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Final Report on Macro and Micro Level Infrastructure Planning

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Executive Summary

A review of the current and proposed macro and micro level charge point infrastructure planning processes among the task partners and in other regions has taken place. Examples of planning processes and charge point installation criteria are shown and discussed. A number of macro and micro level guidelines have been provided.

Attention is drawn to the fact that market models and rules differ depending on the region involved. Planners in different regions may also choose different technology strategies or have different project objectives and as such not all guidelines contained in this document are relevant to each EV charge point infrastructure project. The aim of the report is to provide the planner with a base knowledge with which to implement a specific project depending on the regions characteristics (i.e. demographics, project objectives, stakeholders etc…).

Section 3, and the examples shown in the appendix, demonstrate the differences in planning approach depending on planner type. Municipalities will be less interested in inter-urban travel compared to regional authorities. Utilities will choose sites based on minimal amount of network reinforcement and may have regulated asset funding. Private companies will be looking for short-term revenue streams. The report defines a number of different methodologies for choosing charge point numbers and locations and guides the planner to relevant sources of planning data.

On a micro planning level basis, Section 4 discusses more practical infrastructure implementation topics such as; integration of charge points into existing streetscapes, electrical supply criteria, accessibility, public safety, civil and electrical works and service and maintenance. Charge point installation examples from many different regions are detailed.

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List of Abbreviations

AC	Alternating Current
CCTV	Closed Circuit Television
CP	Charge Point
CPMS	Charge Point Management System
DC	Direct Current
DSO	Distribution System Operator
EV	Electric Vehicle
GIS	Geographical Information System
ICE	Internal Combustion Engine
IEOM	Independent eMobility Operator Model
IIM	Integrated Infrastructure Model
LV	Low Voltage
MV	Medium Voltage
MCB	Miniature Circuit Breaker
OEM	Original Equipment Manufacturer
OJEU	Official Journal of the European Union
PCB	Printed Circuit Board
PR	Public Relations
PTV	Pendulum Test Value
PTW	Powered Two Wheelers
PV	Photo-Voltaic
RCD	Residual Current Device
RFID	Radio Frequency Identification
SIM	Separated Infrastructure Model
SOOM	Spot Operator Owner Model
TSO	Transmission System Operator
XLPE	Cross-Linked Polyethylene

1 Introduction

1.1 General Information

The Green eMotion project is part of the European Green Cars Initiative (EGCI) that was launched within the context of the European Recovery Plan. It supports the achievement of the EU's ambitious climate goals, such as the reduction of CO_2 emissions by 60 percent by the year 2050. EGCI supports the research and development of road transport solutions that have the potential to achieve sustainable as well as groundbreaking results in the use of renewable and non-polluting energy sources.

The Green eMotion project was officially launched in Brussels on 31st March 2011. During the years 2011-2014, it has provided the foundation for the mass deployment of Europe-wide electromobility. The projects total budget was €42 million which was funded by the European Commission to a value of €24 million.

The Green eMotion consortium consisted of forty-three partners from industry, the energy sector, electric vehicle manufacturers, and municipalities as well as universities and research institutions. They joined forces to explore the basic conditions that need to be fulfilled for Europe-wide electromobility. The primary goal of the project was to define Europe-wide standards. To this end, practical research was conducted in different demo regions all over Europe with the aim of developing and demonstrating a commonly accepted and user-friendly framework that combines interoperable and scalable technical solutions with a sustainable business platform.

Work Package 1 of the Green eMotion project was entitled "Synchronization of Demonstration Regions". The objective of Work Package 1 was to set up, implement and synchronize demonstration activities in the different demonstration regions of Green eMotion in addition to those already being carried out. The aim was to ensure a great variety of fleets, vehicle types and concepts as well as to implement mechanisms for data sharing and best practice evaluation among all regions. The municipalities played an important role to support and stimulate the introduction of EVs and the infrastructure. The introduction of EVs was assessed in a greater context and delivered recommendations for the most suitable EV applications and also to the further development of electric vehicles.

The 12 demonstration regions (ten model regions and two replication regions) which were part of Green eMotion leveraged on their existing activities and experiences. In addition, some extra demonstration features were implemented in each region in the context of Green eMotion to enable further tests and a wider spectrum of activities.

1.2 Task 1.2 Objective

Task 1.2 of Work Package 1 of the Green eMotion project is entitled "streetscape assessment and planning of roll-out and allocation of charging infrastructure". This report fulfills Deliverable D1.6, and is entitled "Final Report on Macro and Micro Level Infrastructure Planning." There are 13 contributing partners to the task; Barcelona, BCB, Cartif, Codema, Copenhagen, CTL, ENEL, ESB, Iberdrola, Malmö, PPC, Rome and SenStadt. ESB is the nominated task leader.

One of the challenges facing the deployment of EVs is the availability of charging infrastructure. While many people can charge their EV at home, this is not the case for all. People in the inner districts of municipalities may not enjoy private parking facilities. Hence, there is a need for charge points on public land in order to ensure that everyone is able to charge their EVs. Without the availability of public charging there will not be significant take-up electric vehicles by the public. There is, on the other hand, a significant commercial risk if extensive infrastructure is installed without a guarantee of the availability of vehicles. The solution, advocated by members of the Green eMotion consortium, is to initially install sufficient infrastructure to demonstrate commitment so that the European public will be reassured. Subsequently, the rollout of infrastructure will be planned in a way that it is always sufficiently ahead of the rollout of vehicles to ensure public reassurance without being financially imprudent. This requires the development of a well-planned methodology which will be developed within this task.

It is noted however that some regions in Europe have undertaken a nationwide installation program of EV charge point infrastructure in anticipation of the market maturing rapidly. Whilst this approach may be valid depending on region specific economic factors, it does leave the infrastructure developer more open to the significant commercial risk mentioned in above.

The document is divided into three sections which cover 1) the key considerations to take into account when embarking on a charge point installation program, 2) the macro level location planning issues and 3) the more practical micro level planning issues associated with charge point installation.

2 Charging Infrastructure Planning: Key Considerations

2.1 Introduction

The report is written from the perspective of the potential EV charge point infrastructure planner hereafter referred to as “the planner”. The planner is responsible for the designing and installing an EV charge point infrastructure hereafter referred to as “the project”. In this chapter the fundamental pre-planning criteria for the project is discussed.

The approach taken by the planner will differ depending on what type of body is responsible. Municipalities will be less interested in inter-urban travel compared to regional authorities. DSOs will choose sites based on minimal amount of network reinforcement and may have regulated asset funding. Private companies will be looking for short-term revenue streams.

A detailed analysis of the different types of market models available in the EV charge point infrastructure space is shown in the section below. Completing all the relevant steps and tasks to analyze the appropriate market model for a specific region may involve considerable time and resources. In many cases municipalities or local authorities may wish to start an EV project irrespective of the business case or existing market models. For small or start-up projects, such detailed analysis may be considered too extensive and should not be seen as a barrier to EV project adoption, but rather as a separate project stream to be revisited as business case evolves.

2.2 Market Models

Experience to date with electric vehicles is that most charging has taken place overnight in private locations. But it is universally acknowledged that public charging is required both for psychological reasons and as an important, if minor part, of the charging infrastructure.
There are three broad policy areas for consideration with respect to the provision of an electric vehicle public recharging service. It is also the case that what is most suitable in the short or medium terms may not be so for the long term. Therefore decisions should be made with a view to allowing flexibility for future changes. The policy areas are:

a) Overview of Public Recharging. Is it part of the electricity supply system or otherwise?
b) Bundling or Separation of Public Charge Point ownership from the provision of the “electromobility service”
c) How is interoperability from the customer viewpoint to be guaranteed?

2.2.1 Overview of Public Charging

Public charging may be viewed in two ways:

1) An extension of the electricity supply system or
2) A service to EV drivers provided by someone who is a customer of the electricity system.

In the first case the “service” may be seen as the sale of electricity whereas in the second case what is provided is often a “bundled service” in which electricity is included along with other things such as parking or just the “charging service”.

2.2.2 Charge Point Ownership and Provision of Electromobility Service

The policy decision arises when public policy states that there should be at least some private sector involvement in the Public EV Charging market. The decision area then focuses on whether it should be subdivided into a number of competitive markets. It is possible that what is best in the long term is not suitable or even practical in the short term but it is important that present day decisions do not preclude applying the best solution in the long term.

The key decision area is whether the ownership of public charge points and the provision of the “service” (whether seen as just electricity or bundled with other things) be combined or separated. The spectrum of options is best depicted in the figure below. The five models shown describe the range of market models. They are not discrete models that must exist in totality on their own but can be mixed in different parts of the market e.g. in public locations (such as the public street) or semi-public locations (where the public have free access to private locations such as gasoline stations or supermarket car parks).

In Models 1 and 2 the electricity utility is an active player in the provision of EV recharging. Model 1 is where the utility is a fully integrated organization providing both the distribution system and the sale of electricity. This is the traditional electricity supply model and exists except in places in the world where the different functions have been separated to provide competition in some functions.

Model No.	Market Model Description	Electricity Distribution	Charging Station Ownership / Operation	Provision of Electromobility Service/ Sale of Electricity
1	Combined Electric Utility Model			
2	Integrated Infrastructure (or DSO) Model			
3	Separated Infrastructure Model			
4	Independent Electromobility Operator Model			
5	Spot Operator Owned Model			

Figure 2.1 – Market Models

Each model is described in more detail below but the over-riding difference is that in Models 0, 3 and 4 the owner/operator of the charge point also is the “seller” of the electricity , whether as a bundled service or not. In Models 2 and 3, the owner/ operator of the charge point is a legally separated entity from the seller of the electromobility service.

2.2.3 Description of Models

Model 1 - Combined Electric Utility Model

In this model the Public EV Charging market is fully integrated into the electricity system which is itself unbundled. The charging infrastructure assets are therefore utility assets and the sale of electricity is integrated into the normal electricity market. However because of the nature of the transaction – low value (compared with electricity supply to a building) and mobile customers it is necessary to introduce special arrangements for authorisation and probably payments. The cost of the recharging infrastructure is financed through the electricity system.

Advantages

- The financing of the infrastructure is easier as the utility is used to long term investments and usually does not require a return on investment in the short time scale usually associated with speculative private sector investments
- A utility is experienced with erection of electrical equipment, particularly in public areas and in dealing with logistical, public safety and liability issues that may arise.
- A system of controlling the charge to minimise the negative impact on the electrical network ("Smart charging") is more easily established where the utility is a direct player.

Disadvantages

- The provision of charge points is not of itself a natural monopoly and so allowing the utility establish a first mover position in the EV Recharging business may limit the emergence of market solutions.
- It may be argued on the grounds of equity that the cost of recharging infrastructure should be borne by the users of that infrastructure and not by the general public which it will be if incorporated into the electricity system cost structure. On the other hand it can be argued the grounds of materiality that the small incremental cost is justified given the social benefits.

Model 2 – The Integrated Infrastructure (DSO) Model

In this model the Public EV Charging market is fully integrated into the electricity distribution system (but not the generation or sale of electricity functions on the electricity industry). It can only occur where the electricity business is unbundled. The charging infrastructure assets are therefore Distribution Utility assets. Like other Distribution assets in an unbundled market they may be used on an open and transparent by other market players to provide electricity or sell associated services.

Advantages

- Just like Model 1 the financing of the infrastructure is easier as the Distribution utility is used to long term investments and usually does not require a return on investment in the short time scale usually associated with speculative private sector investments
- A Distribution utility is the part of the Combined that is experienced with erection of electrical equipment in public areas and in dealing with logistical, public safety and liability issues that may arise.
- A system of controlling the charge to minimise the negative impact on the electrical network ("Smart charging") is more easily established where the Distribution utility is a direct player.

- Competition in the provision of electromobility services (including the sale of electricity) by relevant third parties is enhanced as barriers to entry are lowered for this activity. This is because the electromobility service provider does not have to commit capital resources to the provision of the infrastructure and may focus on their particular business strengths of providing customer service and associated products.

Disadvantages

- The provision of charge points is not of itself a natural monopoly and so allowing the utility establish a first mover position in the EV Recharging business may limit the emergence of market solutions.
- It may be argued on the grounds of equity that the cost of recharging infrastructure should be borne by the users of that infrastructure and not by the general public which it will be if incorporated into the electricity system cost structure. On the other hand it can be argued the grounds of materiality that the small incremental cost is justified given the social benefits.
- In a regulated market there may be some initial legal uncertainties as existing regulatory laws will usually have been enacted before EV Public Recharging emerged as an activity.
- There is little if any experience within regulatory bodies as to how to exercise meaningful and fair economic regulation particularly in the immature stage of market development.

The project in Ireland is an example of Model 2.

Model 3 – The Separated Infrastructure Model

In this model the EV charging infrastructure is seen as a new, separate and independent step in the electromobility value chain. However the unbundled aspects also apply. There may be one or more independently licensed EV Charge Point Providers who provide the assets. They are financed however, not directly by the electricity customer, but by the users of the charge points. While the recharging infrastructure is outside the assets of the electricity Distributor/ utility the EV Charge Point Provider is actually a special type of distributor. He is independent of the seller of electromobility services and has no interest in the commercial arrangements made between the customers and the service provider. He receives his payment in the form of a “use-of-system” charge which is ultimately paid by the customer although most probably through the electromobility service provider.

Advantages

- In the long term probably gives rise to the maximum amount of competition in both the provision of charge points and the sale of electromobility services.
- Competition in the provision of electromobility services (including the sale of electricity) by relevant third parties is enhanced as barriers to entry are lowered for this activity. This is because the electromobility service provider does not have to commit capital resources to the provision of the infrastructure and may focus on their particular business strengths of providing customer service and associated products.

Disadvantages

- A new market player is needed (which may or may not be an issue)
- Recharging Infrastructure costs have to be recovered from the users. At the initial immature market stage this is likely to be an insufficient source requiring the “Independent Charge Point Operator” to have sufficient other financing to view the business as a very long term investment.
- Depending on the number of independent operators the use of “smart charging” may be more difficult than if the Distribution Utility were directly involved. However this may be overcome with the emergence of “Aggregators” in the demand side management of the electricity business.
- It is likely that the determination of a “fair” charge for using the charge points will require a regulatory process at least while charge point numbers and independent operators is small.

The Project in Portugal is an example of this model.

Model 4 – The Independent Electromobility Operator Model

In this model the Charge Point Operator is completely external to the electricity business. In this sense he is just another customer of the electricity utility business. Some process needs to exist by which he is licensed to provide a comprehensive electromobility service including the provision of the recharging infrastructure. At least in the initial stage it is likely that the operator will have a license for a large geographic area – a city, region or even a country. The Operator must recover all of his costs directly from the customer. In this case however the capital costs associated with the infrastructure is likely to be the dominant element and so cost of electricity will be a relatively minor element bundled into the overall price.

Advantages

- One organisation takes responsibility for implementing the initiative
- Because of scale it is likely that the Electromobility Operator will be able to negotiate a more attractive price for electricity (where this permitted in the relevant electricity market)
- Interoperability is not an issue as there is only one operator.
- While not as easy as if the electricity utility were directly involved, Smart Charging is likely to be reasonably easy to introduce with one electromobility operator across a defined geographical area.

Disadvantages

- There needs to be a process by which the license/ franchise is allocated.
- There is no competition so EV drivers are obliged to purchase the electromobility service solely from the monopoly electromobility operator.

Model 5 – The Spot Operator Owned Model

In this model charge points are erected at locations either by the owner of the location or by someone doing so under some agreement with him. Having erected the charge point the Operator then provides a charging service (including electricity) to EV drivers. There is no restriction (other than normal planning type restrictions) on who could erect charge points and where they can do it.

Advantages

- Charge points may be erected by many different people for different reasons. Some will expect a commercial return on their investment but others will erect charge points for PR or other reasons.

Disadvantages

- There is likely to be a lot of interest in erecting charge points in “good” locations but less so for less attractive locations. This can militate against a comprehensive charging network.
- Decisions on charge points, plugs & sockets, ID and back office systems may all be taken individually by each operator and so a non-interoperable non-standardised network may emerge.
- A system of licensing for public locations (e.g. roadways) may be necessary where the municipal authority itself does not erect charge points.
- Smart Charging will be difficult to introduce given the lack of standardization and the number of independent operators

Barcelona can be used as an example of the variation of market models available not only in different regions but in the same region (see also Appendix 1). Barcelona has initiated a network of public CPs based upon model 2, recognizing that this may not be the best configuration in the longer term. The Municipality commissioned some 30 CPs and an operating system to monitor their use; this system is open to other parties wishing to provide CPs and participate in a monitoring of the joined offer made available to EV users. Various “sub-networks” of CPs have joined the demonstration. More than one DSO is involved, and some CPs are joined via model 1 and others under model 4. The advantage of the approach is that more CPs are deployed more quickly, but the public financing is unlikely to continue and the model will, at some stage, have to evolve.

2.2.4 Guarantee of Interoperability from the Customer Viewpoint

While there may be commercial or economic benefits from having competitive markets and multiple players such arrangements are likely to give rise to interoperability problems for customers/ drivers. Interoperability problems will restrict the development of electromobility and in the longer term undermine the investment in the charging infrastructure. Where there is only one charge point operator (even with multiple electromobility service providers) there is no interoperability issue. This is the case for Models 0, 1, 2 (with one independent operator) and model 3 (where the geographic area is sufficiently large).

