# Deliverable 1.5

## Interim 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 process 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.

It is noted that the European uptake of EVs has not occurred to the volumes expected and as such many regions have not yet completed any detailed planning processes as they only have to cater for a niche market of EVs. In addition the base line times and level of development of existing partner pilot projects differ greatly. The charge point hardware and IT standardization processes, while gaining some stability, are still in flux. The bulk of the information provided therefore is from a limited number of regions whose EV pilot projects are at a sufficiently advanced stage.

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…).

From a market model perspective the report suggests that the Integrated Infrastructure Model (IIM), where the DSO is the owner of the infrastructure, is best placed to achieve rapid market development. The main reason is that the installation of charging infrastructure is the responsibility of the DSO. A DSO driven approach will allow rapid access to the distribution network and a wider coverage of geographical locations for the distribution of charging stations.

On a macro planning level, 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. 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. Planning examples from a number of different regions are discussed.

On a micro planning level, the report 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 |
| 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. Within four years, it will be fully functioning, providing the foundation for the mass deployment of Europe-wide electromobility. The project has a total budget of €42 million and will be funded by the European Commission with €24 million.

The Green eMotion consortium consists of forty-three partners from industry, the energy sector, electric vehicle manufacturers, and municipalities as well as universities and research institutions. They have joined forces to explore the basic conditions that need to be fulfilled for Europe-wide electromobility. The primary goal of the project is to define Europe-wide standards. To this end, practical research is being 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 is entitled "Synchronization of Demonstration Regions". The objective of Work Package 1 is 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 is 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 play an important role to support and stimulate the introduction of EVs and the infrastructure. The introduction of EVs will be assessed in a greater context and will deliver recommendations for the most suitable EV applications and also to the further development of electric vehicles.

The 12 demonstration regions (ten ongoing or starting and two replication regions) which are part of Green eMotion will bring in their ongoing projects in order to leverage on the existing activities and experiences. In addition, some extra demonstration features will be implemented in each region in the context of the 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 D1.5, and is entitled "Interim 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 that as of the publication date of this document many of the partner projects are at a stage where the partner does not have sufficient planning experience to directly feed into many aspects of this document. Some partners belong to model regions and others to demonstration regions. This document is naturally biased to regions where projects have already been planned and are in implementation stage.

The document is predominantly divided into two sections which cover the macro level planning issues (suitable for initial planning of a charge point infrastructure) and the more practical micro level planning issues associated with charge point installation.

# 2 Project Planning

## 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 heretofore 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.

## 2.2 The Stakeholders

Below is a list of the relevant stakeholders for the project.

- Government and associated bodies.
- Local and regional authorities.
- Automotive OEMs.
- Charge point hosts.
- DSO / TSO.
- EV owners.
- Universities.
- Private sector companies.
- Financers.
- Standardisation Bodies.
- Energy Market Regulators.

## 2.3 Market Models

Four EV infrastructure models are shown below which focus on the rollout responsibilities of public charging stations and their integration with electricity retailers. These purist models provide a good benchmark of the potential industry structures but stop short of considering the economics of charging infrastructure and the operational interaction between stakeholders. The four models and their characteristics are summarized in Table 2.1. It is likely that the Integrated Infrastructure Model (IIM) is best placed to achieve rapid market development. The main reason is that the installation of charging infrastructure is the responsibility of the DSO. A DSO driven approach will allow rapid access to the distribution network and a wider coverage of geographical locations for the distribution of charging stations.

| Key feature of market model | Integrated Infrastructure Model (IIM) | Separated Infrastructure Model (SIM) | Independent eMobility Operator Model (IEOM) | Spot Operator Owner Model (SOOM) |
|---|---|---|---|---|
| **Ownership of infrastructure** | DSO or government-led agency | Owner separated from DSO | Bundled owner/operator/retailer | Parking spot owner/operator |
| **DSO's role** | Ownership/lead role | Facilitate access to network | Facilitate access to network | Facilitate access to network |
| **Support wider geographical rollout** | High | Medium | Low | Low |
| **Degree of standardisation** | High | Medium | Medium | Low |
| **Infrastructure costs distribution** | Costs spread across customer base | Costs spread across customers by region | Costs spread across customers within subscription pool | Costs spread across users on the spot |
| **Ease of market entry for energy suppliers** | High | Medium | Low | Low |
| **Grid system support capability** | High | Low | Low | Low |
| **Tariffs certainty** | High | Low | Low | Low |
| **Integration with electricity market systems** | High | Medium | Low | Low |
| **Need for further government subvention if not meeting adoption target** | Low | Medium | High | High |

