greencharge2020.eu

GreenCharge Project Deliverable: D2.16

Description of Barcelona Pilot and User Needs

Authors: Regina Enrich (EURECAT), Albert Fernández (EURECAT), Ricard Soler (ATLANTIS), Lluís Freixas (ATLANTIS), Baltasar López (ENCHUFING), Alberto León (MOTIT), Valentín Porta (MOTIT)

www.civitas.eu

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

About GreenCharge

GreenCharge takes us a few important steps closer to achieving one of the dreams of modern cities: a zero-emission transport system based on electric vehicles running on green energy, with traffic jams and parking problems becoming things of the past. The project promotes:

Power to the people!	The GreenCharge dream can only be achieved if people feel confident that they can access charging infrastructure as and when they need it. So GreenCharge is developing a smart charging system that lets people book charging in advance, so that they can easily access the power they need.
The delicate balance of power	If lots of people try to charge their vehicles around the same time (e.g. on returning home from work), public electricity suppliers may struggle to cope with the peaks in demand. So we are developing software for automatic energy management in local areas to balance demand with available supplies. This balancing act combines public supplies and locally produced reusable energy, using local storage as a buffer and staggering the times at which vehicles get charged.
Getting the financial incentives right	Electric motors may make the wheels go round, but money makes the world go round. So we are devising and testing business models that encourage use of electric vehicles and sharing of energy resources, allowing all those involved to cooperate in an economically viable way.
Showing how it works in practice	GreenCharge is testing all of these innovations in practical trials in Barcelona, Bremen and Oslo. Together, these trials cover a wide variety of factors: *vehicle type* (scooters, cars, buses), *ownership model* (private, shared individual use, public transport), *charging locations* (private residences, workplaces, public spaces, transport hubs), energy *management* (using solar power, load balancing at one charging station or within a neighbourhood, battery swapping), and *charging support* (booking, priority charging).

To help cities and municipalities make the transition to zero emission/sustainable mobility, the project is producing three main sets of results: (1) *innovative business models*; (2) *technological support;* and (3) *guidelines* for cost efficient and successful deployment and operation of charging infrastructure for Electric Vehicles (EVs).

The *innovative business models* are inspired by ideas from the sharing economy, meaning they will show how to use and share the excess capacity of private renewable energy sources (RES), private charging facilities and the batteries of parked EVs in ways that benefit all involved, financially and otherwise.

The *technological support* will coordinate the power demand of charging with other local demand and local RES, leveraging load flexibility and storage capacity of local stationary batteries and parked EVs. It will also provide user friendly charge planning, booking and billing services for EV users. This will reduce the need for grid investments, address range/charge anxiety and enable sharing of already existing charging facilities for EV fleets.

The guidelines will integrate the experience from the trials and simulations and provide advice on localisation of charging points, grid investment reductions, and policy and public communication measures for accelerating uptake of electro-mobility.

For more information

Project Coordinator: Joe Gorman, joe.gorman@sintef.no

Dissemination Manager: Arno Schoevaars, arno.schoevaars@pnoconsultants.com

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

Executive Summary

This report presents a description of Barcelona pilot and the needs of the users involved in the demonstration activities.

The pilot can only be properly described if a snapshot of the context is provided. In that sense, an overview of the geographical and demographic information is included to derive the challenges at the pilot site.

Barcelona is the second most populated city of Spain. The city and its metropolitan area cumulates over 3.2 million inhabitants (42% of Catalonia population). The surrounding mountains, apart from limiting the geographical spread of the city, create hilly terrain that make the use of electric assisted light electric vehicles attractive. Also the heavy traffic make them attractive.

The main challenges identified in the pilot site are: 1) low penetration of EVs, 2) non- fully interoperable and non-profitable charging infrastructure, and 3) difficulty to build business models based on energy flexibility.