Where there is more than one operator (as in Model 2 with multiple operators), Model 3 outside of the geographic area, and Model 4, interoperability issues will arise unless specific actions are introduced. It may be that the actions can be agreed on a voluntary basis but they may also need to be implemented through government regulation. The two main options for ensuring interoperability where there are multiple operators are

a) Having all operators connect to the one Charge point Management System (CPMS). This can be operated by a “neutral” third party
b) Allowing all operators use their own CPMS but insisting that they must connect with an “overarching IT system” that is designed to interconnect cross-operator transactions.

2.3 Project Risks – Barriers to EV Implementation

A risk register shall be developed for the project and potential risk monitored and their severity graded. Below is a list of potential risks to an EV charge point infrastructure project with their ratings and likelihood. Some remedial measures are included to mitigate these risks however many will be dependent on the specific region of the project.

Risk	Rating	Likelihood
Political change and/or economic constraints will dissolve support for electric vehicles. Mitigation can be achieved through management of key government stakeholders.	High	Medium
Global interest and investment moves to other technologies such as hydrogen fuel, bio-fuels, or another. Mitigation difficult to achieve.	High	Low
A technical failure results in large fleets of electric vehicles being recalled.	Medium	Medium
A safety incident with an EV results in death or injury and associated change in public opinion.	Medium	Medium
The electrical industry regulator does not approve the charging infrastructure on the regulated asset base. Mitigation can be achieved through regulator stakeholder management.	Medium	Medium
Private charge point systems are installed which are not compatible with national systems resulting in confusion for the customer.	Medium	Medium
EV supplier's offering is not sufficiently strong to encourage members of the public to buy EVs	Medium	Low
Local authorities inflate parking fees for EV users as revenue is being lost due to minimal use of parking space. Possible mitigation achieved through local authority CO_2 saving incentive scheme.	Medium	Low

Local authorities do not allow signage and road-markings and do not implement rules/legislation for EV travel and parking (i.e. use of bus lanes / reduced congestion charges). Mitigation achieved through stakeholder management and possible local authority CO_2 saving incentive scheme.	Medium	Medium
Non-EV users are consistently taking up dedicated EV charging spaces resulting in an un-used infrastructure. Mitigation achieved through local authority clamping-tickets.	Low	Medium
Range anxiety rumors continue to effect sales figures.	Medium	Low
The plug/socket type chosen is not as specified in future binding standards and becomes incompatible with new EVs.	Medium	Low
DC or AC charging becomes prominent and the infrastructure for the opposite is obsolete.	Medium	Low
Delays in projects occur due to delayed supply of charging equipment or charge point management / payment systems.	Low	Medium

Table 1 - Risk Table

2.4 Technology Strategy

While this report has not been written to provide the reader with detailed knowledge of EV charge point types and technology, some basic technical knowledge is required by the planner. There are multiple technology options available to the planner and recently there has been an increased level of industry standardization. The planner needs to decide what mix of infrastructure best meets the needs of the potential EV users in their region, taking into account the market model adopted (as discussed in Section 2.2).

2.4.1 AC Charge Points

These charge points are typically single or dual-socket units, with dual-socket units becoming more common. All AC to DC power conversion takes places on-board the EV hence this is referred to as on-board charging. The charge points can be either single or three-phase and typically can supply maximum output current of 16 amps or 32 amps. High power versions allow 63 amp fast AC charging. Charging times with standard AC charge points vary depending on vehicle battery size and supply constraints but typically vary between 1 hour and 8 hours. Fast AC has the potential to charge a standard vehicle battery in approximately 30 minutes. A communications/safety protocol known as “mode 3” (as defined in IEC standard 61851) dictates the power switching and current levels. A typical 44kW double-headed AC charge point is shown in Figure 2.2 below.

Figure 2.2 - AC Charge Point

2.4.2 DC Charge Points

These charge points contain the AC-DC power conversion electronics inside the unit and as such this charging method is referred to as off-board charging. Controlled DC power is supplied directly to the EV battery and charging times can be as low as 30 minutes. A communication protocol called CHAdeMO dictates the power switching and current levels and is the de-facto standard as of the date of this report. Combination connector standards (with a combined AC and DC connector) are muted to be available in the near future. Due to the relatively high cost of DC charge points compared to AC charge points, the planning criteria may be different (i.e. due to the increased safety and security measures). The physical footprint of the DC charge points is much larger than standard AC points. Many manufacturers now also offer combined AC and DC charge points. These typically offer 50kW DC power and either 22kW or 44kW AC power. The Figure below shows a 50kW DC charge point installed in Ireland.

Figure 2.3 - DC Charge Point

2.4.3 Battery Swapping Stations

A battery swapping station is a place to swap a discharged battery pack for a fully charged one, saving the delay of waiting for the EV's battery to charge. In such a station the EV driver does not need to get out of the car while the battery is being swapped and the process can be completed in less than five minutes. This type of technology can only be used where it has the support of OEMs with specifically developed vehicles catering for battery swap. The model is being trialed in demonstration projects in Israel, Denmark and Hawaii but requires significant capital investment compared to the other models.

Figure 2.4 - Battery Swapping Station in Denmark

2.4.4 Inductive Charging

Background
As part of a comprehensive study of electric vehicle charging technology it is important not to look only at the currently available technologies, but also the emerging offerings. One such technology is induction charging. At present this form of charging is not available as an integrated solution with any OEMs from the vehicle industry, however much work has been carried out in this area giving cause to expect OEM solutions within the next generation EV offerings. The advantages of induction charging include cleanliness and tidiness, reducing the need to handle cables as well as offering the ability to access charges for short periods of time where one might not go to the effort of plugging a cable.

Figure 2.5 – Illustration of Inductive Charging

State of Induction Charging Technology

At present all ventures into the area of induction charging are in the form of retrofit and come under the banner of ‘Pioneering solutions’. The designers of these offerings are not directly connected with the vehicle OEMs, offering solutions for a discrete number of vehicles.

It is currently believed by technology experts in the EV industry, that the evolution of induction charging will start in areas such as fixed route buses, working its way into taxis and other public service vehicles. When the technology has proven itself in these areas the next expected market will be luxury, high end vehicles. Finally, as production quantities increase, costs reduce and the OEMs look at increasing ways to add convenience and value to their vehicle offerings, induction charging is likely to become common place in small to mid-size vehicles.

At one level, companies such as Qualcomm IPT are offering retrofit solutions and at another level such as in the Green eMotion project, Nissan, are working with fKA in Germany on the integration of charging coils in the Nissan Leaf. This latter example will be demonstrated and assessed in Ireland by ESB in Q4, 2014.

The charging rates vary according to the suppliers. These can be anywhere from 3kW to 11kW with efficiencies ranging from 70-90%. As these charge rates are well within the scope of those expected for ‘cabled’ on-street infrastructure, the electrical network design requirements are not expected to require significant specific attention.

Induction Charging Pilot

A pilot of induction charging should be undertaken to establish both user and network impact of induction charging. Test beds for the pilot should be considered across a range of use cases.

The following criteria are among those which should be considered in selecting these pilots:

- Safety
- Use case prioritisation
- Network connection
- Driving Profile
- User interfaces/ Authentication methods

- Primary and secondary charging locations

2.4.5 Photo-Voltaic Charging Technology

Background
Solar Photovoltaic installations mainly comprise of the following types:

- Large scale solar parks.
- Rooftop installations in residential or commercial premises.
- Small scale integration with lighting schemes or other electrical systems.

The rooftop PV installation classification can be widened to include installations whereby solar panels are incorporated into carport canopies in car parks under direct sunlight. There are many examples of such schemes internationally.

Charge Point / Solar PV Carport Scheme
Solar PV carport solutions are made available by solar PV suppliers. Considering that a charge point may be capable of delivering 22kW (AC public charge point) or 50kW (fast charge point), the power output from a solar PV panel is much lower (typically approx 4.4kW peak output) and is variable (i.e. only available during daylight hours). The electricity generated by the solar PV panels will partially charge electric vehicles and may be exported to the grid when no vehicles are charging. Some examples of solar carport schemes are shown in the figures below.

Figure 2.6 – Tesla Solar Charging – California ~30 kW Solar and a Solar car park in Bahrain

Figure 2.7 – Fastned installation in the Netherlands

2.5 Marketing and Communications Strategy

2.5.1 Target Groups and Marketing Activities

A fundamental aspect to the success and uptake of EV infrastructure and electromobility is creating awareness and consumer demand in the local marketplace. In this regard development of a marketing and communications strategy is key. The various target groups and marketing activities are detailed below.

Target Groups	
Customers	• Existing EV owners and potential owners • Commercial companies/'Green' Businesses/Taxi firms/Multinationals/Valet companies/Courier companies
Infrastructure Hosts	• Service Stations • Intermodal sites (e.g. metro, airport) • Retail, Malls • Recreation/Sporting venues • Green Hotels

Target Groups	
Press/Media	• Media – Broadcast + Print/Motoring • Motor Supplements • Consumer Affairs/Tech and Online
Key stakeholders	• Infrastructure Equipment Suppliers • Government – Municipalities, Safety Regulators • Motor Industry (Dealers, Vehicle Suppliers to ensure supply of EVs) • Green Businesses • Universities and Third level Colleges • Standardization Organisations • Tourism sector • Other –e.g., Police, First Responders, Insurance companies
General Public	• Other road users including pedestrians , cyclists • School children

Table 2 – Target Groups

Figure 2.8 – Marketing Activities

2.5.2 Brand and Identity

The development of a strong independent brand and identity associated with the charging infrastructure will:

- Develop a unique, stand out identity that is recognizable on charge points, car park spaces and on EVs.
- Build support among and enhances marketing partnerships with key stakeholders/partners (i.e. OEMs, hosts, municipalities).
- Support possible expansion of infrastructure to other regions.
- Provide flexibility for future market models.

The development of consistent visual styles across all charging infrastructure is recommended, specifically in the following:

- Charge point branding
- Charge point signage
- Charge point ground markings*
- Livery on EVs

In conjunction with the physical charging infrastructure, the identity should be fed through and correlated with all marketing (print and on-line) paraphernalia. Examples of ESB ecars branded charging infrastructure and literature in Ireland is presented in the Figure below.

Figure 2.9 – Brand and Identity Examples from Ireland

The project can benefit from co-branding and partnerships with key stakeholders. Co-branding can be incorporated into both the infrastructure (to include host location branding), EV OEMs and as part of jointinitiatives such as with courier companies, insurance companies, e-taxis and green businesses. Examples of co-branding from the Irish experience are shown in the Figure below.

Figure 2.10 – Co-Branding in Ireland

2.5.3 Building Awareness Online

To encourage active participation from the public and in particular EV drivers, online blogs, ezines for EV owners should be used along with regualar social medi outlets such as You Tbue and Facebook. These provide a platform for discussion, sharing ideas and experiences as well as creating an online EV community. Examples of such use from Ireland are shown in the figure below.

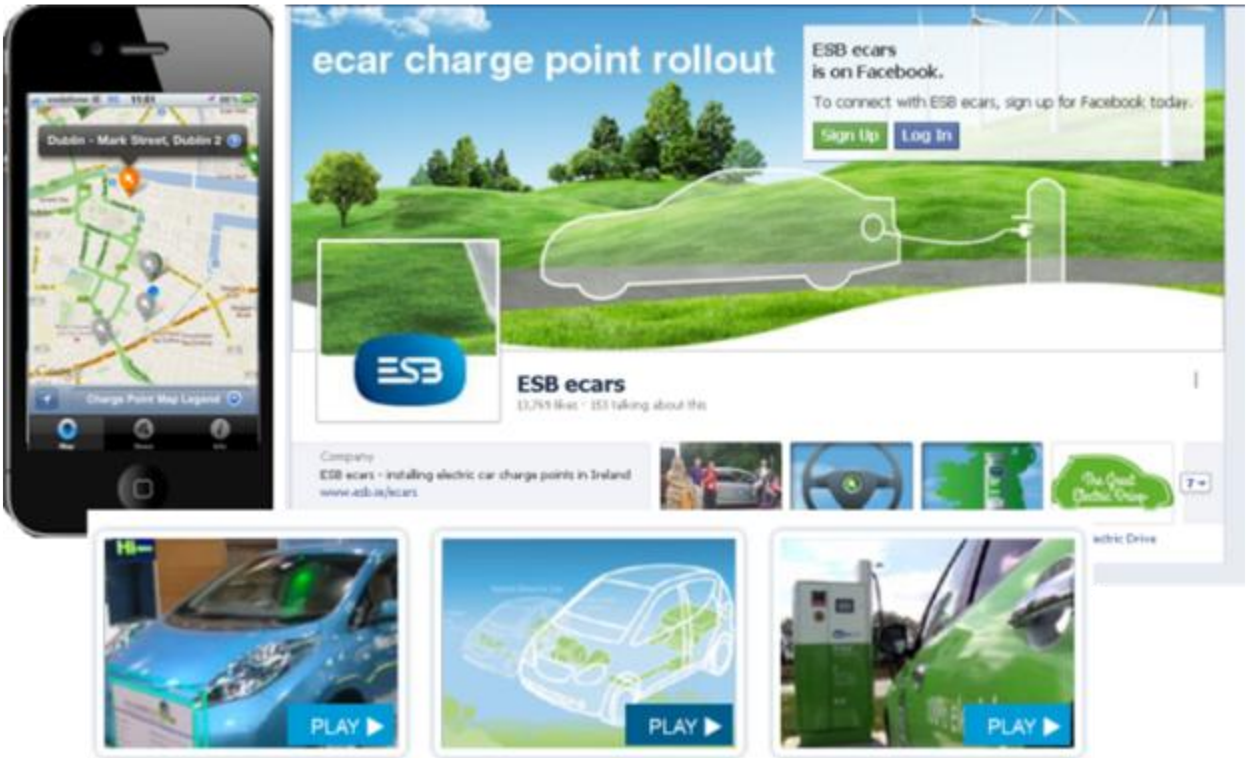


Figure 2.11 – On-line Presence

2.6 Data Capture and Analysis

This section outlines data collection and analysis which would complement and support the ‘Smart’ element of any charging infrastructure initiative. There are numerous types of data which can be collated and subsequently be analyzed. The three main sources of information valuable to planning and optimization of EV infrastructure are:

Vehicle data

- Data from the vehicle relating to driving patterns.
- Data from the vehicle relating to charging patterns / ‘plugged in’ times.
- Data from the vehicle relating to parking times and durations (note: the data can be gathered from additionally installed GPS or with the cooperation of vehicle manufacturers).

Charging data

- Data from the CPMS relating to the charge event, duration, frequency and energy consumed.
- Data from the CPMS relating to the RFID card activating the charge event.
- Locations of Electric Vehicle Supply Equipment (EVSE)
- Data from privately owned non CPMS EVSE

User Attitudes

- EV owner surveys
- Potential buyer surveys
- Test drive experiences

Further to these areas listed above, it would be important to understand the quantities and technologies of the vehicles being supplied to any region.

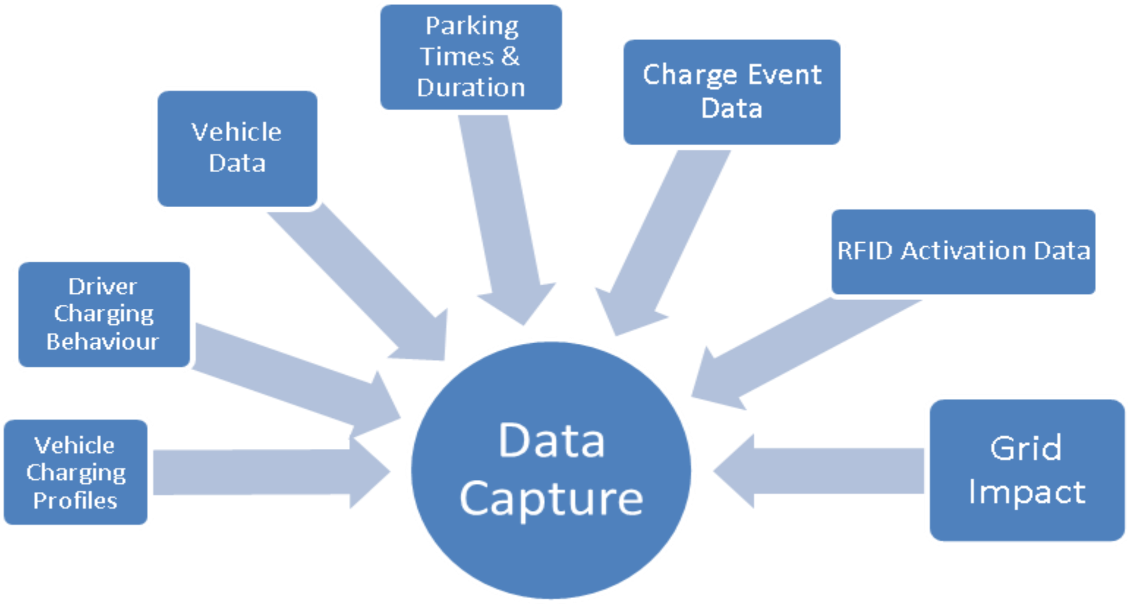


Figure 2.12 – Examples of Collected Data

2.6.1 Vehicle Data

Acquisition of vehicle data can often pose issues both technical and privacy related. From a privacy perspective, users should sign a release form, granting permission for the type of data gathered and the purpose for which the data will be used. Furthermore, the applicable data security laws of the region must be adhered to, particularly where privacy is at risk. On a technical level, vehicle OEM's are very reluctant to give access to data from the vehicles they produce. While it is not totally unheard of for a manufacturer to make data available it is a very rare event. Third party devices can be installed in vehicles and these come in the form of GPS tracking or Data logging with GPS tracking. Tracking in itself can be a simple form of data collection which can easily be installed, however the task of data logging from the vehicle is a more complex matter. Typically the vehicle data is in the form of CANbus protocol, which addresses specific vehicle parameters differently between makes and models of vehicle. As these addresses are not freely shared, it is generally necessary to reverse engineer the CANbus code in order to access the data. Items of interest in the vehicle are parameters such as vehicle State of Charge, climate control usage and ambient temperature conditions, to mention just a few. The communication with the data logger is normally GPRS based.

