research because the government is not pushing on e-mobility to improve the environmental issues, implying the marginality of information management driven by the lack of a tangible e-mobility system.

The interviews can be classified in open-ended questions, tailored to each stakeholder and close-ended question in order to depict a complete and clear stakeholders analysis (missed in the actual scientific literature), investigating and measuring the relationships strength that characterise the e-mobility network. Thus, the interviews have been fundamental in order to develop the stakeholders' analysis, investingating the missing features in the literature review, and the stakeholders clustering, in order to gather a qualitative measure of the relationships strengths.

This approach facilitates the investigation of the motivations behind corporate strategy mostly related to the information management of each stakeholder, without driving off the interviews from the objectives and thesis necessities.

1.3 Results

The new theoretical framework is composed by the analysis of the AS-IS information management situation in the complex e-mobility stakeholder network, a further clustering to improve the effectiveness in the analysis and a final measurements proposition, underlining the network key performances and the potential applications of the information.

The stakeholder information management analysis represents a first identification of the leading e-mobility actors, proceeding with a deep analysis, focusing the investigation on the strategy and particular needs concerning the e-mobility information in order to discover which are the main sources of information and data managed.

Moreover, with the purpose to measure the relationship strength and create clusters that have in common similar strategic objectives, a network analysis has been conducted, specifying the subjects of the relationships, the resource and information that they usually share.

The stakeholders clustering, aimed to group the several e-mobility stakeholders in three clusters in order to decrease the complexity and underline communalities, is structured in both top-down and bottom-up approaches: the first, exploiting the previous stakeholders analysis, identifies three typical e-mobility business profiles, namely e-mobility sponsors, EV providers and infrastructure administrators, grouping all the stakeholders in these predefined clusters (A,B,C). The second methodology, following a bottom-up approach, starts from the main relationships that stakeholders usually build, individuating five drivers and related weights in order to collect an overall score that summarises the intensity of the relationship between couples of stakeholders' clusters. In order to support this measurement, close ended questions during the interviews have been proposed.

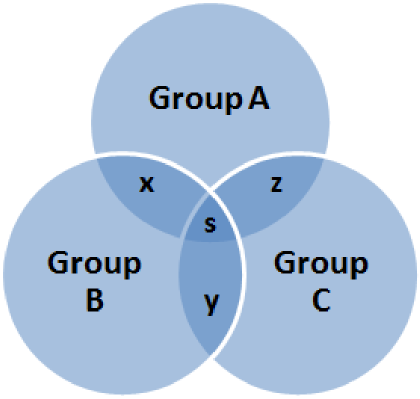


Figure 1: Stakeholders' clustering

Finally, starting from three main e-mobility stakeholders clusters (A, B, C) and critical relationships (x, y, z), some measurements have been proposed in order to underline the e-mobility key performances and present the potential application of the information previously organized and integrated.

1.4 Structure of the thesis

The thesis is structured in 8 chapters. The chapter 2 defines the thesis objectives providing the overview of the e-mobility underlining the complexity and uncertainty drivers which characterise this sector. The chapter 3 is devoted to a targeted literature analysis of the managerial tools suitable for the e-mobility features as well as frameworks to organise the complex and dynamic stakeholders' context. The chapter 4 describes the theoretical framework according to three main research outputs: AS-IS e-mobility information management, stakeholders clustering and network key performances. The chapter 5 describes the methodology exploited to achieve the results, using the action research approach based on an empirical experimentation and case studies, namely interviews. The chapter 6 explains all the results achieved as well as the validation of the theoretical framework. The chapter 7 introduces the strengths and weaknesses of the proposed model, through experimentation in a governmental project, aligned with the theoretical assumptions and aimed to the same research objectives. Finally, the chapter 8 provides the conclusions of the research, leaving open issues to further deepened investigation about the change management approaches.

2. E-MOBILITY COMPLEXITY DRIVERS

The objectives of the following chapter are to present the thesis goals and propose a new definition of e-mobility, underlining the literature gaps in the information and stakeholders' management, covering the main barriers and challenges which characterize this growing industry with structural complexity and uncertainty.

The complexity is presented in the main drivers that shape up the e-mobility competitive environment, influencing the performances of each involved stakeholder. Thus, the creation of a new methodology which improves the information management is crucial to overthrow the typical e-mobility barriers, organising, integrating and measuring the diverse information arisen from the complexity.

2.1 General introduction

In the following years, one of the most important trends in the automotive industry will be the massive introduction of electric vehicle. The spread of the electric vehicle (EV), as a new transportation standard, could be the right solution to move energy consumption from fuel, mostly fossil, to electricity.

The drivers that force the governments as well as the organizations to start this transport revolution are:

- The rapid increase in gasoline prices;
- High level of air pollution in urban areas;
- The increasing dependency of the country on fuel imports;
- The shortage of resources, mostly the fossil fuel;
- Reduction of CO_2 emissions.

Since 1970 the worldwide oil industry has pumped more oil than it has discovered: in the last 5 years for the first time in the history, 15 billion barrels of new oil were found worldwide, during the same 5 years 135 billion of barrels were pumped out. The Hubbert Peak (figure # 2) depicts the new oil consumption trend that is coincident to the last years, signifying that we are in the dangerous phase for the fossil fuel resources, because we are depleting all the reserves of the past years without discovering new oil deposits [Badal; 2009].

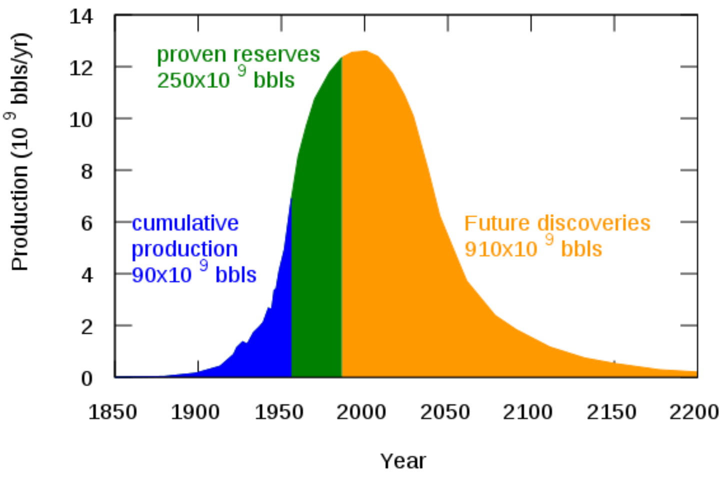


Figure 2: Hubbert Peak [Badal; 2009]

EVs could reduce the consumption of liquid fuels by at least 70 percent compared with the traditional internal combustion engine. In addition they have the potentiality to reduce the total energy expenses for the owner [Srivastava at al., 2010]. EVs to recharge their battery, thus to provide energy to the car, can use renewables energy, coal, nuclear, and reduce the nation's demand for imported oil.

The emission of CO2 has risen 5.9 percent in 2010 (main contribution is represented by coal) and it was the greatest absolute increase since the Industrial Revolution, and the largest percentage growth since 2003. The drop of 1.4 percent in emissions in 2009 (at the beginning of the recession) represents the only exception. However, the experts estimate a growth of CO2 emissions close to 3 percent respect to the last decades.

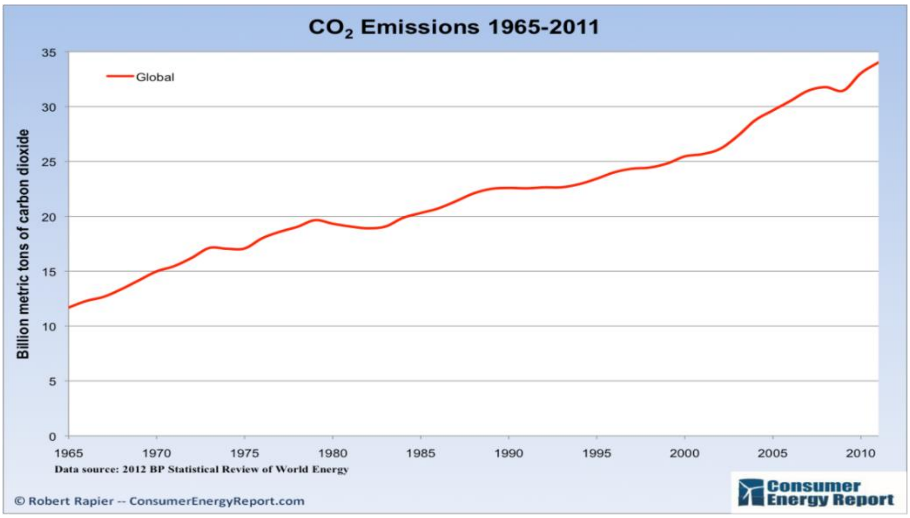


Figure 3: CO2 emissions 1965-2011 [Srivastava at al., 2010]

Many years ago the China overcame the USA concerning the CO2 emissions, emitting 2.2 billion tons of carbon into the atmosphere (increase of 10.4 percent in 2010).

The developing countries, including China and India, have surpassed the developed countries in their overall greenhouse emissions, contributing with 57 percent [British Petroleum plc.; 2012]. The emission of CO2 for recharging the EVs in a country that exploits the renewable energy would be 45-70 g/km respect the 167- 224 g/km for the Internal Combustion Engine vehicles, underlining the huge decrease in GHG emissions carried out by EVs [Chefurka; 2009]. However, the environmental impact of the EVs is complex and not linear to be computed because of the establishment of a new electric grid and the calculation of the environmental impact related to the production process of the vehicle. The additional environmental costs related to the production of the EV are mostly connected to the battery features: weight, size, rare resources usage, recycling and disposal problems.

Since the e-mobility is at the beginning of a growing phase, a comprehensive analysis of the main ***drivers of complexity and uncertainty*** is structured in the following paragraphs in order to underline the gap in the information management that so far constrain the Electric Vehicle propagation:

- Unclear electric mobility definitions
- Variable e-mobility popularity
- Battery technology instability
- Complex distribution grid & charging infrastructure
- The role of standardization in e-mobility
- Uncertain affordability and environmental performances
- Complex system of incentives and regulations

Thereafter a closing paragraph presents a new exhaustive definition of e-mobility leading to an upcoming challenge in information management, which represents a solution to overthrow the typical e-mobility barriers improving the organization of the data derived from the network complexity.

2.2 Unclear electric mobility definitions

The concept of **electric mobility (e-mobility)** is not still well defined in the literature due to its novelty and complexity, therefore practitioners and few researchers have provided their ***own definition***, but still presenting some lacks and weaknesses. However these statements can be classified according to two main streams.

A broad one which embraces all the elements that characterize the system, the infrastructure and communication technologies:

- "Electric mobility (or e-Mobility) represents the concept of using electric powertrain technologies, in-vehicle information, and communication technologies and connected infrastructures to enable the electric propulsion of vehicles and fleets. Powertrain technologies include full electric vehicles and plug-in hybrids. […] E-Mobility efforts are motivated by the need to address corporate fuel efficiency and emission requirements, as well as market demands for lower operational costs" [Gartner IT golossary; 2013].
- "E-mobility as the ecosystems of utilities, services, mobile devices, and software that support the Plug-in Electric Vehicle" [Debevoise; 2012].
- "Electric mobility (e-mobility) is defined as electrification of mobility embedding Electrical Vehicles (EVs) in a wider urban mobility concept, including public transport and new usage models of private cars but also car sharing or leasing models." [Gerst and Jakobs ; 2012].

A focused definition that neglects the concept of system and the related elements, underling the importance of the vehicle itself:

- "E-Mobility refers to vehicles which rely on plug-in electricity for their primary energy, whether or not they have an auxiliary internal combustion engine for range extension or for keeping the battery charged up (Battery Electric Vehicles, Plug-in Hybrid Electric Vehicles and Extended Range Electric Vehicles)". [FIA, European Bureau; 2011].

The ***unclear and different definitions*** are strictly correlated to the huge amount of terms used to classify and define the Electric Vehicle. The complexity generated by the ***confuse nomenclature*** and "what really is the e-mobility" leads to a common drivers' worry towards the new transportation standard. In the following paragraph is presented a brief explanation of the main terms used to define the Electric Vehicle and its extension with their peculiarities.

The **Electric Vehicle (EV)** traction power is provided by an electric engine composed by a battery or an internal combustion engine (ICE). This definition includes all the variety of vehicles, partially or totally powered by electricity.

An electric vehicle that uses only a battery to power the electric motor propulsion, recharged from the grid and the regenerative braking system [Celaschi at al.; 2009], is usually called Plug-in EV

(PEV), Battery EV (BEV) and Zero-emission EV (ZEV). Other EV sub-categories are presented in the following paragraphs.

2.2.1 Hybrid Electric Vehicle (HEV)

A **hybrid electric vehicle** combines conventional propulsion, based on an internal combustion engine, with some form of electric traction. A hybrid is designed to capture the energy that is normally lost during braking and free running to recharge the batteries, but the combination in the usage of the two engines generates two different technologies:

- **A hybrid "serial"** uses the electric motor to provide additional power to the combustion engine when the vehicle faces peaks in demand, for example during acceleration and pace "stop-and-go". Depending on the different combinations and percentages of power of the two engines (normal combustion and electric engine) three technologies are developed: integral (full), medium (mild) or micro hybrids [Celaschi at al.; 2009].
- **A hybrid vehicle "parallel"** uses the electric motor or the internal combustion propulsion.

2.2.2 Plug- in hybrid electric vehicle (PHEV)

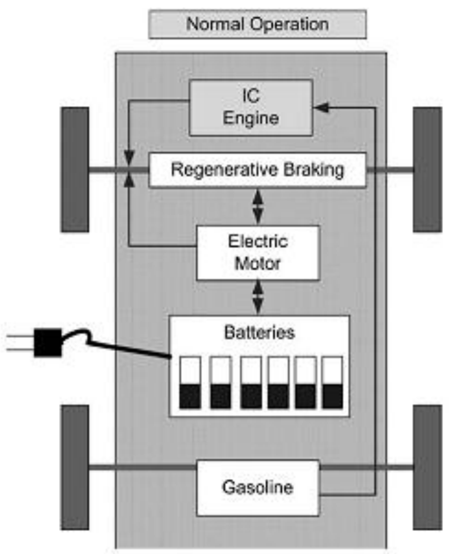


Figure 4: Internal PHEV Architecture

A **plug-in hybrid electric vehicle (PHEV)** is a hybrid vehicle, based on a normal combustion engine, equipped with a battery that can be recharged by connecting a plug to an external power source. The PHEV is composed by different technology forms, depending on the combination of grid electricity, regenerative energy (generated during braking) and power from the internal combustion engine. The combinations of the previous factors vary from modified versions of existing HEV to pure electric vehicles with an additional generator powered by a small internal combustion engine to recharge the battery, called "range extender". Regarding the use of the vehicles, the main difference between BEV and PHEV regards the charging mode [Celaschi at al.; 2009]: while a BEV can travel a range in mileage depending exclusively on its consumption and battery capacity, a PHEV can also rely on an internal combustion engine able to recharge the battery in emergency situations by using fossil fuels. Finally, the main difference between an HEV and a PHEV is the capability of the latter to recharge the battery using a power outlet that provides the required energy through low voltage grid [Srivastava et al. 2010].

2.2.3 Fuel cell vehicle, FCV

In a **fuel cell vehicle (FCV)** the hydrogen and oxygen react with one another, producing electricity, and releasing water. A fuel cell is composed by an element in which hydrogen and oxygen are in contact creating a difference of potential across an anode and a cathode separated, in more modern systems, by a thin polymer membrane. The fuel cell system, applied to the automotive, becomes a kind of battery that powers electric motors, thus frees the car to be recharged with electricity from the power outlet. Anyway, the FCV is not still shipped into large scale market, due to flammability and high cost of hydrogen extraction. [Cianflone; 2009]

2.2.4 Comparison between the configurations

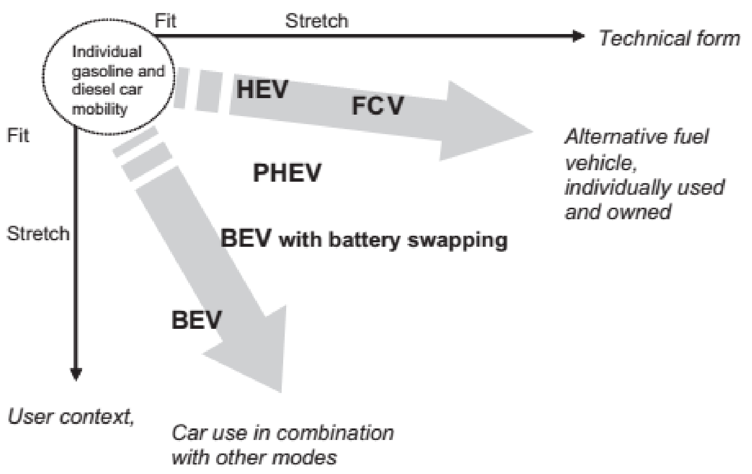


Figure 5: Changing path in the mobility sector

The figure # 5 depicts the different configurations of the electric car: the ordinate represents the range of changes that the costumer could deal with adopting different typologies, i.e. the modification of the costumer habits. On the other hand the abscissa considers the changes related to the technology adopted by the electric car, regarding the source of power of the engine or the level of vehicle’s advancement in technology [Dijk et al.; 2012]. In the figure two different changing paths are shown in order to describe the ***complexity and uncertainty that the users have to face*** adopting as a new transportation standard the EV in terms of travel behaviours and vehicle technologies.

In the upper pathway user preferences and mobility patterns remain more or less unchanged. People are keen to buy a “greener” car without changing their travel behaviours (although high penetration of ICT in cars and infrastructures may change car-based travel experience).

On the other hand in the lower pathway, more changes in the mobility behaviour are expected, especially more active travel planning, mixed use of mean of transportation and less private car ownership. This second path involves further changes in supporting products technology

2.3 Variable e-mobility popularity

The overview of the electric vehicle history between the 1990 and the 2010 underlines a ***not stable popularity*** of the e-mobility in the media means, such as press, because of the its complexity texture arisen from changeable technology advancements, variable governmental incentives and pilot programs which have influenced the EV perception in potential customers' mind.

In fact new trends have moved the interest from the EV to the Hydrogen car once, or FEV and more advanced ICV later on. However the two peaks of EV popularity regard the beginning of the Nineties and the early years of the 2000 in which the public opinion was more inclined to discover the EV opportunities because of the history periods peculiarities [Schwedes; 2012].

The figure # 6 shows the development of the discourses in the print media (newspapers mainly published in Europe) related to the E-mobility.

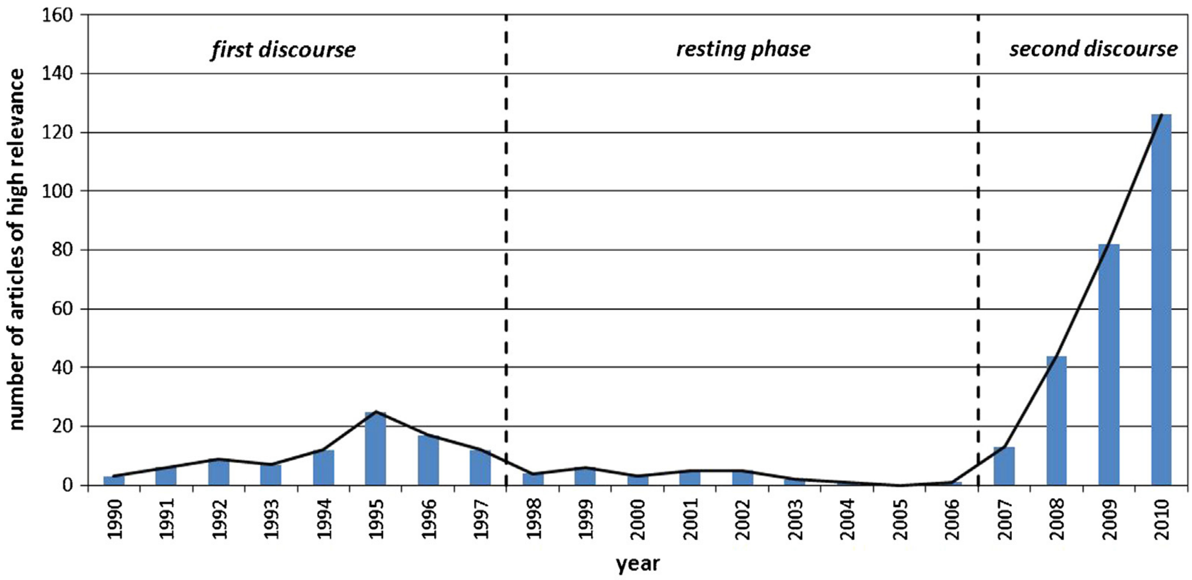


Figure 6: Development of the discourses in the print media

The ***first peak*** occurred during the Nineties due to an incremental environmental debate and the automotive crisis which have fostered governments to push on the introduction of the EVs.

The trigger element was the discourse conducted by American State of California that forced the car manufacturers to introduce zero emissions vehicles (ZEV), because of the high level of toxic emission in the Los Angeles area. Simultaneously General Motors present a BEV concept car (the EV 1), an electric vehicle manufactured in series with a range of up to 100 km. In parallel in the 1992 Germany started a pilot test (the largest field test of its kind worldwide at that time) implying 60 electric vehicles on the island of Rugen [Schwedes; 2012]. However, in 1996 the project was closed due to the convinction that EVs environmental benefits can be tangible only if the source of energy exploited to recharge the battery is renewable. Moreover, just a hybrid car model has succeeded in large scale market, selling more than 1 million worldwide: the Toyota Prius [Schwedes; 2012].

During the first years of 2000, the attention moved from hybrid electric vehicle to hydrogen fuel cell vehicle (FCV), but after this period the Hydrogen fuel cell vehicle did not encounter more approvals among the potential customers due to the high likelihood of explosion for the high hydrogen flammability. Moreover in this period car manufacturers have bet more on the ICV technology developments (80% patents on the improvement of the efficiency of the internal combustion engine) [Schwedes; 2012]. Comparing with the first peak, the automotive industry was again affected by an international economic crisis, even deeper than before.

The ***second peak*** occurred together with an international environmental debate, focused on climate change and the global warming, which has characterized the 21th century because of the increase in the oil prices that pushed governments to think about new renewable sources. Furthermore new development in the battery technology (lithium-ion batteries) has sustained the new e-mobility phase.

2.4 Battery technologies instability

The propulsion solution for EVs represents one of the main critical factors for the vehicle success and a fundamental ***source of complexity*** not only for battery developers and car manufacturers, but for instance, also for charging stations installers which have to comply the requirements of the battery, following the European standard (*see paragraph 2.6*) providing energy without damaging its components. The previous example describes the importance of the information generated by the battery among the different stakeholders and the relative necessity of data sharing.

An **EV battery** is "a pack of strings of cells connected in a series, in order to reach the required high voltage. These strings of cells, i.e. cell-series, are connected in parallel, in order to provide the required current" [Adany et al.; 2012].

The battery pack has to be designed according to a high ampere/h capacity and the high ratio between power/weight, because the overall weight of the vehicle has a huge impact on the performances such as acceleration and high speed. In the last decade many different technologies have been developed, but nowadays the most used is the lithium-ion battery that assures on average 6000 charging sessions.

Regarding the cost per KWh a lithium battery of 8 KWh costs $4000, thus $500 per KWh, however in reality in order to avoid a complete discharged and stress the battery is added 2KWh to the battery pack leading to a final cost per mileage of $ 0.034/mile.

Toyota Prius official web page declares 21 km (13 miles) for a battery of 5,2 KWh which implies a ratio between km and KWh of 4 per KWh. Other researches declare battery capacity of 8km per KWh [Bredsdorff; 2010].

In the last decades three main technologies have affirmed to assure the previous battery performances, showing huge investments undertaken in this field and increasing the uncertainty for all the involved stakeholders: for instance, car manufacturers are widely influenced by the technology developments, deciding to bet on the actual technology or waiting for new advancements. The purpose of these efforts aim to provide a higher battery life (measured as numbers of cycles it can stand) and a more extended driving range, diminishing at the same time.

In the past, the main element of the batteries was based on lead-acid (nickel-metal hydride, NiMH), or on sodium-nickel-chloride (ZEBRA) batteries. Nowadays the EVs use lithium-ion (Li-ion) batteries due to the following advantages [Notter et al,.2010]:

- It is the lightest of all metals, thus impacts much less on the overall weight of the EVs;
- It has the greatest electrochemical potential, which determines higher power and energy density;
- It requires little maintenance, most of the other batteries do not possess;
- It is characterized by little self-discharge;
- No scheduled cycling is required to prolong the battery’s life.

The previous features represent crucial data that guide the decision making of battery developers and car manufacturers, underlining the ***interwoven flow of information***.

The production of the Li-ion battery is centred on the construction of the anode, the cathode and the battery pack, composed by separator, lithium salt, steel box and cables. These components, mainly metals, are the main contributors to the environmental burden, mostly the production of the anode and cathode. The introduction of the lithium-ion has improved the batteries duration as well as the environmental impact, thanks to higher energy and power density. However, automotive lithium-ion batteries introduce new problems as safety, durability, uniformity and cost, limiting the worldwide application in the vehicle [Languang Lu et al; 2012].

Moreover the lithium-ion battery is composed by ***rare resources*** as copper and lithium that “occurs in average concentrations lower than 0.01% in the Earth’s crust and hence can be considered to be a geochemically scarce metals” [Notter et al.; 2010]. In fact, a massive production of lithium-ion battery pack could bring to deplete the resources in about 6 years [Hermann et al.; 2006]. For this reason governments are going to emit regulations in order to force an eco-friendly battery disposal, increasing from one hand the complexity of battery developers, which have to produce recyclable products, and on the other car manufacturers, which have to establish new and expensive recycling system.

In addition, the possible ***secondary usage*** as static energy storage is still investigated, starting from the uncertainty of future battery capacity and at the same time making unpredictable its end-life value. The disposal represents a challenge for the affordability and success of EVs.

Although during these years important improvements have been achieved, the limited driving range represents an important barrier for a wide spread of EVs. Anyway, in order to solve this problem, a solution is the ***battery swapping***, namely the physical substitution of the battery with a charged one, or the chassis swapping, where the entire chassis is substituted in a modular vehicle. Such a system was patented in 2000 by Dr Gordon Dower, who was sure that the drivers should own only the vehicle body, while they should lease the battery [Dower, 2000].

2.4.1 The future: nanobatteries and ultracapacitators

The existing batteries continue to present several limitations and affordability problems, and for this reasons new solutions are investigated. A new finding is represented by electric double-layer capacitors (called also supercapacitators and ultracapacitators), which aim to achieve the energy density of lithium-ion batteries, offering almost unlimited lifespans and no environmental issues. For example while Lithium-sulphur batteries offer 250 Wh/kg, Sodium-ion batteries provide 400 Wh/kg reducing at minimum the expansion/contraction during charge/discharge through a very high surface area [Ellis, 2007].

By comparing the ultracapacitator with the conventional electrochemical battery, the former provides a longer battery life, faster charge and higher power output, but anyway it still presents several disadvantages which do not make them "the actual standard". For example, they own low energy density (and so the weight issue is not solved), high self-discharge rate and low maximum voltage.

Anyway, the uncertainty tied to the definitive technology is making some stakeholders act in a "fence sitter position", by waiting for the release of better technologies, but losing the advantage and know-how typical of first movers. This position is typical of some governments, which are not releasing consistent incentives, and car manufacturers (as FIAT), which prefers not to invest in EVs because still not profitable due to the high costs of advanced battery packs (ultracapacitators).

Thus, if from one hand the main stream to improve the EV performances (range, charging time,…) is focused on ***investing in new technologies***, it presents some side effects such as an increase of the final vehicle purchasing price.

2.5 Complex distribution grid & charging infrastructure

The EVs are transportation means that need to be recharged more frequently than the traditional ICVs filling up, implying an high charging time. The customers can recharge the EV at home or in public areas, exploiting charging stations: thanks to their meters, both represent crucial information sources, collecting important data regarding the customer's charging habits. So far, all the players involved in the charging sessions (Charging service providers, distribution system operators, energy retailers) are not totally exploiting this information, keeping proprietary data inside instead of sharing in the network.

However, the players are investing on faster charging technologies (superchargers), facing high implementation costs and neglecting the importance of cooperation and information sharing that could lead an overall improvement of the service provided to the customer and a better forecasting on future electricity demand.

The following paragraphs investigates the complexity related to this field, focusing on information sources, by defining the required infrastructure components [San Roman et al., 2011] and analysing pricing methodologies and new technologies such as smart grid and vehicle-to-grid. Finally an investigation of the e-mobility impact on the electricity grid is performed, closing with a analysis of the so-called "grid vicious cycle".

2.5.1 Definitions

- **Distribution grid**: network installations, power lines, transformers (to switch high voltage into low voltage electricity) at which EVs are plugged-in.

- **EV charging infrastructure:** composed of EV charging points and their connections to the distribution grid, namely the Electric Vehicle Supply Equipment (EVSE). Additional equipment such as transformers, generators and storage devices could be necessary to improve the quality of the service.

- **Final customer connection point:** interface between distribution grid and customers. A meter is placed at each customer connection point. With the massive introduction of EVs, a new system of communication between cars, grid and charging infrastructure is going to be introduced in order to communicate and control the two-ways electricity flows. The following meters represent ***key information sources*** which generate fundamental data (both structured and unstructured) regarding customer habits and charging behaviours, which represent key information useful to exchange and share among the stakeholders' network:

    - **Final customer meter (FCM):** located at the final customer connection point, it measures the energy consumption (kWh), when and how long they usually recharge the EV determining the peak load (kW) in a period of time in a specific location. The communication can happen on-time or off-time and more advanced smart meters are going to introduce a bidirectional communication with the Distributor System Operator (owner of the distribution grid) and energy supplier for improving pricing methods, like time-of-use (ToU) tariffs to push on off-peak charging.

    - **EV meter (EVM):** connected to a charging point for billing purposes, it is going to measure the energy consumption of the battery and driving habits including the user's range. In future it is going to be linked with EV supplier for potential remote charging control.

- **EV charging point or charging post (CP):** connection point between EV and charging infrastructure, where the EV is plugged-in to be charged. A single or multiple charging posts make up a charging station.

In order to group the previous definitions, the following figure shows a scheme of a **charging station:** the characteristic FCM located at the interface CP, connection point with the distribution grid, and EVMs located at each charging point. The assets owned by the DSO are represented in green colour, the equipment associated with the final customer in blue and the rest of the material owned by intermediate actors in red.

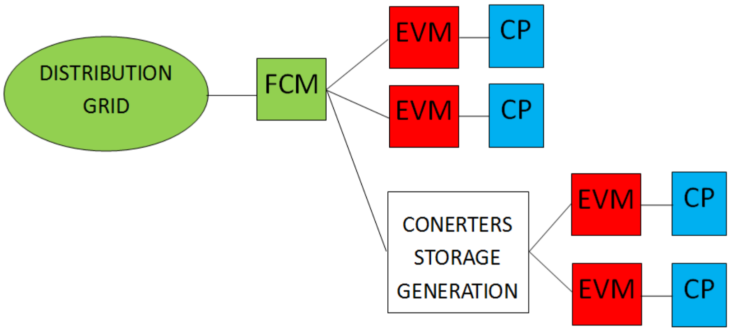


Figure 7: Grid architecture

These meters represents new data sources for the EV manufacturer who can also install additional equipment on the car aiming to provide the right information to the customer. Inside each EV the **On-board EV controller (EVC)**, representing a new source of information, should be installed in order to provide the EV owners with a set of alternatives useful to select the charging methods and enabling the V2G (*explained in paragraph 2.5.4*) according to the owner's requirements. In addition the EVC shows the **on-board EV state of charge indicator (SoC),** which expresses in kWh or percentage of the full charge, the state of charge of the battery, information measured to depict the overall ***drivers' habits***.

2.5.2 Typologies of charging points

The charging points represent another important ***source of information***, collecting all the data regarding the charging sessions (such as duration, frequency,…) related to each driver. Thus differently from the meters, the charging points represent the main source of information outside the driver's house: all the information generated is considered fundamental for all the e-mobility network, because they contribute to define the ***charging customer profile***.

Charging points can be classified through two different dimensions: the target of customers (residential or public charging points) and power supply (or supply velocity).

The first category can be divided in:

- **Residential charging point**: built in residential home or private garage or parking, it belongs to EV owner for private use. It is made of a connector possibly locked by a key, and connected directly to the low voltage (LV) board of the house. In this case, the EV is charged with 230 V at 16 A, which allows charging power of 3kW, even if more powerful charging infrastructure can be installed. Without the need of an EMC, the EV owner would select on its on-board EVC its charging needs and the expected time of connection, optimizing in this way the charging costs. The investment for a traditional "slow" infrastructure is estimated in 300-400€ [E-Bay, March 2014].

- **Public charging point**: located in public or private parking areas it presents public access. The charging point is going to present the following functions: user identification, grant physical access to establish the connection of the vehicle, measure energy flows, billing, and physical locking after payment to prevent vandalism. A public charging point can be powered by slow, standard or fast electricity supply. A communication between the EMC and the EVC should be established in order to provide information about the prices and communicate the requirements of the customer to the energy supplier, underlining the ***importance of cooperation and information exchange between players***. The infrastructure investment, comprehensive of a security package against vandalism, ranges between 4000 and 10000€ [E-Bay, March 2014].

For the power supply dimension, **three charging levels** are identified by the Electric Power Research Institute and codified in the U.S. National Electric Code: slow charging (level 1), standard charging (level 2) and fast charging (level 3) [Idaho National Laboratory, 2008]. Actually the most of existing charging stations (private or public) belongs to level 1 and 2, and they require several hours to recharge the battery. Most of the companies are committed in implementing this kind of technologies, for instance in France EDF and Toyota [EDF press release, 2009]. The level 3 charging stations are today a reality, and, even if the high technology cost, several companies are implementing them around the world. For example, Tesla has installed "Superchargers" in United States (81) and Europe (14), which charge an EV with 120 kW providing more than 200 km of range in less than 20 minutes [Tesla, 2014].

The different charging stations require tailored connections to the infrastructure grid and a complex system to allow the ***energy retailers interoperability***: the challenge, tackled with different national regulations, aims to allow drivers to charge the vehicle choosing the energy retailer, without constraints imposed by charging stations owners. In order to pursue this objective, a fair cooperation between different energy retailers and distribution system operators at international level is necessary in order to foster the data exchange.

2.5.3 Pricing methodologies for charging

This topic represents a discussed argument in the sector because introduces uncertainty for potential EV customers in evaluating possible savings and for infrastructure developers in assessing investments profitability.

For these reasons at the moment three kinds of payment strategies are implemented:

- In the first, shoppers and malls can construct charging stations close to their buildings in order to attract customers offering a **free of charge** service. In the same way, also managers can build charging points for their employees.

- A second strategy is the **point of sale payment**: similarly to current gasoline retail model, the payment is located where the charging is performed, for example in parking lots, with money or credit cards. The most of existing charging stations offers this type of service [Coulomb Technologies, 2010]. This strategy allows a spread availability of charging stations, because customer does not need to verify the brand of the retailer, but can charge as in a traditional petrol station.

- A third alternative open model is defined as **"roaming across power retailers"**. The customers are equipped with an RFID card which allow them to charge their own EVs in every station and the payment is going to be invoiced at the end of a billing period. Similarly to a phone or gas bill, the payment can be charged automatically on a dedicated roaming account integrated with the bank system. This typology of payment involves a ***complex exchange of data*** regarding the amount and the price of electricity charged in proprietary and non-proprietary charging stations among energy retailers and charging service providers. Few applications are already implemented, as for the interesting cross-country project experimented by 365 Energy in Amsterdam (Netherlands) and Bochum (Germany) and based on a single customer ID card for each EV user [Green Car Congress, 2010]. The disadvantage of this strategy lies in the contract signature with a specific retailer. In fact, being tied with a specific retailer, customer is going to pay an additional fee if he charges in main provider's competitor stations, rising also the complexity for V2G capabilities. In addition, if the customer will charge in a foreign country the contract could not cover this possibility.

2.5.4 Vehicle-to-grid technology & smart grids

The V2G technology consists in a reverse charging: the EV, when parked and plugged-in, provides electricity to the grid. The V2G introduces a high degree of complexity in terms of technology and

information management, due to EV active role in data generation and exchange in real time. Once implemented, it will represent an important characteristic of the EV for several reasons:

- By making EV profitable when parked, the EV owner can earn for this service by "selling" information useful for stakeholders' network and releasing electricity into the grid;
- The stakeholders involved in charging infrastructure management benefit from the collection of data coming from the vehicle, describing consumption patterns;
- To leverage the peak demand, providing electricity during peak periods and in this way reducing the energy costs [Acha et al., 2010];
- To take advantage of the integration with renewable resources: the EV is charged when – for example – the power provided by the wind is the greatest and V2G technology could be used to store the energy produced, as shown by an experiment in New York [Hadley, 2006].

Obviously the advantages will be amplified with hundreds of vehicles parked and plugged in at the same time. The main issue of this technology regards the medium-long term impact on the battery, which remains "more active" compared with the traditional one-way recharging. In addition, in order to exploit all the opportunities of V2G technology, the construction of a "**smart grid**" is fundamental to enable an effective information exchange between grid and vehicles. Experts use these terms to define the "coordinated control of large population of electric loads using Information and Communication Technology" [Ipakchi et al., 2009].

Smart grids are designed and introduced also to allow a ***two-ways information flow*** in order to optimize the charging. Technologically, this could be achieved by enabling two-way communication between retailers and customers: from one side the retailer defines a dynamic electricity price which triggers customers to take advantage of it. On the other, the customers provide data about their electricity consumption behaviour. The combination of smart meters and two-ways communication infrastructure is known as "Advanced Metering Infrastructure". Some studies have demonstrated that it has potential savings up to 45% both for customers and energy retailers [Goebel, 2012]. In fact, also the latter ones can save money, given the fact that energy produced during peak period is obtained with temporary sources which usually are more expensive.

Thanks to these technologies the customers are able to select the charging time and mode on their on-board EV controller directly on the car or with alternative "smart" methods. For example, Chevrolet – as several other competitors - has released an app called *Onstar Remotelink* that allows to establish the charging modality of your plugged-in Volt simply from smart phone [General Motors, 2012].

The implementation of smart grid is already realized in concrete pilot projects and results. Accenture has become one of the first mover developing the project in Amsterdam and Boulder. In the city of Boulder (Colorado) it teamed with Xcel Energy to build the "smart grid city of the future", a fully inter-connected electricity system that includes support for EVs and integration of distributed generation technologies (such as vehicle-to-grid technology). Accenture has also found fertile fields in Amsterdam where, with the municipality, has started in 2010 an ambitious smart city program, which enables electric bicycles, cars, commercial vessels and river cruisers to be connected to the electric grid through power hookups around the city streets and canals [Senart et al., 2010].

Italy has been the first nation in the world to implement a nation-wide smart grid in 2006 [Enel, Smart grid, 2012].

Although the actual technologies make feasible the implementation of smart grid and V2G, nowadays a ***proper organization and integration of all the information*** coming from the vehicles has not been implemented, neglecting the potential gains for the e-mobility stakeholders in terms of analysis of customers' behaviours aimed to release more efficient services.

2.5.5 Impact on the distribution grid infrastructure

For years it has been assumed that the impact on the electric grid generated by the mass-introduction of EVs could be insignificant, but today different studies are demonstrating contrasting results. The transmission and distribution system operators are in charge of assuring the ***operability of the electricity grid*** and are today committed in managing the complexity arising from the e-mobility propagation.

In particular while the daily impact on the aggregate demand of electricity is limited, the timing and the location can affect the grid, creating peak periods which in the long term are going to be managed with "smart grids" that can exploit the Vehicle-to-grid (V2G) technology.

Considering the existing technologies, the best way to assure the operability of the grid is the improvement of the information management: the share among the stakeholders of data regarding the customers charging habits (such as charging time, location, frequency,…) can avoid peak loads and grid disturbances. All the business cases presented hereafter, underline the necessity to trace the actual infrastructure performances and improve the management of information through the ***exchange of data***, without investing in more advanced infrastructure technologies.

In the United States, researchers at the US Department of Energy's (DOE) Pacific Northwest National Laboratory concluded that current electricity capacity generated would be sufficient for a large-scale conversion to EVs [Kintner et al., 2006]. In fact the overall impact represents 5-8% on the total demand in 2030 and is not going to have a significant effect on security of supply and grid.

While for the UK, it has been estimated that a 10% market penetration of EVs would result in less than a 2% increase in power generation (equal to approximately one GW) [Ricardo, 2009]. In Canada, it is estimated that the evolving demand of approximately 500000 new EVs can be incorporated into the planned capacity growth of an additional 99 TWh by 2018 [Government of Canada, 2008]. Electricity demand would increase by a maximum of 17% nation-wide compared to a non-electric future [Brown et al., 2010].

A study on Province of Milan has shown as in an optimistic hypothesis of 30% market share, the impact on the 2030 power grid represents only 2.5% but with non-negligible effects on the daily electric power request [Perujo et al., 2010].

On the other hand a research developed in Belgium [Green et al., 2010] has shown that the new load creates power losses and voltage deviations during peak periods and that the impact on the distribution grid cannot be negligible to preserve the reliability of the electric grid.

A set of influencing factors have been identified by Green (2010):

1. Driving patterns, because they define where and when the EV has to be charged. For example, home related dwelling time is 75% of total with an average of more than 10 hours, while work related stops account for just 14% with an average of 6 h [Li Zhang et al., 2011]. Therefore, it was observed that the availability of charging stations in the workplace reduces home peak load for 20% and about 35% if they are present also in commercial areas [Morrow et al., 2008].

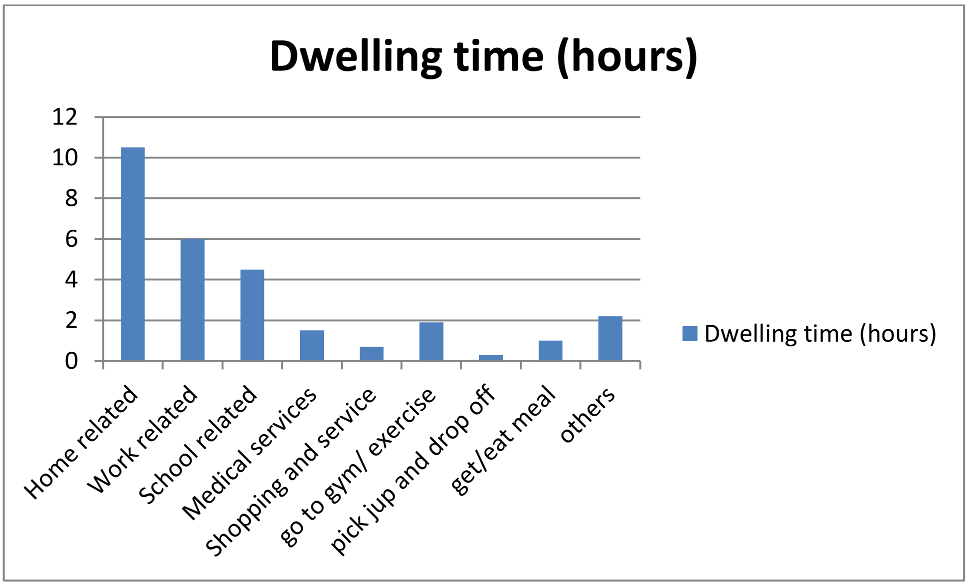


Figure 8: Dwelling time [Li Zhang et al., 2011]

2. Charging characteristics, simply the loading characteristics of EVs in different locations: type of circuit, voltage drawn, load added to the circuit, amount of time that charging takes.
3. The charging timing, which considers both macro scale and micro scale. The former refers to the time and the seasons of the year: summer and winter present peaks periods for the grid because of air conditioners and heaters. An experiment made in Blacksburg [Shao et al., 2009] has shown as in winter/summer the transformer load increases until 68/52 % with normal charging and 98% with fast charging, causing an overload. The micro scale effects, meaning the daily charging tendencies, differs in two kinds of charging:
   - **Uncontrolled charging** (or uniform charging): EV charges when it's plugged in, in absence of smart technologies.

   - **Regulated charging**: based on incentives of information that would coerce people into charging their EVs at specific times of the day. It can incorporate smart technology, which allows an off-peak charging and an improved household load control. In Canada, for example, it has been estimated that half million EVs by 2018 would increase night time electricity demand more than 40%, leveraging the daily demand [Government of Canada, 2008].

4. In addition the number of vehicles and penetration, vehicle-to-grid technology, metrics (reliability of the distribution grid) are crucial factors to be considered [1].

[1] The most used are System Average Interruption Duration Index (SAIDI), System Average Interruption Frequency Index (SAIFI), Customer Average Interruption Duration Index (CAIDI), and Customer Average Interruption; Frequency Index (CAIFI). This is very important as utilities use these measures in the planning and analysis of their own distribution grids.

2.5.5 Grid vicious cycle

The development of a diffuse charging infrastructure is more often interpreted as the premise to overcome the psychological barrier typical of a potential customer. The Charging Service Providers (CSPs), stakeholder responsible of installing charging stations, are willing to invest in public charging infrastructure only when the investment is forecasted as profitable. Unfortunately, more often also potential customers are reluctant to purchase an EV until a charging infrastructure is considered extended and capillary. This deadlock underlines the complexity generated by the tight relationships between the different performances of each stakeholder, which can be overcome with long term investments supported by big players or public administrations or simply financing in an advanced system of information sharing and cooperative environment.

2.6 The role of standardization in e-mobility

The role of **standardization** is crucial in order to reduce the uncertainty tied to different e-mobility fields, introducing common practices and regulations. In fact standards represent both a constraint and an information source for the different e-mobility players, facilitating the cooperation among the complex stakeholders network, as occurs between the charging service providers and the customers when the latter needs to charge the vehicle.

In order to support an emerging market as electric mobility it is important the development of standards related to the below study fields [Brown, 2010; Gerst et al., 2012]:

- Provision of international compatibility between jurisdictions;
- Provision of interoperability for international trade of components in the automotive industries;
- Creation of a mechanism to share knowledge and make this knowledge of a public good;
- Grant of a performance based perspective to interpret new developments in technology.

Standards are the result of a complex consensus-based process, where the opinions of stakeholders, experts, governments and academia come to an agreement on performance levels and procedures. In this perspective Standards Development Organizations (SDOs) play a key role in particular at international level such as International Organization for Standardization (ISO) and the International Electro-technical Commission (IEC). Moreover federal and national institutions (for Europe the Committee for Electro technical Standardization) have to recognize and adopt the defined standards at an operative level. Anyway, as already stated, standards have the purpose to be international in scope, going beyond national boundaries.

Particularly for e-mobility industry, the battery is the most analysed field, with a focus on the disposal (EEC Directive 91/157) and a standardised scale for interpreting technology performances objectively.

Standards should be defined for upcoming V2G technology and its integration with the smart grid. A suite of international and national electric codes and standards already exists for the electrical grid. Anyway, the introduction of smart grids and V2G technologies has to be followed by an upgrade in standards and regulations. At the moment, there is a limited number of standards regarding the two-way electricity transfer between vehicle and grid, and the already existing standards (as ANSI C12) needs to be revised and harmonized jurisdictionally.

2.7 Uncertain affordability and environmental performances

Even if the purchasing price represents one of the most important barriers from customers perspective, more often potential e-drivers are confused about the economic performances of EVs. In fact, the complexity in investigating the total cost of ownership of EV lies in the different cost drivers and assumptions that researchers have to formulate to perform the affordability study. Usually, the cost drivers used to evaluate the ***total cost of ownerships*** are the depreciation costs, fuel costs, maintenance costs, fees and taxes.

The ***EV purchasing price*** is surely higher than a comparable ICV, mostly because of the incidence of battery components on total vehicle cost, which is close to 30%. Anyway, the EV allows lower maintenance costs, due to the simpler mechanical components: the lack of the gasoline engine, tank and tailpipe systems reduces the probability of interventions for fixing potential issues. In addition also operative costs, mainly related to fuel, are favourable for EV.

The drivers of complexity to estimate the affordability of an EV compared with an equivalent ICV lie in two main factors: the depreciation costs and the petroleum price. In fact, for the first factor, actually it is not still possible to evaluate clearly the degradation of battery in the long term and, even some car manufacturers guarantees its quality for several years (e.g. Nissan for five years), the loss of performances tied to a lower driving range makes plausible the chance to switch the battery with a new one, increasing the total cost of ownership as well as the depreciations costs.

Instead the petroleum price represents an important question mark in the medium term: if gasoline price increases, also the convenience of driving an EV raises as well.

Researchers have reached contrasting results in estimating the EV total cost of ownership: if some studies state that the purchase of an EV is not convenient without tax subsidies, others affirm that incentives are useful to reduce the barrier related to purchasing price, even if the vehicle is competitive under an economic perspective.

A recent research of University of North Carolina [Hui-Kuan Tseng, 2013] has shown as actually only the hybrids without plug-in vehicles incur lifetime total costs equivalent to a conventional ICV. Instead the provision of tax incentives makes more affordable the purchase of EVs with a lifetime total cost no higher than 5% (with the exclusion of PHEV with 35 miles of driving range).

On the other hand, an analogous study of Electric Power Research Institute (EPRI, 2013) has shown as the total cost of ownership for PHEV and FEV is lower than ICV and HEV, even in the absence of governmental subsidies.

These contrasting results underline the different interpretations from economic perspective, enforcing the ***uncertainty in estimating the potential monetary gains*** in purchasing an EV.

Also the improvements in environmental performance derived by e-mobility propagation is under debate and more often guide governments to justify investments or “fence sitter” positions in releasing (or not) dedicated incentives.

In the scientific and technical literature different results are the consequence of diverse applied methodologies used to tackle the complexity and different forecasts about future trends of the factors. The environmental performances represent one of the crucial aspects to investigate, and the huge amount of information in this field should be processed and integrated in order to communicate the ***real EV environmental impact and evaluate the alignment with international agreements***.

An important model introduced by US department of energy (2010) is the Greenhouse Gases (GHG), Regulated Emissions and Energy Use in Transportation (GREET). This model underlines that it is not true that EVs are zero-emissions transportation means, but they have moved pollution causes off-board and upstream, generating a non-negligible environmental impact. The GREET model can be used to estimate the emissions associated with the upstream production of vehicle components, vehicle assembly, disposal and recycling, production and disposal of fluids and batteries [Hui-Kuan, 2013]. The results of the model define the level of upstream pollutant emissions in terms of tons of different gases (CO, NO_x, PM10, PM2.5, SO_x, VOC, GHG), and, according to the University of Carolina research, EVs have the worst emissions value. In fact, if compared with ICVs, EVs have a more problematic production of components, first of all the battery.

As demonstrated in this study, the EVs as zero-emissions transport means is a misbelief: different researches, focused only on CO2, have provided only a limited and biased vision of the reality (as Weiller, 2011) and should be extended to all the gases produced.

By considering both production and tailpipe emissions, EVs have higher gas emissions for what regards PM10, PM2.5 and almost the double (82% more) of SO_x, instead the GHG present a flection of 82% if compared with ICVs.

2.8 Complex system of incentives and regulations

In order to overcome the purchasing barrier, several governments during these years have established a number of polices to encourage people to buy electric cars, but in most of the countries a real industry plan is not still defined.

In fact the countries that release modest funds which are consumed in few days (as Italy) enhance the uncertainty of the automotive industry, pushing and grouping the sales in the period in which the incentives are released and for the successive span creating the so called down effect.

In this context the government polices affect the overall ***market uncertainty*** introducing a higher complexity in analysis of the EV success among the population and tightening the dependency of the sales with the incentive promulgation [Bal; 2014].

The establishment of policies is a very ***complex process***, with several stakeholders involved and with an important uncertainty about factors to take into consideration. A common misbelief correlates the amount of released incentives with an improvement of EV sales; however, a better policy analysis based on the collection and integration of data allows to ***make informed decisions***, improving the efficacy of the released policies.

Typically the government policies are structured in two main streams:

- **Regulations**
  They are norms that regulate the purchase of the pollutant vehicles, making them more expensive due to higher tax regime. This can contribute to raise money to pay all the

incentives established for EVs. Although the norms are restrictive, they represent a positive constraint to which the entire population must withstand without a free choice and guide people towards strategic choices that will lead to an eco-friendly future.

- **Incentives**

  On the contrary, the incentives foster the purchase of electric vehicles making them less expensive for those who are going to choose a vehicle exposed to these policies.

  There are three main types of policy incentives. The **direct subsidies** represent a one-time bonus upon the EV purchase, while **fiscal incentives** reduce purchase and/or annual tax for EVs. Finally the **fuel cost saving** are emitted to allow electricity prices to be lower than fuel price, thanks to a lower taxation and/or lower energy costs [RVO, Dutch National Office for Enterprising); 2014].