The low penetration of EVs can be explained primarily by the extra cost involved in the purchase of an electric vehicle compared to a combustion vehicle. Some incentives and subsidies are provided by public authorities at national, regional and local level to help drivers to shift to EVs. The figures are promising but still too low to make an impact on air and noise pollution and grid management. A secondary reason is range anxiety and lack of awareness of EV technologies. GreenCharge will be able to cover user needs that need to recharge their vehicle at work by setting a booking system among Eurecat employees. Besides, analysis on the impact of different charging strategies in the health of the battery, will help to better estimate the SoC and the range. Dissemination events, open days and workshops will contribute to raise awareness.

Regarding non-fully interoperable charging infrastructure, some initiatives are in progress to connect local networks of charging points, mostly publicly operated. Most of them are accessible using an RFID card, but some already provide access through an app. The latter approach will foster interoperability. The reason for charging point infrastructure not being profitable is that most of them are free of charge. With such low penetration of EVs, public administrations, utilities and charging points manufacturers have deployed charging infrastructure open to citizens. The model is not sustainable in the long term; as soon as the number of EVs increases the number and profitability of charging operators will increase.

The final challenge is the difficulty to build profitable business models based on energy market and energy flexibility for mid- and small companies, due to regulation and predominance of 3 big utilities. However, there is still room for optimization at local level for fleet operators that manage a big number of EVs and facility owners that are willing to fulfil EV drivers' needs without big investments in the infrastructure. The Energy Smart Neighbourhood GreenCharge component will be instantiated in the three demonstrators in Barcelona to demonstrate the feasibility of efficiently manage renewable energy locally produced, price tariff variability and grid constraints.

The Barcelona pilot is divided in 3 different demonstrators spread along Barcelona province: 1) Eurecat demonstrator (8 different locations in Catalonia), 2) MOTIT demonstrator (3 locations in Barcelona) and 3) Sant Quirze demonstrator (mid-sized town beyond Barcelona metropolitan area).

The GreenCharge scenarios to be tested in Barcelona pilot site are: booking, charging and enforcement of private charging points open to Eurecat employees, optimal charging station and building management (for the 3 demonstrators) and mobility as a service use cases including the trial of incentives to drop MOTIT e-scooters near the battery hubs (acting as charging stations) and the upgrade of an e-bike sharing service for commuters in Sant Quirze.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

Table of Contents

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

Table of Figures

List of Tables

List of Abbreviations

Table 1: List of abbreviations

Abbreviation	Explanation
AMB	Area Metropolitana de Barcelona; Barcelona Metropolitan Area governance body
CHP	Combined Heat and Power
DER	Distributed Energy Resource
DSO	Distribution System Operator – responsible for operating and maintaining the electricity distribution grid.
FEV	Full Electric Vehicle. A vehicle that uses exclusively electric energy, stored in batteries, for propulsion.
HP	Horse Power
HOV	High Occupancy Vehicle (usually 2-3 or more occupants)
ICAEN	Institut Català de l'Energia. Catalan Energy Authority
ICT	Information and Communication Technologies
LEV	Light Electric Vehicle. Electric vehicles with 2 or 4 wheels powered by a battery, fuel cell, or hybrid-powered, and generally weighing less than 100 kilograms.
MWC	Movile World Congress
NZEB	Nearly Zero Energy Building
PHEV	Plug-in Hybrid Electric Vehicle. A vehicle that combines electric energy with another type of energy, commonly gasoline, diesel or gas. The battery where the electric energy is stored can be charged externally (socket).
PV	Photovoltaic
RES	Renewable Energy Source (see "List of Defintions" below for details).
RFID	Radio Frequency IDentification
SUMP	Sustainable Urban Mobility Plan
V2G	Vehicle to Grid. Refers to using the energy stored in the batteries of EVs connected for charging to provide energy to the grid in peak load situations.
V2H	Vehicle-To-Home
WLTP	Worldwide Light Vehicles Test Procedure