2.6.2 Charging Data

Acquisition of charging data depends mainly on whether the charging infrastructure is connected to a management system or stand-alone. Stand-alone charge points are more difficult; however it is possible to install profile metering which will gather energy consumption data such as time of day and kWhrs consumed. This same energy profiling system which generally logs the information on a 15 minute basis is also usable on private installations with the permission of the owner. Profile metering requires data to be gathered via a meter management system either sometimes available through the Distribution System

Operator (in this case DEWA). The most complete data is generally acquired from a CPMS which gathers data from all charge events on the system, recording the coupon ID used to authorize the charge event.

2.6.3 Driver Data and Behaviour

In order to plan the installation of future phases of infrastructure it is valuable to understand how people are using their vehicles, how long they park, how far they drive and where the vehicle might is parked for suitable time periods. Battery consumption and required charge are also of high importance in understanding how much benefit this offers to drivers. It is useful to know which charge points are being used heavily and if there is a queue to use a charge point. The amount of energy consumed at the CP should be compared to the amount of time a vehicle is plugged into the charge point, therefore occupying the space and hindering use by other potential customers. The RFID or coupon used to authorize the charge event is useful to assess how much the infrastructure is required as an enhancement to long distance travel (e.g. intercity) or how much it allows greater autonomy within the region or urban radius.
The technology and type of vehicles being supplied to a region is of high importance in assessing the impact of short duration charges, the types of infrastructure required and the requirement for charging away from the home base. Of the categories mentioned above, CPMS data is the most valuable regionally.

2.6.4 User Attitudes

The data category ‘user attitudes’ is crucial to understand the likelihood of technology adoption and later on in the project, the user attitude towards services offered in conjunction or integral with EV charging. The interaction with users in these surveys offers an added advantage of helping to bring EV’s to the fore in their thoughts while educating them on the differences between myth and reality of the technology.

2.6.5 Data Analysis

There will be large volumes of data to be analyzed either by the project planner or a third party (e.g. joint partnership with a local university). An indicative plan of activities relating to data capture and analysis in the short, medium and long term is shown in the table below.

Time Period	Activities
Short Term	• Grouping of infrastructure types • Location coordinate grouping • Development of data templates • Algorithms tuning • Vehicle technology assessment • User attitude surveys (technology) • Usage reporting/recommendations
Medium Term	• Validation • Technologies pilots • Integration of new data points • Expansion of algorithms • Services oriented reporting • User attitude surveys (technology & service) • Infrastructure recommendations
Long Term	• Validation of data sets at intervals • Technology validation • Data expansion • User attitude surveys (technology & service) • Extra-regional assessment • Services reporting

Table 3 – Data Collection and Analysis

3 Macro Level Planning

3.1 Introduction

This chapter explores the macro level planning issues that the planner will encounter when initially planning a charge point infrastructure. While existing ICE vehicles are refueled en route in service stations, it is likely that the majority of EV charging will occur while the vehicle is parked at its journey destination with the only exception being for long journeys where intermediate fast charging is required. Note also that in some cases EV users may never use the public infrastructure (i.e. suburban commuting with home and/or work place charging). Monitoring of early EV adopters is necessary in order to inform future charge point placement strategies.

3.2 Sources of Planning Data

The following is a list of data sources for planning an EV charge point infrastructure. While data from all of the sources below may not be essential, the correlation may indicate suitable locations for charge point infrastructure previously unidentified.

3.2.1 Census Returns

The census returns for a region will detail population figures, home and work locations and travel times and modes. This data is typically available free of charge from a region’s central statistics office or similar Government department.

3.2.2 Geographical Information Systems

Systems such as Google Maps, Google Street View or alternatives provide a free and user-friendly method of locating relevant road networks and sites for charge points.

3.2.3 DSO (and other) Infrastructure Records

DSO’s will maintain detailed records of the locations of their electricity systems. Typically these records can be accessed via some computer database with GIS output. In addition municipalities are often also infrastructure owners. Examples include networks of ducts for electricity supply for traffic signal control, for street lighting, ICT services, etc. Municipally controlled operations of car parks, depots of fleet vehicles (bus, street cleaning, etc...) can also provide data that the planner may usefully take into account. Where collaborations exist, such information may assist in the planning of CP works installations and costings.

3.2.4 Travel Patterns and Parking Habits

Work undertaken either by planners to map out travel patterns and parking habits will be invaluable in optimizing locations so that charge point use is maximized. This information may be obtainable from the local transport plans or through the engagement of parking consultants. Organizational travel plans can be used to identify charge point locations for fleet and employee vehicles. They can also be used to identify specific employees for whom electric vehicles might be particularly suited.

3.3 Geographic Coverage

The standard layout of a city lends itself to the placement of charge points (i.e. on-street parking, park houses, park and ride sites and fast charge points on main arterial routes). In city centres however there may be limited availability of parking spaces. The city or transport authorities may be actively discouraging private vehicles from entering city limits. Some regions (i.e. London) may encourage EV use by making EVs exempt from congestion charges. The figure below shows the general planning approach taken by ESB ecars based around Dublin City in Ireland. As can be seen, fast charge points are installed in intercity locations, with park & rides facilities allocated AC charge points in suburban locations and park-houses and on street chargers located in the city.

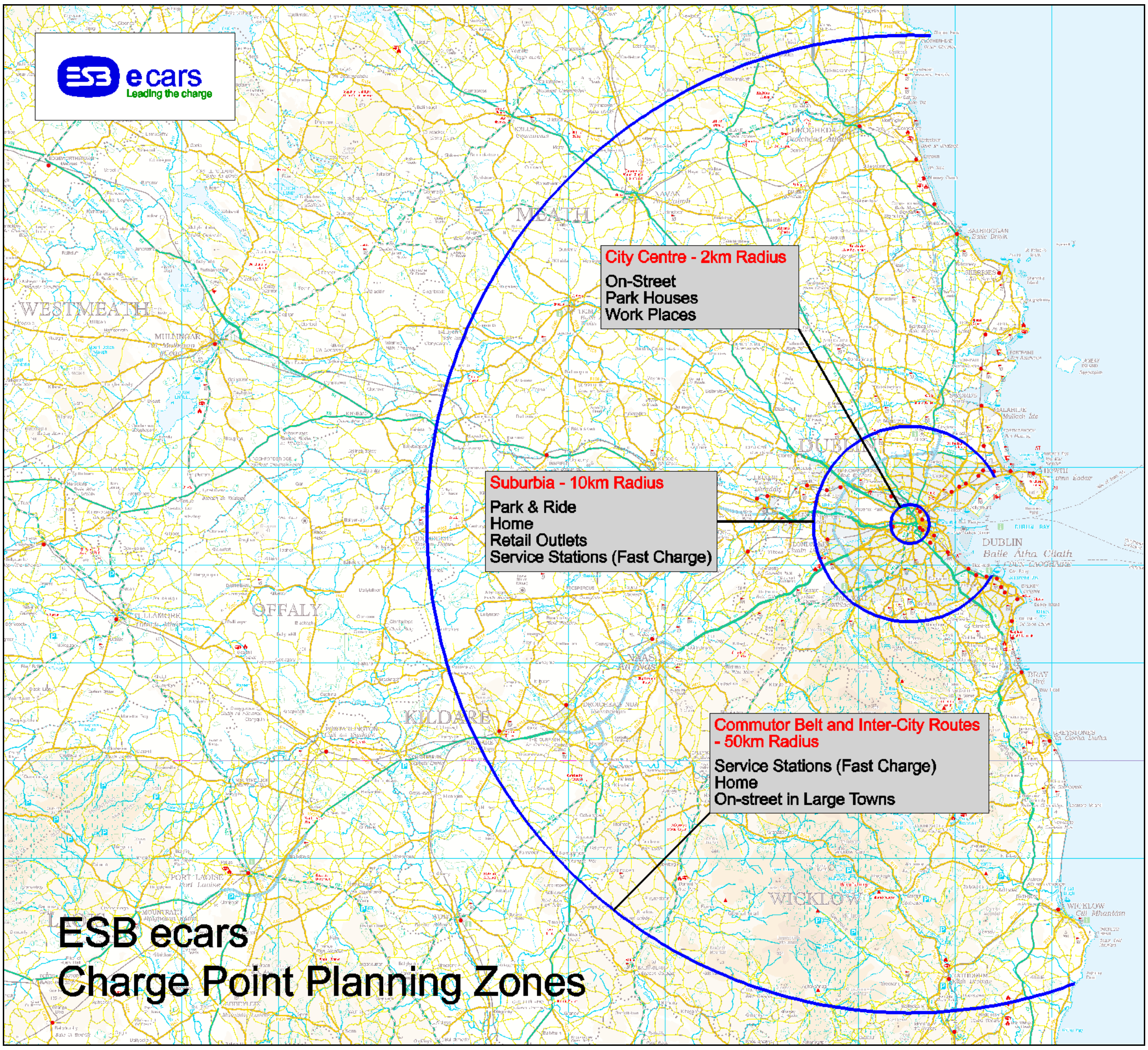


Figure 3.1 - ESB ecars Charge Point Planning Zones

ESB ecars is however rolling out a nationwide publically available charge point infrastructure. The figure below shows installed charge point as of July 2014 (not including home charge points). Fast charge points are installed at distances of approximately 60km along the motorway network. 44kW double-headed (i.e. 2 × 22kW) AC charge points are installed in towns with populations above 1500.

Figure 3.2 - ESB ecars Charge Point Map

3.3.1 Destination Charging

In the long term it is likely that the parking behavior of ICE vehicle users will be replicated by EV users. This is intuitive as once the EV users become accustomed to the range of the EV then they will be less likely to require the use of public infrastructure. Once this information is known the planner can then tailor the charge point infrastructure to meet the needs of the EV user. Parking behavior in different regions may differ in many ways due to regional planning and hence the charge point infrastructures may take different forms. For example the following factors may influence the parking behavior of EV users:

- Park and ride facilities.
- Congestion charges and other private vehicle barriers.
- Level of home ownership and off-street parking.
- Availability of park-houses.
- Availability of on-street parking.
- Availability of work place charge points.
- Free parking.

3.3.2 Fast Charging

For fast charging the location of the fast charge points is dictated by the range of EVs on the market. Currently the range of a modern EV travelling at motorway speeds is approximately 120km. It must be noted however that fast charging of an EV battery can only be achieved between battery states of charge of 10% to 80%. After 80% charge is reached, only a slower rate of charging is available. It is unlikely that the EV user will wait the extra hour or more while the EV charges from 80% to 100%. Therefore the EV user will leave the fast charge point with only 80% battery capacity and hence a range of less than 100km.

Some EVs will have lower ranges than average and some EV users will leave their initial journey start point with less than 80% charge therefore the distance between fast charge points must be considerably lower than 100km. It is unlikely however that new motorway service areas will be built solely to support the introduction of electric vehicles. Existing motorway services areas are suitable locations for fast charge points and are typically located at intervals of approximately 50km along motorway networks. Where these are located at greater intervals, the planner must consider locating fast charge points off the motorway network in adjacent towns.

3.4 Charge Point Numbers

There are no specific guidelines for regions as to how many charge points are required to support a fleet of EVs. Below are some possible design criteria. It is likely that the actual correct number of charge points is some derivative of these.

3.4.1 Existing Fuel Stations

A region will have an existing network of refueling stations (petrol / services stations). A ratio of refueling stations to existing ICE vehicle users can be defined and hence a ratio to predicted EVs can also be defined. A factor may be introduced to represent the fact that the range of an EV is less than an ICE vehicle. This however may be offset by the fact that many EV users will have charge points installed in their homes, an advantage not available to the ICE vehicle user. It must be noted however that the refueling time for an ICE vehicle is shorter than the charging time for an EV which may introduce an additional factor. Each of the factors will be specific to the project region.

3.4.2 Spatial Study

Spatial studies can be used to plan the charge point infrastructure in areas such as city centers. The sample below shows a map of Dublin City centre with 300m diameter circles overlaid. A charge point installed at the centre of each of the circles gives even geographic coverage across the city and ensures that if one charge point is malfunctioning then there are numerous others close-by. This method however has the disadvantage that is does not discriminate between retail, commercial or residential areas of the city.

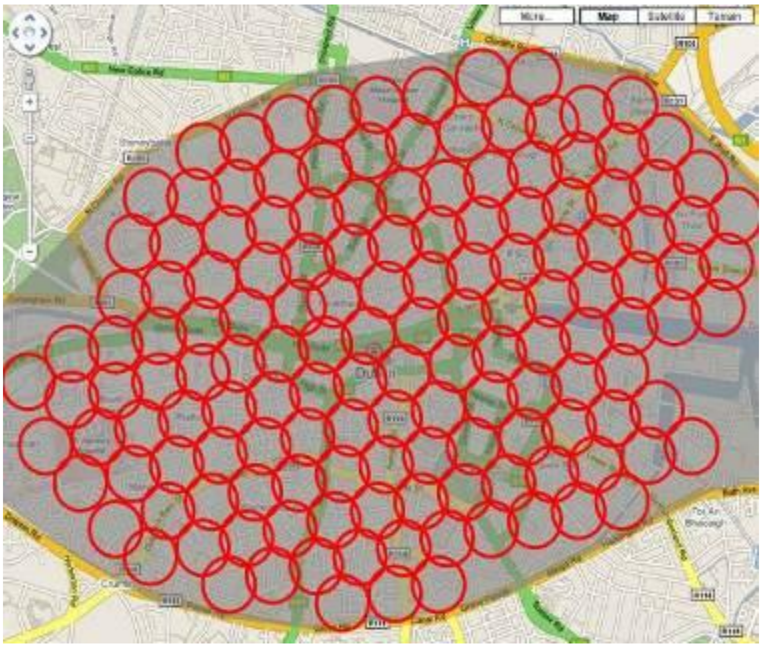


Figure 3.3 - Spacial Study of Dublin City

The figure below shows the preferred charge point locations for the City of Copenhagen covering the metropolitan districts of the inner city and the surrounding suburban areas. These locations are based on the availability of parking, distance to local LV infrastructure and travel patterns.

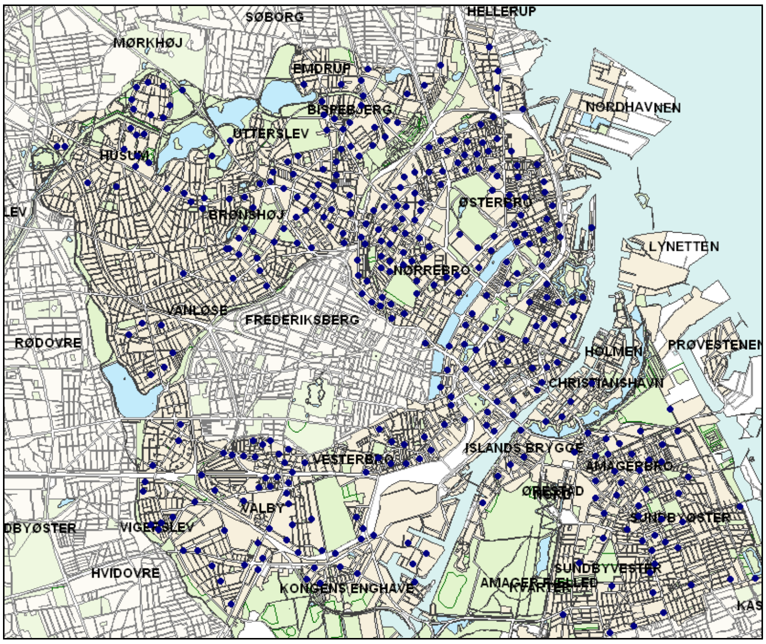


Figure 3.4 - City of Copenhagen Preferred Charge Point Locations

Barcelona, like Malmö, has developed a public CP network comprising both off-street and on-street charging points. Whilst the objective is similar (to facilitate access for the large proportion of citizens living in multiple household buildings where "home" based charging is problematic), the focus in Barcelona is initially upon the on-street CPs since most of those EVs currently owned by citizens are e-scooters. Planners need to consider the type(s) of EV for which the CPs are going to be used when deciding between options for infrastructure provision.

Figure 3.5 - City of Barcelona Charge Point Map (Source: Live Indicators, May 2012)

3.4.3 Number of EVs

Charge point numbers may be estimated by assessing the needs of existing EV users and planning based on expected EV sales figures. Municipalities or regions may dictate that a percentage of vehicles bought by the public authorities must be electric. The charge point infrastructure for the public authority vehicles may be shared with the private EV users.

3.4.4 Population

Charge point numbers may be a ratio of town and city population figures. This is a useful approach at the start of a project in order to get geographic coverage however it is not a practical long term approach as towns and cities of different sizes may have significantly different demographics (i.e. low car ownership but high population in urban centers, unequal distribution of wealth).

