MASTER

# Sustainable business models for public charging points
## scenario planning to stimulate operation of public charging points in Dutch municipalities

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**SUSTAINABLE BUSINESS MODELS FOR PUBLIC CHARGING POINTS**

Scenario planning to stimulate operation of public charging points in Dutch municipalities

**Author**
Welmoed Vollers – student nr. 0614118

**Graduation Program**
Construction Management and Engineering
University of Technology Eindhoven

**Graduation Committee**
Prof. dr. ir. Wim Schaefer (TU/e)
Dr. Qi Han (TU/e)
Ir. Bart van Weenen (TU/e)
Ir. Roland Steinmetz (EVConsult)

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# Preface

Hereby I present to you my graduation thesis for the master Construction Management and Engineering provided by the Eindhoven University of Technology. This thesis is the result of research in the field of public charging points for electric vehicles. The research is performed in association with EVConsult, a consultant agency on sustainable mobility. Moreover, the research is performed under the authority of KENWIB, a program established to develop and share knowledge on energy-neutral environments.

During my studies I became interested in innovations that focus on a durable future. Electric vehicles and the related charging infrastructure are an excellent example of this. This dynamic market is in constant development, making my research very relevant for the nearby future. This made the execution of the research very interesting, although it was sometimes difficult to cope with and anticipate on the constant changes in the market.

I could not have written this thesis without the constant support, advice and cooperation of my colleagues at EVConsult. I thoroughly enjoyed performing my thesis at this innovative and dynamic company. I would especially like to thank my mentor Roland Steinmetz for his ongoing support, interesting discussions and openness to new ideas.

From the TU/e I would like thank the guidance provided by Bart Weenen and Qi Han. They provided new insights for research and helped me structure and shorten the report.

My appreciation furthermore goes to my family, friends and boyfriend for believing and supporting me throughout my entire studies. Special thanks to my mother for her grammar checks and to my boyfriend for looking after me when I got too focused on my thesis.

Finally, my thanks go to all interviewees for their time and effort in providing valuable information and their views on this dynamic ongoing evolving market.

Welmoed Vollers

Eindhoven, March 12, 2013

## Management summary

This thesis argues that operating public charging points is currently unprofitable. There is no long-term viable business case for placing and operating public points in Dutch municipalities. To establish a profitable business case for the operator who places and operates public points until 2020, several measures can be executed to improve the organisational structure, reduce costs or increase income. These measures are combined in scenarios in order to answer the main question of this thesis:

*What is the optimal combination of costs-, income- and organisation measures to stimulate the placement of public charging points, for the benefit of electric vehicle users?*

This question is answered by first mapping the current field of public charging points. Information is gathered trough desk research and participating in meetings and conferences. The information is used to discuss the necessary technical and organisational processes of the points and the relation with electric mobility as a whole. A selection of costs-, income- and organisational measures is made using general morphological analysis. Subsequently these measures are combined applying normative scenario planning. Rules are established to filter out combinations that are unlikely or impossible to implement or do not meet the goal of the research. A financial analysis leads to a range of financial outcomes in the year 2020 for the operator after applying several combinations of measures. Based on the rules six mini-scenarios are developed. Qualitative interviews, held with 14 of the involved stakeholders, reveal their preferences and opinions about the measures. This information is used to construct three final scenarios. An analysis of these scenarios identifies issues on implementation, finance and sensitivity. Based on all the information gathered several conclusions are drawn up to answer the main research question.

The main conclusion states that a positive business case is possible, but due to the dynamic market developments has to deal with high levels of uncertainty. The optimal combination of costs-, income- and organisation measures is highly dependent on the usage of the points and the role and investments of the government. To anticipate on market developments it is advised to allow several business cases in one municipality and put more focus on private and semi-public charging points.

Overall it is recommended to place stations with 2 points of 3,7 kW. Without any costs- or income measures the charging price needs to be raised to €0,40/kWh, combined with a starting rate of €1,-. The charging price can be lowered with at least €0,10/kWh if costs measures are implemented.

Furthermore, changes in the law are recommended, allowing consolidation of the energy tax and to create a new smart connection category with flexible capacity rates. Granting subsidies or investments through funds can reduce the price even further. Points with low usage could be subsidized. Without public financial means, it is advised to allow initiatives from the market. In all cases the municipality must optimize and shorten the procedures for licenses and adjust their parking policy. The government can set basis specifications on exterior, safety, interoperability and location of the points, while the operator is free to innovate on technology and set the price to service providers.

## List of abbreviations

| Abbreviation | English description |
|---|---|
| AC | Alternating current |
| AmvB | Algemene maatregel van Bestuur |
| CAPEX | Capital expenditures |
| CHAdeMO | Japanese Standard for DC charging also called Mode 4 |
| CP | Charging point |
| CS | Charging station |
| DC | Direct current |
| DSO | Distribution System Operator \|netbeheerder |
| ECN | Energy Research Centre of the Netherlands |
| EU | European Union |
| EV | Electric Vehicle(s) |
| FEV | Full electric vehicle |
| G2V | Grid to Vehicle |
| ICT | Information and Communications Technology |
| KENWIB | Knowledge cluster Energy Neutral Living in Brainport |
| NMa | Nederlandse Mededingingsautoriteit |
| NTA | Nederlandse Technische Afspraak |
| OCPP | Open Charge Point Protocol |
| OPEX | Operational expenditures |
| PHEV | Plug-in Hybrid Electric Vehicle |
| V2G | Vehicle to Grid |
| WIOR | Verordening Werken in de Openbare Ruimte |
| WOZ | Wet waardering ontroerende zaken |

# 1. Introduction

## 1.1. Problem indication

The transportation sector is gradually changing from a fossil fuel based sector to a green, durable fuel transportation sector. Fossil fuel driven vehicles are still in the vast majority, but alternative fuels are emerging. One of these alternative solutions is the use of electric vehicles. All over the world, new initiatives are taken and currently over 7000 electric vehicles are in use in the Netherlands (Agentschap NL, 2013). The Netherlands have compared to other countries a high ambition level of 200.000 electric vehicles in 2020 (ECN, 2012). Car manufactures are developing new electric vehicle models, the technology behind the batteries is evolving and consensus is being reached on the software and communication behind the technology. There are, however, obstacles that hinder a successful growth of electric vehicles in the Netherlands.

In May 2012 the Dutch Ministry of Economic Affairs, Agriculture and Innovation published a report on future expectations for the charging points and the energy network for electric transportation (Ministerie van Economische Zaken, 2012) . The report revealed that for the short term the first obstacle in making the EV market suitable for its user's wishes is the limited amount of public charging points. At that time, public charging points were only placed in the G4[1] by public tenders and in the rest of the Netherlands by e-laad, a cooperation of distribution system operators (DNOs). E-laad invested €25.000.000,- in the placement of free public charging stations, currently resulting in 2300 charging points. (Elektrischeauto.nl, 2011). In September 2012 e-laad announced to end the installation of public charging points (Agentschap NL, 2012).

Currently the placement of public charging points outside the G4 is at a halt. To further stimulate the use of electric vehicles the network of public charging points has to be expanded. Currently parties suitable for placing public charging points encounter negative balances in their business cases, discouraging them from placing and operating the points. The uncertainty about developments in the field of electric mobility and energy laws contribute to their cautious attitude. This also applies for municipalities that own the locations were public charging points are placed and therefore these play a significant role in the stimulation or obstruction of electric transportation and the placing public charging points.

To make the electric vehicle market suitable for its users' wishes the obstacles encountered by operators that place and operate public charging points must be reduced, enabling them to place public charging point in close cooperating with the municipalities.

This report will combine possible cost reductions, incentives to generate income and organisation models for operators to place public charging points. The goal is to create different scenarios and related business cases, which will result in a positive budget for the operator in 2020.

[1] The G4 consists of the four largest cities in the Netherlands: Amsterdam, Rotterdam, Utrecht and The Hague.

## 1.2. Problem statement

The problem for this research is stated as: “There is currently no long-term viable business case for the placement of public charging points in Dutch municipalities outside of the G4, inhibiting the stimulation of electric mobility”.

## 1.3. Research questions

**Main question**: *What is the optimal combination of costs-, income- and organisation measures to stimulate the placement of public charging points, for the benefit of electric vehicle users?*

In order to answer the main question the following questions need to be answered. The questions are categorized according to the different parts discussed in the document. The main question will be answered at the end of this research.

**Part 1. Parameters & Values**

1. How is the market currently organised and who are the main stakeholders?
2. Which research parameters will be used throughout the research with regard to amount, time, technical capabilities and use of the charging points?
3. What possible costs reduction measures can be undertaken and how can they be established?
4. What are possible income measures and how can they be established?
5. What kind of organisation models can be applied?

**Part 2. Scenario planning**

6. How can the measures, within the given assumptions, be combined in order to create scenarios with a positive budget for the operator in 2020?
7. How do the stakeholders assess the scenarios based on the measures and assumptions?
8. How can the scenarios be optimized?

## 1.4. Research objective

The objective of this research is: “To develop scenarios that bring operators in the position to develop a long-term viable business case with a positive budget in 2020 for the placement of public charging points to stimulate electric mobility.”

These scenarios can be used to advice the involved stakeholders on the measures to be taken in the near future and their impact on the budget. The social importance of this research is to establish measures that stimulate the placement of public charging points and therefore stimulate the use of electric vehicles. The scientific importance is to reveal the financial effects of the combination of different measures and the assessment of these measures and combinations by involved stakeholders.

## 1.5. Research boundaries

This research is restricted to Dutch municipalities in the G32[2]. The public charging points will be placed in 2013, 2014 and 2015 and will be operated until at least 2020. Measurements applied start in 2013. The costs are only examined for the operator.

## 1.6. Research model

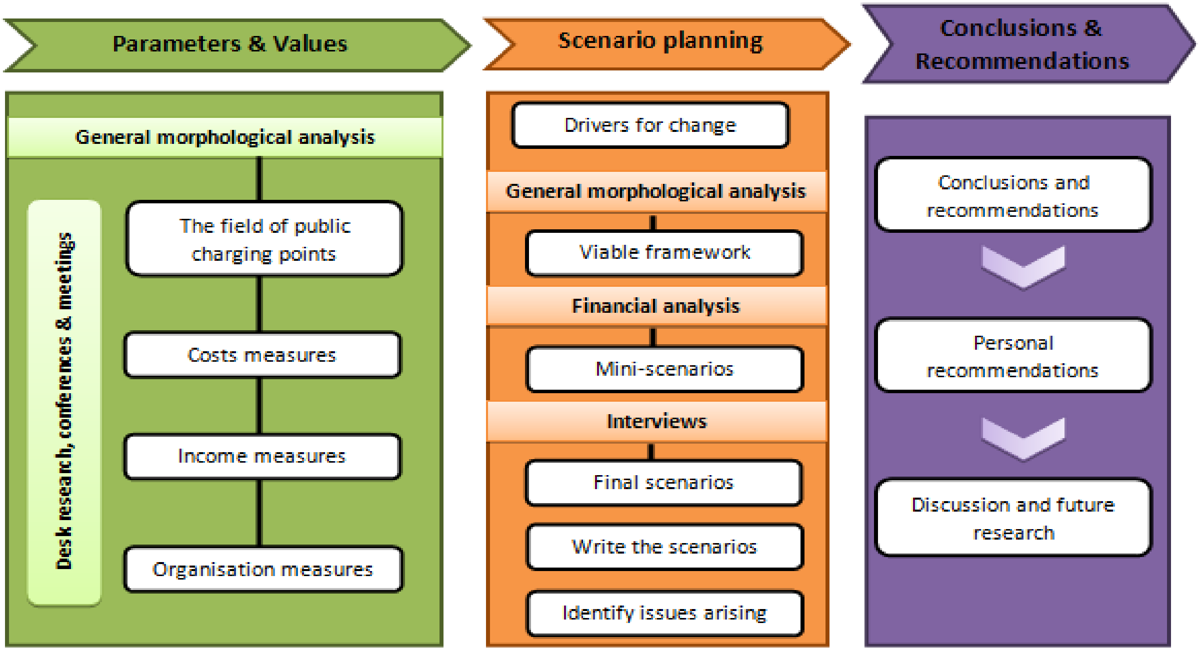



Figure 1. Research model

This research model is divided into three parts, represented by the green, orange and purple blocks. Each part consists of several chapters, visualized as the white boxes. The light shaded bars visualize the used methodology.

The first part describes the parameters and values involved in the research. Distinction is made between fixed and variable parameters. The fixed parameters are set in the chapter *The field of public charging points*. The variable parameters are described in the chapters *Costs measures, Income measures* and *Organisation measures*.

The second part, Scenario planning, first gives an overview in *Drivers for change* of the parameters and values as found in part 1. In chapter *Viable framework* the combinations of parameters and values that are inconsistent with the research question and goal of the research are removed. Rules are established to perform a financial analysis. The results lead to mini-scenarios, in the chapter *Mini-scenarios*. In the chapter *Final scenarios,* interviews are held to assess the mini-scenarios and to use this information to develop three final scenarios. The next chapter describes these final scenarios. The final chapter of this part analyses the scenarios by identifying the issues arising trough information gathered in the interviews, a financial analysis and a sensitivity analysis.

The third part gives conclusions and recommendations on the results found. Personal recommendations are given and discussions and future research described.

[2] The G32 consists of the 34 semi-large municipalities in the Netherlands.

## 1.7. Research methods

During the research, different research methods are applied. The background information on parameters and conditions is gathered trough desk research, conferences and meetings (see appendix 1). General morphological analysis is used to identify the most important parameters and values. The gathered information is combined in scenario planning during the scenario construction, using general morphological analysis in combination with a financial analysis. Different stakeholders using qualitative interviews will assess the mini-scenarios and used parameters. The assessment will lead to an optimization of the scenarios, resulting in three final scenarios. The final scenarios are described and analysed from a stakeholders-, financial and sensitivity analysis point of view.

### General morphological analysis (GMA)

GMA is a method for identifying and investigating the total set of possible configurations contained in a given problem context, using iterative phases of analysis and synthesis (Ritchey, Developing Scenario Laboratories with Computer-Aided Morphological Analysis, 2009). First, the most important parameters are identified and defined, assigning to each parameter a range of relevant values. This occurs during PART 1 of the research. In s*cenario construction* GMA is used to create a morphological field including the parameters and values. In a pair-wise manner, all parameters and values that have internal inconsistency are removed from the analysis, allowing the morphological field to become an inference model (Ritchey, Developing Scenario Laboratories with Computer-Aided Morphological Analysis, 2009). The small scenarios are selected by analyzing possible configurations in the inference model, using a set of rules, like establishing a positive budget in 2020. See appendix 3 for more information.

### Scenario planning

Scenarios can capture possible future states of the world. This research will focus on normative scenarios that investigate how to reach a certain target. There are all kinds of methods and techniques for developing scenarios. This research will focus on scenario planning steps used by Mercer (Mercer, 1995). See appendix 4 for more information.

### Financial analysis

An Excel model is developed for the financial analysis of the inference model with configurations that show the operators' budget over the period 2013 to 2020. Several parameters are included to shift between scenarios. See appendix 5 for a more elaborate description of the Excel model.

### Qualitative interview

To assess the measures and small scenarios, qualitative interviews are held with 14 of the involved stakeholders. The goal of the interviews is to obtain the opinions and preferences of the stakeholders on the given parameters. The main reason for conducting a qualitative interview is to obtain other, not foreseen, opinions and options to create a sustainable business case. See appendix 6 and 7 for a more elaborate description of the interview information and participants.

# PART 1

## Parameters & values

## 2. The field of public charging points

*This chapter will first describe the technology and organisation of public charging points. Secondly, the future expectations on electric vehicle technology and usage are given. Thirdly, the relationships are described between the charging points and electric vehicles.*

## 2.1. Charging stations and points

Electric vehicles are charged at especially developed charging stations. Each charging station has been fitted with one or two charging points. There are private-, semi-public- and public charging points. Private charging points are located on private terrains and can only be used with permission of the owner of the terrain. Semi-public charging points are located on private property, but publicly accessible. Public charging points are located on public property and publicly accessible. This research will only focus on public charging points located on municipality grounds.

### 2.1.1. Technology

#### *Sockets, plugs and modes*

Sockets, plugs and modes differ, depending on the kilowatt needed to charge. The following sockets are currently used for charging an electric vehicle in the Netherlands:

| Charging Point | | Volt / Phase | kW | Socket | Plug | Mode |
|---|---|---|---|---|---|---|
| **Standard socket** | AC | 230 V / 1 phase | 2,3 | Standard (Schuko) | Standard (Schuko) | Mode 1 or Mode 2 |
| **Slow AC charging** | AC | 230 V / 1 phase | 3,7/7,4 | Mennekes | type 2 (Mennekes) | Mode 3 |
| **Fast AC charging** | AC | 400 V / 3phase | 11/22 | Mennekes | type 2 (Mennekes) | Mode 3 |
| **Fast charge** | DC | 400 V | >50 | CHAdeMO | Fast (CHAdeMO) | Mode 4 |

Table 1. Sockes, plugs and modes

Besides the differences in kilowatt, the technology and costs also differ. For standard sockets the costs are low, but the technology and wiring behind the sockets are often not suitable to resist the high voltage and long charging duration, thus risking overheating. For fast charging the costs are high, with prices amounting to €40.000 per station. AC slow and fast charging points involve reliable technology and prices in between the home socket and fast charge points. For these reasons, this research will focus on AC- slow and fast charging for public charging points.

#### *AC type 2 mode 3*

Current public charging points in the Netherlands use this mode and the plug is becoming the standard plug in Europe. Advantages of plug type 2 are that it can withstand higher power and uses all three phases of high voltage current connections. The plug is connected to a cable and has to be physically connected to the vehicle and charging point (Van Woerkom & Hoekstra, 2012).

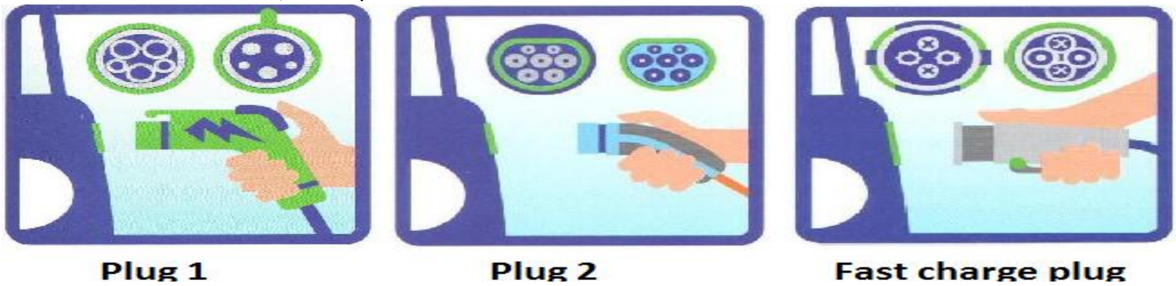



Figure 2. Plug 1, Plug 2 and Fast charge plug (Van Woerkom & Hoekstra, 2012)

### *European regulation*

In 2012 the European Automobile Manufacturers Association, the European Association of Automotive Suppliers and The Union of the Electricity Industry jointly agreed on the need for a single harmonised plug system for both the vehicle and the infrastructural side. Especially since the European electric vehicle and charging infrastructure is developing in different directions in various member states, thwarting cost reduction, user acceptance, cross-border use and predictability to investors. The above-mentioned associations recommend the use of the Type 2 / Type 2 combo plug for EV, as from 2017. This combo-plug is considered the best option for AC and DC charging. The Mennekes type 2/mode 3 plug fits this new combo standard. However, the in the Netherlands used CHAdeMO plug for DC charging is different from the new combo plug. Currently research is carried out to solve this problem (NL, 2012).

### *Identification & Payment*

To use a public charging point a charging pass is required for identification of the driver and management of the payment. Several commercial service providers distribute these passes. Although from different providers, in the Netherlands the passes are suitable for all public points. Users only communicate with their personal service provider who also charges them for the transactions made in a certain period (Rammers, 2012). Providers and operators settle the costs amongst each other.

### *Software and Communications*

To interchange the use of the charging passes, an authentication system called the *Centraal Interoperabiliteit Register* is established in the Netherlands. Service providers can communicate the RFID of their active passes with operators, allowing users to charge at all public points regardless of their charging pass. Furthermore, an Open Charge Point Protocol is developed as an open protocol between charging points and a central system. The protocol started as an initiative from e-laad, aiming to "create an open communication standard that allow charging points and central systems from different vendors to easily communicate with each other" (OCPP, 2013). Currently the protocol is adopted by countries all over the world (OCPP, 2013).

### *Configuration of charging points*

Charging stations can be fitted with one or two charging points, respectively described in this research as AC1 or AC2 stations, where AC stands for Alternating Current. It is possible to create a group of stations all connected to the same grid connection, see figure 3. The group can consist of similar stations, but also of one main station and several small stations, where the main station is used to establish the transaction (Nègre, 2011). For locations with many parking spaces, it can be a solution to place a group of public charging stations together. This report will only focus on locations with high dwelling density and low public parking space where only single stations are placed.

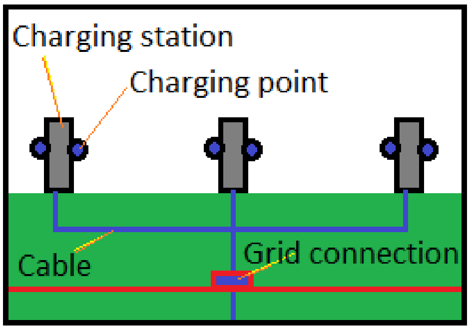



Figure 3. Configuration of charging points

### *Life expectancy of public charging stations*

Since charging stations are still relatively recent, many aspects of the life expectancy of charging stations are unknown. This concerns both the life expectancy of the hardware as the technology used to charge an electric vehicle. What will happen in the nearby future in this field is yet unknown. Based on research suggesting that from 2020 onward electric vehicle use will substantially grow and new technologies will emerge, see paragraph 2.2, the stations will be placed for operation until at least 2020. To narrow this research it is furthermore assumed that stations will be in use during this entire period.

### 2.1.2. Organisation

In the last few years, research and discussions were held by all parties involved on how to organise and manage the public charging points market. During the first years the involved actors agreed to cooperate in a variation on the so-called 'agreements system' (afsprakenstelsel) (Innnopay, TNO, 2010), distinguishing operators and service providers. Users subscribe to a service provider and operators allow all users to charge their vehicles at a public charging point. From the beginning, practice revealed that most operators are also active as service providers. To prevent problems between service providers and operators on interoperability in transactions and usage, these parties established in November 2012 the Association Interoperable Charging Netherlands (Vereniging Interoperabel Laden Nederland), under the name eViolin (e-laad.nl, 2012). The association is open for new members that comply with the agreed criteria. The goal of eViolin is to facilitate the use of EV, to pursue general accessibility of charging points in commercial and technical sense and to establish a level playing field for operators and service providers. The members all agree to commit to the consultations and comply with the decisions made. Trough eViolin operators and service provider can arrange that users choose their preferred service provider and still charge at as many locations as possible in the Netherlands (eViolin, 2012).

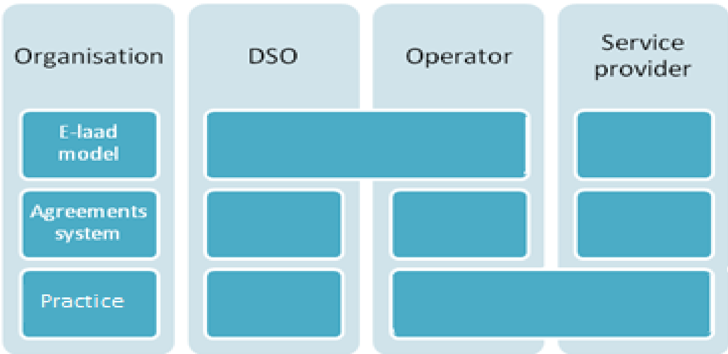


Figure 4. Organisation structures

#### *Request procedure of public charging points*

The organisation of applying for, installing and operating a public charging point differs. Until September 2012, cooperation between DSOs called e-laad, placed free public charging points. Each municipality received, on request, approximately one free station from e-laad per 10.000 inhabitants. E-laad placed points on strategic locations and on request by municipalities and residents. In September 2012, e-laad announced to stop with the free placement due to financial difficulties (e-laad, 2012). The municipalities officially own most stations placed by e-laad. Now e-laad has ended the placement, many municipalities lack procedures for public charging points. Only the G4 have procedures that initiated tenders to organise the placement and operation of public charging points by certain operators.

Amsterdam was the first major city to adopt a procedure independent of e-laad. After a public tender a partnership consisting of the municipality, a utility company and the Distribution System Operator (DSO) was formed. The partnership places public points on strategic locations and on request by residents (Nuon, 2009). The municipality has the final say on the location of the public points (Amsterdam.nl, 2012).

In the public tenders arranged by the G4, the municipality sets criteria for the points and finances a vast share of the placement and operation costs. Although the municipality owns the points, the operator has the economical ownership. Users can apply for a point near their homes by contacting the operator. The operator communicates with the municipality and DSO about the location and the placement procedure. The DSO establishes the grid connection and related cables, and the operator places the points (Amsterdam elektrisch, 2012).