*Table 2.1 – Market Models*

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 the SIM model, 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 the IIM model and others under the SOOM model configuration. The advantage of the approach is that more CPs are deployed more quickly, but the public financing (re-charging is free until the end of 2012) is unlikely to continue and the model will, at some stage, have to evolve.

## 2.4 Project Risks

Below is a list of potential risks to an EV charge point infrastructure project.

- Political change and/or economic constraints will dissolve support for electric vehicles.
- Global interest and investment moves to other technologies such as hydrogen fuel, bio-fuels, or another.
- A technical failure results in large fleets of electric vehicles being recalled.
- A safety incident with an EV results in death or injury and associated change in public opinion.
- The electrical industry regulator does not approve the charging infrastructure on the regulated asset base.
- Private charge point systems are installed which are not compatible with national systems resulting in confusion for the customer.
- EV supplier's offering is not sufficiently strong to encourage members of the public to buy EVs.
- Local authorities inflate parking fees for EV users as revenue is being lost due to minimal use of parking space.
- 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).
- Non-EV users are consistently taking up dedicated EV charging spaces resulting in an un-used infrastructure.
- Range anxiety rumors continue to effect sales figures.
- The plug/socket type chosen is not as specified in future binding standards and becomes incompatible with new EVs.
- DC or AC charging becomes prominent and the infrastructure for the opposite is obsolete.
- Delays in projects occur due to delayed supply of charging equipment or charge point management / payment systems.

## 2.5 Barriers to EV Implementation

Below is a list of potential barriers to EV implementation. Note that these and others have been explored in more detail in Tasks 2.2 and 2.3 of the Green eMotion Project.

- Charge point manufacturers supplying faulty equipment and not meeting delivery deadlines.
- Price of charge points.
- Lengthy procurement processes (OJEU regulations).
- Charge point network planning (i.e. where is best to put them?).
- Difficulty securing agreements with charge point hosts.
- No utility sub-metering arrangements in place.
- Difficulty identifying charge point sites with appropriate power capacity.
- Lack of EV sales.

- Faulty EV's.
- Price of EV's.
- Changing standards (RFID) and no accepted standards (connectors).
- Lack of EV incentives (i.e. use of bus lanes, free parking etc...).

## 2.6 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 2.3).

### 2.6.1 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 2.1 below.


*Figure 2.1 - AC Charge Point*

## 2.6.2 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. Figure 2.2 below shows a 50kW DC charge point installed in Ireland.


*Figure 2.2 - DC Charge Point*

## 2.6.3 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 2.3 - Battery Swapping Station in Denmark*

### 2.6.4 Inductive Charging

Inductive charging uses an electromagnetic field to transfer energy between two objects. Inductive charging has yet to become a mainstream product (ignoring inductive charging paddles used for charging in a number of early EVs). There are a number of different scenarios in which inductive charging can be implemented; 1) installing inductive charging plates in parking spaces so that a vehicle can charge without the user "plugging in" (static charging), 2) installing inductive charging conductors along lengths of roadway allowing the EV access to continuous power whilst driving (dynamic charging).

# 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. 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 however 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 will determine future charge point placement strategies.

## 3.2 Sources of Planning Data

The following is a list of data sources essential for planning an EV charge point infrastructure.