As far as fiscal incentives concern, four main kinds of tax breaks exist. A partial or total exemption from the **Value Added Tax (VAT)**, applied to the vehicle purchase, usually based on its price. Norway is the only country which guarantees the total exemption, with a 25% discount on the final paid price. Secondly the **one time purchase/registration tax**, which more often varies according to the vehicle emissions, power or weight, as in Norway. Thirdly the **annual circulation tax**, tied to the ownership of the vehicle, generally based on vehicle weight, and **company car tax**, applied to corporate fleets.

The following paragraph presents the level of incentives and regulations established in different nations (figure # 9) in order to underline the overall polices pattern of the main countries debated in this research, . The analysed countries are Italy and Netherlands because they represent the states in which the thesis is going to be developed and tested; and Norway because is the European country with the highest penetration rate as well as the strongest system of policies established in the world, useful to benchmark the two targeted countries.

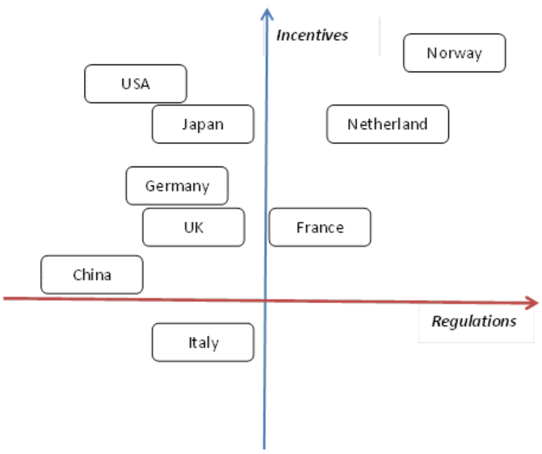


Figure 9: Government policies positioning:

2.8.1 Italy

In 2012 the sold EVs have been 524, reaching a market penetration of 0,041% in the 2013 [Celi; 2013].

These data underline the immature Italian situation in EV segment due to an inconsistent and scattered incentives and regulations plans that targeted 2-3,5 millions of vehicle by 2020.

The European commission has allocated to the eco-vehicle (CO2 emission lower than 120g/km) €40 million for the 2013 and 35 million for the 2014, figures which comprehend the following program of incentives:

- Vehicles that produce less than 50g/km CO2 can benefit of a purchase saving of 20%, even if the maximum amount must be 5000€.
- “Electric vehicles are exempt from the annual circulation tax (ownership tax) for a period of five years from the date of their first registration. After this five-year period, they benefit from a 75% reduction of the tax rate applied to equivalent petrol vehicles in many regions” [ACEA; 2013].

The future proposes for the 2014 introduce regulations programs that follow the modality of “Bonus-Malus” similar to the French one.

The objective of this regulation is to increase the taxes for the more pollutant vehicles and foster the purchase of the ecological ones. The incentives related to the cleaner vehicle are directly paid by the purchaser of less eco-friendly vehicles.

The main problem of Italian incentive system is represented by their volatility tied to the fast depletion: the funds released with the plan “Ecoincentivi 2014” have been depleted in two days, showing not a strategic plan for the future, but creating anxiety and illusion in potential customer [Ecoincentivi 2014, 2014].

2.8.2 Netherlands

In 2013, the sales of the EVs in Holland have reached a penetration of 0.17% and a market share of 5,6% (second largest per capita market in the world), that is a remarkable value considering the United States and Japan (the world's two largest automotive markets) that are around three times less than Netherlands [Cobb; 2014].

The growth in the sales, in the 2013, has been risen about 4 times due to 24512 range-extended and plug-in hybrids sales, 4161 pure electric cars, and 669 electric utility vans [RVO (Dutch National Office for Enterprising); 2014]. These data make Netherlands the first worldwide market in PHEV market share: this is the consequence of the incentives system, more tailored on this kind of vehicle instead of BEV (whose sales remain constant during last two years).

These astonishing results are achieved due to a massive incentive campaign that targeted around 15000 electric vehicles with three or more wheels on the roads in 2015, 200000 vehicles in 2020 and 1 million vehicles in 2025.

The Dutch government incentives are composed as follows:

- In 2014, the pure electric vehicles are not exempt to the registration fee like in the past, but pay a tax of 4% and plug-in hybrids a 7% fee [Nederlandse Omroep Stichting (NOS); 2013].
- The EVs due to new regulations have easier access to the parking spaces, thanks to reserved park for battery electric vehicles.
- High gasoline taxation (which raises prices to 1,65€ per litre in March 2014), which makes the cost of running an ICV five times more expensive than a EV.

2.8.3 Norway

Norway has the highest share of electric vehicles sales (combining BEV and PHEV) with about 6% of all passenger cars sold in 2013 [Gronnbil; 2014].

The parliament of Norway has targeted 50000 zero emission vehicles by 2018 and in order to achieve this ambitious objective has structured an important incentives plan that worth 5942€ per year for each “E-driver” [Alister Doyle and Nerijus Adomaitis; 2013]:

- All-electric cars are exempt from purchase taxes (25% VAT), making the price of EV competitive with the ICV [Lars Ole Valøen; 2012].
- The government has settled very high purchase tax for ordinary cars, depending on their emissions.
- Electric vehicles are exempt from the annual road tax, all public parking fees and toll payments, as well as being able to use bus lanes, respectively valuing 1014€ and 3623€ [Lars Ole Valøen; 2012].
- Electricity price very competitive on gasoline costs.

2.9 Information management

The previous set of paragraphs highlights the intrinsic complexity and uncertainty tied to e-mobility industry. Therefore, the analysis has been conducted in order to organise the different issues characterising the e-mobility world, described and summarised in drivers in the following table.

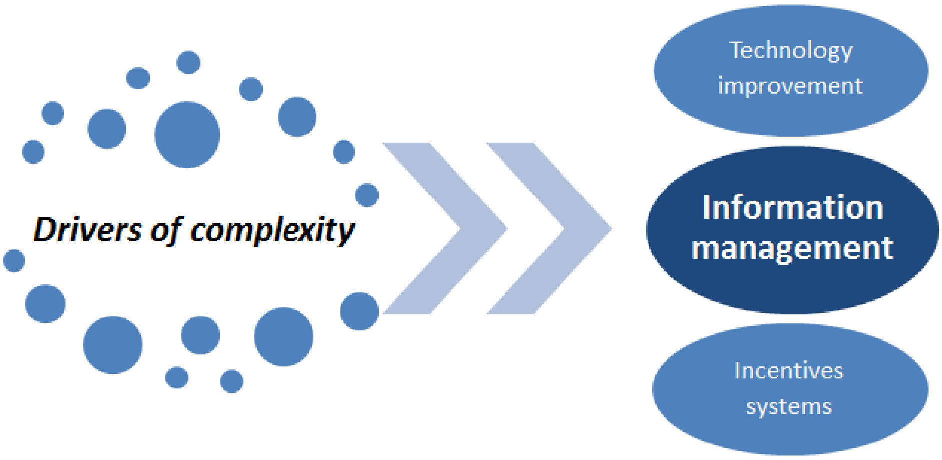
	COMPLEXITY AND UNCERTAINTY DRIVERS
Unclear e-mobility definition	• Many and confuse nomenclature
Variable e-mobility popularity	• Variable media and public interest
Battery technology instability	• There different technology (NiMH, ZEBRA and Lithium ion) in a decade • Rare resources usage • Battery disposal and recycling • Range • Charging time • Battery Management System
Distribution grid and charging infrastructure complexity	• Peak load Management • Pricing methodology • V2G and Smart grid developments • Grid vicious cycle • Information management
The role of the standardization in e-mobility	• New standard requirement (Battery and V2G) • International compatibility • Performance comparison
Uncertain affordability and environmental performances	• Contrasting affordability results on total cost of ownership • Petroleum price • Purchasing price • Environmental performances
Complex system of incentives and regulations	• Different regulations and incentives affecting the EV sales

Table 1: Complexity and uncertainty drivers

The issues arising from the e-mobility complexity (listed in the above table) can be overcome:

- improving the ***existing technologies***, in particular battery pack (*paragraph 2.4)*, distribution grid and charging infrastructure (*paragraph 2.5*);
- releasing more efficient ***incentive systems*** to decrease the purchasing price (*paragraph 2.7*) and to support the development of an established charging infrastructure grid (*paragraph 2.5*);
- improving the ***information management*** characterising the e-mobility world.

While the first two purposes represent the main investigated fields by the main e-mobility stakeholders and scholars, the information management is often neglected even if the abundance of data arisen from the complexity drivers, owned by diverse players which characterises this sector. Therefore, a critical lack is individuated in the integration and organization of information that could overthrow e-mobility barriers and improve the actual performance measurement systems.



2.9.1 Thesis Objectives

The thesis objective is the analysis of the information management in the e-mobility world, underlining the gaps of the AS-IS situation in order to provide the basis for the development of a methodology, which organizes and integrates the different information coming from the e-mobility network in order to reduce the complexity and propose measurements for the e-mobility stakeholders' performances.

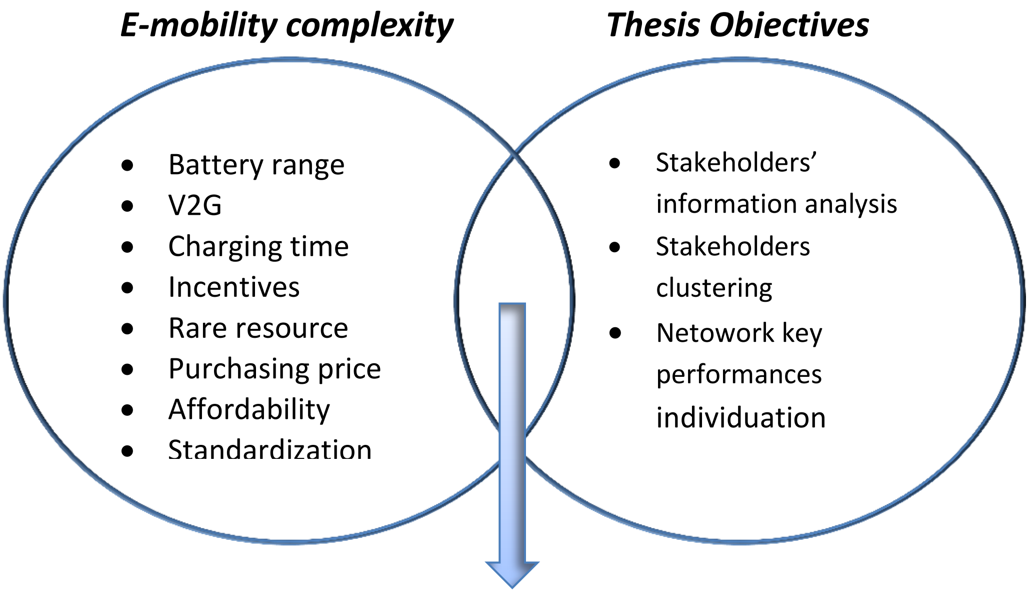
The analysis focuses on the e-mobility stakeholders' information management peculiarities: information strategy, needs, type of data (structured and unstructured), the data sources and the information exchanges among the e-mobility network.

The thesis methodology provides an analysis framework, reducing the network information management complexity, through a stakeholder clustering and managing the typical network accountability issues: data sharing and trust.

In fact, as underlined in the first part of the literature analysis (chapter 2) e-mobility is characterised by a diffuse information management complexity arisen from the multi issues and multi stakeholders environment, generating the necessity to analyse which are the leading actors and the information they own and share in the network.

Therefore the methodology approach is composed by the following steps:

1. Analysis of the information role in the e-mobility sector.
2. Stakeholders clustering according they informative peculiarities and needs, creating different clusters, in order to reduce the network complexity and improve the integration and organization of the existing information. The clustering represents the core of the methodology because the stakeholders belonging to the e-mobility network are characterized by tight relationships (e.g. partnership) between stakeholders and strong similarities between actors regarding business activities and objectives, sharing most of the data.
3. Proposition of indicators, which monitors and underlines the main performances of the network, no more linked to the single stakeholders but aligned with the complex e-mobility network, focusing on the exchange of information among players in the network, with the overall purpose to support and fulfil the weaknesses and lacks in the as-is e-mobility information management.



"E-mobility refers to a complex and dynamic network of stakeholders aimed to foster the widespread usage of the electric vehicle. These interrelations shape up an "eco-system" where knowledge, know-how, structured and unstructured data arise from new sources of information made available 'on the net'."

3. E-MOBILITY INFORMATION MANAGEMENT

The following chapter, starting from the thesis objectives, aims to provide the theoretical basis and frameworks to investigate the information management AS-IS situation in the E-mobility world.

As explained in the chapter 2, so far in the e-mobility sector is not still presented a structured and defined methodology to collect, organize and integrate the huge amount of information coming from the several stakeholders. The different players possess valuable data without sharing them in the network, constraining the cooperation among stakeholders, thus the propagation of the EV.

Therefore the following chapter, composed by three paragraphs, aims to support the study of the information role in the e-mobility world in order to support the creation of a new methodology, based on three steps, which identifies and organizes the amount of data arisen from the multi-actors e-mobility environment and proposes some measurements, underlining the network key performances.

The first step in the literature analysis is the study of scientific papers which support the e-mobility environment understanding, deepening the investigation on the main characteristics of this sector (chapter 2): tight **network of relationships** between actors and a **high number of stakeholders.** The preliminary investigation of the main e-mobility features as well as the analysis of the AS-IS information management situation based on each stakeholders' peculiarities implies the research of the main **stakeholders' analysis** methods and the **clustering** framework, which improve the comprehension of a complex system of stakeholders' network. Therefore the first literature analysis chapter aims to provide the theoretical knowledge to understand and study the e-mobility information background.

Understood the main peculiarities of the e-mobility environment, the second chapter of the literature analysis aims to present the **several typologies of data**, presented in the e-mobility world, and the **collecting methods** crucial to organize this heterogeneous amount of data coming from the interwoven e-mobility stakeholders' network. The second literature analysis chapter provides the theoretical basis for a new methodology in which the e-mobility information are organized and integrated, identifying the stakeholders' data peculiarities and ownership without neglecting the data exchange in the network in order to depict the information role of each e-mobility player.

The last literature analysis chapter, considered the network and multi stakeholders' peculiarities as well as the information management of each stakeholder, presents the analysis of the studies conducted on the accountability focused on the network and no more on the single stakeholders in order to provide a further theoretical knowledge which supports the study of the e-mobility information management and the basis for the proposition of some e-mobility measurements.

3.1 Stakeholders analysis

The e-mobility world is the field where different players not only compete with each other, but also cooperate in order to reach common results. From this perspective, it is easy to figure out the presence of several stakeholders who form, for each fundamental decision, a complex multi-issue network. In fact, the stakeholders' performances are strongly interrelated and the possible failures of single players impact on the overall network results, underlining the importance of the creation of a structured information management methodology which foster the cooperation and the achievement of the stakeholder's objectives.

The literature analysis on the stakeholders' management is structured considering the following stages:

1. Conceptual definitions on the stakeholders as well as the network.
2. Overview on the main methods used to identify and analyze the stakeholders.
3. Stakeholder clustering methods following both bottom-up and top-down approaches.

In particular the stakeholders' analysis and clustering aim to reduce the complexity of the competitive environment improving the effectiveness in the analysis of an interwoven system of actors, grouping together players according to different attributes.

3.1.1 Stakeholder and network conceptual definitions

During the last century several researchers and experts have stated their own definition of the term "stakeholder", the following ones represent only the most significant:

- "Groups to whom the corporation is responsible" [Alkhafaji, 1989];
- "People or small groups with the power to respond to, negotiate with, and change the strategic future of the organization" [Eden and Ackermann, 1998];
- Groups "on which the organization is dependent for its continued survival" [Stanford Research Institute, 1963];

- “An individual or group who can affect the achievement of an organization's objectives or who is affected by the achievement of an organization's objectives" [Freeman and Reed,1983];
- “Any group or individual who can affect or is affected by the achievement of the organization's objectives" [Freeman, 1984];
- "Voluntary stakeholders bear some form of risk as a result of having invested some form of capital, human or financial, something of value, in a firm. Involuntary stakeholders are placed at risk as a result of a firm's activities. But without the element of risk there is no stake“[Clarkson, 1994].

From these definitions three main elements can be extracted:

- A stakeholder can affect directly the organization’s core economic results and even if not part of it he/she has power over the organization;
- A stakeholder is affected by organization results and is dependent on it. From this point of view the organization exercises power over the stakeholder, showing a mutual power dependency.
- A stakeholder bears a risk which is formalized often in contractual relationships and anyway is expressed in a legitimate claim on the organization.

Today the strong interrelationships between stakeholders, inside and outside the firm, has moved the attention of researchers and practitioners from the analysis of the single stakeholders, to the analysis of the relationships between players, which more often form an internal network within the firm and an external network between organizations. This upcoming network concept is opposed to **hierarchy**, namely the traditional approach to study the management of corporations considering the vertical decision making flow: the decisions taken at strategic level provide the objectives for the operative level, thus the decisions and the stakeholders behaviours are analysed under a vertical flow instead of a peer-to-peer relationship that shapes up the network.

“A **network** can be defined as a number of actors with different goals and interests and different resources, who depend on each other for the realization of their goals.” (De Bruijn, 2008)

This definition suits perfectly with e-mobility environment, where different stakeholders, working in different business fields, are more often forced to collaborate with the shared ambition to foster the EV propagation.

Before analysing the relationships between network actors, it is fundamental to study the stakeholder as autonomous entity. An actor can be bearer of opinions, interests and resources of an entire organization: it's possible to speak about **collective actor** if "the interaction mechanisms between the individuals, who constitute itself, present sufficient stability and equilibrium to assure that whoever speaks in its name is effectively representing the interests and objectives of the superior unit and not exclusively their own ones" (Dente, 2011). This means that it is not possible to define an actor as a simple aggregation of individuals, who pursue their individual objectives. Only in case of a manifest sufficient coherence and a collective management of the resources the organization can be treated as a unique actor. In case of heterogeneous coalitions or social movements, even if there is community of interests, often the parties are free to participate (or not) to the decision making process and dissent: for this reason each single party is treated as an actor.

Ultimately it is possible to speak about "collective actor" when three conditions are satisfied (Scharpf, 1997):

- Presence of an main interest of the superior unit, which is recognised by the members, coherent with their opinions;
- Presence of a system of formal and informal procedures that each individual has to follow when he is representing the collective actor;
- Sharing of a sense of collective identity among the individuals.

Networks can be both intra or inter-organizations and both in private and public sectors. Focusing on the first case, an **internal network** is peculiar of organizations in which different societal interests are institutionalised and are in contrast in a resource constrained environment.

In addition profit and no-profit companies are organized through different business and staff units. This fact introduces fragmentation in the organization which has to be tackled through dedicated roles and procedure which take into consideration the internal network as a whole. As underlined by Dente (2011), the decisional fragmentation – moreover in the public sector - has increased the decisional costs, but these overcome the benefits only in case of strict system-internal inefficiencies. It is true that "deciding" is often synonymous of "cutting off" alternatives, but "it's not necessarily true that the best tool to make this action is the sword, or its modern equivalents, i.e. the majority will or the rationality of a governor-manager" [Bobbio, 1996]. The sociological basis of this statement lies in the fact that a society based on the interactions and preferences of individuals tends to work better than one based on the human acting, because it foresees to provide answers to citizens' requirements even when these are contradictory and irrational [Lindblom, 1979].

This fact is nowadays accepted by a large part of researchers, because given the increasing difficulties in making important decisions in contemporary societies, "it is more than reasonable expecting that they implies a plurality of actors with different objectives and resources who influence each other", as stated by Dahl (1961) and at the basis of pluralistic paradigm.

On another perspective companies are dependent on outside stakeholders, from governments to the all supply chain, which have different interests. All these entities form an **external network** with the company itself [Clarke, 2007]. This concept is made more complex because of the raise of the coopetition [Brandenburger, 1997]: actors which usually are competitors, for a certain projects become partners, sharing resources and know-how. The levels of information exchanged with these stakeholders have to be strictly regulated in order not to lose competitive advantages.

Also public administration itself is not the peak of a pyramid, but instead needs the support of the other societal parties: "the outcomes of a public policy decision making process depend on the interaction between diverse kinds of actors, with different objectives and roles, who, within a network which can present different features, exchange resources by using different interaction modalities in order to pursue an objective" (Dente, 2011).

The concept of network is opposed to hierarchy, namely "a system in which members of an organization or society are ranked according to relative status or authority" [Oxford dictionary, 2014]. This **dualism** has been studied by several researchers, and the features of the former are summarised in four attributes in De Bruijn (2008):

- Existence of a certain degree of uniformity within an organization or between organizations. When the level of differentiation rises, several trade-off appears because some interests are in contrast. The higher the degree of uniformity, the larger the span of control allowed for an intervening actor.
- Pyramidal power structure with superiors and subordinates. This assumption is difficult to register in reality, because often the formal hierarchical structure of the organizational chart shows several dependencies in everyday work life.
- Actors are open to interventions of a hierarchically superior actor.
- The hierarchical structure is stable over time and, for example, no organizational units are added or removed in the medium-short term.

These characteristics are reasonably difficult to appear in reality and more often organizations are studied as networks. Anyway, depending on the level of analysis, researchers can focus only on external network (macro analysis) or internal networks (micro analysis), considering in the first case the organization as a hierarchy, guided by a unique entity and internally homogeneous.

All these characteristics make the decision making in a network "capricious and unstructured", not project-based but process based, namely a continuous process of interaction between the interdependent players in the network. It is not composed by sequential phases and problems, but solutions and goals are defined ad re-defined during the process itself. Information represents a key resource from a content perspective, as relations for the network actors.

3.1.2 Stakeholder management

A complex network of stakeholders implies the necessity to manage the intricate system of stakeholders starting from the identification of all the players which own a specific stake in the decisional topic. Afterwards the single stakeholders have to be analysed in detail and group according their peculiarities.

The stakeholders 'clustering, often overlapped to the stakeholders' analysis, aims to ***reduce the complexity*** with the purposes to improve the effectiveness in the information management analysis, attempting to depict the e-mobility information management AS-IS situation.

In fact this process aims to group the actors in such a way that the similar characteristics allow to treat the cluster as a unique entity or to group actors which present high communality, relationship intensity or similar business profile.

Usually the stakeholders' number is very high and a selection of the most influent players and a study of relationships' ties and intensity between stakeholders are necessary to evaluate the possibility to cluster them.

In particular the players are analysed in order to understand, among all their features, ***the data owned***, fundamental resource they bring to the network.

The **stakeholders'** analysis starts with a strict **identification** of all the possible stakeholders, even those not critical. For this purpose, a set of tools, very common among practitioners, are presented:

- **Brainstorming sessions**, namely "A spontaneous group discussion to produce ideas and ways of solving problems" [Oxford Dictionary]. The selection of persons performing this activity is crucial to explore several different minds' perspectives. The interrogation of every people could be crucial to propose possible stakeholders anonymously on stickers, report them on a flip chart and discuss together [Paulus et. al, 1993].

- **Mind mapping** is very useful to unlock creativity by thinking in a structural way. Different kinds of mind maps exist depending on the decision making context. The most common represents tree charts where the branches are occupied by a template of figures which are recurring in the specific field of decision.

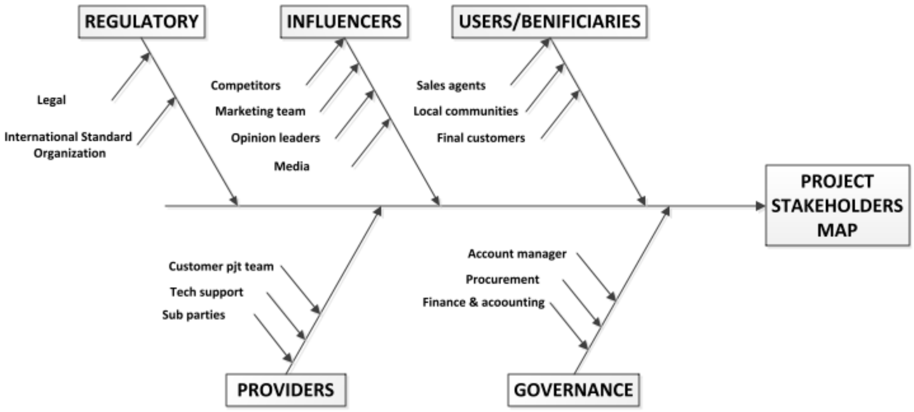


Figure 10: Stakeholder Map example

- **Stakeholders' list** implies a list of hundreds of stakeholders who can be used as a check list in order to identify a rough set of stakeholders and stimulate new ideas. An example is provided in the appendix.
- **Previous projects:** an entire part of the project charter is dedicated to the analysis of stakeholders. For this reason past projects represent a source of information not only for what regards the identification of stakeholders, but they offer a historical analysis of their behaviours and attributes.
- **Organisation charts and directories** are useful to look for both internal and external stakeholders. The use of social media as LinkedIn allows searching for company, industry, and seniority and job roles.

Exploiting the previous tools, aimed to identify the crucial players, a preliminary **stakeholders' analysis** and a following **clustering** is performed in order to study the single stakeholders' features and improve the investigation effectiveness reducing the complexity of the system.

The developments of stakeholder's management frameworks became popular in the management and health policy fields during the nineties. The collection and analysis of the data coming from different stakeholders underline how decisions are taken in a particular environment from the organization perspective. Freeman (1984), Mitchell *et al.* (1997), Eden and Ackermann (1998), Anderson (1999), Bryant (2003), De Brujin (2008) and Dente (2010) have developed methods which consider the stakeholders position, interests, influence, interrelations and networks.

Author and year	**Method's name**	**Stakeholder analysis topic**
Freeman (1984)	Stakeholders map	• Definition of the stakeholders according their main characteristics. • Stakeholders'organizational processes. • Transactions and bargains.
Mitchell *et al.* (1997)	Mitchell model	Salience (power legitimacy and urgency)
Eden and Ackernlann (1998)	• Power versus interest grids • Stakholder influence diagram	• Stakheolder's interests and power in the company future. • Interrelations among the stakeholders.
Bryson Lokkesmoe and Cunningham (2002)	Bases of power-directions of interest diagram	Adaptation and merger of the two methods developed by Eden and Ackernlann.
Anderson and Crosby (1999)	Problem-frame stakeholder maps	Establishment of a winning coalition among the stakeholders analysing their interests and relationships.
Bryant, J. (2003)	Stakeholder-issue interrelationship diagram	Relations between stakeholders and the common interests towards the same issues.
The international Association for Public Participation	Partecipation planning matrix	Commitment and involvement of the different stakeholders in the projects.
De Bruijn (2008)	/	Stakeholders' opinions, interest, resources and power positions.
Dente (2011)	/	Resources and network indicators

Table 2: Stakeholders' management literature analysis

The stakeholders' analysis was born as an approach to conduct policies focused on the distribution of power and the role of interest groups in the decision making and policy process.

Prestion (1990) sustained that the stakeholders' analysis management roots were originated in the 1930s in General Electric Company, in which four interest groups were generated: customers, employees, the general public and shareholders. According to his studies the organization should consider all the needs of the previous groups of stakeholders, evaluating the threats and opportunities carried out by the stakheolders.

In the 1980s within the US health care management the stakeholder analysis became a systematic approach, deppening the investigation on the studies conducted in the 1930 by General Electric Company. The methods were composed by structured steps with the purposes to improve the understanding of the relevant stakeholders, in particular on their behaviour, intentions, interrelations, agendas, interests and the influence or resources involved in the decision making process [Blair and Whitehead, 1988].

Freeman (1984), devolping one of the first and most complete stakeholder analyisis framework, outlined the importance for studying the influence that the stakeholders play on the organization wellbeing and on the achievement of its objectives.

His method was composed by three main levels of analysis according to the processes in which the company manage the relationahips with the stakeholders:

- **Rational level: stakeholders map**
  It consists in the basic definition on who are the stakeholders, how can affect and be affected by the organization goals accomplishement through the creation of a stakheolders'map. The starting point is represented by the general stakeholder subdivision developed by General Electric in the 1930s (Employee, customer, general public and shareholders) and afterwards enlarging the different categories, attempting to cover all the players which contribute and influence the company life.
- **Organizational processes**
  Analysis crucial to esplicit the organizational processes among stakholders, underlining the main relationships and assess if these processes are suitable with the stakholders map previously created.
- **Transactions and bargains**
  The negotiations undertaken by the stakeholders in order to balance their interests in achieving the company goals and evaluate the stakeholder management capability.

The first group of studies related to the stakeholder analysis regarded the investigation on the characteristics of the single stakeholders (behaviour, interest, contributes to the company) and the main relationships tighted in the company. These studies, conducted in the eighties, nelglected the interconnections and influeces between the different stakeholders' attributes (interests, impact on the company, relationships) without achieving a precise classification of them. During the nineties, Eden and Ackernlann (1998) proposed two methods that have been considered the stakeholder analysis pillars and the basis for further studies conducted by Bryson Lokkesmoe, Cunningham (2002) and Bryant, J. (2003), in which the the stakeholders' attributes have been combined in order to evaluate the effect that creates to each other. The simple framework consisted in analysing and clustering the stakeholders according to two matrix dimensions: power and the interest of the stakeholders. By filling the matrix, the decision maker (or the manager) can focus on the highest priority stakeholders, dedicating less effort to the low-priority ones. The matrix – presented here as drawn down by Eden and Ackermann (1998) – shows a set of engagement strategies useful to ***manage the relationships*** with the different kind of stakeholder. The arrows underline the dynamics which can occur over time, when the interests of players increase and, in the same way, also their positions change.

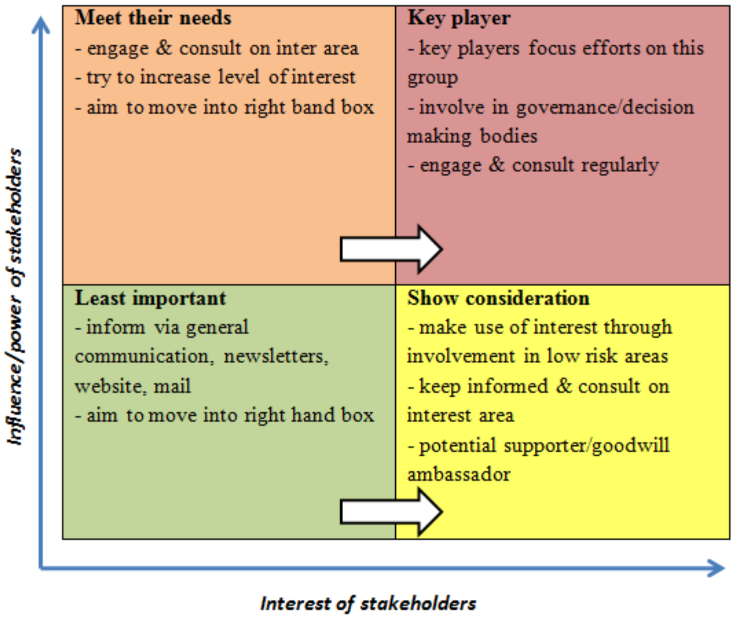


Figure 11: the Bryant's model

The main innovation of the model respect the previous ones lies in the attention dedicated not only to the single stakeholders, but to their interrelationships and the influences to each other. The objects of analysis are now the different clusters with their diverse relative importance during decision making: different strategies are proposed to manage the stakeholders group and not only the single stakeholders, reducing the analysis complexity.

The differentiation of the key players among all the stakeholders is useful for the success of the decision making process. They can present high political interest and enough power to stop or make the process successful.

The other stakeholder management pillar developed by Eden and Ackermann (1998) aimed to show the influence of stakeholders on each other through ties (one or bi-directional) which linked the stakeholders. This was useful to underline the relationships between stakeholders and the flows of eventual issues. The stronger influences could be highlighted in order to point out the most critical ones.

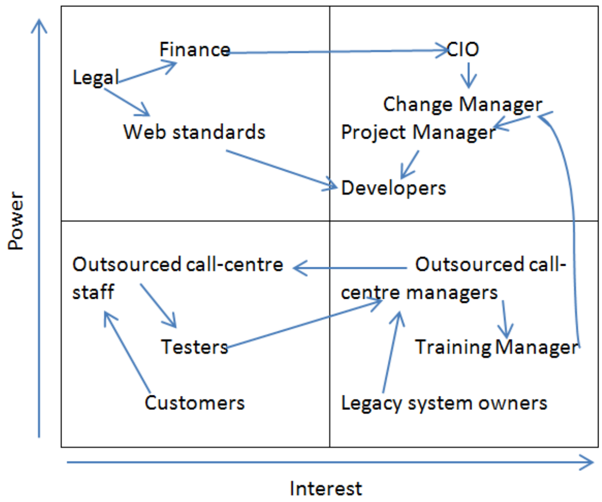


Figure 12: stakeholder relationships

Bryson Lokkesmoe and Cunningham in the 2002s have adapted the Eden and Ackermann (1998) methods, previously described, in a new one, attempting to address more closely at each stakeholder group and the related power and interests, embedding the network leading actors:

- **Bases of power-directions of interest diagram**
  The diagram presents the sources of power available to the stakeholder and the stakeholders' interests and goals in the organization.
  Power arises from money, votes or authority and Interest indicates the expectations of the stakeholder in the company. The diagram focuses on the power and interest precisely in relation to particular organization objectives in order to find common interests among different stakeholders and provide background information on each player in order to foster the cooperation.

On the counterpart Bryant, J. (2003) deppened the stakeholder influence diagram of Eden and Ackermann (1998), focusing on the interreletionships between the stakheolders, individuating the stakeholders related to each interest in different problem and concentrates on the relationships that they usually tight.

- **Stakeholder-issue interrelationship diagram**
  The diagram makes clear the potential areas of cooperation among stakeholders and underlines the stakeholders which are characterized by specific interests in different issues through the use of arrows.

Dente (2011), in addition to analyse the relationships between the stakeholders and the related issues and interests (Bryant, J.; 2003), have conducted investigations aimed to measure the ***relationship strength*** among stakeholders which provided the foundation for a further stakeholders' clustering framework based on the relationship intensity (partnership, joint venture,…):

- It is possible to group stakeholders which are interrelated according to a predefined cluster **width**. Empirically a network characterized by less than 4-6 actors and more than 12-15 does not exist considering just the stakeholders that have a significant role in determining the results. This aspect is due to the heterogeneity of the objective, most of the times in contrast to each other that make impossible the cohabitation of too diverse actors with different purposes in the same network.
- It is possible to cluster a subset of stakeholders which, considering their interrelationships, generates a peculiar **form** of network, embedding the actors involved and the relationship. This gives rise to the opportunity to classify clusters considering the diverse forms made by the relationships: star, nested and total interaction [Dente, 2011].
- The principle of **Homophily** is based on the attitude of actors to make relationships with similar or dissimilar entities regarding socio demographic, behavioural and intrapersonal characteristics, creating homogenous networks. Other variables that could be used for the definition of similarity are gender, race, age, occupation, educational achievement, status and values [McPhersonet al., 2001]. As far as a competitive environment concerns, homophily can be considered as the degree of business similarity between stakeholders.

  The actors tend to establish connections with other similar actors or vice versa, thus studying the features of the stakeholders and the related historical data, the prediction of the future relationships become easier. The method used to assign a score to possible collaborations between actors is called "Jaccard's coefficient" [Wasserman & Faust; 1994]:

$$Score(x,y) = \frac{N(x) \cap N(y)}{N(x) \cup N(y)}$$

  N = the number of neighbours (actors characterized by similar features).
  x,y = The two actors.
  From these scores it is possible to cluster the stakeholders in groups, depending on their homophily.

- The **density** is the quantity of relationship between the actors in a network. A high level of direct or face to face relationships have an important impact on the interactions: better communication and sharing of information [Dente, 2011].

  The density can be measured as the proportion of the linkages between the actors over the total number of linkages:

$$D = \sum ki/(n^2 - n)$$

  D = Density coefficient [0;1]
  n = number of actors present
  ki = Number of the exiting linkages for each actors
  Stakeholders which present high reciprocal interrelationships can be clustered in the same group.

- The concept of **prestige** is strictly related to the centrality: it measures the number of nominations or choices that an actor gets from other stakeholders, determining the degree of prestige (many nominations mean higher level of prestige). The following formula measures the people that have chosen the node, the higher the ratio, the higher is the prestige [Wasserman & Faust; 1994].

$$P'_d(n_i) = \frac{x+i}{g-1}$$

Mitchell *et al.* (1997) proposed simultaneously Eden and Ackermann (1998) an anlaysis and clustering method, considered by experts another stakeholder management pillar, focused on the analysis of the stakeholders' power, which is defined by Mitchell **salience**: "the degree to which managers give priority to competing stakeholder claims". According to the research "this analysis allows and justifies identification of entities that should be considered stakeholders of the firm, and it also constitutes the set from which managers select those entities they perceive as salient". This model steps forward the previous researchers' analysis (Freeman 1984) who have not considered power as a fundamental dimension of analysis. In the framework the salience of a stakeholder depends on three attributes.

Power to influence the firm has been discussed by several researchers and represents "the probability that one actor within a social relationship would be in a position to carry out his own will despite resistance" (Weber, 1947). Pfeffer (1981) has defined the power as the position in "a relationship among social actors in which one social actor, A, can get another social actor, B, to do something that B would not otherwise have done". Also Lukes (1979) provides its own definition: "the majority of power consists in the ability to model the individuals' preferences, in such a way they are going to support the choices which are against their interests".

According to Etzioni (1964) power can be classified in three ways:

- Coercive, when it is based on the physical resources of force, violence or restraint;
- Utilitarian, when is based on material or financial resources;
- Normative, when is based on symbolic resources.

Power is not a status, but is transitory i.e. can be acquired as well as lost. However, power does not guarantee high salience in a relationship between stakeholders. In fact, this happens only when the stakeholder is "aware of its power and willing to exercise it on the firm" [Mitchell *et al.,* 1997].

The second attribute is represented by **legitimacy**, namely "a generalized perception or assumption that the actions of an entity are desirable, proper or appropriate within some socially constructed system of norms, values, beliefs and definitions" [Suchman, 1995]. According to Weber (1947) legitimacy and power are distinct independent attributes that, when combined, give rise to authority, namely "the legitimate use of power".

The last but not least attribute is the **urgency** of stakeholder's claim, namely the degree to which a stakeholder "calls for immediate attention or pressing" (Merriam-Webster Dictionary). It exists under two conditions:

- When a relationship or claim is tied to the time of execution (time sensitivity);
- When the relationship or claim represents a criticality for the stakeholder. For example it can arise from the ownership of firm-specific assets which cannot be used in a different way, from sentiment which locks the relationships (like in a family), from expectation that the firm is going to continue providing value to the stakeholder, or risk exposure to the firm's business [Clarkson, 1994].

Urgency can be defined as "socially constructed perceptual phenomenon" [Mitchell et al., 1997] because can be perceived correctly or falsely by the other stakeholders.

These attributes have three features in common:

- They are variable during the time: dynamic nature;

- They are socially constructed: not objective nature;
- Consciousness and wilful exercise may or may not be present.

The **stakeholder salience** – following the Mitchell et al.(1997) framework – is positively related to the cumulative number of stakeholder attributes (power, legitimacy and urgency) perceived by managers.

In particular:

- Power in combination with legitimacy gains authority and it is exercised through urgency;
- A stakeholder obtains rights when the legitimacy is accompanied by power and voice when legitimacy goes along with urgency.
- In combination with legitimacy, urgency obtains "access to decision-making channels, and in combination with power, it encourages one-sided stakeholder action. In combination with both, urgency triggers reciprocal acknowledgment and action between stakeholders and managers" [Mitchell et al., 1997].

The intersection of these three attributes allows the creation of eight main areas, which summarise the Mitchell framework.

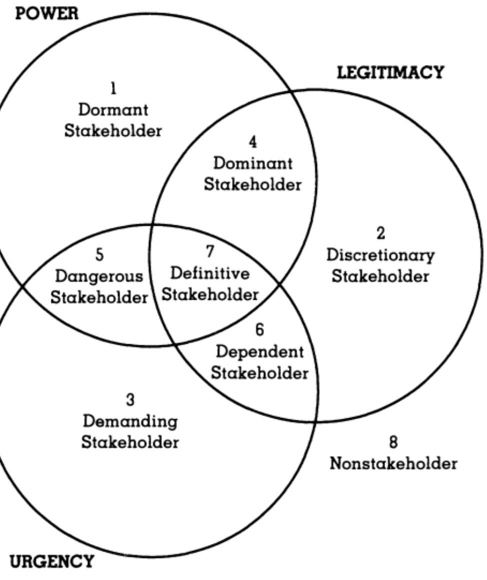


Figure 13: Mitchell Model

According to this model, entities without any of these attributes are considered **non-stakeholders** or potential stakeholders and perceived without any salience (area 8). The areas 1, 2 and 3 represent low salience classes which are defined **latent stakeholders** and own only one of the attributes. This kind of stakeholders is not likely to give any attention or acknowledgment to the firm's decision and the other way around. In this category we can identify three subsets of stakeholders:

- Dormant stakeholders, when the relevant attribute is the power. Clear examples are the stakeholders with a large availability of money (utilitarian) or with a great influence on media (symbolic).

- Discretionary stakeholders, when the relevant attribute is the legitimacy. A non-profit organization or a hospital which receive volunteer donations from the company represent clear examples of this kind of stakeholders.

- Demanding stakeholders, when the relevant attribute is the urgency. These stakeholders are fastidious, but not dangerous. A typical example is represented by shouting picketers.

The areas 4, 5 and 6 represent the **moderately salient stakeholders** identifiable by the possession of two attributes and because they are stakeholders who expect something they are defined **expectant stakeholders**. The combination of two attributes leads a corresponding increase in firm attention to the stakeholder's interests. Under this category we can identify three subsets of stakeholders:

- Dominant stakeholders, with power and legitimacy they form the "dominant coalition" in the enterprise [Cyert & March, 196]. Their importance is recognized by the presence of formal mechanisms in place which underline their relationships with the firm. For example corporate boards usually include workers' representatives and significant creditors, and if the relation with government – by incentives – is strong they dedicate personnel in order to keep track of it.

- Dependent stakeholders, with legitimacy ad urgency. The lack of power makes them "dependent" upon those who own the power necessary to carry out their will. For example, environmental associations play an important role in case of a giant oil spill in the ocean, but their claims can be satisfied only through the power of the oil company board, governments or courts.

- Dangerous stakeholders, with power and urgency. They represent a danger for the firm because they can act without the knowledge arising from the lack of legitimacy, often giving rise to illegal actions such as wildcat strikes, employee sabotages or terrorism.

Finally the combination of all the three attributes defines the figures of **highly salient stakeholders** (area 7), called definitive stakeholders. Any expectant stakeholder can become a definitive stakeholder by acquiring the missing attribute. The most common case is when a dominant stakeholder acquires urgency. For example, when the investors of a large part of the firm's stocks are afraid of stock price drop, this disappointing result can push them to ask for a management removal.

This model shows its strengths when it is used to provide a static map of the stakeholders in a specific point of time. The most important innovation that Mitchell introduces is represented by the ***interrelations between clusters of stakeholders***: even if its model aims to provide managers with a method to select the most influential stakeholders, it also opens a window on stakeholders management: in fact, the importance of the stakeholders grows along with the overlapping of the clusters, showing as the interrelations impact on the clustering criteria.

Anderson and Crosby (1999), exploiting the studies conducted by Mitchell et al. (1997) on the stakeholders' power have developed a technique to support the problem solving through the establishement of winning coalition, deepening the investigation on the relations between the power and the opinions of the stakeholders in the decisions:

- **Problem-frame stakeholder maps**
  The crucial first step of the analysis is the connection between each stakeholder to alternative problem definition through a stakeholder map.
  Afterwards when a winning frame has been discovered, specific management activities and policies can be implemented following the framework previously suggested.

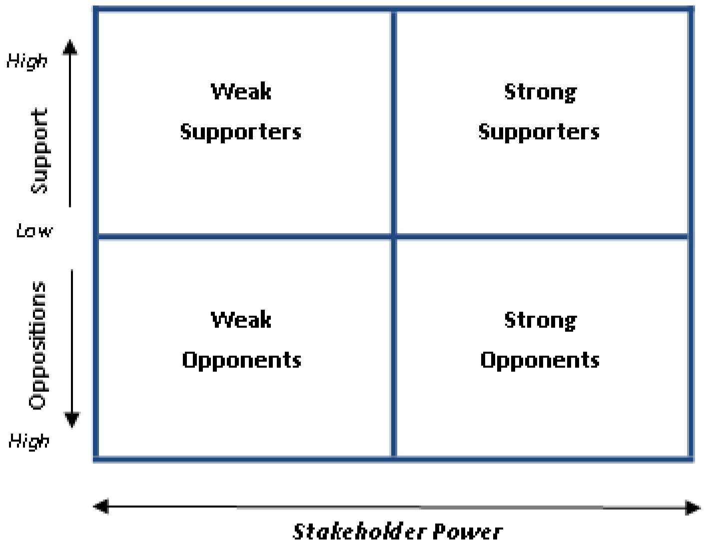


Figure 14: Problem-frame stakeholder maps

The latest studies on the stakeholders' analysis have been conducted by De Bruijn (2008) and Dente (2011) which have combined all the crucial insights carried out by previous studies, introducing new stakeholders' analysis and clustering methods based on the different players' resources and power.

De Bruijn (2008) focused more on a network and on the stakeholder resources analysis, defining an actor according to the following three attributes arising from the studies led by Eden and Ackermann (1998) Anderson and Crosby (1999):

- The **opinion** about the initiative, namely "a view or judgement formed about something, not necessarily based on fact or knowledge" [Oxford dictionary, 2014]. The opinion drives the stakeholders behaviours, expressing their position upon the decision making issue, foreseeing future actions.
- The **interest** about the initiative. This attribute tries to investigate the causes of the affirmed opinion, by answering the question "for what?", translating the motivations that pushes the stakeholder to rely on certain beliefs. The objectives of an actor are strictly tied to its interests. It is possible to distinguish between (Dente, 2011): content objectives, directly tied to the treated problem and/or the solutions to adopt; process objectives, critical when the relations and the resources activated in the decision making process are more important than the solution itself.
- The **resources** can be defined as the degree of influence actors can exploit in order to pursue their interests (authority, reputation, technology, know-how, money).The relations which an actor establishes in a network are considered as resources, for the opportunities that they provide to gain the support of other actors. The larger the network, the higher the importance of support when conflict appears. When a relation presents repetitive character, namely it is going to repeat for several times, the cooperation with that specific actor is critical and important.

Focusing on the resources, a fundamental stakeholders' classification of the main typologies has been proposed by Dente (2011). The **political resource** defines the level of consensus that an actor is able to generate. It derives from several factors, among all actors' charisma, the perception that he has important skills or common ideas on the definition and solution of the problem, or simply from tradition. This kind of resource is essential in case of public policy making.

Secondly the **financial and economic resources** consist in the ability and possibility of mobilizing the money and wealth in order to modify the behaviours of the other actors.

Thirdly the **legal resources** arise from advantage positions that in contemporary States the legislation or the courts assign to specific roles. Important examples lie in the existence of a system of procedures which guides the decision making process, or that a precise decision is up to a specific office for law, or the possibility for a penalised actor to appeal against a decision.

Lastly the **cognitive resources** derives from exclusive information (or sources of information) or interpreting models that an actor owns which allow to orient the decision making process. In the contemporary world, where the increase of the amount of information has shown new ties and interrelations which make the interpretation more complex, the scientific, technological and contextual knowledge plays a key role. Luigi Einaudi statement "Knowing to deliberate" today confers a key position to all the knowledge which is important for the solution of an issue. Anyway "the right information does not exist" (De Bruijn, 2008), because even the experts are accused of favouring their commitments with biased interpretation of data, losing in this way their position of *super partes.*

The different opinions upon a decision making issue, caused by different interests and supported by a portfolio of resources, leads to three **different power positions** owned by an actor (De Bruijn, 2008): production power can establish positive conditions for the realization of a defined objective, bringing to the process fundamental resources; blocking power, when an actor can only exercise its position to stop the progress of the process, the so called "catch-as-catch-can attitude" or can affect the process with disturbs without contributing positively; diffuse power makes the actor ambiguous from the other actors' perspective, because this power position can change over time.

It is possible to classify the stakeholders according to the resources they own, underling the charcteristics and possible behaviours for each category (Dente, 2011).

The **political actors** represent the citizens and act in decision making process on the behalf of them. The role of this actor, is directly proportional to the consensus that the others bestow on them, influencing their choices towards the consensus maximization.

The **bureaucratic actors** pretend to participate to the decision making process because a set of laws or procedures give them the formal competence to intervene. This position makes them far from political actors who instead would like to find a compromise, by looking for a win-win solution.

The **bearers of special interests** pretend to intervene in the decision making process because that specific choice between alternatives has a direct impact on their interests, in the sense that they stand the costs or benefits resulting from the decision. Thus they try to influence the process in a egoistic and utilitarian logic.

The **bearer of general interests** participate in the process in name of those people who they represent, but that cannot defend by themselves. A typical example of this category is represented by non-governmental organizations. They usually fight against the short-term thinking of political parties and are not used to make compromise because guided by a presumed ethical superiority.

The **experts** pretend to participate to the decision making process because of the knowledge that they own about the definition of the problem, the generation and evaluation of alternative solutions. They are usually professional and for this reason their presence in the process is unavoidable. They structure their opinions following a scientific method but it is not unusual to find out strict divergences between them, with accusation of biased interpretation made to favour the client.

3.2 Information Management

The stakeholders' management has underlined the data ownership, expressed as a resource that stakeholders bring into the network. Afterwards, the clustering has reduced the complexity of the network, grouping the different stakeholders, presenting similarities in terms of information, objectives and relationships. Thus, a deeper analysis on the type of data exchanged in the network and the method used to gather these information is necessary to depict the AS-IS information management situation in the e-mobility world.

In the e-mobility different actors operate and interact in a network, generating typologies of data arising from many sources of information belonged to the network. In the world of e-mobility most of the data is derived by the touch points between the driver and the smart grid, identifying as main sources the charging spot and the vehicle itself in which the system is able to collect information about the driving habits of the user and charging behaviours. These data are crucial for stakeholders' management in the network but most of them are **unstructured**, so difficult to be organized afterward analysed. Moreover different sources of information can communicate through technological enablers generating the up-coming opportunity of **internet of things**: the sector of e-mobility is characterized by many smart devices that with the right intelligence technology could communicate exchanging information as the typical interactions Human to Human. Thus, in the following paragraph firstly, some methods are presented to collect and analyse the data coming from different actors and secondly an application of the internet of things in the trasportation sectors is provided underlining the improvements and the peculiarities in the information managment carried out by the **Infomobility**.

3.2.1 Analysis of the information typologies

The networks of stakeholders are generally characterised by a huge amount of etereogenous data, implying the necessity to a proper investigation on the different information typologies, introducing new frameworks and methods crucial to inference this dataset.

Nowadays, Internet is affecting the amount of data processed by the company as well as shared among organizations. Concerning the Web pages (one of the unstructured data source) more than two billions of news pages have been created since 1995.

This demand of new resources and needs fosters the creation of new tools to manage this new type of information, called unstructured data.

The term **unstructured** refers to **information** that does not have a defined data framework thus it is not organized properly like the structured data that are presented in spreadsheets or tables. The unstructured data cannot be stored in rows and columns, but basically it is stored in a BLOB (binary large object) in which through the use of Database management system software (DBMS) is organized.

Otherwise the **structured data** is characterized by definite relationships between the various data, thus can be processed by traditional computer programs and stored in fielded form in databases or annotated (semantically tagged) in documents [Malone; 2007].

Roughly 85% of corporate information and 95% of global information is unstructured, including e-mail files, word-processing text documents, PowerPoint presentations, JPEG and GIF image files, and MPEG video files [Blumberg and Atre; 2003].

New business opportunities are generated by the **analysis of unstructured data**, even though the treatment of non-formatted data presents many crucial issues [Blumberg and Atre; 2003].

One problem related to the Web search engines is the ***non-customized treatment*** for the different requests made by the users. This signifies that the result of the research is equal for different customers without considering personal characteristics or historical user's researches.

Contextual information can be interpreted as metadata, an important unstructured resource that could help managers to pursue their objectives. The following methods tend to solve the previous issues.

One approach used to treat this kind of data is the "***parametric selection***", that through the use of available and filtered metadata, allows the users to identify information on known metadata fields such as region, product code or agent name.

The users, by selecting only the relevant fields, could narrows the number of records used for the search. Another approach is to develop an "***advanced search***" form that lets users draw on metadata for specifying better their searches.

The unstructured data can be handled with ***taxonomy***: organizing data into a hierarchical structure. Taxonomy allows the users to drill down through the categories and subcategories created by itself in order to find the relevant concepts or documents. Moreover the taxonomy decreases the number of queries to specific categories and sub-categories.

The ***extraction tools*** are used to discover unstructured text from entities as people, places, organizations, identifying in which document the terms were found. The typical questions that they are used to answer are: "What people are mentioned in a specific document?", "What organizations are mentioned in the specific document?" and "How are the mentioned people related to the mentioned organizations?" [Langseth et al., 2005].