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

List of Definitions

Table 2: List of definitions

Definition	Explanation
Architecture	The fundamental organization of a system embodied in its components, their relationships to each other, and to the environment, and the principles guiding its design and evolution
Charge management system	The ICT system supporting the operation of charging facilities, taking care of access control (to charging posts), control of the charging process (through communication with the in-vehicle charging and battery management system, booking, billing and other business related tasks necessary to the operation of a charging service. In GreenCharge it will also be responsible for the communication with the Neighbourhood Energy Management system about the coordination of energy demand of the charging facility with other demand in the neighbourhood and local production within the neighbourhood.
Energy mix	The distribution among different categories of electric energy sources involved in supplying a given amount of electric energy. Relevant categories include local renewable, grid renewable, local fossil, grid fossil etc. It is often given as a percentage for each category (altogether amounting to 100%) but can also be the fraction of a particular category, for example the fraction of renewables (the green mix).
Energy Smart Neighbourhood (ESN)	An energy smart neighbourhood (ESN) is a group of buildings embedding local RES and local energy storage and using smart control equipment to adapt the energy demand to the local production so as to reduce the burden on the public grid and the power bill. The smart control equipment does this by predicting local energy demand and energy production from local RES and leveraging demand flexibility and local storage resources to shift the loads in a coordinated way within the neighbourhood. The aim is to minimize the amount of energy taken from the grid, the demand peaks and the energy bill. As these may be partially conflicting goals, the inhabitants of the neighbourhood must define policies defining how to balance them. In GreenCharge there is a particular focus on leveraging the demand flexibility and storage capacity of charging EVs, how this will reduce the need for dedicated stationary batteries (very expensive), and the use of local RES to charge the rapidly increasing fleet of EVs.
Fleet management system	An ICT system supporting the operation of a fleet of vehicles owned by a business and used to operate that business, for example the taxies of a taxi company, the delivery cars of a parcel delivery service company, or the cars of a car rental business. Such systems offers a wide variety of functionality supporting tasks related to the management of fleets, such as vehicle tracking, mechanical diagnostics, maintenance planning, and when dealing with EVs, also charge planning and booking.
Local energy production	Energy produced inside a defined collection of one or more energy consumers and/or prosumers. If there are only consumers, the local energy production will always be zero.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

Definition	Explanation
Measure	A measure is a mobility or charging related action implemented by a city or other stakeholders, e.g. the implementation of a new infrastructure, the provision of a new service, a new organisation of the travel to work, or activities to change awareness, acceptance or attitude and behaviour of citizens or visitors.
Renewable Energy Source	Category of energy sources which does not involve the burning of fossil fuels as part of the energy production process. The most popular RES are photovoltaic panels, windmills and hydroelectric power plants. Typically the carbon footprint of RES (caused by the building, operation and maintenance of the production facilities) lies in the area of 10 – 50 g CO_2 equivalents per kWh, while for fossil energy sources like natural gas, oil and coal the carbon footprint lies in the area of 500 – 800 g CO2 equivalents per kWh. Nuclear power is not commonly counted as a RES, since the energy production process does consume a fuel and does produce a problematic waste (radioactive material). However, its carbon footprint is in the lower end of the RES range.
Scenario	A scenario describes a specific use of a proposed system by illustrating some interaction with the proposed system as viewed from the outside, e.g., by a user, using specific examples. In GreenCharge, scenarios provide high level of descriptions of the system, and can be modelled using one or several use cases.
State of Charge (SoC)	The state of charge (SoC) is an indication of the amount of energy stored in a battery. It is given as a percentage, meaning the percentage of the full capacity currently available in the battery. The SoC is difficult to measure accurately, but several methods are available to give an approximate value, and most EVs has an instrument on the dashboard showing the SoC.
Use case	A use case describes how a system will be used and is a tool for modelling requirements of a system. In GreenCharge, a scenario is a higher level of description of the system and can be modelled using one or several use cases.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

1 About this Deliverable

1.1 Why would I want to read this deliverable?

This deliverable is targeting readers that want a better understanding of relevant user needs and use cases to be realized in Barcelona pilot site, contextualised to the geographical, socio-demographic, political and economic situation. The focus of the Barcelona pilot is on light electric vehicles (scooters and bicycles) of sharing services from the perspective of the fleet manager, but there are also some scenarios concerning private electric vehicles (EVs). This deliverable will describe the starting point (baseline) for the Barcelona pilot site. Based on identified challenges and collected user needs different scenarios are described.