3.4.5 Engagement of EV Owners in CP Deployment

Planners should consider carefully what the larger urban authorities can contribute when developing the CP deployment plans. Often, urban authorities offer EV owners reductions or waiving of local circulation taxes or priority access to car parking. Where they are actively promoting some part of the CP network it is often the case that recharging is offered free of charge – at least in the initial stage of deployment. Some authorities are using card-based registration to manage these incentives. Barcelona is one such city, and the information about EV owners registering into the scheme is used to improve the plan for locating the next batch of CPs – see figures below.

Figure 3.6 - Charge Point Card Registration Point (Source: Pruneda et. al. 2012)

Figure 3.7 - Charge Point Access Card (Source: Pruneda et. al. 2012)

3.5 Conclusion

This chapter has identified some of the essential planning sources needed by the charge point infrastructure planner. In addition, a number of different macro-level planning approaches have been discussed. Planning examples from several different regions are shown. The approach taken by a potential planner will depend on the specific characteristics of the region involved.

4 Micro Level Infrastructure Planning

4.1 Introduction

This chapter explores the micro level issues encountered when planning an EV charge point infrastructure. The micro level issues are much more hands-on than the macro level ones discussed in Section 3. In many cases these issues are already covered in utility or municipality guidelines; they are included here however on the assumption that the planner has no previous experience in the area.

4.2 Design Criteria

The following is a list of design criteria to consider when choosing a charge point location.

4.2.1 Electrical Supply

Public charge points will require a connection to the local electricity system. The lack of a nearby electrical supply or electricity system supply restrictions may mean that placing a chargepoint in a particular area may not be feasible. While modern EVs have certain minimum load requirement, the planner must be aware that future EVs with larger battery packs may require more power. It is recommended to choose locations where future upgrade of the supply capacity is easily implemented.

In Ireland, the DSO has the following guidelines for connection of 2 x 22kW three-phase charge post to the low voltage network.

1. The transformer loading must be maintained within its name-plate capacity.
2. The loading on the LV circuit (including the 44kVA) must be less than 150kVA (approximately 200A) for 95mm^2 copper cables or 200kVA (approx 280A) for other urban circuits.
3. the charge post must be located within the following zones:
    - within 200 metres of MV/LV transformer if on 185mm^2 aluminium XLPE cable.
    - within 130 metres of MV/LV transformer if on 120mm^2 aluminium XLPE cable.
    - within 100 metres of MV/LV transformer if on 95mm^2 copper cable.

In some of the cases above these guidelines are based on experience rather than on direct measurement or calculation. Outside of the above guidelines a new outlet must be designed. Studies are also underway to determine the magnitude of the harmonics being produced by EV power electronics.

4.2.2 Integration into Existing Streetscape

On-street charge points shall be designed and located so that they complement the existing streetscape. Particular note should be made of historic buildings. Locating charge points in areas where there is a large concentration of existing street furniture shall be avoided (i.e. lamp-posts, telecoms cabinets, bins, bollards). Such locations will lead to pedestrians walking around the charge points and will increase the possibility of tripping over EV charging cables. Charge point suppliers suggest that the posts are located approximately 0.5m from the road curb line. Charge points should only be installed in areas with wide footpaths allowing easy access for pedestrian traffic.

The installation of charge points in public off-street car parks needs to be realized in collaboration with the car park operator(s). Ideally, charge points will be located in the floors nearest ground level; this is as much related to ventilation optimization and safety standards as it is to the assignment of preference to EV users.

4.2.3 Size of Parking Spaces

Different EVs can have charging inlets in different locations on the vehicles. In the majority of cases the EV user will have to open the boot of the vehicle, remove the charging cable and plug it into the EV and the charge point. All this additional movement around the car after parking is not required when driving an ICE vehicle. The EV driver therefore may require wider parking spaces than ICE vehicle drivers. The use of large parking spaces can also encourage the purchase of EVs by wheel-chair users.

Collaboration with municipal transport planners is recommended since they have the responsibility for vertical and horizontal signing on streets. A variety of EVs may have to be catered for; the layout for loading spaces for an e-truck - is not the same as that for e-scooters or a Twizzy car-share club.

4.2.4 Road Network Changes

The planner must be cognisant of future road network changes and regional development plans. Early interaction with planning authorities will avoid unnecessary delays and cost.

4.2.5 Parking Restrictions

Carparks with restricted opening hours or maximum stays should be avoided so as to grant the EV users flexibility in their charging regimes.

4.2.6 Single Parking Bays

Single parking bays do not offer expansion capability or flexibility if an ICE vehicle is parked in the EV space. In addition, more charge point manufacturers are offering double-socket charge posts as their standard product and single post options are becoming obsolete.

4.2.7 Lighting and Security

Locations that are well lit are less likely to be subject to vandalism and are safer in terms of slipping and tripping risks. The figure below shows a charge point in a busy shopping centre which has 24 hour security and CCTV.

Figure 4.1 - Charge Point in Shopping Centre Carpark

4.2.8 Location of Other Utilities

While it is desirable to have a nearby electricity supply available, if there is other utilities services (such as water, gas, telecoms etc…) in the vicinity then the civil works cost may increase substantially.

4.2.9 Green Hubs

There is a potential to create green hubs by locating EV charge points next to cycle parking (whether electric or push), car club bays and recycling areas. This may indicate to potential EV purchasers that the region is making significant investment in green hubs and therefore may add further weight to an EV purchase.

4.2.10 Location Profile

High visibility for a small number of public charge points is important to encourage EV uptake however it must be noted that parking spaces in high visibility areas will be at a premium and may be occupied by non-EVs. In addition there is a significant increase in the civil works costs associated with installing charge points in high visibility parking spaces (i.e. resurfacing cobblestone etc…).

A number of early EV adopters have indicated their wish to locate charge points in low profile areas so as to minimise the chance that the EV parking spaces are not occupied by non-EVs. Having said that, a number of ICT technologies exist that can automatically enforce the illegal use of (reserved) parking spaces (i.e. vehicle proximity checks at charge points cross-referenced with charging data). If public investment is aiming to promote the level of EV usage then a balance needs to be sought. The figures below show some of examples of charge point locations as provided by the task partners.

Figure 4.2 - Charge Point in High Profile Area in Ireland


Figure 4.3 - Charge Point Installed on Cobblestone Pathway in Copenhagen


Figure 4.4 - On-street CP for e-Scooters in Barcelona (Source: Live Office 2012)

4.2.11 Local Authority Revenue

In the short-term there may be a loss of revenue for the local authority as the EV parking spaces may not be occupied as often as standard parking spaces. The planner must be aware of municipal policies regarding EVs and re-charging. If revenue maximization is the municipal priority then the planner should try to locate charge points in rarely used parking spaces. However, if the Municipality is actively promoting EV up-take, then the loss of revenue may well be secondary to the aim of demonstrating high levels of EV space use – and the CPs should be located at the points of highest parking demand.

4.3 Sample Locations

4.3.1 Park & Ride Facilities

The parking time at park & ride facilities is typically quite long and hence is suitable to standard AC charge points (16 amp / 32 amp single-phase). Parking at these sites keeps traffic out of city centre areas and hence installing charge points would be agreeable to city planners. An example of charge points installed in a park and ride facility in Ireland is shown below. This site is located in the suburbs of Dublin City and is serviced by the LUAS light rail system.

Figure 4.5 - Multiple Charge Point in Park & Ride Facility in Ireland

4.3.2 Fuel Service Stations

Fuel service stations are convenient sites for locating fast charge points, particularly along inter-urban routes. The sites typically have suitable facilities for short stays such as a shop, hot food, seating area, toilets and may be open 24 hours a day. Note that in some regions emergency switches are installed at fuel service stations which may complicate supply feeding arrangements for the EV charge points (i.e. having two independent supplies at one site may result in isolation issues in the event of an emergency). The planner may consider the use of shunt tripping on isolation points (i.e. a trip of the main site isolator sends a signal to the charge point isolator to trip also).

Figure 4.6 - DC Charge Point in Fuel Service Station

4.3.3 Main Streets

Locating charge points on busy main streets is not advised as the parking time tends to be short and hence it is unlikely that the EV user will plug in to the charge point. In addition local retailers may not wish for dedicated EV parking spaces outside their shop as initially the EV parking spaces will not be in use as often as a regular parking space. Early communication with local stakeholders about these topics is necessary in order to avoid difficulties.

4.3.4 Large Retail Outlets

Large retail outlets tend to have large carparks that are either never fully occupied or only fully occupied during peak times. Those with cinemas and restaurants will have longer parking times and will be most suitable for EV charge points. In addition large carparks offer the ability to complete charge point installation work without much disruption to the retail outlet.

Figure 4.7 – Charge Point in Shopping Centre Carpark

4.3.5 Sporting Venues and Theatres

The parking times for sporting venues (such as football stadiums) or theatres are suitable for EV charging however it must be noted that it is likely that these charge points will only be in use during match / performance times and may lie idle for large amounts of time.

4.3.6 Airports

Airports typically have two parking areas; long-term and short-term. The long term carparks are suitable for standard charging (AC 16/32 amps single-phase). The short-term carparks are suitable for faster charging (AC 32/63 amps three-phase or DC). Airports are also bases for car rental companies which may offer EV rental schemes encouraging green tourism.

4.3.7 Ports

Ports will tend to have waiting areas for car ferries and can be bases for freight delivery companies and as such offer a suitable place for EV charge points. Ports may also be bases for car rental companies which may offer EV rental schemes encouraging green tourism.

4.3.8 Tourist Attractions

Tourist attractions typically have large carparks and the parking times are suitable for EV charging. EV charge points at these locations will also encourage EV rental schemes and green tourism.

4.4 Required Equipment

Below is shown some of the required equipment for charge point installations excluding the actual charge points.

Interface Pillars
Below are some samples of charge point interface pillars which act as the interface point between the utility and charge point infrastructure operator. They are used to house equipment such as fuses, isolators, MCBs and RCDs. A charge point interface pillar is shown in Figure 4.7 below.

Figure 4.8 - Single Charge Post Interface Pillar

Figure 4.9 - Internals of Single Charge Post Interface Pillar

Figure 4.10 - Multiple Charge Post Interface Pillar

Figure 4.11 - Internals of Multiple Charge Post Interface Pillar

Vaults

Where installation of interface pillars is not appropriate or permitted, such as outside historic buildings or in areas where the footpath is narrow, the planner may decide to install the utility fuses and switchgear in an underground vault as shown in Figure 4.11 and 4.12 below. Note that this method may result in problems caused by flooding and reduces accessibility to switchgear during testing and maintenance. In Ireland the use of vaults has been very minimal for the reasons stated above.

Figure 4.12 - Underground Vault in Ireland

Figure 4.13 - Underground Vault in Paris

Bollards and Barriers
Below are examples of bollards and barriers used to protect charge points from vehicles.

Figure 4.14 - Bollards Protecting DC Charge Point

Figure 4.15 - Stainless Steel Bollards Damaged by Vehicle

Even with the use of bollards, charge points may get damaged. Below is a figure of a DC charge point which was reversed into by a truck with its tail gate down. It is not practical to protect charge posts against all eventualities and the planner must take a practical approach to protection bollards and be aware that some charge posts may get damaged in any case.

Figure 4.16 - Damaged DC Charge Point

4.5 Required Works

Below is a description of the works required by a combined civil and electrical contractor in completing EV charge point installations. In some cases these works may be completed by the planner's organization (i.e. as typically civil and electrical works carried out by municipalities or utilities) or contracted out to other organisations. This list is not exhaustive but represents the majority of work involved.

- Liaising with project leader and host management regarding sites meetings and job commencement.
- Liaising with project leader and host engineers regarding charge post location and location of other services.
- Provision of site specific method statements and risk assessments and any documents required by the host in order to obtain work permits.
- Collection of equipment from distribution centres and delivery to site.
- Mobilising a civil crew and equipment on site.
- Cordoning off a restricted zone (with appropriate cones, tape, signage and traffic management solutions so as to ensure public safety and minimise disruption to host customers).
- Identifying appropriate duct routes specific to site conditions.
- Cable tracing.
- Digging trenches (hand digging will be a requirement in proximity mini-pillars, ducting, transformers and other services). Trenches will typically be in grass, bedding, concrete, asphalt or cobble lock (i.e. typical surfaces in car parks or pathways).
- Installing ducts to utility standards.
- Installing mini-pillars, interface pillars, vaults, charge posts, earth pits, bollards, sign poles and plinths.
- Reinstating surfaces as found.
- Remarking of parking bays lines or similar which have been cut through.
- Reseeding of grassed areas and replacing wood chippings, topsoil, plants and shrubs.
- Removal of waste and power hosing of work area if required.
- Ground marking of car parking space.
- Installing and terminating electrical cabling.
- Performing pre-energisation electrical testing (i.e. continuity, insulation resistance, earth resistance).
- Providing electrical certification to electricity standards body (include charge post serial numbers).
- Liaising with utility regarding energisation of supply.
- Commissioning the charge point, uploading white-lists and noting exact coordinates.

Shown below is an example of a civils works drawing for installation of an AC and DC charge point in a fuel service station. In this example, an existing utility transformer was located on site and a low voltage feed was taken via ducting and mini-pillar to a large interface pillar and onto the charge points.

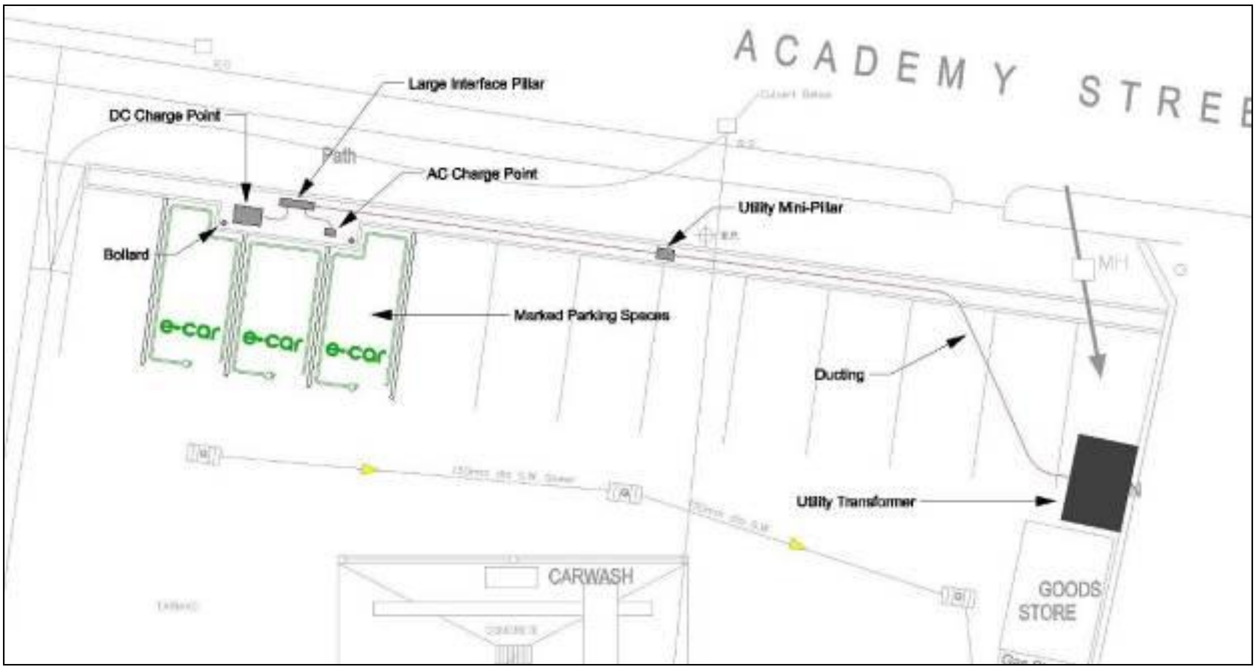


Figure 4.17 - Example of Civil Works Drawing

4.6 Servicing and Maintenance

The development of EV charge points is still in its infancy and certain manufacturers are not yet including communications modules in their products. This however is changing rapidly and it is likely that in the future all communications functionality will be available to those whose request this feature. Remote monitoring of the operating status of each publically accessible charge point is a necessity to avoid EV users getting stranded and the associated negative PR. If a charge point does not have remote communications functionality or a CPMS is not in place then routine inspections of the charge point will be required to check for operational status and vandalism.

Most manufacturers (particular those of DC charge points due to their complexity) do have a service schedule associated with their charge points. Typical requirements are:

- Daily inspection of output cable connector, intake and exhaust vents and charge point exterior.
- Monthly inspection of ventilation filters.
- Bi-annual replacement of ventilation filters.
- Bi-annual inspection of high current paths for sign of discolouration.
- Replacement of batteries on PCBs.
- Planned software upgrades.

In addition there may be other requirements such as:

- Cleaning the enclosure of the charge point.
- Cleaning the display panel.
- Cleaning contaminated data carriers (i.e. SD cards).
- Rebranding the charge point after vandalism.

There may also be a legal requirement from electricity standards bodies to physically test RCDs in charge posts. A selection of spare parts shall be stored by the charge point system operator and a log of charge point warranty dates shall be kept.

4.7 Health and Safety

Below is a list of health and safety issues that may need to be addressed as part of an EV charge point infrastructure project.

Tripping
The use of cables with conductive charging results in the risk of individuals tripping over the cables. This risk can be minimised by the use of bright coloured cables as shown below, coiled cables (may not be available for high power cables) and by locating EV charge points in areas that do not have pedestrian traffic.