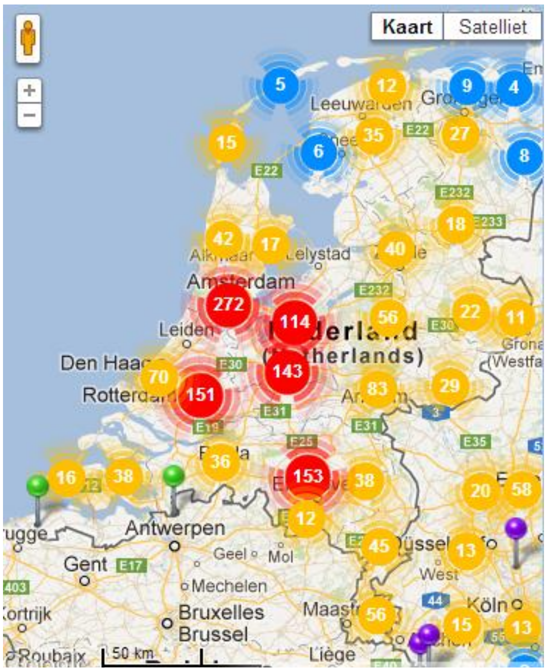


Figure 5.Charging points in the netherlands

### 2.1.3. Volume expectations

The first public charging points were placed in 2009, some by the G4 and some by e-laad. As E-laad.nl no longer accepts new applications, the last points will be installed in 2013, reaching a total of 2500 points. Most public points are located in the major cities, see figure 5 (oplaadpunten, 2013).Figure 6 shows the total amount of public, semi-public and fast charging points placed until 2013 (Agentschap NL, 2013).

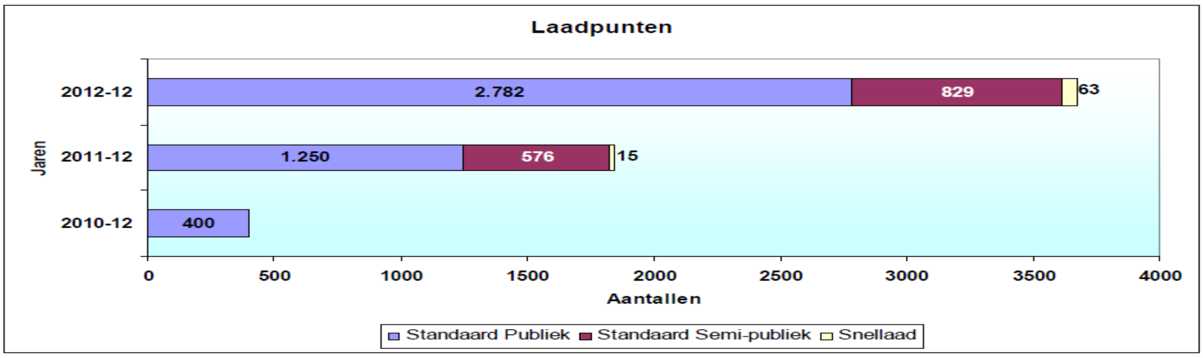


Figure 6. Division public, semi-public and fast charging points

Due to uncertainties in the progress of electric mobility, it is difficult to predict how many public points must be placed until 2015. Until now only the G4 have come up with estimates for their municipalities, but these estimates range between for instance 125 public stations to 2000 public stations to install until 2014 (Essent, 2011).

A report from the national government states that if the public authorities want to achieve 200.000 electric vehicles in the Netherlands in 2020 there should be around 20.000 electric vehicles in use in 2015 (Ministeries EZ, IenM, BZK, 2011). This means that approximately 20.000/17.000.000 = 0,1% of Dutch inhabitants will have an EV in 2015 (Poelman & Van Duin, 2010) (ECN, 2012). This research will focus on large municipalities like Tilburg, Almere and Groningen with roughly 200.00 inhabitants (Wikipedia). As a result an estimated 200.000 x 0,1% = 200 EV will be in use in these municipalities in 2015. Assuming these cities have a relatively low percentage of private parking places and a relatively high percentage of visitors, it is assumed that per electric vehicle one public point has to be placed. The placement is spread over three years: 50 points in both 2013 and 2014 and 100 points in 2015.

### 2.1.4. Stakeholders

Stakeholders are described by Freeman (Freeman, 1984) as *"Any group or individual who can affect or is affected by the achievement of the organization's objectives"*. Stakeholders have their own specific concerns, position, power, attitude and influence on the market model. Figure 7 shows the most important stakeholders involved in the field of public charging points with their roles and functions.

The stakeholders with broken red contours are public parties. The other parties are commercial private parties. Although there are different kinds of roles in this model, it can occur that one actor complies with several roles.

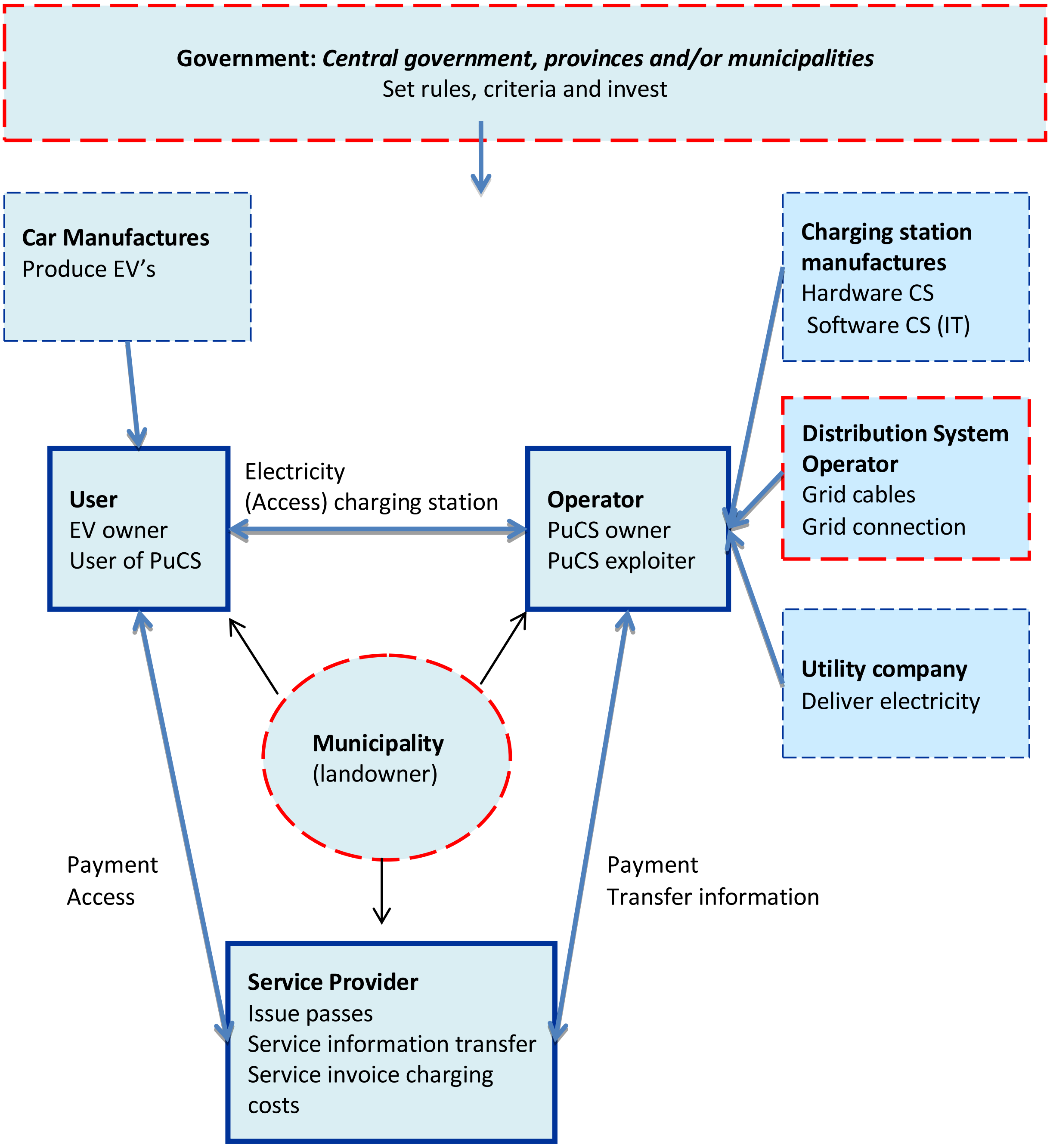



Figure 7. Stakeholders

## 2.2. Electric vehicles

Within the field of electric vehicles, differentiation is made between full electric and hybrid vehicles. Besides a battery, hybrid vehicles also have a conventional engine. Within this group, the plug-in hybrids (PHEV) can charge electricity at a charging point. (Van Woerkom & Hoekstra, 2012).

**Plug-in Hybrid (PHEV):** In a hybrid vehicle, the combustion engine and electric motor work together, using the combustion engine at high speeds and the electromotor at low speeds. Besides charging the battery while using the motor to brake and by means of the combustion engine, the battery can also be charged externally at a charging point.

**Full electric vehicle (FEV):** Designed without a combustion engine and all related aspects. The battery can only be charged trough external charging points or by braking energy.

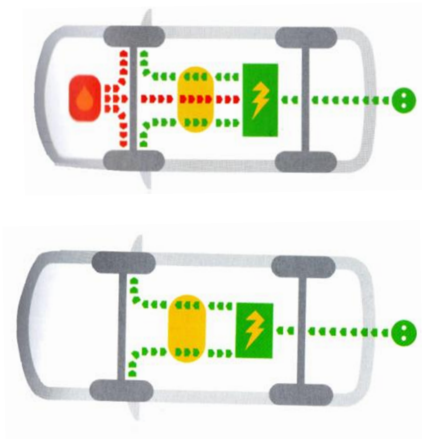


Figure 8. PHEV and PEV (Van Woerkom & Hoekstra, 2012)

A 2012 research revealed that until 2020 and 2030 experts tend to consider PHEVs as more robust than FEVs on factors involving demography, environment, economy, energy and transport (Zubaryeva & al, 2012). It is expected that in the coming years more PHEV than FEV will be sold. How this trend will evolve when batteries are improved or when fiscal incentives are changed, is unclear. Figure 9 shows the growing curve of electric vehicles in the Netherlands until January 2013 (Agentschap NL, 2013). Based on this figure and on future perspectives it is assumed that until 2020 75% of the EV's will be PHEV and 25% FEV.

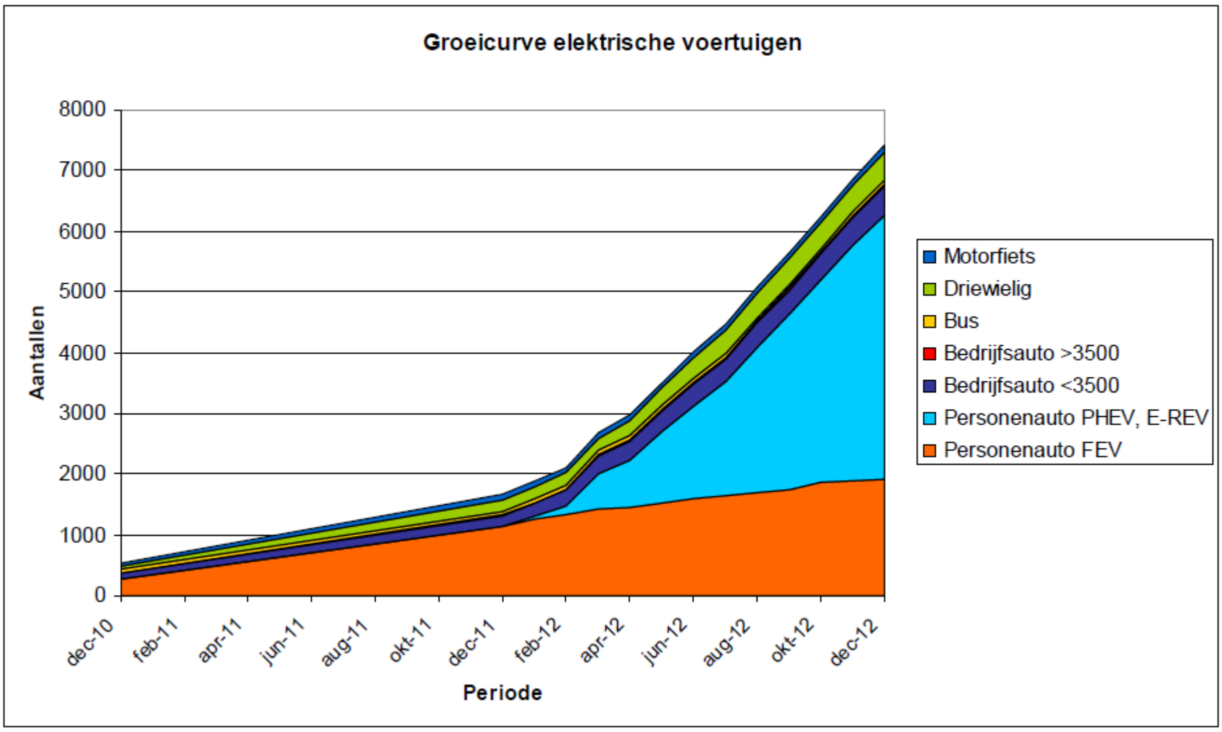



Figure 9. Electric vehicles 2011 and 2012 (Agentschap NL, 2013)

### 2.2.1. Advantages & disadvantages

Advantages of electric vehicles are the environmental friendliness, sound reduction, smart grid opportunities and electricity price. Disadvantages are the high price of the batteries and the limited range. For PHEV these disadvantages are less severe, due to the combustion engine. This allows smaller and therefore cheaper batteries, while the range is comparable to that of conventional cars.

**Environmental friendliness:** The FEV generates, compared to other means of transportation, the highest reduction in CO2, particulate matter and emission of other potentially harmful substances, especially when renewable energy is used (Vondeling & Syrier, 2009). Research revealed that on a well-to-wheel basis for midsized cars electricity use reduces greenhouse emissions by 68% for FEV and 44% for PHEV compared to gasoline (LLC, 2007).
**Sound reduction:** The motor of an electric vehicle does not produce any sound. The only sound comes from friction of the wheels with the road. This can be considerd a benefit, but also a disadvantage, due to other commuters not hearing the electric vehicle approaching.
**Smart grid:** Smart grid opportunities are related to smart usage of the available energy in the grid, related prices, and the future use of the battery for energy storage. When the grid has an overproduction, energy is charged/stored. When there is a shortage, energy is returned.
**Electricity price:** Currently, the costs to drive on electricity are lower than driving on fossil fuels. Table 2 gives an estimation of the prices in the fourth quarter of 2012 (Essent).

| | Electricity small scale consumer | Diesel | Gasoline |
|---|---|---|---|
| **Costs per kWh or liter** | € 0,21 | € 1,40 | € 1,74 |
| **Costs per km** | € 0,042 | € 0,078 | € 0,145 |
| **Total costs at 15.000 km** | € 630,- | €1.167 | € 2.175,- |

Table 2. Price electricity, diesel and gasoline

#### *Battery price and range*

For an FEV the battery price is around half to one third of the total hardware costs (ANWB) The range is around 150 km (Accenture, Oranjewoud, GreenFlux, 2012). In cold circumstances, this range can decrease. The most widely used batteries are variations on the lithium-ion battery (elektrische auto). Currently extensive research is conducted to improve batteries. A research conducted by ING gives an estimation of the timeframe for developments in battery price and battery capacity, which is related to the range, see figure 10 (ING Economisch Bureau, 2011).

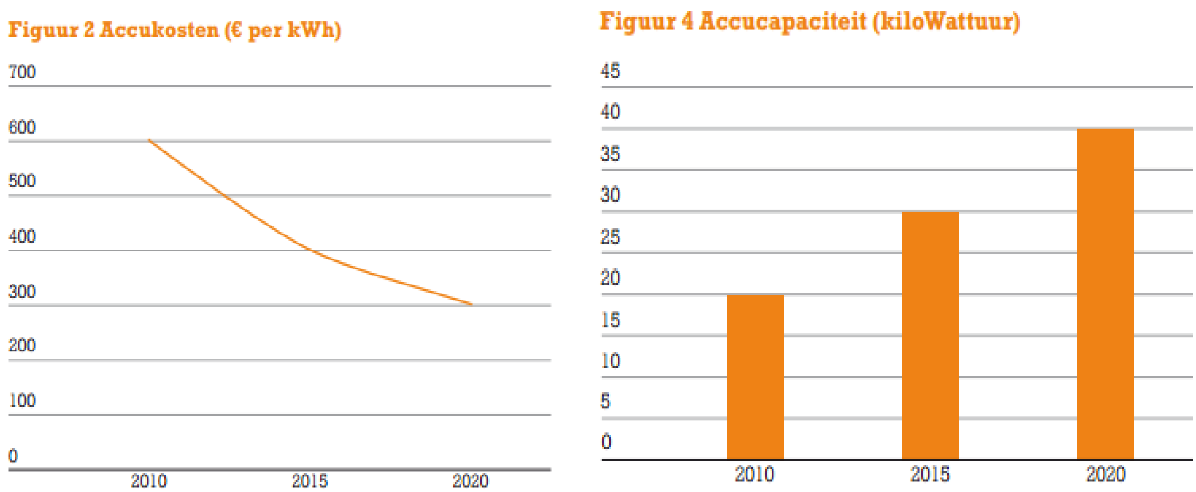



Figure 10. Development battery price and capacity (ING Economisch Bureau, 2011)

In June 2012, a European Roadmap on the Electrification of Road Transport was published. This report predicts that in 2020 technology will have improved and mass production implemented, resulting in batteries providing almost doubled life times and energy density compared to the 2009 Li-Ion technology status. Furthermore, the aim is to reach about 30% of 2009' costs (ERTRAC; EPoSS; Smart Grids, 2012). The current capacity of electric vehicle batteries fluctuates on average between 12 kWh and 52 kWh. For further analysis, the battery capacity of the most widely sold FEV and PHEV in the Netherlands will be used. These are the FEV Nissan Leaf with 24 kWh and the Opel Ampera with a 16 kWh battery (Agentschap NL, 2013).

***Progress in the charger capabilities***

The kW power level of chargers differs between the electric vehicles. The kW charged at a charging point depends on the maximum kW of the point and the type of vehicle. An electric vehicle with a charger capability of 3,7 kW can at an 11 kW point charge a maximum of 3,7 kW, while an EV with charger capability of 22 kW can at an 11 kW point charge a maximum of 11 kW. Figure 12 shows the EV's put on the market in various years, the kW they can charge and the capacity of the battery. Figure 12 reveals that the vehicles that came onto the market in 2011 charge between 3 and 3,7 kW using an AC charger, while the 2013 vehicles are expected to charge up to 11, 20 or 22 kW AC. It is assumed that with the technology improving this trend of higher power levels will continue to grow.

| | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|
| AC\|<br>3 -3,7 kW | **Nissan Leaf**<br>24 kWh\| DC 50 kW<br>**Mitsubishi i-MiEV**<br>18 kWh \| DC 50 kW<br>**Renault Fluence Z.E**<br>22 kWh<br>**Chevrolet Volt**<br>16 kWh | **Opel Ampera**<br>16 kWh<br>**Renault Kangoo Maxi**<br>22 kWh | BMW I3 BEV<br>16 kWh \| DC 50 kW<br>**Volkswagen E-UP**<br>18 kWh \|DC 50 kW<br>Toyota IQ-EV<br>11 kWh \|DC 50 kW<br>Volvo V60 plug-in<br>12 kWh | **Nissan E-NV200**<br>18 kWh\|DC 50 KW<br>BMW i8<br>7,2 kWh |
| AC\|<br>6 - 11 kW | | | **Mitsubishi Outlander**<br>12 kWh \| DC 50 kW<br>**Ford Focus Electric**<br>23 kWh \| 6,6 kW | |
| AC\|<br>16,8 kW | | | **Tesla Roadster**<br>53 kWh | |
| AC\|<br>20 kW < | | **Tesla Model S**<br>85 kWh \| 20 AC | | |
| | | | **Daimler Smart Fortwo**<br>17,6 kWh / 22 AC | |
| | | | **Renault ZOE Z.E.**<br>22/43 kW AC | |

Figure 11. Electric vehicles

## 2.2.2. Usage expectations

***Progress in EV usage***

In the Netherlands, most progress in electric vehicle usage is made in Amsterdam, where currently around 650 electric vehicles are in use and by the end of 2012, nearly 500 public charging points will be in operation. The goal of the Dutch government is to have around 200.000 electric vehicles in the Netherlands in the year 2020 (Ministry of ELI).

The Netherlands have a high ambition level with regard to the number of electric vehicles compared to other countries without a substantial car industry. In the field of R&D, the Netherlands hold a position in the middle, but regarding general market penetration, the

Netherlands are one of the leading countries (ECN, 2012). Currently in the Netherlands around 200 companies are involved in the field of electro-mobility. The introduction of electric transportation in the Netherlands is supported by a high-level advisory group, the so-called Formule E-Team (ECN, 04-07-2012).

How the future of EV will evolve is still unclear. Predictions made on the amount of electric vehicles in 2020 vary between 50.000 and 200.000 vehicles (Formule E-team). This number depends on the willingness of consumers to buy an electric vehicle. Currently reticence mainly exists towards the high initial costs, limited choice in available models, small range, long charging durations and limited availability of charging points (Hoen & Koetse, 2012). Figure 13 gives a prognosis of the percentage of new, sold EV's in the total Dutch car market. As shown in 2020 an acceleration of growth is expected (Ernst & Young, 2012).

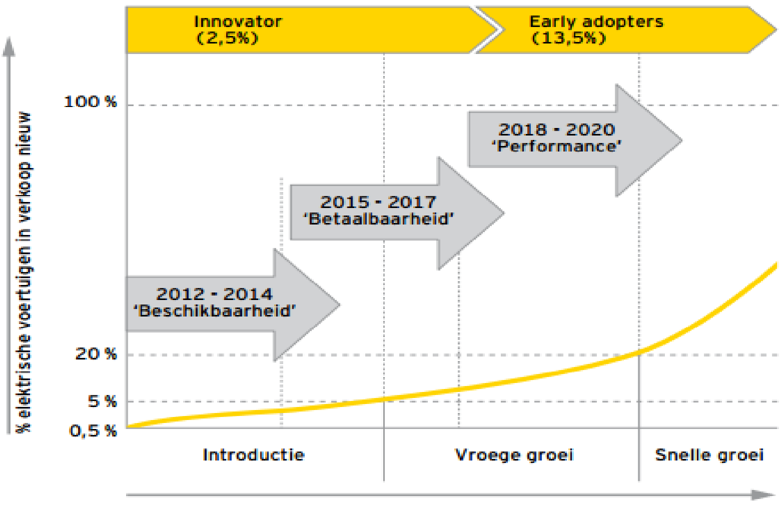



Figure 12. Percentage sold Electric Vehicles (Ernst & Young, 2012)

## 2.3. Relationship electric vehicle usage and charging points

*The previous paragraphs described capacities of the batteries of electric vehicles and the charging capability of the battery and the charging point. This paragraph will examine which charging points fit the wishes of the users' best and the kWh per vehicle per year.*

### 2.3.1. Usage and charging capability

The Netherlands are in the unique position that the majority of its inhabitants cannot park their cars on private property (Van Dijken, 2002). For electric vehicle users this means they are dependent on semi-public or public charging infrastructures. Which kind of public point fits which kind of user best depends on the available time to charge and the location of charging. The following distinction in the usage of public charging points is made.

| Usage of public charging points | Charging time |
|---|---|
| Electric vehicle charged near home or work | > 7 hours |
| Electric vehicle parked at special destination in public space (Supermarket etc) | **< 7 hours** |
| Electric vehicles charged on the route to the destination | < 0,5 hours |

Table 3. Usage and charging time

The time needed to charge the electric vehicle from empty to full depends on three aspects:

- The capacity of the battery: 24 kWh for FEV and 16 kWh for PHEV
- The charging capabilities of the battery: ≈ AC 3 kW - 22 kW
- The charging capabilities of the point: ≈ AC 3,7 kW - 22 kW

For the public AC points, differentiation is made between points that charge 3.7, 7.4, 11 or 22 kW. Until now e-laad and the G4 have only placed 11 kW public charging points. The following distinction can be made between charging points and the related charging times to charge an empty battery until full:

| | Voltage (a) | Current (b) | (apparent) power[3] 1-phase:axb 3-phase:axbx√3 | PHEV battery charging time (16 kWh) | FEV battery charging time (24 kWh) |
|---|---|---|---|---|---|
| **1- phase AC** | 230 V | 16 A | 3,7 kW | 4,3 u | 6,6 u |
| **1- phase AC** | 230 V | 32 A | 7,4 kW | 2,2 u | 3,2 u |
| **3 – phase AC** | 400 V | 16 A | 11 kW | 1,5 u | 2,2 u |
| **– phase AC** | 400 V | 32 A | 22 kW | 0,7 u | 1 u |

Table 4. Charging time per connection

The table reveals that even with the lowest connection type of 3,7 kW it is still possible to charge a battery of 24 kWh in less than 7 hours. If considered that EV users will charge the battery before it is completely empty the charging time will be less.

Data from e-laad.nl show that between September 2011 and September 2012 half of the public charging point users charged at five or more different locations. Only 11% always charges at the same location. Locations are villages/cities (E-laad.nl, 2012), see Figure 14.

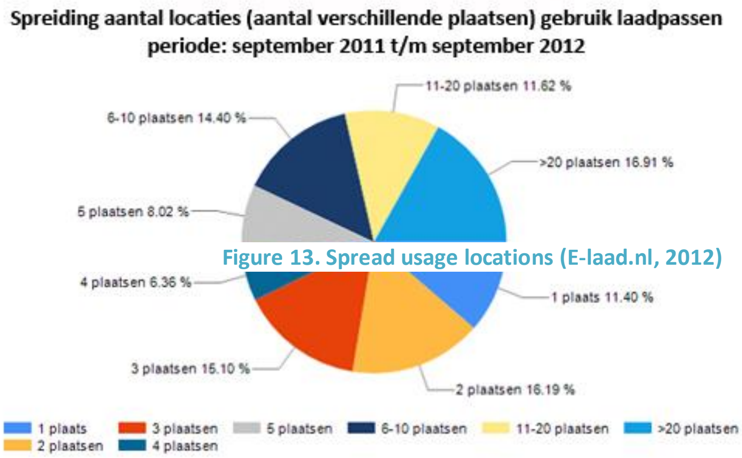



Figure 13. Spread usage locations (E-laad.nl, 2012)

Figure 15 reveals that most transactions on charging points are by users who are connected to the point for many hours on end. And that most of the users that leave within 7 hours do this within the first 2 hours. This suggests that there is a distinctive difference between the first two user groups described in figure 16.