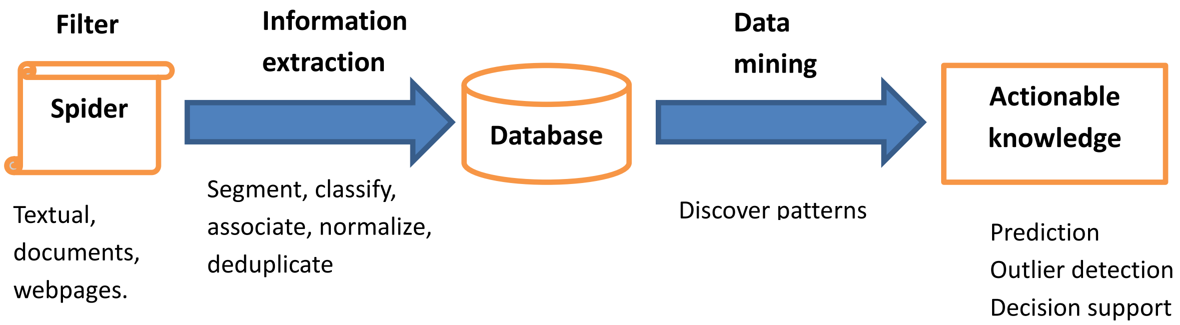


Figure 15: Unstructured data procession

The process of extraction is fundamental to fill the database using unstructured or non-formatted data. It is composed by five main sub-tasks [McCallum; 2005]:

- Segmentation, which defines the boundaries of the fragmented data that will fill the database.
- Classification, determining which database field is the most appropriate for the type of segment.
- Association, allowing identifying which fields belong together in the same record.
- Normalization, which puts the different formats of data in a common standard that is more reliable and comparable.

- Deduplication, namely the elimination of redundant and repeated data that could mislead the users.

The **tools** used for **analysing structured data** are much more reliable and easier to be implemented because the information is already prepared in standard formats that make the access easier and quicker than the unstructured ones [Jangseth et al., 2005]:

- ***Business intelligence tools***: they are composed by dashboards, ad-hoc analysis and facilitate the generation of reports. These tools are typically used to disaggregate information into smaller parts in order to improve the analysis of data referred to higher level of detail. Moreover the business intelligence tools analyse how data is changing over time and the relationships/analogies between different fields.

- ***Data mining tools***: they are typically used for pattern detection, anomaly detection, and data prediction. Questions that can be addressed with these tools are "what unusual patterns are present in my data?", "Which transactions may be fraudulent?" and "which customers are likely to become high-value in the next 12 months?"

As previously described, the tools used for analysing structured data are much more flexible, powerful and easier to implement than the tools used to analyse unstructured data, but the majority of all data is still unstructured. Therefore it would be advantageous to have a ***middleware system*** and a method that allows structured data analysis tools to operate on unstructured data [Langseth et al., 2005].

To overcome the above limitations, a middleware software system has been developed in order to analyse both structured and unstructured data from a variety of sources.

The different information sources, that can be external or internal, are extracted, transformed and placed in a structured schema (***data warehouse***), which is a system that can integrate and elaborate different sources of information.

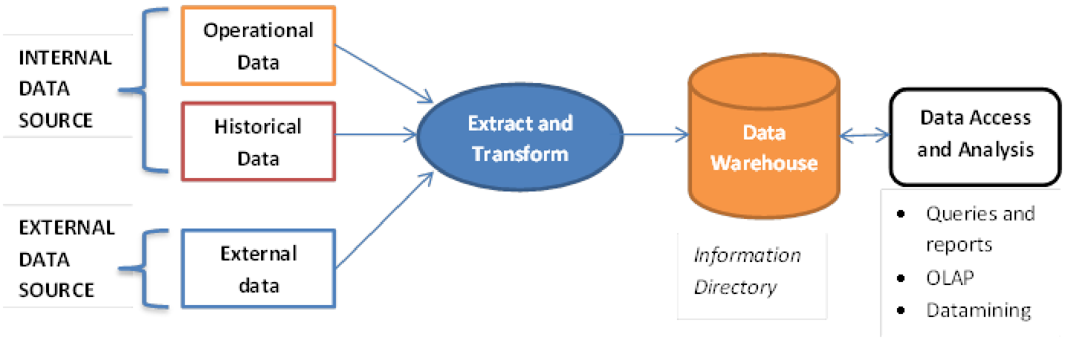


Figure 16: ETL combination of data

In case in which many and complex information (e.g. big data) are collected, the splitting of the data warehouse into several database (***data marts***) is crucial for obtaining a better accessibility to information.

The e-mobility sector is characterized by many smart devices, which in addition to gather a variety of data (mainly structured), usually communicate exchanging information as the typical interactions Human to Human that generates a huge amount of unstructured data that need to be organized and schematized. In fact this new type of communication between things and no more among humans, arises the necessity to introduce new collection and analysis tools in order to individuate the potentiality of this new type of data.

So far the vision of the internet of things (IoT, the term used to call the communication between objects) is in an embryonic state, because most of the elements do not have the digital intelligence that enables the things to communicate, share and exchange information. The definition of IoT is still not well developed, even if its main purpose is clear: the creation of a world-wide network of interconnected objects (belonged to a real world, so physical items), that acquire an active role in the network becoming participants in business and information processes. Moreover, these things do not need to be connected by electronic objects, such as computers, but also other products like cars, books, or even food [Roman et al., 2011;].

The core IoT feature is the wireless sensor networks (WSN) which can link the virtual world to the physical one. WSN is basically a sum of sensor nodes that can collect physical data, process data and undertake informed decisions, and communicate with other objects using wireless channels.

The WSN is a kind of "virtual skin", that allows the things to become aware of other surrounding objects and to **share this information** with other things.

So far, the most used standardizations are the universal identification (UID), recommended strongly by Japan, and the electronic product code (EPC), suggested keenly by Western countries. The creation of standard format must consider the complexity of the human language, the disequilibrium between the levels of output produced and the management in different country.

Thus the format standardization is mandatory, while the standardization can be implemented gradually in the form of recommended standards [Huang and Li, 2010].

The development of the Internet of Things includes three crucial characteristics [Lu Tan and Wang, 2010]:

- **Embedded intelligence**
  Radio frequency identification (RFID), widely applied in e-mobility in order to assure the ***interoperability of charging stations***, is the main enabler of the Internet of Things that allows the objects to be identified by other things, so they can be connected. RFID uses radio waves to identify items, can track items in real-time to get important information about their location and status as well. The RFID is composed by tags and readers: the first one is related to record information about the object and the second allows the users to get information from the things.
- **Connectivity**
  So far, with the use of RFID the objects work alone without operating in a network, then through connection technologies (RFID, ZigBee, WPAN, WSN, DSL, UMTS, GPRS, WiFi, WiMax, LAN, WAN, 3G) interactions among smart devices are possible.
- **Interaction**
  The things can communicate by themselves, but new smart things have to be created in order to process information, self-configuration, self-maintenance, self-repairing and making independent decision. Finally, things can interact, changing the form of communication from human-human to human-thing to thing-thing.

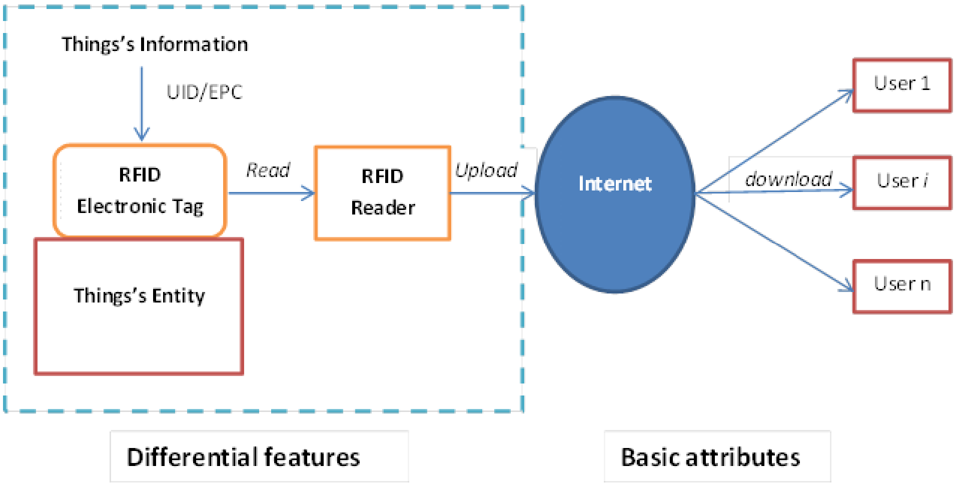


Figure 17: Internet of things working process

The Internet of things working process is based on the following steps:

1. The information coming from an entity has to be written in UID or EPC code in order to have a common language, understandable for all the objects in the network.
2. The RFID electronic tags, embedded in the object, record the information and the RFID reader understands the thing's information from the RFID electronic tag by non-contact form.
3. The thing's information is uploaded into Internet, thus the users all over the world in real time can share and exchange this kind of data.

An application of the internet of thing working process is clear in **the Intelligent Transportation Systems (ITS)**, in which the ability to collect, elaborate and distribute the best information about traffic network status and available transportation services, aims to decrease the traffic congestion as well as the dangerous level of pollution in certain urban area. Therefore ICT involves the application of internet of things technologies to make "skinful use of advanced electronic and communication technologies to merge people, vehicles and roads into integrated, intelligent systems" [Adler, 2001; Lerboyle, 2004]. ICT is based on intelligence, which involves data collection aimed to gain knowledge about the network and integration related to connecting and co-ordinating the system elements.

The term **Infomobility** indicates the set of technologies and procedures which provide the required information to managers and customers in order to obtain an efficient mobility of private and public transport. It assumes a relevant importance in sharing real time information to the users about the congestion of the network system and communicating the information in anytime and in every place [Adler, 2001; Lerboyle, 2004].

The key element arisen by the definition is represented by the information, which can be defined as the massage transferred from a subject to another, using a physical support (Internet of things technologies).

Although the infomobility information are hardly classifiable due to the high level of integration and interrelation, the ***network information exploited in the info mobility*** can be classified facilitating further integration.[Wotton; 2000]:

- Descriptive information: supporting the knowledge on the state of the network, underling the traveling time on a predefined path, the congestion of several links or the occurrence of special events, like car accidents.
- Predictive information: inform the user on the best mean of transportation and trip paths. The information can be used by the drivers, depending on its confidence level and reliability.

The steps used to exploit the information generated by the infomobility are fixed in order to increase the level of reliability and completeness, providing a better service to the customers:

- Data collection on the state of the network (performed by traffic counters, sensors, camcorders, intelligent gate, electronic payment counter, webcam, etc.);
- Management of the information;
- Elaboration of the information;
- Diffusion of the information to all the users.

In conclusion the main advantages that a better integration of the information, arisen for the different sources in the network, carried out by the infomobility system, aims to improve the environmental condition, the security and the overall efficiency of the transportation system [Taniguchi, 2001].

The **environmental improvement** are driven by the reduction of travel times, implying higher usage of public transport. The transport cost reduction indirectly affect the decrease of GHG emission, in certain area until 50%, due to the better customer awareness on the traffic situation.

In terms of **efficiency, control strategies,** Infomobility increases the average speed on the highways due to the automatic systems for the payment of the road fees.

Besides, the automatic adaptation of traffic lights times reduces the driver waiting times, the congestions of the main road and improve the parking availability as well as the priority for the public transport.

Finally for what regards **safety,** benefits are achievable due to the reduction of maximum speeds and of accidents in fog and rain conditions due to the better information about the weather condition which can guide the drivers. The monitoring systems installed on commercial vehicles also determine a reduction of the number and the entity of accidents as well as a reduction of emergences vehicles arrival time in case of emergency calls. Some figures are provided in order to depict better the huge improvement carried out by the Infomobility technologies: decrease of the level of accidents of the 30% and the number of murders and injures of the 40%, the maximum speed of the 10%, the accident in rain condition of the 30% and the accident in fog condition of the 85% [Adler, 2001; Lerboyle, 2004].

3.2.2 Network data collection and analysis

The e-mobility refers to a social structure composed by nodes that represent the individuals or organizations in the system and the related ties between the actors that represent the relationships between them and generate a huge variety of information that need to be collected with appropriate methods.

The social network is based on the assumption of the importance of the interaction between actors, considering, as a unit of analysis, a set of entities and the related linkages such as the relationships between actors, and not the single stakeholder [Wasserman & Faust, 1994].

The **data collection** in a complex network of stakeholders is crucial for the measurement and the following analysis of the entire group of social entities [Miller *et al.*, 2011]. The main key challenges in the data collection are:

- ***Network boundaries***, which are difficult to define due to the different features and importance of the stakeholders involved that make time consuming the clustering of actors.
- The ***information about the members*** of the network should be balanced for what regards the level of detail.

The limitations of these challenges have been overcome by Miller (2011) through his research focused on two different assumptions. The **whole network** studies examine actors “that are regarded for analytical purposes as bounded social collectives” [Miller *et al.*, 2011] and starts from the assumption that all the stakeholders already analysed are organised in a closed list (as clusters):

the data collection is easily implemented, because the information has been already gathered previously. Anyway, the creations of closed lists could be hard to be implemented in networks in which many actors are interrelated.

On the other hand the **Egocentric network** studies are focused on specific actors (egos) and the others social entities that have relations with them (alters). The definition of the network and data collection are driven by asking to a targeted stakeholder (ego) the information he owns about himself and arising from the relationships with other actors (alters). This activity is repeated by changing the targeted stakeholder (ego) in order to obtain a comprehensive view of the network.

The data collection in the Egocentric network is based on two layers:

1. An ego-network level, focused on the ego's features and the information he owns about the network, considered as a comprehensive entity.
2. An ego-alter level, requiring to the ego all the information about the stakeholders that tie a relationship with him (alters).

In the egocentric network the choice of an appropriate egos and related network members could be crucial in defining the network boundaries:

- Egos must be representative of the analysed domain.
- Need to decide the adequate sample of egos within the large size of network stakeholders in order to elicit "appropriate" network members.

The most common method to elicit network members is the **name generator**, which consists of free recall questions that individuate alters from an ego's network. Moreover the number of elicited alters can be limited by a specific number or unlimited.

The name generators have a key role in the **measurement of the tie strength** among egos and each alter, and between alter-alter.

The next step is the collection of further information about the characteristics of each alter (e.g. socioeconomics, relationship with the ego), and ego-alter relationships (e.g. frequency and characteristics of interaction). The most used method is a general sampling strategy that ensures a sufficient amount of information collected and a good level of reliability. This issue could become harder if the amount of alters is not defined.

Another similar method is the **snowball technique**, which solves some of the challenges typical of network data collection, under the ego-network assumption: it is a non-probability sampling technique that is used when the members of a population are difficult to locate. It is based on the collection of data on few members of the target population that it is easy to locate, then become easier to ask the previous members information to locate the new ones [Agichtein & Luis Gravano; 1999]. The snowball technique is structured in the following steps:

1. Defining the core subset of actors within the network, such as firms producing similar products or services.
2. Gathering informants from the group of organizations with the purpose to nominate other actors to whom their firms are linked through specified types of relationships, such as resource and information exchanges, and interlocking directorates.
3. Interview informants from the group of nominated organizations, who are also asked to nominate relevant actors.
4. This process is repeated until the network and the related participants are described sufficiently complete.

Other **traditional methods** are investigated such as observation and archival records. ***Observation*** between actors is widely used for a limited group of actors who have face to face interactions in variety of social settings (university, work group, fraternity). This method could be necessary when the object of the analysis is not able to fill up the questionnaires or answer to the interviews [Wasserman & Faust, 1994].

Archival records such as newspaper, articles, executive meetings in which the researchers can measure ties among all the actors in the set [Wasserman & Faust, 1994].

3.2.3 Network accountability

Althought the scientific literature has not provided a deppened investigation on the management of information based on network and relationships, this paragraph describes **the network accountability challenges and opportunities,** attempting to integrate methods to gather and analyse new typologies of data (structured, unstructured, internet of things) trying to foster a new sharing approach (open data).

Afterwards the collection and the evaluation of data, the literature analysis focuses on the managerial frameworks to organize and measure the information coming from different stakeholders (structured, unstructured, internet of things), exploiting the huge potentiality of data generated by the network.

Nowadays, firms have to collaborate with each other in order to pursue more effectively and efficiently stringent objectives regarding the customers' satisfaction due to the increasingly competitive environment, and the consumers' needs variability.

Considering the **frequency of partnerships and alliances**, crucial to handle the up-coming complex business environment and expected to generate a competitive advantage, the role of performance measurement is becoming even more fundamental than in the past, promoting the consensus and improving the alignment with the different goals of the alliance or the partnership among the company network.

Several researchers (*table 3*) have studied these topics during the last decade, focusing on the analysis of the potentialities and utilities of accountability in a network.

Author year	**Research topic**
Moorman et al. (1992)	Definition of Trust
Sako (1992)	Features of Trust
Ganesan (1994)	Features of Trust
Anderson et al. (1994)	Relationship in the network and efficient exchange of information
Brinberg (1998)	Interfirm cooperation
Seal et al. (1999)	Accounting within the supplychain and interfirm relationship
Van der Meer-Kooistra and Vosselman (2000)	Accounting within the supplychain and interfirm relationship
Tomkins (2001)	Information requirement in the relationship
Das & Teng (2001)	Trust: challenges and opportunities
Dekker (2003)	Accounting in the buyer-supplier relationships
Dekker (2004)	Trust: challenges and opportunities
Cooper & Slagmulder (2004)	Trust: challenges and opportunities
Coletti et al. (2005)	Trust: challenges and opportunities

Table 3: Network accountability literature analysis

Anderson et al. (1994) was one of the first reserchers who considered the relationship as an element in a network, eliminating the typical boundaries related to each organozation. From this point of view an efficient coordination would require simultaneous connections to different business relationships, increasing the necessity of information exchange.

Brinberg (1998) have developed one of the first network accounting frameworks, starting from the assumptions and insights conducted by Anderson et al. (1994), to foster the interfirm cooperation based on five dimensions analysing the single relationships between stakeholders:

- the degree of absolute and relative commitment;
- the symmetry of the reward;
- the extent of uncertainty present;
- the degree of mutual trust between the parties;
- the length of the relationships.

Seal et al. (1999), Van der Meer-Kooistra and Vosselman (2000) and Dekker (2003) have analysed the role of the accounting within the supply chain in order to minimize the transaction costs:

- In particular Seal et al. (1999), concentrating the researches on the studies of dyadic relations, have underlined three important roles in the accounting management with the purposes to establish collaborative inter-organizational business relationships: make-or-buy decision, leading to a partnership, the use of accounting in the management of a partnership and the decision of the partners' responsibilities, which implies a role for performance measurement.
- Dekker (2003) investigated deeply the role of accounting in the value chain concentrating on two important needs: analysis of the cost performances through the integration of data; support decision making such as investments and future developments.

Moreover Dekker (2004) focused his studies more on the network PMS issues, such as appropriation concerns and coordination requirements are considered more relevant: the appropriation concerns challenge is strictly linked to partner's opportunistic behaviours, raising the most important issue in the network accountability: the **trust.**

Trust has been defined in different ways, for instance Moorman et al. (1992) recognized two main stream of definition in the literature studies:

- trust as a belief or expectation about a trustee;
- trust as a behavioral intention that reflects a reliance on the trustee and involves vulnerability and uncertainty on the part of the trustor.

Combining the studies conducted by Sako (1992), Ganesan (1994), Das & Teng (2001) and Dekker (2004) trust can be classified according to their impact on each area:

- The companies can generate competence-based trust through investments, moving their knowledge and technology to their partners, through the proactive collection of information, satisfaction with the relationship and achieving good results, on the counterpart, the reliability can be accomplished through education.
- Goodwill-based trust regards the establishment of mutual objectives, interests and a common system of values and norm through the deployment of investments in resources dedicated to the partner, provision of complementary services, technical assistance and IOR formalization and participation in decision-making. Moreover the two-way exchange of information can avoid opportunism behaviours enhancing the trust.

Das and Teng (1998) have deepened the analysis on the MCSs and trust relations, identifying communalities in the source of confidence: the confidence, in partner cooperation, is defined as a "firm's perceived level of certainty that its partner firms will pursue mutually compatible interests in the IOR". Companies tend to have greater confidence in the IOR when they expect a higher control over their partners, generated by trust.

Coletti et al. (2005) have studied the impact of the MCS in the level of trust, which in most of the cases leads to an enhancement of cooperation and commitment through the sharing of information and reducing the possibility of opportunistic behaviors [Tomkins, 2001); Seal et al., 2004].

In contrast, Dekker (2004)and Meer-Kooistra and Vosselman (2000) have individuated trust as an alternative to accounting, representing in some cases a stronger opinion to sustain network relationship.

More over trust can be considered as a condition for the development of advanced forms of book accounting sharing and retained evaluation criteria on the relationship success [Cooper & Slagmulder, 2004].

Regarding the last studies in the network accountability, the investigation conducted by Kaplan and Norton (2010), Bititci (2012) and Pekkola (2013) are focused on moving the establishment of the alliances by service level agreements (SLAs), which underline what each partner requires from the other party and what it hopes to gain from the partnership. The SLAs emphasize operational performance metrics rather than strategic ones, leading to quick obsolescence according to the changes in the business environment [Kaplan et al.; 2010].

In the network context, different stakeholders try to speed up the innovation process and decrease the huge start-up investment, by building partnership or signing business alliances, requiring a successful performance measurement system suited to a collaborative network. A **network performance measurement** system can be used to manage the network business, guiding the actors in networks to pursue the joint targets [Pekkola; 2013].

Bititci (2006) sustains that the most of the companies have not achieved the required integration with both suppliers and customers yet due to the difficult implementation of network-wise collaboration and the widespread dynamism not covered by the performance measurement system studies.

Kaplan underlines the main issues carried out by the companies that can limit the success of the alliances:

- Firms are still focusing more on the contractual terms of the alliance than on a joint strategy;
- They are spending more time and effort trying to sponsor and communicate the advantages of the alliance internally than managing its strategy;
- They are focusing more on the alliance control (extracting profit) than on overthrowing the barriers that limit the execution of the strategy.

Hoverer, even if the difficulties in building alliances are clear, the existing studies and scientific papers, in the area of performance management, are still investigating the performance at the single enterprise, although the focus on collaboration between enterprises (supply chain, extended enterprise and virtual enterprise) are gaining relevance [Bititci et al.:2012].

Several studies have analysed the issue of local versus overall performance measures, underlining the importance of embracing business network-wide measures in collaborative performance measurement systems in order to maintain relevance and effectiveness in the collaborative enterprise business model. Although the majority of metrics, today, are focused only on local performance, the collaborative enterprise business model is based on braking down traditional physical boundaries allowing the actors to behave as a single unit, integrating different organizations.

Thus, the repositioning towards a new collaborative performance measurement pushes the customers and suppliers to consult the performance information of their firms, but even these data regard other partners in the network. By **sharing performance data** with partners, companies underline bottlenecks and “weak links” in the network, improving the overall performance.

The collaborative enterprise network, considered as a group of companies, can exploit the existing theories for developing a network performance measurement dealing with the **team performance**

management. Macbryde and Mendibil (2003) have moved the focus on the process measures in order to ensure a performance measurement that embraces all the company critical success factors, without neglecting the importance of the flow of information inside and outside the company. Moreover they sustain that team performances measurement is crucial to establish a network culture and stimulate the employees' attitude to work in group leading to facilitate the integration with other cultures and teams.

Afterwards a training period, the employees will be able to work in a team environment leading to prepare the workers, thus the company, working in a **collaborative enterprises network,** enlarges the previous measurement area (process measurement and team performances) in a network perspective, no longer tailored to a team one.

However, Lambert and Pohlen (2001) have introduce some issues in defining appropriate balanced set of measures dedicated to collaborative performance management due to the complexity of overlapping business network and to the information sharing between organizations, which generates privacy and strategic behavior issues.

In order to overcome these challenges Kaplan et al. (2010) have shown how the companies have to set the strategic objectives, following BSC practice, according to the network as well as the alliances performances:

- Living the alliance: underlining the importance of having the right culture (including trust), communication, leadership, people development, IT and rewards.
- Collaboration: focusing on the creation of a transparent network, which fosters the use of resources and services across organizations and third parties.
- Speed and process innovation: improving the achievement of the objectives, levering on the global expertise and enhancing the startup and innovation process, leading to achieve breakthrough results.
- Growth: collaborating on decisions to develop compounds and accelerate the flow of compounds into the clinical development phase.
- "Value for both": create value for both organizations by conducting all these activities jointly.

Based on the pervious strategy guidelines, Zhao (2011) provides a list of the main CSFs and the related KPIs that include both financial and operational measures (represented in the table 3), improving the achievement of joint goals of both companies involved in the partnership.

Critical Success factor	**KPIs (Example)**
Commitment	Time and nature of contribution by partners
Communication	Frequency, mode and nature of communication between partners
Sharing	Frequency/amount and type of info/data exchanges by partners
Trust	Frequency of meeting one's expectation about another party's behaviour and/or having confidence in another party
Profitability	Profit margins realised from collaborative projects
Productivity	Number/percentage of collaborative projects finished within time and budget
Market Share	Percentage of market share obtained through partnership
Corporate Social Responsibility	Speed and nature of responsiveness to environmental issues
Employee Attitude	Employee turnover rate
Innovation and improvement	Number of new initiatives for improvement introduced
Customer Satisfaction	Customer satisfaction rate

Table 4: Partnership CFS and KPIs

In conclusion, future operations management researches should start by clearly understanding collaboration and its mechanisms, and developing theories, methods, tools and KPIs to ensure that all partners involved can clearly define and manage joint goals and responsibilities.

The measurement systems should be designed to embrace both external relations efficiency and internal extended processes, supporting proactive management based on both feedback and feed forward operations control accessing to a new information source generated by all the stakeholders involved: the **open data**.

The World Wide Web, or simply Web, has radically altered a way to share content and information of all kinds, facilitating the authors' publication and the readers' access.

The Web is a tool to vehicular heterogeneous data, interwoven by hypertext connections (hyperlinks), which allow to associate different information according to keywords and fostering the creation of further information available to the readers. Thus, the web becomes a place in which the users can insert data and, when they need, withdraw the information, creating a global web of data.

In the Web usually the resources are described in HTML (Hypertext Mark-up Language) and published in the areas of aggregation, which are the web sites. However the nature of the relationship between two related resources is implicit (the information related to the relationship is embedded in the resource itself) since HTML is a language not sufficiently expressive to handle the inferences between different resources and relationships. From the lack of the HTML language, the necessity to describe the data using formats that can manage the relationship between different information becomes fundamental.

In order to fulfil this requirement, the web is evolving from a collecting and connecting documents space to one in which the raw data contained in the resources are easily connectable by machines: Linked Data [Bizer et al.; 2009].

The **Linked data** is a methodology that allows aggregating and collecting data from distributed sources in order to make fully accessible this information to the world of the Web. Afterwards the same data must be published under the use conditions "open" that become available to be consulted or aggregated by the users.

The **Open Data**, is the school of thought that seeks to address the needs to have data legally "open" or freely usable by the user, for any purpose.

The objective of the Open Data can be achieved by law, as occur in the U.S. where the information generated by the public sector belongs to the public domain.

In order to explain the concept of Open Data it is provided an analogy with the Open Linked to Open Data and Internet to Web: the Open Data is the infrastructure (or the " **Platform** ") that needs the Linked Data to create the network of inferences between the various scattered data on the Web [Rizzo et al.; 2010].

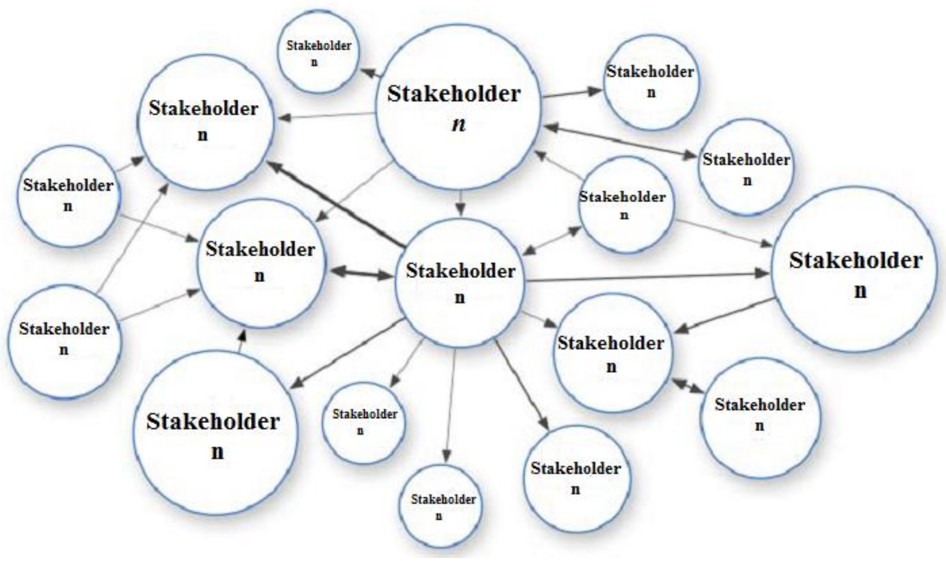


Figure 18: Open data approach

The **interoperability of data** is one of the most important advantages of Open Data model. In fact the data value increases significantly when it is aggregated freely by users from different data sources, and published independently from different subjects. This aggregation process is generated by applications to create "views" on the available data, allowing distinguishing the content, implementing the separation of concerns (SoC).

The economic value of these applications is represented by the exploitation of a large open archive in order to provide services, starting from particular “users’ view”. This view can be of different types and non-unique, due to the nature of the view chosen by the data user and the shape of the data is not decided by the supplier (decide only the content) of the information rather by the reader. The data have to be linked among them, establishing a direct link, when the data (possibly arisen from different sources) refer to identical items or in relation.

In conclusion, the data have to be shared among the users involved in order to foster the aggregation and integration which create ***better and complete information***. By using the analogy of a plant's life, the data are the roots which are located in the ground, which is the place where the data are inserted, the Open Data, while the plant is born from the union of roots, Linked Data. The meeting between the roots creates new plants which give rise to a new structured and complete information [Aichholzer et al.; 2004].

4. CONCEPTUAL FRAMEWORK

The objective of this chapter is to propose a new framework for analysing the complex stakeholders' information environment aimed to fill the literature gaps in the e-mobility information management, which do not propose any methods and tools to organise, integrate and measure the data arising from the network (*figure 21).*

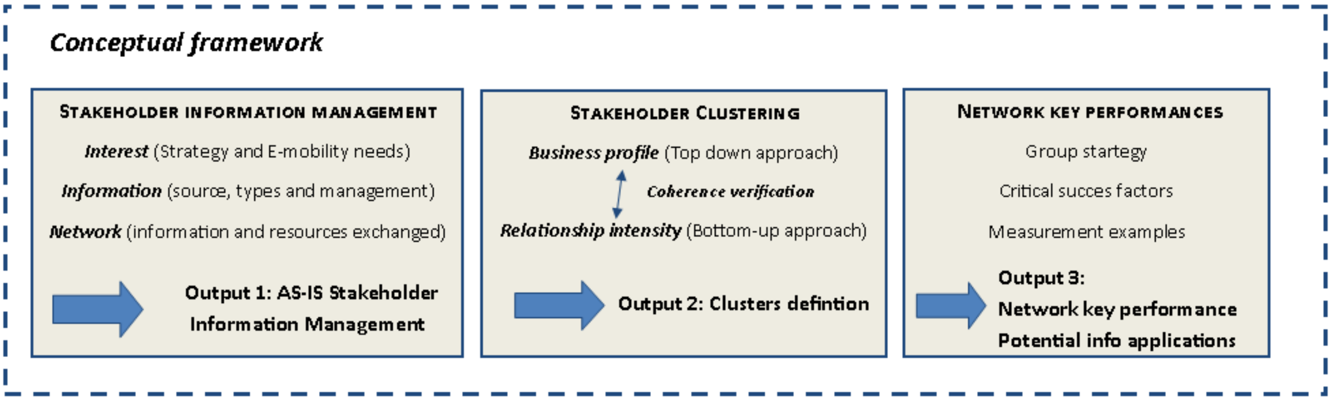


Figure 19: Conceptual framework scheme

The scenario in which the analysis is developed, takes place in Netherlands, which is a front runner for the e-mobility industry. The know-how achieved during the research, strongly correlated with Dutch advanced market features, leads to the creation of a model crucial for triggering the e-mobility start-up in countries, such as Italy, less developed under this perspective.

The framework, presented in the chapter, is structured in a first analysis of how the main stakeholders manage the information owned and they behave in the e-mobility environment, identifying their information roles. Secondly, a new methodology for clustering the stakeholders is defined in order to reduce the complexity in the analysis of the information management AS-IS situation, grouping all the stakeholders according their information/business profile and the relationship intensity. Finally, exploiting the different clusters, a measurement proposition is developed in order to underline the e-mobility key performances and present the potentialities of a structured and organized set of data, no longer related to a single stakeholder but also to the main relationships and the different stakeholders group.

4.1 Stakeholder information management

The preliminary step to analyse the stakeholders is represented by their **identification**. Starting from the study of *Universidad Pontificia Comillas* [San Roman et al., 2011], which has provided a rough list of the main leading actors, other models, such as Mitchel et al., have supported a more deepened analysis introducing a general scheme to analyse not only the players in favour of e-mobility propagations, but also the marginal and opponents actors. In fact the secondary players role could be underestimated leading to dangerous scenarios for the EV diffusion.

Moreover several methods and practices have been developed, and among them, two main techniques have been used in order to obtain a complete and precise list of all the leading actors that affect the e-mobility destiny: ***brainstorming sessions*** [Paulus et al., 1993] and ***stakeholders lists*** [San Roman et al., 2011]. The challenges tackled during stakeholder’s identification are related to the network boundaries definition due to the different features and interrelationships among the network stakeholders. The issue has been overcome combining the ***name generator*** approach [Miller et al., 2011] and the ***snowball technique*** [Agichtein et al., 1999], identifying all the influent stakeholders through the direct interviews with the leading actors (*Appendix 2*).

The stakeholder information management analysis has been influenced by several researchers. In particular, De Bruijn (2008) has analysed the stakeholders’ network according to the opinions, interests, resources and relations. Also Dente (2011) has focused his attention on the role of the resources in a stakeholders’ network, defining four typologies of resources which characterise the different stakeholders from this perspective: political, legal, cognitive and financial & economic.

Starting from the previous studies, the new framework arises from the merger of experiences provided by researchers, but with an inclination towards the organization of information useful to a further integration and implementation for a following clustering and a measurements proposition.

The further investigation is preceded by a brief description on the main drivers’ needs, highlighting the crucial changes in their habits in order to establish the stakeholder information analysis towards the removal of the typical e-mobility barriers, facilitating the adoption of the EV.

Therefore, the investigation of the stakeholders is focused on two points:

- **Interests**
  The stakeholder interests are analysed starting from a general overview of the **strategy**, including the different opinions [De Bruijn, 2008] on the future development of e-mobility and underlining the mission, the main objectives and the core business which determines the main performances.
  The evaluation of the **needs concerning the e-mobility** sector aims to verify the coherence with the company’s strategy and which are the main necessities to integrate the e-mobility practices into the company’s core business.

The previous analysis aims to provide a general e-mobility profile for each player, embedding the core characteristics to distinguish the different stakeholders among them in order to support a further targeted information management analysis for each player.

- **Information**

  The e-mobility needs, previously analyzed, express the key stakeholders' performances and guide the analysis of the **AS-IS information management** exploited by the e-mobility stakeholders when exist. The information is analyzed under two viewpoints: the source of information, which leads to a more efficient data collection, and its typology, distinguishing between structured and unstructured data. The inclusion of the latter typology represents a starting point for further improvements, inasmuch, particularly in the e-mobility, roughly 85% of corporate information and 95% of global information is unstructured [Blumberg and Atre; 2003].

- **Network**

  The e-mobility world is composed by a network of stakeholders with different goals, interests, resources and information exchanged, who depend on each other for the realization of their goals (De Bruijn, 2008). This concept is made more complex because of the raise of the coopetition [Brandenburger, 1997]: actors which usually are competitors, for certain projects become partners, sharing resources and know-how. The levels of information exchanged with these stakeholders have to be strictly regulated in order not to lose competitive advantages.

After having assessed the main characteristics of the stakeholders and their information needs, the evaluation of the relationships among them, expressed by a network, is necessary to **identify** the main collaborating actors and the information they usually exchange). The **type** of relationship is used to understand the strength of the collaboration (partnership, joint venture,…) as well as the resources that the stakeholders are used to share in order to reach a common goal. These **resources** can be defined as the degree of influence actors can exploit in order to pursue their interests such as authority, reputation, technology, know-how and money (De Bruijn, 2008). The classification of Dente (2011) is used to assess what are the critical resources that stakeholders usually share, such as large availability of capitals ready to invest (economic & financial), the property of specific knowledge and skills (cognitive) and the power in decision making (political). The resource types presented by Dente are useful to explain the stakeholder's typology and what are the critical resources it can bring to the overall network as well as their weaknesses and dependencies on stakeholders owing complementary assets.

Output 1

All these analyses aim to carry out a precise and complete information management AS-IS situation targeted for each of the e-mobility stakeholders, fostering an intuitive stakeholders clustering, with the purpose to organise and tidy up the complex system of shared objectives, relationships, performances, resources and information which characterise the single stakeholders.

4.2 Stakeholders clustering

The objective of this framework section is to identify a method to cluster the stakeholders according to their business profile and relationship intensity reducing the complexity of analysis.

4.2.1 Business profile and relationship intensity

The followed approach arises from the studies performed by Mitchell (1997) and Provan (2001) who have proposed models in which different stakeholders are grouped using a **top-down approach** according to different drivers. In addition they have focused their studies on the role of relationships between clusters to assess possible relational behaviours, as previously investigated by Bryant (1995), who has based its clustering methodology on the relationships that the different actors usually build.

The "***Holistic Value Added***" [Fletcher et al., 2003] methodology introduces the importance of combining both a top-down and **bottom-up approach**, in which after a clustering based on a top-down approach, the stakeholders are grouped underlining the different stakeholders perceptions on the relationship drivers and the strength of the relation within the network. In addition to this theory, the ***snowball techniques*** [Agichtein & Luis Gravano; 1999] represent a valid method to collect the different stakeholders opinion on the other ones, achieving a complete relationship's pattern overview.

From the previous studies, the following framework integrates both bottom-up and top-down approaches in order to validate the results provided with one method with the other one due to the opposite analysis flow. Moreover the analysis covers the different opinions expressed by stakeholder on another one and vice versa.

The stakeholders' clustering is based on two main streams:

- **Business profile**

  The first level of analysis exploits a top-down approach, consisting in the inclusion of all the stakeholders previously identified and analysed in three predefined business profiles acting in the e-mobility industry. The ***Provan model*** (2001) has proposed three business profiles in public-sector organizational network, in which the stakeholders are classified considering who finance, administrate and exploit the network services. At the same way, from the analysis of the e-mobility world, three main roles appear clearly and become fundamental for the overall industry operability. The **e-mobility sponsors** finance with incentives and funds the EV industry, which, belonging to a start-up phase and requiring more advanced technology, consumes large amount of capitals to support the necessary developments. The **EV providers** are the actors in charge of developing and delivering the electric vehicle in conformity to final users' necessities. The **infrastructure administrators** instead support the development of a widespread charging infrastructure and grant the EV usability.

  The business profile is developed by starting from the business activities and resources that characterise itself, leading to common performances that could be achieved with an overall strategy, structured in common objectives.

  Finally, all the stakeholders previously identified and analysed are embedded according to their business features to the previous business profiles.

- **Relationship intensity**

  The second level of analysis follows a bottom-up approach: the relationships strength between actors is estimated starting from the relative point of view of each stakeholder about the other ones, and taking into consideration the reverse opinion, exploiting the Miller et al.(2011) egocentric network approach. A set of drivers are used to assess the relationship intensity and for each factor a percent weight and a score (within 1 to 5) are associated in order to grant a better and balanced final estimation. In particular, a higher weight is conferred to the more relevant factors and the score presented in Analysis of Results represents the average of the scores given directly by the interviewed stakeholders (*Appendix 2)*. The relationship intensity is estimated by the following drivers, which partially arise from the studies developed by Dente (2011) and Wasserman & Faust (1994) on the relationship strength, but with a particular focus on information management:

  a. **Long-standing business relationship** (weight 10%): duration of the relationship that characterises two or more stakeholders. The impact of this driver is low because, even if the time helps to increase the trust between stakeholders, new stronger relationships were born and tightened in a short time-lapse in the e-mobility industry.

b. **Degree of shared resources and information** (weight 15%): the collaboration between stakeholders is supported by the complementary know-how and knowledge shared in order to achieve common purposes. Even if more often the integration of resources and information represents a key point for a strong relationship, the associated weight characterizes a factor necessary but not sufficient to declare a relationship as very intensive.

c. **Efficacy of shared knowledge** (weight 25%): as previously described the shared knowledge, if sterile, does not cause a gain for the involved stakeholders. Only when resources and information are exploited in order to obtain a value-adding result the partners invest more on the relationship, increasing its intensity.

d. **Degree of business integration** (weight 30%): the possible synergies in resource management represent the most important driver for tightening a relationship, as well as the collaboration with a partner which operates directly in a close phase of the supply chain reinforces the connection.

e. **Homophily** (weight 20%): the business activities and the overall business similarity represent key drivers, inasmuch stakeholders that behave in network in a similar way tend to collaborate and build relationship to each other. Thus, all the stakeholders that present communality in business profile, even if not part of the same supply chain, are considered strongly tied [McPhersonet al., 2001; Wasserman & Faust; 1994].

For each stakeholder a *table 4* presents the score of each weighted driver, which describes the relationship with the others ($Stakeholder_i$).

	1 DRIVER **SCORE (10%)**	**2 DRIVER** **SCORE (15%)**	**3 DRIVER** **SCORE (25%)**	**4 DRIVER** **SCORE (30%)**	**5 DRIVER** **SCORE (20%)**
$Stakeholder_i$	$Score_{1i} \times 10\%$	$Score_{2i} \times 15\%$	$Score_{3i} \times 25\%$	$Score_{4i} \times 30\%$	$Score_{5i} \times 20\%$

Table 5: Relationships' intensity

The Total stakeholder score defines the **relationship intensity** that an actor ties with a specific player and is calculated as follows:

$$
\begin{array}{c}
(Score_{1_i} \times 10\%) + \\
(Score_{2_i} \times 15\%) + \\
(Score_{3_i} \times 25\%) + \\
(Score_{4_i} \times 30\%) + \\
(Score_{5_i} \times 20\%) = \\
\hline
Total\ Stakeholder_i\ Score
\end{array}
$$

4.2.2 Clustering methodology

The evaluation of each relationship, adopting the system of scores previously described, has provided the content for the creation of a table that summarizes the $Total\ Stakeholder_{ij}\ Score$ (**$TS_{ij}S$**), namely the total score related to the relationship strength between the Stakeholder “I”(rows) and “J”(columns).

I ; J	**TSO**	**DSO**	**CSP**	**PC**	**CFO**	**A**	**G**	**BD**	**B**	**ER**	**CM**
TSO		$TS_{ji}S$	$TS_{21}S$	.	.	.	.	.	.	.	$TS_{M1}S$
DSO	$TS_{ij}S$		.	.	.	.	.	.	.	.	.
CSP	$TS_{21}S$	.	.	.	.	.	.	.	.	.	.
PC	.	.	.	.	.	.	.	.	.	.	.
CFO	.	.	.	.	.	.	.	.	.	.	.
A	.	.	.	.	.	.	.	.	.	.	.
G	.	.	.	.	.	.	.	.	.	.	.
BD	.	.	.	.	.	.	.	.	.	.	.
B	.	.	.	.	.	.	.	.	.	.	.
ER	.	.	.	.	.	.	.	.	.		$TS_{MN}S$
CM	$TS_{N1}S$	.	.	.	.	.	.	.	.	$TS_{NM}S$	

Table 6: Relationships intensity

In particular the *table 5* underlines the biuniqueness of the total score, namely the overall relationship strength between two stakeholders could be different if the result was computed from the point of view of the stakeholder “I” ($TS_{ij}S$) or from the point of view of the stakeholder “J” ($TS_{ji}S$). This aspect is crucial to highlight the relation priority of the different players involved in the network and the relative importance of each built relationship; in fact the values of the relationship strength varies from different points of view: $TS_{ij}S \neq TS_{ji}S$.

The *table 5* is processed and analyzed with the purpose to find intuitive and clear stakeholders’ groups that share common strategies and performances in the e-mobility world as well as build strong relationships within the cluster.

- **First grouping**

  The first methodology, developed to define the first clustering, aggregates all the stakeholders that collect the highest scores ($TS_{ij}S$ or $TS_{ji}S > \mathbf{3}$). The result is pretty aligned with the business profile of each stakeholder, identifying a first aggregation of stakeholders characterized by strong relationship and same business profile.

- **Second grouping**

  The second methodology processes as input data the first clustering of actors, aiming to embed to the existing groups the other stakeholders with communality, no longer tied with the single stakeholder but with the overall group.

  The main two challenges for this methodology regard firstly the way of discovering the similarities of one single stakeholder with the existing cluster composed by different stakeholders with diverse peculiarities and relationship intensity, and secondly the communality between the groups.

  For instance $TS_{12}S$ could be very high, thus in the first grouping the player 1 and 2 have been included in the same cluster. With the second grouping a stakeholder like 3 could have $TS_{31}S$ very low but $TS_{32}S$ high, thus it is characterized by similarity with 2 but not with 1. The challenge was to decide how the stakeholder 3 can belong to the existing group composed by the stakeholder 1, 2.

  The first issue has been overcome using the following formula, which computes the relationship strength between one stakeholder and a Group:

$$\boldsymbol{i} = Stakeholder\ not\ belonging\ to\ the\ Group\ s\ [1..X]$$

$$\boldsymbol{X} = groups\ defined\ in\ first\ grouping$$

$$\boldsymbol{p} = Members\ of\ the\ Group\ s\ [p\ ...\ N]$$

$$\boldsymbol{N} = total\ number\ of\ members\ of\ group\ s$$

$$\boldsymbol{TS_{ip}S} = Strength\ of\ the\ relation\ between\ the\ member\ \boldsymbol{i}\ and\ \boldsymbol{p}$$

$$\boldsymbol{TS_{pi}S} = Strength\ of\ the\ relation\ between\ the\ member\ \boldsymbol{p}\ and\ \boldsymbol{i}$$

$$k = max_s = \left[\frac{\sum_p^N \left(TS_{ip}S \times \frac{TS_{ip}S}{5} \right) + \sum_p^N \left(TS_{pi}S \times \frac{TS_{ip}S}{5} \right)}{2} \right] \forall s$$

$$\Rightarrow \boldsymbol{Stakeholder\ i\ \in k}$$

Equation 1: First grouping equation

The *equation 1* computes each $\boldsymbol{TS_{ip}S}$ considering its weight, in terms of relationship strength (from 1 to 5) on the overall relationship in order to obtain an evaluation of the similarity that a stakeholder "I" has with the entire group and on the other hand which are the communalities between the selected cluster with the stakeholder "I". Afterwards the average between the two values is computed with the purpose to test if it would be significant to include it into the group: the stakeholder is inserted in the cluster which presents the highest average.

The second challenge, the evaluation of the communality between groups, is crucial in the individuation of the key relations between groups and who are the leading actors involved in them.

An extent of the *equation 1* has been developed:

$$Defined\ the\ clusters\ set\ Y: s, j \in Y$$

$$\boldsymbol{i} = Members\ of\ the\ Group\ s\ [i \dots M]$$

$$\boldsymbol{p} = Members\ of\ the\ Group\ j\ [p \dots N]\ with\ j \neq s$$

$$\boldsymbol{TS_{ip}S} = Value\ of\ the\ relation\ between\ the\ member\ \boldsymbol{i}\ and\ \boldsymbol{p}$$

$$belonging\ to\ the\ different\ two\ Groups$$

$$\sum_{p}^{N} \sum_{i}^{M} \boldsymbol{TS_{ip}S} \frac{\boldsymbol{TS_{ip}S}}{\boldsymbol{5}}$$

Equation 2: Second grouping equation

The *equation 2* computes the weighted (over a maximum of 5) relationship strength of each stakeholder belonging to the Group S with each stakeholder belonging to the Group J (j≠s), obtaining an overall score that signifies the overall relationship strength between the two Groups.

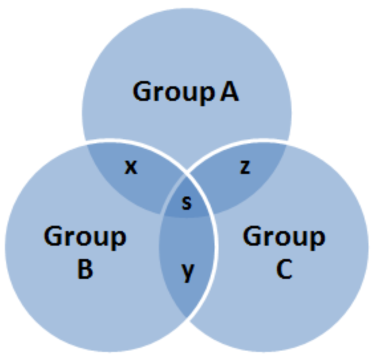


Figure 20: Stakeholders clustering

The overall result of the clustering is the creation of three main Groups of stakeholders characterized by same business profile and high relationships strength measured by the *equation 1*. Moreover the developing of the *equation 2* provides the basis for a new method structured in two levels to analyze the relationships between couples of clusters (**x, y, z, s**) and their relative stakeholders:

- **Macro analysis**
  The first level of analysis is the individuation of the relationship strength through the use of the Formula 2, computing for each relationships (x,y,z,s) the two values derived from the different clusters' perspectives.
- **Micro analysis**
  The second level of analysis aims to explain the reasons behind the value obtained by the Macro analysis, firstly underlining what are the so called leading actors of the relationship, which collect higher $\boldsymbol{TS_{ip}S}$ and secondly clarifying the activities and objectives they share to justify the strong relationship depicted by the high $\boldsymbol{TS_{ip}S}$.

Output 2

The output provided by the Stakeholder clustering is the grouping of all the actors in different clusters and the analysis of the relationships between them underlining which are the information objectives and the common activities performed by all Groups. Both the top-down (business profile) and bottom-up (relationships intensity) approaches lead to common and coherent results, even analyzing the stakeholders' network in a business and relationship strength perspectives.

The stakeholder clustering organizes the different stakeholders in groups that tackle similarly the e-mobility challenges and opportunities in order to reduce the complexity of the environment, providing the basis for a measurement proposition, underlining the key e-mobility performances, thus the potential information applications in the e-mobility world.

4.3 Network key performances

The e-mobility start-up phase is characterised by a huge amount of information, owned by different stakeholders, which more often is not organised and analysed. Even if several players agree on the fact that sharing information among network's actors, in an "open data" perspective, could support the overall e-mobility industry fostering collaborative behaviours, actually few pilot projects in the leading countries are in place without exploiting the entire potentialities of the network data generated by the stakeholders.

The conclusion of the research consists in the individuation of the network key performances for the e-mobility industry structured according both the main relationships between clusters and the groups themselves: for each stakeholders' cluster (previously defined) and for their relationships between the other clusters has been identified a set of key performance areas and potential information applications. Even if in the last decade several researchers have focused the attention on measuring partnership performances [Kaplan, 2010; Bititci et al., 2012], actually in the scientific literature a framework to tackle clusters' performances lacks.

The individuation of a set of key performances is crucial for the analysis of the information management applications, testing the utility of the data organized and integrated in a network point of view. Therefore the first step has been the translation of the corporate strategy of each cluster in Critical Success Factors (CSFs), in order to define for each cluster as well as for clusters' relationships the main performances to be traced exploiting the information gathered and managed by the e-mobility stakeholders.

4.3.1 Cluster's Module

The studies conducted by Kaplan (2010) and Bititci (2012) investigate the collaboration mechanism in order develop a measurement system designed to embrace both external and internal relationships, preparing the field for the individuation of the network key performances.

The preliminary step is represented by the **definition of the strategy** which is shared by the stakeholders belonging to the same cluster. In order to state the cluster's strategy, the stakeholder analysis and clustering have provided the organised information useful for this purpose.

A set of **Critical Success Factors** (CSFs) characterise the main link between the cluster's strategy and highlight the **Key Performance Areas**. In fact they represent the managerial elements which influence deeply the performances of the cluster's stakeholders and guide their activities towards future success. The studies conducted Zhao (2011) have provided a list of CSFs and related key performances including both financial and operational measures that aim to improve the performances of the network.

The definition of the CSFs is introductory for the proposition of a set of measurements which explain with examples the most important performances to be traced, linking the information exploited. The Measurement proposed are linked to the more common Key Performance Indicators (KPIs) associated to each CSF. In particular the measurements selection is driven by the typical KPI criteria [Azzone, 2006]:

- Completeness, namely the MCS capacity to monitor all the competitive differentials of the cluster, covering all the Critical Success Factors (and thus the strategy).
- Measurability, namely the capability to associate to each performance a KPI measurable in an objectively and impartially way.
- Long-term orientation, KPIs can be long term oriented depending on the object of analysis, if this is strictly correlated and coherent to the main objectives of the cluster.
- Precision, namely the correlation between used KPIs and the creation of economic value.
- Specific responsibility, namely the capability to associate to each organizational unit only the performances it is able to determine. In this case, given the wide spectrum of analysis, the responsibility is associated to the single stakeholders, without unbounding the organization in its units.
- Timeliness, namely the capability to provide rapidly the required information. An integration of the Information and Communication Technologies (ICTs) among the stakeholders is required in order to share information in an open data perspective.