### 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.

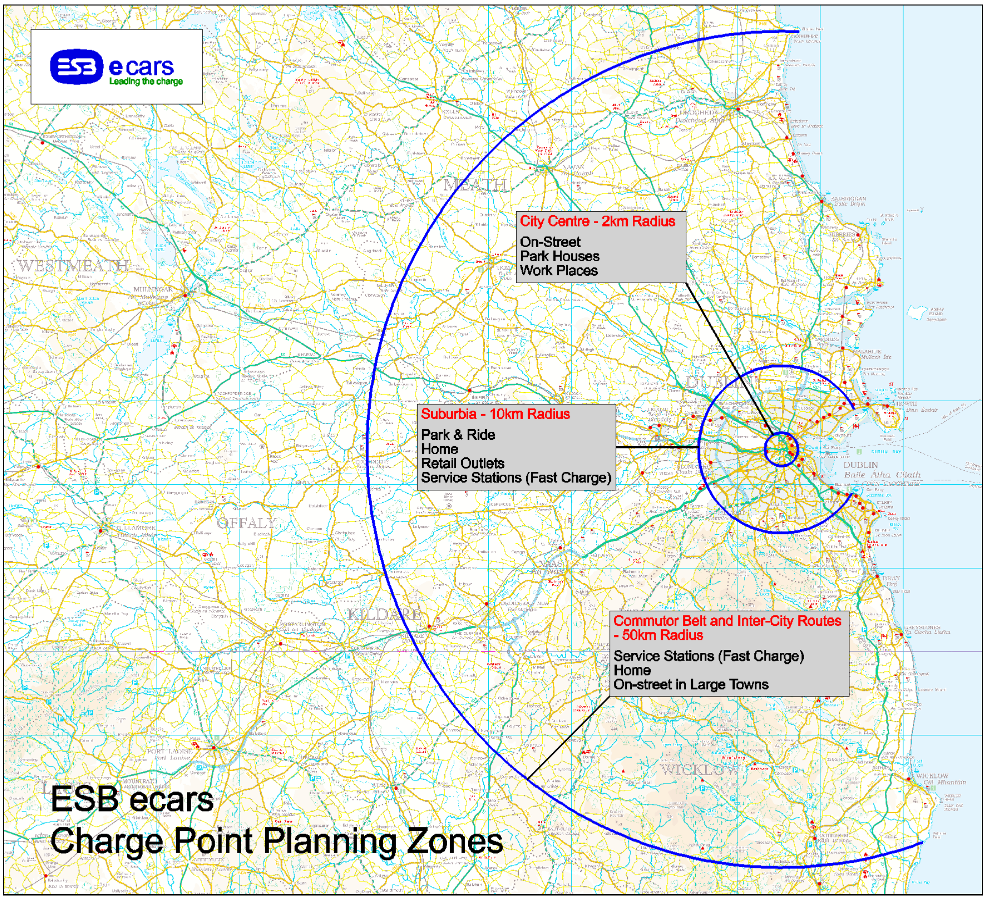



*Figure 3.1 - ESB ecars Charge Point Planning Zones*

ESB ecars is however rolling out a nationwide publically available charge point infrastructure. The figure below shows installed charge point as of July 2012 (not including home charge points). 50kW DC 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. 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.

### 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 another factor.

### 3.4.2 Spatial Study

Spatial studies can be used to plan the charge point infrastructure in areas such 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.