Figure 4.18 - Yellow Coiled Charging Cable

Slipping
It is typical to mark or paint the EV parking spaces. Depending on the paint used this can create a slipping hazard. In order to mitigate this risk the painter should ensure that the finished surface has a pendulum test value (PTV) of greater than 35. Slip resistance tests should be conducted at a sample number of sites. Designs that reduce the painted surface area, as well as the use of slip-resistant coatings, are other factors to take into account.

Figure 4.19 – Fully Painted Parking Spaces

Figure 4.20 - Partially Painted Parking Spaces

Manual Handling

Publically accessible AC and DC charge points can be quite heavy with masses ranging from 50kg to 400kg. Transport and installation of the equipment may result in manual handling associated injuries. To mitigate this risk, manual handling guidelines given by the manufacturers shall be adhered to and forklifts, lifting slings, HIAB's and hand trucks shall be available if required.

Figure 4.21 - Installation of DC Fast Charge Point using HIAB

Road Safety
Due to the near silent nature of EV driving there is an increased risk (particularly in urban areas) that pedestrians and cyclists may be unaware of EV traffic. Some manufacturers are engineering synthetic noises which make people aware of an approaching EV. Planners should also include education activities directed at the general public and in particular school children.

Figure 4.22 - School Visits by ESB ecars in Ireland

4.8 Conclusion

On a micro planning level, this chapter discusses more practical infrastructure implementation topics such as; integration of charge points into existing streetscapes, electrical supply criteria, accessibility, public safety, civil and electrical works and service and maintenance. Charge point installation examples from many different regions are detailed.

Appendix 1 – Project Examples

Listed in this appendix are planning examples from the task partner regions. Certain partners have different roles in each of their projects (i.e. some are only overseeing projects whereas others are completing the detailed design). This is the reason why some examples are only described briefly whereas others are given in much more detail.

Malmö (Sweden)

Malmö has 300,000 inhabitants with 19% living in villas and 81% living in apartments. At the end of 2011, there were 15 electric cars registered in Malmö. Out of those, 7 are owned by the City of Malmö and 8 are owned by private persons or other organizations.

The network of recharging stations for electric vehicles in Malmö was formed, in March 2012, by 19 charging stations, which represent about 30-40 points. Out of these, approximately 21 charging points are located on ground surface and 19 in garages. There are two DC fast charge points. Locations can be found at http://www.uppladdning.nu.

The main base for the planning of allocation of charging infrastructure in Malmö is that charging will take place mostly at home and at work. Earlier demo projects (for example demo project CABLED run by E.ON in UK) have shown that the public charging was infrequent, despite free parking and electricity. Thus the main challenge is seen in providing charging infrastructure for people living in the apartments.

The first tests with installing charging spots on the streets in Malmö have shown that the costs for this is very high. Those installations were done in connection with test households: 20 families got the opportunity to use electric vehicle for 3 months. In connection to this, a charging spot was installed close to where the test families lived to enable charging of the vehicle.

The intention is to move most the parking and charging of the electric vehicles into parking houses, where the electricity is already available and no digging in the road or extension of cables is needed. It is estimated by the City of Malmö that most of the households living in the apartment houses have a parking garage in a reasonable distance from their home. Today there are approximately 20 charging boxes installed in the parking houses. Some of those are going to be rented for “long term renting” for the tenants and some are for short term parking.

Currently, there are preparations done for charging stations connected to solar panels. Those chargers (4-6) will be located on the parking lots in newly developed areas with focus on renewable energy and sustainability. As there are still very few electric vehicles in Malmö, the users, car sharing company, has been taken into consideration when choosing the location. One of the charging points will be used by a car sharing company and this will ensure that the charging point will be used daily. Also the demonstration purpose and visibility has been taken into consideration when deciding the location.

A1 1 - Charge Point in Park House in Malmo 1

A1 2 - Charge Point in Park House in Malmo 2

A1 3 - Charge Point in Park House in Malmo 3

The municipality has the aim to provide a functioning charge infrastructure for the citizens and visitors of Malmö. The aim is to reach a covering of Malmö where there are not more than 500 meters to the nearest charge point wherever you are positioned in the city.

The city of Malmö has made a decision not to own any charging infrastructure in the city. The infrastructure is to be built, owned and provided by private market actors. However, the city of Malmö is taking an active role in the planning and building of the infrastructure, partly to stimulate and kick-start the market and partly to make sure there will be some kind of standardization in payment solutions and distribution of charge points.
At the moment, the city is offering any organization who wants to build a charge spot to do this with financial aid from the city. This has been made possible due to EV projects such as Green eMotion. The 50% contribution from European Commission is combined with a 25% contribution from a national EV project and the remaining 25% is paid with tax money by the city. When the charge spot is built, the ownership is transferred to the part who wanted a charge spot by paying the 25% the city used. In this way, the building of charge infrastructure is stimulated. Since there are very few EVs in Malmö (about 18 out of 108000 registered cars in Malmö), the risk of building a large scale infrastructure is too great for a private company. By providing the mentioned financial help, this challenge is met and the discussion "no cars, no charging – no charging, no cars" is cut.

At the moment we have procured and deal with the charge spot provider Chargestorm. Chargestorm is a small development business who is delivering an advanced charging spot, meeting the specifications needed to deliver the data asked for in the Green eMotion project.

So far, few charge spots has been installed in Malmö. This makes the procedures slow since there are few or no routines in the city administration how to handle permissions and planning. Also, the market is still a bit slow in the region, but is wakening and will hopefully burst open in a very near future.

Bornholm (Denmark)

The number of homes on the island of Bornholm is near 20,500, in 2012, many of which are houses. The percentage of homes with dedicated parking spaces is estimated to around 75%. Data logging on vehicles has proven that the general travel patterns on Bornholm do not change much when converting the car to electric. This is due to the fact that the island is small and has not bridges connecting it to the mainland. Recent tests have shown that 50% of driving trips were less than 10km long with the vast majority of trips being made in the afternoon. The average speed was 40 km/h, with the max speed of 90 km/h (no highways on the island).

A1 4 - On Street Charge Points in Bornholm

A1 5 - On Street Charge Points in Bornholm

A1 6 - Car Park Charge Points in Bornholm

Copenhagen (Denmark)

According to the Copenhagen Climate Plan, the City of Copenhagen's vision is to become CO_2 neutral by 2025 and to reduce CO_2 emissions by 20% from 2005 to 2015. However, the goal of a 20% reduction by 2015 was already achieved by 2011, when CO_2 emissions were reduced by 21% compared to 2005. Nonetheless, green transport - e.g. electric vehicles – will play an important role in achieving the 2025-goal.

The City of Copenhagen is set on promoting EVs as an alternative to traditional cars. However, having a solid infrastructure is crucial for the citizens to feel comfortable choosing an EV. While many people can charge their EV at home, this is not the case for all. Most of the people in the inner districts of Copenhagen live in apartments and do not enjoy private parking facilities. Hence, there is a need for charging points on public land in order to ensure that all citizens are able to charge their EVs.

The City of Copenhagen is cooperating with external partners / private sector companies, such as CLEVER, establishing the public infrastructure for EVs. In order to encourage more Copenhageners to drive EVs, the City has given the external partners permission to establish more charging points than needed. The City will offer long-term concessions to ensure the full-scale roll-out of infrastructure on public land, when EU standards have been agreed upon. As harmonization of standards is very important for the mass rollout of EVs, the City will support the standardization efforts.

The population of the City of Copenhagen amounts to 549,050 people, and geographically the City is an area of 74.4 square kilometres. According to statistics, there are 95,000 cars in the City. Unfortunately, it is not possible to obtain data on the number of EVs in the City, but on a national level, the number amounts to 842.

Parking spaces with charging facilities are reserved for EVs, and the Copenhagen City Council has decided that 500 parking spaces on public roads can be reserved for EVs. If the need for EV parking spaces exceeds 500, the City Council will decide on how to proceed on the basis of the Technical and Environmental Committee's recommendations. As it is generally difficult to find a parking space in Copenhagen, the City expects that the reserved parking spaces will encourage Copenhageners as well as commuters to choose EVs. In May 2012, 75 charging points and 148 parking spaces were established for EVs. Additionally Better Place has established a battery switch station just outside the City of Copenhagen.

Permission to establish charging points is given by The City of Copenhagen for a period of 10 years. All expenses are covered by the private companies, except for signposting which is paid for by the City of Copenhagen. The City requires the external partners to ensure that all EVs have equal access to the charging points. As part of an application the EV-operator specifies the address in question and describes in detail the desired location of CPs and the accompanying meter cabinet, including underground cabling. Prior to applying for a permit, the individual EV-operator typically co-ordinates onsite installation and cabling needs with DONG Energy (one of the leading energy groups in Northern Europe and the national electricity provider).

Each charging station serves two EVs. The deployment norm for CPs in the City of Copenhagen to date has been 2 CPs per location with each CS featuring 2 power outlets of 16 amps each. Thus, an application for a CS-permit has typically resulted in an additional electricity requirement of 64 amps per location.

The City of Copenhagen is cooperating with DONG Energy to make a plan for the infrastructure for EVs on public land in Copenhagen. The plan was completed by the end of 2012. The City will request the Danish government to allocate funding for a national infrastructure for EVs. Without national co-financing, it is likely that the siting of the charging points on public land will be patchy and that the charging points will not be intelligent.

Additionally, the City is working with other Danish municipalities and Swedish municipalities in the Oresund Region to develop a common strategy for infrastructure for EVs. One example is the Interreg-funded E-mission project, which also entails the promotion of EVs.

Since January 2011, all passenger cars bought by the City (to be used by its employees) have been electrical or hydrogen cars. In May 2012, the City owned 38 EVs and 6 hydrogen cars. Before 2015, 85% of the City's passenger cars will run on electricity or hydrogen, equaling approximately 600 new cars. Petrol and diesel powered cars are replaced by EVs along with the need for their replacement.

The City has both experienced successes and hurdles with the municipal EVs in regards to infrastructure. The City of Copenhagen uses a slow charge system with a Mennekes plug. The number of CPs has been determined by the number of EVs on a 1:1-scale. As an alternative charging system, battery swapping was considered. Nonetheless, it was deemed unnecessary, as the current charging system is sufficient in regards to the needs. However, the infrastructure for the City of Copenhagen's cars is not fully complete yet. As we are dealing with new technology, one of the main hurdles is time consumption (e.g. if an EV has to be replaced, so does its CP, and the case processing time is rather long). Another hurdle arises due to the issue of parking spaces and CPs on public land. The problem arises as the CPs are placed by a parking space on public land, and there is no way to reserve the specific space for the City of Copenhagen's EVs. The 7 administrations (of the City of Copenhagen) may have to rent parking spaces from one another or rent spaces from an external provider, and licenses and permits must be applied for. Furthermore there must be a power source close to the parking space. The situation becomes more complex as the parking spaces cannot be located more than a certain distance from the offices, where the employees of the City of Copenhagen work (e.g. home care assistants must not walk more than 200 meters from their offices to their cars). On the positive side however, the CPs have generally worked fine. The overall performance level of the CPs has been a success, as the CPs have proven reliable.

A1 7 - Battery Switching Station in Copenhagen 1

A1 8 - Battery Switching Station in Copenhagen 2

A1 9 - On Street Charge Point in Copenhagen

A1 10 - Presenting RFID in Copenhagen

A1 11 - Close-up of Charge Point in Copenhagen

A1 12 - Plugging-in in Copenhagen

Barcelona (Spain)

Barcelona has 1.6 million inhabitants within $101km^2$ with a total of 4.2million people in the metropolitan region. Some 30% of the 1 million registered vehicles are powered-two-wheelers (PTW). At the end of 2011, there are 271 electric vehicles registered in Barcelona according to figures from the national MOVELE inventory.

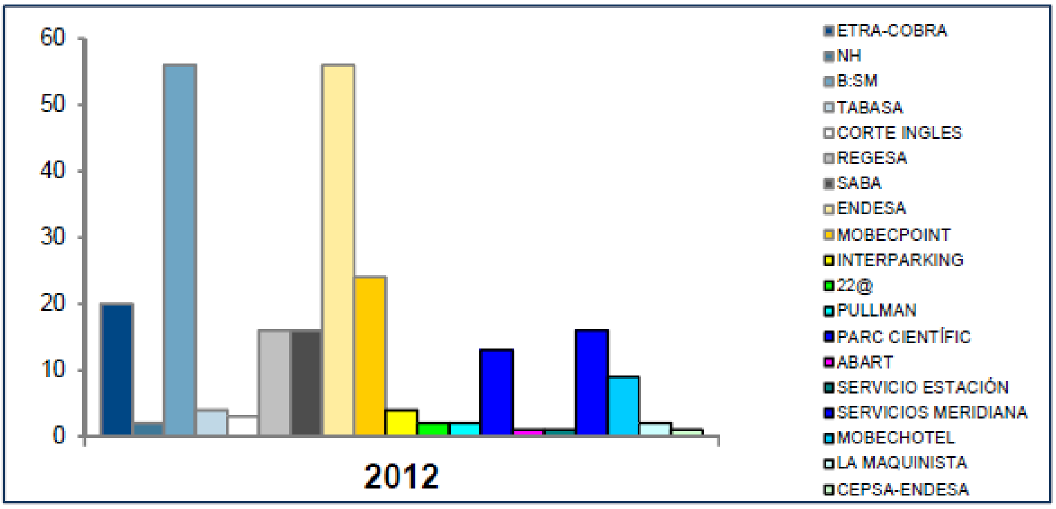
Survey data (2010) for the mobility split for internal and connecting city movements serves to identify two movements (as listed below) that can be targeted if electro-mobility is to positively impact on the city mobility and its environmental impacts (note: this survey data does not include goods movements for which survey data is not available but which are, in any case, a priority for the city):

1. PTW movements within the city (302,000 trips/day).

2. Car connecting movements (691,000 trips/day).

A1 13 - Electric Vehicles and Charge Points in Barcelona

Barcelona has an open policy toward infrastructure implementation - with a view to generating knowledge of what different technologies can achieve and at what cost. Various recharging infrastructure technologies are being implemented; AC for normal and semi-fast charge and DC for fast charge. In the case of AC the infrastructure is based on plugs of Type 2 combined with a Shucko type mode 1 for the first stage of implementation due to important penetration of PTWs. At the end of May 2012 there are 249 CPs (49% on-street, 51% off-street). The following figure shows that a large number of operators are involved in developing the CP network, the main ones being ENDESA and B-SM but with several operators each supplying 10 to 30 points (MOBEC POINT- IBERDROLA, ETRA-COBRA, SABA, REGESA). ENDESA is also operator of the Fast Charge pilot charge point. This is not just a pilot demonstration; it is operational at a CEPSA petrol station for all EV users who want to charge their vehicle.



A1 14 - Charge Point Suppliers in Barcelona

In the period up to 2012 it is important to establish a Municipal Control Centre (Network Operational Centre – NOC) to coordinate the various infrastructure offers such that users can be provided with clear information about what infrastructure is available for their type of vehicle and the specific conditions (point availability, price, etc...). The investment in electromobility in Barcelona over the period 2009 – 2012 is estimated to be over €3 million - more or less equally shared by the Municipality, central Government (MOVELE) and the private sector (note this investment does not include the Municipality's investment in human resources – at least 3 persons dedicated full-time coordinating actions across the Departments of Mobility, Environment and Economic Promotion). Green eMotion is of central importance concerning the demonstration of standards - but the level of coordination that is achieved will depend upon the brokerage of participations from the private sector.

The locations of public charge points can be found at www.livebarcelona.cat or http://w41.bcn.cat/web/guest.

The following figure shows that the recharging infrastructure remained unchanged during 2012 (249 points in total), with additional on-street charging points becoming operational during the first month of 2013. The total of on-street points (135) now slightly exceeds the total of off-street points (127).

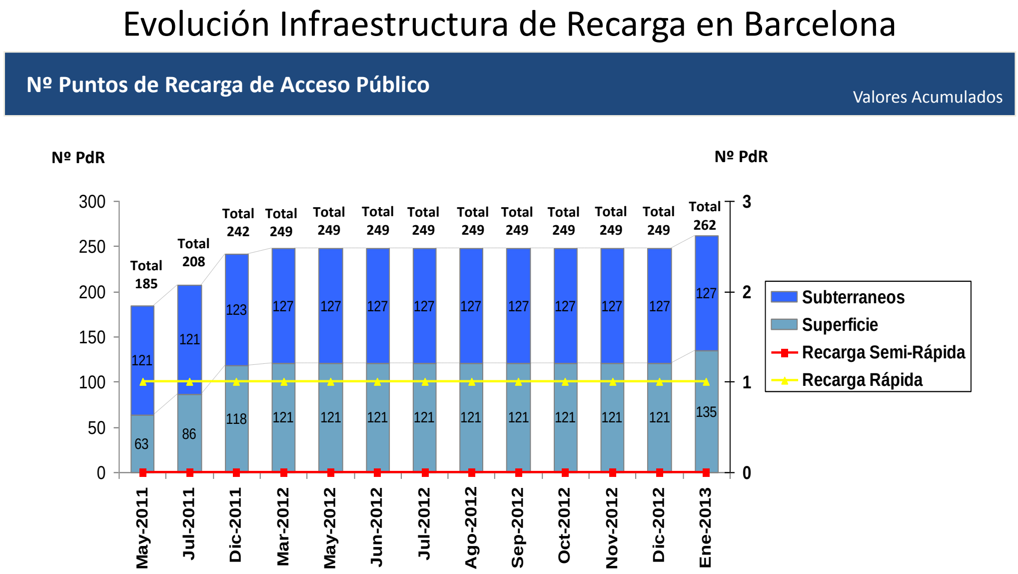


Figure A1.15 – Evolution of Charging Infrastructure in Barcelona

The next figure shows the trend in points and charging operations for on-street points. This shows that the majority of on-street points are dedicated to electric scooters. There were 4,329 recharges during 2012 (5,083 in total since monitoring started in the 2nd quarter of 2011) with an average consumption of 1.43KWh / charging operation. The monthly charge rate is fairly constant – around 360 charges per month.