Each measurement example is defined according to six main characteristics [Bartezzaghi, 2010]:

- KPI definition: the description and the related explanation on the measurement associated to the KPI;
- Metrics: the computation formula, definitions of the variables exploited for the computation;
- Source of Information: the font where the information is taken for measuring the KPI which varies according to the KPI nature;
- Frequency: the time horizon for the release of the KPI performances;
- Responsibility: the stakeholder responsible of the performance enhancement and target achievement. In case of a KPI influenced by several actors, the responsibility is assigned according to a prevalence principle;
- Further implementation: KPI possible future development or extension, mainly based on the exploitation of unstructured data, infomobility (internet of things) or/and face-to-face feedback collection (direct interviews to service beneficiaries)

4.3.2 Relationship Module

After the definition of the modules related to the three stakeholders' clusters, including the **Critical Success Factors** and the **Key Performance areas**, it is possible to identify the key performances for each relationship between couples of clusters. The study conducted by Macbryde and Mendibil

(2003) underlines the importance to measure the performances within a team, which could be introductory for an enlargement in a collaborative enterprises network.

In this way, starting from the peculiar relationship's CSFs identified by the micro analysis in stakeholder clustering, the performances which have an impact on both clusters are shared and exploited as a trigger to tighten the relationship. In addition to the shared performances, new measurements examples are introduced in order to evaluate joint results deriving from the network formed by the two clusters.

Output 3

The final research output is the proposition of measurements which covers all the network key performances, underlining the utility and applications of the information arising from the complex e-mobility environment.

5. Methodology

The objective of this chapter is to present the methodology exploited for managing the information coming from the e-mobility stakeholders' network composed in the following three stages:

- Literature review and interviews with the main e-mobility stakeholders both in Italy and Netherlands in order to depict the AS-IS information management situation, analyzing how each stakeholder organize and exploit the overall amount of data owned and their overall strategy in the e-mobility sector as well as their information needs (*Paragraph 6.1*).
- A first experimentation of the research, based on co-creation of the new methodology with Antea Consulting Group, was concentrated on the clustering method composed by a bottom-up and top down approach as well as on the proposition of some measurement examples.
- Final action research aimed to validate the methodology, focused on the new method to organize and manage the overall e-mobility data, in a governmental project called CINK, underlining the methodologies weaknesses (Charging Infrastructure Network Knowledge).

The methodology can be properly defined as "the theoretical analysis of the methods appropriate to a field of study or to the body of methods and principles particular to a branch of knowledge" (Mifflin, 2000)

We have structured the development of the thesis in seven main phases represented in below chart.

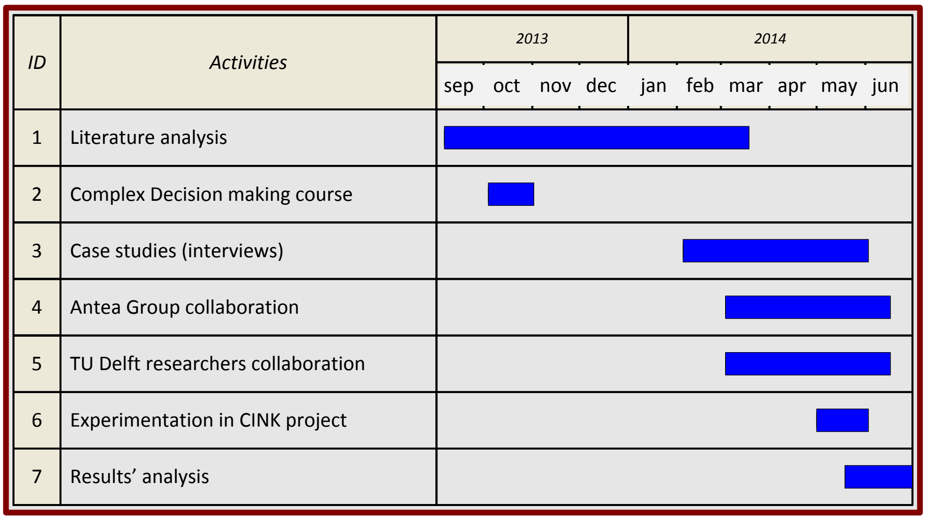


Figure 21: Activities Gantt

The literature review started on September 2013, covering the main e-mobility topics in order to look for the knowledge lack and define the thesis objectives which can fulfil a research gap (*chapter 2*). The literature analysis ended on March 2014, with an overall review on the methods so far developed to organise and measure the existing information, subjects investigated both in prof.

Arnaboldi course of Management Control Systems (taken in first semester of academic year 2013) and a targeted literature analysis, underlining the literature gaps in network accountability (*chapter 3)*.

The interviews, aiming to depict a precise e-mobility information management AS-IS situation, have started during the same period of literature analysis and intensified during the Dutch stay, started on March 2014, and lasted for three months. In this period we've collaborated with the following entities:

- TU Delft researchers (Bauke Steenhuisen, Remco Verzijbergh, PhD researchers) of Management and Policy Analysis department, under the supervision of prof. De Bruijn, in the co-creation of the conceptual framework;
- Antea Consulting Group, with the senior consultant Geert Roovers, in the development of the research output;
- CINK project, particularly with Sonja Munnix and Vivianne Tersteeg, members of governmental agency RVO directly involved in Formula E-Team, for the experimentation of the modular Balanced Scorecard.

5.1 Empirical analysis

The empirical analysis (presented in the *chapter 6*) is composed by two main methodologies: action research (experimentation) integrated with case studies (interviews).

5.1.1 The Antea Group and the CINK project action research

The **action research** (AR) "seeks to bring together action and reflection, theory and practice, in participation with others, in the pursuit of practical solutions to issues of pressing concern to people, and more generally the flourishing of individual persons and their communities" (Miller, 2003).

We've decided to use the action research to create and validate our research output because it promotes the human interaction and the validation of theoretical framework in the field. Thus, this approach should bring improvements into the new information management methodology. In fact the design of a framework to organize and exploiy the existing data in the e-mobility environment represents an innovation which tries to provide for the identified literature analysis gaps.

The action research we've developed is composed by preliminary and ex post interviews, aiming to provide the information for the research and validate the results. A final experimentation has allowed passing from theory to a real project, underlining the research weaknesses and further improvements.

The typology of action research is identified as the most suited is the practical, which requires both researchers and practitioners to work together with the purpose to underline potential causes, problems, finding possible solutions and interventions: the studies propose the self-reflection in discovering solutions (Kemmis and McTaggart, 1998; Holter and Schwartz-Barcott, 1993).

In fact, we’ve decided to co-create the research output in collaboration with Antea Group, in order to apply the theoretical knowledge in a dynamic and result-oriented contest, as a consultancy company. This experience, made of several meetings with different consultants, have helped us to develop and validate the research output, aligned with the consultant practices, in order to highlight the gap between theory and real business cases, which mainly regards the lack of a structured information management. While the investigation of the e-mobility industry and stakeholders analysis have been structured through interviews and practitioners, the development of the information management methodology, stakeholders clustering, and the individuation of the network key performances have been created with Antea due to the high degree of innovativeness and the linkages with the field experience, unfillable with the only academic analysis, even based on active interviews.

In addition, considering as the customer of our research output the Dutch government, the **experimentation** (*chapter 7*) in the **governmental project CINK** has been useful to validate our output and find new weaknesses in order to discover further improvements.

The experimentation has been conducted following the next steps [Walton, 1986]:

1. Plan: establish the research objectives and activities necessary to achieve the expected results. This process has been conducted together with Antea Group, which has supported us in defining the possible criticalities, and with Ms Munnix and Tersteeg, in order to provide the draft activities plan for the experimentation;
2. Do: implement the plan according to CINK project reality, adjusting the indicators to its objectives, selecting the ones which are more suitable with the project purposes;
3. Check: starting from the results collected by the implementation in the project, we’ve controlled the misalignment between the actual and planned management control system, underlining the weaknesses of the research output and its strengths;

4. Adjust: according to the weaknesses discovered in the previous step, we have defined a solution that tries to make up the difficulties in applying a theoretical framework in a real project.

5.1.2 Interviews

A **qualitative research interview** seeks to cover both a factual and a meaning level, getting the story behind a participant experiences, deepened the investigation around the targeted topics (Kvale et al., 1996; Mc Namara et al., 1999).

The research interviews have been one of the most important method to provide for the lacks of the literature analysis, in particular fresh data and new advancements on the e-mobility complexity, contributing to describe in depth the method used by the stakeholder to manage the information in the e-mobility network (chapter 6). In addition, the interviews have been exploited to create the clustering method, obtaining the information useful to define the action network and the relationships intensity of the different stakeholders. In fact the relationship strength has been measured using five drivers, arisen by practitioner and scientific literature analysis, and fulfilled with the interviews feedbacks: for instance in each interview we asked the perception of most important relationships, allowing the interviewees to assign a rough score.

The interviews have been conducted both in Italy and Netherlands, meeting sometimes face-to-face the stakeholders, while other times by Skype. In order to support both types of interviews, we've developed a brief presentation of the research objectives, and a questionnaire based on open-ended questions ad hoc to each stakeholder.

The following scheme proposed by Mc Namara (1999) and Patton (1990) provides us with the guidelines to analyse in depth the stakeholder's peculiarities and behaviours in the e-mobility network, designing different interviews tailored to the peculiarity of the main e-mobility stakeholders.

Interview methodology

1. Explain the purpose of the interview, in a brief MS Power Point presentation, and ask for the possibility to record the meeting.
2. Explain the format of the interview, based on less than 10 questions, about the e-mobility world and the relations with the stakeholders that characterize the sector.
3. Indicate how long the interview usually takes, in most of the cases less than 20 minutes, but when the interviewee has been met face-to-face, the meeting has lasted more than one hour.

4. Tell them how to get in touch with you later: often they require being update with the research results.
5. Integrate the new information into the already developed research topics.

Types of Interviews

We've decided to use a standardized open-ended interviews, in which the same questions are asked to all the interviewees (the respondents are free to choose the answer). This approach facilitates the investigation on the opinions, feelings as well as motivation behind corporate strategy. In addition to measure the relationships stakeholder strength, we've created close fixed-response interviews, in which the same questions are asked to all the stakeholders, and they have to choose among the same set of alternatives. This method is used to guide the interviewees along the research questions, leaving them the time and space to motivate their answers, turning a close ended question in an open ended one.

The following table summarises the conducted interviews, ensuring that all the main e-mobility stakeholders are covered, underlining the country, the company name, the interviewee, the date, location and duration.

N°	**Date**	**Country**	**Stakeholder type**	**Company name**	**Person**	**Location & Duration**
1	January 15th	Italy	CFO	ASF	Annarita Polacchini	35 minutes, Como
2	January 28th	Italy	CFO	Green Mobility Rental	Leonardo Cavaliere	28 minutes, Skype
3	February 18th	Italy	CM	Nissan	Sales force	30 minutes, Saronno
4	February 20th	Italy	CM	Tesla	Sales force	60 minutes, Milan
5	April 10th	Netherland	Consulting	APPM	Mark Van Kerkhof	40 minutes,Skype
6	April 14th	Netherland	CSP	The New Motion	Niels Nobel	54 minutes, Skype
7	April 16th	Netherland	DSO	Eneco	Taco Van Berkel	36 minutes, Skype
8	April 28th	Netherland	CSP	e-laad	Rowald Oosterkamp Arjan Wargers	31 minutes, Skype
9	April 30th	Netherland	G	Ministry of Economics	Julia Williams Jacobse	76 minutes, Den Haag
10	April 30th	Netherland	G	Ministry of Transports & Environment	Mario Fruianu	76 minutes, Den Haag
11	May 5th	Netherland	DSO	Enexis	Leenart Verhenijen	25 minutes,

						Skype
12	May 5th	Italy	CSP	General Electrics	Perico Nicola	15 minutes, Skype
13	May 5th	Italy	DSO	Enel Distribuzione	Carlo Saporiti	15 minutes, Skype
14	May 5th	Netherland	CM	Nissan	David Schoorl	15 minutes, Skype
15	May 6th	Italy	ER	A2A	Alessandro Bartolini	17, minutes Skype
16	May 6th	Italy	G	Senato della Repubblica – Commissione Lavori pubblici	Senatore Stefano Esposito	15, minutes Skype
17	May 6th	Italy	ER	AXOPOWER	Gabriele Bertholet	15 minutes, Skype
18	May 6th	Italy	ER	Illumia	Matteo Bernardi	23, minutes Skype
19	May 7th	Italy	ER	VP Tremagi Group	Massimo Bello	20 minutes, Skype
20	May 13th	Netherland	G	NEA	Sonja Munnix Vivienne Tersteeg	1 h, Utrecth

Table 7: Interviews chart

The previous case studies have been conducted in order to deepen the analysis on the stakeholders' characteristics in the e-mobility world. The interviews have been structured discussing the main interests of the players focusing on the overall strategy and the particular needs on the e-mobility sector. Afterwards, an investigation is performed on the main information sources and the relationships built in the network.

All the interviews are transcribed in appendix 2.

6. ANALYSIS OF RESULTS

The objective of the following chapter is to present the research results, obtained coherently with the framework described in chapter 4, exploiting the interviews with all the main e-mobility stakeholders (*appendix 2*) and the collaboration with Antea Group and TU Delft researchers.

In the first place an overall e-mobility information management overview for each stakeholder underlines the AS-IS methods and models used to manage and organize the existing information. Afterwards, a stakeholder clustering is developed according to their characteristics (business profile and relationship intensity) previously discovered and it becomes input resource for the individuation of the key network performances and the potential information applications in the e-mobility environment.

6.1 Stakeholders information management analysis

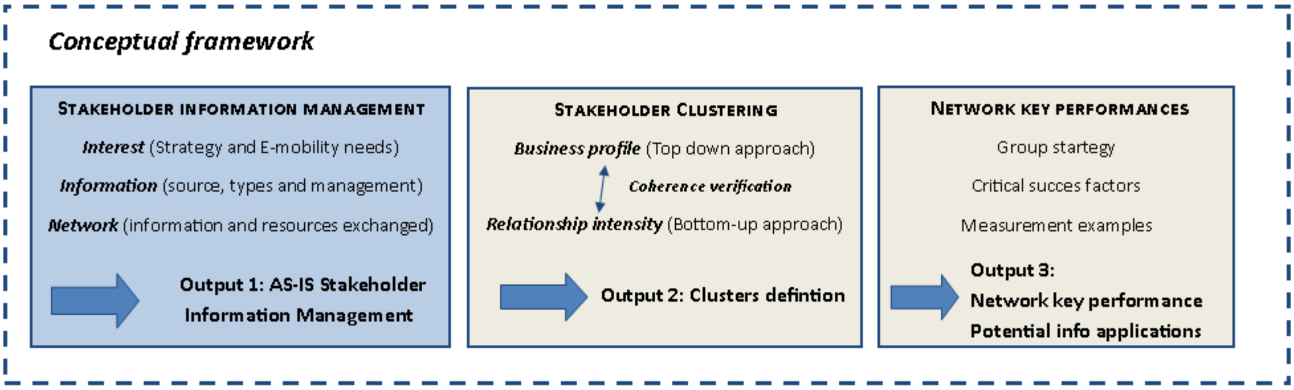


Figure 22: Conceptual Framework Phases

The e-mobility industry has attracted the attention of already existing actors, playing in different sectors, and has represented a chance of business for new entrances.

So far in the e-mobility environment has not been developed a structured and defined information management methodology for all the stakeholders. In fact the different players manage and organize the huge amount of data, arising from the network, in a variety of ways. For this reason the investigation of the AS-IS information management situation has been conducted for each stakeholders starting from the general methods used to analyse the stakeholders, for instance the *Universidad Pontificia Comillas* (San Roman et al., 2011) provides the basis for a further deepened research based on 20 interviews headed to the leading e-mobility actors (*appendix 2*).

The interviews have been conducted in order to ask directly to the leading e-mobility actors the information not available online, such as the methods exploited by the stakeholders to manage the existing data used to their core business and the related information needs.

The structure of the following paragraphs, coherently with the framework presented in chapter 4, aims to define "**The AS-IS stakeholder information management**", underlining the strategy, the e-mobility information needs, the information sources, type and exchanged in the network.

6.1.1 Petroleum Companies (PC)

The Oil & Gas corporations are involved in the exploration, extraction, refining and selling of petroleum derivatives. The market is dominated by the so-called "Seven Sisters" (Exon, Mobil, Royal Dutch Shell, Chevron, Texaco, Gulf Oil). The main players in Italy and Netherlands, the two targeted countries in the thesis, are Eni, Edison, API, ERG for the former, and Royal Dutch Shell for the latter.

Interest

Stakeholder strategy

The petroleum companies interpret the e-mobility under two contrasting viewpoints. On one hand, the massive EVs sales are seen as a threat for the reduction in gasoline consumption. On the other, they exploit the opportunity to invest in correlated "green businesses" as bio-fuels and renewable energy.

Sustainability plays a key role in the mission statement, involving action program which aims to improve company's image associated with pollution and limitless profit. Triple bottom line is one of the main elements in the strategy, including the following actions [Exxon and Shell, 2014]:

- reduce waste and zero spills target,
- save energy with 20% GHG reduction, by investing more on gas extraction and biofuels,
- extend equipment life,
- improve product efficiency with a higher driving mileage for petroleum, namely lower fuel consumption,
- foster large scale adoption of renewable sources with their products.

Needs on e-mobility

Peter Voser, Chief Executive of Royal Dutch Shell, sees a "rosier future for electric vehicles" and forecasts the EV sales will be 40 percent of the worldwide car fleet by 2050 [Bergin, 2012]. EV is going to become the new transportation standard so petroleum companies should adapt assets and strategy to the new upcoming revolution:

- As noticed in official media channels, petroleum companies are focusing and investing on correct and trustworthy forecasts, by keeping future business opportunities open. In the near future the adoption of EV can overturn their core businesses by leading some companies to the bankrupt while others surviving through differentiation in "green businesses".

- Petroleum companies invest in e-mobility as differentiation strategy, with operative projects and cooperation with other stakeholders. Eni and Enel are developing an experimental programme for testing electric vehicle charging options via "fast-charging columns" with Enel technology, by means of a set of recharge points that will be installed at Eni service station. The time needed for a recharging stop allows customers to buy coffee or a lunch at an Eni station, leading to a new source of profit [Enel, 2014].

- The widespread diffusion of EVs introduces new challenges related to the source of energy: if the electricity used to charge the vehicle derives from renewable sources, the overall emissions will be lowered, as well as the environmental impact. Some petroleum companies, as Eni, are investing in stations that already own renewable power generation systems installed (such as photovoltaic panels) [Enel, 2014].

- Although most of petroleum companies are trying to exploit e-mobility opportunities, they are still defending their core business looking at e-mobility as a threat for undermining future profits coming from oil & gas. In fact, e-mobility diffusion leads to an overturn of investments target as well as assets composition, without assuring a safe long-term profit, but introducing new degrees of risk.

Information

The main source of information for petroleum companies derives from statistics which describe customers' attitude and e-mobility world. This structured and unstructured information is useful for:

- Developing forecast in order to depict future transportation and fuel consumption scenarios;
- Benchmarking behaviours of competitors in tackling this upcoming challenge in order to decide to become first-mover or a follower.

- Analysing profitability and side effects of the investments that they've already implemented, as Eni-Enel partnership project.

Network

The so called "Fossil fuel lobby" is the umbrella term used to identify those companies which tend to affect the governmental policies. In several countries, these corporations have a strong impact and dependency upon political parties. In US, they have contributed with $19 million for the 2006 political campaign [Opensecrets, 2007]. Their active role in climate change policies (as Kyoto protocol) aims to affect the decision making of companies and countries regarding what are the best policies for them and also for the government. Oil and gas companies, deciding where to place the energy infrastructure (like gas pipelines), influence the power of the countries which are dependent on them, and affect their GDP.

Petroleum companies sign partnership with Distribution System Operators (as occurred in Enel-eni project) in order to discover new profit sources and take advantage of new business opportunities offered by the partnership. Besides, Petroleum companies are part of energy supply chain, by producing electric energy and providing it to Trasmission System Operators.

Resources

The tight and influential relationship with governments bestows on the petroleum company high **political** power, affecting the policy making and the most important government decisions. Besides the huge amount of funds provided to parties give the right to take part to negotiations.

Four corporations, among the first 500 fortune top 10, are oil and gas companies, with the highest profit rate. [500 fortune, 2014] This data shows the huge **economic and financial** potentiality of this industry.

Since the core business of oil companies is the extraction and production of energy resources, they develop **cognitive resources** in these fields such as engineering and chemical knowledge that could be exploited to undertake investments in similar fields as the production of electricity.

6.1.2 Car Manufacturer (CM)

Among the hundreds of the car manufacturers in the world, 21 produce and sell EVs. Only five manufacturers have established their own core business in the development of EVs: Lightning car company, MIA electric, Fischer, Tesla, Venturi Automobiles.

Not all the vehicles are sold all over the world: actually in Italy only Renault, Smart, Nissan, Citroen, Peugeot, BMW and Tesla have sold an EV, in particular Nissan presents the largest market share with 323 Leaf sold, while in Netherlands the leader is Opel which has sold 2218 Ampera in 2013 [Interviews 3,4,14, *appendix 2*] . Anyway the introduction of Tesla in the Dutch market in 2013 has affected the Opel sales, with a decrease of 17%, by selling 1192 Tesla Model S [RAI Vereninging, 2014].

The global EV market has been hit deeply by the 2008 economic crisis, which has slowed down the sales and cut the investments because of the lack of financial resources. Anyway several governments have tried to cushion manufacturers from recession's effects by introducing a strong policy system.

Interest

Stakeholders' strategy

The EV manufacturers are strongly divided in two groups. On one side, those which believe that the EV is going to become the next transportation standard and, with a long term view, invest strongly in R&D in order to reach a leading position. On the other hand those which produce EV just to comply the national regulation, even if they are convinced that the future will be dominated by ICV and EVs represent only a temporary fashion.

Sergio Marchionne (Fiat & Chrysler CEO) belongs to the latter category, sustaining that a large scale production of EVs will lead to an unitary loss of $ 10000, also referring to the most attractive market worldwide, the "golden state" California which is characterised by a limited market share of only 1% [Repubblica, 19/4/2013].

On the contrary Elon Musk (Tesla CEO) and Carlos Ghosn (Nissan CEO) with a more long-term view, wants to become the first mover in the EV market, by investing a higher percentage of their revenues in R&D. Thus, while Marchionne belongs to an opposite "current of thought" which prefers to wait for further developments in battery and charging technologies, the leaders of automotive industry (Volkswagen and BMW) present a fence sitter position, investing 85% less than Nissan (€ 600 million versus € 4 billion) [Ciferri, 2014].

The car manufacturers are more often pushed by governments to produce “greener” vehicles in order to reduce the large amount of pollution coming from transportation. This fact has been formalized in a raising establishment of strict regulations for what regards internal combustion engines and high incentives for hybrid and full EVs. From this perspective car manufacturers are actually investing resources, in different amounts depending on their opinion, in order to comply with regulations from one hand, and to become the future market leader, even if almost all the players are not actually making profits with EVs.

<u>Needs on e-mobility</u>

The satisfaction of the final customer is directly related to the sales as well as the car manufacturer performances. Hence, the needs of the customer are turned in critical success factor for the company, introducing new marketing levers to better satisfy the customer requirements [interviews 3,4,14, *appendix 2*]:

- Marketing promotion

  The actual low profitability of EVs is absorbing the high investments in R&D and reducing the effort in promotion campaigns. As far as marketing concerns, car manufacturers are not investing in direct promotion (television, radio,…) but they push on “reflected image” given by politicians, Hollywood stars and CEOs who have bought and are using EVs. In addition the EV effect on the company image earns the approval of even non-profitable investments, justified by an eco-friendly attitude.

- Pricing

  A common market strategy is perfectly explained Tesla business case. In order to reach an exclusive image, Tesla has firstly focused on a niche-top gamma model (Roadster) in order to get accustomed the client about the premium brand that Tesla is developing. Afterwards, when the brand awareness is clear for the customer, Tesla has launched the Model S to reach new customers decreasing the cost of the vehicle. The next move of Tesla Motors will be the introduction of a mass electric vehicles, without undermining the exclusiveness of the brand.

- Timing

  For what regards e-mobility, the number of players competing in the market is still low. The competing factors now include the affordability and the possibility to recharge the vehicle when necessary. When in the future the typical EV issues will be overcome, the competing factors will move to internal and external design, acceleration, comfort, range reliability, charging and IT interconnectivity.

- Battery technology development

  The car manufacturers are now demanding developments in battery technology. For this reason a strict cooperation with the battery developers is now in place (e.g. Nec for Nissan and Panasonic for Tesla) in order to reduce the cost (actually $ 1000-1200 per kWh) of about 60-65% in 2020, thanks to the economy of scale [BCG, 2010]. These cooperations provide a higher innovation degree, a quicker time to market thanks to a faster experimentations, and higher fidelity and security. The battery ownership is another field where cooperation plays a key role: solutions as battery swapping (e.g. Better Place) or leasing require integration between players. After the life of the vehicle batteries maintain 70-80 % of their capacity: for this reason, joint venture between key players, such as Nissan and 4R Energy Corporation, stand for reuse, resell, refabricate and recycle of battery pack. Even if technically possible, the battery disposal is still problematic from an economic point of view.

- Infrastructure development

  The standardization of elements which characterizes an infrastructure of charging stations plays a key role in reducing the overall cost: important players, such as Nissan, have established a partnership with AeroVironment and Better Place to foster the construction of charging points and spots. In regards to the previous objective, Ghosn (Nissan CEO) has underlined the fundamental role of a well-established charging infrastructure, even more than a cheaper battery pack: no one is going to "buy a gasoline car if there were no gasoline station" [Ghosn, 14/11/2013].

Information

By introducing a new auto line, the core business of car manufacturer changes affecting its performances and the overall internal processes structure. The sources of information are the same deriving from the production of traditional ICV, but changing the investigated object in order to keep track of the performances tied to EV. The EV manufacturing processes are deviated from ICV regarding the production of power train and batteries, focusing more on rare earth elements' issues (reducing the usage, re-using, recycling and disposing). The complete change of resources usage and the their modifications in processing and the overall environmental impact have moved the attention from achieving more efficient and low pollutant internal combustion engines, towards sustainable usage of raw materials (Lithium, graphite, aluminium,…). Therefore, the further challenges concerning overall consumers' behaviours are focused on meeting the upcoming needs, such as ownership cost, safety and green consumer sentiment. Car manufacturers receive the entire battery pack available to be assembled, reducing the operations tied to the internal combustion engine development, but maintaining most of the operations tied to the vehicle construction. In this way, the measurement system focuses on the differential performances and is based on the following sources [Ference et al., 2011; Habidin et al., 2012]:

- Strategy, which defines financial targets and the internal overall cost structure as well as the changes related to the EV revenues.
- Internal processes, with particular attention to environmental issues such as recyclable elements, usage of rare materials, usage of renewable energy in production.
- Integrated processes with partners, in particular for what regards battery development and production such as sharing of human resources, knowledge and capitals.
- Market reports, about the customers' needs and trends that nowadays are focused on lifecycle energy cost, safety and green attitude.

Part of the information they manage is related to the partnership relationship with battery manufacturers involving specific CSFs and indicators that measure the success of the alliance (explained in detail in the paragraph 6.7 Battery Developer).

Network

The automotive industry, and its satellite activities, in several countries represents one of the most important employment sources, with 45000 workers in Netherlands and 200000 in Italy [FHA, 2010; Tropea, 2013]. For this reason, more often these companies exercise a huge power on the governments, in order to preserve the workplaces. One of the most explicative examples is represented by the governmental reaction to American automotive crisis, begun after the 2008 financial crisis. The US president Obama with the Recovery Act (June 2009) has saved over one million workplaces in Chrysler and General Motors by allocating $ 6.6 billion of loan in exchange of the transfer of some worker rights, among all the strike right until 2015. In the European Union the single state cannot sustain the business of national companies in order to avoid the protectionism, because this is going to be included among the forbidden State Aid [European Commission, 16/8/2013]. Anyway, if the intervention is unanimously approved by the European Commission, the government can release State Aids. For instance in Italy the government has financed the construction of Fiat plants in Melfi and Pratola Serra with € 1.28 billion in order to cushion the unemployment in those areas [Falcioni, 2013]. An important role for providing funds to companies during the worldwide crisis as well as to foster innovation investments (as usual for

EVs) is covered by the bank system, which provides liquidity, constraining the car manufacturers with multi-year loans.

Several players are now signing strategic alliances: the new technology necessary for the development of EVs cannot exploit preceding findings tied to internal combustion engines and is investigated through huge joint investments. For example, Nissan and Renault have signed a joint venture in order to develop EVs, exploit synergies and spread the invested capitals on a higher number of cars and models, by enjoying scale economies. On the other hand, large players have now an advantage to compete on the global market, as testified by the merger between FIAT and Chrysler.

In addition, several car manufacturers are tying partnerships with battery developers as Tesla and Panasonic, NEC and Nissan. Further details are explained in paragraph 6.7 Battery Developer.

Few companies are nowadays involved in the development of a charging infrastructure. Tesla has installed “superchargers” in Europe and United States. Toyota, Nissan, Honda and Mitsubishi, assisted by Japan government (100.5 bln Yen), are investing in the installation of chargers for EV (EV Research, 2013). The four companies will collaborate with the current charging service providers (Japan Charge Network Co., Ltd., Charging Network Development, llc and Toyota Media Service) to create a more cohesive and convenient charging infrastructure network.

Resources

The car manufacturers, operating under governmental subsidies and in turn creating new job positions, own a high level of **political resources** in the relationships with government.

The **economic and financial resources** have been prosperous since in the 2008-2010, during the automotive financial crisis that has affected European and Asian car manufacturers but mostly American ones. The most hit segment is characterised by low fuel economy vehicle, showing a breakthrough of the customers driving habits towards “greener” vehicles. The market saturation, moreover in Europe, has caused the closure of temporary plants. In Italy FIAT announced the dismissing of Pomigliano d’Arco because of the drop in demand and revenues of 19%, which has raised the total debt to € 5.9 billion [BBC, 2009].

Although automotive companies have developed in decades a proper know-how and **cognitive** skills, the EV revolution introduces research fields far from traditional ones. In fact, the battery propulsion accompanies a set of new skills which face chemical, electronic and mechanical issues.

Several automotive companies are not developing these competences inside, but they have signed partnership with specialised battery developers. In particular, these skills include [Hamilton, 2012]:

- R&D: at the moment the lithium-ion batteries represent the standard propulsion engine. Anyway, as presented in paragraph 6.7 Battery Developer, future revolutionary technologies are close to appear. The automotive companies usually do not own internally these competences and for this reason they build alliances with specialised battery developers, which own chemical and electronic engineers.

- Industrialization: after the discovery of new technology, chemical, electronic and mechanical engineers carry out the project turning documents in real product; the industrial engineer studies the way they can be processed in dedicated plants.

- Maintenance and ancillary services: these skills involve infrastructure professionals (as electricians, installer and repairer) and competences related to battery management, as swapping, disposal and leasing of it.

6.1.3 Multi-level governments (G)

The governments are playing a core role in the e-mobility penetration, establishing, at different levels, incentives and regulation systems. Considering the two targeted countries, Italy still presents some weaknesses concerning incentives adopting the European policies without adding further funds. This represents one of the main reasons why EVs are still not accepted by population as new transportation standard. On the other side, Netherlands is the second largest country per capital market in the world and this is due to the massive incentive campaign promulgated by the government, which has led to a sales growth of 338% in 2013 [RVO, 2014; interviews 9,10, *appendix 2*].

Interests

<u>Stakeholder's strategy</u>

The first objective of governments is to provide a sustainable environment from social, economic and environmental point of view to all the citizens. It regards the respect of international agreements as well as the over-national and the national targets. The Kyoto Protocol belongs to the first category and specifies ambitious CO2 reduction targets at international level. Forty countries worldwide – except US – have signed this protocol and have recognized the target in national laws and regulations. E-mobility is one of the most effective solution to reach this goal and over-national institutions, as European Union, has formalised its efforts in Europe 2020, a plan to reduce CO2 emissions of 20% compared to 1990 levels within 2020 [Duncan Clark, 2012]. Besides each local government has the possibility to spread and/or increase the European funds.

Needs on e-mobility

The governmental needs on e-mobility cover very different and broad action fields:

- Respect international agreements. The Kyoto Protocol foresees a CO_2 reduction of 5% worldwide, with some differences between developed and developing countries (cutting or slowing) [Duncan Clark, 2012]. The European Countries, to answer to Kyoto protocol, have proposed EU Emissions Trading System (EU ETS) that helps the EU members to accomplish the Kyoto regulations. The transport system counts for 20% of CO_2 emissions, in 1999 the EU proposes a directive (1999/4/EC) that ensures to the consumers the information related to the fuel economy of each vehicle in order to enable drivers to make an informed choice regarding the vehicle emission: the creation of the labels Euro 0,1,2,3,4,5. Since 2009 the EU regulation (No 443/2009) sets new CO_2 emission limitations targeted 130 g/km which will be extended to 95 g/km in 2021 [European Press Release, 2008]. Each car manufacturer which overcomes these limitations has to pay a fee of 95 € per g/km [ICCT, 2014].

  In order to respect the European constraints, the local governments have the necessity to push the sales of vehicles that stay within these emission targets. On average, an EV produces 45 g/km to 70 g/km, figures that widely place within the CO_2 boundaries.

- Boost energy efficiency. The widespread adoption of EV involves the electric system, because the battery pack can store power coming from renewable sources and deliver it in the grid during high demand periods. With this additional capacity the EV can help to smooth the energy consumption curve.

- Increase employment. Large scale EV diffusion aims to add 1.9 million new American jobs by 2030. Part of these new employments are due to the lithium-ion power plants, charging stations manufacturers, local electricians and other job positions [Mattila & Lowell Bellew, 2012]. The main driver of the EV production is the employment of qualified workers instead of low cost labour force, thus the developed countries can take advantage of it by employing more engineers and chemists, by bringing back the vehicle production. The main EVs plants are placed in California, Germany and Netherlands [Lynch, 2013].

- Reduce dependency on oil. Actually several countries are dependent on petroleum companies for the energetic independency: a massive penetration of EVs could reduce the consumption of liquid fuels by at least 70 percent compared with the traditional internal combustion engine [Srivastava at al., 2010].

- Increase inner city air quality and reduce noise. The EV has the potentiality to reduce fine dusts generated by ICV tailpipe and, at the same time, lack of a combustion engine allows to move silently, improving in this way the overall city welfare.

Information

Governments are developing models to foster the introduction of EVs that satisfy the previous needs (respect international agreements, boost energy efficiency,…), hence they are gathering, analysing and measuring data which steer investments towards the most effective subsidy solution. The information that supports governments' decision making can be classified according to the following drivers which generate structured data [interviews 5,9,10,16, *appendix 2*]:

- Municipal characteristics, sourced by statistics authorities (ISTAT in Italy and Central Office of Statistics in Netherlands) which are mainly related to demographic background of a territory:
    - Average population income: the higher the income, the more likely people can afford an expensive EV.
    - Population: the number of inhabitants negatively affects the effectiveness of incentives; because the EV sale strongly impacts on the relative EV market share if the population is small.
    - Density of houses: in places which the lack of parking is diffused, the parking benefits dedicated to EVs can have a strong impact on the sales increase.
    - Island: the geographical features can fit the EV limited range, avoiding the drivers' range anxiety.
- Presence of past incentives, which has accompanied the EV sales.
    - Launching customers: public administration can purchase EVs for their fleet. The direct effect is related to the increase of EV registrations, while the indirect effect increases physical visibility and in turn the reliability of the car from the point of view of the customer.

- Charging point subsidies: one of the main drivers for a capillary diffusion of a charging infrastructure is represented by incentives for building charging stations.
- Purchasing subsidy: the EVs are characterised by high purchasing costs, hence an incentive that decreases the EV price could foster the sales.

- Additional characteristics:
    - Percentage of HEV: the HEV owner represents a similar potential driver profile of an EV.
    - Pilot projects: they can improve the visibility and reach better customer awareness about e-mobility which could improve the understanding of the strengths and weaknesses of this kind of technology.
    - Share of environmentalist parties: in municipalities, in which public support to parties particularly inclined to environmental and transportation issues, increases the probability of success of EVs.
    - Lease car: the presence of a leasing company on the municipal territory can affect negatively the effectiveness of incentives; in fact, even if the company is going to purchase hundreds of EVs, these will circulate outside the reference area.

Network

Governments promote efficiency interventions aimed to improve environmental situation through dedicated authorities: AEEG (Authority for Electric Energy and Gas) in Italy and ACM (Authority for Consumers and Markets) in Netherlands. These relationships established between governments and authorities aim to grant better competitive scenario and ensure lower price and better service quality for final users.

Moreover the governments are the usual initiators of e-mobility projects, providing standards for EV adoption and favouring stakeholders' integration, with the purpose to reduce at minimum the allocated funds, pushing on the actors' synergies. They collaborate with charging service providers and car manufacturers in order to foster the construction of new charging stations. For instance, Tesla has announced that it is "working with a government-affiliated partner to set up battery changing stations at various locations" to service their Model S platform cars [Ramsey, 2009]. As far as the charging infrastructure providers concern, the usually local government does not finance and invest in the activities of these players, rather it becomes a big customer, buying the charging stations for the public usage [interviews 9,10,16, *appendix 2*].

In addition governments are collaborating with car manufacturers for establishing on one hand purchasing incentives and on the other adopting EVs in public fleets. In the last years European public administrations invested in transport sectors purchasing 110000 passenger cars, 110000 light duty vehicles, 35000 heavy duty vehicles and 17000 buses [Nesle, 2012].

Resources

The governments play the key role in the **political** scenario. They decide at national level the incentives and regulations system as well as educative programs which trigger strongly the penetration of EVs. At the highest level, Europe, in particular, has allocated € 5 billion in the European Green Cars initiative. On the other hand municipal government can foster the spread of EVs by facilitating car sharing initiatives and the construction of charging stations [Neslen, 2012].

The 2008 financial crisis has affected deeply the **financial** potentiality of several countries. The strict constraints fixed with the European Fiscal Compact do not allow to exceed the deficit-GDP limit of 3%, limiting the possibility to undertake strategic choice even in electric mobility. Anyway each country has invested in e-mobility incentives [explained in detail in *paragraph 2.8*] with different amounts depending on the country priorities.

By investing in "green mobility", governments are strategically favouring the development of a precious and new **cognitive** skills and human capitals related to e-mobility topics. As seen previously, the importance of having qualified workers could be differential in placing the EV production plants in developed countries, increasing the number of available job positions.

In additions morphological studies are fundamental for the establishment of a diffuse infrastructure system: in fact, in some countries the presence of hills and mountains is critical because it leads to a decrease of EV performances (driving range) and an incremental complexity in installing a charging points grid [interviews 5, *appendix 2*].

6.1.4 Authorities (A)

As far as e-mobility concerns, the authorities can be classified into two streams [interviews 9,10,16, *appendix 2*]:

- Standard Developments Organizations (SDOs) which aim to support rapid implementation of EV and improve the comprehension of relevant new aspects of EV in order to overcome the issues related to safety and barriers for widespread diffusion of EVs. The most important SDOs concerning e-mobility are International Organization for Standardization (ISO) and International Electro-technical Commission (IEC) at international level and Committee for Electro technical Standardization in Europe [*see paragraph 2.6*].

- Regulatory authorities, which aim to help governments in definition of incentives and laws (consultative power) as well as regulate the market to grant a fair competitive environment (regulatory power). In Italy this role is covered by the AGCM (Antitrust authority) and Authority for Electric Energy and Gas (AEEG) and in Netherlands by the Authority for Consumers and Markets (ACM) which has merged inside NMA (Netherlands Competition Authority) and owns the Dutch office of Energy Regulation.

Interest

Stakeholder's Strategy

Regulatory authorities in the first place control and regulate the competition in the market in order to improve the effectiveness and the efficiency with the final goal to optimise customers' welfare and protection, by ensuring well organized ad transparent market processes as well as fair treatment of customers. They operate primarily under European and national guidelines to promote further development of European single markets, by making possible an effective cross border market and consumers. In particular, they regulate the energy market establishing the tariffs for TSO and DSO [interviews 9,10,16, *appendix 2*].

On the other hand Standard Development Organizations aim to provide international compatibility between jurisdictions, interoperability for international trade of components, a mechanism to share knowledge and make this knowledge of a public good to foster a better performance comparison between new technologies.

Needs on e-mobility

As far as e-mobility concerns, SDOs need to establish new standard systems for the following fields [*see paragraph 2.6*]:

- Car manufacturing: ISO 6469 and IEC TC69 help manufacturers to design fail-safe electrically propelled vehicles.

- Battery technology, in order to allow a fair comparison between different technologies in terms of performances as well as the compatibility of charging infrastructure (connectors, inlet, battery charger, cords, attachment plugs, transformers,…).

- V2G technology and its integration with the smart grid: SEA Electric Vehicle Conductive Charge Coupler (J1772) covers the general physical, electrical and performance requirements for the electric vehicle conductive charge system.

On the other hand, the main role of regulatory authorities aims to set tariffs that ensure service quality customers and a sufficient profitability for DSO and TSO. They determine the price of electricity provided to the private households and public facilities, impacting on DSO and TSO internal processes (cost structure).

Information, resources and network

The authorities represent the executors of government decisions, collaborating with government and using the same type of data and resources to undertake decisions. The network in which they are involved represents the same of the governmental one, because the authorities represent part of public political institutions. The main peculiarity that distinguishes the authority from the government is the more expertise on the execution practices, for instance they follow government consultancy and guidelines to set precise standards and tariffs, as occurs in the decision of the commodities price and standards, affecting all e-mobility stakeholders [interviews 9,10,16, *appendix 2*].

6.1.5 Banking system (B)

The banks are the financial institutions in charge of providing risk capitals to those companies which are eager to invest in the new upcoming e-mobility industry. The most committed banks are Morgan Stanley and Deutsche Bank, which have developed deepened studies to understand the financial potentiality of e-mobility [Deutsche Bank, 2011; Sharf, 2014].

Interest

<u>Stakeholders' strategy</u>

The corporate banks have a clear vision of the short-term future: "Given that the earth‘s oil reserves are finite and oil prices on the rise, hopes are now being pinned on electricity as an alternative fuel for road transport to point the way out of this cost conundrum" [Deutsche Bank, 2011]. Analyst Adam Jonas of Morgan Stanley affirms that the stock price of EV manufacturers, such as Tesla, is going to increase of 170$ due to a well-known thought that its market share is going to double up [Sharf, 2014].

The overall banks strategy aims to offer great results on investments with an excellent service to a diversified customer (governments, companies, final customers). For example, the main player which deals with e-mobility sector is Morgan Stanley because the features of e-mobility market are aligned with the typical targeted market in which Morgan Stanley operates [MorganStanley.com, 2014]:

- Target Size Focus: middle market, with enterprise values of $100 million to $1 billion.
- Target Investment Size: $75 million to $150 million (with flexibility to partner opportunistically for larger targets).
- Sector Focus: Multi-sector (leveraging operating partner and investment professional sector expertise).

Needs on e-mobility

The banks interests regard the e-mobility sector, as mentioned in the strategy, follow two main streams as well as the key performance area that characterized the Banking measurement control system:

- From the speculative point of view, banks are eager to tackle the new appealing market to take advantages of the volatile trading situation that nowadays ensures very high gains.
- From the financing point of view, banks are supporting with funds the developments of all the infrastructure plants and R&D, looking for new sources of profit as well as financing the final customer purchase with loans and leasing.
- The most of the Banks consider as the main key performance area, the quality of the relationship with the citizen: the banks have to ensure that the business activities reflects broader societal and environmental considerations, contributing to growth through financing, supporting businesses and ensuring our products and services support sustainable progress.

Information

The e-mobility market offers to the banking system a fundamental new source of revenue generated by the exploitation of new business opportunity and the correlated improvement in the company image. In order to keep track on these performances banks exploit the following source of unstructured and structured data [Barclays, 2014; Zhang et al., 2009]:

- The level of innovation of the service delivered: the new financial service or derivative support the purchase of the electric vehicle, production of the infrastructure grid or the development of new battery technology, improving the performances related to the innovation degree.

- The alignment with the new customer needs: more and more drivers are showing higher awareness of the potentiality of the EV in the future; however some barriers are still limiting the purchase of new EV. The role of the bank could be crucial to overthrow these barriers mostly related to the higher implementation cost.
- Relationship with the citizen: the bank image is often associated to entities that only aim to increase their profit and avoid the support to green project or no-profit investments. The e-mobility presents a good opportunity to combine a profitable investment with a green, sustainable project that gives to banks a better image, improving customer reputation.

In order to keep track on the improvement of the previous critical performances the source of information is the annual "Customer relationship" report of which each bank draw up every year and most of the data gathered is structured in order to be more efficient in the collection and analysis .

Network

The banking system represents the financier of the e-mobility system, financing all the stakeholders involved, fostering and speeding up the adoption of the e-mobility as a new transportation standard: role partially played by governments.

Since the 2008 world crisis the government and the Banks have tightened the relationship due to the lack of liquidity, trying to collaborate in financing similar profitable projects in order to achieve common objectives, sharing financial resources. This is precisely the case of the jointed funds provided by both government and banks to foster the propagation of the EV in infrastructure and battery technological development.

Resources

The relationship between banks and real economy has appeared with all its strength during the economic crisis started in 2008 after the failure of Lehman Brothers. The intervention of governments in saving banks in trouble was due to preserve the economic system from a collapse and has demonstrated all their huge **political power**.

In addition Banks present great **financial and economic resources**, owning and managing a large slice of the worldwide capitals, with the potentiality to influence the success or the failure of projects from the very beginning. For example, Morgan Stanley manages $ 1.7 trillion, figure very close to overall Italy GDP.

Banks do not own particular **cognitive resources** about e-mobility, although they have the capability to assess the profitability of a new sector in the future, by exploiting analysis and forecasting skills. Concerning the latest studies, e-mobility sectors can make up for the decrease in the stock price of oil petroleum industry.

6.1.6 Charging service providers (CSP)

The charging service providers are responsible to build the physical charging point (public or private), providing some ancillary service to the drivers in order to facilitate the vehicle charging (billing, installation, maintenance, information). The upcoming EV penetration requires both an adequate charging infrastructure and a fair competition between energy suppliers for selling energy on all the public charging points.

Interest

Stakeholders' strategy

The strategy of CSP aims to design a service aligned to station owner's needs, increasing the value of the product delivered to the final customer; the CSP serves three different final customers [interviews 6, 8, 12, *appendix 2*]:

- The individual citizen, who are willing to install a charging point due to the purchase of an EV.
- Municipalities, which install charging station in public areas.
- Private corporations (Mall, Parking companies,…) which through the installation of charging spots offer a more valuable service to their customer/employees improving the company image.

The customers after the agreement with the CSP receive an RFID card which allows them to recharge in every charging spots, even those not owned by the subscribed provider. Another functionality provided by the card is the payment management and the billing: when a driver recharges in a spots diverse from the original CSP has to pay an additional fee.

The CSP are the owner of the charging points, although they do not directly trade energy, they buy electricity from the retailer and they resell the energy to the customer: the final price offered to the customers is strictly dependent on the retailer chosen by them.

In general their activities involve the development of the hardware and the charger, the analysis of data coming from the charging spot, installation, maintenance and billing. Anyway some companies strategically cover just few businesses.

The main profitability source arises from the maintenance, billing and data management services as well as the installation of new charging spots [interviews 6,8, 12, *appendix 2*].

Needs on e-mobility

Taken into consideration the strategy, the needs of CSPs can be summarised as follows [interviews 6,8, 12, *appendix 2*]:

- Customers' satisfaction, through the achievement of their requirements:
  - Wide visibility to the station availability and charging status by developing app for navigators and smartphones;
  - Receive hassle-free 24/7 support for drivers' issues;
  - Development of intuitive interfaces with customers based on multi-lingual and touch-screen interactive system informing the customer on the billing situation;
  - Generate usage reports and analytics;
  - Visibility of the proprietary brand in charging spot.

- Cost and energy savings: the construction of EV charging infrastructure implies maintenance costs (lights, cables, outlets,…) as well as the minimization of energy dispersion;

- Scale charging station for future growth: as far as the EV growing phase concerns, CSPs are subjected to continuous changes implying unavoidable modular platform which can be differentiated and modified;

- Ability to network other EV energy suppliers' hardware to proprietary network: the Open Charge Point Protocol (OCPP) is an application protocol for communication between EV charging stations and central management system (also known as a charging station network) which allows the customer not to be tied to the single CSP. In fact if a charging station developer ceased to exist, the host could switch to another OCPP-based network.

Information

The main source of information is the charging station, which is networked thanks to an incorporated Sim card which allows to share information in real time. Moreover it provides information at three different levels [interviews 6,8, 12, *appendix 2*]:

- Charging session: manage information regarding the duration, the consumption of energy and the start and stop time.
- Charging spot: it provides information about the charging type (three phases or one phase), the current type (alternating or direct), the location and the state (occupied, free or out of order).
- Charging network: gather information about number of spots per location (city or province), preferred customer spot and data exchanged with the competitors about roaming charging (charge in a station diverse to the ones owned by charging service provider).

Moreover the charging service provider commonly use general information about the e-mobility world such as the EV sales, installation of new charging spots, developments of new technologies.

All the data previously faced are related to structured information because the development of a sentiment analysis considered useless and too time consuming. However if there are particular issues related to a customer complaint, specific open questions are structured to deepen the analysis generating unstructured data.

Moreover some costumer interfaces are developed in mobile phone & internet portal in order to inform the driver about the current state of the fuel and greenhouse gas savings, the availability of charging spot as well the closest to the driver in real time, general information about e-mobility world as tips, special offers and the pattern of new incentives regulation.

Network

Regarding the three types of clients listed before, the relations with the retailer change [interviews 6,8, 12, *appendix 2*]:

- Individual citizen, the charging service provider installs the charging spot allowing every retailer chosen by the customer to provide electricity to the vehicle; however there are not significant relations between the two actors.

- Corporations, the retailer is chosen by them avoiding any kind of relations with the charging service provider.
- Municipalities, the retailer for each charging spot is decided by the CSP, establishing an agreement with the energy supplier.

The previous situation represents only the actual scenario, in fact in the future every retailer could provide electricity in every charging spot in a liberalize market.

The relationship with competitors underlines the importance of information sharing arising from roaming charges, collaborating in a network of data useful for the performances of all the actors involved. The information exchanged with these players regards the consumed energy for billing purposes.

The CSPs collaborate with Distribution System Operators (DSOs) for the electric grid connection and the sharing of information to improve the efficiency of the overall supply. Moreover it ties relationships with car manufacturers, the main investors and financers of their activities. For instance, Ford Motor is partner with Coulomb Technologies to provide nearly 5,000 free in-home charging stations for some of the automaker's first electric vehicle customers, under the Ford Blue Oval Charge Point Program [Ford Motor Company, 2012].

The government does not release dedicated funds for the development of the charging infrastructure, but they contribute at regional level purchasing public charging spot, becoming a profitable new customer for them.

Resources

The CSP does not own particular **financial and political resources**, but they have the potentiality to manage a huge amount of information bestowing on them a big **cognitive** power, crucial for the widespread of e-mobility as well as the improvement of the performances efficiency in the overall system.

In fact all of these information gathered and analysed by them are shared among the stakeholders which have signed a commercial agreement; in addition they scent the business opportunity derived by the value of the possessed information, which can be sold.

6.1.7 Battery developer (BD)

Lithium-ion is today the best-established standard for the development of EV batteries because it provides the best combination between safety, power, energy, duration and cost, and, even if the number of circulating vehicles with NiMH (Nichel Metal Hybride) battery is still higher, the new electric cars are equipped with only lithium-ion [*see paragraph 2.4*].

The global automotive lithium-ion battery market will grow to $ 9 billion by 2015 and, even if actually is globally composed by 11 players, within 2015 five front runners will own the 70 % of market share (AESC, LG CHEM, PANASONIC/SANIO, A123, SBLi motive) [Berger, 2012]. China represents the leading country because of the presence of the rare metal, located primarily in the Lake Zabuye (Tibet). Several analysts have stated that the strong “China’s interest in Tibet might be more than political, with the hold over the region likely to do more with economics, taking into consideration the region’s wealth of natural resources, particularly in terms of prospective lithium reserves" [Mohit, 2008].