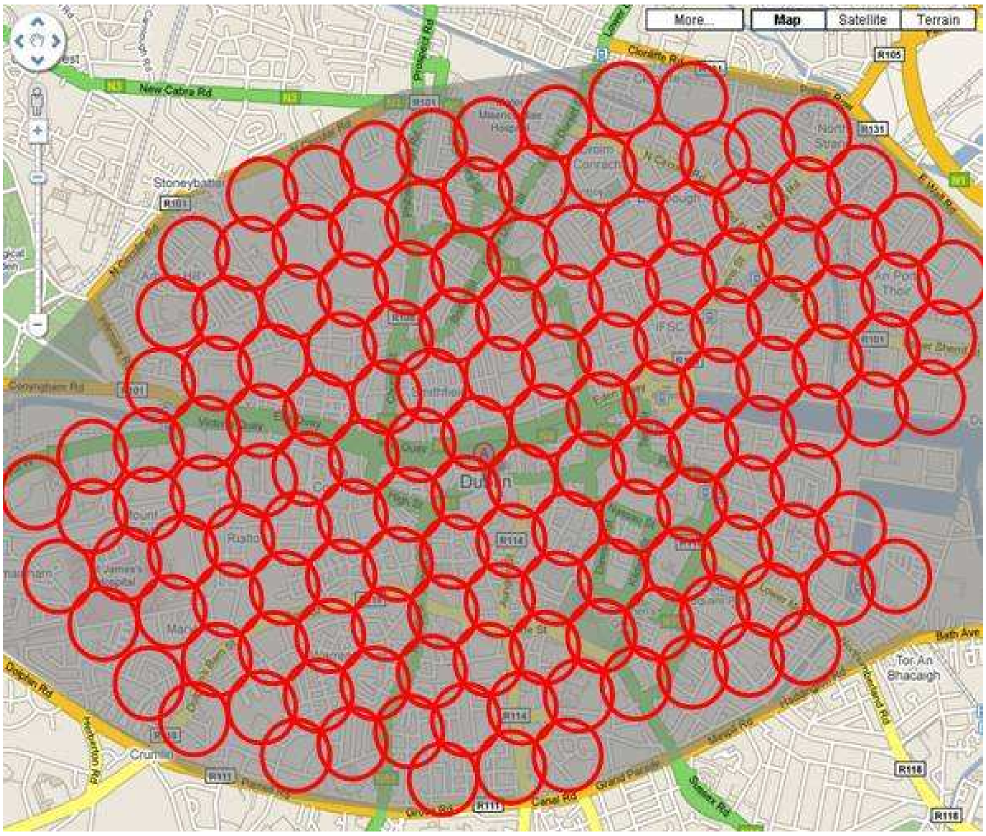



*Figure 3.3 - Spacial Study of Dublin City*

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.