1.2 Intended readership/users

This deliverable is mainly targeting to group of readers:

- Solutions developers within GreenCharge that will implement the different prototypes to fulfil user needs.
- As a public delivery the larger audience of innovators, including innovative companies and other organizations, seeking to provide valuable products and services to the domain of EV charging, based on an understanding of user needs and related scenarios.

1.3 Structure

The document is organised following a "zooming" approach. It starts, in chapter 2, with an overview of the pilot site taking into account the geographical and socio-demographic situation that contextualised the challenges. In chapter 3, it follows a zoom-in to the current situation (baseline) of electro-mobility from national to local level. Chapter 4 describes the scenarios and their associated stakeholders to be implemented in GreenCharge particularised to the Barcelona pilot site while Chapter 5 deeps into the details of the use cases and user needs. Finally, in Chapter 5 an overview of the technological requirements is given.

1.4 Other project deliverables that may be of interest

- **D2.1 Initial Strategic Plan for Pilots -** This deliverable is input to the strategic plan.
- **D3.1 Stakeholder Analysis Report** – Describes the result of the stakeholder analysis, identifying the concerns and needs from all stakeholders relevant for GreenCharge
- **D2.17 Implementation Plan for Barcelona Pilot** – Describe the planning of the tests to be carried out at the pilot site. It includes scenarios to be demonstrated, time schedules, stakeholders and locations selected, users selected for workshops and for testing, hardware and software to be installed, tests to be run and data to be collected, etc.
- **D2.21 Final Report for Barcelona Pilot: Lessons Learned and Guidelines -** Describe the Barcelona pilot, including the implementation, operation, the tests carried out, services and the data collected. Describe lessons learned and guidelines for apartment buildings.
- **D2.3 Description of Oslo Pilot and User Needs** – "Sister" deliverable describing the specific situation in Oslo pilot.
- **D2.9 Description of Bremen Pilot and User Needs** – "Sister" deliverable describing the specific situation in Bremen pilot.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

2 Introduction to the pilot site

The demonstration activities in this pilot site will include not only Barcelona city but its surrounding area, and will extend to Barcelona province. Three different demonstrators can be identified:

- EURECAT demonstrator, instantiated in 2 of its 8 offices, in Barcelona province
- MOTIT demonstrator, a e-scooter sharing service operating in Barcelona city
- Sant Quirze demonstrator, a e-bike sharing service operating in Sant Quirze del Vallès, a town 20 km away from Barcelona city.

2.1 Geographical location

Barcelona and its metropolitan area

Barcelona is the capital city of Catalonia and the second largest city of Spain. It is located on the North East of Spain, on the coast of the Mediterranean Sea, between the mouths of two rivers: Llobregat and Besòs, and bounded to the West by the mountain range called Serra de Collserola. It has an extension of 101.35 km^2 and its particular geographic location hampers its horizontal spreading, and fosters a vertical growth and a high population density. There are some hilly areas, shown in red-violet shades in the topographical image[1] in Figure 2-1, that affects mobility patterns for non-motorized journeys.