Interest

Stakeholder strategy

The director and president of AESC (Joint venture between Nissan and NEC) Shoichi Matsumoto sustains the importance of a partnership between actors that possess the know-how to handle the trade-off between battery costs and performances: car manufacturers and technology developers. Lithium is considered the present and the future of this industry, even if R&D costs are still high in order to develop new technologies, as ultra-capacitators and nanotechnologies.

One of the crucial driver is the availability of rare resources, among all lithium, that forces the battery manufacturers to establish their production plants in few countries rich of this kind of raw materials (south America, far East, East Asia), as well as these countries are the leader in the development of advanced technologies as Panasonic, Samsung, LG and Toshiba [*see paragraph 2.4*].

By using the Kraljic matrix tool, the battery is classified as strategic item [Kralijc, 1983]:

- Novelty, the massive production of batteries has started in 2010 with the Nissan Leaf release, when the supplier did not have previous experience necessary to fulfil the delivery. Moreover the advancements in battery technologies were at the beginning; in fact the most used metal was Nichel instead of Lithium.

- Complexity, the battery is composed by different kinds of metals (aluminium, copper,…) with an advanced technology level required.
- Uncertainty, the market is very volatile in this beginning phase, with no security of being a "bubble", as for HEV. Although the drivers' needs are clear (range extension, fast charging,…), the actual technology cannot still fulfil them completely.
- High importance, due to the high weight on EV purchasing price (almost 30%) and influence on performances.

Therefore the battery features previously listed oblige the producer to seek economies of scale in two ways:

- Signing partnerships with one car manufacturer in order to become the strategic provider decreasing the supply risk, participating in the creation of the product, improving the required customers' technical specifications and assuring a fix amount of sales per year, as done by Panasonic with Tesla and AESC with Nissan and NEC.
- Selling as independent supplier to several car manufacturers, oriented to increase the production mix and satisfying more customers, leading to a lower dependency, as done by LG to General Motors, Renault, Volvo and Honda.

<u>Needs on e-mobility</u>

The following list wraps up the needs on e-mobility, core business of the battery developers [Dubarry et al., 2007, Liaw et al., 2007, EDTA, 2007]:

- Reach economy of scale in order to spread the R&D costs and reduce the price;

- Achieve economy of scope, which is one of the main reason to sign strategic alliances with car manufacturers;

- Improve the technology performances in order to fulfil the car manufacturers requirements in terms of weight, design and power of the battery, increasing the drive range without undermining the charging time;

- Guarantee safety standards, at international level. EVs actually suffer of a medium risk of flammability as occurred in Seattle and Washington with Tesla Model S.

- Recycling battery materials: in the last years the Lithium price has risen due to the demand increase and the limited presence in few countries (Cina, Cile, Argentina, Bolivia). The high incidence on the battery pack implies the purchase of lithium not 100% recyclable but less expensive. Therefore the recycling and disposal of Lithium is not technology but price driven, and for this reason no main recycling facilities are present in the world that treats automotive lithium batteries, but only few pilot plants such as Umicore'shoboken in Belgium and Lancaster in US [Kumar, 2013].

Information

The battery performances are crucial in determining the success of the vehicle sold by car manufacturers as well as satisfying the customers' needs. The source of information used to keep track of the critical success factors (CSFs) is focused on the battery itself and generates structured data, underlining three main performances [MIT, 2008, Dubarry et al., 2007, Liaw et al., 2007, EDTA, 2007]:

- Capacity, the state of charge management system never lets the battery become 100% full or 100% empty in order to preserve the chemical features and ensure the performances. So a relevant measure could be introduced (battery usable capacity) which describe real kWh available for the use, on the average the 60%, 70% or the rated capacity. The reduction of internal resistance and open circuit voltage (between batteries terminals with no load applied) affects positively the state of charge, increasing the usable capacity.

- Range is the main issue derived by the EV driver. High and low temperatures reduce the range as well as the battery performances such as quick acceleration and top speed. Specific power (W/kg), namely the maximum available power per unit of mass, affects the battery weight and so its performances. The maximum current at which the battery can be discharged continuously is used to prevent excessive discharge rate in order to preserve the main performances (top speed, acceleration). Energy density (Wh/L, namely the nominal battery energy per unit volume) and specific energy (Wh/Kg, namely the nominal battery energy per unit mass) varies on the battery chemistry and the packaging, determining the range.

- Charging issue arises from two customer's crucial resources: time and money. How long an EV takes to charge the battery depends on the battery size and the voltage of the charger. The price is mainly related to the place and the time in which the customer usually recharges. The charging time is also affected by the capability of the battery to stand high temperatures because the superchargers work at high voltage increasing the overall battery temperature, however this improvement in the charging time implies the decrease of the efficiency and worsens the safety of the vehicle. In fact, charging at high voltage (namely at high temperatures) requires 15/20 % of the energy used to cool the battery. Concerning the safety issue, as occurred in Tesla vehicles, the high temperature reached during the charging may lead to flame the components close to the battery [MIT, 2008].

In addition, the partnership with car manufacturer requires a shared performance measurement system which allows to exchange information generated by the internal processes of the battery producers.

Network

The battery developers work in a strict relationship (often a partnership) with the car manufacturers thus the battery manufacturers in the e-mobility world are defined as an extension of the R&D department of the car manufacturers. In fact car manufacturers' results are widely affected by battery developments and its performances, receiving as main and critical component, prepared to be assembled, the battery pack.

Resources

Inasmuch part of R&D efforts of car manufacturers, battery producers own peculiar **cognitive resources** for the development of this kind of technology. BD, that produces for different car manufacturers (therefore without a partnership agreement), presents a large size as well as a large availability of **financial resources** and the development of EV battery packs represents a diversification strategy to tackle new future business opportunities.

6.1.8 Energy stakeholders

The energy supply chain is composed by several players which cooperate or compete in a liberalised environment, as established by European Commission in 1996 (Directive 96/92/CE). The decree was promulgated to guarantee a fair competition in European countries which were often dominated by monopoly and establishes four main independent stakeholders involved in the overall electricity management.

Figure 23: Energy supply chain

In the e-mobility world, the more involved energy stakeholders are the Distribution System Operator (DSO) and energy retailer because they are more tied to the infrastructure grid needed for the EV charging. Thus in the following analysis a deepened explanation has been developed just for them, while the other energy players are only introduced.

6.1.9 Electricity producer

The electricity production represents the first step which grants the availability of energy from centralised or distributed fonts. In the first case powerhouses generate electricity from diverse sources such as nuclear, geothermic, sun, wind, fossil fuels and renewable fuels (biogas, biomass). The liberalization introduced by Europe forces every production company not to own more than 50% of national demand, in order to avoid monopolistic behaviours. Instead, distributed production defines the self-production systems deployed on the distribution grid [Interviews 7,11,13, *appendix 2*].

The choice of the energy source has a strong environmental impact on the CO2 emissions and in particular affects the green performances of the EV: a country where 59% of national requirements is satisfied by renewable sources presents CO2 emissions 61.5% less than a country with only 9% alternative sources [Chefurka, 2007]. For this reason, several developed countries are nowadays installing and fostering production coming from renewable sources. For instance, Italy energy production is composed by 1.6% geothermic, 5.5% solar (with an increase of 10 times from 2010 values), 3.9% wind, 3.8% biomass [Terna, 2012], while in Netherlands renewable energy counts for 4,1% of national requirements.

6.1.10 Transmission system operator (TSO)

The TSO is an independent entity entirely committed to grid operations. The electric energy transmission is the intermediate step from the production to the distribution of electricity. The infrastructure allows the transmission to long distances and high voltages. The TSO is in charge of matching in every instant the supply and demand of electricity (namely "energy dispatching"), by forecasting long-term trend of electricity production and consumption. TSO, in addition, handle peak demand periods, by communicating the additional requirements to energy producers [van Werven et al, 2010]. Usually, the TSO is the legal owner by concession of the natural monopoly of the grid. In Italy this role is covered by 11 companies (even if 98.5% of national is covered by Terna S.p.A), while in Netherlands is covered by TenneT TSO B. V [Interviews 7,11,13, *appendix 2*].

6.1.11 Distribution system operator (DSO)

The DSO is the owner and operator of the distribution grid, not trading energy, but providing network services transforming the electricity received by TSO from high to medium-low voltage for final usages. DSOs are responsible of three core activities:

- the connection between customers and TSO to the electric grid;
- transportation of the energy produced, ensuring the quality requirements (power and voltage);
- Measurement of electricity parameters.

In Netherlands the DSO sector is liberalised since 1998 while in Italy since 1999. While in Netherlands eight players coexist (Enexis B.V., Alliander N.V., Stedin B.V,…), Italy presents a more fragmented situation, composed by 143 companies often participated by public administrations.

Interest

<u>Stakeholder's strategy</u>

The DSO services cost are established by dedicated national authorities (AEEG in Italy, ACM in Netherlands) and these companies try to compete mainly on four main levers [Interviews 7,11,13, *appendix 2*]:

- Electricity quality: the company aims to provide a continuous flow of electricity to customers (without any interruptions) fulfilling the electricity demand in terms of voltage and power. Therefore the DSO is responsible of the service quality perceived by clients:

the main indicator used by the principal Italian DSO Enel Distribuzione is SAIDI which measures the average interruption duration of the system that is the main driver of the service quality [Enel, 2014].

- Service quality, fulfilling the minimum level of "customer care" service established by the authority for the energy (in Italy AEEG ARG/elt. n. 198/2011; ACM in Netherlands).

- Cost efficiency, driven by set tariffs of the provided services established by energy authorities (AEEG in Italy, NMA/ACM in Netherlands) which leads to a fixed income. Therefore the cost efficiency represents the only lever to increase the profit. In fact in Italy, where the competitive scenario is very fragmented, small companies try to merge in order to reach economy of scale by obtaining higher negotiation power.

- Safety, the product which DSO carries is characterised by high voltage ad for this reason is very dangerous for human health. Thus, all the innovations introduced by the DSO have to follow rigid security processes to ensure a safe work environment.

- Green profile, DSOs, being controlled by local governments, are inclined to foster the withdraw from alternative resources building a cable system to connect private renewable energy spots and the grid.

Needs on e-mobility

DSO plays a key role for the development of e-mobility, granting the deployment of a technically and economically sustainable charging infrastructure for the EV. In fact the propagation of EVs impacts dramatically on the electricity system: it changes the consumption patterns, the peak load congestions and integrates renewable sources into the grid [Interviews 7,11,13,15,17,18,19 *appendix 2*]:

- For the previous reasons, DSOs change their role in the infrastructure system becoming fundamental in the construction of public charging stations, as part of other grid expenditures. The DSO, due to the Authority for Energy regulations, are obliged to grant free access to charging stations to all the retailers: the commercial relationship for the supply of energy is between users and retailers, and the DSO receives a tariff for the coverage of the initial investment and the regular maintenance. On the other the DSO has to allow charging points producers to access the grid granting electricity provision.

- Through the usage of smart grid DSO handles peak loads and the related grid congestion, by making grid and vehicle communicate. Their investment in smart grid is estimated in € 1 billion when the EVs will count for 1 million [Brun et al., 2010].

- Future developments in the battery technology affect the charging patterns of the vehicle. DSO has to manage the charging process in order to fulfil the upcoming demand of a higher power in the charging spots. Future batteries, in fact, will allow higher driving range as well as the reduction of average charging times thanks to powerful chargers (22kW) but increasing the electricity demand for a shorter time laps [EDSO, 2012].

- DSO must comply national and international standards and support the updating of existing rules in order to foster the interoperability of charging infrastructure as final objectives under two perspectives. On one hand interoperability with retailers in order to grant free access to the charging infrastructure (as already discussed). On the other, a set of common standards between car manufacturers and DSOs, in order to allow all EVs to be charged with standard outlets.

Information

The role of information is fundamental in the measurement of the electricity quality (mainly related to the voltage) and the service quality (related to the ancillary services towards customers).

DSO measures its performances using data coming from different sources of information aimed to assess the previous quality drivers.

For the voltage quality the sources of information are represented by [Interviews 7,11,13,15,17,18,19 *appendix 2*].:

- Measurement means (meters), installed in critical points along the distribution grid and on public and private charging spots in order to keep track of electricity consumption patterns of the users very helpful to avoid peak loads and at the same time satisfying electricity demand.

  The type of information generated by meters can be classified as structured and regards the following performance areas: voltage frequency, width and standard deviation; flicker, unbalanced voltage and black out.
- New information generated by the communication between the charging spot and the smart grid (thing-to-thing) are related to unstructured data. For instance, an unstructured data

could be generated by the structured data arisen by the grid parameters (frequency, voltage, width,…) and the structured data related to driver charging habit: this new information allows the smart grid to fulfil the energy demand avoiding peak loads.

- The aggregation and integration of the information coming from the different DSOs is performed by a central database owned by the TSO (Terna in Italy); this allows to have a global view of the different source of information thanks to the exploitation of both structured and unstructured data.

For the service quality the performances are established by the Authority for Energy and measured by the following sources of information:

- The operator who performs the maintenance and management activities that records performances related to its behaviours, in terms of time and percentage of complaints. Mainly the operator has to fulfil a report regarding the performed activities with information related to, for instance, the execution time (structured) and further notes about the intervention (unstructured).
- Customer who interacts with the website and "customer care" operators who records and manages the complaints. Depending on the "type of question" (open-ended or closed-ended) the data can be structured (operator delivery time) or unstructured (complaints or comments).
- The crossed check between the two sources of information (operator and customers) generates a new source that in case of comparison between time performances is structured, while in case of comparison of customer impressions and operator observations must be further investigated.

Network

The DSO in the past has been part of a unique entity, grouping together TSO and energy retailer. Nowadays the national and European authorities have forced the unbundling of these stakeholders, which have kept strong business relationships working with the final customer in the same supply chain. In fact the performance measurement of TSO, CSP and energy retailer is achieved by the sharing of data among them in order to improve the final results which include the transmission and usability of the energy by final customers.

In addition, the relationships between DSO, local governments and energy retailers vary from Italy to Netherlands [Interviews 7,11,13, *appendix 2*]:

- In Italy, Enel, shared by governments for 31%, covers the different roles of DSO, energy retailer and charging service provider on the majority of national territory (which builds and owns the charging station and is in charge of providing maintenance services); in fact it has installed 1114 charging stations which can be used only by Enel clients.
- In Netherlands, the relationship with the government is the same (namely the majority of shareholders are municipalities or governments) but on the contrary the charging service provider, the DSO and the supplier are three different entities. The DSO is only in charge of providing grid services to the charging stations, built by the charging service provider. The unbundling between these three actors has been made by governments to allow a fair competition among all the energy retailers, which can sell electricity independently, allowing the interoperability of the suppliers.

In both countries the role of standardization and energy authorities (AEEG in Italy, NMA/ACM in Netherlands) is fundamental in setting the energy tariffs as well as regulations.

Resources

The main DSO **cognitive resources** are related to the huge amount of data that they gather in the network. The collaboration between TSO and suppliers (described before) fosters the integration of the data collected from different stakeholders; the ability of these stakeholders is to exploit the huge amount of data to forecast future energy patterns and match them with the customers' habits. Then, the main resource of DSO is the information related to the energy market as well as the customers' needs.

Regarding the **political resources**, the DSO has lost with the unbundling the power of being the monopolistic energy player thus affecting the government decisions. Nowadays the DSOs can present differences in size and **economic and financial resources**: for instance in Italian market very big companies as Enel coexists with medium-small companies (as Hera). The fragmentation on the national territory has influenced over time their power to impose their will on strategic political decisions. Anyway, several companies are shared partially or totally by local or national governments, fact which impacts positively on their political power.

6.1.12 Energy supplier or retailer (ER)

The ER sells energy to final customers, who, in countries where the energy supply is unbundled by grid services, pay the ER which in turn pays the DSO. In other countries, there is a unique vertically integrated utility which provides energy and the related grid services.

Interest

Stakeholder's strategy

The electricity retailers aim to enlarge the market share and perform four main strategic activities [Interviews 15,17,18,19, *appendix 2*]:

- Contract pledging: the sales force is involved in searching new customers and keeping update on the news related to the energy sector. One of the main issue is represented by the matching of needs of the customers and DSO.
- Billing & payment: one of the main objectives is to increase the customers' fidelity by achieving billing transparency and accuracy. The supplier offers a diversified portfolio of payment methods (bank transfer, web payment, direct bank withdraw), deferments, refunds in a strict collaboration with the bank system.
- Customer care service: this activity is the core business of energy suppliers which aim to reach the complete customer satisfaction, discovering the concrete needs and expectations. Different services are available like call centres, front office, web app and self-caring on the net.
- Green profile: retailers more often offer electricity coming from renewable sources as an option for clients in order to improve their sustainable image.

Needs on e-mobility

With the introduction of e-mobility the suppliers are directly involved in the energy selling through the charging stations (private or public) [Interviews 15,17,18,19, *appendix 2*]:

- Integration of new information: adopting the electric vehicle customers generate new information about charging patterns, time and location. This new information can be integrated in the company's database in order to develop new tailored contractual solutions and attract new electric driver. Moreover this information must be aligned and shared with the DSO, in order to allow DSO to provide physically the electricity, avoiding grid inefficiencies.

- Billing management: Netherlands, one of the most advanced country concerned e-mobility, the role of charging service provider and energy supplier is separated. In fact, several retailers compete in an open environment, and the customers are allowed to charge the EV in every charging stations, increasing the complexity of the billing. The new challenge is represented by handling the different billing systems owned by different suppliers in the charging stations in collaboration with the DSO. On the counter part, Italy presents a more simplistic but less competitive scenario by covering in one single actor (Enel) all of the three roles (supplier, DSO, charging service provider).

Information

The position of the energy supplier is fundamental because it manages the touch points with the customers, handling a huge amount of consumers' data [Interviews 15,17,18,19, *appendix 2*]:

- The main source of information is the customer itself, analysed through different channels by the supplier which collects information about customers' habits and the feedback of the company performances. The former is composed by a website, a phone application and a call centre, while the second one is structured in formal questionnaires based on the following drivers: timely of the service provided, kindness of operator, efficacy of the service. The type of data collected varies from structured (waiting time to talk with an operator, survey answers,…) to unstructured (comments, complaints collected by call centre,…).
- Data arising from public/private charging stations: in Italy the main issue is the matching of information related to the actual consumption of the customer and the forecasted one (using the customers' historical data). In fact the DSO is in charge of reading the meters in the charging stations and communicates the information to the supplier. In Netherlands the new player (charging service provider) ties a relation with the suppliers, sharing information arising from the charging station with the purpose to improve the awareness of the customer profile and the billing management. The data typology in this case is structured because follows strict formats.

Network

The suppliers, DSO and charging service provider belong to the same supply chain and are part of the main actors involved in the infrastructure system. For this reason, they are strictly related with each other for the sharing of information (previously explained) as well as in some cases these roles are covered by the same actor (as Enel in Italy). Moreover the tight relationship with the final customer leads to a new collaboration with the banking system, in fact the supplier provides a set of financial services, such as refunds, loans, delaying of payments. In addition, in countries in which the new figure of charging service provider is already established, the banking system collaborates in the billing management between the supplier and the owner of the charging spot. The tight relationship between these two actors become crucial to improve the overall service provided to the customer: the sharing of information, as well the collaboration in the billing, allows every customer to recharge the EV in each charging spot, increasing the degree of freedom in choosing the supplier and the charging spot.

Resources

The energy suppliers do not own particular **political or financial resources**, even if in some cases, covering also the DSO role, they increase their overall power. The most important resource is **cognitive**, dealing with the typical marketing skills: market research, segmenting, positioning, customers' analysis. In addition to the cooperation with banks, suppliers need to be update about financial services and billing methods.

6.1.13 Car Fleet Operator (CFO)

A car sharing company offers a mobility services in which the drivers pay an annual or pay per use fee based on a binary tariff, namely a combination between usage time and driven distance. Each car is "shared" among the users and remains of company's property.

On the other hand both leasing and rental companies allow the driver to guide an unique car, but in the first case all the maintenance and ownership costs are charged on the driver, while in second case they are charged on the company.

Interest

<u>Stakeholder's strategy</u>

In all of the three modalities described above, the focal point is the servitization, namely the value is moved from selling the product to providing services, thereby turning demand from reduced material use into a strategic opportunity (Rothenberg, 2007). In case of car sharing you don't purchase and possess a car anymore, but you purchase the "usage" of a car, leading to a lower amount of inventories (not producing the final product they do not have the inventories related to components).

The car fleet operators aim to acquire customers changing the users' cost structure from high fixed cost (the car purchase) in favour to periodic and mileage fee that embeds all the costs related to the vehicle usage (upfront costs, maintenance, fuel,…). Thus, spreading the high purchase cost of the car among different consumers leads to a decrease of the individual ownership cost.

The fuel and maintenance represent some of the main issues to handle by car fleet operators, because they represent the main part of total costs sustained by them and the principal lever to increase the profit.

<u>Needs on e-mobility</u>
As seen in the car fleet operators' strategy, the reduction of the operative costs is crucial for the company's success. Therefore, the introduction of low emission vehicles as EVs, presents remarkable advantages. For instance, bee-green mobility sharing declares an overall decrease of € 3000 adopting an EV because it sustains lower assurance cost, assistance, fuel and maintenance [Bee Green, 2014].

The typical city usage of the vehicle with a shared car is characterised by short trips and is suitable for the typical EV patterns, also considering the wider presence of charging stations in city. In fact, the main problems that limit the adoption of EVs are the short range and the lack of a wide spread system of charging stations, constraints overcome by the usage of a shared EV.

In long-term leasing or rental, the extraordinary interest of potential customers about EV is still limited by the affordability of the service (more expensive compared to a similar ICV). In fact, the most leased and rented vehicles are small-size cars as Renault Twizy and Smart For Two for more affordable price and more suited urban usage. The challenge is represented by concretising the potential customers' interests with real sales of the service [Interview 2, *appendix 2*].

Information

Car fleet operators manage different sources of information in order to keep track of the EV performances and improve customers' service. The main drivers' needs which have to be measured with metrics are the following [Car2go, 2014; Interview 1,2,6, *appendix 2*]:

- The localization of parking lots, in which the vehicles are grouped, impacts in the easiness of finding an available vehicle, critical performance for customers. Car fleet operators have to study in detail the positioning of these parking areas and the movements of the vehicles in order to grant the availability of the service.

- Mandatory vehicle reservation and fixed rental duration, which can reduce the service flexibility obliging the driver to plan the rental and the usage time of the vehicle.
- Some companies oblige the users to bring back the vehicle to the original starting location, which worsen the service quality.
- Level of cleanliness and tidiness of the car received.

All the previous needs are measured exploiting different sources of information [Interview 1,2,6, *appendix 2*]:

- Battery Management System is an electronic system that manages a rechargeable battery (cell or battery pack), such as by protecting the battery from operating outside its Safe Operating Area, monitoring its state, calculating secondary data, reporting that data, controlling its environment, authenticating it and/or balancing it [Barsukov, 2013]. Car fleet operators control physically the BMS about every 5000 km in order to keep track of the historical evolution of voltage, temperature, state of charge, state of health, coolant flow and current performances of the battery as well as the travel behaviour of the drivers. The data generated by BMS are structured.
- On-board computer, an optional tool with similar to BMS purposes. The information are transmitted in real time by a SIM card which allows to gather data about recharging time, the EV location and the usage patterns. All the previous information are subjected to privacy issues and for this reason it is not mandatory. The data generated by the on-board computer are structured.
- Three sources of information (Internet portal, RFID card and smartphone application) create a link between the data possessed by the car fleet operators (previously described) and the consumers. In addition the RFID card allows to charge the vehicle in the different charging spots. The data generated by the touch point between RFID and charging spot derives from the “internet of things”, because the communication is between two “smart” objects, generating unstructured data. The other sources generate mainly structured data with the exception few unstructured data derived by costumers’ impressions and comments.
- A big source of unstructured data (exchange of feedbacks about the service provided, the weaknesses and strengths of the service) is the car sharing community which some

companies are putting in place among users to allow them to recharge the vehicle in the private charging spots. This method aims to reduce the charging price avoiding the intermediary role played by DSO and energy retailer.

Network

The main relationships with the car fleet operators is tied to the car manufacturers that in most of the case own the company or even create new branches to handle this market, as happened in Daimler that has created Daimler AG or Bee-green mobility sharing was born by the synergy between Renault and infrastructure developer [Car2go, 2014; Bee green, 2014].

In some cases car fleet operators diversify their business installing and maintaining private charging spots and establishing relationships with the DSO and CSP. In addition, they collaborate with energy suppliers in order to provide the RFID card which allows to charge the vehicle in every charging station.

The banking system finances car fleet operators in the purchase of EVs or battery leasing.

Resources

The green attitude that characterise the car fleet operators make them appealing for local government, providing a service that decrease the overall CO2 emission as well as traffic congestion. For these reasons the activities performed by the car fleet operators are often supported by the government, bestowing on them more **political power** than other not eco-friendly car operators.

The collaboration and in some cases the belonging to a car manufacturer leads to similar **cognitive** skills and competences more related to marketing areas: the car operators do not manufacture any vehicle, but deliver a service, in which the relationship with the customer is crucial, developing marketing research and sales competences.

6.2 Stakeholder Clustering

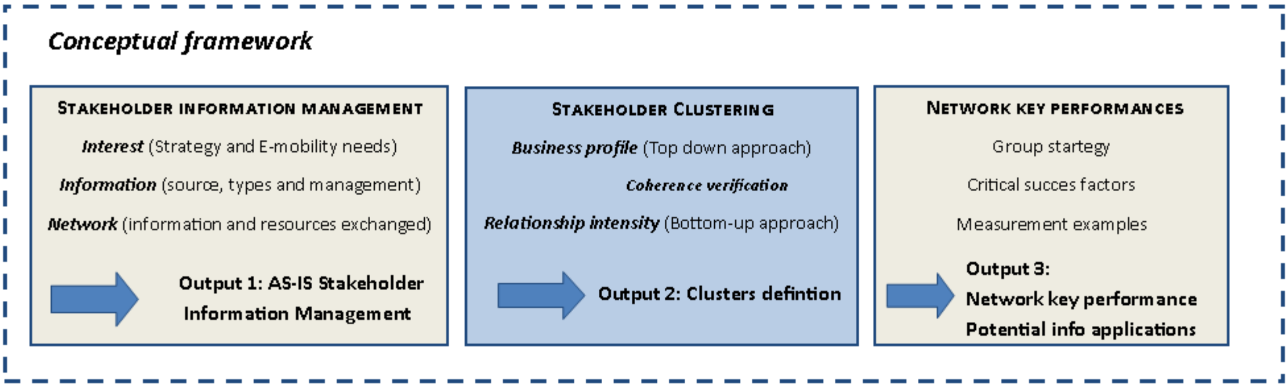


Figure 24: Conceptual Framework phases

The previous analysis of the e-mobility stakeholders has provided the input data for grouping the players into clusters. In particular the previous paragraph 6.1 has structured the analysis underlining the information managed by different stakeholders in the network accentuating the complexity of the environment and the unconformity of the method used to organized and exploit the data. The amount of data gathered and analysed provides the foundation for a stakeholders clustering aimed to improve the effectiveness of the analysis of the information managed by different stakeholders as well as to reduce the investigation complexity.

The clustering methodology is structured by two main approaches:

- **The business profile**, namely the business activities, objectives, performances and resources which characterize an homogeneous group of stakeholders;
- **The relationship intensity**, which, starting from the stakeholder network, underlines the type of relationship between stakeholders, the object of the relation, the common or complementary resources.

The first level of the analysis follows a top-down approach, identifying three different business profiles in which the stakeholders are grouped according to their business characteristics and how they behave in the e-mobility world, in order to ensure the operability of this sector.

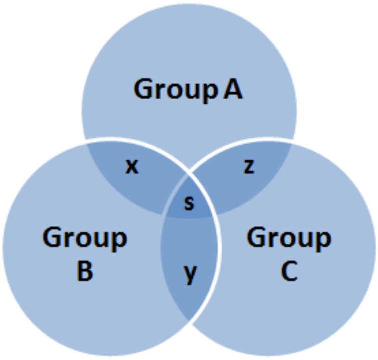


Figure 25: Stakeholders clustering

The second level exploits a bottom-up approach, in order to verify the coherence of the composition of the three predefined business profiles and to measure the relationship strength that characterise the e-mobility network, grouping the stakeholders that present high relationship intensity (e.g. partnership,…).

The objective of the paragraph 6.2 is the creation of homogeneous clusters of stakeholders (A,B,C), implying the study of the relationships among them (x,y,z,s). The overall output is presented in the figure 25 which provides the six different entities (A, B, C, x, y, z) for a successive proposition of measurement examples related to the network key performances.

The overall output provided in the following paragraph has been developed with Antea consulting group and with the interviews support:

- The relationship strength has been measured through a set of questions to the involved stakeholders.
- Antea group have supported the individuation of the main relationship intensity drivers as well as the development of the entire methodology.

6.2.1 Business profile

The approach used in defining the different business profiles of the e-mobility network is top down, namely the stakeholder are clustered according to three crucial roles in this sector, determined exploiting the literature review and confirmed by practitioners and interviewees: E-mobility Sponsors, EV Providers and Infrastructure Administrators.

E-mobility Sponsors

Identification: Banks, Government, Authorities

Business activities: the government pushes the EV propagation by releasing incentives to decrease the implementation cost of the new market. It decreases the purchasing EV price and supports the charging infrastructure development through a system of regulation and authorities that ensure a fair competition, setting tariffs of the energy services and establishing new standards.

On the other hand the bank system supports the sector by financing the technology development of the product itself as well as the diffusion of an efficient infrastructure system, without undermining their willingness to increase their profit.

Resources: All the stakeholders to perform their activities are characterized by a strong political power, mostly the government and the authorities symbolize the entities that undertake decision, exploiting a notable amount of financial resources affecting the country destiny. The Bank mainly possesses a huge amount of financial resources, which could be employed to invest in a wide portfolio of business opportunities, which bestow on them a great political power, cooperating and financing the government activities, as well.

From the previous analysis a common cognitive resource comes up, that deals with the analysis of demographic, social, cultural and financial data that support valuable forecasting in order to assess the feasibility of the investment and the possible future profitability scenarios.

Activity performances: As far as the government and authorities concern, the achievement of national and European environmental targets as well as the financial aids (subsidies) in order to decrease psychological barriers and foster business that increases the overall country welfare in terms of employment and quality of the environment.

On the counterpart the banking system aims to improve their damaged image investing in green businesses that generate a source of profit. Moreover the services provided by banks must be aligned with the new customer trends to keep constant or even better improve their profitability.

Objectives: although the actors involved in the cluster have different specific purposes, they share an overall objective, by supporting the electric vehicle penetration by financing and regulating the overall e-mobility industry, ensuring the profitability of the stakeholders involved, a fair competition and a better reaction to environmental issues.

Infrastructure administrators

Identification: Energy producer, Petroleum Company, TSO, DSO, Energy supplier, Charging service provider (CSP).

Business activities: the infrastructure administrators are in charge to provide the electricity to the final driver, in fact they belong to the energy supply chain performing the generation, transportation, voltage transformation, distribution, trading of the energy and the implementation of a charging infrastructure fitted to the up-coming needs of the new e-driver. In particular the energy producers grant the availability of energy from centralized or distributed fonts, after that the TSO transmits the energy at national level and at high voltages, afterwards the DSO turns the high voltage electricity in low one, connecting the charging station (developed by CSP) to the grid. The supplier trades energy directly with the final customer, matching the right amount of energy desired by the customers with the DSO supply and complying with the CSP to provide energy to the charging spot. The diffusion of the electric vehicle implies the improvement of the efficiency of the grid and the exchanges between the energy supply chain actors. The infrastructure administrators have to align their existing practices to the up-coming e-mobility needs being a crucial intermediary facilitator between the drivers and the EV itself.

Resources: The overall resource owned by the infrastructure administrators is cognitive, with some differences depending on the type of actors. In fact while TSO and DSO deal with infrastructure electricity management skills, the energy retailer and the CSP perform more marketing and data management processes because they are closer to the main touch point with the customer, thus they collect all the information related to the customer behaviour with the EV.

Although all the cognitive resources seem different, they are complementary to each other from the integration of the electric vehicle perspective, bestowing on the infrastructure administrators a crucial role in the generation and integration of the charging and customer information, cutting down the typical e-mobility barriers that limit the EV propagation.

Activities performances: The activities performed by the DSO and TSO aim to control and regulate the electricity flow avoiding the peak load, grid congestion and grid black out. In fact massive introduction of the EV is going to increase the electricity demand, changing the consumption pattern of the users. Inasmuch the tariffs are regulated by the authorities, the profit is mainly generated by decreasing the cost of the operations, without undermining the quality of the supply. The energy supplier and CSP are closer to the customer needs because they deal with the quality of the service provided, rather than the quality of the energy supplied. In fact they handle the integration of data coming not only from the customer behaviour analysis but also on the charging profile.

All the stakeholders have to assure a safe charging environment both for the workforces and the drivers due to the danger caused by electricity.

Objectives: Even if all the stakeholders cover different roles in the energy supply chain, all of them contribute to the electricity provision for the electric vehicle charging. The introduction of EV signifies a huge change in the electricity consumption implying a deeper analysis of the new customer needs, behaviours and habits. The differences in the roles and information gathered by diverse stakeholders are complementary to a better service quality, needing cooperation and information sharing.

EV Providers

Identification: Car manufacturers, Car fleet operators (CFO) and Battery developers.

Business activities: the EV providers are in charge of developing a vehicle competitive and greener, compared with the new ICV, ensuring a profit for all the players involved. In particular the tight relationship with the battery manufacturer and car manufacturer aims to create a battery that satisfy all the customer's needs, such as longer range, shorter charging time. The battery developers produce the main component which the EV will be equipped, focusing on the quality of the output, being the most important one and on the related environmental performances. Since the car manufacturers are no more producing the "engine" all the activities are moved from the R&D related to the engine towards marketing activities regarding the vehicle. The most important ones are related to the pricing of the vehicle, timing, promotion, which in this case is achieved by investing in the diffusion of the charging stations as well as an efficient infrastructure grid. In order to overcome the high purchase cost, the CFO offers, instead of the vehicle ownership, the servitization of the product itself, representing an EV provider as well, but focusing on the service delivered.

Resources: The EV providers have developed specific competences, classified as cognitive resources, in their business fields. Although the engine production is no more performed, the car manufacturers deal with design, marketing skills and the assembly the overall EV. In fact the car manufacturers record the market response in terms of sales and overall success of the EV, bestowing on them the possibility to share this data among the infrastructure administrators and trigger their actions. The battery manufacturers have produced for decades lithium battery for other products, developing dedicated skills and technologies in this field. The car fleet operators can gather data about charging behaviours and customer habits, because they provide also a charging service, collaborating with the infrastructure administrators. In addition the EV providers are linked to the governments because they undertake green projects and are often participated by governments and exploit public subsidies.

Activities performances: The car manufacturers are instrumental to produce a profitable, green and appealing product for the customer. In fact the car manufacturers have to follow the EU restrictions regarding the environmental emissions, modifying their vehicle in order to respect these constraints. This up-coming challenge implies a redefinition of the features of the vehicle, which must be aligned with the customer needs. In this context the timing of the product launch is crucial for the success of the vehicle. Since the battery manufacturers sustain high cost for the development of new technologies and are more pollutant on the production of the battery pack, the economy of scale and scope represent a key performance as well as the evaluation of the battery impact on the environment (rare resource, life cycle assessment and recycling). Car fleet operators contribute to the improvement of the environmental conditions and, representing a service provider, they gather the feedback of the customer about the service quality performances.

Objectives: the overall objective of the EV provider aims to create and deliver a competitive and appealing product that can be easily integrated with the existing infrastructure without overturning the assets of the manufactures and developers.

6.2.2 Relationship intensity

The analysed business profiles show the communality of the stakeholders in terms of resources, business activities and performances which have allowed the generation of the three different clusters. Anyway, even if the business similarity is evident, not necessarily the stakeholders' relationships are in line with them.

Therefore the objective of the following paragraph aims to investigate the similarity according to the degree of relationship intensity. The relationship strength is measured using a bottom-up approach, identifying all the ties, which a stakeholder builds with the others, and it is expressed by the following drivers:

1. **Long-standing business relationship**
2. **Degree of shared resources and information**
3. **Efficacy of shared knowledge**
4. **Degree of business integration**
5. **Homophily: business profile similarity**

For each of the previous drivers, a score (from 1 to 5) and a weight is set according to the evaluation expressed by stakeholders during the interviews [*appendix 2*], identifying the most tight relationships which are going to form a cluster.
In the following paragraphs, for each stakeholder analysed in the paragraph 6.1, an evaluation of the relationship intensity towards all the other players is conducted, collecting scores for each of the weighted drivers aimed at a successive clustering.

6.2.2.1 Petroleum companies (PC)

1) Long-standing business relationship

- Government, Authorities: score 5

  For a long time the petroleum company lobbies have affected the government decisions due to the huge financial resources owned and the criticality of the good sold.
- TSO: score 3

  The TSO has been often and for a long time the direct client that receives the output (energy) produced by the Petroleum Company, but only if the petrol is used to generate electricity.
- DSO: score 1

  Only with the introduction of the electric vehicle the DSO has built relationships with the petroleum companies in order to differentiate their business, by building some charging points in the gasoline stations owned by the petroleum companies.

2) Degree of shared resources and information

- Government, Authorities: score 2

  The petroleum companies often have financed the political activities affecting the strategic decisions of the government such as the placing of the pipelines in the country and the environmental regulations.
- DSO: score 2

  The petroleum companies in order to differentiate their business deal with the DSO to install charging spots in the existing gasoline stations, thus the sharing of resources aims to promote and release incentives for these activities. Anyway it covers just a limited part of the overall investments undertaken by the petroleum companies.
- TSO: score 2

  The TSO, being one of their customers, shares part of the information regarding the electricity provided.

3) Efficacy of shared knowledge

- Government, Authorities, TSO, DSO: score 2

  The information very often are hidden and not completely shared, but they remain still useful for the previous proposes explained in the second driver.

4) Degree of business integration

- Government: score 1

  Some companies are partially regulated by the government authorities and vice versa, building a tight relationship.

5) Homophily: business profile similarity

- TSO: score 2

  It belongs to the same supply chain, even if the overall output of the petroleum company is partially dedicated to it.

- DSO: score 2

  As occurs for the TSO the DSO, it is part of the same supply chain although it deals with different activities and has not a direct relationship with them, except the differentiation business previously explained.

Stakeholder Petroleum firms	1 DRIVER SCORE (10%)	2 DRIVER SCORE (15%)	3 DRIVER SCORE (25%)	4 DRIVER SCORE (30%)	5 DRIVER SCORE (20%)	TOTAL
TSO	3	2	2	0	2	**1,5**
DSO	1	2	2	0	2	**1,3**
CSP	0	0	0	0	0	0
Banks	0	0	0	0	0	0
Government	5	2	2	1	0	**1,6**
Authorities	5	2	2	1	0	**1,6**
Car manufacturer	0	0	0	0	0	0
Car fleet operators	0	0	0	0	0	0
Battery developers	0	0	0	0	0	0
Energy supplier	0	0	0	0	0	0

Table 8: PC Relationships intensity

6.2.2.3 Distribution System Operators (DSOs)

1) Long-standing business relationship:

- TSO and ER: score 5

  In the past they have belonged to a unique entity and nowadays tight relationships are still present. Even if after the unbundling they cover different roles, they have in common the same final customer and their performances are strictly interrelated.

- Governments, authorities: score 4

After the unbundling these actors tightened stronger relationships due to tariff, regulation and standard establishment.

- CSP: score 1

  The CSP has not existed before the introduction of electric vehicle and the collaboration with the CM is born with the introduction of the EV.
- Petroleum companies: score 1

  See the Petroleum companies.

2) Degree of shared resources and information

- TSO: score 3

  The exchange of information is limited to ensure the operability of electricity grid.
- Energy retailer: score: 5

  The energy retailer possesses information about customer's energy consumption and shares it with DSO to grant billing and energy transfer.
- CSP: score 4

  The score is barely minor than energy retailers, because CSP exchanges information only for what regards the billing system (for public charging stations).
- Government, Authorities: score 3

  Information share with the purpose to set fairly tariffs and regulations.
- Petroleum companies: score 2

  See the Petroleum companies

3) Efficacy of shared knowledge

- Energy retailers, CSP: score 4

  The main database of information belongs to the energy retailers and CSP, which embeds all the data related to the charging customer habits, very useful for the DSO to fulfil the new energy demand.
- TSO: score 4

  All the information that the TSO provides to the DSO are crucial for ensuring a good level of service and to provide all the data needed to proceed the following operations.
- Government and authorities: score 3

  The data shared among these three actors is crucial for setting the most suited regulations and tariffs.
- Petroleum company: score 2

See the Petroleum companies.

4) Degree of business integration

- TSO: score 4

  Traditionally DSO and TSO have been part of the same company. Today the agreements about energy and service quality between the two actors show a reliable integration.
- Energy retailers: score 3

  Today electricity represents a commodity which is distributed by DSO and traded by energy retailers. The service provided by energy suppliers to final users depends on the performances of DSO and often the same company which embeds a DSO, presents also an energy supplier.
- CSP: score 2

  For public charging infrastructure, the CSP manages the billing of the supplied energy communicating with the DSO.

5) Homophily

- TSO: score 5

  The operations performed by TSO and DSO are similar in terms of electricity transportation and management.
- Energy retailer: score 4

  The strong synergies between DSO and energy retailers is demonstrated by the usual presence of a branch dedicated to sell energy in the DSO companies.
- CSP: score 2

  Even if the charging infrastructure requires the connection to the electric grid, the development and installation of charging spots requires different competences which often the DSO difficulty owns.
- Petroleum companies: score 2

  See the Petroleum companies.

Stakeholder DSO	**1 DRIVER SCORE (10%)**	**2 DRIVER SCORE (15%)**	**3 DRIVER SCORE (25%)**	**4 DRIVER SCORE (30%)**	**5 DRIVER SCORE (20%)**	**TOTAL**
TSO	5	3	4	4	5	**4,15**
Petroleum company	1	2	2	0	2	1,3

CSP	1	4	4	2	2	**2,7**
Banks	5	0	0	0	0	0,5
Government	4	3	3	0	0	1,6
Authorities	4	3	3	0	0	1,6
Car manufacturer	1	0	0	0	0	0,1
Car fleet operators	0	0	0	0	0	0
Battery developers	0	0	0	0	0	0
Energy supplier	5	5	4	3	4	**3,95**

Table9: DSO Relationships intensity

6.2.2.4 Transmission System Operators (TSOs)

1) Long-standing business relationship

- Government, Authorities: score 4

  Long since, A and G influence the TSO by setting tariffs and regulations (e.g. unbundling).

- DSO, Energy Producer (Petroleum companies): score 5

  The strong integration in the supply chain is due to the belonging to a single entity in the past, which nowadays is still demonstrated by the interrelationships between these actors.

2) Degree of shared resources and information

- Government, Authorities: score 3

  The TSO keeps informed government and authorities on the grid performances and possible lacks which can cause a national black-out.

- DSO, Petroleum companies: score 3

  The grid operability is granted by a limited communication about electricity dispatching and voltage quality.

3) Efficacy of shared knowledge

- Government, authorities: score 3

  The information are crucial to manage the black out and to fulfil the overall national energy demand.

- DSO: score 4

  See DSO

- Petroleum companies: score 4

  See the Petroleum companies

4) Degree of business integration

- DSO: score 4

  They are part of the energy supply chain: even if the roles are different, they are strongly integrated and dependant on each other.

5) Homophily

- DSO: score 5

  Both the actors cover similar roles in the energy supply chain: while the TSO transports energy on national scale at high voltage, the DSO distributes it at regional level converting it into medium-low voltage.

- Petroleum companies: score 3

  See Petroleum companies

Stakeholder TSO	**1 DRIVER SCORE (10%)**	**2 DRIVER SCORE (15%)**	**3 DRIVER SCORE (25%)**	**4 DRIVER SCORE (30%)**	**5 DRIVER SCORE (20%)**	**TOTAL**
DSO	5	3	4	4	5	**4,15**
Petroleum company	5	3	4	0	3	**2,55**
CSP	0	0	0	0	0	0
Banks	0	0	0	0	0	0
Government	4	3	3	0	0	1,6
Authorities	4	3	3	0	0	1,6
Car manufacturer	0	0	0	0	0	0
Car fleet operators	0	0	0	0	0	0
Battery developers	0	0	0	0	0	0
Energy supplier	0	0	0	0	0	0

Table 10: TSO Relationships intensity

6.2.2.5 Energy retailers (ERs)

1) Long-standing business relationship

- DSO: score 5

  In the past these roles have been covered by the same stakeholder.

- Government, Authorities: score 4

  From the liberalization of the energy market, the authority for energy releases the licence to operate in the retailing market.

- CSP: score 1

For few years, they cooperate in order to provide energy in the energy stations.

- Car fleet operators: score 1

  The car fleet operators build agreements for releasing the RFID charging card.

2) Degree of shared resources and information

- DSO, CSP: score 3

  The CSP transmits data about electricity consumption to the DSO and energy retailers in order to maintain grid operability and bill distribution services tariffs. *See DSO*

- Car fleet operators: score 2

  The car fleet operators manage the billing in collaboration with different energy suppliers.

3) Efficacy of shared knowledge

- DSO, car fleet operators, CSP: score 5

  The information generated by roaming charging allows the energy retailers, as well as DSO, CSP and car fleet operators, to inference data in order to discover new customers' behaviour and develop dedicated marketing strategies.

4) Degree of business integration

- DSO: score 5

  See DSO

- CSP: score 4

  The CSP is in charge of building the charging stations with dedicated competences which provides the energy retailers with the physical means useful to sell energy.

- Car fleet operators: score 3

  The car fleet operators, similarly to CSP, provide a means (the EV) which fosters the energy selling.

5) Homophily

- DSO, TSO: score 2

  The energy retailers, as well as DSO and TSO, act on the electricity grid affecting the voltage quality and the creation of peak loads with dedicated customers' tariffs, but with a different role.

- CSP: score 3

The CSP installs the charging stations and collaborates with energy retailers only because the lack of licensing does not allow them to sell energy.

Stakeholder ENERGY RETAILER	**1 DRIVER SCORE (10%)**	**2 DRIVER SCORE (15%)**	**3 DRIVER SCORE (25%)**	**4 DRIVER SCORE (30%)**	**5 DRIVER SCORE (20%)**	**TOTAL**
DSO	5	3	5	5	2	**4,1**
Petroleum company	0	0	0	0	0	0
CSP	1	3	5	4	3	**3,6**
Banks	0	0	0	0	0	0
Government	0	0	0	0	0	0
Authorities	4	0	0	0	0	0,4
Car manufacturer	0	0	0	0	0	0
Car fleet operators	1	2	5	3	0	**2,55**
Battery developers	0	0	0	0	0	0
TSO	5	0	0	0	2	0,9

Table 11: ER Relationships intensity

6.2.2.6 Banking System (B)

1) Long-standing business relationship

- TSO, DSO, Energy retailer, CSP: score 1

  Business relationship has started few years ago with the diffusion of the electric vehicle and the necessity of a new source of liquidity for the up-coming investments.
- Car fleet operators, Battery developers: score 3

  These players were present before the introduction of EV, but the diffusion took place in 2000.
- Petroleum company, Government, Authorities, Car manufacturer: score 5

  Relationship has been lasting for decades.

2) Degree of shared resources and information

- Government, Authorities: score 2

  Mostly during the world crisis the government has investigated in the bank system, operating together.
- Energy retailer, CSP: score 1

  For the billing activities, these players collaborate with the banking system as well as the final customer.

- Car manufacturer, Battery developers, Car fleet operators: score 1

  The sharing of information is necessary to foster and finance the high up-front costs and investments as well as they provide financial support to purchase the vehicle (leasing).

3) Efficacy of shared knowledge

- Government, Authorities: score 2

  The secrecy and danger of the operations limit the efficacy of the sharing.

- CSP, Energy retailer: score 1

  The limited task shared (billing) contribute to a low level of efficacy.

- Battery developers, Car fleet operators, Car Manufactures: score 1

  Limited task shared and low strategic level.

4) Degree of business integration

- Government, Authorities: score 3

  Partially owned by the government, mostly due to the lack of liquidity caused by the world crisis.

5) Homophily: business profile similarity

- Government, Authorities: score 3

  Belonging to the same business profile, even if the features of the activities are a bit different.

Stakeholder BANK	**1 DRIVER SCORE (10%)**	**2 DRIVER SCORE (15%)**	**3 DRIVER SCORE (25%)**	**4 DRIVER SCORE (30%)**	**5 DRIVER SCORE (20%)**	**TOTAL**
TSO	1	0	0	0	0	0,1
DSO	1		0	0	0	0,1
CSP	1	1	1	0	0	0,5
Petroleum company	5	0	0	0	0	0,5
Government	5	2	2	3	3	**2,8**
Authorities	5	2	2	3	3	**2,8**
Car manufacturer	3	1	1	0	0	0,7
Car fleet operators	3	1	1	0	0	0,7
Battery developers	3	1	1	0	0	0,7
Energy supplier	1	1	1	0	0	0,5

Table 12: Bank system Relationships intensity

6.2.2.7 Battery developers (BD)

1) Long-standing business relationship

- Car manufacturer: score 1

  The relationship has been built with the introduction of the EV; before the battery pack was not a car component.

- Bank, Government: score 4

  Since the battery developers usually sustain high R&D costs, due to the high level of technology required by the customer, the Banks and Government financial funds become fundamental for keeping competitive the battery developers in the market.

2) Degree of shared resources and information

- Car manufacturer: score 5

  The battery developers share with the car manufacturer all the most important information because the success of vehicles is strictly related to the development of the battery. In fact the biggest EV manufacturer have built partnership with the battery developers or tight agreements, ensuring a fair exchange of information aim to improve the overall competitiveness both for the car manufacturer and the battery developer.

- Bank, Government: score 2

  The shared resources are just related to the investment or funds.

3) Efficacy of shared knowledge

- Car manufacturer: score 5

  For the reasons explained before the efficacy of the shared knowledge is very high, in fact the relationship between car manufacturer and battery producer is the most important and tight.

- Bank, Government: score 2

  Medium level of efficacy due to the poor amount of information exchanged and the related purposes of the sharing.

4) Degree of business integration

- Car manufacturer: score 4

The car manufacturers very often build partnership with battery developers as occurs between Tesla and Panasonic or NEC and Nissan. The two companies keep on developing their core business but parts of the investments are dedicated to the production of the battery. The management and the ownership of the company are separated, but for the development of the battery most of the resources are shared.

5) Homophily

- Car manufacturer: score 4

  They belong to the same business profile, but the core business, as far as the concerns activities involved to the production of the battery, is pretty different.

- Bank, Government: score 1

  The activities and the business profile are completely different, even if some battery developers, due to the huge size, undertake some investments and financial activities, bestowing on them a bit similar profile to the banks.

Stakeholder Battery developers	1 DRIVER SCORE (10%)	2 DRIVER SCORE (15%)	3 DRIVER SCORE (25%)	4 DRIVER SCORE (30%)	5 DRIVER SCORE (20%)	TOTAL
TSO	0	0	0	0	0	0
DSO	0	0	0	0	0	0
CSP	0	0	0	0	0	0
Petroleum company	0	0	0	0	0	0
Government	4	2	2	0	0	1,4
Authorities	0	0	0	0	0	0
Car manufacturer	1	5	5	4	4	**4,1**
Car fleet operators	0	0	0	0	0	0
Bank	4	2	2	0	1	1,4
Energy supplier	0	0	0	0	0	0

Table 13: BD Relationships intensity

6.2.2.8 Charing Service Provider (CSP)

1) Long standing relationship

- Energy retailer, DSO, Car fleet operators: score 1

  The CSP role was born few years ago and its relationship with energy retailers, DSO and the Car fleet operators lasts only from that moment.

- Car manufacturer: score 1

  Recently car manufacturers are investing in public and private charging infrastructure as done by Tesla with its "superchargers" and the participation to the E-laad project in Netherlands.

- Governments and Authorities: score 1

  Nowadays the major charging infrastructure they represent investors at regional level are local governments. Actually the energy supply market in public charging stations is not fully liberalised, in fact the choice of the energy retailer is not up to the driver, but to the CSP. It's foreseen that in the short term the authorities will regulate and liberalise more this market.

2) Degree of shared resources and information

- Energy retailer: score 4

  The CSP, which sells the energy traded by energy retailer, shares the information about customer's charging behaviours to the supplier which can inference data coming from the different charging stations and provide better services.

- DSO: score 3

  The CSP provides DSO with data about electricity quality and charging behaviours and collaborates in order to avoid peak loads and voltage disturbances.

- Governments: score 3

  If government is the principal investor, it wants to be informed about results in order to develop future policies.

- Car manufacturer: score 3

  The car manufacturers invest in this business to differentiate their activities and collect the feedbacks from the customers; inasmuch the CSP handles the touch point with the customer.

- Car fleet operators: score 4

  The car fleet operators sometimes diversify their business, installing and maintaining the charging stations, but in most of the cases collaborate with the CSP to exchange information about the customer’s behaviour and to negotiate the price of the collaboration.