Figure 14. Time of charging transactions (E-laad.nl, 2012)

[3] The time for charging the battery depends on the phase of the network, the voltage and current. For a 1 phase network power = voltage x current. For a 3 phase network the apparent power can be calculated by multiplying the current with √3, but only if the power factor (cosϕ) is not taken into account ad set to 1, leading to 1 kW=1 kVA.

For the first group, users who charge at home/work, the duration of being connected to the point can last for several hours, making 3,7 kW points sufficient. It is assumed that 90% of the public points fall in this category. For the second group 22 kW AC points are advised. However, most vehicles are not suited for a 22 kW connection. Therefore charging points at special destinations will be equipped with an 11 kW connection. The last group will benefit most from fast DC charging points and will therefore not be taken into account. See figure 16 for a résumé of the different groups. During the process of the research assumptions on charging power shifted, see paragraph 2.4.

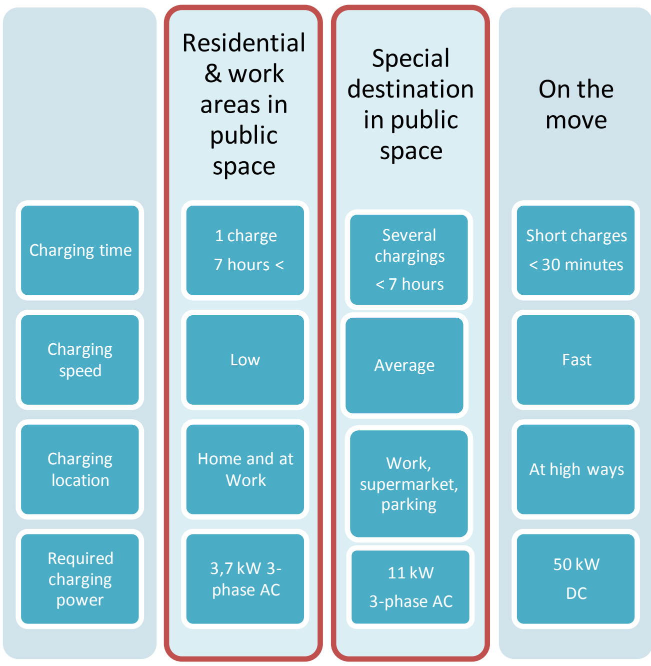


Figure 15. User groups

## 2.3.2. Usage and the amount of kWh charged per year

In 2012 the average distance Dutch passenger cars drove in and outside the Netherlands was 13.300 kilometres per year (Staline CBS, 2012.). The electricity consumption per km differs per vehicle, being influenced by factors like size, weight and speed. Based on a research from 2012 it is assumed that European FEV and PHEV use on average 20 kWh/ 100 km (Helmers & Marx, 2012). However, PHEV drive less km on electricity than FEV due to the combustion engine. Research from the Dutch lease company Arval found that its customers drove 80% more on fossil fuels than expected (Arval, 2012). However, this does not include all PHEV users. Figure 17 reveals that an Opel Ampera with a battery of 16 kWh can drive 70% of its trips on electricity (Steinbuch & Hoekstra, 2012).

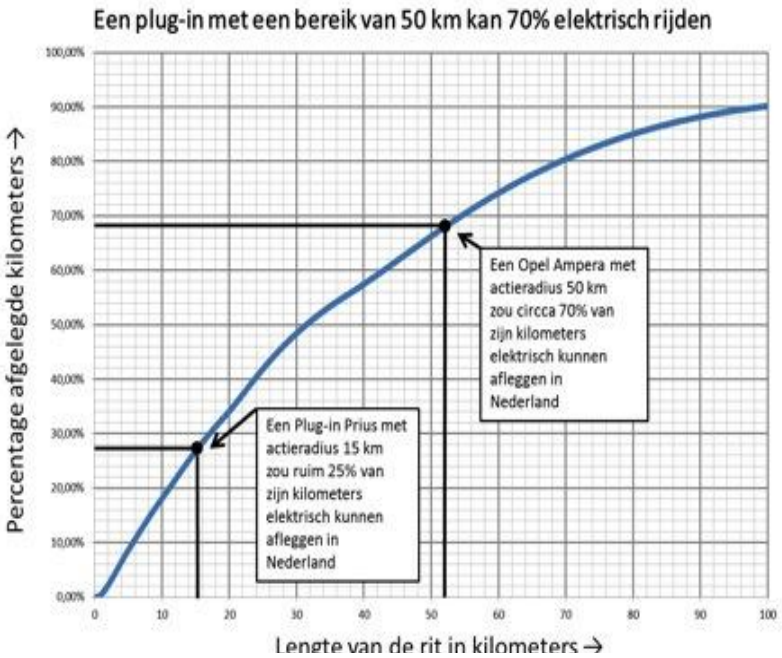


Figure 16. Range plug in vehicle (Steinbuch & Hoekstra, 2012)

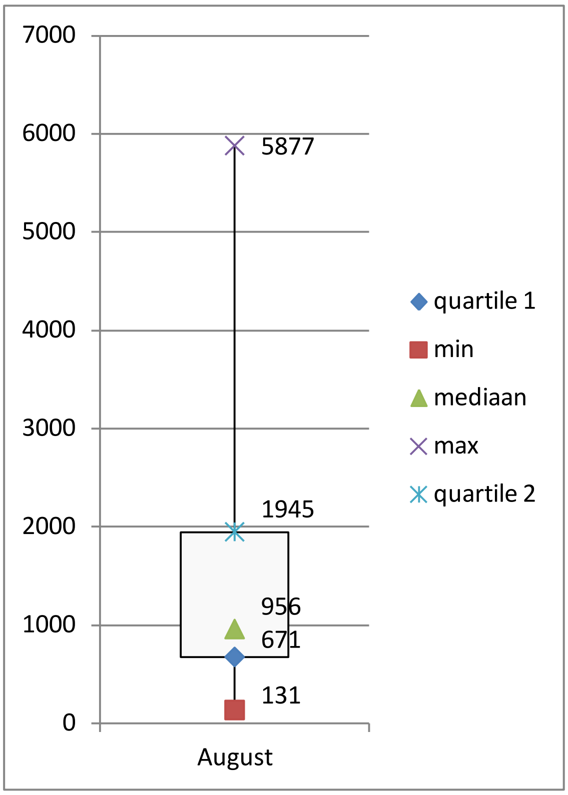
Combining this information with the conclusion from paragraph 2.1 that 75% of electric vehicles is PHEV and 25% FEV, leads to an average amount of 2000 kWh/year/EV, see table 5

| EV | KM per year | KM % on electricity | KM/year on electricity | kWh /km | kWh/year | Percentage PHEV and EV | Average kWh/year/EV |
|---|---|---|---|---|---|---|---|
| **FEV** | 13.300 | 100% | 13.300 | 0,20 | 2660 | 25% | 2061,5≈2000 |
| **PHEV** | 13.300 | 70% | 9.310 | 0,20 | 1862 | 75% | |

Table 5. Average kWh/year/EV

Whether the same amount will be charged at public charging points can be tested by analysing data from existing points. The data from public charging points in Utrecht leads to the following conclusions.

Between January 2012 and December 2012 the median usage per point was 956 kWh while 75% charged less than 1945 kWh. It must be taken into account that not all points were in use during the entire year, leading to lower kWh amounts. Furthermore, there is a big difference between the best and the least used point. Considering that usage will continue to grow and points are used the entire year on, these numbers will increase. Based on these arguments the amount of 2000 kWh is realistic. Assuming that points will at least have one regular user or multiple users a day, this amount could rise. How and if the amount of kWh charged per point will grow until 2020 is uncertain. Based on the assumption that EV usage will grow, the increase of kWh per point will be set at 5% per year.



Graph 1. Usage public points Utrecht 2012

## 2.4. Changes in fixed parameters and values

*During the research the general opinion of market changed on some fixed values. As a result, some values used in the interviews differ from values used in the final scenarios. This paragraph gives a description of the fixed values that changed.*

**Charging points of 3,7 kW or 11 kW:** The combination of progress in higher charging capacities of electric vehicles and the placement of only 11 kW points so far, let to the decision to only analyse the placement of 11 kW points in the mini-scenarios.
During the research, the general opinion on placing 3,7 or 11 kW points shifted. Most parties now belief that it is more important to create a sufficient charging network, then to place technically profound 11 kW points with higher costs and limited extra usage value. The final scenarios are based on 10% 11 kW points for special destinations and 90% 3,7 kW points for public residential- and work areas.
**kWh per point per year:** The mini-scenarios are based on 3000 kWh per year. This amount was established by assuming that electric vehicles users drive more km per year than the Dutch average, more FEV are used and the points are used by more than 1 user. Some interviewees find 3000 kWh per year realistic, but most find it too high. Especially since one of the two points of a station is often unused. Combining this information with new data, has led to the new assumption of 2000 kWh per year/point.

### 2.4. Conclusion

*Sub questions one and two were answered in this chapter. A summary is given below.*

**1. How is the market currently organised and who are the involved stakeholders?**

**Research parameters – Paragraph 2.1.**

- Public charging points are placed on municipality grounds
- Only e-laad and the G4 have placed public points
- The G4 organised public tenders to choose one or two operators
- Points are placed on request by users and on strategic locations
- Users must be subscribed at a service provider
- Service providers and operators cooperate on interoperability trough eViolin
- Other involved stakeholders are the government, car manufactures, charging station manufactures, DSO and utility companies

**2. Which research parameters will be used throughout the research on the scope of amount, time, technical capabilities and use of the charging points?**

**Research parameters - Paragraph 2.1.**

- AC mode 2 type 3 stations will be placed
- With configuration AC1 or AC2
- 50 points installed in 2013 | 50 points in 2014 | 100 points in 2015
- The points will be in use until at least 2020. What will occur after this date will not be taken into account

**Research parameters - Paragraph 2.2.**

- For FEV the battery capacity is set at 24 kWh
- For PHEV the battery capacity is set at 16 kWh
- Electric vehicles that charge over 3,7 kW are entering the market
- Of the electric vehicles in the Netherlands 75% will be PHEV and 25% FEV
- In 2020 the battery capacity is expected to double
- In 2020 the battery price is expected to half

**Research parameters - Paragraph 2.3.**

- At residential and work locations 3,7 kW points are placed = 90% of points
- At public destinations 11 kW points are placed = 10% of points
- Electric vehicles use on average 2.000 kWh/year
- Public charging points deliver on average 2.000 kWh /year
- A growth of 5% kWh per year

## 3. Costs measures

*This chapter first describes the current costs of public charging stations. Secondly, in the final scenarios possible cost measures and their cost values as used. Thirdly, the differences are described between the cost values used in the interviews and in the final scenarios.*

### 3.1. Current costs of public charging stations

The scope of this research is restricted to the costs involved in placing, installing and maintaining public charging stations with one or two charging points. These costs are divided into capital expenditures (CAPEX) and operational expenditures (OPEX). See table 6 for a description of the cost variables. The first mentioned costs apply to the placement of the stations, while operational expenditures are annually recurring costs.

| Capital expenditures (CAPEX) = initial costs paid once | |
|---|---|
| ***Station variables*** | *Description* |
| **Hardware with software** | The hardware and software of the public charging station |
| **Placement** | |
| Construction works, licence and exemption | Construction works in the public space, the licences and exemption for these construction works (WIOR[4]), |
| Placement station | Costs for placing and testing the stations and points. |
| **Grid connection** | The instalment of the grid connection is paid to the DSO. |
| ***Management variables*** | *Description* |
| **Project management** | Management of setting the locations and organisation |
| **Operational expenditures (OPEX) = yearly returning costs** | |
| ***Station variables*** | *Description* |
| **Connection** | To maintain the connection a yearly fee must be paid to the DSO. |
| **Capacity** | Capacity costs are transport dependent and based on the capacity category of the connection. These costs recur every year. |
| **Standing charge** | Yearly standing charge costs are based on independent transportation. |
| **System services** | Costs for using the electricity grid (maintenance and compensation to Tennet). Till 3x80 Ampere this is a fixed amount per connection. |
| **Meter** | The meter installed at the grid connection to measure the amount of electricity transported. Property of the measurement company, often part of the DSO. Includes rent, measurement and data processing costs. |
| **Energy** | |
| **Energy price** | Energy companies apply different prices for different subscriptions. This research will only use a fixed rate. |
| **Energy tax & tax rebate** | The government sets the energy tax per year. The tax is calculated per kWh/year, with lower prices for higher quantities. Tax rebate is granted per grid connection per year. |
| ***Management variables*** | *Description* |
| **Management** | Organisation of points, 24-hours (malfunction) desk, and communication to service providers with regard to billing/usage |
| **Maintenance** | The maintenance costs include repairs, cleaning and corrective maintenance like updates of software and hardware |

Table 6. Cost description

[4] Werken in de openbare ruimte

The costs depend on the grid connection category of the station. As described before the research will focus on points with an AC 3,7 kW and AC 11 kW charging capacity and the configuration of 1 or 2 points per station. These are described as AC1 and AC2. The kW per station and related grid connection is shown in table 7.

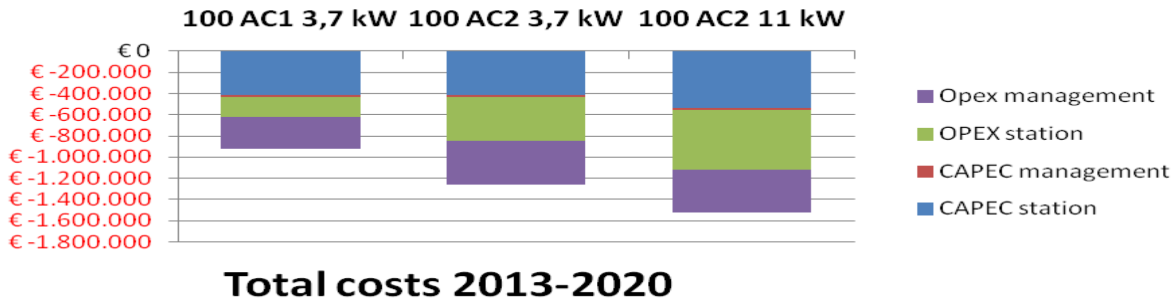
| | | kW per point | |
|---|---|---|---|
| | | 3,7 kW | 11 kW |
| Station configuration | AC1 | 230 V \| 1 x 16 A \| station 3,7 KW | 400 V \| 3 x 16 \| station 11 kW |
| | AC2 | 230 V \| 1 x 32 A \| station 7,4 kW | 400 V \| 3 x 32 \| station 22 kW |

Table 7. KW per point | Station configuration

The DSOs categorise the grid connections, differing in power and costs. The costs between DSOs differ. In this research, the categories and costs from Stedin are used (Stedin, 2013):

- Category: *> 1×6 A ≤ 3×25 A* AC1 3,7 kW | AC2 3,7 kW | AC1 11 kW
- Category : *> 3×25 A ≤ 3×35 A* AC2 11 kW

All costs of the variables are paid by the operator to the charging station manufacturers, DSO, utility company and municipality. Graph 2 gives the current cost for the configurations.




Graph 2. Total costs 2013-2020

### 3.1.1. Costs not taken into account

Costs related to discontinue the project are not taken into account, because it will be assumed that the station will remain in use until 2020. These costs are the residual value of the station and the costs for removing the station, disconnection of the network and work preparation. Furthermore, the costs for the construction of the parking places and facilities, like lines and signs, are paid for by the municipality. Costs made by other parties besides the operator are not taken into account, because this is beyond the scope of this research.

### 3.1.2. Fixed and variable costs

For all costs involved, it is possible to investigate cost variation. Some variations are beyond the scope of this research and will be fixed during the research. Paragraph 3.2 describes costs measures. Some of the costs will vary depending on the measures taken. The fixed and variable costs are given below.

| Fixed costs | Variable costs |
|---|---|
| Hardware with software | Placement |
| CAPEX project management | CAPEX grid connection |
| OPEX management and maintenance | OPEX grid connection |
| Energy price | Energy tax and tax rebate |

Table 8. Fixed and variable costs

### *Fixed costs*

**Hardware with software:** The price declines due to improvements and production increase. The decline is assumed at €500 a year for AC2 stations and €350 a year for AC1 stations.

**CAPEX project management:** Based on external sources management for setting the locations and organisation is set at €7.000,- per year of placement.

**OPEX management and maintenance:** Based on external sources the OPEX management costs are set at €200,- and the maintenance costs at € 400,- per station/year.

**Energy price**: Utility companies apply different energy prices for different subscription types. The fixed rate of €0,0665 per kWh of the utility company Essent is used (Essent, 2013).

| Variable | | Factor | AC1 | AC2 |
|---|---|---|---|---|
| **Capital expenditures (CAPEX)** | | | | |
| **Hardware with software** | 2013 | Station | € 3.000 | € 4.000 |
| | 2014 | Station | € 2.650 | € 3.500 |
| | 2015 | Station | € 2.300 | € 3.000 |
| **Project management** | 2013-15 | Per year | € 7.000,- | € 7.000,- |
| **Operational expenditures (OPEX)** | | | | |
| **Management** | | Station/year | € 200,- | € 200,- |
| **Maintenance** | | station/year | € 400,- | € 400,- |
| **Energy price** | | Per kWh | €0,0665 | €0,0665 |

Table 9. Fixed costs

### *Variable costs*

**Placement costs:** It will be assumed that the operator pays for the construction works, licence and exemption (€325,-), the placement of the PuCS (€350,-), the grounding (€200,-), technical check (€ 50,-) and related logistics (€ 35,-).

**CAPEX grid connection:** Public charging stations have the same grid connection as regular households. The cost for a maximum of 25 meters of cable and excavation are included.

**OPEX grid connection:** The price depends on the connection category (Stedin, 2013).

**Energy tax and tax rebate:** The government sets the energy tax per kWh/year. All payments start in zone 1. The tax is paid to the utility company that pays it to the government (Essent, 2013). Tax rebate is income, but related to cost measures. Each WOZ[5], grid connection, without residential function, receives €119,62, exc. VAT (Essent, 2013).

| kWh/year | Zone | Price 2013 |
|---|---|---|
| **0 ≤ 10.000** | 1 | € 0,1165 |
| **10.001 ≤ 50.000** | 2 | € 0,0424 |
| **50.001 ≤ 10 mln.** | 3 | € 0,0113 |

Table 10. Energy tax

| | Cost variables | > 1×6 tm 3×25 A | > 3×25 A tm 3×35 A |
|---|---|---|---|
| | Placement | € 960,- | € 960,- |
| | CAPEX Grid connection | € 616,- | € 990,- |
| **OPEX grid connection** | Connection | € 19,63 | € 39,05 |
| | Capacity | € 147,20 | € 736,00 |
| | Standing charge | € 18,00 | € 18,00 |
| | System services | € 4,16 | € 19,98 |
| | Meter | € 26,98 | € 26,98 |
| **Electricity costs** | Energy tax | Dependent on kWh per year | |
| | Tax rebate | Income of € 119,62 per WOZ/year | |

Table 11. Variable costs

[5] Wet waardering onroerende zaken. Dutch law that regulates the valuation of all property in the Netherlands for the purpose of taxation (Raad van State, 2013).

## 3.2. Cost measures

There are many measures possible to lower the costs involved in public charging stations, see Appendix 2. Based on General Morphological Analysis, Appendix 3, the most important parameters must be chosen for the analysis. The choice is made to focus on cost measures that are related to the variable costs and that are currently most discussed by involved stakeholders. Distinction is made between practical measures and law related measures.

| Practical measure | | Law related measures | |
|---|---|---|---|
| 1 | Placement cooperation | 4 | Meter - option 2. Remove measuring device |
| 2 | Extended private grid connection | 5 | One large scale consumer |
| 3 | Meter - option 1. Change requirements | 6 | New connection category |

Table 12. Cost measures

### 3.2.1. Placement cooperation

Several steps must be taken to physically place and install a public charging station. Several actors are responsible for these steps, see table 13.

| Steps | | Stakeholder |
|---|---|---|
| **1** | Enclose the parking spot | Municipality |
| **2** | Place the PuCS | Operator |
| **3** | Connect to the grid | DSO |
| **4** | Test the PuCS | Operator |
| **5** | Fix the pavement and signs | Municipality |

Table 13. Placement cooperation

This process takes around 3 days and requires solid coordination. With a different cooperation model, this process could be done in 4 hours, reducing time and costs (Van de Ven, 2012). It could be a solution to let the entire process be carried out by one certified party, guaranteeing a no risk policy for the municipality, DSO and operator. The responsible party could be the operator. This measure can be performed without a law change, but the stakeholders must make agreements on the organisation. Taking into account that the grid connection costs remain fixed but that the municipality pays for taking over their tasks, the cost for the operator are shown in the table to the right.

| Placement costs | |
|---|---|
| **Current price operator** | € 960,- |
| **New price operator** | € 760,- |
| **Law change required** | No |

### 3.2.2. Extended private grid connection

Currently each station has its own grid connection and WOZ value. By connecting the station with an existing grid connection, for instance the connection of a household, a new connection is not needed. Figure 18 gives an idea of this practical solution.

In January 2013 a research by Movares, in assignment of the national government, was published on this subject (Movares Nederland B.V., 2013). Based on the Movares' research it is concluded that this solution is a possibility and is very likely to succeed when the following recommendations are taken into account:

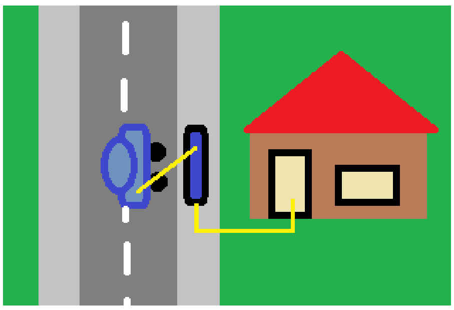


Figure 17. Extende private grid connection

AC1 charging point of 3,7 kW: The household connection must withstand the extra power. Most household connections are category > 1×6 tm 3×25 A, and not all households have a 3 phase connection. The connection can be raised for around €100,00, but the operational grid costs rise and the house wiring must be able to withstand higher power levels. Therefore it is advised to only place 3,7 kW points and connect them to a new group in the cupboard with its own residual-current device.

kWh measuring device: To settle the costs for charged energy, a kWh-meter can be installed. If the point is owned by the house owner, the meter does not have to meet the established specifications. To prevent energy shortage for other electric devices a smart meter can be installed. The operator can settle the costs with service providers of other users.

Ownership charging point and connecting cable: It is advisable that the station is owned by the house owner, as in that case the cable between grid and station does not require involvement of the DSO or meet certain specifications. There are no norm-technical or juridical objections in the law. Agreements must be made between the house owner, if desired an operator and the municipality for using their property and placing and maintaining the connection cable. The municipality remains owner of the locations. The operator is responsible for maintenance.

Parking policy: It will be assumed that in a residential area the public charging point is available to other users during the day. During the evening/night the owner has exclusive rights to use (one of) the points.

Costs: No raise in grid connection is needed. Since the station does not need to meet DSO standards the hardware is €1000,- cheaper and the construction costs are assumed at €700,- (Movares Nederland B.V., 2013).

| Variables | New AC1 3,7 connection | Extended private connection |
|---|---|---|
| **Hardware with software** | 3000,- | 2000,- |
| **Placement/construction costs** | 635,00 | 700,00 |
| **CAPEX grid connection** | 616,00 | - |
| **OPEX grid connection** | 215.97 | - |
| **Law change required** | No | No |

Table 14.Exended private grid connection costs

### Adjust the measuring device

Currently each charging station is obligated to have the standard NTA[6] measuring device from the DSO for small-scale consumers (Taskforce Formule E-team, 2012). Based on the NEN2768 and het Bouwbesluit the measuring device must be attached to an at least 18 mm thick wooden board and the cupboard must include the same devices as household cupboards. As a result, stations are relatively large and unneeded costs are made. Especially since most points are equipped with their own (smart) meter to manage the identification and transaction of users. There are two aspects related to reducing the current cost for the measuring device: the requirements of the device can be changed or the device can be removed.

[6] Nederlandse Technische Afspraak

### 3.2.3. Option 1. Change requirements

The NTA measuring device requirements are an elaboration of the AMvB [7] Meter requirements. This AMvB offers enough freedom to design a measuring device without the NTA meter, but with a smaller communicating meter (Taskforce Formule E-team, 2012). This can be established when all the DSOs settle an agreement about this new measuring device in cooperation with the hardware manufactures and in terms with the NMA [8]. This can reduce hardware, installation and renting cost.

### 3.2.4. Option 2. Remove measuring device

The obligated NTA measuring device can be removed. Probably this will need a change in the MeetCode Elektriciteit (Taskforce Formule E-team, 2012). The smart meters of the points must comply with the Metrologiewet (MID meters). The connection with the grid can be made in the station, but also centrally in the Meet-, Stuur- en Regelsystemen (MSR) that performs the actual data processing. A separate NTA meter is not needed. Requirements are that the energy use of the station itself is measured separately, that the data from the MID meters is available to the DSO and that the DSO must have the possibility to control the meter.