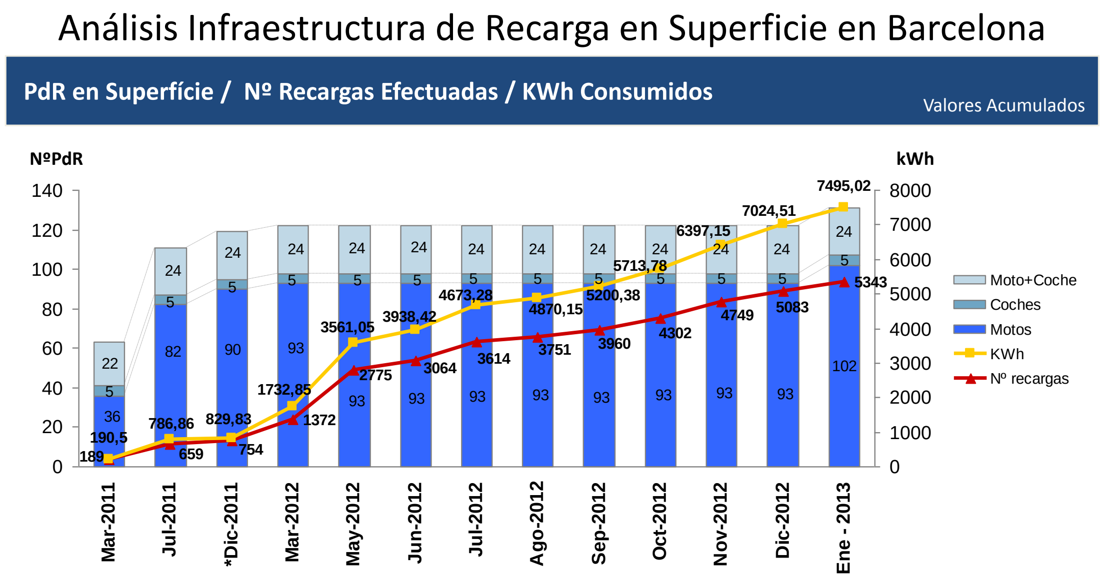


Figure A1.16 – Analysis of Charging Infrastructure Usage in Barcelona

Small vans continue to constitute the main part of the public fleet of electric vehicles, accounting for two-thirds of the total of 294 vehicles in 2012. All types of vans account for 265 of the total. In 2012, the number of electric cars (“turismes” in the figure) in the public fleet increased from 2 to 14 vehicles, with the total of electric scooters rising to 13 (public fleet) vehicles.

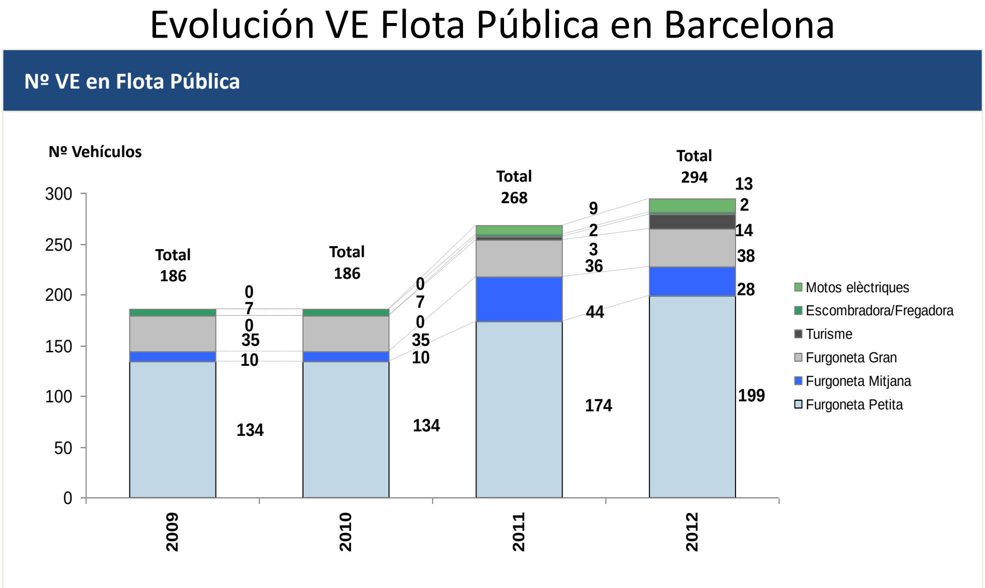


Figure A1.17 – Analysis of EV Fleets in Barcelona

We have data for the number of private electric vehicles estimated from the number of cards issued for accessing recharging infrastructure. The table below shows the trend in the numbers of private electric vehicles over the second six months of 2012 (the period of time for which data has been collected in this format). The table also shows the total number of electric vehicles (this combines the estimate of private vehicles with the public fleet vehicles presented above).

	June 2012	**Jan 2013**
nº of Private EVs (estimated from cards issued)	**126**	**347**
Motorcycles	84	129
Cars & Vans	31	161
Lorries	0	17
Mopeds	11	40
nº TOTAL of EVs	**394**	**641**

Table A1.1 – Number of EVs in Barcelona

There has been a strong increase (175%) in the number of private electric vehicles (from the base of 126 vehicles) in 2012. The number of cars and vans has increased over fivefold, and the total of 161 vehicles is similar to the total of 169 electric two-wheelers (motorcycles and mopeds). The first electric trucks have also appeared over this time. In Deliverable 2.3 of the Green eMotion Project an estimate of 96 private electric vehicles was presented for the end of 2011. From this we can compute the increase in the number of EV in a period of 1 year as being 261%.

It is also observed that the estimated number of private electric vehicles (347) exceeds the public fleet total (294) at the end of 2012.

Rome (Italy)

This section shows the EV charging site selection process use in Rome.

1. Site Choice

Nine possible positions were selected for the micro-mobility stations of the Rome demonstration. The “freight limited traffic zone” (ZTLM) of the centre of Rome has been chosen as boundary of the area of the intervention, however one possible station has been positioned out of the Freight ZTL. These stations have been placed strategically in correspondence with the main metro and tram stations and terminals of the city centre of Rome: Ottaviano, Flaminio, Termini, Ponte Vittorio; Argentina; Venezia, Cavour and Circo Massimo

Micro-mobility Station	Nearest Public transport station	Notes
Via Ottaviano	Metro A Ottaviano	Out of ZTLM, in an area with several relevant attractors
Flaminio, piazza del Popolo	Metro A Flaminio; interchange with Rome-Viterbo rail link	At boundary of ZTLM, close to a metro-regional rail interchange node
Stazione Termini	Metro A and B Termini, FS rail terminal	At boundary of ZTLM, close to the main transport hub of Rome
Ponte Vittorio Em. II	Bus interchange station	At boundary of ZTLM close to a bus interchange terminal
Largo Argentina	Bus route	Within ZTLM, position alternative to Venezia
Piazza Venezia	Bus route	Within ZTLM, position alternative to Argentina
Via Cavour	Metro B Cavour	Within ZTLM, completes coverage of area between Argentina and Termini
Circo Massimo	Metro B Circo Massimo	At boundary of ZTLM, completes coverage of southern area
Porta San Paolo	Bus and tram terminal, proximity with metro and major rail stations	At southernmost corner of ZTLM

Table A1.2 – Micro Mobility Stations

These nine points represent possible locations for micro-mobility stations, but their choice does not imply that all stations will be needed. In particular, the catchment areas of Largo Argentina and Piazza Venezia stations largely overlap; the catchment area of Ponte Vittorio is almost entirely covered by Ottaviano and Argentina together; the catchment area of Cavour overlaps with those of Termini, Circo Massimo and Venezia.

More detailed analysis on different parameters of choice will tell which and how many stations will be essential to provide an adequate service of micro-mobility for the central area of Rome. If a limited number of stations are required for an initial demonstration, some choices will be favored in respect to others:

Stazione Termini is by far the most important transport hub in the central area of Rome. Although it does not lie inside the ZTLM, it is an almost compulsory choice for a micro-mobility station. However, the traffic generated by Termini may be too high for a station of small size

Largo di torre Argentina and piazza Venezia: these two stations are largely interchangeable, both are placed centrally within the ZTLM and in an area with several relevant attractors; Piazza Venezia, in particular, is in the middle of the ZTLM and guarantees optimal accessibility to the whole area. Both represent good choices thanks to the accessibility they guarantee but neither is adjacent to a metro station.

Via Cavour: it lies within the ZTLM, close to a metro station and to relevant attractors. It is close to Termini station and its catchment area largely overlaps with that of Termini.

Ponte Vittorio, Circo Massimo and piazzale Flaminio: together with Termini, mark the four corners of the ZTLM guaranteeing a good coverage of the area, however they are not central.

Ottaviano San Pietro; this station is out of the ZTLM but close to a metro station and relevant attractors. It may replace Flaminio

Porta San Paolo; this station is at a corner of the ZTLM and very close to a number of public transport terminals. It may replace Circo Massimo.

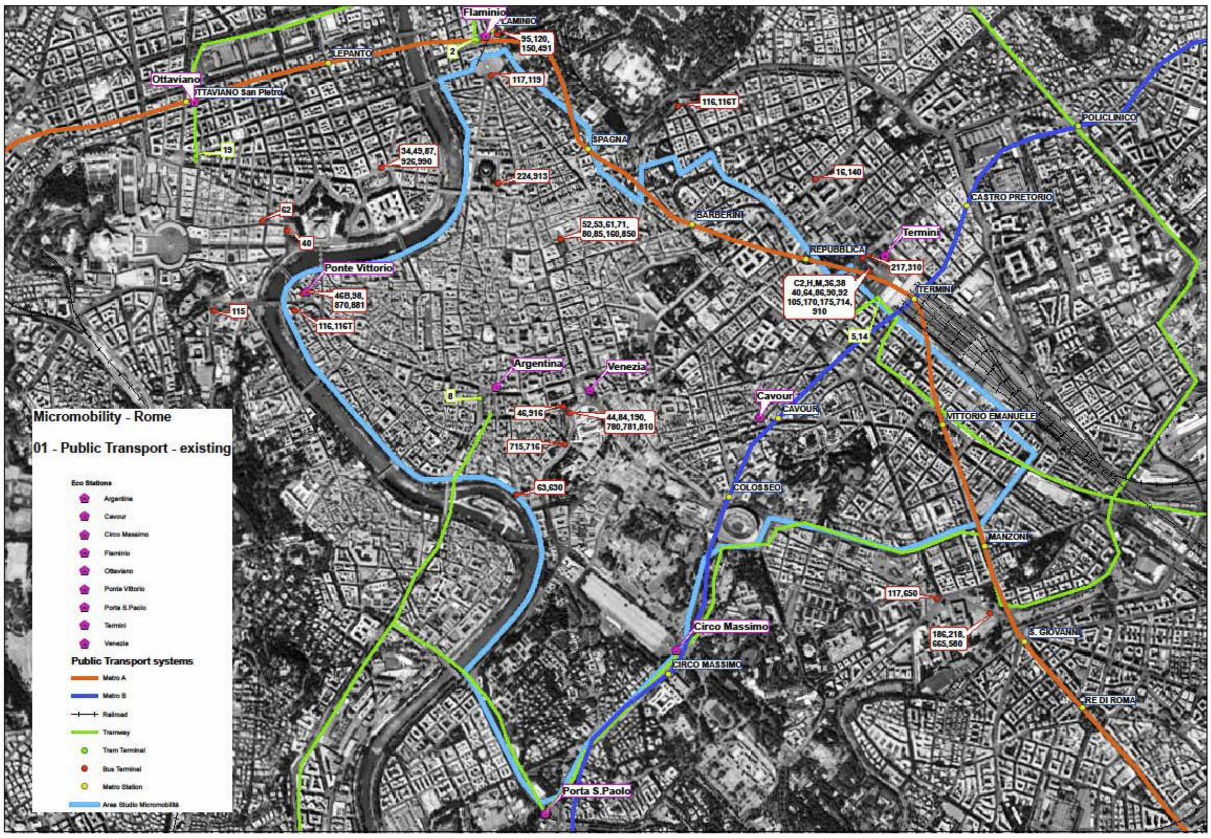


Figure A1.18 - Current Public transport system in the historical centre and possible eco-stations

2. Isochronal accessibility

In order to visualize the accessibility offered by micro-mobility in the city centre of Rome, a number of isochrones were calculated, which compare the accessibility area offered by micro-mobility with that offered by walking, within the same travel time intervals.
In order to produce the isochrones, speed has been set at 4 km/h for pedestrians and 15 km/h for micro-mobility vehicles. The increase of speed by a factor of 3.75 increases the covered area by a theoretical factor of 14. In reality, since the simulation is carried out on the existing networks for motor vehicles and for pedestrians, this factor of increase can be different.
The time intervals simulated (duration of trip) are 5 minutes and 10 minutes respectively. The images show the areas that can be covered within these two time intervals by each mode of travel, starting from the proposed micro-mobility stations, travelling on the existing network.
In the Isochrone maps below, the area that can be reached in 5 minutes is shown in green; the area that can be reached in 10 minutes is shown in yellow. From the images it is clear that the study area is fully connected by micro-mobility and most of it can be reached in 5 minutes (this time does not account for vehicle pick-up and parking), while walking only covers a limited and not connected area within the same time intervals.

Area	Extension of network within the ZTLM	Percentage of ZTLM network covered
Study area	148 km	100%
Walking isochrones 5 minutes	19 km	13%
Walking isochrones between 5 and 10 minutes	47 km	31%
Total walking isochrones	66 km	44%
Micro-mobility isochrones 5 minutes	135 km	91%
Micro-mobility isochrones 10 minutes	13 km	9%
Total micro-mobility isochrones	148 km	100%

Table A1.3 Area covered by micro-mobility and by walking

The table above shows the extension of network within the study area that is covered by the isochrones, respectively for walking and for micro-mobility. It must be noted that increasing the speed of a factor of 3.75 (15/4) will increase the area covered in a given time interval of a factor of 3.75^2 or about 14 times.
The Freight Limited Traffic Zone (ZTLM) area is highlighted and represents an area of reference for the project, although the study area will not necessarily be limited to this area. In fact, there are other important attractors outside the ZTLM that are of significant interest for the implementation of micro-mobility. Among these, the area served by the Station of Ottaviano. For this reason, the study area could be extended to the area covered in 5 minutes by micro-mobility from all the stations (green area in the images below).

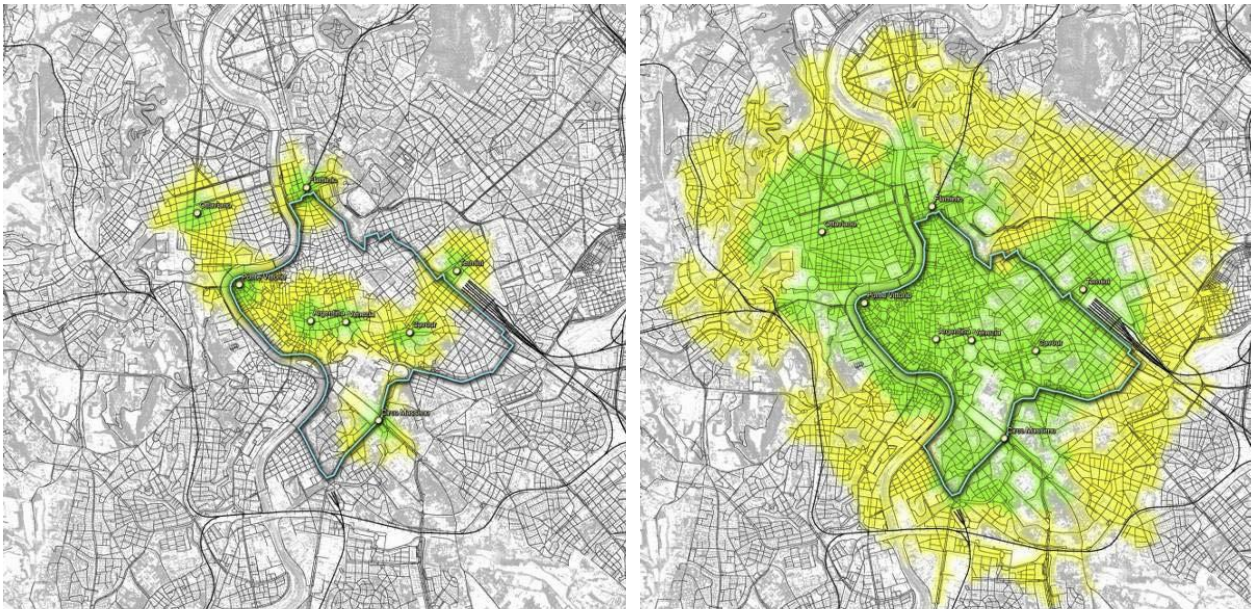


Figure A1.19 Combined 5 and 10 minutes isochronal accessibility from the 8 proposed micro-mobility stations in the historical centre of Rome: walking (left) and micro-mobility (right) compared

It is clear that the micro-mobility locations proposed are largely sufficient and even redundant to allow reaching nearly any point of the historical centre of Rome within 5 minutes from one station. The station of Venezia alone is actually sufficient to cover the entire ZTLM, although not entirely within 5 minutes.
The number and position of micro-mobility stations, both for the initial demonstration and for a full deployment of the service, will therefore be determined mainly by other parameters such as availability of floor space; spatial integration with public transport, presence of other services which may be in competition for space or customers; etc. A high level of accessibility is largely guaranteed by the choice made, even with 2-3 stations.
One station that was initially considered is that of Porta San Paolo. This location is an important tram line terminal and lies very close to the metro station of Piramide and the train station of Roma Ostiense. A micromobility station there would be conveniently placed near an important intermodal node. However, this location was discarded from the choice for a possible demonstration site, since it is very marginal in respect to the ZTLM and to the historical centre of Rome. An isochronal accessibility study has not been performed for this station.
The following images show a comparison between the accessibility guaranteed by walking and micro mobility in 5 and 10 minutes from a sample of the proposed stations. The difference is always apparent and in some cases substantial like at Circo Massimo, where walking guarantees a very low level of accessibility because of the lack of a proper network around it.