3) Efficacy of shared resources

- Energy retailers: score 5

In the e-mobility world one of the most important exchanges of information is between the CSP and the energy retailer because they are the main players that gather data about the customer's habit as well as charging spots.

- Government: score 4

  The government does not release any incentive for the charging infrastructure, but some local government becomes a big customer, thus the amount of information exchanged is just limited to the predictable results.

- Car manufacturer: score 3

  More and more car manufacturer companies are investing in charging service provider in order to get the feedback from the market.

- DSO: score 2

  The exchange of information is mainly related to the billing activities and the connection to the grid, but the energy retailer is the main intermediary, between these two actors.

- Car fleet operators: score 3

  For the reasons previously explained the level of resources shared, is related to collection of the feedback and the results, as well as the implementation costs of the charging infrastructures.

4) Degree of business integration

- Car manufacturer, Car fleet operators: score 4

  In most of the cases the CSP are mainly shared by the CM , CFO or at least they usually invest in this business.

5) Homophily

- Energy retailers: score 4

  The only differences in the core activities with the energy retailer are the maintenance and the installation of the charging spots, but for all the remaining activities they are performing at the same level.

- DSO: score 3

  They are part of the same business profile but they perform very different tasks.

- Car fleet operators: score 2

  Even if they are part of different business profiles, they deal with similar activities and are strictly correlated; sometimes they are embedded in the same entity.

Stakeholder CSP	1 DRIVER SCORE (10%)	2 DRIVER SCORE (15%)	3 DRIVER SCORE (25%)	4 DRIVER SCORE (30%)	5 DRIVER SCORE (20%)	TOTAL
TSO	0	0	0	0	0	0
DSO	1	3	2	0	3	1,65
Car fleet operators	1	4	3	4	2	**3,05**
Petroleum company	0	0	0	0	0	0
Government	1	3	4	0	0	1,6
Authorities	0	0	0	0	0	0
Car manufacturer	1	3	3	4	0	**2,5**
Battery developers	0	0	0	0	0	0
Bank	0	0	0	0	0	0
Energy supplier	1	4	5	0	4	**2,75**

Table 14: CSP Relationships intensity

6.2.2.9 Car fleet operators (CFO)

1) Long-standing business relationship

- Bank: score 4

  See Bank

- Car manufacturer: score 4

  The car manufacturers have always provided to the car fleet operators the vehicle required to start their business activities as input resources.

- Energy supplier: score 1

  See Energy supplier

- Government: score 1

  The government begins to support the car fleet operators business when they have decided to invest in green projects as the EV, which improves the overall environmental condition.

- CSP: score 1

  See CSP

2) Degree of shared resources and information

- Bank: score 2

  The resources they share with the banks regard the way of financing the vehicle purchase as well as to offer an ancillary service to the customers in order to make the purchase of the vehicle more affordable.

- Car manufacturer: score 3

  In the case in which the car fleet operators is a branch of the car manufacturers, the degree of shared information is very high, anyway in most of the case the car fleet operator is valuable for the car manufacturer to get the feedback directly from the market.
- Energy supplier: score 2

  See Energy supplier
- Government: score 2

  The government aims to support with funds the green projects and requires to know the project objectives and the possible benefits tied to the launch of the new projects.
- CSP: score 3

  See CSP

3) Efficacy of shared knowledge

- Bank: score 2

  For the reasons explained, the efficacy of the shared knowledge is limited to the ancillary services provided to the customers.
- Car manufacturer: score 4

  As explained previously, the car fleet operators gather the feedback from the market, which is crucial for the car manufacturers.
- Energy supplier: score 2

  See Energy supplier
- Government: score 2

  For the reason explained before, the average efficacy is due to the limited amount of information shared, the government has not the availability to invest many resources and time in these projects.
- CSP: score 3

  See CSP

4) Degree of business integration

- Car manufacturer: score 3

  Sometimes it is a branch of the car manufacturer as occurs in the Mercedes Benz group.
- Energy supplier: score 2

  See Energy supplier
- CSP: score 4

See CSP

5) Homophily

- Car manufacturer: score 4

  It belongs to the same business profile, and there are slightly differences concerning the core activities.

Stakeholder Car fleet operators	**1 DRIVER SCORE (10%)**	**2 DRIVER SCORE (15%)**	**3 DRIVER SCORE (25%)**	**4 DRIVER SCORE (30%)**	**5 DRIVER SCORE (20%)**	**TOTAL**
TSO	0	0	0	0	0	0
DSO	0	0	0	0	0	0
CSP	1	3	3	4	0	**2,5**
Petroleum company	0	0	0	0	0	0
Government	0	0	0	0	0	0
Authorities	0	0	0	0	0	0
Car manufacturer	4	3	4	3	4	**3,55**
Battery developers	0	0	0	0	0	0
Bank	4	2	2	0	0	1,2
Energy supplier	1	2	2	2	0	1,5

Table 15: CFO Relationship's intensity

6.2.2.10 Car manufacturer (CM)

1) Long-standing business relationship

- DSO: score 1

  See DSO

- Government: score 5

  The car manufacturers, representing one of the most important industries in several countries, are always strictly related to the overall country welfare, providing a huge number of job positions.

- Battery developers: score 1

  See Battery developers

- Bank: score 5

  See Bank

- Petroleum company: score 5

  See Petroleum company

- CSP: score 1

  See CSP
- Car fleet operators: score 3

  See Car fleet operators

2) Degree of shared resources and information

- Government: score 3

  The government mostly in the recent period has financed the car manufacturers becoming involved in the destiny of these companies. The levels of shared resources regard the data about investment results and feasibility.
- Battery developers: score 5

  See Battery developers
- Bank: score 1

  See Bank
- Petroleum company: score 2

  See Petroleum company
- CSP: score 4

  See CSP
- Car fleet operators: score 3

  See Car fleet operators

3) Efficacy of shared knowledge

- Government: score 4

  The destiny of the car manufacturer more often depends on the recovery made by the government with funds, bestowing a crucial role on the sharing of information as well as the collaboration.
- Battery developers: score 5

  See Battery developers
- Bank: score 1

  See Bank
- CSP: score 4

  See CSP
- Car fleet operators: score 4

  See Car fleet operators

4) Degree of business integration

- Government: score 2

  Very often the government shares part of the company or is in tight relation with the car manufacturer, for the reasons previously explained.

- Battery developers: score 4

  See Battery developers

- CSP: score 4

  See CSP

- Car fleet operators: score 3

  See Car fleet operators

5) Homophily

- Battery developers: score 4

  See Battery developers

- Car fleet operators: score 4

  See Car fleet operators

Stakeholder Car manufacturer	**1 DRIVER SCORE (10%)**	**2 DRIVER SCORE (15%)**	**3 DRIVER SCORE (25%)**	**4 DRIVER SCORE (30%)**	**5 DRIVER SCORE (20%)**	**TOTAL**
TSO	0	0	0	0	0	0
DSO	1	0	0	0	0	0,1
CSP	1	4	4	4	0	**2,9**
Petroleum company	5	0	0	0	0	0,5
Car fleet operators	3	3	4	3	4	**3,45**
Authorities	0	0	0	0	0	0
Government	5	3	4	2	0	**2,55**
Battery developers	1	5	5	4	4	**4,1**
Bank	5	1	1	0	0	0,9
Energy supplier	0	0	0	0	0	0

Table 16: CM Relationships intensity

6.2.2.11 Government (G)

1) Long-standing business relationship

- DSO, TSO, Car manufacturer: score 4

  See DSO, TSO, Car manufactures
- Bank, Petroleum company: score 5

  See Bank, Petroleum Company
- Car fleet operators: score 1

  See Car fleet operators

2) Degree of shared resources and information

- DSO: score 3

  See DSO
- TSO: score 3

  See TSO
- Petroleum company: score 2

  See the petroleum company
- Bank: score 2

  See Bank
- Car fleet operators: score 2

  See Car fleet operators
- Car manufacturer: score 3

  See car manufacturer

3) Efficacy of shared knowledge

- DSO: score 3

  See DSO
- TSO: score 3

  See TSO
- Petroleum company: score 2

  See the petroleum company
- Bank: score 2

  See Bank
- Car fleet operators: score 2

See Car fleet operators

- Car manufacturer: score 4

  See Car manufacturer

4) Degree of business integration

- Petroleum company: score 1

  See the petroleum company
- Bank: score 3

  See Bank
- Car manufacturer: score 2

  See Car manufacturer

5) Homophily: business profile similarity

- Bank: score 3

  See Bank

Stakeholder Government	**1 DRIVER SCORE (10%)**	**2 DRIVER SCORE (15%)**	**3 DRIVER SCORE (25%)**	**4 DRIVER SCORE (30%)**	**5 DRIVER SCORE (20%)**	**TOTAL**
TSO	4	3	3	0	0	1,6
DSO	4	3	3	0	0	1,6
CSP	0	0	0	0	0	0
Petroleum company	5	2	2	1	0	1,6
Car fleet operators	1	2	2	0	0	0,9
Authorities	5	5	5	5	5	**5**
Car manufacturer	4	3	4	2	0	**2,45**
Battery developers	0	0	0	0	0	0
Bank	5	2	2	3	3	**2,8**
Energy supplier	0	0	0	0	0	0

Table 17: Government Relationships intensity

6.2.2.12 Authorities (A)

The authorities have been considered as a unique entity with the government, being an executive governmental extent. For this reason all the drivers' scores have reached the maximum degree.

6.2.2.13 Relationship intensity summary

All the previous values (expressed from tables 9 to 19), which underline the strength of the relationship between stakeholders, have been organized in a table that shows the bi-univocal nature of relationships and provides the necessary data processed in the following clustering methodology.

	TSO	DSO	CSP	PC	CFO	A	G	BD	B	ER	CM
TSO		4,15	0	2,55	0	1,6	1,6	0	0	0	0
DSO	4,15		2,7	1,3	0,1	1,6	1,6	0	0,5	3,95	0,1
CSP	0	1,65		0	3,05	0	1,6	0	0	2,75	2,5
PC	1,5	1,3	0		0	1,6	1,6	0	0	0	0
CFO	0	0	2,5	0		0	0	1,2	1,2	1,5	3,55
A	2	2	0	0	0		5	0	1	0	2
G	1,6	1,6	0	1,6	0,9	5		0	2,8	0	2,45
BD	0	0	0	0	0	0	1,4		1,4	0	4,1
B	0,1	0,1	0,5	0,5	0,7	2,8	2,8	0,7		0,5	0,7
ER	0,9	4,1	3,6	0	2,55	0,4	0	0	0		0
CM	0	0,1	2,9	0,5	3,45	0	2,55	4,1	0,9	0	

Table 18: Relationship intensity - Overall scenario

6.2.3 Clustering methodology

6.2.3.1 First grouping

The first grouping has been developed considering the stakeholders that build very strong relationships (greater than 3 and coloured in red in table 20) mostly due to the affinity to similar business profiles; thus through the first grouping the stakeholders are clustered coherently with the top down approach (business profiles, paragraph 6.2.1), verifying the alignment of the two methods.

From this methodology, the following groups are defined:

- **Group A:** TSO, DSO, ER.
- **Group B:** CFO, CM, BD.
- **Group C:** A, G.

6.2.3.2 Second Grouping

Some stakeholders (CSP, PC, B), which present a strong relationship with only some group members, are excluded by the first grouping even if their relationships with the cluster business profile is evident.

In order to cluster these stakeholders in the previous groups, the equation 3 measures the relationship strength between the existing clusters (A, B, C) and the remaining stakeholders, underlining the missed communality:

$$\boldsymbol{i} = Stakeholder\ not\ belonging\ to\ the\ Group\ s\ [1..X]$$
$$\boldsymbol{X} = groups\ defined\ in\ first\ grouping$$
$$\boldsymbol{p} = Members\ of\ the\ Group\ s\ [p \dots N]$$
$$\boldsymbol{N} = total\ number\ of\ members\ of\ group\ s$$
$$\boldsymbol{TS_{ip}S} = Strength\ of\ the\ relation\ between\ the\ member\ \boldsymbol{i}\ and\ \boldsymbol{p}$$
$$\boldsymbol{TS_{pi}S} = Strength\ of\ the\ relation\ between\ the\ member\ \boldsymbol{p}\ and\ \boldsymbol{i}$$
$$k = max_s = \left[\frac{\sum_p^N \left(TS_{ip}S \times \frac{TS_{ip}S}{5}\right) + \sum_p^N \left(TS_{pi}S \times \frac{TS_{ip}S}{5}\right)}{2}\right] \forall s$$
$$\Rightarrow Stakeholder\ i\ \in k$$

Equation 3: First grouping

Considering the CSP, the relationship intensity of this stakeholder with the groups is defined as follows:

$$\mathrm{CSP_{groupA}} = \frac{0}{5}0\ (TSO) + \frac{1,65}{5}1,65\ (DSO) + \frac{2,75}{5}2,75(ER) = 2,06$$

$$\mathrm{CSP_{groupB}} = \frac{3,05}{5}3,05\ (CFO) + \frac{0}{5}0\ (BD) + \frac{2,5}{5}2,5(CM) = 2,7$$

$$\mathrm{CSP_{groupC}} = \frac{0}{5}0\ (A) + \frac{1,6}{5}1,6\ (G) = 0,22$$

On the other hand, the relationships between the Groups and CSP are calculated:

$$\mathrm{GroupA_{CSP}} = \frac{0}{5}0\ (TSO) + \frac{2,7}{5}2,7\ (DSO) + \frac{3,6}{5}3,6(ER) = 4,05$$
$$\mathrm{GroupB_{CSP}} = \frac{2,5}{5}2,5\ (CFO) + \frac{0}{5}0\ (BD) + \frac{2,9}{5}2,9(CM) = 2,93$$
$$\mathrm{GroupC_{CSP}} = \frac{0}{5}0\ (A) + \frac{0}{5}0\ (G) = 0$$

In order to evaluate the inclusion of CSP in one of the three groups, the maximum average relationship intensity is computed, driving the choice:

$$k = \max_{s} = \left(\frac{2{,}06 + 4{,}5}{2}; \frac{2{,}7 + 2{,}93}{2}; \frac{0 + 0{,}22}{2};\right) = 3{,}05$$

$$\Rightarrow CSP \in Group\ A$$

Computing the previous formula for B, the following result is achieved:

$$k = \max_{s} = \left(\frac{0 + 0}{2}; \frac{0{,}84 + 0{,}1}{2}; \frac{1{,}77 + 3{,}14}{2};\right) = 2{,}45$$

$$\Rightarrow B \in Group\ C$$

The following chart summarises the calculations previously described:

	Group A	**Group B**	**CSP**	**PC**	**Group C**	**B**
Group A		1,3	4,05	1,64	2,62	0
Group B	0,45		2,93	0	1,69	0,84
CSP	2,06	2,7		0	0,22	0
PC	0,79	0	0		1,02	0
Group C	1,02	2,16	0	0,5		1,77
B	0	0,1	0,5	0,5	3,14	

Table 19: First grouping

Petroleum Company is considered more an opponent to the introduction of the EV because it builds relationships with many actors without being deeply involved in the propagation of the EV. The petroleum company aims to protect their core business, analysing the future trend and opportunities, bestowing on it a marginal role for the scope of the thesis, thus in the following analysis it is no more considered as a key player that can cooperate to foster the propagation of EV.

The extension of the previous formula is used to compute the value of the relation between predefined couples of clusters, useful to analyse the motivations behind the values of the relationships strength:

$$Defined\ the\ clusters\ set\ Y: s, j \in Y$$

$$\boldsymbol{i} = Members\ of\ the\ Group\ s\ [i \ldots M]$$

$$\boldsymbol{p} = Members\ of\ the\ Group\ j\ [p \ldots N]\ with\ j \neq s$$

$$\boldsymbol{TS_{ip}S} = Value\ of\ the\ relation\ between\ the\ member\ \boldsymbol{i}\ and\ \boldsymbol{p}$$

$$belonging\ to\ the\ different\ two\ Groups$$

$$\sum_{p}^{N} \sum_{i}^{M} \boldsymbol{TS_{ip}S} \frac{\boldsymbol{TS_{ip}S}}{\boldsymbol{5}}$$

Equation 4: Second grouping

An example is provided in order to calculate the relationship strength between the Group A and the Group B.

Members Group A: TSO, DSO, ES.

Members Group B: CM, BD, CFO.

$$\text{TSO} = \frac{0}{5} 0\ (CFO) + \frac{0}{5} 0 (BD) + \frac{0}{5} (CM) = 0$$

$$\text{DSO} = \frac{0,1}{5} 0,1 + \frac{0}{5} 0 + \frac{0,1}{5} 0,1 = 0,003$$

$$\text{ES} = \frac{2,55}{5} 2,55 + \frac{0}{5} 0 + \frac{0}{5} 0 = 1,3$$

$$\text{Value of the relation among the Group A and B} = 0 + 0,003 + 1,3 = 1,303$$

The iterated utilization of the previous formula for all the relationships among groups and for both the perspectives aims to analyse the strength of the relationships between couples of clusters.

	Group A	Group B	Group C
Group A		4,41	2,32
Group B	3,38		2,53
Group C	2,62	2,46	

Table 20: Relationships strengths between clusters

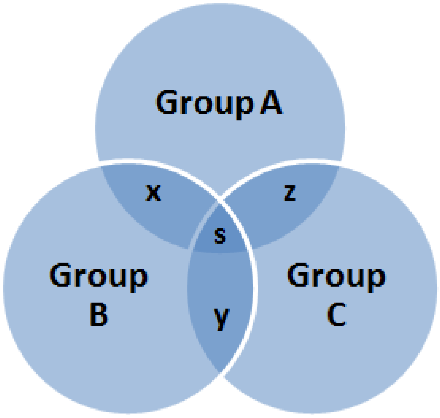


Figure 26: Identified clusters

The previous classification provides the input for the analysis of the four types of relationships (x,y,z,s) at a **macro and micro levels**. The first one regards the overall intensity between two groups. The second one, unbundling the group members, analyses the relationships value between stakeholders belonging to different clusters involved in the targeted relationship (x,y,z,s) in order to investigate the motivation behind the values collected in the macro evaluation.

6.2.3.3 Relation type y

Macro evaluation: within 3,38 and 4,41

Micro evaluation:

- [1,5 ; 2,55] between the ES and CFO

  The ES and CFO collaborate by exchanging data about the billing of energy used by car belonged to the fleet.
- [2,5 ; 3,05] between the CFO and CSP

  They exchange information about the charging.
- [2,55 ; 2,9] between the CSP and CM

  The CSP business is dependent on the number of vehicles sold by CM. In addition, some CMs have diversified their strategy by investing in charging infrastructure.

6.2.3.4 Relation type x

Macro evaluation: within 2,46 and 2,53

Micro evaluation:

- [0 ; 1,4] between the BD and B,G

  The BD sustains high R&D cost for new battery innovation and incurs debt with banks and receives incentives from the government as an extent of car manufacturers.
- [2,45 ; 2,55] between the CM and G

  The CM presents a tight relationship with governments for the EV incentives and regulations for reducing pollution and respect national and international environmental agreements. In addition during the 2008 financial crisis, the relationship has been tightened for protecting the employment generated by automotive industry.
- [0,7 ; 1,2] between the CFO and B,G

  The CFO provides a “green service” through the car usage servitization, thus the local governments foster this initiative to reduce air pollution and traffic issues. In addition banks support this business by providing financial services to CFO and final customer.

6.2.3.5 Relation type z

Macro evaluation: within 2,32 and 2,62

Micro evaluation:

- [1,6 ; 1,6] between the TSO and G,A
  The governments and authorities regulate the TSO business through laws and policies.
- [1,6 ; 2,00] between the DSO and G,A
  Also for DSOs, governments and authorities regulate their business as occurs for TSO.
- [1,05 ; 1,05] between the CSP and G
  More often, government becomes a CSP client for what regards the installation of public charging stations.

6.2.3.6 Relation type s

From the observation of the *figure 25*, three main relationships combine some performances and information sources of all the stakeholders. In the relation type s the roles of ER and DSO are not considered because all the information about customers' behaviours are shared by the CSP. The stakeholders which are crucial for the relation s are the CSP, Governments and Banks.

CSP Macro evaluation: 2,86

The CSP possesses the main source of information of the e-mobility industry, which is used by all the stakeholders to develop their performance measurement systems.

Micro evaluation:

- 2,1 with Group A
- 3,11 with Group B
- 0,5 with Group C

Bank Macro evaluation: 2

The bank system fosters the different businesses which characterize the e-mobility world with funds and financial services focusing on the investment profitability and the market attractiveness.

Micro evaluation:

- 0,1 with Group A
- 0,29 with Group B
- 3,14 with Group C

Government Macro evaluation: 4,5

Although the role seems to be similar to banks, government deal more with effectiveness of their incentive system instead of profit orientation. Moreover, it regulates the market according to EU and worldwide policies.

Micro evaluation:

- 1,02 with Group A
- 1,36 with Group B
- 4,5 with Group C

6.3 Network key performances individuation

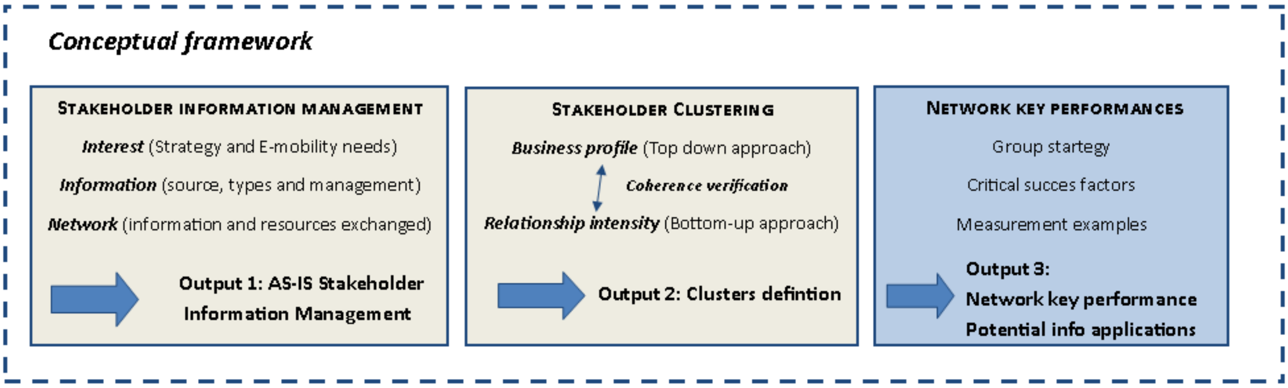
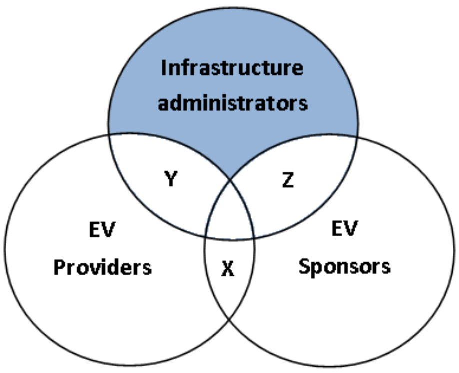


Figure 27: Conceptual Framework Phases

The stakeholders clustering has defined the composition of the three main players' groups and provided the knowledge basis for the proposition of network measurements in order to identify the potential information applications. The collaboration with Antea Group, added to the practitioners' analysis as well as the TU Delft researchers' support, has filled the gap between theory and real business cases. In the following paragraphs the network key performances has been defined for each cluster and for each key relationship between stakeholders' clusters. Firstly the group strategy is investigated in order to identify the overall objectives coherence among the group's members, secondly the Critical Success Factors are identified, and covering the strategy and finally a proposition of measurements is presented.

6.3.1 Group A Module: Infrastructure Administrators

6.3.1.1 Group strategy



The infrastructure administrators have to maintain the operability of the infrastructure grid, by assuring the electricity and service quality and integrating the different roles covered by these stakeholders in the energy supply chain and infrastructure development. The interoperability of the different energy retailers has to be granted in all the charging stations and the billing all over the energy supply chain must be coordinated and integrated through an higher awareness of all the players on the electricity flow as well as exchanged information. The final customers' requirements must be fulfilled concerning the service quality, safety and information necessity. The group strategy covers the image improvement and the respect of government restrictions by installing new energy renewable sources, however the fixed tariffs imposed by authorities (for DSO and TSO) imply a reduction of operating costs aimed to increase the profitability.

6.3.1.2 CSF and key performances

From the group strategy it is possible to identify a set of strategic objectives which are deployed in several CSFs that cover the main performance fields, representing the drivers of further measurements.

Safety

The electricity is the product traded in the energy supply chain, incurring a high degree of risk for employees and users because of high voltage. The TSO and DSO are in charge of providing rigid security processes to ensure a safe work environment for their workers. The CSP acts directly on the grid assuring a safe charging environment for the e-drivers in trade off with the time of charging (the higher the voltage, the lower the charging time).

1. **Increase employee safety (example of indicators)**
2. **Increase processes security**
3. **Increase users safety**

Example of key performance indicators

- **Reportable accidents (including fatalities) per hours worked**

With this indicator companies can keep track of the degree of security of the work environment, expressed as the number of workers' accidents, which can include also fatalities, occurred in 100.000 hours worked. For their maintenance and installation activities, TSO, DSO and CSP are the most exposed to accidents and this indicator measures the aggregated value of each type of stakeholder, giving a comprehensive view of the environmental security.

Metrics	$\sum_{i}^{N} \frac{Total\ number\ of\ accidents\ (including\ fatalities)}{Total\ number\ of\ worked\ hours\ /\ 100000}$ $i = All\ the\ players\ more\ exposed\ to\ accidents: DSO, TSO\ and\ CSP$
Source of Information	Employee's reports
Frequency	Annual
Responsibility	TSO, DSO, CSP
Further implementation	In the future, employee palmtop could inform in real time about this data. In addition interviews to employees can represent a useful source of unstructured data to exploit to improve safety policies.

- **Percentage of staff with adequate OHS training**

Companies are investing in Occupational Health & Safety training, but often the workers do not attend courses aimed to improve their knowledge about security issues. For this reason this indicator aims to trace this performance with a target value of 100%. Once again, TSO, DSO and CSP are the most involved actors in measuring this performance.

Metrics	$\sum_{i}^{N} \frac{Number\ of\ employees\ with\ adequate\ OHS\ training}{Total\ number\ of\ employees}$ $i = All\ the\ players\ more\ exposed\ to\ accidents: DSO, TSO\ and\ CSP$
Source of Information	Corporate Human Resource reports
Frequency	Annual
Responsibility	TSO, DSO, CSP
Further implementation	/

Cost efficiency

Since the authorities through the European regulations establish for TSO and DSO a fixed tariffs for the electricity sold, the reduction of the operative costs represents a crucial performance aimed to improve the profitability of these actors. In particular, the DSOs tend to exploit economies of scale in order to spread the fixed infrastructure cost and improve their negotiation power, with the risk to diminish the services quality offered to the energy retailers.
The maintenance costs, regarding the cables owned by TSO and DSO, is a crucial driver to work out as well as the charging spot installed and maintained by CSP.

4. **Increase profitability**
5. **Reduce maintenance costs**
6. **Reduce operative costs**

Example of key performance indicators

- **CSP profitability**

The CSP revenues are generated by payment of its e-drivers subscribed and the assignment of advertising rights regarding the billposting on the charging stations. On the other the costs regard the electricity traded by the ER in its proprietary or other CSPs' charging station as well the tariffs for the charging rights in non-proprietary charging spots. This indicator is useful to understand the level of profitability of this actor which is crucial for all the e-mobility industry inasmuch it deploys the charging infrastructure; an unsustainable level of profitability should force the ER to sell at a discount price the electricity, signing tailored agreements.

Metrics	$Profit_i = \sum_i^M REV_i - \sum_i^M \sum_k^N ER_{ik} + \sum_z^S REV_z - \sum_z^S \sum_k^N ER_{zk} - \sum_z^S T_z - \sum_i^M Maintenance_i + \sum_i^M Adv_i$ Where: $REV_i = Revenues\ of\ CSP\ in\ its\ proprietary\ charging\ station\ i$ $ER_{ik} = Energy\ supplied\ by\ the\ energy\ retailer\ k\ in\ the\ charging\ station\ i$ $REV_z = Revenues\ of\ CSP\ in\ not\ proprietary\ charging\ station\ z$ $ER_{zk} = Energy\ supplied\ by\ the\ energy\ retailer\ k\ in\ the\ charging\ station\ z$ T_z $= Tariff\ that\ CSP\ has\ to\ pay\ for\ the\ usage\ of\ non\ proprietary\ charging\ station\ z\ by\ its\ clients$ $Maintenance_i = cost\ for\ maintenance\ of\ charging\ station\ i$ $Adv_i = CSP\ revenues\ derived\ by\ the\ advertising\ rights\ on\ the\ charging\ spot$
Source of Information	Charging stations; financial department
Frequency	Monthly
Responsibility	CSP, ER
Further implementation	/

This indicator can be "unpackaged" into two indicators which take into consideration single aspects of CSP profitability. In fact in order to maintain the interoperability of charging stations, the CSP has to conserve a minimum level of profitability also when its customers recharge in non-proprietary charging spots. On the other hand it has to measure the profitability coming from proprietary charging spots.

- **Total cost and time for maintenance**

The maintenance costs (MC) and time (MT) comprehend the DSO, TSO and CSP efforts in maintaining the charging infrastructure usable from final customers and to trace the efficiency performed by the company, crucial for increasing the profit since the authorities set the TSO, DSO tariffs. Thus, the funds and time effectively implied in these activities can be calculated to keep track of the effort needed to keep the infrastructure operative and efficient.

Metrics	$\sum MC_{DSO} + MC_{TSO} + MC_{CSP}$ $\sum MT_{DSO} + MT_{TSO} + MT_{CSP}$
Source of Information	Charging stations; financial statement
Frequency	Monthly
Responsibility	DSO, TSO, CSP
Further implementation	Also in this case it's possible to have real time data with the usage of on-line palmtops.

- **Charging data management**

The drivers' behaviours towards the charging station affect the electricity patterns, generating - in uncontrolled charging - peak loads and electricity disturbances. The charging habits can be exploited by energy retailers in order to provide ad hoc tariffs which allow to satisfy entirely the customers' needs and improve the grid efficiency required by DSO and TSO. In addition the CSP is interested in monitoring the areas of high charging request which are more suitable for a future charging infrastructure enlargement. In particular the analysis is focused on the single charging session (duration and energy consumption), charging spot (location, state,…) and charging network.

7. Improve E-drivers' behaviours tracking

Example of key performance indicators

- **Charging station Behaviour** (set of KPIs)

The information coming from the customer behaviour on the charging station is crucial for the entire e-mobility world: better placing of the stations and research of the closest available one.

Metrics	• Localization of the charging station • Single utilization of each station • Available charging station • Number of the private charging station • Number of public station • Broken charging station
Source of information	Charging stations
Frequency	Daily
Responsibility	The CSP is in charge of collecting this type of data and sharing among the clients, other CSPs and ERs.
Further implementations	Integrating all the previous indicators in order to create a complete charging station map for each city or region and show it to the customer using social network, web site and mobile applications. Besides the map could be improved embedding the personal experience of E-drivers, introducing unstructured data and customer opinions.

- **Charging behavior** (set of KPIs)

The charging behaviour of the customer is fundamental to manage the peak load during the day through the measurement of the KW used by the customer during the day. This information is crucial to the energy producer as well as to the energy carriers (TSO, DSO) to handle efficiently the electricity flow.

Metrics	• Duration of the charging • Consumption (KW) • Start and end recharging time • $\frac{Energy\ used\ to\ charge\ the\ EV}{Total\ energy\ used}$
Source of information	Charging station, Meter
Frequency	Daily
Responsibility	CSP are in charge to trace this information and share it among the interested stakeholders.
Further implementations	Integrating all of the previous indicators in order to create a complete customer charging profile and share it through social networks, web sites and mobile applications. Besides the customer profile could be further integrated with customers' impressions and personal habits or energy supplier's data doing with customer habits as well.

Service quality

The change of electricity pattern implies an improvement of the management of interruption, black out and peak loads in order to provide the exact quantity of energy at a uniform level of quality. The e-driver presents a customer profile which is very inclined to a complete awareness about costs and performances in charge of the different stakeholders. For this reason, he is willing to know the source of energy used to produce electricity and the CO2 savings derived by the chosen source as well as the billing composition.

8. **Improve electricity quality**
9. **Improve information completeness**

Example of key performance indicators

- **Electricity quality** (set of KPIs)

The electricity arrived to the final customer in the charging station has to comply with regulations established by authorities regarding the power and the voltage. The measurement of the crucial characteristics of the electricity is fundamental for further analysis in order to evaluate the alignment with the customers' needs and government regulations. Moreover one of the most important measurements (SAIDI) regards the number of interruptions in the grid that widely affect the quality of the electricity.

Metrics	• Voltage width • Voltage standard deviation • Voltage frequency

	• Electricity power • SAIDI
Source of information	Electricity reports
Frequency	Weekly
Responsibility	The electricity report, namely an ID of the electricity composition, shows all the main features listed before. The DSO and the TSO are in charge to trace the pattern of the voltage and power.
Further implementations	Each actor in the supply chain has to be informed on the degree of electricity conformity in real time, mostly combining the results of different measurement, evaluating the effects that one feature can cause on the other and vice versa.

- **Percentage of renewable energy used** (set of KPIs)

EV customers are willing to receive information about the energy source used to charge their vehicles and the saving that can gain in terms of CO2 emissions. The type of energy used to generate electricity is crucial in determining the level of environmental sustainability of the vehicle and the related CO2 emissions. Thus, a first level of measurement regards the percentage of renewable energy engaged in the generation of electricity as well as a CO2 reduction and a second level deals with the degree of customer awareness on the source of energy used.

Metrics	$\frac{\text{Electricity genereted by renewable resources}}{\text{Electricity genererated}}$ $\frac{\text{CO2 produced using renewable energy}}{\text{CO2 produced}}$ $\frac{\text{Energy Retailer EV Clients totally informed (source of energy and CO2)}}{\text{Energy Retailer EVClients}}$
Source of information	Electricity reports
Frequency	Monthly
Responsibility	The electricity report that is an ID of the electricity composition is shared among the actors involved in the energy supply chain, thus the ER has to pick up this document from the TSO, DSO and show the "ID of the Electricity" to the Client.
Further implementations	Creation of a web portal and mobile application for the ER client that in real time can check the source of the energy used to generate electricity, allowing them to know if the electricity used comes from renewable source or not.

Cooperation efficacy

The Group A is characterised by a huge amount of data mainly arisen from the cooperation between CSP and energy retailers which exploit as information sources the charging station and the customers' habits. In addition, the information about the energy supplied is shared in real time with the rest of the energy supply chain, i.e. TSO and DSOs. Moreover the interoperability of the different energy suppliers in the charging stations forces the retailers to share information about roaming charging.

10. **Improve cooperation between CSP and ER**
11. **Improve cooperation between CSP and CSP**
12. **Improve cooperation between CSP, ER and DSO**

Example of key performance indicators

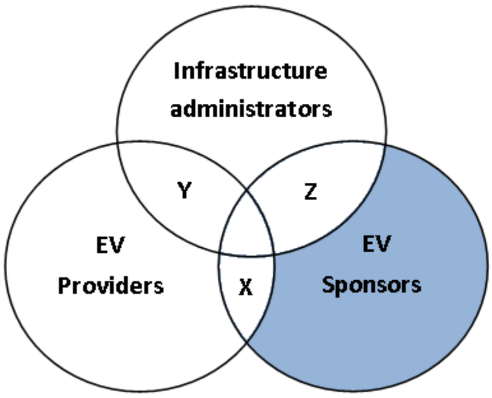
- **Preciseness in billing documents**

The CSP and the ER are the players that deal with the billing activities. The CSPs buy the energy from the energy retailer and sell it to the customer. The price proposed to the final customer is comprehensive of the fee regarding the energy retailers. The correct sharing of information is fundamental to improve the preciseness in the billing documents and assure revenues for both ER and CSP. The indicator measures the percentage of documents received by the customer containing errors.

Metrics	$\frac{\sum_i^N \text{N° of documents with errors}}{\sum_i^N \text{Total billing received}}$
Source of information	Billing documents
Frequency	Monthly
Responsibility	Each CSP and ER have to ensure a correct sharing of data and effective cooperation in order to ensure a precise billing.
Further implementations	The CSP and ER could share the data in real time with RFID technology when the customers charge their vehicle. Moreover random interviews to the customers, that have encountered errors in the billing, could introduce new unstructured data.

6.3.2 GROUP C Module: E-mobility sponsors

6.3.2.1 Group strategy



The e-mobility sponsors are in charge to support the stakeholders, by releasing loans, incentives and regulating the market with tariffs and standards. Through these initiatives, governments aim to reach environmental targets, respecting national and international agreements as well as they ensure the profitability of the investments and a fair competition. With the e-mobility breakthrough, the government aims to reach welfare gains (in terms employment, air quality, oil dependency) rather than pure financial returns. On the other hand, banks are forced to manage a trade-off between profitable investments and ruining the company's image.

6.3.2.2 CSF and key performances

Regulation

The European countries, in order to answer the Kyoto protocol, have promulgated the program "Europe 2020"; setting challenging targets also for transportation industry, by establishing in 95 g/km the maximum CO2 emission of an automotive vehicle. A campaign of incentives has been established to boost energy efficiency by respecting the mandatory environmental targets. Other European organizations, as SDO, aim to support rapid propagation of EVs imposing standards regarding safety and interoperability of components in order to overcome the typical national differences. The regulation authorities in order to ensure a fair competition and profit for companies which transmit the electricity, set tariffs which are continuously updated according to new trends (distribution costs, energy price,..).

1. **Improve vehicle safety**
2. **Effective Tariffs setting**
3. **Reach environmental targets**

Example of key performance indicators

- **Average score obtained by vehicles which respect the standard**

The penetration of EVs represents from one hand a set of new threats tied to the flammability of peculiar components (battery first) and, on the other, an opportunity to improve the safety standards reducing the fatalities in case of accident. For this reason, the improvements from this point of view can be estimated by the European New Car Assessment Program (NCAP) which allows to understand the performance of EVs exposed to huge stresses, such as an accident.

Metrics	$Average\ NCAP\ stars\ of\ EVs\ subjected\ to\ standards$
Source of Information	NCAP laboratory (Brussels)
Frequency	Annual
Responsibility	CM
Further implementation	New tests for controlling the battery reaction to an accident should be developed in order to sustain the launch of new and surer technologies. Moreover further interviews can be conducted in order to investigate the customer's insights, generating unstructured data to be organized and analysed.

- **Impact of tariffs on kWh final customer price**

The authorities for energy set the tariffs for the transmission and distribution of electricity operated by TSO and DSO. Their services are billed to the final customer but, because they operate in natural monopoly regime, the prices of their services are fixed and updated continuously in such a way they can gain a minimum level of profitability. The impact of these costs on the final kWh price of electricity has to be revised and evaluated to guarantee a fair price for their services and protect the consumers.

Metrics	$\frac{TSO\ tariffs_{KWh} + DSO\ Tariffs_{KWh}}{Final\ customer\ electricity\ price_{KWh}}$ $Tariffs_{KWh} = the\ price\ established\ by\ authorities\ for\ the\ energy\ trasmission$ $Final\ customer\ electricty\ price_{KWh} = price\ of\ 1KWh$
Source of Information	Authorities regulations
Frequency	Annual
Responsibility	Authorities
Further implementation	/

- **CO2 reduction effectiveness and CO2 reduction due to e-mobility**

The ambitious environmental targets set by governments and translated by authorities in transportation standards (engines Euro 1, 2,) demonstrate great efforts towards reducing CO2 emissions and respect international agreements (Kyoto protocol, Europe 2020). In order to reach these objectives, governments are monitoring these indicators in order to understand the total CO2 reduction due to e-mobility and evaluate if the annual targets are reached, comparing effective and planned reductions.

Metrics	$Total\ CO2\ reduction\ due\ to\ e\text{-}mobility$ $\frac{CO2\ effective\ reduction}{CO2\ planned\ reduction}$
Source of Information	Ministry of environment
Frequency	Annual
Responsibility	Governments, CM
Further implementation	/

Country welfare

The government aims to keep track of the positive or negative impact related to e-mobility, for what concerns three main fields. The improvement in the level of employment and the attraction of new graduates for the work positions represents one of the most important long term e-mobility effects. New engineers are employed for the design of EVs and charging stations as well as skilled technicians for their installations and maintenance. In addition governments are sensible for the reduction of oil dependency at national level and the improvement of air quality in cities.

4. **Increase Employment**
5. **Reduce Oil dependency**
6. **Improve Air quality**

Example of key performance indicators

- **Percentage of new workplaces due to e-mobility,**
- **Percentage of graduated workers in e-mobility industry**

Governments are interested in the growth of human capitals which find in e-mobility industry a fertile environment. From one hand, the construction and maintenance of EV and charging station increase the number of workplaces contributing to the level of national employment; from the other, the new workplaces employ mostly skilled workers, which contribute to the country welfare and growth.

Metrics	$\frac{New\ workplaces\ due\ to\ e\text{-}mobility}{Total\ annual\ Empolyment}$ $\frac{Number\ of\ graduates}{New\ workplaces\ due\ to\ e\text{-}mobility}$
Source of Information	Ministry of Labor and Social policies

Frequency	Annual
Responsibility	Governments
Further implementation	This indicator could be developed for different sector in order to assess which is the most attractive area for the EV employment: Charging infrastructure, Car manufacturer, Energy retailer, …

- **Reduction of imported oil**

The EV engines are supplied by electricity instead of gasoline. For this reason the country can reduce the dependency on petrol products, moreover if the energy is produced by renewable energy. The higher efficiency of batteries compared to internal combustion engines can be exploited to reduce the overall energy requirements.

Metrics	$\frac{Imported\ oil_{t+1}}{Imported\ oil_t}$ $Imported\ oil_{t+1} = tons\ of\ oil\ imported\ after\ the\ EV\ introduction$
Source of Information	Statistics authorities, energy producers
Frequency	Annual
Responsibility	Energy producers
Further implementation	/

- **Annual Air quality index**

In several European cities, the traffic presents in the town's centres, generates dangerous levels of fine dusts which can affect the human health. The EV has the potential to avoid tailpipe emissions, with a positive effect on public health and environment. With the Annual Air quality index (AAQI), municipalities can measure and communicate the level of air pollution throughout the year and compare to European air quality norms.

Metrics	$I = \frac{I_{high} - I_{low}}{C_{high} - C_{low}} \times (C - C_{low}) + I_{low}$ $I = Air\ quality\ index$ $C = pollutant\ concentration$ $C_{low} = concentration\ breakpoint\ that\ is\ \leq C$ $C_{high} = concentration\ breakpoint\ that\ is\ \geq C$ $I_{low} = index\ breakpoint\ corresponding\ to\ C_{low}$ $I_{high} = index\ breakpoint\ corresponding\ to\ C_{high}$
Source of Information	Statistics authorities, municipalities
Frequency	Annual
Responsibility	Governments

Investment efficacy

The main peculiarity for the e-mobility sponsors is the measurement of the effectiveness of the incentives, in terms of increase in sales and improvement of data collection useful to support the forecasting and the analysis of the area more appealing for EV incentives. The Banks and the governments are interested in knowing the profitability of the investments in terms of financial returns (Banks) and the number of vehicle sold due to the incentive campaign (Governments), thus the efficacy of the territory analysis could be fundamental in the decision on which are the most attractive area to propagate and adopt as a new transport standard the EV.

7. **Effectiveness of incentives**
8. **Territory attractiveness**
9. **Investment profitability**

Example of key performance indicators

- **Average percentage of purchasing incentives per EV**

The overall amount of incentives dedicated to the purchase of the EV is limited according to the liquidity availability of different countries. The measurement of the EV purchases with and without incentive, underlines and assesses the importance of having a financial support to decrease the high purchasing cost.

Metrics	$\frac{EV\ purchase\ with\ incentives}{EV\ sold}$
Source of information	Market sales, reports
Frequency	Monthly
Responsibility	The governments in order to assess the real importance of the incentives are in charge to gather data of the sales and see what are achieved with the assistance of incentives and vice versa.
Further implementations	The opinions of the customers about the efficacy of the incentives could be crucial in order to identify the right amount of money provided and their importance on the purchase. These new types of data can be analyze with sentiment analysis in order to extract and integrated important unstructured data.

- **Image improvement in the media and press opinions**

The indicator measures the value obtained by the combination of the positive opinions on the media and press before and after the decision to enter the e-mobility world. Moreover it assesses the placement improvements in the most important eco-friendly brand ranks. This measurement is crucial, mostly, for the banks because they are often seen by the population as a player that aims only to enlarge their profit without considering the environmental and civil issues.

Metrics	$\frac{Positive\ opinions\ (after\ enter\ the\ Emobility\ world)}{Positive\ opinions\ (before\ enter\ the\ Emobility\ world}$ $\frac{Placement\ (after\ enter\ the\ Emobility\ world)}{Placement\ (before\ enter\ the\ Emobility\ world)}$
Source of information	Market sales, reports
Frequency	Monthly
Responsibility	The Banks are in charge to keep track on their environmental awareness improvement in the public opinions.
Further implementations	The opinions of the bank clients as well as of the media could be crucial to evaluate more deeply the public viewpoints.

- **Demographic indicators**

The success of a certain incentive campaign can be predicted using some indicators that measure the attractiveness of the territory regarding the adoption of electric vehicle. These measurements are strictly related to the efficacy of the investments or incentives usage monitoring all the factors that directly or indirectly foster the purchase of EV or predict a favourable field for the EV introduction. [*See paragraph 6.1.3*]

Metrics	• Average population income • Density of houses • Charging point subsidies and diffusion • Percentage of HEV • Lease car company • Pilot projects
Source of information	Demographic and statistic reports
Frequency	Monthly
Responsibility	Banks, Governments
Further implementations	The analysis of blog, web sites, or data coming from Facebook pages measures the popularity of the e-mobility topics among the population.

Alignment with customers' needs

More and more the drivers are showing higher awareness on the potentiality of the EV in the future; however some barriers are still limiting the purchase of new EV, offering to the banks a great new business opportunity to overthrow these barriers mostly related to the higher implementation cost. However the relationship between the bank and the citizen is often complicated because the bank image is always more frequently associated to entities that only aim to increase their profit and avoid the support to green project or no-profit investments. In this context the e-mobility presents a good opportunity to combine a profitable investment with a green, sustainable project that gives to banks a better image, improving customer reputation.

10. Financial services innovation

Example of key performance indicators

- **Innovation Level of the financial services provided**

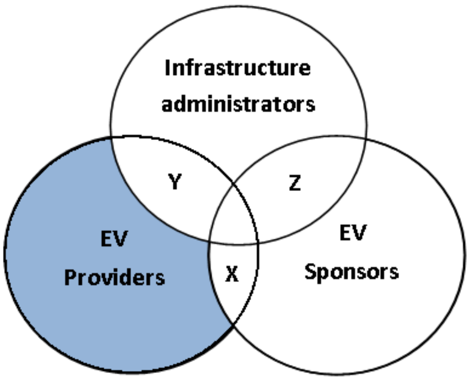
One of the main banks performances is the innovation level of the services provided in order to totally fulfil the new customers' needs. Since the EV is going to become a great business opportunity and always more frequently the clients are requiring funds for purchase electric vehicle or install the charging stations, the banks should update their service portfolio in order not to miss the new profit opportunities. The indicators measure the presences of the banks in the e-mobility market and the capability of them to satisfy the new requests.

Metrics	$\frac{N° \ of \ EV \ financial \ services \ released}{N° of \ EV \ financial \ serivices \ required}$ *Total investments in the E-mobility sectors*
Source of information	Financial statements
Frequency	Monthly
Responsibility	Banks
Further implementations	Opinions of the customers could be crucial to underline the importance of the banks support in the overall EV ownership cost.

6.3.3 GROUP B Module: EV PROVIDERS

6.3.3.1 Group strategy

The EV providers are in charge of designing, developing and transferring the EV to the final users. In particular the car manufacturers, which do not have to invest anymore on the engine itself, are more focused on marketing activities, such as pricing, timing and promotion of the product, and sign crucial agreements (more often partnerships) with battery developers. The latters, building a partnership with car manufacturers, are in charge of investing in the battery technology, in order to discover new solutions in terms of performances (long range, short charging time,…) and lower impact on environment, increasing the customers satisfaction. Finally, also the Car Fleet Operators are in charge of providing the electric vehicle to final users, but with a different business model: they offer the vehicle usage as service instead of ownership, diminishing the initial purchasing investments by providing car sharing or vehicle rental.



6.3.3.2 CSF identification

Battery

The battery represents the strategic components of the EV and its performances influence notably the sales and success of electric mobility. In the last decade, three main equipments have affirmed (NiMH, Zebra and Lithium-ion) and even if actually the lithium-ion battery represents the standard, new R&D investments are implied for discovering high performance technologies, such as Nanotechnologies and Ultracapacitators.

1. **Improve battery performances**

Example Key Performance Indicators

- **Driving performances**

The driving range depends on the features and the performances of the battery. In particular with specific power, energy density (depending on battery chemistry and packaging), the battery developer can estimate and communicate the energy storable in the battery. In addition, the discharge power expresses the maximum current at which the battery can be discharged continuously and is used to prevent excessive discharge rate in order to preserve the main performances (top speed, acceleration).

Metrics	• Specific power (W/kg) • Maximum discharge power • Energy density (Wh/L) • Specific energy (Wh/Kg)
Source of information	R&D department
Frequency	Monthly
Responsibility	BD
Further implementations	/

- **Structural performances**

The structural performances express the ability to improve the battery chemistry, in order to increase the usable capacity (kWh) without damaging the lithium, the reduction of internal resistance and open circuit voltage (between battery terminals with no load applied), which affects the state of charge. In addition, it is important to keep track of the overall weight, which influences dramatically the battery performances, in order to register possible improvements.

Metrics	• Battery usable capacity • Weight • Reduction of internal resistance and open circuit voltage
Source of information	R&D department
Frequency	Monthly
Responsibility	BD
Further implementations	/

Partnership indicators

The relationship between car and battery manufacturers is often formalised in a partnership aimed at improving the battery technology with joint investments, diminishing the battery cost and increase the overall partners' profitability. The trust and communication in a partnership perspective represent important ways to measure the health and success of the relationship.

2. **Diminish battery costs**
3. **Increase commitment**
4. **Increase communication & trust**

Example Key Performance Indicators

- **Partnership profitability**

The partnership aims to exploiting the synergies that both car manufacturers and battery developers own inside their boundaries. Its profitability can be calculated as the profit generated by collaborative efforts, derived by the increase of sales and technology degree achieved through the partnership.

Metrics	$\frac{\text{profit}_{t+1} - profit_t}{profit_t}$ $\frac{\text{sales}_{t+1} - sales_t}{sales_t}$ $\frac{\text{technology}_{t+1} - technology_t}{technology_t}$ $Tenchnology_{t+1} = Level\ of\ Technology\ achieved\ after\ the\ partnership$ $Sales_{t+1} = the\ sales\ achieved\ after\ the\ partnership$ $Profit_{t+1} = the\ profit\ achieved\ after\ the\ partnership$
Source of information	Financial department
Frequency	Monthly
Responsibility	BD, CM
Further implementations	/

- **Battery cost reduction**

By reaching economies of scale thanks to the EV sales increase, the battery cost is expected to decrease and, given the fact that the battery weighs for around 25 % of final purchasing price, this represents an incentive for further sales.

Metrics	$\frac{battery\ cost_{t+1} - battery\ cost_t}{battery\ cost_t}$ $Baterry\ cost_{t+1} = Battery\ cost\ after\ an\ increase\ in\ sales$
Source of information	R&D department
Frequency	Monthly
Responsibility	BD
Further implementations	/

- **Joint investments**

The value of partnership lies in the possibility to make joint investments with the monetary participation of partners. More often, the partnership commitment is expressed and measured with the amount of funds implied.

Metrics	$INV_i = \sum_i CMIncentives_i + \sum_i BD\ Investments_i$ $\text{INVi} = \text{investments released to player i, belonging to the same partnership}$
Source of information	R&D department; financial departments
Frequency	Monthly
Responsibility	BD, CM
Further implementations	/

Eco-friendly profile

Car manufacturers and battery developers are often invoked as critical pollution responsible, because of the CO2 emissions generated by vehicles and the exploitation of rare resources such as lithium and copper. Anyway, companies are investing to improve their "green image" reducing tailpipe emissions and recycling rare resources. Also the European Commission has introduced ambitious targets for CO2 reduction in automotive industry, and penalties has been established for companies which do not respect these constraints. In addition, battery developers are dependent on these scarce materials and, because their price is rising for high demand, they are introducing indicators to keep track of these performances.