For option 1 the cost reduction is set at 50% of the hardware costs. The rent remains the same, because the less advanced meter will have a shorter pay-back period than household meters. The cost for the hardware is set at €100,-. For option 2 the rent is set at zero, but the hardware costs remain the same, due to establishing changes to the smart meters. Costs for establishing the changes are not taken into account.

| Variable | Current situation | Option 1 | Option 2 |
|---|---|---|---|
| **Annual rent/station/year** | € 26,38 | € 26,38 | € 0,- |
| **Hardware cost meter** | € 100,- | € 50,- | € 100,- |
| **Law change required** | No | No | Yes |

Table 15. Measuring device costs

### 3.2.5. Large scale consumer

The DSOs distinct between small-scale consumers (connection category ≤3 x 80 A) and large-scale consumers (connection category ≥ 3 x 80 A). This distinction influences the relation between user and DSO, energy producer and measurement company. In article 1, lid 2 of the Electricity Law one exception is described for large-scale consumers with connection types under 3 x 80 A. These users often have a large number of small connections, without a residential function and with a total ampere higher than 2MVA, such as public lighting and telecommunications.

It is possible to qualify a network of public charging stations as one large-scale consumer by complementing art 1, lid 2 with an exception, especially for operators of public charging stations. In that case it is needed to extend art 95a, lid 2 E-law for describing the group of connections as belonging to one specific organisation or to extend art 95n (multi-site determination), allowing a group of connections to deviate from the standard procedures (Taskforce Formule E-team, 2012).

[7] Algeme maatregel van bestuur

[8] Nederlandse Mededingingsautoriteit: The NMa is an executive agency of the Ministry of Economic Affairs and is responsible for the implementation of the Competition Act 1998.

Consolidation of energy tax: The energy tax can be consolidated per geographical area, which is set as the area of one municipality (Van der Hoeven, 2008). Small consumers pay the energy tax from zone 1, while large consumers use all three zones, see table 10.
Tax rebate: Being considered a large-scale consumer with only one WOZ value means that only for one connection tax rebate is received (GDFSUEZ, 2013).
Other aspects of being treated as a large scale consumer: When the connection value exceeds 10 MVA the connections can be realised by procurement. The work proceedings can be bundled. Furthermore, large-scale consumers have more freedom in choosing their energy supplier. These options will not be taken into account, due to the scope of the research. Table 16 gives the total energy costs per year for small and for one large user.

| | Connections | kWh per connection/year | Tax rebate per WOZ | Energy tax zones | Total price | Law change |
|---|---|---|---|---|---|---|
| **200 small cons.** | 200 | 2000 | € 119,62 | 1 | -€ 22.676 | No |
| **1 large consumer** | 200 | 2000 | € 119,62 | 1, 2 & 3[9] | -€ 6.816 | Yes |

Table 16. Larg-scale consumer costs

### 3.2.6. New connection category

Currently public charging stations have similar grid connections as households and companies. The amount of kWh per year may be similar, but the (control on the) usage is different. The smart meters of the charging stations allow smart grid options. These involve controlling the charging time, the charge capacity and the charging costs. The time and charging capacity can be tuned with the current capacity of the grid (Mets, 2010). When an operator can control multiple charging points, the grid and related costs are used optimally. By aligning the points and their usage high peaks in the grid can be prevented and the total amount of capacity needed at a certain moment can be lowered.

Currently the flat energy tariff does not motivate the implementation of smart charging. In art 29 lid 4 (E-law) it is stated that the Minister can by Order in Council (AMvB) set rules concerning transportation costs. This would mean that in art. 3.7.13 A tarievencode NMa the 'grid connection categories' are changed, possibly lowering the costs (Taskforce Formule E-team, 2012).

| Variables | > 1x6 tm 3x25 A | > 3x25 A tm 3x35 A |
|---|---|---|
| **CAPEX grid connection** | € 462,- | € 742,50 |
| **OPEX Connection costs** | € 14,72 | € 29,29 |
| **OPEX Capacity costs** | € 110,40 | € 552,00 |
| **OPEX Standing charge** | € 13,50 | € 13,50 |
| **OPEX System services** | € 3,12 | € 14,99 |
| **OPEX Meter costs** | € 26,98 | € 26,98 |

Table 17. New connection category costs

The connection categories must be defined based on their usage and not on their function. A special category for public charging stations only is therefore not possible. It is possible to add a connection category for connections in the public area with certain kWh per year and set lower CAPEX and/or OPEX prices for this connection. The costs of such a new connection

[9] Total kWh/year of one large consumers is set at 2000 kWh x 200 points = 400.000 kWh/year

category are, however, unknown. This research will assume cost reduction in CAPEX and OPEX grid costs of 25%. Only the meter costs will remain the same, see table 17.

## 3.3. Changes in costs parameters and values

*During the research, more information became known about the costs values. As a result, the costs values used in the mini-scenario differ from the final scenarios. This chapter gives a description of the changed costs as used in the mini-scenarios.*

**OPEX management and maintenance grid costs:** The mini-scenarios assume management costs of €100,-/station/year and maintenance costs of €50,- /point/year, based on 'old' information.

**Extended private grid connection:** The mini-scenarios focus on 11 kW charging points. The household connection of 3x25A is raised to 3x35 for AC1 stations and 3x50 for AC2 stations, to prevent electricity shortage for the household. Raising the connection costs to €131,23 (Liander, 2013), the extra placement costs are set at €1000 per station and the operator pays for discrepancies between the old (3x25) and the new (3x35|3x50) connection.

**Meter device - option 1:** This option was not taken into account in the mini-scenarios.

**Meter device - option 2:** The mini-scenarios do not include hardware reduction costs.

**Large-scale consumer:** In the mini-scenarios it is assumed that 4 stations are connected to one transformation station, consolidating the energy tax and capacity costs, while each paying CAPEX grid costs. During the interviews this options was considered difficult to implement. Most interviews also discussed the option described in paragraph 3.2.5.

**New connection category:** The costs reduction of 25% remained the same.

## 3.4. Conclusion

*Sub question three was answered in this chapter. A summary is given below.*

**3. What are possible costs reduction measures and how can they be established?**

| Measures/parameters | | Values | |
|---|---|---|---|
| Practical measure | | Mini-scenarios | Final scenarios |
| 1 | **Placement cooperation** | Reduction €200/station | Reduction €200/station |
| 2 | **Extended private grid connection** | Costs for 11 kW points | Costs for 3,7 kW points |
| 3 | **Meter - option 1. Change requirements** | Not taken into account | €50,- hardware reduction |
| Law related measures | | Mini-scenarios | Final scenarios |
| **4** | **Meter - option 2. Remove measuring device** | No meter rent | No meter rent |
| **5** | **Large-scale consumer** | Per 4 stations: energy consolidation, tax rebate and OPEX grid connection | Consolidate energy 200 points and 1 tax rebate. |
| **6** | **New connection category** | 25% discount grid costs | 25% discount grid costs |
| Fixed costs | | Mini-scenarios | Final scenarios |
| | **OPEX maintenance operator** | € 100,- station/year | € 400,- station/year |
| | **OPEX management operator** | € 50,- point/year | € 100,- point/year |

# 4. Income measures

*This chapter describes the parameters and values of income measures.*

## 4.1. Income measures

Income is generated by selling electricity to service providers who in turn sell it to users who charge their electric vehicle at a public charging point. Income for the operator can also be generated by receiving discounts on rents, subsidies or a revolving fund. Parties that provide these measures can be the government, banks, DSO and car manufactures.

### 4.1.1. Rent discount

For placement and operation, investments have to be made. A loan with rent can be settled with the bank. The rate is set at 5%. Investments can be stimulated when the rent is discounted. The discounted rent is set at 2% and 0% rent. Inflation is not taken into account. Banks can grant this discount when a guarantee agreement is made with the government.

### 4.1.2. Subsidy

A subsidy can finance the capital expenditures of the operator. These expenditures include the hardware, connection to the grid and placement and instalment of the station. The subsidy can be granted by the government, like the province or municipality, or by external parties like DSO, car- and hardware manufactures. Arguments to invest are stimulating electric mobility or gain insight in the usage. The subsidy is granted during the years of placement. The following values are analysed: 100%, 75%, 50%, 25% and 0% subsidy.

### 4.1.3. Revolving fund

A revolving fund is established by the government or by external investors. The fund finances the capital expenditures during the placement years. The operator repays the investment when all points are placed. This occurs between 2016 and 2020. Rent and inflation of the fund are not taken into account. The fund prevents high debts in the beginning of the project. The following values are analysed: 100%, 75%, 50%, 25% and 0% fund.

### 4.1.4. Energy price

The operator asks a fee from the service provider for the usage of the charging points by the subscribed user. Each service provider pays the same fee to the operator. This fee can be set by the operator or by a public party. These options will be described in chapter 5 *Organisation measures*. The price can be based on transaction, kWh, charging time, parking time and can include a starting rate. This research focuses on charged kWh and/or starting rates. Service providers are free to deviate from these price setters in their subscriptions. To establish a fitting price per kWh and/or starting rate it is assumed that the price must compete with fossil fuels prices and not deviate too much from private charging.

***Compete with home charging.***

To prevent dangerous situations the price of public charging must not differ too much from home charging with a standard socked. At home users pay on average €0,23/kWh inclusive VAT (€0,19 excl. VAT). Costs for the grid connection and tax rebate are not taken into account. To compete with a private charging point the prices are around €0,31 cents including VAT (0,27 excl. VAT)[10]. For home charging, with or without EV socket, the price on average is € 0,27 cents inclusive VAT.

### *Compete with fossil fuels*

For an electric vehicle to compete with fossil fuels the price per km must be lower. Table 18 gives the prices per litre for diesel and gasoline including VAT, the average amount of litre/kWh per km and the price for 13300 km per year. The table reveals that €0,59/kWh results in the same price as the lowest fossil fuel price for 13.300 km/year. This price does not take in account the on average higher costs of electric vehicles compared to conventional cars due to the high battery costs.

| Price setter: €/kWh | | | |
|---|---|---|---|
| | Price/litres[11] | Litres/km[12] | Price 13.300 km[13] |
| **Diesel** | € 1,51 | 0,078 | € 1.570,- |
| **Gasoline** | € 1,82 | 0,091 | € 2.206,- |
| **EV** | € 0,59 | 0,2 kW/km | € 1570,- |
| | € 0,27 | 0,2 kW/km | € 718,- |

Table 18. Compete with fossil fuels

A starting rate would be paid per transaction. Assuming that users charge 10 kWh per transaction and charge 2000 kWh per year, this would result in 200 transactions per year. If the price is only based on a starting rate, then €1,570,-/200 = €7,85 must be paid per transaction. Combining a starting rate with €0,27/kWh results in: (€1,570 - €718)/200 = € 4,26 starting rate. This means that 10 kWh x €0,27 = €2,70 is paid for 10 kWh and €4,26 just to start the transaction. This is considered a too big a difference. A starting rate of € 1,- is considered the maximum amount acceptable for users. The income per point would than rise with € 200,- per year.  For charging 10 kW for €0,27/kWh and €1,- starting rate gives a rise of 37% total costs, while still being 42% cheaper than Diesel.

| Price setter: €/transaction | | | | |
|---|---|---|---|---|
| **Price/ transaction** | kWh/ transaction | kWh/ year | Transaction/ year | Price/ year |
| **€ 7,85** | 10 | 2000 | 200 | € 1.570 |
| **€ 1,00** | 10 | 2000 | 200 | € 200 |
| **€ 0,50** | 10 | 2000 | 200 | € 100 |

Table 19. Starting rate

## 4.2. Conclusion

*Sub question four was answered in this chapter. A summary is given below.*

**4. What are possible income measures and how can they be established?**

| Measures/parameters | Values | | | | |
|---|---|---|---|---|---|
| **Rate** | 5% | 2% | 0% | | |
| **Subsidy** | 100% | 75% | 50% | 25% | 0% |
| **Revolving fund** | 100% | 75% | 50% | 25% | 0% |
| **Energy price** | Min. € 0,27 /kWh | Max. €0,59/kWh | | | |
| **Starting rate** | Min. € 0,- | Max. € 1, - | | | |

[10] Cost private charging point: €500 (hardware) + € 500 (wiring and adjustments to home installation). Yearly use 3000 kWh (15.000 km/year and 0,2 kWh/km). Pay-off time of 4 years = €1000,-/(4 x 3000) = € 0,08/kWh. Total price consumer 0,19 + 0,08 = **€0,27/kWh** excl. VAT, grid costs & tax rebate (EVConsult , 2012).
[11] Based on the average price in the Netherlands on 30/01/2013. (ANWB, 2013)
[12] Based on estimations for the total car fleet in Europe in 2010 (Zachariadis, 2006)
[13] Based on average km in 2010 per vehicle in the Netherlands (CBS, 2012)

## 5. Organisation measures

*There are many options for stakeholders to cooperate in the placement of public charging points. This research focuses on cooperation on station specifications and price setter. The parties involved are the operator and the government*

## 5.1. Organisation measures

### 5.1.1. Specifications

Several aspects define who establishes the specifications of the station. The first aspect is ownership. The point can be owned by the operator or by the government. Since the point is located on municipal grounds special agreements must be made. It is assumed that the municipality will not agree on selling the grounds to the operator. The operator can, however, acquire a 'recht van opstal' by means of a notary deed registered in the Land Register (kadaster). This agreement is set for a certain period. The agreement can only be signed by an alderman of the municipality and often by board members of the operator company. This process takes time and money. Therefore, an agreement is made giving the municipality juridical ownership and the operator economic ownership. This construction is also used in the G4. The specifications are set by one or both owners. Specifications include exterior, safety, technical specifications, exploitation time and exchange of data. The party that has the decisive say on the specifications can be either the government or the operator.

### 5.1.2. Price setter

The price the service provider pays to the operator can be set by the operator or by the government. The price the users pay can be included in this decision. Table 20 shows the general options between the price set by the government or the market. Each option is briefly described, after which the link with the stakeholder cooperation models is given.

| | | Operator -> Service provider | |
|---|---|---|---|
| | | Government | Market |
| Service provider -> User | Government | Complete regulation | Fixed user price |
| | Market | Fixed operator price | Complete market competition |

Table 20. Price setter

***Complete regulation:*** When the government sets the prices incentives for market parties to innovate and optimize their market models are minimized. In return for fixed prices, operators and service providers can claim financial public support. Problems can occur for users from other municipalities with other subscriptions, like paying per minute.

***Fixed user price:*** The government wants to regulate the price to users. The operator is free to establish the price to service providers. Disadvantages are a reduction in the different subscriptions and problems for external users that have other subscriptions. And operators can charge more per kWh than service providers can charge their users, resulting in a loss for service providers. (EVConsult , 2012).

***Fixed operator price:*** The government regulates the operators' price, while the price for users is established by market competition. Advantages are access for all service providers, while all pay the same maximum price. This is comparable to the optical fibre network. Differences in subscriptions are possible. Disadvantages are the lack of competition between operators and operators can claim financial support from the price setter to make their business case viable. Furthermore, the government cannot control the maximum price users pay, but has to depend on market competition between service providers.

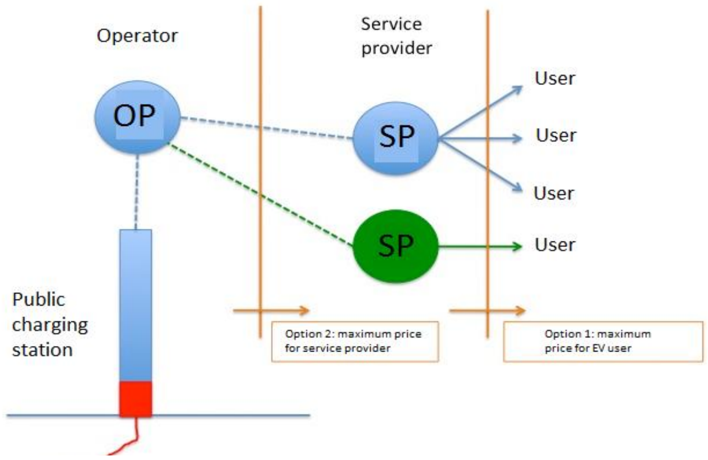


Figure 18. Price set options (EVConsult , 2012)

***Complete market competition:*** Operators and service providers set prices. This model is similar to the eViolin association (eViolin, 2013). Operators must intent to allow service providers and service providers must intent to gain access to charging points by agreements with operators (eViolin, 2013). Market competition leads to the lowest prices for the required quality. A downside is that operators can decide not to open their points to all service providers, reducing the usability of the network. If access to all charging points is of interest to the users, then the market will facilitate this based on market competition (Jansen, 2012).

### 5.1.3. Combination specification and price

Which combination is most appropriate depends on the role the government want to play. It is advisable that the price users pay is set by the market. If the municipality wants to influence the specifications and organise a public tender in which one or two operators are chosen to perform the assignment, than only a fixed price for operators is recommendable. The ministry of ELI and the NMA also advise this option, which is also used by the G4 as their organisation model, where municipalities co-finance the points. If the government wants minimal market interference, than they can choose complete market competition. This however does need an association where all operators and service providers agree to intent to cooperate with each other. The municipality can set specifications. High governmental influence on specifications or the price would result in a concession for 2 or 3 operators. Minimal governmental influence can be described as a licence, open to all operators.

| Stakeholder cooperation | | Price setter | |
| --- | --- | --- | --- |
| | | **Government** | **Operator** |
| **Specifications** | **Government** | Public tender | Concession |
| | **Operator** | Concession | Licence |

Table 21. Stakeholder cooperation

## 5.2. Conclusion

*Sub question five was answered in this chapter. A summary is given below.*

**5. What kind of organisation models can be applied?**

| Parameters | Values | |
| --- | --- | --- |
| **Most influential on specifications** | Government | Operator |
| **Price setter operator-service provider** | Government | Operator |

- The government has juridical ownership of the location and stations
- The price between service provider and user is set by the market

# PART 2

## Scenario planning

## 6. Drivers for change

The drivers for change are the fixed and variable parameters and values described in part 1. Paragraph 3.3 described how some of the parameters changed during the research. The values used in the mini-scenarios and final scenarios are shown in the table below.

| Parameters | Values mini-scenarios<br>Values per configuration | | Values final scenarios<br>Values per configuration | |
|---|---|---|---|---|
| | AC1 (11 kW) | AC2 (11 kW) | AC2 (3,7 kW) | AC2 (11 kW) |
| **SCOPE** | | | | |
| **Connection category** | 3 x 25 A | 3 x 35 A | 3 x 25 A | 3 x 35 A |
| **Amount of kW point\|station** | 11 \| 11 | 11 \| 22 | 3,7 \| 7,4 | 11 \| 22 |
| **kWh per point \| station** | 3000 \| 3000 | 3000 \| 6000 | 2000 \| 4000 | 2000 \| 4000 |
| **Growth kWh per point/year** | 5% | | 5% | |
| **stations placed 2013\|14\|15** | 50 \| 50 \| 100 | 25 \| 25 \| 50 | 23\| 23\| 45 | 2 \| 2 \|5 |
| **FIXED COSTS** | | | | |
| **Price Unit** | 3000 \| 2650 \| 2300 | 4000 \| 3500 \| 3000 | 4000 \| 3500 \| 3000 | 4000 \| 3500 \| 3000 |
| **WIOR, licence and exemption** | €325,- | | €325,- | |
| **CAPEX management operator** | € 7.000,- in 2013\|14\|15 | | € 7.000,- in 2013\|14\|15 | |
| **OPEX management operator** | | | | |
| Maintenance by operator | 100,- per unit | | € 400,- per station | |
| Management by operator | € 50,- per point/year | | € 100,- per point/year | |
| **COSTS MEASURES** | | | | |
| **Price placement old \| new** | € 635 \|€ 500 | | € 635 \|€ 500 | |
| **Meter costs old \| new** | € 26,- \| € 0,- | | € 26,- \| € 0,- | |
| **Discount new connection category** | 25% | | 25% | |
| Costs to change | CAPEX & OPEX | | CAPEX & OPEX | |
| **Stations one large scale consumer** | 4 (4 points) | 4 (8 points) | 100 (200 points) | |
| OPEX change | Capacity & standing | | - | |
| Energy change | Stacked & tax rebate | | Stacked & tax rebate | |
| **Extended private grid connection** | 3x35 | 3x50 | 3x25 | 3x25 |
| Price hardware | - | - | Minus €1000,- | - |
| Costs for connection change | € 131,23 | | € 700 | |
| OPEX | Difference 3x25 \| 3x35 | Difference 3x25 \| 3x50 | € 0,- | |
| **INCOME MEASURES** | | | | |
| **Rates of the loan** | 5% \| 2% \| 0% | | 5% \| 2% \| 0% | |
| **CAPEX subsidy** | 0% \| 25% \| 50% \| 100% | | 0% \| 25% \| 50% \| 100% | |
| **Revolving fund** | 0% \| 25% \| 50% \| 100% | | 0% \| 25% \| 50% \| 100% | |
| **Price** | €0,27 … € 0,59 | | €0,27 … € 0,59 | |
| **Starting rate** | - | | €0,- … € 1,- | |
| **ORGANISATION MEASURES** | | | | |
| **Ownership (specifications)** | Government \|operator | | Government \|operator | |
| **Price setter** | Government \|operator | | Government \|operator | |

Table 22. Parameters and values mini- and final scenarios

# 7. Viable framework

*There are many different combinations possible between the different measures. To reduce the options, a framework is established. This framework will first focus on possible cost measure combinations. Secondly, the chosen cost combinations are combined with income and organisational measures. Rules are established to construct the mini-scenarios.*

## 7.1. Cost measure combinations

Chapter 3 described the cost measures taken into account in the analysis. It is possible to use none, one or several measures into one scenario. To reduce the amount of possible scenarios 6 different combinations of cost measures are chosen. Each combination will be described and given a name.

### Combination 1: Base-case

In this combination, none of the costs measures is included, as is the case in the current situation.

### Combination 2: Small and relatively easy to implement measures

This combination focuses on measures that are most likely to be quickly implemented according to the possibilities the law offers. These measures have minimal financial impact. The combination consists of cooperation in the field of placement and meter costs.

### Combination 3: Multi-sites

This combination focuses on possible changes in the law making it possible for public stations of a single operator to be treated as multi sites, thus allowing the operator to act as large scale consumer. Since the cost measures for placement and the meter costs are relatively easy to implement, these measures will be included in the combination.

### Combination 4: Smart grid opportunities

This combination includes a new grid connection category based on the smart grid possibilities. Similar to combination 3, the cost measures for placement and meter costs will be part of the combination

### Combination 5: Major law changes

This combination assumes changes of the law, allowing the operator to act as a large scale consumer, while the stations are placed in a new grid connection category. Costs for placement and meter costs will also be implemented.

### Combination 6: Operate without DSO involvement

This combination focuses on the extension of the private grid connection. Costs for placement and meter costs are also included.

## 7.2. Rules

Now the cost measure combinations are reduced to six combinations they can be combined with the income and organisational measures. This will be done using a cross-consistency matrix. The matrix is established by removing combinations with contradictions or constraints. These will lead to rules for establishing the mini-scenarios in chapter 8.

### 7.2.1. Measure combinations

The variable parameters and values are shown in the table below. Combining one value from each parameter (measure, results in 5400 possible scenarios.

| Costs measures | | Income measures | | | | Organisation measures | |
|---|---|---|---|---|---|---|---|
| | | Rate | Subsidy | Revolving fund | Energy price | Ownership | Price setter |
| 1 | - | 0% | 0% | 0% | 0,27 | Government | Government |
| 2 |  | 2% | 25% | 25% | 0,35 | Operator | Operator |
| 3 |  | 5% | 50% | 50% | 0,59 | | |
| 4 |  | | 75% | 75% | | | |
| 5 |  | | 100% | 100% | | | |
| 6 |  | | | | | | |

| Variable | Description |
|---|---|
|  | Placement cooperation |
|  | Meter device |
|  | Large scale consumer |
|  | New connection category |
|  | Extended private grid connection |

| | Costs | Income: Rate | Income: Subsidy | Income: Fund | Income: Price | Stakeholder | Total of possible scenarios |
|---|---|---|---|---|---|---|---|
| Nr. Of variables | 6x | 3x | 5x | 5x | 3x | 4= | 5400 |

Table 23. Measures and scenarios

### 7.2.2. Cross-consistency matrix

In order to find the most optimal scenario an analysis is performed using a cross-consistency matrix, see Table 24. In this matrix, combinations of parameters and values that are inconsistent are removed. There are three types of inconsistency involved (Ritchey, 2011): purely logical contradictions, empirical constraints and normative constraints.

The first two types are visualized in a matrix to help develop rules for the framework. On each axe, the parameters and their values are placed. Inconsistent combinations are removed. The following contradictions and rules are established.

#### *Purely logical contradictions*

- The government subsidizes 50% or more and the operator sets the specifications. This is unlikely, because who invests most, will want to have influence.
  - Rule: With ≥ 50% government subsidy, specifications are set by that government.
- The operator repays ≥ 50% of the revolving fund and the government has ownership or sets the price. Unlikely, because the operator will want control to repay the fund.
  - Rule: With ≥ 50% revolving fund, the operator has ownership and/or
  - Rule: With ≥ 50% revolving fund, the operator can set the price
- The government subsidizes and is guarantee for the rate. This is unlikely, as the government will not want to over stimulate the market
  - No rate when subsidies are granted and vice versa

#### *Empirical constraints*

- When the CAPEX are 100% subsidized, a fund of 100% is impossible and vice versa.
  - Rule: Subsidy and revolving fund cannot exceed 100%

### 7.2.3. Rules related to the normative scenarios

It is also possible to implement normative constraints (Ritchey, 2009). These are implemented in a financial analysis using Excel. Per combination of cost measures, other income parameters and values can be appropriate to reach a positive business case. The financial analysis is executed using the Excel function ‘scenario management’.