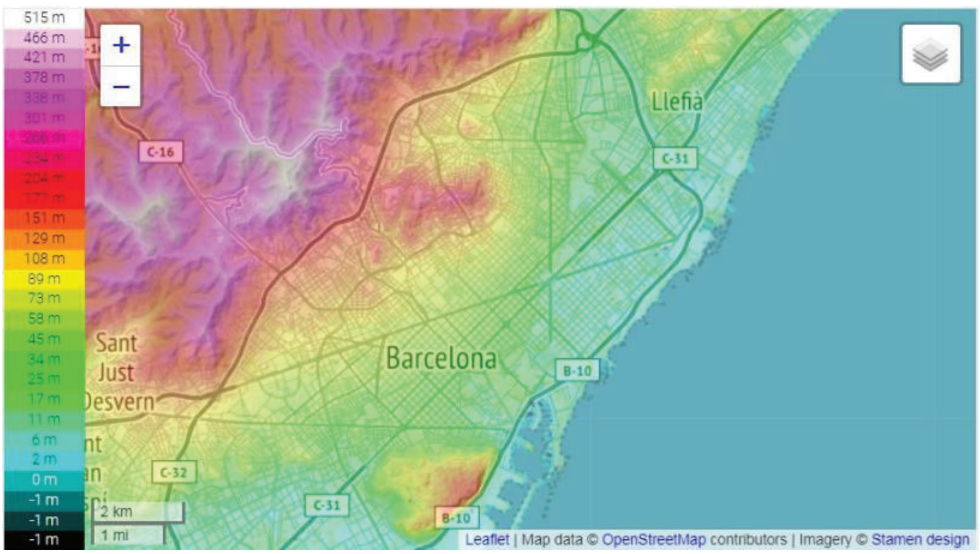

Figure 2-1: Barcelona topographical view

Barcelona is surrounded by the so called Barcelona Metropolitan Area. This area encloses 36 towns and covers an area of 636 km^2 (see Figure 2-2). It is set on the central Catalan coast and around the capital, Barcelona. The metropolitan area can be divided into two zones:

- The boundary zone forming the conurbation with the city of Barcelona itself. Bordered by the Mediterranean Sea and the Serra de Collserola, the towns in this zone are Badalona, Hospitalet de Llobregat, Santa Coloma de Gramenet and Cornellà de Llobregat. Here the boundaries between municipalities are set by streets, avenues or the Llobregat and Besòs rivers.

[1] Source: http://es-es.topographic-map.com/places/Barcelona-234154/

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

- The adjacent metropolitan zone, made up of several towns surrounded by predominantly residential suburban areas with detached, semi-detached and terraced housing, industrial estates, parkland and woods, such as Sant Vicenç dels Horts, Sant Cugat del Vallès and Cerdanyola del Vallès.

Figure 2-2: Barcelona metropolitan area

A governance body, called AMB (Area Metropolitana de Barcelona), has competencies on territorial planning, transport and mobility, environmental and sustainability. They have promoted several initiatives on electro-mobility, such as a fast charging networks and subsidies for the purchase of electric bicycles that are relevant to the pilot sites. The AMB is part of the Local Reference Group of GreenCharge project.

Sant Quirze del Vallès

Beyond the official metropolitan area, there are the so called rings (second ring, third ring,…), with increasing distance to Barcelona. Although there are not directly managed by the AMB, some measures have an impact on the territory as well. One of this town is Sant Quirze del Vallès, located 20 km from Barcelona, inland as seen in Figure 2-3.

Figure 2-3: Sant Quirze del Vallès location

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

It has an area of 14.1 km^2 and an altitude of 188 m above sea level, with some hilly zones, which makes it suitable for electrical assisted bicycles. It has grown in the last two decades especially with housing development of detached houses spread along the municipality. There are some industrial areas, too, which are relevant for one of the use cases. Yet, the urban ground represents 34.1% of the surface, while forests are 57.3%. Its main activity is the tertiary sector, follow by industry.

Eurecat

Eurecat is the technology centre of Catalonia and their premises are spread all over Catalonia region. Currently, there are 11 different offices, distributed as shown in the Figure 2-4.