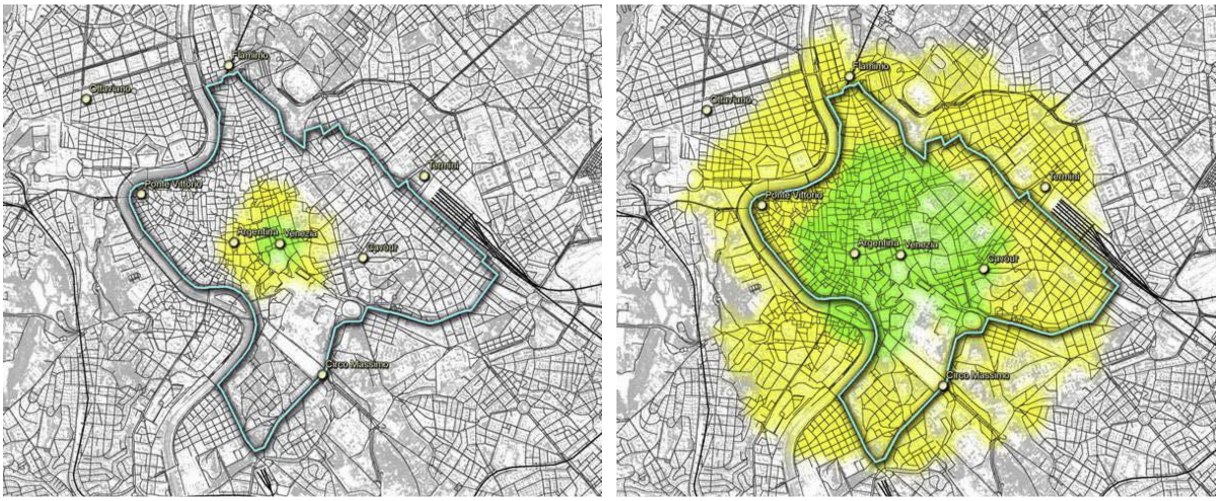


Figure A1.20 5 and 10 minutes isochronal accessibility from the micro-mobility station of Piazza Venezia: walking (left) and micro-mobility (right) compared

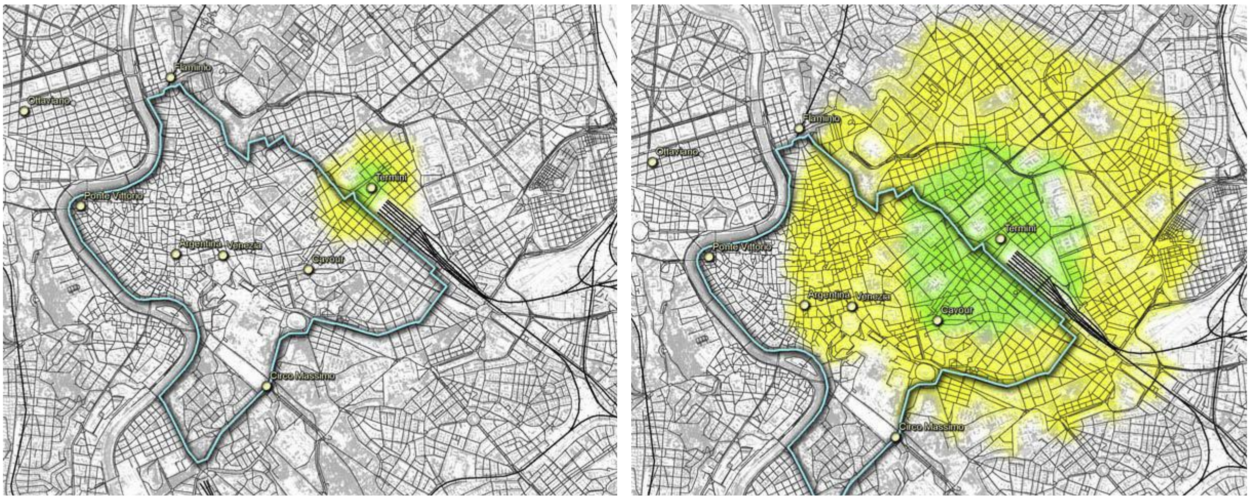


Figure A1.21 5 and 10 minutes isochronal accessibility from the micro-mobility station of Termini: walking (left) and micro-mobility (right) compared

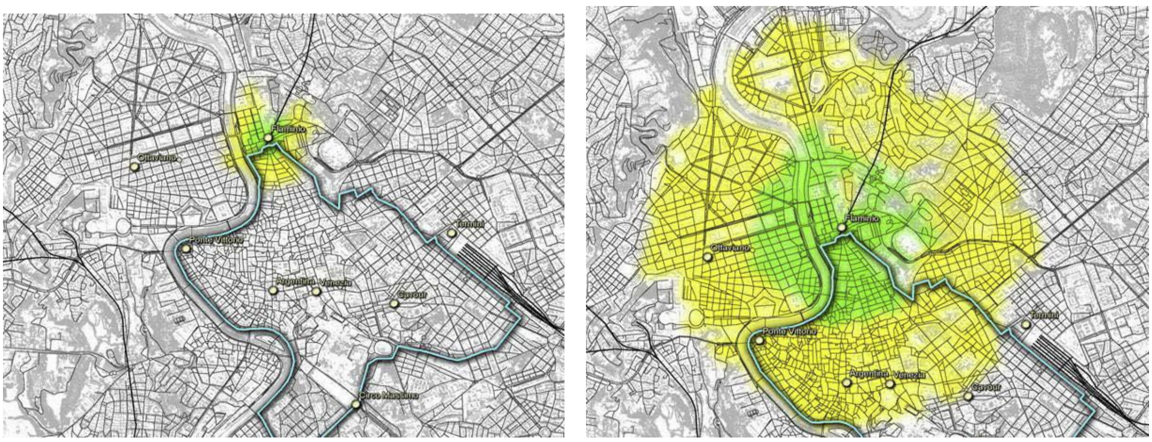


Figure A1.22 5 and 10 minutes isochronal accessibility from the micro-mobility station of Flaminio: walking (left) and micro-mobility (right) compared

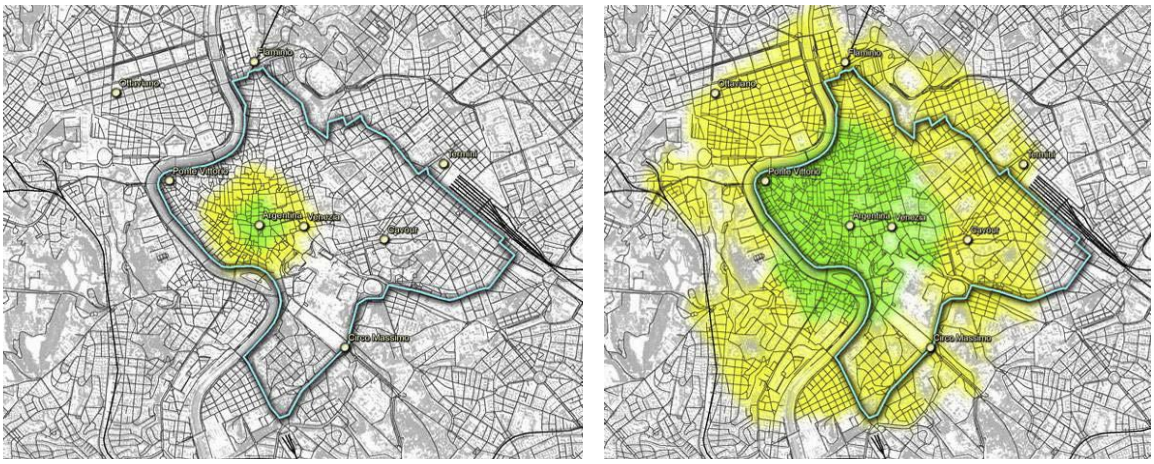


Figure A1.23 5 and 10 minutes isochronal accessibility from the micro-mobility station of Largo Argentina: walking (left) and micro-mobility (right) compared

Figure A1.24 5 and 10 minutes isochronal accessibility from the micro-mobility station of Circo Massimo: walking (left) and micro-mobility (right) compared

3. Design of the Stations

A preliminary schematic design of the stations has been made. This design is not site specific, but it is meant to provide a general guideline for the final design of each specific station. The schematic station has been designed based on the following parameters:

- modular design to accommodate city cars (e.g. E-Smart); quadricycles (e.g. Renault Twizy, Estrima Birò, Ducati Free Duck); electric scooters and “pedelec” (electrically assisted bicycles), in variable proportions
- presence of one information panel and one user interface “totem” as well as one recharge point corresponding to each vehicle stall

The total surface of the stations will depend on the number and mix of vehicles chosen, as well as on the layout, which will determine the maneuver spaces. The layout will be specific for each station and the modular construction of the station will allow a high degree of freedom in its determination. The figures below dictate elements and typologies of the micro-mobility station in different examples of layout. The layout chosen is only representative and can be modified both in the position, overall number and mix of vehicles, depending on the specific location and choices made. For example, on a streetside the stalls would be aligned on a single row. The sizes of the stalls depend on the size of the vehicles

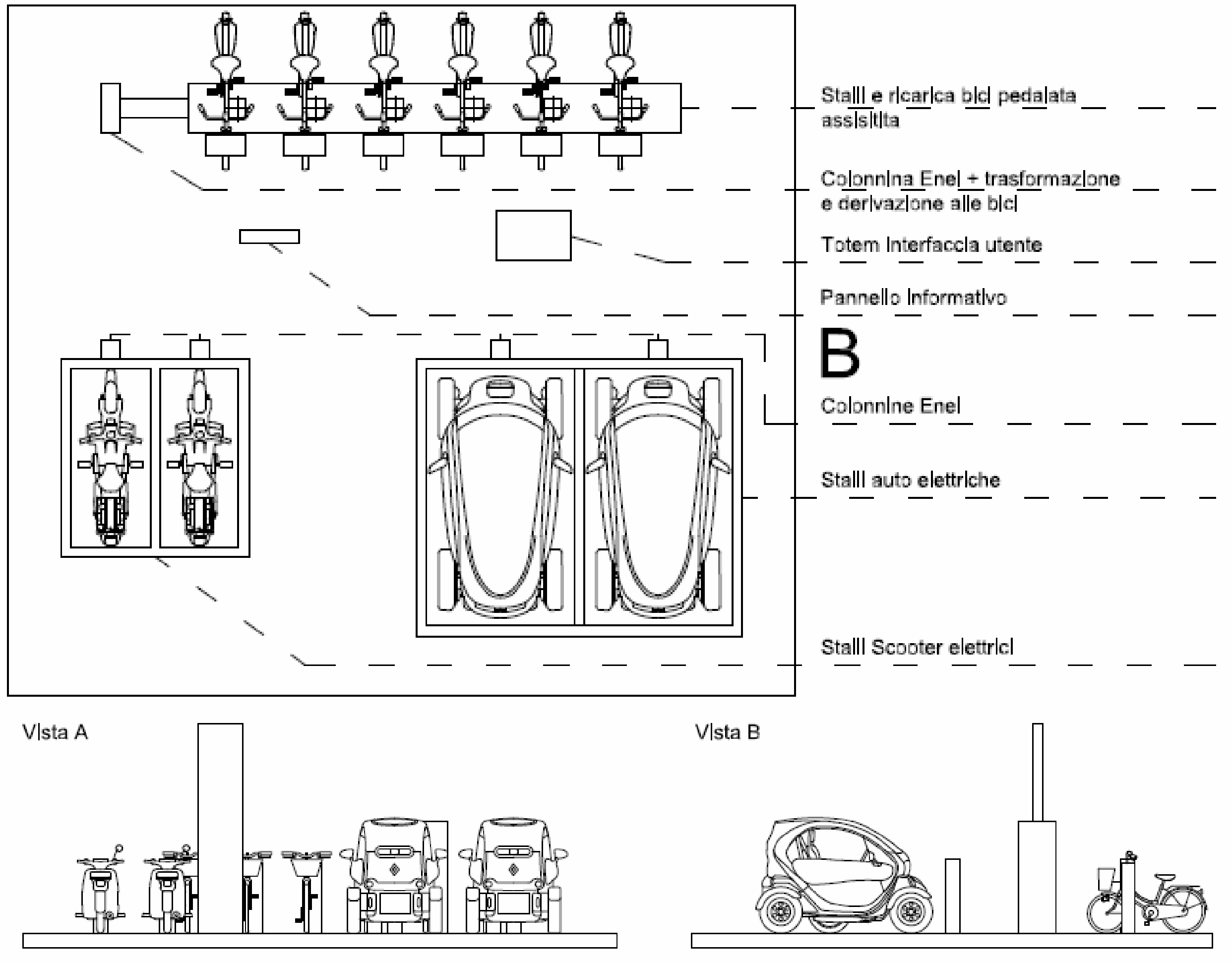


Figure A1.25 Schematic layout of a micro-mobility station with six pedelec, two electric scooters and two quadricycles (Twizy)

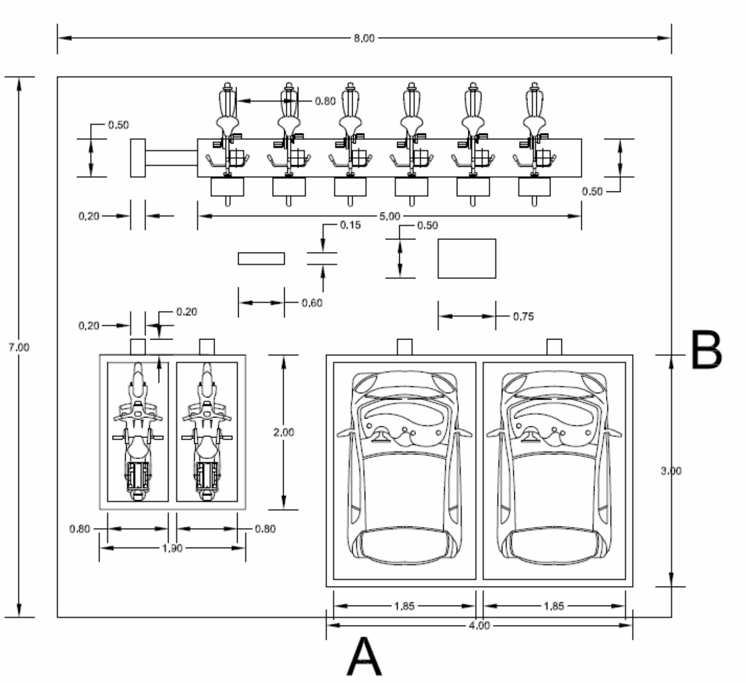


Figure A1.26 Layout with relevant measures of a micro-mobility station with six pedelec, two electric scooters and two city cars (E-Smart).

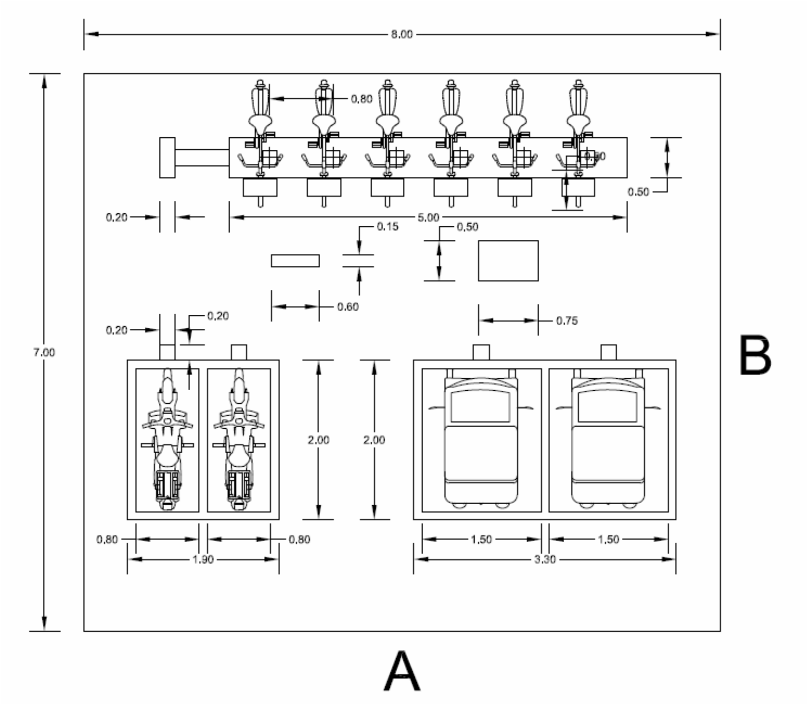


Figure A1.27 Layout with relevant measures of a micro-mobility station with six pedelec, two electric scooters and two city cars (Free-Duck).