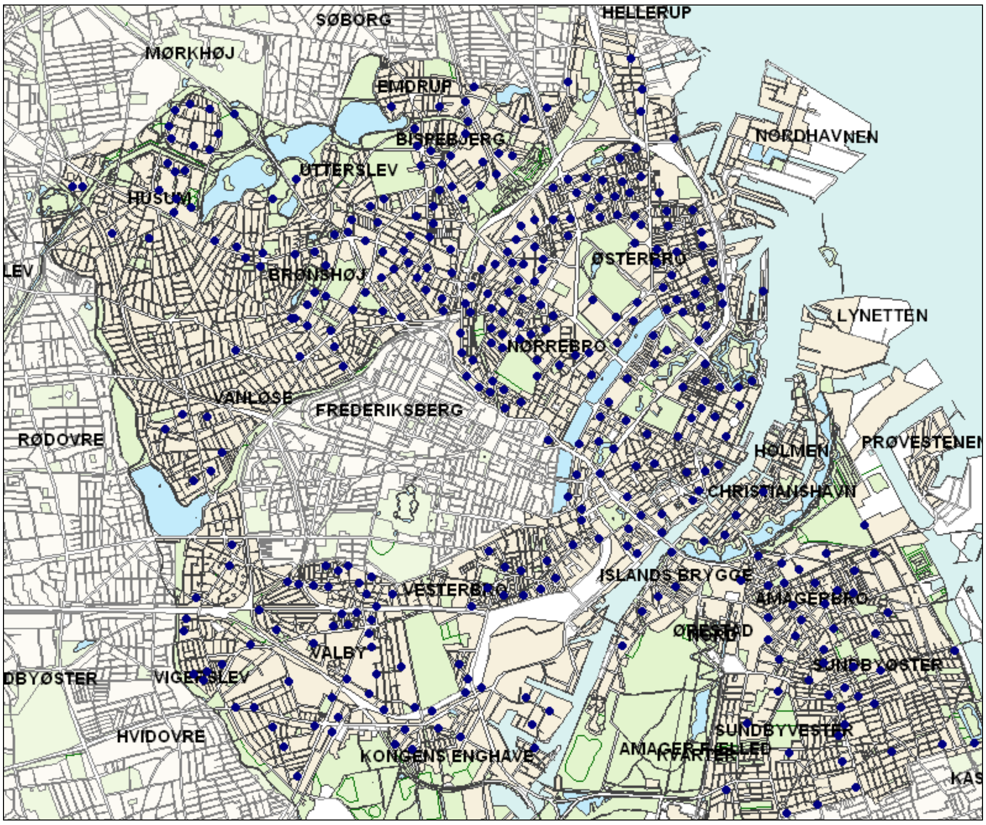



*Figure 3.4 - City of Copenhagen Preferred Charge Point Locations*

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

**Formatiert:** Nummerierung und Aufzählungszeichen

This chapter has detailed some of essential planning sources required 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 practical than the macro level ones discussed in Section 3 and 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. 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.

### 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; 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.

*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.

### 4.3.4 Large Retail Outlets

Large retails 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.

### 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.

### 4.4.1 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 4.7 - Single Charge Post Interface Pillar*

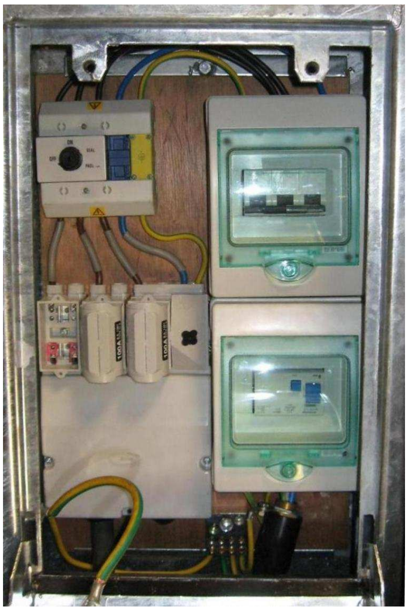


*Figure 4.8 - Internals of Single Charge Post Interface Pillar*

*Figure 4.9 - Multiple Charge Post Interface Pillar*

*Figure 4.10 - Internals of Multiple Charge Post Interface Pillar*

### 4.4.2 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 4.11 - Underground Vault in Ireland*

*Figure 4.12 - Underground Vault in Paris*

### 4.4.3 Bollards and Barriers

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


*Figure 4.13 - Bollards Protecting DC Charge Point*


*Figure 4.14 - 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 4.15 - 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. 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.

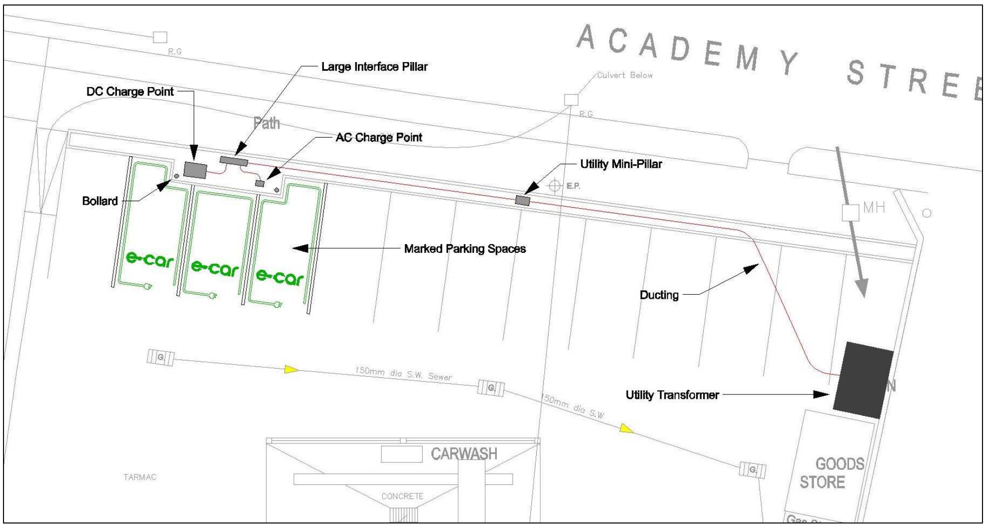



*Figure 4.16 - Example of Civil Works Drawing*

## 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.

### 4.7.1 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 4.17 - Yellow Coiled Charging Cable*

### 4.7.2 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 4.18 – Fully Painted Parking Spaces*

*Figure 4.19 - Partially Painted Parking Spaces*

### 4.7.3 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 4.20 - Installation of DC Fast Charge Point using HIAB*

### 4.7.4 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. There is also a need to educate the general public and in particular school children of this new mode of transport.