5. **Decrease rare elements dependency**
6. **Increase recyclability**
7. **Improve compliance with EU regulations**

Example Key Performance Indicators

- **Battery Price elasticity of rare resources demand**

The battery pack requires the usage of rare resources such as lithium and copper (for anode and cathode). During next years, the higher demand is expected to generate a critical increase in the price of these materials and their usage and cost should be monitored.

Metrics	$\frac{\Delta Price}{\Delta Rare\ resources\ demand}$
Source of information	R&D department
Frequency	Monthly
Responsibility	BD
Further implementations	/

- **Recyclability ratio**

The battery disposal is fundamental to recover lithium for secondary usage and will be regulated in order to limit the waste of materials, which are going to be depleted in less than one decade without an efficient recycling system. Moreover the price of the Lithium is strictly correlated to the percentage of recyclability of the material, thus the indicator measures the impact of the level of Lithium recyclability on the market price: for instance in the market are present many qualities of Lithium and the higher the price, the closer to 100% is the level of recyclability.

Metrics	$\frac{\Delta \text{ recycled lithium}}{\Delta \text{ lithium price on the market}}$
Source of information	R&D department
Frequency	Monthly
Responsibility	BD
Further implementations	/

- **Effectiveness in EU target achievement**

Cars are responsible for around 12% of total EU emissions of carbon dioxide (CO2), the main greenhouse gas. European Union legislation sets mandatory emission reduction targets for new cars: only the fleet average is regulated, so manufacturers are still able to make vehicles with emissions above the limit balanced by low-pollutant vehicles. The indicator measures the average fleet emission of each car manufacturer comparing to the other: introducing into the production system more EV is the easiest way to decrease the value measured by this indicator.

Metrics	$Avg\ fleet\ emissions\ CMi = \frac{\sum_i \text{sold vehiclesemissions}}{\text{Total number of sold vehicles}_\text{i}}$

Source of information	Sales department
Frequency	Monthly
Responsibility	CM
Further implementations	/

Customer satisfaction

The Electric vehicle providers are focused on the sales of the electric vehicle and mostly the CFO handles the touch point with the customer, identifying as a main goal the overall customer satisfaction that implies the sales increase.

The EV total cost of ownership is lower than the ICV one because required less maintenance and expenses due to the much lower electricity price and the lack of an internal combustion engine. Moreover the EV safety and the overall impact on the environment is particularly important for the e-drivers because are more careful to the environmental issues and the recent fires occurred to Tesla vehicles have risen the attention on the EV safety peculiarities.

8. Improve total ownership cost

9. Improve safety

10. Improve life cycle emissions

Example Key Performance Indicators

- **Ratio between the ICV ownership cost and EV ownership cost**[2]

The lower cost of EV ownership (maintenance, interests, insurance, taxes, depreciation and fuel price) is one of the main advantages to own an EV mostly for the Car fleet operators as well as the final customer. The indicator tries to present the cost structure and shows which are the different contributions of each component, providing evidences of lower ownership cost, even if the purchase cost is much higher.

[2] Total cost of Ownership Model for Current Plug-in Electric Vehicles; 2013; EPRI

Metrics	$$Ownership\ Cost = Dep + Fuel + Int + Ins + Mant + Tax$$ $$\frac{EV\ Ownership\ Cost}{ICV\ Ownership\ Cost}$$ Where: $Dep =$ vehicle depreciation proportional to the time of ownership and the purchasing price $Fuel =$ Fuel cost depending the miles driven per year and the avg fuel price in an entire year $Int =$ When the drivers ask for loans the ownership cost increases by the interest $Ins =$ The insurance is variable depending on the vehicle type $Mant =$ The maintenance for most of the car is covered by warranties for the first two years $Tax =$ the overall tax regime of each country
Source of Information	National Statistics and reports
Frequency	Yearly
Responsibility	Car Manufacturer or consulting companies
Further implementation	/

- **Effectiveness of the protection against electrical shock** (set of KPIs)

The main European indicator that measures the safety of vehicles is the so called Euro NCAP that right now is starting to test also the EV security. Mainly the issues related to the EV regard the voltage of the battery, thus the EuroNCAP commission has to test the post-crash battery integrity and the proper functioning of the battery cut-off switch that isolates the high-voltage battery in the event of a crash.

The following indicators regard the monitoring of the protection of driver against electrical shock and for the first two indicators are required on-board measurements and the next two can be monitored at any time after the test.

Metrics	• Absence of high voltage • Low electrical energy • Physical protection • Isolation resistance
Source of Information	The vehicle tested
Frequency	Yearly
Responsibility	CM
Further implementation	/

- **Life cycle assessment Ecoindicators 99**

The Ecoindicators99 assess the seriousness of three damage categories (Human health, Ecosystem Quality and Resources) derived from the overall impact of the product on the environment caused during the entire product lifecycle. This indicator is pretty useful mostly in the car industry because more often the customers are focused on the CO2 emission of the tailpipe, neglecting the more important energy consumed and wasted in the production process.

Metrics	Eco indicators99
Source of Information	The entire life cycle of the product
Frequency	Yearly
Responsibility	Consulting company that refers the result to the car manufacturer and the battery developers
Further implementation	/

Product competitiveness

With the introduction of the EVs, the cost and profit structure have been changed in favour of lower variable cost (cheaper maintenance, internal engine lacking) and profit mainly arose from incentives instead of real operative activities.
Moreover an important revolution about the core business of the EV providers regard the main activities performed by the Car manufacturers, which are no longer internal engine designer and developer, rather they are in charge of the typical marketing activities such as promotion and pricing.

11. Increase profitability

12. Improve perceived image

Example Key Performance Indicators

- **Car manufacturer Profit**

The changes in the profitability of each vehicle regard the incentives released by the government. In fact nowadays without the government aid the profit arising from the operative activities is always negative considering the high cost of the battery and R&D. The indicator measures the contribution of the electric vehicle to the overall company profit without considering the government incentives in order to assess the real product appeal in the market.

Metrics	$$EVProfit = PoV - OperativeCost + \frac{Incentives}{N°Sales}$$

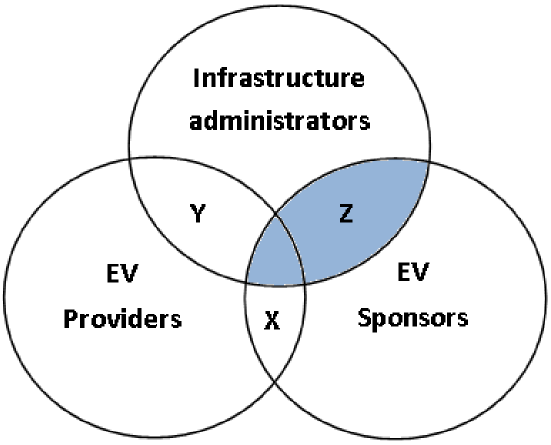
	$$Profit = EVProfit + ICVProfi - \frac{Incentives}{N°Sales}$$ $PoV =$ Price of the EV Operative cost = All the costs related to the production of the vehicle, including the cost of the battery that counts for the 25% of the overall cost.
Source of Information	Financial statement
Frequency	Yearly
Responsibility	Car manufacturer
Further implementation	/

- **Promotion effectiveness**

The high investments in R&D imply a reduction in promotion campaigns. The EV producers are no more investing in direct promotion but they push on reflected image conferred by politicians, Hollywood stars, CEOs who promotes for free the product. The indicator measures the effectiveness of reduction in advertising compared to the sales increase, benchmarked with traditional Internal Combustion Vehicles. If the indicator is higher than one the EV effectiveness in promotion is higher than ICV one.

Metrics	$$\frac{\frac{Pr_{ICV} - Pr_{EV}}{Pr_{EV}}}{\frac{Sales_{ICV} - Sales_{EV}}{Sales_{EV}}}$$ $Pr_{ICV} = Expenses\ in\ ICV\ promotion$ $Pr_{EV} = Expenses\ in\ EV\ promotion$
Source of information	Financial statement
Frequency	Monthly
Responsibility	CM
Further implementations	The promotion effectiveness can be measured integrating unstructured data coming from blog, forums and social media.

6.3.4 Relation Z Module: E-mobility Sponsors & Infrastructure Admin.



The relation z introduces a new facet of government as a big customer of infrastructure administrators. From this point of view, the CSP can share the information sourced by charging stations and, on the other hand, governments can share demographic data about the population to foster a better placing of charging stations owned by both government and CSP. In addition, government typically behaves as a regulator – through the authorities - for the infrastructure administrators impacting on their core business with safety standards and tariffs, but on the counterpart the infrastructure administrator's performances affect the overall government welfare in term of employment increase and work environment improvement.

Shared information efficacy

The final goal of relation z is the improvement in placing charging stations over the national territory. The feasibility of this objective is strictly related to the quality and quantity of shared information among the players of group A and C. In particular the government possesses social and demographic data aimed to measure the attractiveness of a certain area in terms of presence of EVs and potential charging sessions. On the other hand, CSP, representing the charging station owner, has the potentiality to share charging stations data to improve governmental actions.

1. **Territory attractiveness**[3]
    - Demographic indicators
2. **Improve customer's behavioural tracking**[4]
    - Charging station Behaviour
    - Charging behaviour

- **Impact of infrastructure administrator performances on country's welfare**

The infrastructure administrators, operating actively on the national territory, contribute to the country's welfare in different fields. Firstly, their choice regarding the installation of renewable energy sources affect the environmental sustainability, by pushing also on the EV usage. Secondly,

[3] The indicators have been explained in the paragraph 5.3.2.2 relatively to the CSF 8.

[4] The indicators have been explained in the paragraph 5.3.1.2 relatively to the CSF 7.

these stakeholders attract skilled human capital and increase the overall country's employment. Lastly, through the mechanism of regulation they affect the customers' energy purchasing power and their safety performances for what regards the work environment.

3. Improve environmental performances[5]

- Percentage of renewable energy used
- CO_2 reduction effectiveness and CO_2 reduction due to e-mobility

4. Improve the overall quality employment[6]

- Percentage of new workplaces due to e-mobility
- Percentage of graduate workers in the e-mobility industry

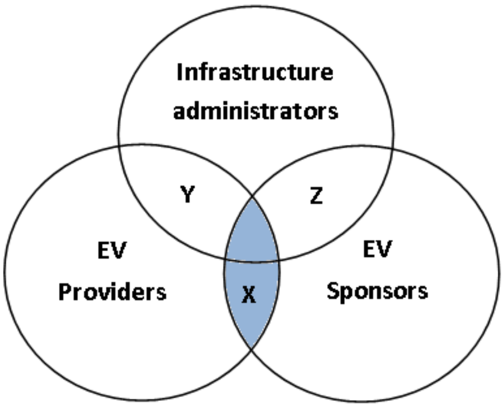
5. Customer's purchasing power[7]

- Impact of tariffs on kWh final customer price

4. Safety[8]

- Reportable accidents per hours worked
- Percentage of staff with adequate OHS training
- Reportable accidents per charging stations

6.3.5 Relation X Module: EV Providers & EV Sponsors



One of the main objectives of governments is to grant the welfare of the country and respect the EU regulations in order to invert the dangerous trend in which the environment is worsening year by year. Thus, governments have decided to invest in EV providers because they represent the players which can lift up the negative situation, producing vehicles which reduce the overall product lifecycle environmental impact and widely comply the regulations released by European Commission. However, the EVs are characterized by new challenges such as the consumption of rare resources and their recyclability percentage.

Moreover, EV sponsors have to assess the effectiveness of their investments and the related improvement in the battery and vehicle performances that can help the e-mobility propagation.

[5] The indicators have been explained in the paragraph 5.3.2.2 relatively to the CSF 3 and 9.
[6] The indicators have been explained in the paragraph 5.3.2.2 relatively to the CSF 4.
[7] The indicators have been explained in the paragraph 5.3.2.2 relatively to the CSF 2.
[8] The indicators have been explained in the paragraph 5.3.1.2 relatively to the CSF 1,2,3.

While the banks usually keep track of the investments' profitability with specific indicators, governments are not used to measure the performances of their incentives and the car manufacturers' capability to respect the regulations.

Country's welfare

In the assessment of the environmental EV providers' performances, governments focus on rare resources usage and materials' recyclability as factors which burden the environment, and on CO2 emissions reduction to respect European and international agreements. The practices performed by the lifecycle assessment embed all the environmental impacts of EV compared to ICV. Moreover the introduction of new vehicles creates new job positions and the EV features require skilled workforce which lead to internal production for advanced countries.

1. Improve lifecycle emissions

- Ecoindicators 99[9]
- CO2 reduction effectiveness and CO2 reduction due to e-mobility[10]
- Effectiveness in EU target achievement[11]

2. Improve material usage

- Battery price elasticity of rare resources demand[12]
- Recyclability ratio[13]

3. Improve country's welfare[14]

- Percentage of new workplaces due to e-mobility
- Percentage of graduated workers in e-mobility industry
- EVs produced in the country

Effectiveness of investments and incentives

The investments success measurement regards the improvements in sales and battery performances due to the joint funds provided by banks and governments. The incentives and investments released by governments and banks aim to foster the battery technology developments, as well as the purchase of the EV. In fact, the higher the EV sales, the lower the overall CO2 emissions. Banks and governments support the EV propagation by investing in battery development for the first actor,

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[9] The indicators have been explained in the paragraph 5.3.3.2 relatively to the CSF 10.
[10] The indicators have been explained in the paragraph 5.3.2.1 relatively to the CSF 3.
[11] The indicators have been explained in the paragraph 5.3.3.2 relatively to the CSF 7.
[12] The indicators have been explained in the paragraph 5.3.3.2 relatively to the CSF 5.
[13] The indicators have been explained in the paragraph 5.3.3.2 relatively to the CSF 6.
[14] The indicators have been explained in the paragraph 5.3.2.2 relatively to the CSF 4.

and reducing purchasing barriers for the latter; their combined funds improve the effectiveness of the final results: a cheaper EV with better battery performances.

4. Improve sales

- EV Penetration ratio[15]
- Average percentage of purchasing incentives per EV[16]
- Ratio between the ICV ownership cost and EV ownership cost[17]

- **Incentives elasticity of sales**

The elasticity measures the sales increase derived by a variation of the incentives released by government, thus the efficacy of the latter.

Metrics	$\dfrac{\dfrac{Sales_{t+1} - Sales_t}{Sales_t}}{\dfrac{Incentives_{t+1} - Incentives_t}{Incentives_t}}$ $Sales_t = EV\ sales\ in\ period\ t$ $Incentives_t = Incentives\ released\ in\ period\ t$
Source of information	Financial statement
Frequency	Annual
Responsibility	CM, G
Further implementations	/

5. Improve investment profitability

- Average payback time-ROI[18]

- **Joint investments**

The efficacy of banks and governments efforts lies in the ability to combine investments both in battery development and reduction of purchasing price. This indicator keeps track of the total released funds towards EV providers.

Metrics	$INV_i = \sum_i CMIncentives_i + \sum_i BD\ Investments_i$ INV_i $=$ overall investment released to player i, belonging to the same partnership

[15] The indicators have been explained in the paragraph 5.3.3.2 relatively to the CSF 11.

[16] The indicators have been explained in the paragraph 5.3.2.2 relatively to the CSF 7.

[17] The indicators have been explained in the paragraph 5.3.3.2 relatively to the CSF 8.

[18] The indicators have been explained in the paragraph 5.3.2.2 relatively to the CSF 9.

Source of information	Financial statement
Frequency	Annual
Responsibility	G, B
Further implementations	/

6. Improve EV performances

- Average score obtained by vehicles which respect the standard[19]

- **Bank investments elasticity of battery performances**

The indicator measure the variance in battery performances according to the variation of investment dedicated to battery development. The battery performances summarises the score collected by the indicators listed in the CSF "Improve battery performances" in EV providers.

Metrics	$$\frac{\frac{BPerformances_{t+1} - BPerformances_t}{BPerformances_t}}{\frac{Investments_{t+1} - Investments_t}{Investments_t}}$$ $BPerformances_t = average\ battery\ performances\ in\ period\ t$ $Investments_t = Investments\ released\ in\ period\ t$
Source of information	Financial statement
Frequency	Annual
Responsibility	BD, B
Further implementations	/

- **EV sales elasticity of emissions**

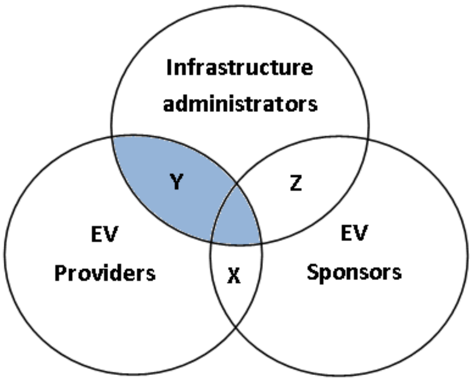
The elasticity measures the variance of the emissions compared to the variation of the EV sales. The indicator should decrease with the increase of EV sales and be lower than 1.

Metrics	$$\frac{\frac{Emissions_{t+1} - Emissions_t}{Emissions_t}}{\frac{Sales_{t+1} - Sales_t}{Sales_t}}$$ $Emissions_t = Total\ amount\ of\ emissions\ released\ in\ period\ t$ $Sales_t = EV\ sales\ in\ period\ t$

[19] The indicators have been explained in the paragraph 5.3.2.2 relatively to the CSF 1.

Source of information	Financial statement
Frequency	Annual
Responsibility	BD, B
Further implementations	/

6.3.6 Relation Y Module: EV Providers & Infrastructure Admin.



This relation represents the touch point between the driver and the infrastructure grid, in which the user faces the main risk during the charging, thus the players involved in this relationship have to ensure and prevent potential risks caused by electricity leaks. Moreover other important goal is to assure the completeness of the billing between energy retailers and CFOs as well as the exchange of information between charging service providers, CFOs and CMs. The infrastructure administrators receive as a demand for the charging stations development, the number of sold EVs inasmuch the higher the sales, the higher the number of charging spots. In addition, in order to grant a better cooperation, the actors share not only information strictly needed, but also more general data about customers' and charging habits.

Safety

As seen in the description of EV providers and infrastructure administrators, safety represents a crucial issue due to the danger tied to the electricity high voltage, therefore the players involved in these two groups have to grant high safety in order to reassure the customers about charging station performances.

1. **Improve touch point safety**
    - Reportable accidents (including fatalities) per charging stations[20]

Completeness of Exchanged info

The car manufacturers and CSPs are characterised by pretty strong relationship because of the exchange of information regarding the number of sales that are strictly related to the number of charging spots that CSPs have to build and maintain. Moreover, these two players possess other

[20] The indicators have been explained in the paragraph 5.3.1.2 relatively to the CSF 3.

types of data about customers' habits and battery performances useful to be shared in the e-mobility network. The charging service providers need to know what are the main battery performances (charging time, range,…) in order to fit the charging spots with the features of the battery. On the other hand, the collaboration between ER and CFO is demonstrated by the billing integration and requires high level of precision in exchanged documents. Finally the CM is becoming a main investor in charging infrastructure in order to collect useful information for the production of EV.

2. Improve infrastructure development proactivity

- EV Penetration ratio[21]

- **Charging stations elasticity of sales**

The indicator measures the impact of sales increase on the number of new charging stations installed. In fact, the number of EV sold can be an indicator to forecast the future investments dedicated to the charging infrastructure.

Metrics	$\dfrac{\dfrac{Sales_{t+1} - Sales_t}{Sales_t}}{\dfrac{CS_{t+1} - CS_t}{CS_t}}$ $Sales_t = EV\ sales\ in\ period\ t$ $CS_t = Number\ of\ new\ charging\ stations\ installed$
Source of information	Financial statement, Market report
Frequency	Monthly
Responsibility	CSP
Further implementations	/

- **Investments elasticity of revenues**

The investments performed by CM in charging infrastructure can generate new revenues in terms of monetary gains, or on the other hand even if in case of monetary returns lack they anyway increase the level of shared information pushing future sales. In the indicators, $Revenues_t$ includes not only the direct revenue generated by investments, but also those deriving by sharing of information.

Metrics	$\dfrac{\dfrac{Revenues_{t+1} - Revenues_t}{Revenues_t}}{\dfrac{CSI_{t+1} - CSI_t}{CSI_t}}$ $Revenues_t = revenues\ generated\ by\ CSI\ in\ period\ t$

[21] The indicators have been explained in the paragraph 5.3.3.2 relatively to the CSF 11.

	$CSI_t = Investments\ in\ charging\ stations\ in\ period\ t$
Source of information	Financial statement
Frequency	Monthly
Responsibility	CSP
Further implementations	If the revenues are lower than zero, this data does not mean that investment has not been profitable, but the main gain has derived from the enlargement of charging infrastructure which pushes the sales.

3. Improve exchange of information[22] [23]

- Charging station Behaviour
- Charging behavior
- Battery structural performances
- Delta charging time in standard conditions
- Extra energy consumed with superchargers

4. Increase billing preciseness

- Preciseness in billing documents[24]
- Percentage of exchanged documents with mistakes or missings[25]

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[22] The indicators have been explained in the paragraph 5.3.1.2 relatively to the CSF 7.

[23] The indicators have been explained in the paragraph 5.3.3.2 relatively to the CSF 1.

[24] The indicators have been explained in the paragraph 5.3.1.2 relatively to the CSF 10.

[25] The indicators have been explained in the paragraph 5.3.3.2 relatively to the CSF 4

7. EXPERIMENTATION

The objective of the following chapter is the validation of the information management methodology, testing the foundations at the basis of the models and introducing new weaknesses deriving from the network accountability, thus the stakeholders' cooperation.

The strengths of the framework lie in its flexibility in adapting to the peculiar features of different realities, by mapping and structuring the typical e-mobility information complexity. Thus, the information analysis is not focused only on the single stakeholder, but on the entire network of players operating in the e-mobility industry.

For this reason the choice of the CINK project, belonging to Formula E-Team span of control, supports a good validation of the research strengths as well as presenting the side effects and weaknesses.

The validation of the methodology is focused on the method to obtain the network key performance measurements and not on the indicators themselves. In fact the experimentation presents the potential improvements carried out by the new information management, underlined by the final set of measurements, in which the overall information is organized and exploited for identifying the network key perfomances.

7.1 Formula E-Team context of analysis

In Netherlands government and authorities have established a strategic business plan for the e-mobility industry, aiming to assure:

- Environmental targets
  The main European environmental targets are presented in the plan Europe 2020, which constrains the members to reduce GHG emission of 20% respect to 1990 levels and enhances the exploitation of renewable sources of 20% by 2020. The improvement in the vehicle consumption efficiency represents the best way to achieve these objectives, remembered as 20-20-20.
- Oil independency
  The increase in petroleum price and the dependency upon producer countries, more often not democratic, can influence the growth perspective of Netherlands. For this reason, the EV propagation represents one of the most suited points for pushing fossil fuels

independency, integrating the transport revolution with a higher renewable sources engagement.

- Air quality
  The morphological territorial characteristics and the unfavorable wind and current patterns channel the pollution, produced by one of the most industrialized European areas as well as the usage of ICV, into the area of Netherlands because of the depression (most of the territory is under the sea level). Under the previous conditions the national government is forced to release a set of regulations and incentives to improve the actual dangerous environmental situation.
- Employment
  The Dutch government believes in the propagation of EV as motivation to escape from European recession. In fact the start-up of a new huge sector involves from the human resources perspective new knowledge, know-how and skills, and from the financial perspective a new capital market where foreign and native investors could exploit new profit sources. In addition, the Ministry of Economics has provided figures that support their belief on the capacity of e-mobility to improve economic situation towards 2015 [Fruianu et al., 2014]:
    - By tripling the employment (e-mobility),
    - By quadrupling the turnover,
    - By increasing 10 times the export.[26]

The Dutch government has exploited the high sensibility of the population towards environmental issues by implementing a successful EV incentives campaign tailored on PHEV, which have resulted in the highest market share worldwide (5% increase) due to largest total fiscal incentives provided (75% on vehicle base price) [Mock et al., 2014].

[26] Respect to 2012 levels

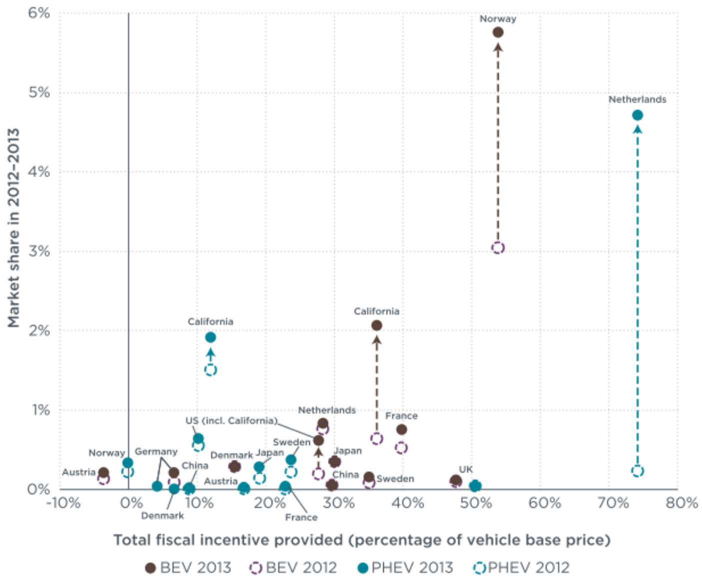

Figure 28: Worldwide EV market share [Mock et al., 2014]

Holland definitely wants to confirm itself as a leader in the field of electric transport and exploit the opportunities of green growth.

In this fertile environment, several association and organizations composed by the main e-mobility stakeholders working with government have implemented programs aimed to foster the EV propagation through the cooperation between members with the establishment of common platforms and community where to freely share data, such as RAI Association, Energie Netherlands, E-Violin and Formula E-Team.

7.2 Formula E-Team

Formula E-Team plays an ambassador and leadership role in the field of electric transport in the Netherlands. The organization forms a business team in which crucial e-mobility stakeholders take part contributing with their valuable knowledge and cooperate with government in order to optimise the funds release. The government does not represent the chair of the organization, but only a peer-to-peer member which exploits Formula E-Team as advisory body. The administrator is elected each year by stakeholder's members, which cover the main associations dealing with EV (RAI, Energie-Nederland, AutomotiveNL, VNA, VNG,…) and representatives of Ministry of Economics and the Technology University of Eindhoven.

The Formula E -Team discusses the progress of electric cars in the Netherlands and brings important opinions for the government and other stakeholders on electric driving aspects. The

Formula E -Team inspires the parties to work out creative solutions towards problems that the organization has discovered and arisen firstly .

In addition, one of the priorities faces the trade-off between energy efficiency and usage of renewable resources, namely the complete vehicle charging in less time, integrated with low environmental impact energy consumption.

Formula E –Team supports the governmental e-mobility business plan and has deployed an action plan for 2014 and 2015 in order to pursue the following objectives [RVO, 2014; interview 20, *appendix 2*]:

- Fiscal policy
  The Formula E-Team is committed to the constant promotion of electric vehicles by fiscal policy until 2017 due to the tight relationship with the government which develops policies based on the knowledge derived by their field experience. Moreover, being part of the organization, government has the chance to discuss and communicate draft plans.
- Enforcement MIA and Vamil
  The Formula E -Team provides support for the application of MIA (Environmental Investment) and Vamil (depreciation case of environmental investments) for the purchase of electric vehicles and electric charging infrastructure.
- Charging points network development
  Formula E-Team proponents encourage the building of charging stations to structure a Netherlands charging network based on data sharing regarding the main information arisen from charging spots (charging time, frequency, location, drivers' behaviours,…).
- Governments as the main customers
  As previously described government takes advantage of the advisory role provided by Formula E-Team for policy making and in addition it becomes a fundamental customer for the installation of public charging stations, as well as for the shared common ambition of EV propagation.
- Niche markets
  Formula E-Team supports the stimulation of targeted niche markets (especially in cities), as electric taxis, car sharing and urban distribution and in addition it promotes public transport with appropriate electric and fiscal policies.

7.3 Alignment with experimentation proposal

So far the main thesis research objective has aimed to diminish the complexity (*see chapter 2*) of e-mobility industry in its growing phase, characterised by the following drivers:

- **Stakeholder management**
  In the electric vehicle world different actors (DSO, CSP, Energy Retailer,…) coexist with different opinions on the e-mobility feasibility. Moreover, all the stakeholders are strictly interrelated and possess different business objectives. Anyway they are forced to cooperate in order to reach the common ambition of e-mobility propagation.
- **Government incentives and regulations**
  Both drivers and governments need to overthrow typical barriers such as purchasing price, cost of ownership and limited charging infrastructure in order to support the EV propagation. These objectives can be achieved with a better establishment of incentives and regulations, knowing what is required by drivers and the government availability in terms of liquidity and degree of freedom respect to European authorities.
- **Charging infrastructure**
  Actually a widespread charging infrastructure is not still developed, even if huge efforts are made in this direction. Nowadays some areas show a high concentration of charging spots while in others only a scattered presence.
- **Information management & standardization**
  According to the development of a charging infrastructure, the information management is fundamental in order to optimize the placing, individuating which are the most demanding areas, and analyses the customers' habits patterns. In addition, an efficient releasing of standards is crucial for a well-established charging infrastructure as for other fields.

In this context the different issues arising from the complexity drivers generate a huge amount of new information made of structured, unstructured and network data, which fosters and forces the stakeholders to cooperate and share the existing information with the purpose to overcome the main complexity criticalities. However is not still presented a structured and defined methodology to collect, organize and integrate the huge amount of information coming from several stakeholders.

From this perspective, Formula E-Team represents a perfect environment where all the main e-mobility stakeholders collaborate with the direct supervision and support of government (straight involved in Formula E-Team) with the purpose to share the huge amount of knowledge they generate from their businesses: most of them would be hidden in the lack of this particular environment. These conditions represent a unique opportunity to experiment the research output, inasmuch it solves the main limitations such as stakeholder collaboration and trust, sharing of competitive data, strategic behaviours.

Formula E-Team represents the typical multi-issue multi-stakeholders decision making scenario which suits to test the effectiveness in cooperation between stakeholders with the aim to reach a package deal and a final result which generates a positive gain for all the involved stakeholders.

The scenario in which the analysis is developed, takes place in Netherlands, which is a front runner for the e-mobility industry as well as concerning the open data approach which fosters collaborative behaviours.

For the previous scenario, the experimentation is applicable only in countries in which the motivation arises from the main e-mobility players and it is not imposed by government, creating a fertile environment for collaborative behaviours and e-mobility propagation.

Thus, the new information management methodology (see chapters 4 and 6), tailored to the projects undertaken by Formula E-Team, represents a way to organise and structure the information in order to support decision making process. While the research framework, described in the chapter 4, has started from the analysis of the AS-IS information management for each stakeholder ending with the proposition of some measurements which trace the network performances, in this experimentation a reverse approach is applied in order to verify the application of the previous framework to a constrained project, starting from the network strategy:

1. Network strategy definition identifying the data exploited to structure the information management of the project (CINK project).
2. Definition of network Critical Success Factors (CSFs) and key performances, with a particular attention to stakeholders performances;
3. Network measurements proposition, tied to single CSF, which are responsibility of particular stakeholders.

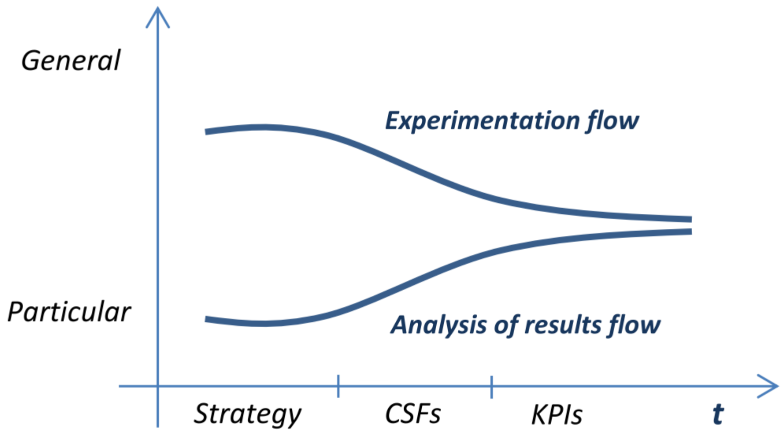

Figure 29: Logical flow

In addition the peculiar flexibility of the methods developed allows a tailored shaping by adapting the KPAs to the project objectives, reducing the number of KPIs and improving the coherence with new indicators.

The particular project individuated perfectly aligned with the thesis objectives as well as Formula E-Team goals is the so called Charging Infrastructure National Knowledge Platform (CINK) in charge of NKL Task force.

7.4 The experimentation project: CINK

7.4.1 Project activities

Formula E-Team (FET) has created the NKL (National Infrastructure Knowledge Platform) task force, a temporary organization (2014-2016) which is an advisory body in the charging infrastructure field covering the following business activities:

- Information gathering, with the collaboration of CBS (Central Bureau of Statistics) and CPB (Central Politics Bureau), regarding profitability and feasibility of charging points, charging infrastructure data, incentives patterns, EV sales, international macro trends caused by European authorities.
- Information processing and interpreting, with the purpose to provide thorough forecasts based on previous data.
- Financial and political advisory, providing stakeholders with an informative base for decision making. In particular authorities process the information provided by NKL for releasing new norms, which become an input data for NKL.

- Data & knowledge sharing, communicating information to stakeholders which consider NKL as a reference point to enhance R&D activities. In particular a dedicated front desk is established with the purpose to share this knowledge.
- Collaboration with European entities to share and enlarge knowledge in terms of incentives, norms and standard.

All the listed activities can be realised under an open data perspective, where the precompetitive data sharing is fundamental to foster the cooperation between stakeholders: the realised dataset will be available on-line for all the Dutch organizations and people interested in e-mobility issues. These data are not considered by companies as strategic, inasmuch they do not provide a subset of actors with a competitive advantage, but a peer-to-peer support to generate a win-win situation, reducing the innovation costs and improving the output quality coherently with customers' requirements. Thus, the release of crucial data such as driving habits and information related to charging stations provides the basis for a successful cooperation. NKL task force is the only entity in charge of managing data and, if necessary, to treat them anonymously.

The NKL beneficiaries are the typical e-mobility stakeholders even considering small-medium enterprises belonging to these sectors, in particular governments (Dutch provinces and municipalities), DSO, CSP, ER, authorities, consumers organizations and research institutions.

The beneficiaries of CINK projects are represented by the organization's members, explained in detail in the following paragraph.

7.4.2 NKL members & finances

The NKL task force is composed by several Dutch associations and players, which deal with e-mobility industry contributing to the overall project with different funds released progressively in three years (2014-2016)[27], thus they can be clustered according to the thesis research grouping:

Infrastructure administrator

- Netherlands Energie: the largest independent energy providers in Netherlands which connects 750.000 customers and supports NKL with € 300.000.
- Netbeheer Nederland: association which comprehends all the Dutch DSOs. It participates with € 300.000.

[27] All the listed funds are managed and controlled by Formula E-Team

- Elaad Foundation: non-profit organization which have developed the largest Dutch public charging infrastructure with 12.500 charging stations nationwide. It provides NKL with € 1.200.000.

EV providers

- National government: aware of jurisdiction and incentives patterns, it is in charge of allocating € 1.500.000 for a period within three years, according to the European legislation for State Aids. It covers an advisory role providing the NKL beneficiaries with the required information about incentives patterns and legislation useful to accomplish the planned project.
- Province Noord Brabant (admin. Corone Jeroen): facilitate with € 500.000 the pilot project of public charging infrastructure in their reference area, with a focus on energy tariffs and development of new services and products. In addition it sponsors companies which decide to invest in green projects such as start-up CSP (e.g. Clean Tech Fund).
- Different Municipalities (Luteske Lindeman, Roosmarijn Sweers): finance the development and maintenance of infrastructure grid with € 150.000.
- Technique University of Eindhoven (Auke Hoekstra): support with research projects without monetary resources, but with human capital.
- RAI Vereniging: shareholder of RAI Exhibition and Congress Centre of Amsterdam, is now committed in initiatives towards sustainable transportation. It provides NKL with € 60.000.
- Doet Vereninging: association which aims to foster EV propagation with the involvement of 100 membered organizations, contributing with € 150.000.

7.4.3 Roadmap and information basis

The activities explained in *paragraph 7.4.1* are explicated in the following projects, strictly interrelated to each other (the relations are shown in *figure 34*), realised in the time-lapse of three years with an overall financing of € 5.000.000:

Project 1: Charging infrastructure customer care (B2B): implementation of a customer care service tailored to the needs of local authorities, associations such as RAI and DOET, which install charging stations and require a certain level of service quality. The knowledge developed by NKL as well as the network of relationships with key stakeholders allow the fulfilment of complaints regarding the issues of charging points.

Project 2: Data warehouse with real time data sharing: the creation of the platform in collaboration with CBS which allows to the joint stakeholders to upload/download data from this platform. This project is fundamental for ensuring market transparency and improving the awareness on e-mobility issues.

Project 3: Data processing & forecasting: while the project 2 is focused on data sharing, the project 3 provides the processed information (about infrastructure tariffs, sales,…) which will be shared.

Project 4: Standardization of charging infrastructure: assurance of homogeneous standards in charging stations according to European norms with the purposes to ensure a fixed charging price and stations with similar features to facilitate the energy retailers interoperability at European level.

Project 5: Open data platform: the overall projects results have to be uploaded in an open data software with the collaboration of all the involved stakeholders. The introduction of the protocol OCPP 2.0 allows a communication driven by open standard.

Projects 6,7: improvement of the process of charging station installation: CSP, DSO and municipalities work together in order to establish a procedure which assures low implementation costs and low charging price. The creation of this procedure is strictly related to the European project Covetos.

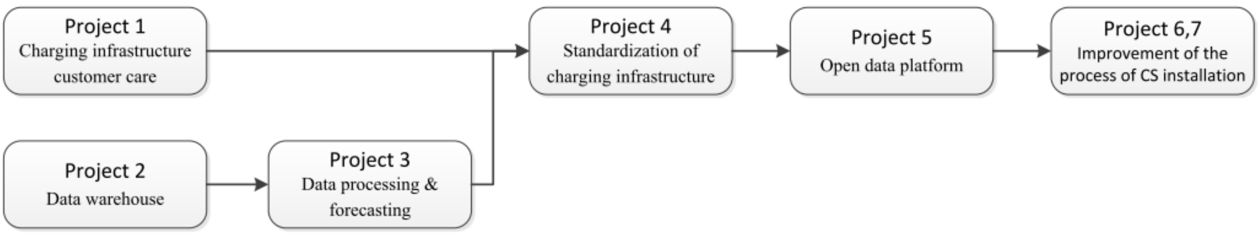

Figure 30: Projects roadmap

7.5 CINK Information management

7.5.1 NKL network strategy and information

NKL task force aims to realise in three years (June 2014 and June 2016) a set of **objectives**, through the accomplishment of the projects, aligned with the overall goals of Formula E-Team. First of all the employment due to the investments undertaken with CINK which are going to create new skilled positions contributing to the overall employment. Secondly, the environmental impact for all the concerned project has to pursue the achievement of the Europe 2020 targets, reducing the air pollution in cities and the overall oil dependency by improving the exploitation of renewable sources.

Afterwards, concerning the precise objectives related to the seven CINK projects, the common ambition aims to force the data and knowledge sharing between stakeholders in order to boost EV diffusion and cooperation between players. In particular the exploitation of the huge amount of data generated by the charging spots supports the management of peak loads through controlled charging, assuring the electricity quality. Moreover, the interoperability at European level of the energy retailers becomes fundamental in order to allow customers to cooperate increasing the flexibility of the infrastructure grid, supporting an open innovation driven by final customers.

The data arisen from charging points provide the basis to further forecasting about future trends and needs, granting the information transparency towards final users and supporting the future development of a stable charging infrastructure system aligned with future demand.

Concerning the development of the charging infrastructure, the seven projects aim to improve the cost efficiency and the profitability of DSO, ER, CSP without neglecting customers' satisfaction. In particular, the accountability is focused on maintenance costs, different sources of revenues and investments undertaken to ensure a sufficient safety level for both users and employees.

According to project 1, the customers satisfaction is crucial for the success of CINK project, levering on the management of customers complaints, electricity quality, pricing and billing among the stakeholders.

NKL tasks force has the ambition to enforce the international position of Dutch companies, valorising the Dutch products and services (regarding charging infrastructure sector) towards the European market. In this context the release of norms, standard and incentives that determine the entrance of new players is integrated in an European collaborative process (with ISO and IEC): they have to compromise the national market features with the guidelines provided by European agencies.

7.5.2 From network strategy to CSF

The previous objectives provide a comprehensive network strategy useful for the application of the new information management methodology that aims to support the progress of the project and organize the entire amount of information as well as monitor the real achievement of planned objectives through the individuation of the key network performances.

Firstly, Formula E-Team, representing the CINK project supervisor, is eager to assess the achievement of its objectives, mainly regarding country welfare in the seven projects developed by NKL task force. Afterwards, the CINK stakeholders need to evaluate the profitability and the success of the seven projects undertaken and structure with quantitative measures a knowledge database also useful to be shared with the beneficiaries of the project (DSO, CSP,…) that are willing to receive an information support to carry out their activities.

Thus, the new information management methodology satisfies and supports all the previous requirements of different organizations and e-mobility players, by structuring and organising the information with the purpose to create new knowledge crucial to support the decision making and afterwards monitor the main performances and results with the proposition of quantitative measures.

From the network strategy, planned by NKL task force with the supervision of Formula E-Team, the entire amount of information, collected in the different project, has been translated in different strategic objectives, deployed in several CSF, crucial to cover the main performance fields monitored by some measurement examples (defined according the *paragraph 6.3*).

- **Safety**
  The infrastructure administrators, the main beneficiaries of CINK project, deal with the electricity (Netbeheer Nederland, DSO association), incurring a high level of risk for employees and users, for its dangerous characteristics (high voltage). In particular DSO and TSO are mainly related to ensure the security of work environment for the employees, obliging them to enforce appropriate equipment and procedures. On the other hand, the CSP acts assuring a safe charging environment for the final drivers.
    1. **Increase employee safety:** **Reportable accidents (including fatalities) per hours worked.**
    2. **Increase customers' safety:** **Reportable accidents (including fatalities) per charging stations.**

- **Cost efficiency**
  NKL task force, through the overall accomplishment of CINK project, aims to ensure a certain level of return of the global investment (€ 5.000.000), partially improved by the profitability of charging infrastructure considered by them the principal way to support the nationwide charging infrastructure development. In addition, most of the players in the charging infrastructure sector, as CSP, usually face difficulties in starting up their business. Thus, the seven projects aim to enforce the position of Dutch small-medium enterprises on

the European market, analyzing their source of profit and focusing on the cost of ER interoperability.

Since the authorities through European regulations establish tariffs for the sold electricity, the DSO and TSO profit is strictly related to the reduction of operative and maintenance costs.

3. **Increase profitability: CSP profitability**
4. **Reduce maintenance costs: Total cost and time for maintenance**

- **Charging data management**

  In the data management the collection of information deriving from drivers' behaviours and charging patterns is crucial with the purpose to improve the management of peak load and electricity disturbances. In fact the charging habits can be exploited by energy retailers to align their businesses to the customers' requirements (price) and improve the grid efficiency required by DSO and TSO. Finally the CSP is in charge of monitoring the high requested charging area in order to assess which is the most suitable place to develop a charging infrastructure.

  5. **Improve e-drive behaviour tracking: Charging station Behaviour, Charging behavior**

- **Service quality**

  The customer care related to the B2B customers is crucial to improve the charging infrastructure system, managing the complaints such as electricity interruption, black out, peak load, providing the exact quantity of energy and a uniform level of quality. Moreover, the uploaded data in the platform have to comply with a certain level of reliability and preciseness, coherently with the customers' needs and grant the transparency of exchanged documents in an open data perspective, driver of stakeholders' cooperation.

  6. **Improve electricity and charging quality, Electricity quality**
  7. **Improve information completeness**

- **Country welfare**

  Coherently with Formula E-Team goals, the CINK project has to trace the positive or negative impact of e-mobility, underlining the level of employment and the attraction of new graduate positions, representing one of the most important e-mobility effects. In addition, the decrease of oil dependency leads the exploitation of renewable sources, improving the air quality in cities.

8. **Increase employment: Percentage of new workplaces due to e-mobility, Percentage of graduated workers in e-mobility industry**
9. **Reduce oil dependency**
10. **Improve air quality: Annual Air quality index**

- **Investments efficacy**

  In the NKL task force, one of the main roles is played by government which contributes to the overall CINK funds and in addition releases incentives to diminish the EV purchasing price. Thus, it is in charge of the measurement of incentives effectiveness in terms of sales increase and improvement of data collection, useful to structure the forecasting and analysis of the areas more attractive for EV incentives. In this scenario, the analysis of the territory could be fundamental in the decisions on which are the most appealing areas to invest and push the e-mobility as a new transportation standard. However, all the data collected towards the measurement of incentives effectiveness is useful for other players, mostly for infrastructure administrators, because they take part to the charging infrastructure development.

11. **Territory attractiveness: Demographic indicators**
12. **Effectiveness of incentives**

Incentives elasticity of sales

The elasticity measures the sales increase derived by a variation of the incentives released by government, thus the efficacy of different policies towards the e-mobility propagation. This data is particularly useful for government's policy analysis, but also for supporting the forecasts (project 3) and shape up the open data ware house (project 2,5).

Metrics	$$\frac{\frac{Sales_{t+1} - Sales_t}{Sales_t}}{\frac{Incentives_{t+1} - Incentives_t}{Incentives_t}}$$ $Sales_t = EV\ sales\ in\ period\ t$ $Incentives_t = Incentives\ released\ in\ period\ t$
Source of information	Financial statement
Frequency	Annual
Responsibility	TU/E
Further implementations	/

Charging stations elasticity of sales

One of the main objectives of the creation of the NKL task force is the optimization of the charging infrastructure in order to support the diffusion of the electric vehicle (project 6,7). Thus, the indicator measures the impact of sales increase on the number of new charging stations installed, defining which is the impact of the charging infrastructures on the sales, crucial to lead future investments in the charging grid.

Metrics	$$\frac{\frac{Sales_{t+1} - Sales_t}{Sales_t}}{\frac{CS_{t+1} - CS_t}{CS_t}}$$ $Sales_t = EV\ sales\ in\ period\ t$ $CS_t = Number\ of\ new\ charging\ stations\ installed$
Source of information	Financial statement, Market report
Frequency	Monthly
Responsibility	TU/E
Further implementations	/

7.5.4 Strategic Behaviours and Public Sector peculiarities

The proposition of the measurements and the entire methodology are based on the collection of data among the stakeholders and the following management. However some e-mobility players due to strategic reasons do not share the amount of data making unfeasible the development of the methodology.

In particular one of the most dangerous threats is represented by the possible strategic behaviours of some stakeholders, which affirm to share their own data in the first place, but then act opportunistically deciding to share only a part of their proprietary information misleading the research and the development of the methodology.

Moreover the attention of the managers, working in public (or semi-public) organizations, is focused not on the establishment of structured network accountability, considered by them peculiar of a private company, but on a Policy Analysis tool. In fact, they state that in a ***public organization*** it is not possible to ***undertake decisions basing only on numbers***, because they continuously work in network with several stakeholders and the repetitive character of these relationships force them to consider psychological and cultural variables, difficult to embed in fixed methodology and quantitative indicators. In fact, the CINK project funds are voluntarily collected from private companies, which are not completely inclined to keep track of the performances and returns of their funds, because the purposes of CINK projects are not profit oriented, but moved by social attitude.

The challenge of the experimentation is to provide them with a new methodology which, if opportunely exploited, can allow them to ***make data driven decisions, give specific responsibilities*** to the single participant stakeholders and ***evaluate the CINK performances*** basing on their tangible results, expressed by key network performances.

The main data availability challenges, arisen from the CINK project, are represented in the following table, underlining the requirement of a dedicated effort by the e-mobility players to force the data owner (CSP) to share the information in the network, because they process the fundamental data to achieve the objectives of NKL task force as well as FET.

KPI		**CSF**	**Data availability issues**
4	**CSP profitability**	**CSF 3**	Even if these indicators are the most exposed to privacy issues, NKL and FET can treat these data anonymously thus creating an average profitability of the stakeholder CSP. The KPI 7 has not been considered because it is not possible to average it, maintaining a relevant problem of data availability. The KPI 9 has not been selected because the CINK projects are not totally profit-oriented.
5	CSP profit from non-proprietary charging stations		
6	CSP profit from proprietary charging stations		
7	Interoperability cost ratio & Interoperability revenues ratio		
8	**Impact of tariffs on kWh final customer price**		
9	Average Return On Investments (ROI)		
10	Total cost and time for maintenance	CSF 4	The strategic nature of the data used to develop this KPI does not allow to include it.
11	**Charging station Behaviour**	**CSF 5**	This CSF is widely covered by three KPIs, being critical information to achieve NKL objectives. However, most of stakeholders are not willing to share the entire amount of owned data, limiting the KPIs application.
12	**Charging behaviour**		
13	**EV Penetration ratio**		
21	**Demographic indicators**	**CSF 11**	The KPI 21 should represent the basis for decision making, being an indicator easy to compute and based on available data.
22	**Incentives elasticity of sales**	**CSF 12**	The data used in these indicators are widely available and cover the main NKL and FET strategy.
23	**Charging stations elasticity of sales**		

Table 5: CSF coverage

In conclusion from the experimentation and the above table it is possible to identify two main **weaknesses**:

- Limited data availability, leading to difficult measurement feasibility;

- Difficult application in public organizations, due to cultural and background barriers.

However some methodology **strengths** have been confirmed by the experimentation with NKL task force:

- Structured and organized information in the e-mobility network for the first time;
- Proposition of quantitative measurement;
- Support decision making based on data.

8. CONCLUSIONS

The objective of the chapter is to conclude the research analysis providing a comment on the achieved goals and developed methodology, discovering possible future implementations based on the insights of the project weaknesses.

The investments in e-mobility industry seem to be the best solution for tackling the upcoming environmental issues, such as dependency on fossil fuels and the increase in the GHG emissions.

In the last five years the consumption of fossil fuels has overcome the oil fields discovers, reaching the so called Hubbert peak. The GHG emission has risen by 5,9 % and the Kyoto protocol and European environmental agreements (Europe 2020) are pushing more and more on the reduction and achievement of ambitious environmental targets in order to assure to the future generations a sustainable liveable world.

Thus, the electric vehicles can reduce the overall GHG emissions cutting the consumptions of fossil fuels by 70%, respect to the internal combustion vehicles, allowing each national government to easily respect the international and European targets.

Nowadays, all the countries worldwide, believing in the success of electric vehicles, are investing in the development of this new transportation mean, leading this sector to an important growing phase, begun less than 5 years ago. The scenario at European level is pretty heterogeneous depending on different countries, for instance in Norway and Netherlands the sales have increased annually by four times, showing the huge potentiality of this business.

On the other hand, many issues related to e-mobility world contribute to increase the uncertainty and the complexity of this new sector: the battery technology represents the main barrier for the electric vehicle propagation, due to the its high weight (30%) on the overall vehicle price. Moreover, the battery developments still affects the limited driving range and is constrained by the consumption of rare materials, such as lithium, that require time and cost consuming recycling and disposing processes.

In addition, the e-mobility sector presents a “grid vicious cycle” in which higher sales lead to more investments in charging infrastructure, and the main contribution to the enhancement of the sales is carried out by the improvements in battery technology. As represented by the “grid vicious cycle”, the single stakeholders cannot face all the e-mobility challenges alone, but they are forced to cooperate, improve the technology developments or convince the governments of the positive gain on the environmental issues.

Actually researchers are focusing on these two solutions, partially neglecting the management of the information in the e-mobility industry, where a huge amount of information arisen from the interrelationships (grid vicious cycle) and complexity drivers is not still analysed and integrated aiming to a common objective: EV propagation.

Therefore the investigation objective, individuating the research gap in the information management, has concentrated the analysis on the as-is information management situation, starting from a better exploitation of the existing information, owned by different stakeholders, focusing on the data ownership: the e-mobility industry is composed by different stakeholders, with different objectives and information sources, although all the players tend to hold inside their information, worrying about the competitive advantage spill-over. In this context the challenge is represented by convincing the stakeholders to cooperate in an open data perspective, by sharing the owned valuable data in the network, pursuing the shared ambition of e-mobility propagation.

Therefore, the research objective is the development of a methodology which exploit and organized the existing information, aiming to support the decision making of the entire sector, without focusing on just one player and the related objectives, but fostering the stakeholders' cooperation in order to boost EV diffusion, considered as the overall network shared ambition.

The preliminary step in order to reach the research output is represented by the stakeholders identification and the analysis of the information used by them in order to understand the AS-IS data management. A first literature analysis has been conducted consulting more than 100 papers, covering almost all the research studies published (2000-2014) with the purpose to understand the main criticalities in the e-mobility world and trying to discover the research gap in this field. The analysis has been conducted aiming to identify and organise the main e-mobility complexity issues:

- Unclear e-mobility definitions: the e-mobility concept is not still well defined by researchers as well as there are a lot of partial nomenclatures for describing the EV.
- Variable e-mobility popularity: the unstable e-mobility fame has characterized the last five years and the related public opinion interests.
- Battery technology instability: in the last decade, three different technologies have been developed, being constrained by rare resources usage and related battery disposal and recycling. The battery pack is still limiting the range and charging time.