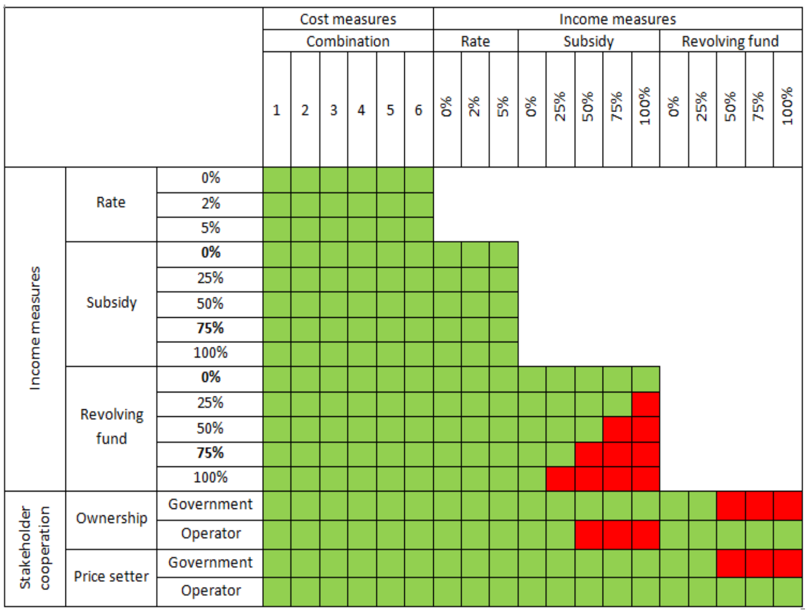



Table 24. Cross-consistency matrix

*Normative constraints*

- The goal of the research is to establish a positive budget for the operator in 2020
  - Rule: Reach a positive business case for the operator in 2020
- The goal of the research is to stimulate the use of electric vehicles
  - Rule: Pursue the lowest price for users, with a minimum price of € 0,27 per kWh
- The scope of the research is set until 2020
  - Rule: The revolving fund must be paid back in 2020
- The research goal is placing 200 points and establish a positive budget in 2020
  - Rule: The configuration with the highest profit for operators is chosen
- The goal is reaching a sustainable businesses case for operators
  - The lowest possible costs for governmental parties
  - Preferable no extreme debts in the time frame till 2020

### 7.2.4. Order of rules

The rules formed by the constraints must be set in a certain order of importance. This will help to distinguish between scenarios that apply to one cost measure combination. The order is based on the goal of the research as stated in chapter 1

- Focus point of scenarios are the cost measure combinations
- 6 scenario’s, each based on a different cost reduction variable combination
  1. Each scenario has one of the cost measure combinations as starting point
  2. The scenario must comply to the cross-consistency matrix rules
  3. A positive business case for the operator must be reached in 2020
  4. The revolving fund must be paid back in 2020.
  5. The lowest price for users of € 0,27 per kWh is pursued
  6. The lowest possible costs for governmental parties
  7. Preferable no extreme debts in the time frame till 2020
  8. The configuration with the highest profit is chosen
  9. When scenarios have too great an overlap one of the values can be changed in order to investigate the influence of the parameters and values.

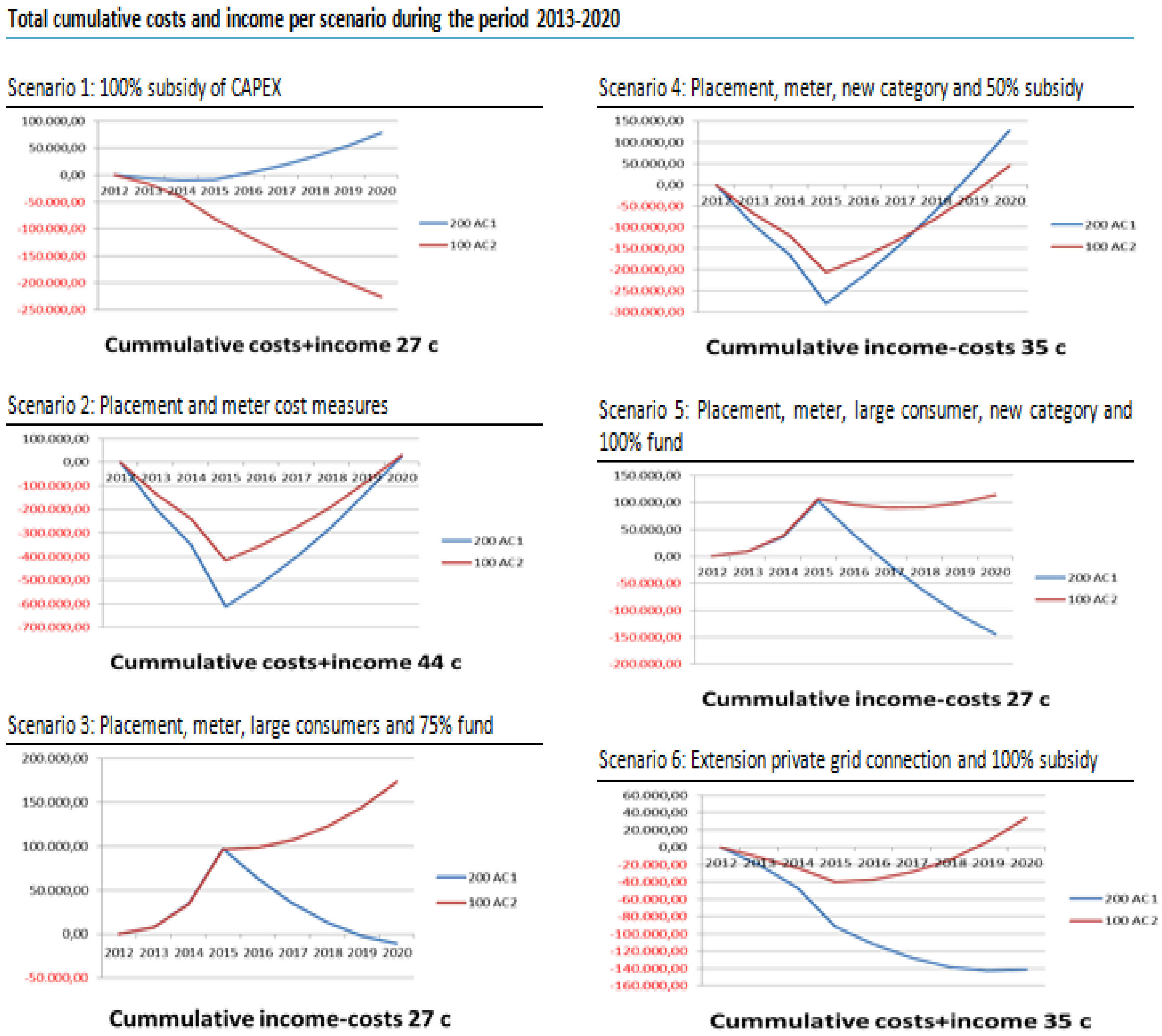
# 8. Mini-scenarios

## 8.1. Construct mini-scenarios

The analysis based on the rules described in the previous chapter results in the following six mini-scenarios

| Mini - scenario Costs measures | | Income measures | | | | Organisation measures | |
|---|---|---|---|---|---|---|---|
| | | Rate | Subsidy | Revolving fund | Energy price | Ownership | Price setter |
| 1 | - | - | + 100% | - | 0,27 | Government | Government |
| 2 | | - | - | - | 0,44 | Operator | Operator |
| 3 | | 5% | - | - 75% | 0,27 | Operator | Government |
| 4 | | - | + 50% | - | 0,35 | Government | Operator |
| 5 | | 5% | - | - 100% | 0,27 | Operator | Operator |
| 6 | | - | + 50% | - | 0,35 | Government | Operator |

Table 25. Overview mini-scenarios




Graph 3. Total cumulative costs and income mini-scenarios

# 9. Final scenarios

*This chapter will first describe the procedure of the interviews held. Secondly, the most important results from the interviews are given. In the third paragraph the final scenarios will be revealed. Values used are based on the interviews and described in part 1.*

## 9.1. Interview analysis

To test the scenarios and used parameters and values qualitative interviews are held with 14 involved stakeholders. A list of the interviewees and the questions asked are given in appendix 4. Questions are asked on:

- Each variable parameter and its values
- The scenarios as a whole
- Some of the fixed variables
- Open space for non-discussed parameters the interviewee believes are of interesting value for the research

The underlying principle for the qualitative interviews is the innovative and fast evolving research field within the market of public charging points. New ideas are constantly generated and opinions constantly changed. Data are therefore quickly out-dated. Qualitative research can respond to these new developments (Folkestad, 2008).

### Process of analysing the interviews

The interviews are analysed in the following manner:

1. Record each interview and make a summary
2. Make a list including the subjects : parameters, values and extra information
3. Order the interview fragments into the list
4. Combine fragments from all interviews regarding one subject
5. Compare the fragments and reach conclusions.

Step 4 can be found in appendix 5, where an extensive comparison of the fragments per subject is given. Paragraph 9.2. includes the most important conclusions.

### Interviewees

The 14 interviewees belong to different organisations, forming an overall picture of the market of public charging points. These include government, operators, distribution system operators, utility companies, service providers and construction companies. Users as a specific group are not taken into account, due to time limitations. The interviewees, whom are also user or potential users, did answer several questions from a users' point of view.

## 9.2. Interview results parameters and values

### Fixed parameters

**KW per point:** The majority of the stakeholders' first priority is to establish a covering charging network of 3,7 kW points. When this is laid, 11 kW points can be placed to fit future needs. Some also believe that locations with multiple users can benefit from 11 kW points.

**KWh per point:** Some stakeholders find 3000 kWh per point realistic, but the majority disagrees and assumes, based on their own calculations, that 2000 kWh per year is more to the point. 3000 kWh is especially high considering that for an AC2 station both points have to deliver 3000 kWh/year.

**Station configuration:** The majority of the stakeholders feel that in rural areas an AC2 point should only be placed when the costs are comparable to those of AC1 points

**Management and maintenance costs:** The management and maintenance costs are considered too low and have to be increased to give a more realistic picture.

### Variable parameters: Cost measures

**Cooperation in placement**: All parties see benefits in cooperation in placement. Collaboration problems may arise with the DSOs, as they have contracts with their own constructers. Municipalities are open for cooperation provided it is based on solid agreements and price benefits can be gained. Negotiations with municipalities are considered time consuming, so guidelines should be formulated.

**Meter device:** All parties favour changes in the meter. Renting costs are not expected to decrease, due to the short payback period. Hardware costs can be lowered by €100. - per station. Removing the meter is possible, but this requires extensive negotiation. DSOs will always desire some sort of control in order to prevent overloads.

**Large-scale consumer:** All parties see benefits in large-scale consumer measures. These measures require a law change and the actors doubt this will happen in the near future.

**New connection category:** Operators are less enthusiastic about changing the connection category, because this is considered a sort of subsidy. A reduction of 25% is considered plausible, but arguments for paying for a lower connection are mentioned too. Reductions mean that other grid connections will become more expensive. Operators and DSOs do prefer a new category that allows more flexibility in capacity tariffs.

**Extended private grid connection:** All parties find the extended private grid connection very interesting. There is doubt on the feasibility, mainly whether user and municipality will accept it and how the parking policy will be shaped.

### Variable parameters: Income measures

**Rate:** None of the actors believes that fixed rates or subsidies generate a sustainable business case, but it is mentioned that reducing rates will stimulate new entrepreneurs.

**Subsidy:** All parties agree that subsidies do not stimulate innovation or establish sustainable long-term business cases. They fear that the market will collapse once subsidies end. Some state that in the current transition phase some form of subsidy is advised. This subsidy should be reduced over the years. The option is mentioned to not subsidise the capital investments, but the kWh charged. This would stimulate innovation, market competition and usage.

**Revolving fund:** All parties prefer a revolving fund to a subsidy. Some argue not setting it on 100%, because the investors take the risk and they could well decide to act as operator themselves. Other parties do not favour a fixed payback, but advocate a percentage of the income, making the fund part of the investors' business case. The fund should be established by public and private parties to reduce risks and raise investments. Municipalities do not always have the necessary funds and need approval of the community. According to the national government, the market should be self-regulating. If contribution is necessary, the government is only willing to contribute in the first years, provided sound cooperation between public and private parties exists. Parties invest to stimulate their own business goals.

**Energy price:** Almost all parties agree that the price should exceed €0,27/kWh in order to get a feasible business case. One option mentions the introduction of a starting rate, similar to that of mobile phone use. All parties agree that the price should be less than that of fossil fuels, but that it could be raised considering EV users are in general financially capable of contributing more and will understand that public use is more expensive than private use.

### Variable parameters: Organisation measures

**Ownership/specifications:** Overall, the actors believe that the major investing party should also set the specifications. Governments are responsible for setting specifications in the fields of safety, exterior and durability. Operators in general prefer making their own specifications to stimulate innovation and market competition. They argue that governments sometimes lack economic view and incentives when setting specifications.

**Price setter:** Some argue prices should be set by the largest investor, while others, mainly operators, believe the market should set them in order to stimulate market competition.

**Cooperation models:** Governments prefer to cooperate with one operator, because this requires the least amount of effort, time and money. Operators prefer market competition between different operators.

**Multiple scenarios:** Several stakeholders mention that different income, costs organisational measures scenarios can co-exists in one municipality. Prices per kWh can differ based on the attractiveness of the locations; subsidies can be given to points with less usage and the municipality can assign an operator to a certain location, while leaving other locations free for the market.

## 9.3. Selection parameters & values

*To select parameters for the final scenarios, the outcome of the interviews is combined in this paragraph with a financial analysis. The values used are described in part 1.*

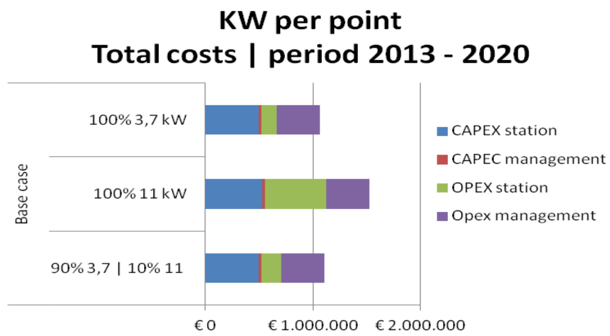
### Fixed parameters:

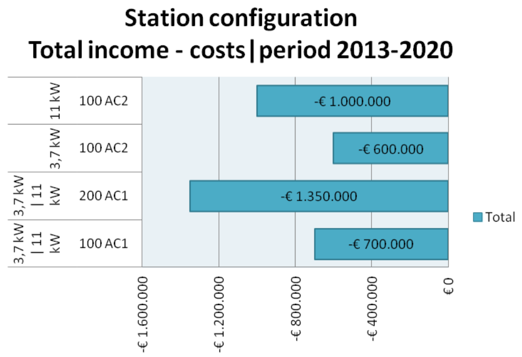
**KW per point:** The majority prefers to first place 3,7 kW points. A financial analysis without cost and income measures reveals in graph 5 that the costs are reduced by 30% if only 3,7 kW points are placed instead of 11 kW points. The difference between 100% 3,7 kW points or 90% 3,7 kW & 10% 11 kW points is around 3%, making this also an interesting business case. It is advised to place 90% 3,7 kW points and 10% 11 kW points.

**KWh per point:** Graph 6 shows that without cost and income measures the required price per kWh to establish a positive business case in 2020 is very dependent on the kWh/year. Especially till 3000 kWh/year. Taking into account this significant dependence, the various opinions and the insecurity about market development, it is advised to calculate with 2000 kWh/year.

**Station configuration:** Graph 4 reveals that placing 100 AC1 points is even more expensive than 100 AC2 3,7 kW points. Although hardware and management of AC2 points are more expensive than for AC1 points, their energy income is much higher. Taken into account the opinion of stakeholders,, it is advised to only place 3,7 kW AC2 points.

**Management and maintenance costs:** The management and maintenance costs must be raised for a realistic image. New information is used to establish the prices, see part 1.




Graph 4. Station configuration | Total income - costs

Graph 5. kW per point | Total costs

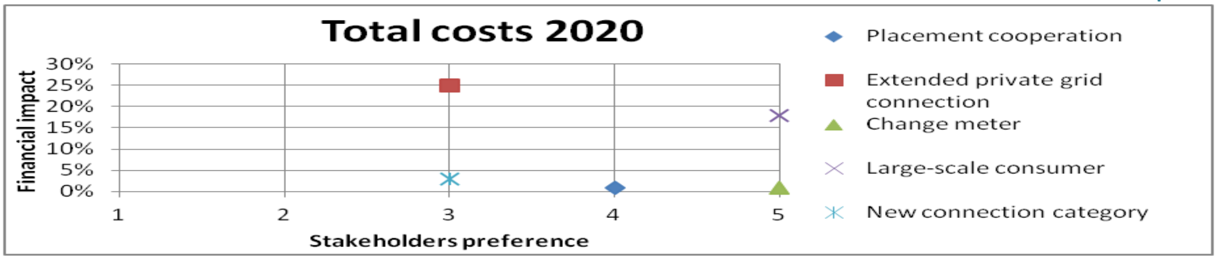

Graph 6. Effect kWh | price | subsidy

### Cost measures: combination interview analysis and financial analysis

Each stakeholder has its own preferences on cost measures to implement. An average of these opinions is used in graph 7, see table 26 for axe values. The preference is combined with the financial impact of the cost measures on the total costs. The costs are assumed for 180 AC2 3,7 kW points & 20 AC2 11 kW points, both with 2000 kWh/point/year.

| X- axe value | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Description** | Absolutely not preferred | Not preferred | Neutral | preferred | Very preferred |

Table 26 . X-axe description



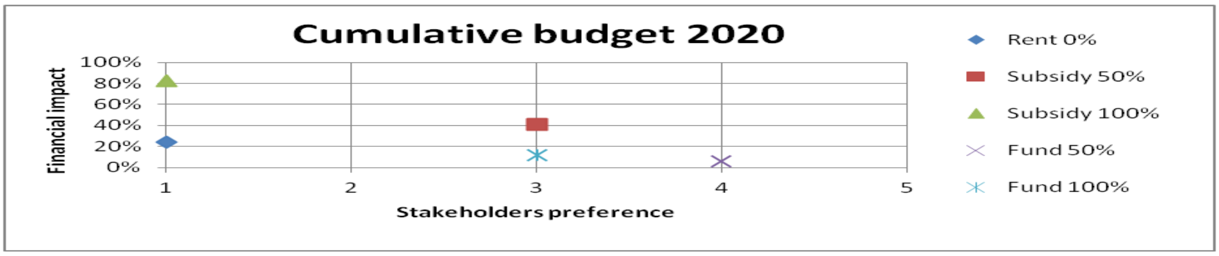

Graph 7. Costs combination financial impact | stakeholders preferences

Extending the private grid connection has most financial impact, but large-scale consumer measure are preferred although having less financial impact. The impact of a new connection category is only 3% of the total budget, but stakeholders mention that implementing this measure could simultaneously result in a new meter device. Placement and meter device are preferred, but their financial impact is minimal. Advise to put most effort in implementing the measures in the following order:

1. Large-scale consumer
2. Extended private grid connection
3. New connection category – simultaneously change the meter
4. Placement cooperation – always with municipality; only with DSO when costs are low

### Income & organisational measures: combination interview analysis and financial analysis

The average preference of stakeholders on different income measures is visualized in graph 8. The financial impact is based on the cumulative budget in 2020 for 180 AC2 3,7 kW points & 20 AC2 11 kW points, both with 2000 kWh/year and an energy price of €0,30/kWh. The base case involves no cost measures and 5% rent on loans.




Graph 8. Income combination financial impact | stakeholders preferences

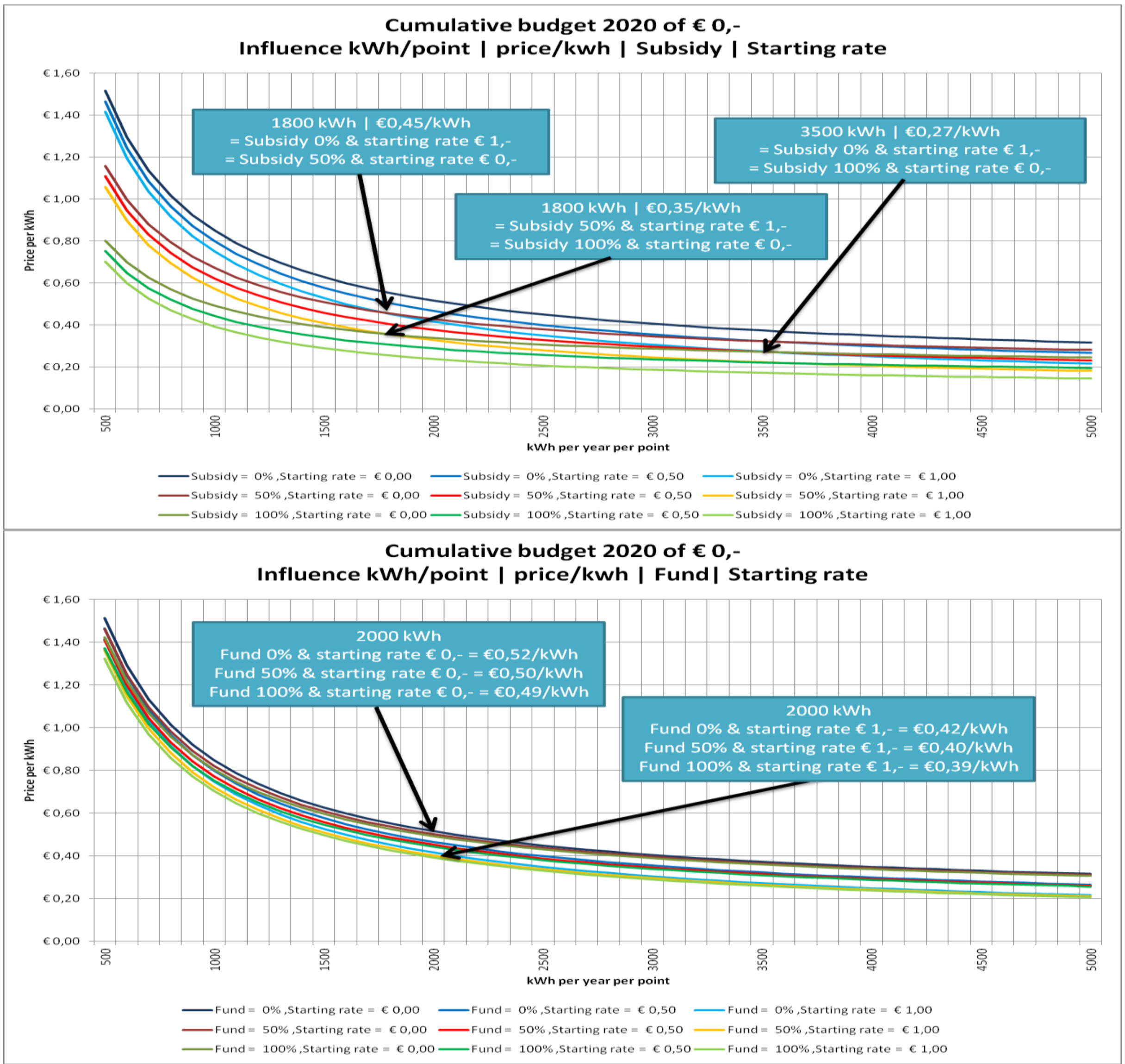
Subsidies and a discount on rent have most financial impact, but are not really preferred. Funds are most preferred by stakeholders. Especially since a fund can lower the maximum debt in the beginning of the project. The final income measures depend on the impact of cost measures and the role of the municipality. Advise:

1. Municipality has most influencer on specifications and price: subsidy
2. Operators have most influence on specification and price: fund
3. Contract duration to recoup investment: Longer period, less subsidy needed

## Influence of kWh/point, price/kWh, subsidy or fund and starting rate

The income measures are interlinked with each other and the kWh/point/year. Graph 9 shows the influence of combining several income measures. The lines represent a business case with a cumulative budget in 2020 of €0,-; the moment the negative budget turns positive. The blocks describe crossings between several values. Main conclusions:

- Usage of the points is most influential on the price until around 1500 kWh/year
- Above 3000 kWh the influence of subsidies and a starting rate reduces
- Above 1800 kWh a 1 euro starting rate is more influential than 50% subsidy
- Above 3500 kWh a 1 euro starting rate is more influential than 100% subsidy
- A starting rate is more influential than the percentage of fund.
- Subsidy is more influential than a fund on the total budget.
- **Examples of prices for certain combinations with 2000 kWh/year**
    - 2000 kWh, no subsidy, no fund and no starting rate = €0,52/kWh
    - 2000 kWh, no subsidy, no fund and 1 euro starting rate = €0,42/kWh
    - 2000 kWh, 100% subsidy and no starting rate = €0,34/kWh
    - 2000 kWh, 100% fund and not starting rate= €0,49/kWh




Graph 9. Cumulative budget 2020 of €0,- | subsidy | fund

## 9.4. Construct final scenarios

The final scenarios are each based on themes. These themes are based on the major aspects revealed by the interviews. The blue highlighted measures used in the related scenarios.