*Figure 4.21 - School Visits by ESB ecars in Ireland*

## 4.8 Conclusion

Formatiert: Nummerierung und Aufzählungszeichen

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

## 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 has 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*

## 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

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 Better Place and 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.

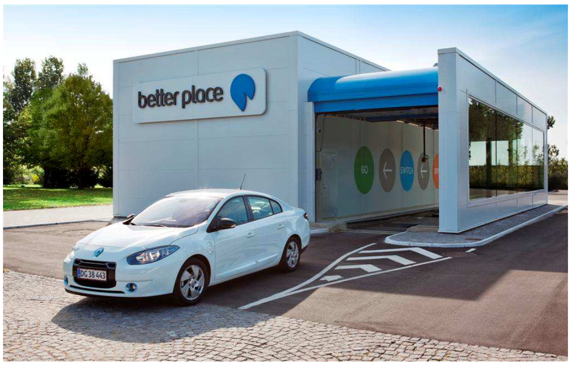
The City of Copenhagen is cooperating with DONG Energy to make a plan for the infrastructure for EVs on public land in Copenhagen. The plan will be completed by the end of 2012. The City will request the Danish government to allocate funding for a national infrastructure for EVs. Without national co-financing, 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.

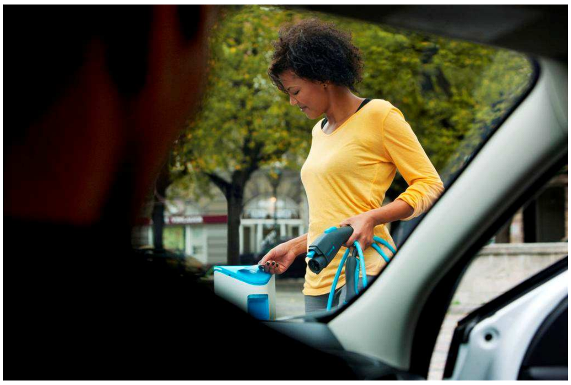
The City has both experienced successes and hurdles with the municipal EVs in regards to infrastructure. The City of Copenhagen uses a slow charge system with a Mennekes plug. The number of CPs has been determined by the number of EVs on a 1:1-scale. As an alternative charging system, battery swapping 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

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.

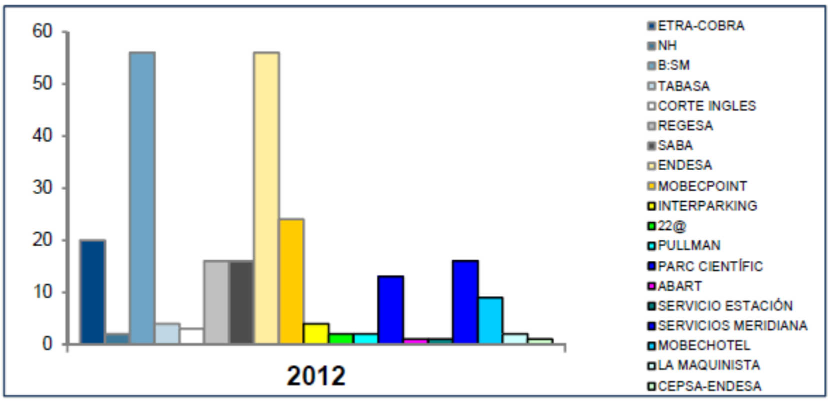
Survey data (2010) for the mobility split for internal and connecting city movements serves to identify two movements (as listed below) that can be targeted if electro-mobility is to positively impact on the city mobility and its environmental impacts (note: this survey data does not include goods movements 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.

## Paris

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 16 - AutoLIB Charge Points in Paris 2*

A1 17 - AutoLIB Charge Point Payment System in Paris


A1 18 - AutoLIB Charge Point User Interface