- Distribution grid and charging infrastructure complexity: the charging stations represent the main source of information for all the e-mobility stakeholders, requiring an appropriate information management and their collaboration to solve the grid vicious cycle. In addition the V2G and smart grid management has to be controlled needing new knowledge and know-how.
- The role of standardization in e-mobility: the introduction of the new transportation standard requires the release on appropriate standards with international compatibility;
- Uncertain affordability and environmental performances: one of the main psychological barriers is still represented by the purchasing price, widely affected by petroleum price. Moreover contrasting environmental and total cost of ownership studies have been conducted without providing a precise result.
- Complex system of incentives and regulations: different regulations and incentives have been released by different countries affecting the EV sales.

The issues arising from e-mobility complexity can be overcome improving the existing technologies, releasing more incentives and ad hoc regulations or improving the information management.

During the literature analysis, several studies have been developed in order to discover new technologies to improve the existing battery pack or charging infrastructure. Besides, the enhancement of efficient incentives and regulations is still related to the government willingness and country's culture. Thus, the information management is still representing the only solution not yet explored and neglected even if the abundance of data characterising the complex e-mobility world. Therefore a critical weakness in the existing studies is individuated in the integration and collection of data, mainly related to the different leading e-mobility actors.

After a literature analysis on the e-mobility features, an investigation targeted to the stakeholders is conducted based on 20 interviews, covering all the stakeholders' roles as well as an analysis of the practitioners using common search engines, in order to discover the opinions and knowledge arisen by their field experience.

Starting from these activities, a new framework, arisen from the merger of experiences provided by practitioners and interviews, has been developed in order to investigate the e-mobility stakeholders' data management peculiarities:

- The stakeholders' interests are analysed starting from a general overview of the strategy and the successive evaluation of the needs concerning the e-mobility, verifying the coherence with company's vision, because in some cases the e-mobility represents a marginal business.
- The e-mobility needs, expressed by stakeholders' performances have provided the guidelines for the evaluation of information deriving from different stakeholders. The analysis has focused on the source of information, which expresses the font for the Balanced Scorecard data collection, and its typology, distinguishing between structured and unstructured data.
- The e-mobility world is composed by a network of stakeholders with different goals, interests and resources. The evaluation of the relationships among them is structured considering the type used to understand the strengths of collaboration (e.g. partnerships, joint venture,…) as well as the resources that the stakeholders usually share.

All these analyses, conducted exploiting 20 interviews and wide spread practitioners' investigation, aim to organise and tidy up the complex system of shared objectives, relationships, and performances which characterise the single stakeholders.

A second literature overview, jointly with the Complex Decision Making course, has been conducted to investigate the different methodologies and frameworks proposed by researchers in order to analyse the complex and interrelated network of stakeholders. This investigation has provided us with the basis for further organization and clustering of the existing e-mobility stakeholders, integrating both bottom-up and top-down approaches in order to validate the results provided by the two different methods with an opposite analysis flow:

- The first level of analysis exploits a top-down approach grouping all the stakeholders in three predefined business profiles. In fact the e-mobility world can be studied in three main roles aimed to ensure industry operability: e-mobility sponsors, the financers of EV industry; EV providers, in charge of developing and delivering the EV in conformity to final users' needs; the infrastructure administrators, supporting the development of a widespread charging infrastructure and granting EV usability.
  The business profiles have been developed focusing on business activities and resources leading to common performances as well as an overall business profile strategy
- The second level of analysis supports a bottom-up approach, in which the relationships between actors have been measured following a set of drivers, characterized by specific weights:

- Long standing business relationships (weight 10%);
- Degree of shared resources and information (weight 15%);
- Efficacy of shared knowledge (weight 25%);
- Degree of business integration (weight 30%);
- Homophily (weight 20%).

Both the weights and the score systems (developed to describe the relationship intensity) have been supported by 20 interviews with all the main leading roles as well as an analysis of information provided by practitioners and official websites.

	TSO	DSO	CSP	PC	CFO	A	G	BD	B	ER	CM
TSO		4,15	0	2,55	0	1,6	1,6	0	0	0	0
DSO	4,15		2,7	1,3	0,1	1,6	1,6	0	0,5	3,95	0,1
CSP	0	1,65		0	3,05	0	1,6	0	0	2,75	2,5
PC	1,5	1,3	0		0	1,6	1,6	0	0	0	0
CFO	0	0	2,5	0		0	0	1,2	1,2	1,5	3,55
A	2	2	0	0	0		5	0	1	0	2
G	1,6	1,6	0	1,6	0,9	5		0	2,8	0	2,45
BD	0	0	0	0	0	0	1,4		1,4	0	4,1
B	0,1	0,1	0,5	0,5	0,7	2,8	2,8	0,7		0,5	0,7
ER	0,9	4,1	3,6	0	2,55	0,4	0	0	0		0
CM	0	0,1	2,9	0,5	3,45	0	2,55	4,1	0,9	0	

Figure 31: relationship intensity

Combining all the scores collected by the relationship intensity (represented in the *table 32*) and considering the predefined business profiles, three main stakeholders clusters are generated decreasing the complexity of analysis and providing the information basis for the development of some measurements which show the organized and integrated information potential applications. The output provided after the stakeholders analysis is the stakeholder clustering composed by three different groups, underlining the relationship between them and the way of manage the information. Each cluster tackles similarly the e-mobility challenges and opportunities:

- **EV providers**: car manufacturers, battery developers, car fleet operators;
- **E-mobility sponsors**: banks, governments, authorities;
- **Infrastructure administrators**: DSO, TSO, CSP, ER.

The third step of the research lies in the individuation of some measurements which can introduce the potentialities of the information in the e-mobility context.

Thus, the collaboration with Antea Consulting Group aims to find the best adaptations of the information management on the e-mobility features: multi-issue and multi-stakeholders environment, with different objectives that shape up a complex and uncertain network, but characterised by the shared ambition of e-mobility propagation. The environment characteristics generate the necessity to develop a new set of measurements which cover the following peculiarities:

- Network strategy no more focused on the single stakeholders, but on clusters of players;
- The performances particular to each stakeholder are integrated and organized with the ones peculiar to the other players in network critical success factors, thus no more strictly related to each player.
- Innovative focus on the relationships that drives the creation of ad hoc measurements for each cluster and clusters' relationships.

The final research output is developed starting from the definition of the strategy among the stakeholders belonging to the same cluster, defining critical success factors which represent the main connection between the cluster's strategy and some measurement examples, which support to figure out the potential applications of the new information management methodology. The same process has been developed for the relationships' modules.

The final experimentation of the methodology in the governmental CINK project, managed by NKL task force, represents a good validation for the research strengths as well as presenting the side effects and weaknesses. In fact, it represents a task force which aims to comply the main Netherlands ambitious targets, such as employment increase and GHG emission reduction. In particular the NKL task force pursues the data sharing between stakeholders in order to improve the existing charging infrastructure assuring a better service quality. The interoperability at European level of energy retailers becomes crucial to allow customers to recharge in different national charging spots and exploit the different data arisen from them that provides the basis for forecasting about future trends and needs, granting information transparency that supports potential developments of a stable charging infrastructure aligned with future demand.

The thesis methodology has contributed to support the progress of NKL project and monitor the achievement of planned objectives by structuring and organising the information with the purpose to create new knowledge, fundamental to support the decision making and afterwards propose some Network key performances measurement examples.

On the counterpart the experimentation with CINK project has been crucial to validate our research output, underlining which are the strengths, coherently with the obtained results, and introduce new weaknesses deriving from the field experience.

First of all, with the experimentation we've validated the flexibility of the methodology, adapting the different steps to the complex network of stakeholders participating to NKL task force. In fact in the experimentation, we've started from the analysis of the AS-IS information managed by different stakeholders, proceeding with the translation of this information in project objectives, shared by all the e-mobility actors, defining critical success factors tailored to the network strategy useful to define a set of measurement examples. In the proposition of measurements we've exploited as input data, the previous stakeholders' analysis and clustering.

The experimentation has been useful to validate the alignment between the research modules and the CINK performances, mostly because the starting point is no more the single stakeholders' performances, but a reverse approach:

- Analysis of the Information managed by the stakeholders involved
- Translation of the information in network strategy coherently with CINK project;
- Definition of network CSFs;
- Proposition of measurements.
- Evaluation of the alignment between existing modules and the CINK performances.

The public context, in which the NKL task force operates, is not focused on the development of an information management system which organizes, integrates the existing information, supporting the creation of measurements useful to trace the key network performances, but it is considered a peculiar method tailored to private company and not useful for policy analysis. However, NKL task force states that the new thesis methodology could contribute to make data driven decisions giving specific responsibilities to the single players and evaluate the CINK performances basing on their tangible results, expressed by measurements. Moreover, the peculiar policy analysis network environment, characterised by several stakeholders and relationships, is pretty aligned with the capability of the new information management methodology to deal with the multi-issues and multi-stakeholders scenario. Although the members of NKL task force usually undertake decisions considering mainly psychological and cultural variables, the measurement examples are mostly non-financial, covering most of the peculiar policy analysis variables.

However the main issues arisen in the experimentation of the methodology was the data availability to depict the overall AS-IS information situation and propose measurement example, introducing the privacy issues:

- Corporate privacy: most of the stakeholders believe on the competitive advantage derived by data ownership, leading them to avoid cooperation and data sharing. In fact, some players although declare to share the data about charging station they partially hide them, impeding the measurement of some key performances
- Drivers privacy: the improvement of charging infrastructure is directly linked to the complete and precise description of the customers’ habits and behaviours towards the charging. For this reason, the data generated by drivers should be treated freely, without compromising their privacy rights.

One solution to the previous challenge could be the application of the new information management methodology to a restrict field in which the data availability is assured in order to create a proper background useful for wider application and, at the same time, show the improvements generated by the exploitation of the new information management adopted, so called quick wins.

Therefore, an incremental change seems to be the best approach to tackle the resistance to change in the e-mobility environment, considering the upcoming necessity to be flexible and effective in a dynamic sector. However, the shared ambition in an open data perspective presents some resistance to change:

- Technical reasons: new skills are required, measurement and network accountability based on quantitative measures and data sharing.
- Political reasons: overturn the organizations power due to data sharing and cooperation. In fact big firms are in charge of sharing information as well as small-medium enterprises, leveling the knowledge basis.
- Cultural reasons: so far the companies usually do not share data, believing on its competitive advantages, neglecting the open data potentiality.

We see the possibility of further investigation in change management, finding new approaches that foster the cooperation between stakeholders and data sharing, following the guidelines provided by incremental change: the improvements should be carried out step by step, influencing only a part of the organizations through a continuous improvement.

Once the cooperative behaviour is settled, further investigations on unstructured data and data arisen from infomobility (internet of things) could be processed towards the establishment of a modular balanced scorecard, no more based on only structured data.

Finally, all the weaknesses, strengths, opportunities and threats focused on the peculiarities of the research are summarised in an extent of the SWOT analysis.

Strengths	**Opportunities**
• Information management flexibility suitable for the network complexity; • Structure, organise and integrate existing information; • Quantitative financial and non-financial measurements; • Support decision making with data driven decisions.	• Exploitation of unstructured data and info-mobility opportunities (internet of things); • Development of new knowledge for further analysis; • Open data forces collaborative behaviours; • Improvement of the company environment due to change management.
Weaknesses	**Threats**
• Limited data availability, leading to difficult measurement feasibility and hardly stable information management system; • Difficult application in public organizations, due to cultural and background barriers; • Corporate and drivers privacy.	• Strategic behaviour, partial data sharing; • Competitive spill over; • Difficulties in the implementation of incremental change management (time and cost consuming).

Table 6: Information management methodology SWOT Analysis

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APPENDIX

1. Stakeholders list

Accounting
Accounts Receivable
Actuaries
Analytics/Reporting
Audit
Billing
Board members
Business Analysts
Business Community
Catering
Charities and not for profit
Chief Creative Officer (CCO)
Chief Executive (CEO)
Chief Finance Officer (CFO)
Chief Information Officer (CIO)
Chief Operations Officer (COO)
Chief Technology Officer (CTO)
Civil service
Client project team
Community and community organisations
Company Secretary
Competitors
Customer Service
Customers
Department heads
Designers
Directors
Distributers
Emergency services
Engineering
Environmental groups
Expenses department
Facilities
Finance
Fraud
Government
Health and Safety
Hospitality
Human Resources (HR)
Insurance
Inventory
IT
Key Individuals
Lease holders
Legal
Lobby groups
Local authority/local governance
Local interest group
Local people
Logistics
Maintenance
Managers
Manufacturers
Marketing
Media
Networking
Non - human e.g. Animal
Occupational Therapy
Operations
Other Programme and Project Managers
Partners
Planning
Pressure Groups
Procurement
Product team
Professionals e.g. medical
Programmers
Project team
Property owners
Public Relations (PR)
Publishing
Quality Assurance
Recruitment
Regulators (Health & Safety, Central Government)
Research
Resellers
Residents
Revenue recognition
Sales
Security
Senior Management Team
Service providers
Shareholders
Social Media team
Specialists
Staff
Subject Matter Experts
Suppliers
Supply Chain
Telephony/Telecommunications
Trade Unions
Travel agent
Treasurer
Trustees
Unions
Users
Venture capitalists
Venue provider
Veterinary
Vice Presidents (VPs)
Volunteers
Wages (Payroll)
Web development
Working parties
Zealots (any person who is fanatically committed)

Source: **www.stakeholdermap.com**

2. Case studies

N°	Date	Country	Stakeholder type	Company name	Person	Location & Duration
1	January 15th	Italy	CFO	ASF	Annarita Polacchini	35 minutes, Como
2	January 28th	Italy	CFO	Green Mobility Rental	Leonardo Cavaliere	28 minutes, Skype
3	February 18th	Italy	CM	Nissan	Sales force	30 minutes, Saronno
4	February 20th	Italy	CM	Tesla	Sales force	60 minutes, Milan
5	April 10th	Netherland	Consulting	APPM	Mark Van Kerkhof	40 minutes,Skype
6	April 14th	Netherland	CSP	The New Motion	Niels Nobel	54 minutes, Skype
7	April 16th	Netherland	DSO	Eneco	Taco Van Berkel	36 minutes, Skype
8	April 28th	Netherland	CSP	e-laad	Rowald Oosterkamp Arjan Wargers	31 minutes, Skype
9	April 30th	Netherland	G	Ministry of Economics	Julia Williams Jacobse	76 minutes, Den Haag
10	April 30th	Netherland	G	Ministry of Transports & Environment	Mario Fruianu	76 minutes, Den Haag
11	May 5th	Netherland	DSO	Enexis	Leenart Verhenijen	25 minutes, Skype
12	May 5th	Italy	CSP	General Electrics	Perico Nicola	15 minutes, Skype
13	May 5th	Italy	DSO	Enel Distribuzione	Carlo Saporiti	15 minutes, Skype
14	May 5th	Netherland	CM	Nissan	David Schoorl	15 minutes, Skype
15	May 6th	Italy	ER	A2A	Alessandro Bartolini	17, minutes Skype
16	May 6th	Italy	G	Senato della Repubblica – Commissione Lavori pubblici	Senatore Stefano Esposito	15, minutes Skype
17	May 6th	Italy	ER	AXOPOWER	Gabriele Bertholet	15 minutes, Skype
18	May 6th	Italy	ER	Illumia	Matteo Bernardi	23, minutes Skype
19	May 7th	Italy	ER	VP Tremagi Group	Massimo Bello	20 minutes, Skype
20	May 13th	Netherland	G	NEA	Sonja Munnix Vivienne Tersteeg	1 h, Utrecth

For each of the 20 interviews conducted, we follow the below framework, adapting the questions to the different players' characteristics and regard the Skype calls we translate the list of questions in slides in order to support the interview.

Objective of the research

We're developing a modular multi-stakeholder Balanced Scorecard, namely a management dashboard of Key Performance Indicators, for the e-mobility world. The stakeholders will be organised in clusters and for each cluster, as well as for the intersections of clusters, a module will be developed, taking into consideration both the different and common objectives of the stakeholders subsets. Each module is organised in Key Performance Areas, which synthesizes the Critical Success Factors of a fundamental performance field.

Interview objectives

Since we are developing a dashboard of indicators that summarizes the performances of the e-mobility stakeholders, in your case "*classification/name of the stakeholder*", the goal of the interview is to deepen the understanding of "*classification/name of the stakeholder*" role, underling the crucial performances for what regards the introduction of e-mobility, and the performances related to the most important relation with the others e-mobility players).

- ***Actual management control system (after the introduction of e-mobility)***
- ***Management control system before the introduction of e-mobility***
- ***Purposes of the partnership and relationship with the main players***
- ***Information shared with the previous stakeholders***

1) What are the managerial performances that are changed with the introduction of e-mobility?

2) What is the actual management control system? And how does it change with the introduction of electric vehicle? What are the managerial metrics used to keep track of the development and the introduction in the production system of EV?

3) What are the sources of information used to fullfill the mesurement system?

4) What are the purposes of the partnership with the others e-mobility key stakeholders?

5) What are the informative needs of this partnership?

6) Which kind of information do you share with the main partners? What are the purposes of the infromation sharing?

7) Are you building business relationship with other main stakeholders (government, charging infrastructure providers,…)? If yes, what are the purposes of these relations and what are the information that you share?

1. ASF (CFO, 35 minutes, Como)

ASF Autolinee, 51% owned by SPT Spa and 49% owned by Omnibus Partecipazioni, provides urban and extra urban transport services in Como and in the province.

The CEO of the company, Annarita Polacchini has released the interview.

Interest

The bus represents the principal mean of transportation exploited by ASF Autolinee in its business. Ing. Polacchini (ASF Autolinee CEO) sustains that the application of an electric engine in the public transportation (bus) is hard to be implemented, because the large size and the heaviness of the buses require a big battery with a huge capacity (kW) in order to assure a sufficient range, compromising the affordability of the investment.

The CEO underlines the trade-off that the transportation tackles: small bus (limited passengers' capacity) or a big bus leading to huge investment related to the battery pack enlargement.

The solution, trade-off optimization point, is represented by the application of electric bus just in limited areas regarding the city center: short distance routes and little size of the bus due to the limited space in the downtown (in Florence all the City center bus fleet is equipped by electric engine).

However the application of an electric engine to a limited part of the bus fleet leads to another economic issue: the adoption of a new transportation standard, involving the charging infrastructure and the operators training, not for the entire bus fleet would imply a no total payback for the investment.

In particular the cost related to the battery equipment is spread on 15 years, thus considering an average distance of 35000km per year for each bus, the battery would be change every 4 year, leading to huge investment.

The adoption of electric bus would imply up-coming worries about the source of energy exploited for the recharging and the real E-bus environmental impact: Although the electric bus reduces the CO_2 emission and the consumption of fossil fuel, it constrains the passengers capacity, increasing the relative consumption (per person) and reducing the internal bus capacity mainly reduced by the space occupied by the battery pack.

Network

The relationship with the government is crucial because the company is partially shared by the municipality of Como as well as local government are pushing the reduction of the CO2 emission with restrictive regulations. For instance, in California the government obliges the public transportation company to have a certain percentage of buses equipped by electric engine, making aware the firms as well as the final customer on the environmental challenges.

2. Green mobility rental (CFO, 28 minutes, Skype)

Green Mobility Rental is an Italian company which sells, lease and rent “green vehicles”, among all EVs. Leonardo Cavaliere, business administrator, has released the interview.

Interest

GMR is the first car fleet operator in Italy which has established a fleet of only EVs. Actually, it owns also natural gas as green vehicles. Today the EVs weigh 15 % (115 vehicles) on the total fleet, and the most rented vehicles are Renault Twizy and Smart ForTwo.

The interest for EVs of potential customers is great, but it partially turns in a real due to the high purchasing price, which represents the first barrier. The company provides customers with ancillary services as the installation of charging station and an RFID card which allows them to charge in every charging station on the national territory.

The most important clients are companies which integrate EVs in the corporate fleet, even if private customers are present. They usually invest in a charging station “level 2” to diminish the charging time.

GMR receives information of the vehicle in two ways: from a check every 5000 km, when an employee controls the Battery Management System and the state of the car; from the on-board computer, an optional element which allows to get information in real time like car localization and usage parameters, with the customers’ permission. In addition, GMR has created a community of customers which can exchange information and represents an important source of unstructured data.

Network

The GMR cooperates with several players. Firstly with banks, for the credit evaluation of potential customers, inasmuch the leasing and renting are a sort of financial service.

Secondly, they have signed agreements with energy retailers for allowing customers to charge EV in every charging station. In fact every customer is equipped with a RFID which allows to charge in every public charging station. Thirdly, with car sellers, particularly in Norway and France, in order to sell second-hand EV.

Thirdly with clients, who cooperate for creating a community where subscribers can freely recharge the vehicle. In fact every charging station installed in public areas by final GMR customers is freely accessible by other clients.

3. Nissan sales force (CM, 30 minutes, Saronno)

The car dealer of Saronno represents the first in Italy to provide the customer with a test driver as well as sell the Nissan Leaf. The interview has been conducted with the sales manager of the Saronno branch.

Interest

The Nissan have sold in the Italian market more the 323 car in the 2014 representing the most sold EV. In the Scandinavian countries and in Netherland the Nissan Leaf has sold more than 2000 units.

During the first period of selling, Nissan leaf has raised curiosity among the customer, asking at least five test drive at week, but is not translated in sellings for the following reasons:

- The limited range (170-200km) is still representing a barrier for the customer even if the Italian customer in average drive 60km per day.
- The Nissan Leaf cannot represent the first and unique car for the driver due to the impossibility to travel more than 100 km in the highway due to the charging braking system, which does not work properly without any brake, halving the overall range.
- The high purchasing price, 24000 euro for the average version, is much higher than the traditional ICV comparable segment.
- The Italian incentives are inconsistent respect the other European country, 5000 euro, and last at maximum one day (the last time were depleted in 24 h).
- The EV obliges the customer to change the driving style in a more fluent way, otherwise the drive range decrease substantially.
- The issue derived by the total absence of the engine noise could represent a problem for the pedestrian as well as the cyclists, thus force the driver to take time in order to get used to it.

The typical Nissan Leaf customer is represented by the freelance professional, who lives in the big Italian city, like Milan where he does not pay any parking fee and can benefit from the green status symbol provided by the EV. In addition due to the EV self-promotion provided by the Hollywood stars inclined to environmental issues, increases the glamour of the vehicle and the one of the owner.

The monetary advantages in owning an EV regard mainly the reduction of the ownership cost:

- The EV is not subjected to car taxes because the electric engine does not develop any KW and the warranties costs are almost halved due to the common practice of the EV drivers not to drive in the highway reducing the risk of car crashes.
- The not presence of any combustion engines reduce drastically the maintenance costs as well as the engine brake reduces drastically the brakes usury.
- The substantially reduction in the fuel consumption mainly due to the exploitation of electricity, much cheaper than petrol and the EV aerodynamic characterized by a barycenter very low.
- The battery lasts more than 10 years and many payment methods are present, such as the battery leasing and rental, where a discount of 5000 euro is released and the entire vehicle maintenance during the use is at the expenses of the car manufacturer.

Regarding the information expolited in the Nissan car, in the dashboard are present the charging level, the usury of the braking system, temperature of the engine very important due to the recent Tesla accident and the driving range to go, considering the last 10 km of the day before.

The developments of particular mobile phone applications allows user to communicate with the vehicle, particularly through the on board computer, which controls the so called Battery management system as well.

Network

- Government: the most intensive relationship due to the importance of the incentives in the propagation of the EV, still not sufficient in the Italian market (total depletion in less than one day);
- Battery developers: the limited range is the main EV issue, leading to further technology developements to improve the battery performances.
- Infrastructure developers: it has not been established a widespread infrastructure grid that still limiting the diffusion of the Nissan Leaf.

- Bank: system of payment to facilitate the purchase such as leasing and rental.

4. Tesla sales force (CM, 60 minutes, Milan)

The interview has been released by a sales operator of the unique Tesla store in Italy, settled in the city of Milan.

Interest

The main Tesla market of reference is represented by Norway and Netherlands in which, particularly for the first, the Tesla Model S is the most sold, mainly due to the higher EV range (500km) without compromising the astonishing performances and the uniqueness of the brand, considered for most of the client a masterpiece of the car history. Tesla is installing in the north of Italy some supercharger stations, in which the driver can reduce the charging time (one of the main barriers) to only 45 minutes, but still presenting some difficulties in the cold weather condition.

The vehicle dashboard presents some of the typical indicators such as the average range performed in the last 10, 25, 50 km and a Tesla application that allows the user to communicate with the vehicle, generating a huge amount of information useful to trace the customer habits and behaviors toward the vehicle.

The pricing strategy of Tesla regards the incremental decrease of the price according to a graduate vehicle shipping, more aligned to a mass market: Tesla has firstly focused on a niche-top gamma model (Roadster) in order to get accustomed the client about the premium brand that Tesla is developing. Afterwards, when the brand awareness is clear for the customer, Tesla has launched the Model S to reach new customers decreasing the cost of the vehicle. The next move of Tesla Motors will be the introduction of mass electric vehicles, without undermining the exclusiveness of the brand.

More over in order to ensure the exclusiveness of the brand the promotion strategy is carried out by the costumer of Tesla itself, which represents an elite driver, like Hollywood stars or politicians, without allocate any cost for the promotion of the Tesla vehicle.

Network

- Government: it represents a fundamental contribution to the decrease of the purchasing price, in Norway the government releases, through different form of incentives and regulations, around 15000€ for each Tesla.
- Battery developers: the range anxiety is drastically recovered by the longer range, extended due to the partnership with Panasonic tighten few years ago in order to assure a longer driving range.
- Infrastructure developers: one of the constraints that still limiting the diffusion of Tesla vehicle is represented by the absence of a supercharger station capillary infrastructure.

5. APPM consulting (Consulting, 40 minutes, Skype Call)

APPM is a Dutch consulting firm, which operates mainly in eco-friendly projects undertaken also by the Government. The interview has been released by Mark Van Kerkhof, manager responsible of the transportation sector.

Interest

The Dutch electric transport is drastically increasing: by the end of 2012 there were more than 6.000 electric passenger cars on the road. About 20% were Full Electric Vehicles (FEV) and 80% were Plug-in Hybrid Electric Vehicles (PHEV) or Range Extended Electric Vehicles (REEV).

The Netherlands local governments influence the propagation of electric cars, exploiting several instruments to stimulate EV’s in their municipalities, implying a huge importance on the policies making effectiveness.

APPM has conducted an important studies in 75 Dutch municipalities aimed to identify the main drivers and characteristics that could lead to a better effectiveness and efficiency of the incentive released.

Characteristics of the municipality

- Average income: the higher the income the more likely it is that people are able to afford a relatively expensive EV.
- Number of inhabitants: with a low number of inhabitants (and thus a low number of cars), the use of 1 electric vehicle (i.e. by the municipality) has a relatively strong impact on the relative percentage of EVs.

- Percentage of hybrid cars: the presence of hybrid cars can increase the chances of people buying an EV in certain municipality.

- Pilot projects: they can affect the EV vehicle purchase, showing to the municipality population the potentiality of a greener vehicle and foster the diffusion of EV.

Policy instruments

- Charging infrastructure: the number of public charging points in a certain municipality can have a positive effect on the number of EV's.
- Launching customer: launching customer means the positive effects carried out by the EV municipality adoption, leading to an improvement of the image of the EV among the citizens.
- Investment subsidy: it reduces the purchasing price as well as the ownership cost.
- Parking benefits: the total exemption of parking fees could represent a positive impact on the EV sales, mostly in cities where the density of cars is high, implying a reduction of the available parking lots.

6. THE NEW MOTION (CSP, 15 april, 50 minutes)

The New Motion (TNM) is an important Dutch charging service provider. Niels Nobel has been interviewed as expert in charging infrastructure.

Interest

All the energy suppliers can sell their energy in TNM charging points. The company is in charge of the development of the hardware and the charger, data analysis (in the back office integrating data coming from charging stations), the installation of the charging stations and the billing management. Some competitors have chosen to focus only on a part of these activities.

The New Motion has introduced an RFID card which allows the customers to charge in all the property and non-property charging stations, with a pay per use tariff. The customers can be clustered in three categories. The private customer as parking companies, mall, hospital, decides to install a charging station and which is the most suited energy retailer for each charging station provided and installed by the new motion. On the other hand, private citizens who install a charging spot in their own house, maintain their home energy suppliers. In this case the energy spot is like a vacuum cleaner that you plug in your house electric outlet. For public locations, the charging service provider decides independently the energy provider for each single charging station, required by the municipalities.

In close future the customers will be able to choose the energy supplier for charging their vehicle in all the charging stations.

The CSP profitability source is represented by a tariff received for the maintenance, billing and data management services. At the moment, an important threat is represented by energy retailers which are entering the business exploiting synergies arising from the ownership of energy license.

The information management is a key activity for the company: considering the individual charging session they know the duration, the consumed energy, start and stop time; for each charging station they know the charging type (three-phase or one-phase), the current type (alternating current or direct), location, state (occupied or free or out of order).

In addition TNM gathers information from the network of charging stations as the number per location (city or province), in which stations people charge the most and for how much time. Moreover competitors share info about subscribers who have charged in another company’s charging station, for billing purposes: in fact TNM has to pay back the competitor as commission. In addition TNM gathers data about the sales of EVs and about the behaviors of competitors. Most of charging stations in Netherlands uses RFID card, only few allow pay-per-use while others are even for free.

The customers’ requirements at the moment lie in the RFID card which allows roaming charging, and information request. In fact they want to know if the charger is free, occupied or out of order and when it’s going to become free: for this reason TNM has developed a smartphone app for android ad iOS to share information with customers in real time. Finally they require a clear bill, which expresses the location, duration and price for each charging session.

Thanks to the sim card installed in the charging stations, the data arrive in real time and are integrated in TNM dashboard. The main measured performances are related to the network. Anyway also other indicators as the number of service sales (installation and maintenance), number of charging sessions or new subscriptions are computed.

At the moment sentiment analysis is not made systematically, but only in case of customers’ patterns research. The focus in now on the analysis of charging stations that are critical for availability or location, in order to understand where to place new charging stations.

Finally, the main factors which affect the company's success can be summarised in customers' satisfaction, cost and energy savings, scale charging station for future growth and ability to network other EV energy suppliers' hardware to proprietary network.

Network

TNM has a relationship with energy suppliers and DSOs and shares with them information not in real time (not yet) about charging duration and location. In addition it collaborates with some car manufacturers with which it shares (not in real time) data about customers' needs, complaints, duration and timing of charging.

Anyway TPM shares information only with partners which have a specific agreement, and it's evaluating the possibility to sell as service the information about the market that it owns.

In addition TPM collaborates with customers: car manufacturers, private citizens, parking companies, corporations, municipalities and malls.

At the moment the only relationship with governments regards the installation of charging stations in municipalities. The e-laad project has involved the cooperation of all the different DSOs (8 on regional base in Netherlands) to stimulate the development of a public charging infrastructure. E-laad has not to be considered as a competitors, because the development of public charging stations is still not profitable, but it has allowed to smooth the psychological barrier of the EV drivers.

7. Eneco (DSO, 36 minutes, Skype)

Eneco is one of the largest producers and suppliers of natural gas, electricity and heat in the Netherlands, with more than two million business and residential customers. The interviewer, Taco Van Berkel, is an Eneco business developer and is an expert in DSO and energy supply.

Interests

Eneco group, as a whole, covers different roles in the energy supply chain: energy producer, DSO and energy retailer. Another DSO is part of the group (Stedin) as well as a branch for the construction of charging stations (CSP).

As DSO, Eneco is in charge of distributing energy, switching high voltage electricity into low one for domestic usage. Actually, e-mobility impact is very small, the energy demand is increased only considering, in a micro scale, customers who have installed a private charging station. Actually

Eneco is not investing in public charging infrastructure for the competitive issues arisen from the presence of actors supported by governments and important large actors (as e-laad).

Even if the amount of electricity required by EVs is not so huge, some issues are arisen in residential areas where the presence of vehicles requires fast chargers, damaging the energy transformers. The maintenance and improvement of these components is expected as particularly expensive.

The final customers require to be informed about the structure of the billing, differentiating in domestic and charging usage of electricity and highlighting the sources (fossil fuels or renewable). This fact has made the billing more complicated.

Actually, an important requirement of customers is represented by the velocity in installing new charging stations, which on average is actually 18 weeks.

For what regards the DSO perspective instead, the customers require a perfect operability of the electric grid in terms of electricity and service quality (regulated by authorities through standards) and the exploitation of new renewable sources. The tariffs for the distribution of electricity are fixed by authorities and for this reason the only lever to increase the profit is represented by a reduction of efficiency losses. With the introduction of e-mobility the DSO has changed partially its role in the energy supply chain, handling the new peak loads and the related grid congestion.

Network

Eneco exploits the different roles covered in the supply chain, by proposing the energy provision to new e-drivers, collaborating with car rental in order to “follow the car from the beginning” and exploiting the opportunity for new business: installation of charging stations. The DSO profitability source is the tariffs established by authorities (as operated also for the national TSO TenneT TSO B. V) and paid for the electricity distribution, billed to the final customer. Hence, DSOs collaborate with authorities in order to obtain a fair degree of profitability.

In addition, the possibility of roaming charging has increased the collaboration with several energy retailers for billing purpose.

Actually Eneco does not share information if not strictly necessary in order to preserve the potential competitive advantage arise by business intelligence. In fact, a dedicated back office is in charge of integrating the different data coming from charging stations for improving business performances.

In addition in the short future they are going to exploit the new information generated by the communication between the charging spot and the smart grid (thing-to-thing).

The collaboration with governments is weak, for the absence of subsidies, and regards only the collaboration with municipalities for the installation of public charging stations.

8. E-LAAD (DSO, 31 Minutes, Skype)

E-laad is a Dutch foundation supported by seven DSOs, which is in charge of developing and installing a large public charging infrastructure nationwide. Actually, it manages one of the most wide charging network worldwide with 12500 spots. The interview has been taken with the e-laad project leader, Rowald Oosterkamp, and management assistant, Arjan Wargers.

Interest

The main goal of e-laad is the development of a nationwide charging infrastructure useful under two viewpoints: on one hand it is going to decrease the "range anxiety" of potential e-drivers, supporting the EV sales; on the other it can generate new knowledge for DSOs and CSPs.

In fact the foundation is supported by all the Dutch DSOs, which participate monetarily in order to support the e-mobility and study the impact on the grid of the new energy requirements, following the so called "market model": the investments related to the public charging infrastructure are in charge of DSOs as other grid expenditures as done in Luxemburg, Portugal and Ireland.

The role of e-laad in the energy supply chain is untraditional: it operates in a B2B market and, supported by DSOs, finance the CSPs in order to install their charging stations in public places. Thus, the main activity up to e-laad is represented by the billing, and not the installation of charging spots.

E-laad is not the only entity which installs charging stations: also several municipalities (Amsterdam, Utrecht,…) are investing in this field.

Network

E-laad actually acts in a network made by three main stakeholders. Firstly, the DSOs, unique font of monetary investments which support their activities and require information generated by the charging stations. Actually, the only data exchanged in real time are the availability of the charging spots and their location. In short term, all the data regarding the charging will be exchanged in real time. In addition, every three year a report is generated (as for households meters) in order to keep track of the charging station performances.

Secondly the CSPs: e-laad subcontracts the construction of charging stations with predefined CSPs. At the moment, one criticality is represented by the interoperability of energy retailers: in fact, actually only one ER is allowed to charge in a specific CSP’s charging station, with a decrease of competiveness, but in the short future new steps forward are expected.

E-laad is working in an open data perspective to share information and push the propagation of e-mobility with open protocols: its reports, released on its website, can be freely downloaded.

E-laad represents a form of strong cooperation in the e-mobility industry, showing that the information sharing is generating more results that a strict privacy policy.

9 & 10. Ministry of economics and Infrastructure & environment (76 minutes, Den Haag)

In the Ministry of Economics headquarters in Den Haag we’ve met the two Dutch governmental managers in charge of e-mobility propagation: Mario Fruianu, who works for Infrastructure & Environment ministry, and Julia Williams Jacobse, who works for Economics ministry.

This meeting has represented an extra-ordinary opportunity to understand the reasons behind the great Dutch performances in e-mobility and has ended with the provision of contacts for the research experimentation.

Interest

The Dutch government does not push on e-mobility as final solution for the transportation problems, but thinks that this industry can speed up a sustainable society.

In particular the government bets on e-mobility firstly to reach the European environmental targets as far as Europe 2020 and air quality standards concern. Considering the last objective, the four main Dutch cities (Amsterdam, Utrecht, Rotterdam, Den Haag) have overcome the European pollution limits and worried the Ministry of Environment, which is very influent in the Netherlands: new funds have been released for installing charging station in these cities.

In addition, the Netherlands is pushing on energy efficiency to reach Europe 2020 targets: from this perspective e-mobility represents the main programme to reduce the dependency on fossil fuels, starting from energy innovation.

Netherlands wants to be the front runner in this sector, which has provided excellent results also for the employment: while in 2013 the e-mobility workplaces have tripled considering the previous year levels, for 2015 a growth of 6 times is expected.

In addition, the Dutch companies are becoming the leaders in the sector, with an expected increase of the exports for 2015 of about 10 times. Moreover, several multi-national corporations have found in the Netherlands a fertile environment where to place the European headquarters, first of all Tesla in Amsterdam.

As far as policy analysis concerns, the interviewees are reluctant to recognise the importance of a management control system, because they think that the only way to treat the information is with simulation tools, or making consideration at a rough guess. This strategy has provided them with great results, considering the achieved results and the undertaken public investment. The information processed for this purpose is represented by the results obtained with past policies and the overall information about municipal characteristics.

Considering the research clustering, the interviewees have expressed doubts about the group E-mobility providers, underlining the difficulty to consider banks and government in the same group.

Network

The Dutch national government works together with all the main e-mobility stakeholders to understand their opinions and release efficient incentives. In particular actually in order to solve the air pollution, the central government has released funds for pushing the four main cities to install charging stations, overcoming this customer's barrier. The Dutch scenario, in which the motivation towards e-mobility comes more from the society than the government, the public administration is involved, but not as leading actor, in the Formula E-Team, a board of all the main stakeholders which are cooperating for pursuing the shared ambition of e-mobility propagation by investing in several initiatives. First of all, the CINK project, which aims to provide the stakeholders with a on-line database which integrates the information, in an open data perspective. In this project, the interviewees have noticed several communalities with our research and have provided us with the contacts of Formula E-Team and NKL task force, Sonja Munnix and Vivienne Tersteeg. They still present some problems about data ownership and privacy issues.

This e-mobility community is guided by the stakeholders, and not by government, which instead is present only to study the needs of the different players for a successive policy making. The motivation derives directly from the market, and not from public administrations.

In addition government collaborates with Standard Development Organizations (SDOs) and regulatory authorities, such as ACM, which plays a consultancy role in defining new laws.

11. Enexis (DSO, 25 minutes, Skype)

Enexis is a Dutch DSO which operates in the provinces of Groningen, Friesland, Drenthe, Overijssel, Noord-Brabant en Limburg. Lennart Verheijen, Enexis employee, has released the interview.

Interest

Actually the DSO role in the supply chain is not changed so much by e-mobility. The number of EVs and charging stations has a limited impact on the electricity grid. If government is going to reach the target of 1 million EVs in 2025, the impact will be tangible and is going to require the load management to avoid electricity issues. This represents the main challenge for DSO and requires flexible tariffs for final customers.

Four main drivers influence the DSO performances: safety of employees and customers, affordability and reliability of the grid and customer satisfaction.

Network

DSO tariffs are established by authorities for energy and the only lever to increase profits is a progressive cut of operative costs. Government provides DSO with strict regulations to protect final customers by natural monopoly.

The customers of DSO can be defined in two stakeholders. Firstly energy retailers, because the price of energy includes also tariffs for DSO and TSO. Secondly, CSPs which physically link the charging station to the electricity grid.

In particular actually the tariffs for the connection of charging stations is not still defined by authorities, but it depends on the distance of the charging station from the transformer.

12. General eletrics (Italy, 14 min, Skype)

General Electrics has started the production and installation of charging station as leader in the construction of electrical components. Nicola Perico, field product manager, has released the interview.

Interests

In Italy General Electrics is treating the charging station as a common electrical component. The performance measurement system is not changed with the introduction of e-mobility. The first important difference in Italian scenario is represented by the management of information generated by charging spots which is up to the energy retailers and not to the CSP. In other countries, General Electrics has signed agreements with ICT partners in order to tackle this issue, but its core business remains the construction of charging station as electrical equipment.

Last year (2013) has represented a breakthrough in charging stations sales in Italy: several logistics companies as well as parking and malls have required charging spots for fulfilling customers' needs or exploit lower operative costs. Private customers usually are satisfied with traditional household connection (3kwh). The public administrations at the moment are not investing because of spending review constraints, even if some cities and public companies have bought some charging spots for public usage.

Network

Actually in Italy the CSP does not sign agreements with energy retailers, but its choice is up to final customers. Also the management of charging data is in charge of ER and General Electrics provides only hardware and software. The RFID card is released by ER, even if also General Electrics sells a standard product. The only important relationships are with DSO, for the charging station installation, and with final customers.

13. Enel distribuzione (DSO, 15 min, Skype)

Enel Distributione represents the DSO branch of Enel in charge of distributing the energy through its 1.000.000 km of electric grid. The point of view of a DSO is fundamental to understand the actual impact of electric mobility on the electric grid and for this reason Carlo Saporiti, manager of Enel Distribuzione, has been interviewed.

Interest

Enel Distribuzione is in charge of managing the distribution of electricity and the operability of the distribution grid. Actually it is in charge of managing the European project ADRESS which aims to develop an European smart grid, collaborating with more than 24 partners, universities and corporations.

The impact of e-mobility on the distribution grid is actually very limited in Italy, because of the low number of EV sales. Anyway the company is tracing the EVs progress and studying their long-term impact on the infrastructure grid, aggregating data coming from charging stations.

Network

The company collaborates first of all with the Authority for Electric Energy and Gas (AEEG) in order to communicate data about its performances and establish in a fair environment the tariffs for energy distribution. In addition some CSPs are now committed in installing private charging spots, required mostly by companies which want a charging station in their offices.

Moreover, the parent company Enel has started installing more than 700 charging stations nationwide with the projects Enel Drive and E-mobility Italy. For this reason Enel Distribuzione is collaborating with the other company's branches and with public administration when the usage of public territory is involved.

The relationship with the government is still strong given the high participation in the Enel stocks (31%).

14. Nissan after-sales service department (CM, 15 minutes, Skype call)

The interview has been released by David Schoorl, manager in charge of the after-sales service department of the European headquarter of Nissan, settled in Amsterdam.

Interest

The after-sales department refers mainly on the commercial activities aimed to the complete customer satisfaction, without dealing with the quality of the product and the manufacturing of it.

The main objects of this department are the shipping of a reliable car without implying further maintenance costs and the alignment with the customer requirements. Moreover the EV driver is more inclined then the ICV user to learn about the up-coming trends of the EV world as well as be more informed about the new advancements in terms of battery technologies and charging infrastructure grid.

Network

The diffusion of the electric vehicle is strictly related with the incentive of the government and the development of a capillary charging infrastructure grid: Grid vicious cycle.

Moreover partnerships or tight agreements with the Charging service provider represent a key challenge for the car manufacturer that can foresee the potentiality to offer a service to the customer, which can charge everywhere without facing further payments for the vehicle recharge.

Moreover partnership allows the car manufacturer to access to a huge amount of information regarding the customer behaviour and habits, owned by the charging service provider.

Some agreements with the Car fleet operators, such as leasing and rental companies, are built in order to improve the innovation process and share information and skills.

15. A2A (ER, 17 minutes, Skype)

A2A represents the official energy distributor as well as energy retailer in the Area of Milan and it is one of the first DSO that have implemented a considerable number of charging station in Italy.

The interview has been released by Alessandro Bartolini, A2A senior Manager and responsible of the environmental sustainability programs undertaken by A2A

Interest

A2A has designed and installed more than 64 charging station in Milan, 36 in Brescia, 60 for the Lombardy car sharing and other in the region collecting more than 168 public charging station in the whole Lombardy.

The development of the charging stations has been performed due to a public contract, which declared the construction of 168 charging spots of 20 Kw in Lombardy. In Milan A2A represents the leader, concering the installation of charging point, and is the unique Italian ER, DSO that ensure the interoperability of the spots. In fact the authorities (AEG, AEEG) are establishing some norms to foster the interoperability of the energy retailer in the charging spot, bu so far is not still defined a precise regulation Moreover the authorities have already released the standard for the charging spots: outlet, plug and energy power.

In Italy the EV sales have reach a stalemate situation due to the European economic crisis, in which all the companies are no more interested in long term investments, because of the scarcity of liquidity. Thus, the few firms investing in the EV business are aiming just to improve the company image through investments in a greener business and not increase the profit: so far the charging station enrollments are only 245, leading to a huge skepticism in this transportation business. Although the Government are releasing 1400€ for each charging spot, the station is still barely sustainable considering the development and operative costs, leading to a return in the company image improvement, which is measured through the enhancement in the public opinion (newspapers) and the frequency in the European environmental meetings.

The Data arising from public/private charging stations represents one of the main information traced by A2A. In Italy the main issue is the matching of information related to the actual consumption of the customer and the forecasted one (using the customers' historical data). In fact the DSO is in charge of reading the meters in the charging stations and communicate the information to the supplier.

The main source of information is the customer itself, analysed through different channels by the supplier which collects information about customers habits and the feedback of the company performances. The former is composed by a website, a phone application and a call centre, while the second one is structured in formal questionnaires based on the following drivers: timely of the service provided, kindness of operator, efficacy of the service. The type of data collected varies from structured (waiting time to talk with an operator, survey answers,…) to unstructured (comments, complaints collected by call centre,…).

Network

The key relationships built by A2A regard the tight involvement with the authorities and the government, in setting tariffs as well as incentives.

A2A group is composed by a branch that deal with the energy selling (ER) and another is related to the distribution of the electricity, grouping two separated entities in one big firms.

16. Senato della Repubblica Italiana – Transport Commission (15 min, Skype)

The senator Esposito, vice-president of the Transport commission of the Italian Senate, has released an interview talking about the choices of Italy in the e-mobility industry.

Interests

Considering the e-mobility sector, Italy is at "year zero", with a comprehensive situation which is far from comparable European countries such as France and Germany. Only few companies have developed electric prototypes for buses and car as, for instance Pininfarina.

The senator has underlined as the absence of a national industrial policy towards this sector does not represent a governmental choice, but a lack of willingness which has not provided a proper legislation and incentives system.

Even if the new government, led by the prime minister Renzi, who has installed several public charging infrastructure in Florence when he was major, the commission is not committed in developing an appropriate strategy.

Network

The most important influence derives from the car manufacturer FIAT, because the government wants to preserve the workplaces in Italy by supporting its choices which unfortunately do not include electric vehicles. In fact FIAT is the only big European car manufacturer which has not released an electric vehicle, even if it was one of the front runner during the last decade in its development in the advanced Turin research centre, which has represented the exchange object with the American government during the merger with Chrysler.

The FIAT general manager Marchionne has decided to bet on natural gas vehicles and the Italian government has released, during these years, incentives for promoting this kind of technology.

The senator Esposito does not blame Marchionne, who is considered a good manager, but the government which has followed for 10-15 years the choices of a private company, without a strategic plan: "we're prisoners of the FIAT, which has taken advantage of the weaknesses of the country".

17. Axopower (ER, 15 min, Skype)

Axopower is a private company involved in the electricity and gas brokering and is in charge of purchasing these commodities on the competitive market and redistributing to the final customers, namely energy consuming companies.

This company represents an independent point of view on what is happening in Italy and has confirmed, though its CEO Gabriele Bertholet, the scarce impact of electric mobility towards energy retailers and DSOs. Only few companies are investing in a private charging infrastructure close to their offices, even if in the last period more requests are arriving, showing the beginning of a growing phase.

18. Illumia (ER, 23 minutes, Skype Call)

Illumia is a national energy retailer operating mostly in the North Italy. Matteo Bernardi, Head of Gross Market, has released the interview.

Interest

In the Italian market are present more than 150 qualified energy operators likewise resellers not qualified, namely they cannot buy energy from the stock market, but only sell.

The energy retailers are in charge to analyze the customer consumption, foreseeing the hourly energy price and demand, purchasing the energy in the stock market or in bilateral contracts with other traders or producers depending on the variability of the energy price.

Moreover Illumina is evaluated by the DSOs, concerning its capability to provide reliable forecasts: all the energy not foreseen is monetized with an higher price incurring in fees with the DSO.

Illumia is not operating in the EV sector considered not profitable and not mature to undertake a new business adventure in this field, but considering a future scenario the Illumia core business could change according to the following factors:

- The EV can affect the promotion activities offering a new set of ancillary services to the B2B customers (higher marginality because of 65% taxes in the B2C market and presence of penalties in the B2B market that tied the two actors longer) such as the delivery of EV for commercial initiatives in order to enhance the fidelity of the customer and the increase the provision period.

- The diffusion of the EV could shake up the consumption pattern for the B2C market, forcing the ER to establish new pricing and consumption analysis methods. In addition the huge change in the electricity consumption could introduce a redefinition of the relationship with the DSO, which could install the charging station, identifying some energy retailer with the purpose to cooperate.

19. Illumia Tre group (ER, 10 minutes, Skype call)

Illumia is a company which deals with the electricity selling (Energy retailer) mainly operating in Emila-Romagna. The interview has been released by Massimo Bello the CEO of Illumia Tre group.

Interest

Illumia, representing an Energy retailer and not a DSO, is not operating in the development of charging infrastructure. In addition in Italy the scarce presence of EVs does not imply any business reconfiguration to the new consumption pattern caused by EV.

The main activities performed by Illumia are related to the billing and payment: transparency and accuracy are the main drivers to improve the customer fidelity and the customer satisfaction, which are the most crucial ER objectives. In fact the Energy retailer offers different method of payment (bank transfer, web payment, direct bank withdraw), deferments, refunds in a strict collaboration with the bank system.

The regulation regarding the charging station interoperability is not still defined and clear. In fact not all the energy retailers possesses the freedom to sell the electricity in any station.

In each charging station is installed a meter that is linked to a DSO that have previously installed the station. The DSO is in charging of the maintenance, facing all the operative costs. Thus the development of a interoperable charging system with all the energy retailers does not seem the best solution to recover all the cost that the DSO have sustained to build the station due to the division of the profit among many actors.

Network

DSO installs the charging station under agreements with the Government and the tariffs set by Authorities. The DSO build agreement with a restrict number of ER (often belong to the same company in order to payback quicker the investments) which is in charge to sell energy to the EV drivers.

3. Emperical experimentation proposal

Delft University of Technology

MSc THESIS

EXPERIMENTATION PROPOSAL

MILANO

INTRODUCTION

The e-mobility nowadays represents a great solution to tackle the upcoming issues related to CO2 emissions, foster the exploitation of renewable resources and the dependency on fossil fuels. The public reaction is impressive in the Netherlands with 25.000 Electric Vehicles sold in 2013.

Nevertheless the e-mobility context is characterised by a huge complexity, following different drivers:

- Stakeholder management: in the electric vehicle world different actors (DSO, CSP, Energy Retailer,…) coexist with different opinions on the e-mobility feasibility. Moreover, all the stakeholders are strictly interrelated, for instance the charging service provider (CSP) fosters the adoption of new EVs (helping the manufacturer's sales as well) establishing a widespread charging infrastructure network.
- Battery technology: it represents the main barrier to the propagation of EVs, concerning the principal performances such as range, charging time, etc.
- Government incentives and regulations: crucial to overthrow typical barriers such as purchasing price, cost of ownership and charging infrastructure.

In this context the different issues arising from the complexity drivers generate a huge amount of new information made of structured, unstructured and network data, which fosters and forces the stakeholders to cooperate and share the existing information with the purpose to overcome the main complexity criticalities.

FINAL OUTPUT

The research output is the development of a modular Balanced Scorecard, namely a managerial dashboard of Key Performance Indicators, which measures the performances of each stakeholder with a particular attention on the relationships they build and the role they play in the e-mobility industry.

OBJECTIVES

Actually the draft modular Balanced Scorecard is already developed and validated with Antea Group (consultancy company) and TU Delft supervisor prof. de Bruijn.

We're looking forward to test our final output in a Formula E-team governmental project because our research output lies on the same assumption and overall objects of the Formula E-team mission: foster the cooperation among the e-mobility stakeholders in an open data perspective in order to boost and facilitate the electric vehicle propagation.

We're not focused on the specific stakeholders' performances involved in the governmental project, but on its actual Management Control System, in order to trace the actual and potential improvements due to our modular Balanced Scorecard.