### Government in control: public tender

| AC2 kW / point | Costs measures | Income measures | | | | Organisation measures | |
|---|---|---|---|---|---|---|---|
| | | Rate | Subsidy | fund | Energy price | Ownership | Price setter |
| 3,7 | Placement | 0% | 0% | 0% | 0,27 | Government | Government |
| | Meter | | 25% | 25% | | | |
| | New connection | 2% | 50% | 50% | 0,30 | | |
| 11 | Large user | | 75% | 75% | | Operator | Operator |
| | Extended connection | 5% | 100% | 100 | Starting rate | | |

### User in control: Concession

| AC2 kW / point | Costs measures | Income measures | | | | Organisation measures | |
|---|---|---|---|---|---|---|---|
| | | Rate | Subsidy | fund | Energy price | Ownership | Price setter |
| 3,7 | Placement | 0% | 0% | 0% | 0,27 | Government | Government |
| | Meter | | 25% | 25% | | | |
| | New connection | 2% | 50% | 50% | Free \| 0,40 | | |
| 11 | Large user | | 75% | 75% | | Operator | Operator |
| | Extended connection | 5% | 100% | 100 | Starting rate None\| 1.00 | | |

### Operator in control: Licence

| AC2 kW / point | | Extended connection | | | | | |
|---|---|---|---|---|---|---|---|
| | | Rate | Subsidy | fund | Energy price | Ownership | Price setter |
| 3,7 | Placement | 0% | 0% | 0% | 0,27 | Government | Government |
| | Meter | | 25% | 25% | | | |
| | New connection | 2% | 50% | 50% | 0,40 | | |
| 11 | Large user | | 75% | 75% | | Operator | Operator |
| | Extended connections | 5% | 100% | 100% | Starting rate 1,00 | | |

## 10. Write the scenarios

### 10.1. Government in control: Public tender

The government decides to stimulate electric mobility by changing the energy laws. A group of public charging stations is considered one WOZ for the energy tax, allowing energy consolidation. A new connection category is established, making connections in the public space until 3x35 ampere 25% cheaper in grid costs. Grid costs for connections over 3x35 ampere are raised. The new category enables smart grid usage and flexible pricing. This allows the operator to manage the overall usage of the point with approval of the users. The meter is changed to standards needed for the new connection category. The DSO installs the grid connection, but the placement time of 18 weeks is restricted to 4 weeks. The operator takes over the construction work of the municipality. The municipality organises a public tender, making one operator responsible for all public points until 2020. As a result the new energy law is optimally used. The municipality pays 75% of the CAPEX and sets the maximum price to service providers, preventing monopoly on pricing. The operator can increase profit by smart grid usage. To stimulate users to allow flexible charging, the price to the service provider is €0,30/kWh when flexible charging is allowed and €0,35/kWh when it is not allowed. It is assumed that users always allow smart charging.

### 10.2. User in control: Concession

The extended private grid connection is applied. Users, operators and municipalities cooperate. The stations consist of two 3,7 kW points. One parking place is open for all vehicles. The other place can only be used by electric vehicles and is reserved for the grid connection owner during certain specified hours a day. The house owner owns the station, but the municipality and operator set the specifications. Service providers settle the payments. The municipality allows a maximum of only 3 operators to be active on the market. The operator can agree on personalized specifications with the user depending on smart meter usage or kW per point. The user pays 50% of the hardware, €150,- per year for maintenance and management and no extra energy costs. These amounts are set by the operator. The operator pays all other costs and manages and maintains the point until 2020. Other users pay a price set by the operator. This is assumed at €0,40/kWh and €1,- starting rate. Only one point is used by paying customers.

### 10.3. Operator in control: License

In this scenario, the operator is in control. The law is not changed, but practical cost measures are introduced. The meter is changed by a simple variant more appropriate for public charging points. The operator takes over the installation work of the DSO and construction works of the municipality for furnishing the parking place. The operator creates a profitable business case by introducing a starting rate. At the start, the operator applies for a fund of 75% of the CAPEX. This fund is instigated by a group of public and private investors who all want to stimulate electric mobility. Once the market matures this fund becomes superfluous. No interest has to be paid over the fund. The market is open to all operators that comply with the basic criteria established by the municipality on exterior, durability and safety. Since the location remains property of the municipality, the municipality gives a license for 8 years. Agreements are made that the municipality can remove the point when the operator is guilty of neglected maintenance or unreliable management.

## 11. Identify issues arising

*This chapter identifies issues arising in the final scenarios, based on arguments derived from part 1 and the interviews.*

### 11.1. Issues in implementing the measures per scenario

#### Government in control

Changing the law takes time and money

Grouping stations as one WOZ can be resisted by the Ministry of Justice who a decline in income is feared. The 'Waarderingskamer' makes the final decision, but this takes time. Furthermore, agreement must be reached about what is considered a geographical area. The proposed new connection category is appreciated by the actors, due to DSOs not discriminating and including other functionalities in the public space, like ABRIS. This makes the category more stable and less considered as a subsidy on public charging points. Results of smart grid usage and flexible capacity tariffs are outside the scope of this research.

The DSO must agree with a shorter installation period

In the placement, issues can arise in the shorter installation period for DSO. Although DSO's constructers make the connection and state 18 weeks is too long, they still have to cooperate. With situations mentioned of DSOs changing the plans on short notice or crossing the limit of 18 weeks, shorting the period can become difficult.

Subsidies do not stimulate innovation and market competition

None of the actors prefers a subsidy, but there is agreement that those who invest should also set the specifications. Since the municipality chooses one operator to execute an assignment with set specification and price, the municipality has to subsidise. Establishing the price is needed to prevent a monopoly abuse of the operator. To stimulate innovation and market competition the contract period can be shortened. This enables anticipation on new market developments and innovations. Since the points belong to the municipality, it can reduce the contract period. Important is that the operator recoups its investment.

Government must be able to give the subsidy

Not all governmental parties are able or willing to subsidise. Without subsidies, the price per kWh is raised to get a positive business case for the operator.

#### User in control

Municipality must allow construction and the new parking policy

Municipalities are reluctant in allowing public construction works and objects. Furthermore, one of the most important issues in a municipality is its parking policy. Adapting this takes time and effort. Municipalities can cooperate in setting specifications and guidelines. By giving a concession to a maximum of three parties, communication and control can improve. When operators break the rules, the concession ends.

Users must be willing to invest

Considering that the house owners would otherwise pay for the hardware and maintenance of a private charging point, these costs are acceptable. Especially with exclusive parking included.

The operators must be willing to invest when the main users do not pay energy costs.
This can be solved by placing AC2 points. Agreements on parking policy are vital, enabling other electric vehicles to use the points. The contract period with the municipality and house owners must enable the operator to recoup investments. When the user moves before an agreed date, it can be arranged that the user co-finance the removal.

Issues between users and operators in case of undesirable behaviour
There is a risk that the operator does not maintain the point properly, withholding the user from using it. Or that the user prevents other users to use the point. These situations can be solved if the municipality acts as supervisor. Agreements must be reached on management, maintenance and usage. If agreements are broken, the municipality intervenes and the point is removed at the offenders' expense.

### Operator in control

The DSOs must agree with new meter specifications
All the DSOs must accept the new criteria. This takes time. The DSOs also want to change the meter. By complying with international standards, the market is extended, thereby reducing costs and increasing income.

The DSO and municipalities must allow the operator to take over the installation/placement
The DSO must change contracts with its own constructers. This can be difficult. Problems are also foreseen in communication with the municipality, since they have to deal with many operators. The municipality must formulate construction procedures.

Public and private parties must be willing to invest in the fund
All actors consider the fund interesting, but risk-full. Risks are reduced, when the fund owns the points until repayment. Investors must find public charging stimulating for their own business case, like electric vehicles vendors. Not all actors advocate this form of funding. Some want to have a share in the points and receive a percentage of the income.

Users must be willing to pay 40 cents/kWh and a starting rate of 1 euro per transaction
The energy price and starting rate can be considered too high. Actors, however, believe that users will find higher prices acceptable, because they understand that public services are more expensive than private services. If this turns out not to be the case, than the government can decide to subsidise the point or the users per charged kWh.

The municipality must be willing to give licenses
Municipalities want to set specifications on exterior, safety, durability and location of the points. With more freedom to the market, market competition is stimulated, increasing innovation and choices for users. The market can become too differentiated, as it is unclear what operators do and stand for. The municipality must intervene when an operator neglects the maintenance or is accused of unreliable management.

Operators refuse to place points on locations with low usage and without exclusivity
This is a fear mentioned by some operators, while others believe one frequent user can already be profitable. A solution is the municipality obligating operators to cooperate. To prevent too much competition, rules can be set on minimal distance between points.

## 11.2. Financial analysis

*For each scenario, the influence of the costs and income measures will be described.*

### Influence costs measures

The table below reveals that scenario 'User in control' has most influence on the total costs in the period 2013-2020. The reduction is established by the following measures:

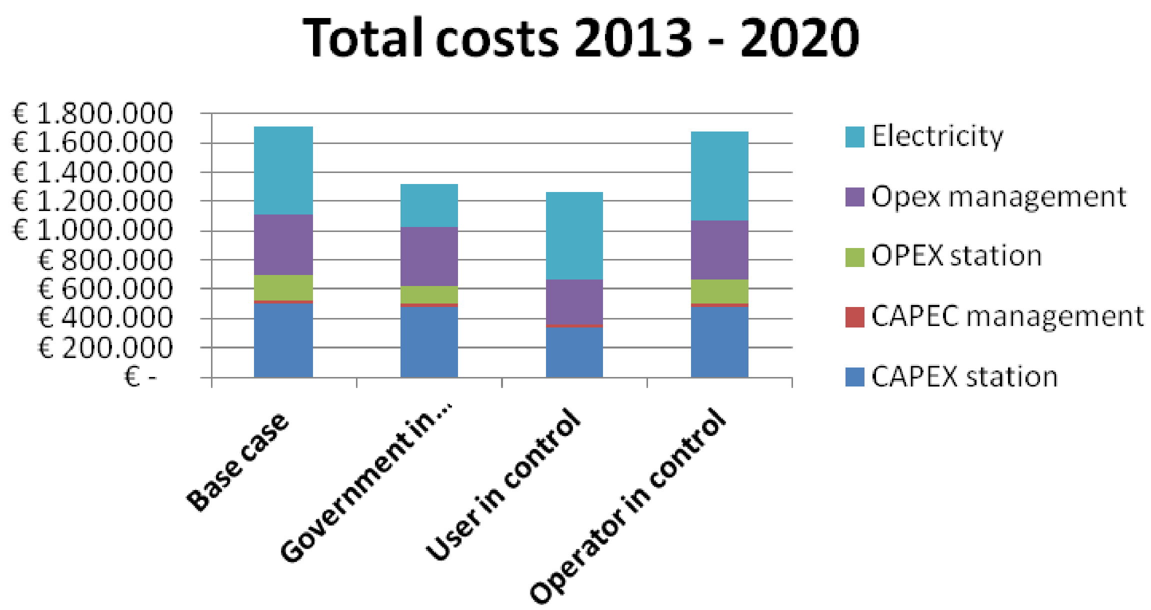
- No capital and operational grid costs
- A reduction of €150,- management & maintenance costs per station/year
- A reduction of €1000,- per station due to simplified hardware
- 100% AC2 3,7 kW stations instead of 90% AC2 3,7 kW and 10% AC2 11 kW stations

The scenario 'Government in control' creates almost the same significant cost reduction as 'User in control'. The reductions are now established by the following measures:

- The electricity tax is consolidated for all points, reducing the costs per kWh/year
- The grid connection costs are reduced with 25% due to a new connection category
- The meter and placement costs are reduced

For the scenario 'Operator in control' the cost difference is lowest compared to the base case. This reveals that if the law is not changed and only the practical measures of meter costs and placement cooperation are implemented, the profits are minimal.

Furthermore, the base case reveals that the hardware and electricity have most influence on the costs. Paragraph 11.3 Sensitivity analysis will analyse the impact of changing the kW and configurations of the stations.



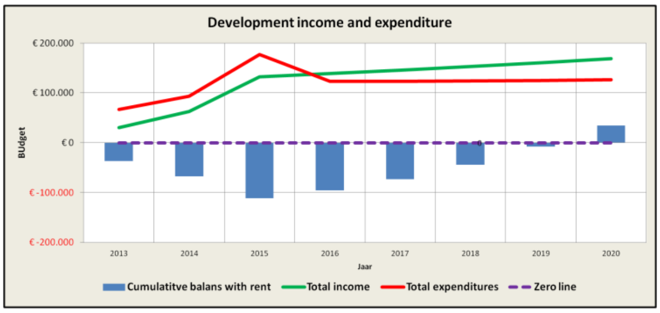

Graph 10. Total costs 2013 - 2020 final scenarios

## Influence income measures

The impact of the income measures is related to the costs per scenario. Therefore, the income, expenditures and cumulative budget per scenario are analysed.

<u>Government in control</u>

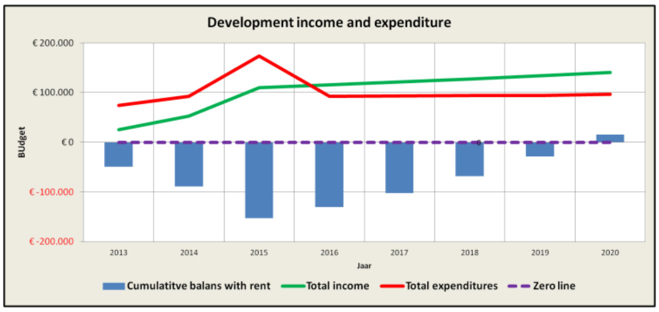
To cover the cost a subsidy of 75% is granted and the energy price is set at €0,30/kWh. Despite the subsidy on capital expenditures, until the end of 2015 the costs will still exceed the income. The difference is never higher then € 50.000 per year and the highest debt is reached in 2015 at around €100.000,-




**Graph 11. Scenario government in control | income, expenditures, cumulative budget**

<u>User in control</u>

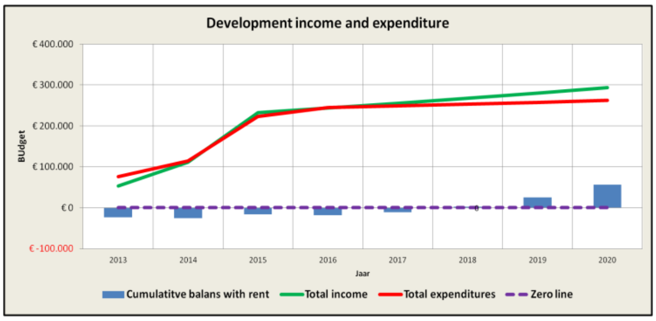
The owner pays 50% of the capital expenditures, while not paying extra for the energy charged. The operator can only gain income by charging other users. It is assumed that only 1 point will be used by other users for 2000 kWh per year. These users pay €0,40/kWh and a starting rate of 1 euro. Compared to the scenario 'Government in control' 25% less subsidy is received. As a result the highest debt is doubled to reach nearly €200.000,-.




**Graph 12. Scenario user in control | income, expenditures, cumulative budget**

<u>Operator in control</u>

Due to the fund of 75% significant debts are prevented. At the start of the payback period the income and expenditures are nearly the same. The graph also reveals that the income of this scenario is almost twice as high as that in the other scenarios. This is due to the fact that the starting rate applies to both points. Not visualized in this table is the period after 2020, when the fund is repaid. The cumulative budget will steeply rise after this date. A fund has two main benefits for the operator:




**Graph 13. Scenario operator in control | income, expenditures, cumulative budget**

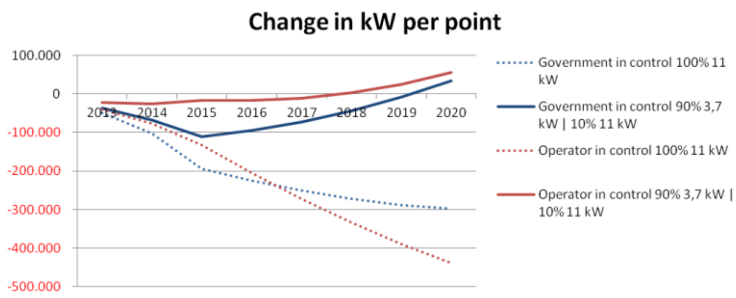
- The operator has more financial independence compared to receiving a subsidy, while his influence on specifications and price increases.
- The debts are spread over 8 years, minimizing high debts in the beginning.

## 11.3. Sensitivity analysis

*The interviews revealed that opinions differ on kW per point, kWh per year, configuration of the stations and the management and maintenance costs. This paragraph will analyse the influence of these 'fixed' parameters on the scenarios in a sensitivity analysis.*

### KW per point

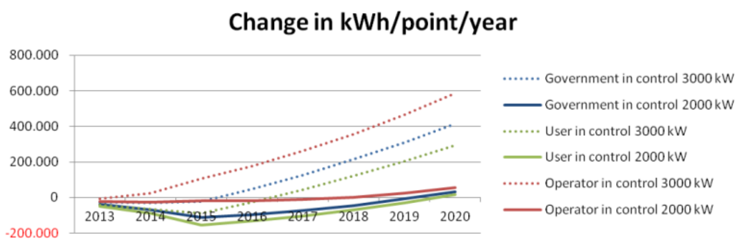
For scenarios Government in control and Operator in control it is possible to place 11 kW as well as 3,7 kW AC2 points. Reducing the amount of 11 kW points from 100% to 10% has significant influence on the cumulative budget in 2020. The reason for the decline in budget with 100% 11 kW points are the higher grid costs.




Graph 14. Sensitivity analysis kW per point

### KWh per year

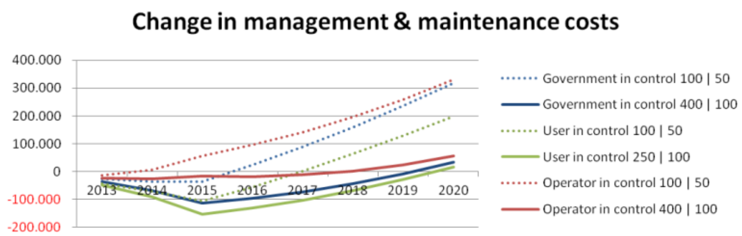
In the mini-scenarios, the kWh per year per point was set at 3000. In the final scenarios, 2000 kWh/year/point is used. The cumulative budget steeply rises when the kWh is set to 3000 kWh per year.




Graph 15. Sensitivity analysis kWh per year

### Management and maintenance costs

In the mini-scenarios the maintenance costs were set at €100,- per point and the management costs at €50,- per station. These values are changed in the final scenarios to maintenance costs of €400,- per point and management costs of €100,- per point. For the scenario User in control these costs are €150,- lower per year, due to contribution from the house owner. The cumulative budget steeply rises for all scenarios when the costs are lowered.




Graph 16. Sensitivity analysis management and maintenance costs

## 11.4. Conclusion

It can be concluded that all parameters are dependent and interlinked with each other. Table 27 combines the scenarios on qualitative and financial aspects.

| Level of | Comparison final scenarios | | |
|---|---|---|---|
| | Government in control | User in control | Operator in control |
| Stimulating electric mobility | 1 | 1 | 0 |
| Stimulating innovation | -1 | 0 | 1 |
| Ease of costs measure implementation | -1 | -1 | 0 |
| Ease of income measure implementation | -1 | 0 | -1 |
| Ease of organisation implementation | 0 | -1 | -1 |
| Certainty involved parties | 1 | 0 | -1 |
| Financial debt | 1 | 0 | 1 |
| Public investment | -1 | 1 | 0 |
| Expected long-term revenue | 0 | 0 | 1 |
| **TOTAL** | **-1** | **0** | **0** |

Table 27. Comparison final scenarios

It can be concluded that each scenario has its own benefits and downsides. Choosing one optimal scenario is not possible. In table 27 the aspects are considered equally important in establishing a total value. In reality, some stakeholders value different aspect over others.

Since the points are placed on municipal grounds and subsidies are not expected to come from the national government, the municipality is the most important actor on deciding which scenario to be executed in their municipality. Their choice depends on two aspects:
- The level of control they wish to have on ownership, specifications and price
- Their willingness and capability to invest in public charging points

If a municipality want to have a high level of control and invest in points, then 'Government in control in most appropriate'. This research is based on semi-large municipalities that often lack the funds to invest. If they want the operators to contribute a large share, then operators will want to gain more freedom in specifications and price. Both scenarios 'User in control' as 'Operator in control' are appropriate for this case.

A combination of all three scenarios would be the most optimal scenario for a municipality without funds to subsidise. The costs measures from 'Government in control' and 'User in control' can be aspired. The subsidy from 'Government in control' and the fund from 'Operator in control' can be implemented for points with low expected usage, in order to give all inhabitants the possibility to apply for a public charging point. The organisational measures from all three scenarios can be combined; letting the municipality set main specifications and the operator the technical specifications and price. With more investments required from the operator, a starting rate is advised. Allowing different business cases and scenarios in one municipality, stimulates innovation and gives more freedom to involved parties to focus on their preferred business case.

# PART 3

## Conclusions & Recommendations

## 12. Conclusions and recommendations

*This chapter will present the general conclusion, answering the main research question:*
*"What is the most optimal combination of costs, finance and organisation measures that stimulate the placement of public charging points, in the benefit of electric vehicle users?"*

Knowledge gained by literature, discussions and interviews led to an overall image of the possibilities to establish a feasible business case for public charging points. The research and analysis revealed that at this moment, not all public points are profitable to operate, but by combining certain measures, a positive business case can be established. Opinions of stakeholders on which kind of costs-, income- and organisational measures will lead to the optimal business case, differ. The scenario planning, financial analysis and sensitivity analysis showed that the measures are profoundly interlinked and must be seen as part of a whole.

Overall, the research reveals that small differences in parameters significantly influence the budget of the business case. Changes in for instance the usage per point from 2000 to 3000 kWh per year, makes essentially unprofitable scenarios very profitable. Predictions on these parameters are uncertain, due to the dynamic developments in the field of electric mobility. As a result, business cases implemented during this period of development and innovation are linked with high risks, but also with interesting opportunities worth investing in.

Due to the many different correlations between aspects involved in establishing a positive and sustainable business case for operators in 2020, several combinations of measures to stimulate the placement of public charging points are possible. Depending on the cost measures implemented, the three final scenarios revealed which income and organisational measures are required to establish a positive budget for the operator. By analysing these scenarios, it was concluded that a combination of the scenarios complies with the preferences of most stakeholders, see paragraph 11.4. By combining the different scenarios, it is possible to place and operate points with limited public financial help. This is especially interesting for semi-large municipalities without financial budget. The market is made commercial and users are expected to contribute by higher prices per kWh and a starting rate. To operate commercially the municipality must set rules operators must oblige to. The optimal combination of costs-, income- and organisational measures is dependent of the public investments, usage and progress in implementing costs measures. For these reason it is advised to allow several business cased in one municipality. The municipality can subsidize points with low usage, while allowing the market to set the price. This price will decline ones more costs measures are implemented. Figures from paragraph 9.3 are used to show the financial impact and stakeholders' preference on the costs and income measures.

## Main conclusions

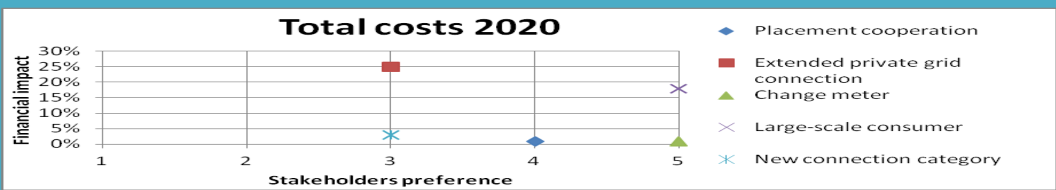
- Put main focus on private and semi-public charging
- Only place stations with two points of 3,7 kW
  - Only on request by users & locate at the nearest street corner
- Allow several business cases in one municipality
  - **Operator in control**
    - High usage locations without public investments
    - Minimal usage each point: 2000 kWh/year
  - **Government in control**
    - Low usage locations with 25% public subsidy
    - Minimum usage each point: 1500 kWh/year
  - **User in control**
    - Extended private grid connection
    - House owner pays 50% point | € 150,- a year| no energy costs
    - semi-exclusive parking place
    - Minimal usage second point: 1000 kWh/year

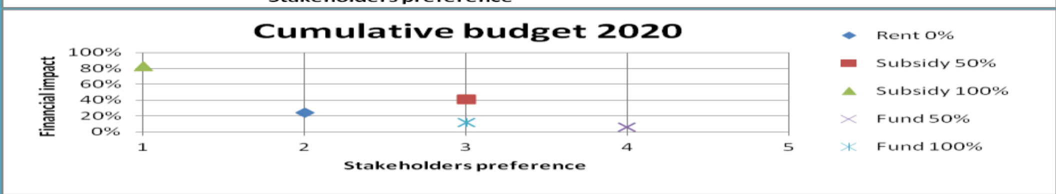
- Operators set the price and implement a starting rate
- Without cost measures the price required is: **€0,40/kWh & € 1,- starting rate**

- With cost measures the price drops to €0,30/kWh & €1,- starting rate
  - Focus on treating stations as one large-scale consumer
  - Change connection category allowing flexible capacity rates
    - Reduce grid costs for public connections under 3x35 Ampere
    - Simultaneously change the meter device, no sooner.

- Shorten municipal procedure for licences & parking policy to maximum 4 weeks
- Shorten installation period for distribution system operator to maximum 4 weeks
- Municipality sets basis specifications: exterior, safety, interoperability & location

- If the municipality has the financial means: subsidise points with low usage
  - Otherwise: optimise procedures and allow market initiatives



## 13. Personal recommendations

*Besides the conclusions and recommendations from the research itself, I personally have some recommendations to stimulate the placement of public charging points.*

### Open the market to all operators complying to set specifications

Due to the dynamic market developments, I recommend not giving an exclusive contract to a set number of operators for a specified period. Opening the market enables new initiatives. This positively influences market competition and innovation. Furthermore, I advice a minimal distance between two points, reducing the risks attached to competition. The municipality should set specification as mentions in chapter 12. These can be extended with minimal limits to interoperability, management and maintenance.

### Municipality sets maximum price per kWh and starting rate. Operator can lower the price.

To make the market self-sustaining I advise to let the operator set the price. This model enables fair competition with semi-public points outside the municipal scope. To prevent price increases for users who are dependent on public points, the municipality can decide to set a maximum price of €0,40/kWh and € 1,- starting rate.