4. Operator Activities

4.1 Activities that must be performed by the operator

The activities that must be performed by the operator of the micromobility service can be divided in four broad categories:

1. Customer side activities: activities related to the customer
2. System side activities: activities related to the management of the operation of the system
3. Components side activities: activities related to the management of the hardware and software components of the system.
4. Supplier side activities: activities related to the services offered by external suppliers

CUSTOMER-SIDE ACTIVITIES
- accounting and billing
- information and publicity
- helpdesk and troubleshooting
- road assistance and rescuing

SYSTEM-SIDE ACTIVITIES
- real-time fleet management,
- system re-balancing and energy management
- system performance monitoring
- fleet activity data collection

COMPONENTS-SIDE ACTIVITIES
- station maintenance and surveillance
- vehicle insuring,
- vehicles maintenance and replacement
- battery maintenance and replacement
- safety and security monitoring, prevention and resolution

SUPPLIER SIDE ACTIVITIES
- Liaison with the provider of electric energy
- Liaison with the public authorities
- Liaison and coordination with the public transport operator
- Liaison with the providers of other services

4.2 Management of the micromobility service

It is important to define more in detail a part of the activities defined before. The activities related to the day-to-day management of the service and relationships with the customer will be described below, including some alternative options that will require further discussion.
The integration with Public Transport, especially Urban Public Transport, is one of the main characteristics of the Micromobility system. From the point of view of the customer this means low ticket price, fare integration and spatial integration with public transport lines. From the point of view of the public administration this means to consider the micromobility service at the same level of the traditional public transport services in terms of tendering and fare compensation.
As with the traditional public transport services, the customer doesn't bear the total operational cost of the system, and the traffic revenues must cover only a percentage of the operational costs. The remaining quota is compensated by the public administration to account for economic benefits that characterize the Public Transport system such as reduction in pollution, CO2 emissions, noise, safety, space occupancy and so on. In general public transport companies have to guarantee a revenues-to-costs ratio greater than 35%. This is an important issue to take in mind both for public administration, planners and legislators when define the management of the micromobility systems.

The other important issue is that the micromobility management and fare system must be set paying attention to the competition with traditional car-sharing. Micromobility shall be limited in space and hire time, and must not compete with traditional car-sharing system, which is more appropriate for longer distances, longer use time and, in general, not integrated with the public transport system.

Providing micromobility as a form of public transport also means guaranteeing certain availability of vehicles during the time when the service is working. For micromobility this means that the customer should always be able to find a vehicle at the station and the operator must have a continuous and complete knowledge of vehicle' positions at any time. Appropriate vehicle re-distribution and assistance services must be defined, as well as the area where the micromobility vehicles are allowed to operate.
For the Rome Demo it is suggested to have as maximum hiring time 20-30 minutes and the vehicles can operate only within the railroad ring. In case of misusing high penalties are applied (50€).

Listed below is a series of issues that require to be set and quantified for an appropriate Micromobility system.

Registration modality

- Registering on web site, and at all public transport customer service points.
- Provide personal identification document, driver license, credit card reference
- Deposit (€)
- Reductions should be foreseen for PT users with annual subscription card or car sharing users.
- Annual subscription (integrated with TP subscription)
- Monthly subscription (integrated with TP subscription)
- Weekly subscription (integrated with TP subscription)
- Daily Subscription (integrated with TP subscription)
- A maximum number of micromobility subscriptions will be defined (e.g. 10x number of vehicles available)
- During the demo a specific subscription modality should be defined

Travel document

- Personal RFID1 Smart card, integrated with public transport annual subscription card or/and car sharing users

Access to vehicle

- Should be the same as car sharing system

Delivery of vehicle

- At the end of hire period, customer returns vehicle to station of departure or different station.
- Customer will be required to return vehicle to a station if maximum time is reached or supervisory system records a fault.
- Hire will be terminated by plugging in the recharging cable. Customer will lock the doors of the vehicle using RFID Smart card.
- An interactive screen at the station will show details of travel and cost on request. Details can be sent by e-mail or text message. The client will receive a monthly receipt.

Fares and penalties

- Minutes free within a specific area, within a given time (e.g. first 10 minutes)
- Cost for each minute after a given time. The cost for the service should be in line with the car-sharing cost.
- Penalty (50 €) is applied if a maximum hiring time is reached plus the cost for the hiring time.
- Penalty (50 €) is applied if the vehicle is out of specific area also before reaching maximum time
- Cost for each km out of specific area also before reaching maximum time

- Customized fares for frequent users(more than a given amount of h/week) or occasional users (less than a given amount of h/week) can be defined, see the Zurich experience.

Vehicle Reservation
- Within 20 minutes
- Using web site, via mobile phone, via iApp or phone line

Parking reservation of parking slot at the destination station
- Within 20 minutes using a totem at the station of origin, mobile phone, www, etc.

Parking
- During hire, free at any legally allowed parking within specific area

Control position and distance travelled
- By GSM on board integrated with supervisory system

Re-distribution
- Normally not performed
- Incentives to users to park at station suggested by control system
- Alternatively, redistribution is performed by operator.

Service information
- General information on billboard at station
- Totem at station, web site, call centre
- During the 1 month duration of the demo it is suggested to have a person to provide info at the station during day time

5. Fleet Scenarios

In this chapter two scenarios will be illustrated in terms of mix of vehicles available at the eco-stations.
The scenarios differ for the presence or not of pedelecs. We highlight that the terms of “electrically assisted bicycle”, “E-bike” and “pedelec” indicate a bicycle where the energy provided by the electric motor is in addition to that provided by pedal power; a sensor with a power control (PAS) delivers assistance only if the rider pedals. Electric motor assistance will stop if the speed exceed a defined value, generally 25 km/h. These features are important to classify this vehicle as a bicycle which is not subject to the laws and regulations regarding certification and operation of motor vehicles.
Electric scooters or e-scooters do not have these features, and the electric motor is independent from pedalling, if present.

5.1 Scenario 1 - Eco-stations with pedelecs

This is the standard scenario described in the chapter 3. Six pedelecs are provided in addition of two e-scooters and two quadricycles or mini-cars. The figure below show the version with the Renault Twizzy quadricycle. The dimensions of the stalld do not vary significantly if a different electric powered quadricycle is chosen (e.g. Estrima Birò or Ducati FreeDuck). They will vary instead if proper “electric mini-cars” such as the e-Smart are chosen To guarantee parking availability, the number of eco-station modules can exceed the number of vehicles.

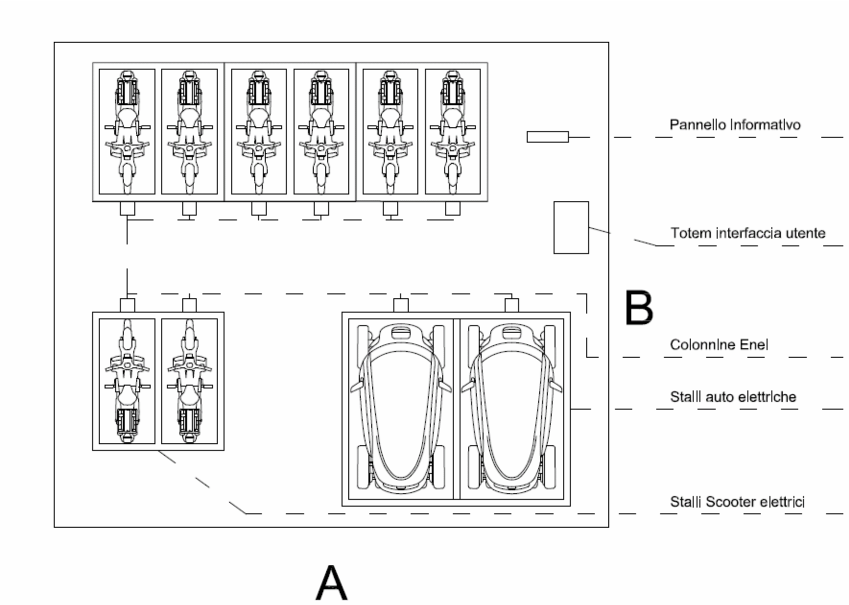


Figure A1.28 Station (7m x 8m) with electrically assisted bike – A linear module (14m x 5m) more appropriate for streets can be provided (see also next paragraph)

5.1.1 Scenario 2 - Eco – stations without electrically assisted bicycles

This scenario provide the same number of vehicles but using only e-scooters and quadricycles in two variants: eight e-scooters and 2 quadricycles or six e-scooters and four quadricycles. Figures below show the first solution. As before, the quadricycle proposed as an example is the Renault Twizzy.

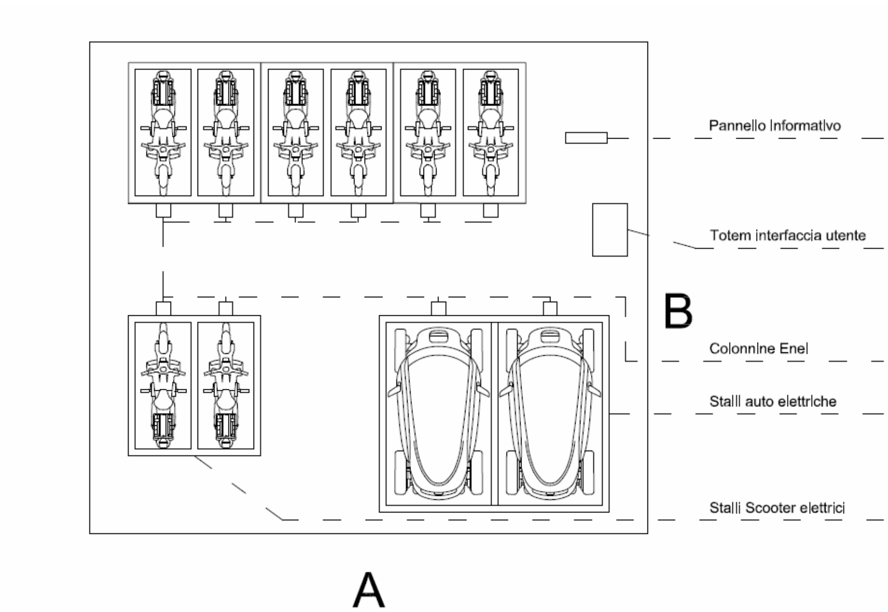


Figure A1.29 scenario 2a - station (7m x 8m) with e-scooters and quadricycles only

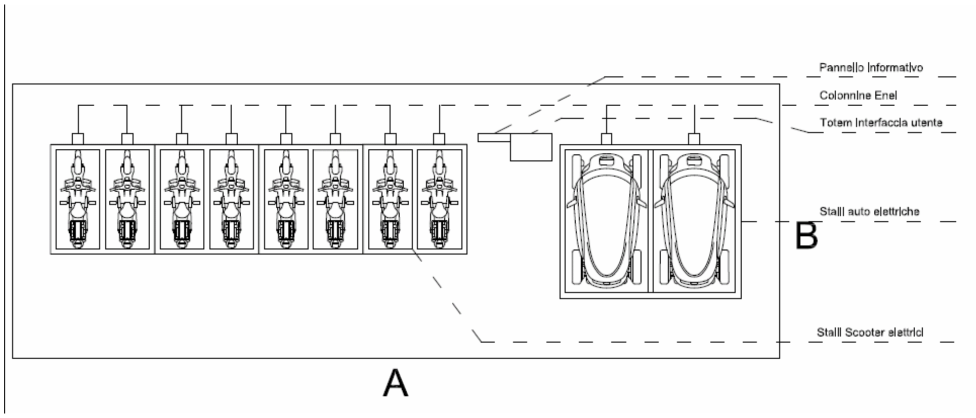


Figure A1.30 scenario 2a - (14m x 5m) with e-scooters and quadricycles only

5.1.2 Investment for the vehicles costs and differences between scenarios

Table 1 shows the differences in terms of investment costs for the vehicles for three different scenarios:

- Scenario 1: the number of vehicles is divided in roughly equal parts between pedelecs and other vehicles
- Scenario 2a: the number of e-scooters is increased to replace the pedelecs
- Scenario 2b: both the number of e-scooters and the number of electric quadricycles are increased to replace the pedelecs.

The number of vehicles has been set in 30 plus 10% for replacement. Clearly, given the same number of vehicles, the scenarios that do not include pedelecs but only motor vehicles determine a higher costs of investment. The costs assumed for the vehicles are indicative for each typology of vehicle. In the following tables some example of pedelecs, e-scooters and quadricycles available on the market are listed.

vehicles	unit cost (VAT excluded)	Scenario 1 n° of vehicles	Scenario 1 total cost	Scenario 2a n° of vehicles	Scenario 2a total cost	Scenario 2b n° of vehicles	Scenario 2b total cost
pedelecs	€ 1.000,00	17	€ 17.000,00	0	€ -	0	€ -
e-scooters	€ 3.000,00	8	€ 24.000,00	25	€ 75.000,00	20	€ 60.000,00
Quadricycles (Ducati Free duck)	€ 5.000,00	8	€ 40.000,00	8	€ 40.000,00	13	€ 65.000,00
		33	**€ 81.000,00**	**33**	**€ 115.000,00**	**33**	**€ 125.000,00**

vehicles	unit cost (VAT excluded)	Scenario 1 n° of vehicles	Scenario 1 total cost	Scenario 2a n° of vehicles	Scenario 2a total cost	Scenario 2b n° of vehicles	Scenario 2b total cost
pedelecs	€ 1.000,00	17	€ 17.000,00	0	€ -	0	€ -
e-scooters	€ 3.000,00	8	€ 24.000,00	25	€ 75.000,00	20	€ 60.000,00
Quadricycles (Renault Twizzy) - (1) (2)	€ 6.500,00	8	€ 52.000,00	8	€ 52.000,00	13	€ 84.500,00
		33	**€ 93.000,00**	**33**	**€ 127.000,00**	**33**	**€ 144.500,00**
(1) - 52,89 €/month battery hire							
(2) 578 €/month leasing car+battery							

vehicles	unit cost (VAT excluded)	Scenario 1 n° of vehicles	Scenario 1 total cost	Scenario 2a n° of vehicles	Scenario 2a total cost	Scenario 2b n° of vehicles	Scenario 2b total cost
pedelecs	€ 1.200,00	17	€ 20.400,00	0	€ -	0	€ -
e-scooters	€ 3.000,00	8	€ 24.000,00	25	€ 75.000,00	20	€ 60.000,00
Quadricycles (Smart electric) - (1)	€ 15.500,00	8	€ 124.000,00	8	€ 124.000,00	13	€ 201.500,00
		33	**€ 168.400,00**	**33**	**€ 199.000,00**	**33**	**€ 261.500,00**

Table A1.4 Hypotesis of investment costs for vehicles

The energy use cost of e-scooters and quadricycles are higher in respect to the pedelecs, being about 6 €cents per 10 km for pedelecs, 12 €cents per 10 km for e-scooters, 25 €cents per 10 km for a quadricycle (Renault Twizzy)2.
From the point of view of the user the scenario 1 is preferred. This is because the more are the typologies of vehicles available, the more different segments of demand can be captured. The pedelec is in absolute terms the most familiar and easiest to use of these vehicles. In respect to e-scooters, the pedelec is lighter and easier to handle. The pedelec is more appropriate for short distances and easier to park, also out of dedicated parking if required. Due to its compact dimensions and low weight, a bike is easier to reallocate or replace where needed and this means a better service reliability.

A cheaper fare can be provided for the use of pedelecs and this means a more accessible service. Last but not least, as stated at the beginning of the chapter, “electrically assisted bicycles” are compared by the law to a traditional bicycle and road tax, insurance, specific driver license are not required.

e- scooters require a driver license, insurance and the payment of a road tax (from which they are exempt for the first 5 years). They are relatively easy to use; they can transport a passenger if the driver is an adult and can transport luggage with greater ease and generally allow a cleaner and more comfortable ride than a pedelec thanks to the protection offered by the hood and the larger seat.

e-Quadricycles have a lower investment cost than electric city cars but they offer generally lower performance, less weather protection, less comfort and less luggage space. On the other hand they can be driven with a motorcycle license, or for some models even with a moped license and occupy less space which makes them easier to park and allow to build smaller, less intrusive eco stations. Their initial investment cost is about half of that of a proper electric city.

Paris (France)

Autolib is an electric car sharing service which was inaugurated in Paris, France, in December 2011. The scheme intends to deploy 3,000 all-electric Bolloré Bluecars for public use by late 2012, based around 1,120 citywide parking and charging stations. As of July 2012, the service has 27,000 registered subscribers, of which 9,000 have an annual subscription. A fleet of 1,782 Bluecars has been registered for the service through June 2012.

A1 15 - AutoLIB Charge Points in Paris 1

A1 32 - AutoLIB Charge Points in Paris 2

A1 33 - AutoLIB Charge Point Payment System in Paris

A1 34 - AutoLIB Charge Point User Interface