### Focus more on private and semi-public charging points

I agree with some operators, to put more emphasis on private and semi-public points. They cost less and do not need municipality interference. Furthermore, most users drive a hybrid electric vehicle, reducing the need for acutely charging and vehicles can charge during the day at work locations. This optimizes smart grid usage with decentralized energy production. In my opinion, electric vehicles must be considered part of a bigger electricity transition network, fulfilling a vital role in future smart grid applications.

## 14. Discussion and future research

With yet no procedures for points placed outside het G4, discussions still involve all major stakeholders. It is of importance to reach consensus soon, because otherwise it will negatively affect the image users have of electric mobility. In the current economic situation, I do not expect smaller municipalities to take over the procedure of a public tender used in the G4. Municipalities simply lack the required finance. Operators, however, are willing to take the financial risk, provided municipalities fasten their procedures for placing objects in the public space. If municipalities set the specifications and maximize prices, I believe a sustainable market can be develop and expanded without public investments. Municipalities should provide the framework and let the market fill in the rest.

Future research should focus on the specific specifications set by municipalities, the interaction between operators and service providers, the behaviour of users in case of more differentiation between market models and the optimal division between AC- and DC charging points, which in my opinion are complementary to each other. It is also interesting to investigate some other measures mentioned by the interviewees. These measure were outside of this research' scope, including subsidising the usage instead of the points; reduce the subsidies through the years; or implement an energy tax per charged kWh.

I am looking forward to the dynamic period ahead. I am convinced that by taking the initiative now, electric mobility and charging at public points will in 2020 be part of the standard street scene in Dutch municipalities and beyond.


Figure 19. Public charging point Amsterdam (Bontenbal, 2011)

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# Appendixes

- Appendix 1: Desk research, conferences and meetings
- Appendix 2: Cost measures
- Appendix 3: General morphological analysis
- Appendix 4: Scenario planning
- Appendix 5: Excel model
- Appendix 6: Interviewees and interview information
- Appendix 7: Interview analysis

## Appendix 1: Desk research, conferences and meetings

**Literature**

Literature from sources found in the Bibliography

**College TU Delft**

Participated as expert on electric mobility for the master course SPM413 'Designing in multi-actor systems from an actor perspective'. This course is part of the master 'System Engineer, Policy Analysis & Management' provided by the Technical University of Delft. Participated on two occasions: 5th of October 2012 and the 16th of November 2012.
Module manager: dr. Ir. Bauke Steenhuisen

**Smart grid game**

Participant smart grid game organised by Netbeheer Nederland on September 4th 2012.
The Smart Grid Game is a physical role play in which the players on the basis of a concrete example challenges smart grid usage on economic and social level.

**Ecomobiel**

Visited the Ecomobiel fair on the 9th of October and 10th of October 2012 in Rotterdam.

**European Electric Vehicle Congress (EEVC), Brussels**

Participated in the European Electric Vehicle Congress (EEVC) between 20th and 22th of November 2012 in Brussels. This international congress was attended by 393 delegates from 43 countries. The congress is a global platform to foster exchange of views between the R&D actors, the industry, the authorities, the end-users and the NGO's in the field of eMobility.

**Ronde tafel gesprek Noord-Brabant**

Participant brainstorm session on the financing and organisation of public charging points in the Province of Noord-Brabant. The session was organised by the Province of Noord-Brabant on the 19th of December 2012 in Den Bosch. Around 20 delegates from government, grid companies, operators and car manufactures participated.

## Appendix 2: Cost measures

To limit the scope of the research only a selection of costs measures are taken into research. This appendix gives a description of other measures interesting for future investigation. The measures are based on cross-cultural, cross-functional, cross-sectoral and other ideas currently being investigated in the field of electric mobility.

### Cross-cultural

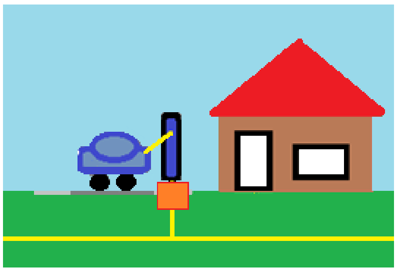
All over the world investigations are held on public charging infrastructure. Some countries subsidise charging points, while others subsidise electric vehicles or give incentives like free parking and using the bus lane (Norsk Elbilforening, 2012). Most countries distinct operators and service providers. One exception is Ireland, which has only one DSO, which is the main operator of Ireland, installing nationwide private and public charging points and fast charge points (ESB, 2012). Cost reduction investigated in other countries is similar to experiments performed in the Netherlands (ECN, 2012).

### Cross-functional

**One station with multiple technical functionalities:** Charging stations can be combined with other object in the public spaces, like parking meters, phone boots and lanterns. By combining them, only one grid connection is needed

**Commercial ads:** Cost can be generated by allowing advertisements on the stations. Currently it is possible to design a charging station with a personalized logo. An option is commercially selling the advertisement space.

**Solar panel:** By combining a charging station with a solar panel less energy need to be bought. The initial costs are however high. It could be possible to not connect the station to the grid and fully depend on the solar panel.



### 7.3. Cross-sectoral

**Optical fiber grid | putkast**

A cross-sectoral example of connecting different operators to the same grid is the optical fiber grid (glasvezel). About 90% of all connections is owned by KPN through a joint venture with Reggefiber. A connection is established and the house owner subscribes at a service provider who activates the connection. Service providers differ in subscription. If the subscription is ended, the physical connection remains, lowering the costs and risk for service providers. For public charging a regulated party can establish a fixed connection box. Operators can then place a temporally charging station on this connection. The operator pays rent and operational cost to the regulated party that owns the connection and box. With no station connected, the connection is set on hold. Especially in new build neighbourhoods easy to implement, although they often have enough private parking places.

**Multiple configurations**

This solution was discussed in chapter 3. It was decided to not focus on other configurations.

## Appendix 3: General morphological analysis

Around 1967 Fritz Zwicky developed the method (General) Morphological Analysis (GMA) exploring all the possible solutions to a multi-dimensional, non-quantified problem complex (Ritchey, 2011). Since this time GMA has been extended and computerised.

Ritchey (Ritchey, 2009), described that analysing "compels policy fields and developing future scenarios presents us with a number of difficult methodological problems". These problems include first that involved factors are not all quantifiable, due to strong social-political dimensions and conscious self-reference among sectors. Secondly, the uncertainties related to the problem complexes are in principle non-reducible and in most cased cannot be fully described. Thirdly, there seldom are adequate descriptions of the process from the initial problem definition to the solutions. These factors lead to relative uselessness of quantitative models or scientific control over the results from scenario development.

An alternative to the quantitative methods is a non-quantified modelling 'relying on judgemental processes and internal consistency, rather than causality' (Ritchey, 2009).
By synthesise sets of non-quantified conditions into well-defined relationships or configurations there is no fundamental difference between quantified and non-quantified modelling (Ritchey, 2009).

The GMA begins with identifying and defining the most important issues, or parameters of the problem and assigning to each parameter a range of relevant values. An advantage of GMA is that 'there are no formal constraints to mixing and comparing such different types of issues'. To get to the bottom of the policy problem all relevant parameters must be treated together (Ritchey, 2011).

**Fixed and variable parameters**

Part 1 of the research will identity and define the most important parameters related to placing and operating public charging points and assigning to each parameter a range of relevant values. Since there are many different parameters involved, several parameters will have a fixed value during the research. Other parameters will have variance in values. These parameters are divided in cost-, income- and organisation measures. This division is made based on most discussed measures in the market.

## Appendix 4: Scenario planning

**What are scenarios?**

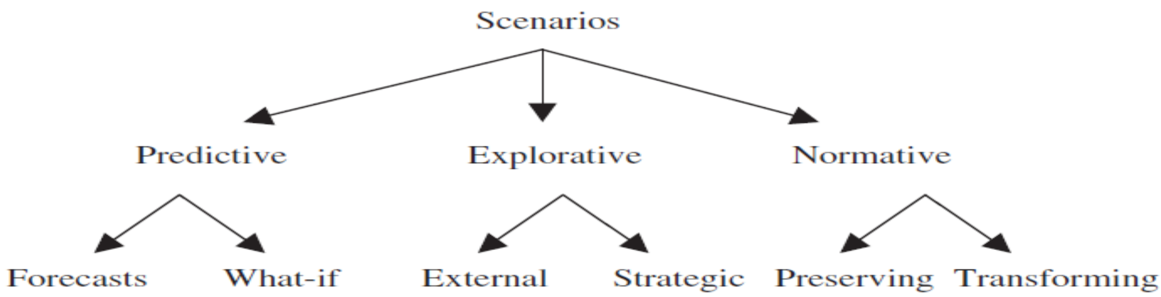
There a several options to analyse the future state of the world. Some people try to predict the future state of the world based on statistical numbers. Another option is to use scenarios. In scenarios different plausible condition and different assumptions are used to sketch possible future states of the world. Not every possibility is equal likely to happen but every option is taken into account. The Intergovernmental Panel on Climate Change (IPCC) uses the following definition:

(IPCC, 2008): *''A scenario is a coherent, internally consistent and plausible description of a possible future state of the world. It is not a forecast; rather, each scenario is one alternative image of how the future can unfold.''*

As they say, a scenario is not a prediction of the future instead a scenario give possible options about how the future can unfold and also what kind of roads can be taken to come to an alternative future. In this way scenarios can be used for planning over long time horizons but also it can help in the decision making on the short term because short term decisions can have consequences for the long-term. Here the scenarios can widen the perspectives and also it can lighten some key issues that otherwise could be missed.

### Scenario categories and types

Various typologies have been suggested throughout the years to describe scenarios, without consensus being reached on scenario typologies (Borjeson, Hojer, Dreborg, Ekvall, & Finnveden, 2006). Borjeson et al established a typology of scenarios in which they distinguish between predictive "What will happen?", explorative "What can happen?", and normative "How can a specific target be reached' scenarios categories. Each category has two types, see figure below (Borjeson, Hojer, Dreborg, Ekvall, & Finnveden, 2006).




To reach the objective of the research "To develop a scenario that brings operators in the position to develop a long-term viable business case with a positive budget in 2020 for the placement of public charging points that will stimulate electric mobility" the scenarios are constructed to reach the target of a positive budget in 2020. For this reason the scenario category used will be normative.

Normative scenarios have an explicit starting point and focus on certain future situations or objectives and how these could be realised. Differentiation can be made between two types distinguished by how the system structure is treated. In preserving scenarios, adjustments are made to the current situation and this structure is continued till the target is reached. In transforming scenarios, such as back casting, marginal adjustments of current development

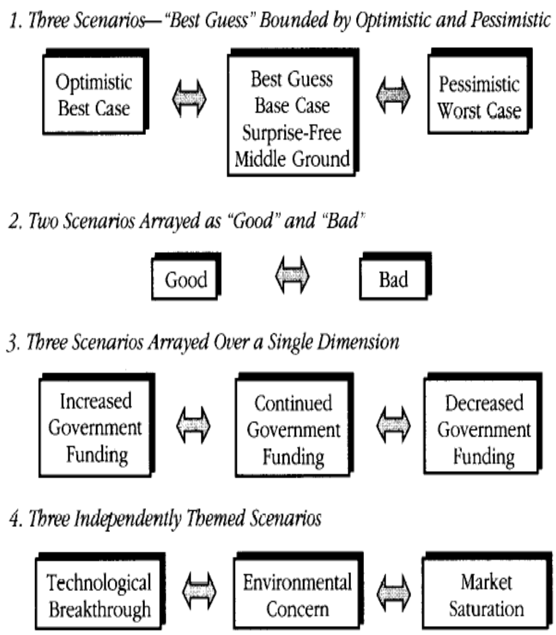
are not sufficient and trend breaks are necessary to reach the target. The system structure can change on several aspects during the time frame.
One of the boundaries set in this research is that all measures will become in effect in 2013 and continue till 2020. Regardless of the measures, each scenario will follow one linear structure until 2020. For this reason the scenario type preserving is chosen.

The task in normative preserving scenarios is to find out how a certain target can be efficiently met. Often this means how quantitatively cost-efficiency can be met (Borjeson, Hojer, Dreborg, Ekvall, & Finnveden, 2006). Efficiency can however also be reached in a more qualitative way, where the scenarios are not optimising in a mathematical sense, but in merely 'satisfying' sense. In this research the scenarios will be optimized both quantitative as qualitative. The combinations between measures will be establish using financial quantitative calculations to reach a positive balance in 2020 and qualitative judgement to assert if certain measures can indeed be combined when used in practice.

Another aspect of normative preserving scenarios is the focus on internal and external factors. Internal factors are controllable by the actors in question and external factors are out of the scope of influence of the actors. The internal factors of this research are the implementation of the measures. External factors are for instance the usage of the points.

## Scenario themes

Scenarios can be based on a certain generic theme. Depending on the theme the number of possible scenarios can be set. There is much debate on this number, with some experts claiming a maximum of two scenarios, while others think 4 or 5 scenarios are also acceptable (Schnaars & Ziamou, 2001). The reason for keeping the amount of scenarios low is that research revealed that manager who implement the scenarios only cope effectively with a maximum of three versions (Mercer, 1995). The four most popular generic themes used in for scenarios are shown in figure to the right (Schnaars & Ziamou, 2001). The scenarios to be developed for this research focus on specific combinations of several dimensions/parameters. The scenarios are therefore so different from each other, that they each have their own theme.




**Scenario planning approach**

There are all kinds of methods and techniques for developing scenarios (Wulf, Meissner, & Stubner, 2010). This research will mainly focus on the scenario planning steps developed by Mercer (Mercer, 1995). Mercer based his approach on the scenario planning methodology developed by Shell, but reshaped it on the basis of practical experience with 1000 students writing more than 4000 scenarios. His approach should "allow a wider range of organizations to gain the very valuable benefits offered by the technique." (Mercer, 1995) His approach will be used as the basis for the scenario planning. A cross-impact matrix from the general morphological analysis, an method almost mandatory in scenario planning methods of earlier times (Mercer, 1995), will help defining the parameters and values for the scenarios. First a short description of the steps and elements is given, after which each step is executed in separate research sections.

Step 1. Decide drivers for change

*MERCER: The results from the environmental analysis are examined, to determine the most important factors that will decide the nature of the future environment within which the organization operates* (Mercer, 1995)

This step is linked to the first part of the report in which the first phase of GMA was used to determine the most important parameters and conditions/values in the field of establishing a positive business case for operators in 2020.

Step 2. Bring drivers together into a viable framework

*MERCER: "The next step is to link these drivers together to provide a meaningful framework… It is where managers' 'intuition' - their ability to make sense of complex patterns of 'soft' data which more rigorous analysis would be unable to handle - plays an important role."* (Mercer, 1995)

In this report, the framework consists of a set of rules the scenarios must comply to.
The rules are developed using the second phase of GMA and the normative goal of the scenarios. The framework of rules can be applied into a financial Excel model, to reveal the budget of the operator until 2020 for all parameter combinations that comply to the rules.

Step 3. Produce initial (7-9) mini-scenarios

*MERCER: "The outcome of the previous step is usually between seven and nine logical groupings of drivers. In our experience this is usually surprisingly easy to achieve."*

The most interesting combinations of parameters that comply to framework will be selected.

Step 4. Reduce to 2-3 scenarios

*MERCER: "The main action, at this next stage, is to reduce the seven to nine mini-scenarios/groupings detected at the previous stage to two or three larger scenarios... This usually requires a considerable amount of debate - but this typically produces fundamental insights into what are the really important (perhaps life and death) issues affecting the organization."*

In this report, six mini-scenarios are reduced to 3 final scenarios based on qualitative interviews held with involved stakeholders. The interviews focus on the specific scenarios and relate to the different parameters, chosen values and other more preferred or disliked combinations of parameters and values.

*MERCER: In the scenario planning approach of mercer a sub step of step 4 is included to test the final scenarios for viability. If they do not make sense to the stakeholders or intuitively* *not 'hang together' a return to the first step must be made, redoing the scenario planning process.*

Due to limited research time, this sub step is replaced by an analysis of the scenarios using the information gathered in the interviews. Since the interviews were held using a broader scope then a fixed view on the mini-scenarios this is possible.

5. Write the scenarios

*MERCER: "The scenarios are then 'written up' in the most suitable form...for use by the managers who are going to base their strategy on them."*

The scenarios are written in Word with the inclusion of some numeric data and diagrams.

6. Identify issues arising

*MERCER: "The final stage of the process is to examine these scenarios to determine what are the most critical outcomes; the 'branching points' relating to the 'issues' which will have the greatest impact (potentially generating 'crises') on the future of the organisation."*

This report will examine the scenarios based on the information gathered in part 1 and through the interviews.

## Appendix 5: Excel model

To execute the financial analysis an extended Excel model is developed. In this model all the parameters and values can easily be changed, revealing the costs and income of the operators in the period 2013 – 2020. Besides the calculations a variation of charts is developed in the model. All charts used in the thesis are developed within the same excel model. The model consists of several spreadsheets. Sheet 1 is visible to all users. Values for the main values can be changed in this sheet and final outcomes are given. The other sheets contain the calculations and 'fixed' values. The figure below shows a part of sheet 1.

Ontdek de mogelijkheden van elektrische laadpunten

| Stap | 1 | 2 | 3 | 4 |
|---|---|---|---|---|

**Kun je ons wat details vertellen van je plan?**

| Jaar | Aantal laadpunten te plaatsen | | | |
|---|---|---|---|---|
| | AC1 (3.7) | AC2 (3.7) | AC2 (11) | Totaal |
| 1 | 0 | 50 | 0 | 50 |
| 2 | 0 | 50 | 0 | 50 |
| 3 | 0 | 100 | 0 | 100 |

| | |
|---|---|
| Verwachte gebruikte KWH per jaar | 2000 |
| Verwachte groeifactor KWH per jaar | 1,05 |
| Prijs elektriciteit | € 0,30 |
| Starttarief | € 1,00 |

| Kies je scenario | User in control |
|---|---|

| Kosten veranderingen | Toegepast? |
|---|---|
| Placement & construction | ja |
| Meter costs | nee |
| Groot verbruiker | nee |
| Nieuwe category | nee |
| Bestaande grid connectie | ja |

| Scenario beschrijving | |
|---|---|
| Government in control | Alle maatregelen ivm wetsveranderingen |
| User in control | Private netverbinding, management kosten, alleen 3,7 kW |
| Operator in control | Alleen plaatsing en meter kosten |
| Base case | Geen kosten maatregelen |
| - | |
| - | |

## Appendix 6: Interviewees and interview information

| Stakeholders company | Interviewee |
|---|---|
| Taskforce: The national government portfolio | Ingrid Post |
| Ministry of Economic Affairs | Tjalling de Vries |
| Province Noord-Brabant | Gerbrand Klijn |
| Taskforce: The local governments portfolio | Maarten Linnenkamp |
| Municipality Zaanstad | Tom Groot |
| E-laad | Onoph Caron |
| Alliander \| Liander | Mereille Klein Koerkamp |
| Nuon | Joris Hupperets |
| Essent | Collin Willems |
| Heijmans | Jorrit van den Breemer |
| EV-Box | Robert van de Vegte |
| Greenflux | Hans de Boer |
| Cofely | Jacco van den Burgh |
| The New Motion | Wouter de Ridder |

**Interview information**

***Email and information send to the participants:***
De hoofdvraag van mijn onderzoek luidt:

*Wat is de optimale combinatie tussen kosten-, financiële- en organisatorische maatregelen om de exploitatie van publieke laadpunten te stimuleren, ter bevordering van elektrisch vervoer?*

Om deze vraag te beantwoorden heb ik onderzocht welke kostencomponenten grote invloed hebben op de exploitatie van een publiek laadpunt en welke wijzigingen hierin kunnen worden verwacht. Er zijn wijzigingen in de kosten en in de inkomsten onderzocht. Daarna zijn een aantal wijzigingen gecombineerd en is het financiële resultaat van de maatregelen berekend. Uitgangspunt is een lage prijs voor gebruikers en positief resultaat voor de laadpuntexploitant over een periode tot 2020. Het organisatiemodel per scenario is gebaseerd op 2 aspecten: het eigendom van de paal en de beslissende partij wat betreft kWh prijs. Het totaal van deze combinaties heeft tot 6 scenario's geleidt. Om het onderzoek af te bakenen, heb ik een aantal uitgangspunten vastgesteld. Een korte beschrijving van de genomen maatregelen en de uitgangspunten staan beschreven op de volgende pagina's.

Doel interview:
Om de scenario's te beoordelen, zou ik graag de mening van de betrokken partijen willen weten over de genomen maatregelen, uitgangspunten en uiteindelijke scenario's. Hiermee kan per scenario de voor-en nadelen in kaart brengen en mogelijke discussiepunten aankaarten voor verder onderzoek. De vragen voor het interview staan op de laatste pagina.

Bij deze alvast mijn dank voor je medewerking!

**Algemene uitgangspunten:**

- De plaatsing van 200 laadpunten in een middelgrote gemeente
- Plaatsing over 3 jaar verdeeld
  2013 | 50 punten    2014 | 50 punten    2015 | 100 punten
- Exploitatie van laadpunten tot 2020. Verwijdering van palen niet meegerekend
- Twee soorten laadpalen
  - AC 1: Laadpaal met 1 laadpunt van 11 kW & netaansluiting 3 x 25 A
  - AC 2: Laadpaal met 2 laadpunten van ieder 11 kW & netaansluiting 3 x 35 A
- Verbruik per laadpunt 3000 kWh per jaar met een groei van 5% per jaar
- Verkoopprijs stroom minimaal € 0,27 cent/kWh

**Vaste kosten uitgangspunten**

- Kosten laadpaal:
  - AC 1: 2013|€ 3000,-    2014|€ 2650,-    2015|€ 2300,-
  - AC 2: 2013|€ 4000,-    2014|€ 3500,-    2015|€ 3000,-
- Management kosten: € 21.000,- voor management organisatie van de plaatsing
- Onderhoudskosten: € 100,- per paal/jaar
- Backoffice, facturatie : € 50,- punt/jaar

**Betrokken partijen**

- Laadpunt exploitant: Management van de laadpaal
- Consortium van publieke partijen (gemeente, provincie, rijk): Stelt criteria aan de laadpaal, bepaald de uiteindelijke locaties en kan financieel bijdragen
- Externe financiers (banken of een partij die in ruil voor financiering toegang tot data van laadpaal kan krijgen)
- Service provider: Koopt energie van exploitant en verkoopt deze aan de gebruiker
- Gebruiker: Aanvrager van publieke oplaadpunten en gebruiker van laadpunten.
- Netbeheerders: Installatie en beheer van de netaansluiting en elektriciteitsnet.

**Beschrijving kosten maatregelen**

<u>Samenwerking plaatsing & installatie laadpunt</u>

Momenteel zijn bij de plaatsing/installatie de gemeente (afzetten parkeerplaats en deze in orde maken), de netbeheerder (netaansluiting maken) en exploitant (paal plaatsen en testen) betrokken. Door 1 partij verantwoordelijk te maken, zijn kosten en tijd te winnen.

<u>Meter kosten</u>

Een onderdeel van de netkosten zijn kosten voor huur en onderhoud van de meter. Het is mogelijk om deze meter te vervangen door een gecertificeerde eigen meter. De jaarlijkse meterkosten komen hiermee te vervallen.

<u>Grootverbruiker</u>

Een wetsverandering kan ertoe leiden dat laadpalen als grootverbruiker worden behandeld (vergelijkbaar met openbare verlichting). Deze verandering houdt o.a. in dat er per groep laadpalen maar 1 keer transportkosten betaald worden en elektriciteit voor een lager tarief ingekocht wordt (gestapeld). Er is uitgegaan van 4 palen per groep.

Nieuwe aansluitcategorie
Een wetsverandering kan leiden tot een nieuwe aansluitcategorie speciaal voor laadpunten. De argumentatie hierachter zijn de smart grid mogelijkheden van laadpunten die ervoor kunnen zorgen dat piekbelasting voorkomen wordt. Er is vanuit gegaan dat de eenmalige en jaarlijkse netkosten met 25% verlaagd worden.

Aansluiting op bestaande netaansluiting
In plaats van een nieuwe netaansluiting, kan de laadpaal ook aangesloten worden op de aansluiting van een naburig gebouw. Er wordt vanuit gegaan dat de bestaande connectie voor €131,23 verhoogd wordt van 3x25A naar AC1|3x35 of AC2|3x50. De exploitant betaald het verschil in jaarlijkse netkosten van deze verandering en €1000, - wordt gerekend voor eventuele extra bouwwerkzaamheden.

**Beschrijving inkomsten maatregelen**
Rentekorting
De standaard rente van 5% voor een lening kan voor de exploitant verlaagd worden naar 2% of 0%. Deze verlaging van 3% of 5% wordt gefinancierd door publieke- of externe partijen.

Subsidie 2013 (fund)
De publieke- of externe partijen kunnen een subsidie geven voor de bekostiging van de eenmalige investeringskosten (CAPEX). Onder deze kosten vallen de hardware, netaansluiting, plaatsing en installatie van het laadpunt. Er wordt uitgegaan van een subsidie van 25%, 50%, 75% of 100% van de CAPEX.

Subsidie 2016 (revolving fund)
Er kan ook een tijdelijke subsidie van de CAPEX gegeven worden. Deze wordt (deels) terugbetaald in de periode 2016-2020. Deze subsidie voorkomt voor de exploitant grote schulden in de beginjaren. Er wordt vanuit gegaan dat inflatie en rente door de publieke- of externe partijen bekostigd wordt. Het percentage van subsidie dat terugbetaald wordt, kan 25%, 50%, 75% of 100% zijn.

Energie verkoopprijs
De exploitant verkrijgt inkomsten door energie aan de dienstverlener te verkopen die het op zijn beurt doorverkoopt aan de gebruiker. Naar aanleiding van huidige marktprijzen wordt uitgegaan van een minimale prijs van €0,27 cent/kWh. Leidt dit in combinatie met andere inkomsten tot een onrendabel marktmodel, dan kan de prijs verhoogd worden tot een rendabel marktmodel bereikt is.

**Beschrijving organisatorische maatregelen**
Algemeen
Er wordt vanuit gegaan dat publieke partijen (gemeente, provincie, rijk) samen een consortium vormen. Dit consortium kan beslissen over criteria en financiële maatregelen. Er zijn 3 verschillende organisatiemodellen: aanbesteding, concessiemodel en vergunning. Deze worden in dit onderzoek gebaseerd op het eigendom en de prijsstelling.

*Eigendom*

Hoewel de paal in puur juridische zin eigendom van de grondeigenaar/gemeente is, is er variatie mogelijk in de invloed van de publieke partijen en exploitant op de specificaties van de paal, de exploitatietijd en uitwisseling van data. Indien de zeggenschap bij de publieke partijen ligt, worden deze aangeduid als eigenaar en hetzelfde geldt voor de exploitant.

*Prijstelling*

Er is variatie mogelijk in de prijsstelling per kWh. De publieke partijen kunnen vastleggen dat alle exploitanten binnen de gemeente een maximum prijs per kWh aan de gebruikers mogen vragen. Publieke partijen kunnen er ook voor kiezen om exploitanten hierin vrij te laten.

| | | **Prijs** | |
|---|---|---|---|
| | | Publieke partij | Exploitant |
| **Eigendom** | Publieke partij | Aanbesteding | Concessie |
| | Exploitant | Concessie | Vergunning |

# Scenario's

| **Scenario** | **Kosten** | **Inkomsten** | | | | **Organisatie** | |
|---|---|---|---|---|---|---|---|
| | | Rente korting 2013 | Subsidie (fonds) 2013 | Revolving fund 2016 - 2020 | Energie prijs | Eigendom | Prijs-stelling |
| **1** | - | **-** | **+ 100%** | **-** | 0,27 | Publiek | Publiek |
| **2** | | **-** | **-** | **-** | **0,44** | Exploitant | Exploitant |
| **3** | | **- 5%** | (100%) | **- 75%** | 0,27 | Exploitant | Publiek |
| **4** | | **-** | **+ 50%** | **-** | **0,35**[1] | Publiek | Exploitant |
| **5** | | **- 5%** | (100%) | **- 100%** | 0,27 | Exploitant | Exploitant |
| **6** | | **-** | **+ 100%** | **-** | **0,35** | Publiek | Exploitant |

1. Met €0,27/kWh en 100% subsidie ook positief marktmodel mogelijk. Gaat subsidie omlaag, dan is dit de eerstvolgende combinatie voor een positief eindresultaat.

| **Variabele** | **Beschrijving** |
|---|---|
| | Samenwerking plaatsing & installatie laadpunt |
| | Meter kosten |
| | Grootverbruiker |
| | Nieuwe aansluitcategorie |
| | Aansluiting op bestaande netaansluiting |

## Interviewvragen

**Kosten maatregelen**

1. Wat vindt je van de verschillende maatregelen om de kosten te verlagen?
2. Welke gevolgen denk je dat de maatregelen op jou werkgebied hebben?
3. Denk je dat de maatregelen een stimulans vormen voor exploitatie van palen?
4. Zie je kans voor de verschillende maatregelen om geïmplementeerd te worden?

- ➢ Welke rangschikking van scenario's m.b.t. kosten maatregelen heeft jouw voorkeur?

**Inkomsten maatregelen**

5. Vind je het bij de rol van de publieke partijen passen om financieel bij te dragen?
6. Welke andere partijen zie je bereidt om financieel bij te dragen?

7. Wat is je mening over rentekorting?
   Is dit een goede maatregel om de onrendabele top te financieren?
   Wat is je mening over de hoogte van de rentekorting?

8. Wat is je mening over het subsidiëren van de eenmalige investeringskosten?
   Is dit een goede maatregel om de onrendabele top te financieren?
   Wat is je mening over de hoogte van de subsidie?

9. Wat is je mening over een subsidie in de vorm van een revolving fund?
   Is dit een goede maatregel om de onrendabele top te financieren?
   Wat is je mening over de hoogte van de subsidie?
10. [Ben je bereidt om de maatregelen toe te passen? Waarom wel/niet?]

11. Wat vindt je van een minimum prijs van 27 cent per kWh voor gebruikers?
12. In hoeverre moeten publieke laadpunten kunnen concurreren met private punten?

- ➢ Welke rangschikking van scenario's m.b.t inkosten maatregelen heeft jouw voorkeur?

**Organisatorische maatregelen**

13. Wat is je mening over eigendom van de laadpaal? Publieke partijen of exploitant?
    In hoeverre vind je dat publieke partijen invloed moeten hebben op specificaties?
    Welke publieke partij zou hier een rol in moeten hebben (rijk, gemeente, provincie)?
14. Wat is je mening over het vastleggen van de kWh prijs door publieke partijen?
15. Welke samenwerkingsvorm biedt de meeste stimulans om palen te exploiteren?

- ➢ Welke rangschikking van scenario's mbt organisatie heeft jouw voorkeur?

**Scenario's**

16. Hoe zou je de scenario's rangschikken wat betreft optimale combinatie van maatregelen om de exploitatie van laadpalen te stimuleren?
17. Heb je nog vragen/opmerkingen over de scenario's?
18. Zijn er nog punten die je graag wilt bespreken?

**Algemene uitgangspunten**

19. Wat is je mening over de configuratie van de palen? AC1 | AC2
20. Wat is je mening over het palen van 11 kW of 3,7 kW? Waar zie je meer potentie in?
21. Wat is je mening over de groei van kWh per paal? Is 3000 kW en 5% groei realistisch?

## Appendix 7: Interview analysis

For each measure, the parameters and values will be discussed according to the information gathered in the interviews.

**Cost measures combinations**

### Placement cooperation

Cooperation in placement is considered by all actors as a good thing. Having one organizing party would simplify the planning. A suggestion is given to use online planning tools. Currently there are already parties that effectively cooperate, like Nuon and Heijmans in Amsterdam. Cooperation with the municipality is considered a viable option by the involved actors. Municipalities value the cost and organizing reduction. Problems are foreseen with the DSO. They are considered quite conservative and reluctant to deviate from their role and the contract they have with their own constructers. Problems are reported of DSO changing the plans, not deliver or cross the 18 weeks limit. The DSOs mention they also find the 18 weeks to arrange the connection too long for charging stations. The DSOs consider cooperation challenging, due to organisations time and money to align all parties.

### Meter costs

The actors' opinions differ on changing or removing the measure device. Operators believe removing the meter will result in about 100 Euros profit, but this lower due to adjustment of the smart meter to standards of the DSO. This profit is considered by some not worth the effort needed to implement it. One actor states the fear that 2 connections are made instead, for each smart meter one. The possibility to make the stations smaller when the meter changed/removed is received positively, although changing again can be annoying, because of familiarity with the current stations. The most important aspect is a flexible and cooperative attitude of the DSO. Currently the DSO is obligated to have the meter, but they see opportunities in changing it. If they are allowed to differ from technology as stated in the law, they can use different meter measurement and use the new meter internationally. This is now not possible due to small differences in grid connections in other countries. A universal meter will have a larger market and thus more income.

### Large-scale consumer

All actors find the large-scale consumer measure very interesting, due to its impact on energy tax. Some operators already negotiated with the government, but did not succeed. The tax authority wants to treat a group as one WOZ, but the ministry of Finance opposed. The final decision has to be made by the Waarderingskamer, but this takes time.

The option of 4 stations on one string is considered interesting, but expensive due to the construction costs involved (stations 250 meters apart). When placed together it can be profitable, but in semi-large municipalities there is no need yet for so many points near one location. It is recommended to stay within small-scale consumer categories, due to the large top rate and small kWh can be a disadvantageous combination if treated as a large user. The DSO only demands that the stations are physically connected and safe, also behind the meter. Furthermore, the municipality must agree to the construction work. They prefer to place points on street corners, attracting more users.

The option of placing 4 stations behind one grid connection, paying for each once the connection costs, but only once the operational grid costs, is not possible by law. It can be implemented through pilots, but if this options is taken outside of pilots then also other customers are entitle the this right. This creates a risk, because other clients must reimburse the lost investment trough socialisation. And changing the law takes time. First all DSO must agree en then apply a law change.

### New connection category

Actors' opinions differ and many different arguments are given. Some stakeholders believe it is a very good measure, because the usage of smart grids can be fully utilized. Others do not consider it as durable, but as a subsidy on the connections being dependent on DSOs. The energy savings are considered very interesting. The stations are not the important factor, but the energy network behind the stations and the control on energy usage.

The actors agree that discussion on the new category is needed. The category cannot be based specifically on charging points, because then the DSO discriminates. It can be based on for instance 'connections in public area with a max use per year'.

Some find 25% grid cost reduction plausible, while other want to focus on flexible capacity tariff, making the prices more comparable to large users. It is suggested to create a category between 3x30 and 3x40 and give this a lower rate. Or pay 3x25 for a 3x35 connection. The DSO must regain lost income trough socialising, making other users pay more for their grid connection. A possibility is to sponsor till 3x35 and make higher categories more expensive, discouraging high connections. Some actors question why to investigate this option at this moment, when grid connection reduction can be first reached by lowering the category and in time investigate a new category related to smart grid possibilities. Besides, it is mentioned that changing the law will take at least two years.

The DSOs state smart charging is a solution to resolve risks for overload. DSO wants to have an emergency brake in case there is an overload. This is possible on all levels: high locally or in the station itself. DSOs are in principle not involved with the end user. A new category can give DSO more freedom in setting price based on incentives. This can give DSOs control on smart charging, differentiating in charging prices. A new category is also discussed by the DSOs for other objects in the public space, like ABRIS that keep getting more functions and therefore become unpredictable and are actually not an exception anymore. In all cases, the client decides what can be controlled and what not. The DSO prefers a new category, but not convinced that this will lead to lower prices, but it can create more freedom.

### Use existing grid connection

All actors consider this interesting, but doubt its feasibility. There are doubts if the owner will allow other users and wants the risks and fuss. Also agreements must be made what will happen if the house owner moves. Cooperation with municipalities is considered a problem, because they will want to have control on exterior, placement and underground construction of cables. It is expected municipalities will judge this measure to include too much organisation and fuss. For the e-laad stations the amount of time put in negotiations with municipalities was very high, so this solution will also require long negotiations. But when the municipality cooperates it is considered very interesting. Municipalities state that similar exterior is important. They see problems in ownership of the point (users treading the station as their own resulting in problems with other EV users), the parking policy and what will happen to the point when the user moves. This option has no impact on the DSO and therefore the DSO will not oppose to it. The DSO just wants the existing grid connections to be safe. Furthermore it is mentioned that the wiring in the house must withstand the extra power and the distance between the connection and station cannot be too big.

### Costs measure combinations

Overall the operators believe that cooperation in placement should be pursued. The meter should be changed or removed, but the cost impact is minimal. Most benefit is seen in large scale consumer treatment. The extension of the private grid connection and a new grid connection have their pro and cons. The DSO sees most profit in a new grid connection, because this allows more freedom in smart charging possibilities and pricing. The governmental parties are mainly concerned with organisation, exterior and parking policies. Furthermore, they want measures in combination with smart grids and decentralize production.

The national government is also investigation these costs measures, while looking at the whole spectrum. Their role is enabling pilots and experiments. They investigate if the measures are future resistant within the law and how the law can be changed. Electric mobility is currently just a little part of the developments in the energy market.

**Income measurers**

### Rate

The operators assess this as a nice solution, but not something with high profits. Not paying rent is by one operator considered important for all durable investments. It is doubted banks will cooperate. The investment is risk full and competing with other projects. Banks will probably want to have some percentage. A guarantee is necessary. There is doubt if the government want to stand guarantee. The governments from all layers consider it an interesting idea to stand guarantee. For municipalities it is doubted if agreement is reached and in the national government, these mechanisms are not appreciated by the ministry of Finance, making the national government reticent to it.

### Subsidy

Overall, the operators agree that subsidy should never be the goal, because this is not sustainable. In the end it must become a commercial market. For now a subsidy is considered a good solution. Some operators state the subsidy should never be 100%, because this does not stimulate innovation and sustainable businesses cases. It is mentioned by that currently no risks are taken, while it is good for the investor to take some risks. To prepare the market for the subsidy ending, it is suggested to make a constructive and reducing subsidy, with a reducing percentages/year. And operators should have the same chance receiving subsidy if they meet certain criteria.

Another suggestion is not subsidising the point, but the user by giving a subsidy on the energy. Disadvantage of subsidising points is juridical difficulty in arranging it without giving state support. And subsidies do not stimulate optimisation of stations and usage. If the kWh is subsidised than the market can take over. This subsidy per kWh can be given to the operator (user also possible, but this means actions for the user). It is important the subsidy is set for a certain amount of time, enabling the EV owners and stakeholders to calculate the expenses for the upcoming years. The subsidy could be reduced by a percentage per year. This will create consciousness on the costs. Make everything transparent.

The government can also set criteria for receiving subsidy, for instance on location, where locations with less usage receive more subsidy. This non-uniform system is appreciated, since not all operators are willing to place points in the suburbs, due to unmanageable risks. By subsidising low usage points, all potential users are able to drive electric.
In the end the user should pay for the stations. The user must therefore get used to higher prices. One of the operators mentions the time for investigating subsidies is over. Now investigate how the user can pay. More focus on income then cost reductions.

The national government feels the market should evolve to a sustainable market without governmental support. They realize that in the current transition phase something must be done, but they mainly see opportunities in public or semi-public charging. They do not want to just say it is an impossible business case and grant a subsidy, because this does not stimulate the market. Now the market must show what is possible. Furthermore, private parties must contribute. They established a greendeal in which public and private parties cooperate. If all parties cooperate, then the government will co-finance the ppp by a reducing subsidy only for the intermediate phase. Doubt if a whole arrangement is made. The national government already subsidises the EV market with the VAMIL. The decision can be made to not subsidies EV but infra, but other parties can also contribute to this. Provinces can also contribute, but it depends on their funds. Opportunities are seen, but not in subsidies, because this does not give incentives to market parties to optimise their business case. Instead, a revolving fund or pre-commercial public procurement is preferred.
The municipalities can also contribute but it depends on their own budget and goal. When the municipality want to co-finance, they cannot disturb or counteract the market. Incentives to subsidies are image & air quality.  Most municipalities are unfamiliar with public charging and/or lack the funds. Especially in the current economic situation. This is also revealed by the e-laad stations that are not taken over by municipalities, because they cost money.

The DSO does not want to give any more subsidies, because the government declared they do not subsidy 100%. Paying to gain data is not an option. Data can be gained in other ways.
All parties agree that the actions taken by e-laad have been helpful for stimulation the market. It however created friction in the market and parties do not see a future role for e-laad as operator. Their contributions to the points in the G4 are appreciated, but it also considered minimal, considering their incomes through the grid connections.

### Revolving fund

The revolving fund is considered an interesting option by the operators. Most actors prefer a revolving fund to subsidy, because more incentives are created. They all have own ideas on shaping this fund. Some mention it should never be 100%, because then the investors can better do it themselves. There is also uncertainty on how long the stations will be kept in use. The technology changes too rapidly. Organising the fund takes time. And the conditions are set for a few years, not creating a level playing field. Other operators mention it is important who has the risk and they question who want to invest.  Municipalities have not got enough money and too risky for private companies. It is mentioned to cooperate with many public and private parties to split the costs and risks. Large municipalities or provinces with fund can cooperate in a revolving fund. The fund can be repaid after a few years with inflation and no or minimal rent. They like a fund,  because investment can be earned back.

The fund could become owner of the station. The money returned to the fund is reinvested in new stations. The final goal is a situation without financial help. An option is to receive fund by a share of the income. The first millions are considered a loss, but when income is generated and reinvested in new stations, a business case is developed.

### Energy price

All operators agree that the current price is not realistic for establishing a sustainable business case. Most mention current electric vehicle users are capable of paying more. Often they are lease drivers with good salaries and companies paying for transportation. The vehicle itself is also expensive, so users do not buy an electric vehicle just for the price. It has to do with image. The user has enough money to co-finance. It is argued that users will understand public charging is more expensive than private charging, similar to drinking coffee at home or in a café.   In the current situation people do not get adjusted to higher prices. The importance of a smooth transition to higher costs is mentioned. The opinion of the government on price differs. Some feel the user should contribute, while other believe the price should be as low as possible, preferable even free, because users should be seduced and not counteracted in this young market. In later times the price can be raised.

The government cannot continue financing everything. Actors agree that action must be undertaken on more aspects, so costs and income. The final profit doesn't need to be large, but also not a loss. If everything is commercial, then the price per kWh will be higher than €0,27 cents, but market competition is believed to lead to lower prices. All parties agree that the price must be lower than fuel prices.

Several options are mentioned to raise the price to create a sustainable business-case.
One option is changing the model of tariffs. No maximum to the price. On good locations a higher price can be charged, similar to parking tariffs. The costs per kWh could also vary based on charging time, related to smart grid charging.
Another option mentioned by several operators is a starting rate, similar to the mobile phone sector. One operator states it takes at least 1 euro to start and 30 cent/kWh. The price will probably start around 50 cent and starting rate, and lower in time.  The user will not like this, but that is not a reason not to implement it. Another operator argues that the starting rate should be around 80 cents and the price per kWh comparable to prices for home charging, because it otherwise cannot be justified to users who compare it to home charging. This argument is not shared by all parties. Some believe that public charging cannot be compared to private charging because they differ in business case.

Another suggestion is asking a fee from users who apply a public charging point. Also possible to implement penalties or bonuses for users who park too long or short, in order to prevent EV unnecessary occupying a charging point counteracting other users.
It can also be decided to subsidise the energy paid by users.  Some operators mention to look at more than kWh, for instance payments per month or transaction. Price can be changed based on technology of the stations, making charging at 'better' stations more expensive.  And it must be able to trade in kWh without being considered an electricity trader.

**Organisational measures**

Ownership (specifications)

All parties agree the municipality should have juridical ownership of the location, otherwise it is too expensive and too much arrangement. On the ownership of the actual point, the parties agree that the party that invests should also be the owner and have saying on the specifications. If the government invest then they make agreement with the operator regarding the criteria. Operators believe the municipality will always want to set certain criteria on exterior, durability and safety. This is confirmed by the governmental parties. It is however mentioned that municipalities currently lack the knowledge, experience and economical incentives. They do not have the pressure and view for economic feasibility. And they can make wrong choices on specifications.

It is mentioned that if the points is not owned, noting is owned. Value can be gained by including the parking area. Another option mentioned is making the municipality owner or at least take the risks, even if they do not invest, because private companies do not want the stations on their balance as assets. Due to risks, extreme high costs are calculated into the balance. For tax technical, liability and insurance the municipality can own the points and put the risks on their balance. This is considered an enormous stimulation for the market. Agreements can be made on costs for repairs and maintenance.

The national government do not see a role for them in ownership. It depends on the province and municipalities. They say that when investing much, they also want to influence on specifications and operator. It however also mentioned to only set a few simple basis specifications, because the more the municipality decides, the more costs are made. Some municipalities prefer an assignment for 3 years. After these years a new operator can be chosen, anticipating to the market. If other parties co-finance they can also participate in the decisions. It is also possible to organise a public private partnership were all parties co-finance and decide on specifications. Another main aspect for municipalities is the parking policy. Municipality receive parking money. By raising the parking rate the price for energy can be covered. The location should remain municipal grounds. Municipalities are open to make agreements for using the location for a couple of years. The location is preferred on street corners. The government mentions investigations on linking procurement of municipalities are currently undertaken. A procedure for municipalities is constructed.

Price setter

The opinion on who sets the price differs. Most actors want the market to establish the price, while others feel that if the government invest a lot, they should set the price.

One operator states that publicly controlling the price is based on distrust. Currently the market is not trustworthy, but in principle, the market should set the price. Most agree that a fixed price is not market competition. It is mentioned that municipalities can only offer under the market price when there is public interest. Question if public points are in public interest. It must be prevented that municipalities act market disturbing. The market must become self-sustaining. Some operator mentions that with more EV and service providers entering the market the price will automatically drop. The price is indirectly set by the client.

One operator mentions it is also a risk to make the price commercial, because if the price rises for an isolated point with a user dependent on this point, then the users has no choice. A solution mentioned is separating the charging point in the form of a putkast, see appendix 2. This putkast is mentioned by several operators, including e-laad.
Others say that when municipality invest, they have right to set or influence the price. The more they invest, the more saying they should have on the price to the end user. With less investment, more freedom should be established for operators. There are also governmental parties that prefer the market to set the price, because market competition will automatically lead to lowest prices. One operator mentions the model used in the G4, is in practice difficult, because it is difficult to make bilateral contracts with commercial service providers that want other price setters. A fixed price for users can be settled when the market is complete commercial. Trough eViolin parties address this issue at the G4.
Another argument given is allowing freedom to operators in setting prices to users. This means that operators are able to offer users free energy, without counteracting service providers counteracting.

Cooperation models

Opinions on the combination between ownership and price setter differ. Most operators agree that there is no uniform system for all stations in the Netherlands. On good locations the operator can set specifications and price and on bad locations the government. If an assignment or concession is given, then the operator must be obliged to operate good and bad points. Operators will probably counteract placing bad points, so agreements must be made. Assignments do not stimulate innovation. Is considered by some as an old model. Now business cases must be developed by the market. Municipalities prefer cooperation with one operator, because then everything is arranged, similar to ABRIS with only one operator

It is also stated that there can be cooperation between the market and public parties. For instance, a deal in which the government pays for the coming 5 years and then hand it over to the market. By organising everything with one party the costs will be lower. Comparable projects are all started by public parties (roads, rail). Many market parties look at the result, while this is not yet the case. After a few year money can indeed be made, but not in the current situation. First, place something. Government must make a statement. Do either something or not. Now they want the market to do it and being the guiding country. Municipalities want the government to create a uniform procedure and give a manual to municipalities. Then not all municipalities need to investigate it for themselves. This can also be province. They can bring parties together and help financing. There is currently much contact between municipalities on this subject, They can cooperate with other parties to establish the finance or procedures. This reduces the price and risks, but it is difficult to organise.

**Fixed parameters**

Configuration

All operators agree that when the same grid connection category is used for an AC1 or AC2 station, then AC2 stations should be placed. This second point is a bonus. A second point will give more guarantee the point is available. For parking policy, it is suggested to make one place strictly EV and the other open for all vehicles. Municipalities often also want an AC2 station. In case an AC2 requires a higher connection category than operators mention they prefers AC1 in neighbourhoods with one users. The benefit of AC2 is not needed, so do not make extra costs. In multi-use areas with many but many possible users all operators want to place AC2 points. Only place on request by users.

### 11 kW or 3,7 kW

The debate on 11 kW or 3,7 kW is very recent. The opinions among operators vary. There are two groups distinguished.

The first group wants to place 11 kW points, because they believe the EV technology is heading towards this. They want points to comply with minimal quality demands and are prepared for the future. Points that charge faster are more appropriate for smart grid options. Furthermore, 11 kW allows more users a day.

The second group, and currently the largest group, wants to place 3,7 kW points. They want to create a basic charging network in the Netherlands and then improve it to higher values. The lower costs are an important argument. Another argument is that cars often stand still for many hours, still allowing smart charging, especially since a lot of EVs are PHEV. Although one operator mentions that, he does not believe much will be gained from smart girds in the Netherlands. Furthermore most electric vehicles can only charge 1x16 making 3,7 sufficient for 90% of the users. It is also expensive to place a 3-phase charger in the vehicle itself.

Other ideas mentioned are only placing 11 kW points on specific request of the users and for higher subscription costs. Also at areas with high refresh rates, which according to one operator entail around 20 locations in the Netherlands. Another operator believes 11 kW is only interesting for offices that have a high grid connection and employees that travel during office hours. E-laad only placed 11 kW points, but they now agree that for the majority of users 3,7 points are a fine solution. They feel it is more important to create a network and to get trust from the users. They placed 11 kW points because they came from a different situation in which they were the first and everything was new and uncertain.
The national government feels it is up to the market. Some municipalities also feel that technology does not need to be made so difficult. Simple sockets can be placed without the whole ICT. The municipality can pay the energy and the user just plugs in. This however can be seen by market parties as market disturbance.

### 3000 kWh per year and 5% growth

Some operators calculate with 2000 KWh, while other believe 3000 kWh per point is more realistic. Some say a point should not be placed if 3000 kWh is not reached. If you have one determined users then 3000 is reachable. Focus on stations with one certain user. Usage also depends on the amount of points related to the amount of vehicles. Currently it is around 1:1. If an AC2 point is placed then it is unrealistic to double the kWh, because this second point might not be used. It is agreed that it is difficult to give a number to the amount of kWh or growth, because there is too much difference between points. A risk of users moving in this time is considered relatively low. And taking risks is also part of being entrepreneur.

Other fixed costs

The management and maintenance costs are considered too low. The hardware price is low. And the assumption that points are used every year is considered very positive.

**Other parameters**

Focus on private and semi-public charging

Some actors find the fixation on public points strange, because it is much more expensive then private and semi-public charging and has an impact on the existing parking places. Not placing public points on a large scale, does not need to be a bad thing. Just let the free market and innovation do their work. One operator mentions to believe in semi-public charging at companies, because people will then charge during the day, which is better with the use of solar panels. And cheaper because no new connection needed end energy tax consolidated. Also is the EV battery technology is evolving and for hybrid there is already no problem. People solve problems of today, while they should solve problem for over 5 years.

One of the governmental parties suggests placing many simple sockets in parking garages without charging energy costs. Income can be generated by higher parking rates. Just simplify the points. Would the municipality execute this option, then it can counteract market competition. It can also be investigated to combine the stations with other functions, making them more profitable.