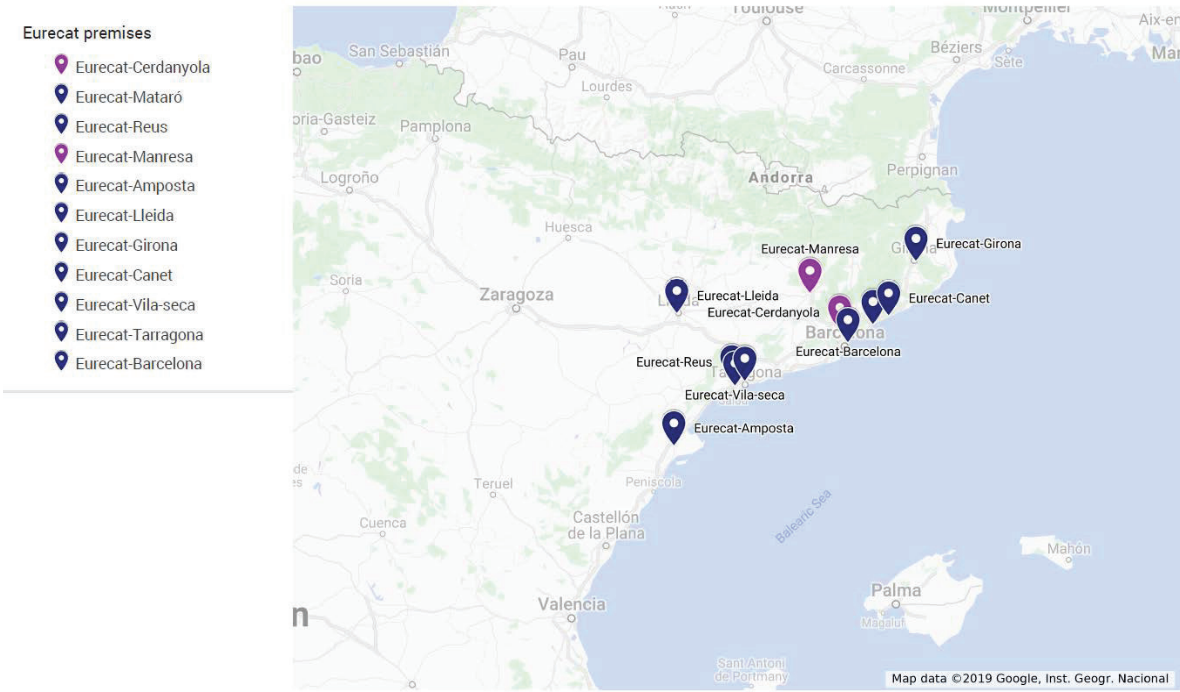

Figure 2-4: Geographical location of Eurecat premises

In particular, two of them will be directly involved in one of the scenarios: Cerdanyola del Vallès and Manresa, separated by a distance of 80 km.

2.2 Demographic data

Barcelona and its metropolitan area

Barcelona city is the capital of Catalonia and the second largest city of Spain with a population of 1,620,343 inhabitants[2] and a density of 15,985 inhabitants/km^2, while its metropolitan area accounts for 3.2 million people, including the second most populated town of Catalonia, Hospitalet de Llobregat with a population of 257,057 inhabitants and a density of 20,730 inhabitants/km^2. Beyond its stable population, Barcelona is very popular touristic destination, with tourists coming all year long, but especially in summer. In 2018 the total

[2] Source: Instituto Nacional de Estadística, 2018 https://www.ine.es/jaxiT3/Datos.htm?t=2911

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

number of tourists exceeded 9 million[3]. The increasing number of tourists has an impact in the city in a variety of aspects. On the one hand, some districts are becoming very popular and locals are forced to migrate to other parts of the city or towns because of increasing cost of rents (some neighbours have seen an increase of over 100% in three years); to turn old flats into touristic apartment is a lucrative activity. The average cost of rent on February 2019 is 929 €[4]. On the other hand, the needs for mobility not only of tourists but also of visitors coming to big events (fairs, concerts, …) in the city has an impact of mobility services. For instance, passengers from cruises that come to visit the city for a day (867 cruises stopovers and 3 million tourist passengers in 2018)[5] or MWC. Some mobility services are offered to tourists to visit the city, among them, a wide variety of light electric vehicles, like bikes, segways, scooters, twizzies, or motorbikes.

Sant Quirze del Vallès

Sant Quirze del Vallès has a population of 19,549 inhabitants and a density of 1,400 inhabitants/km^2. As mentioned earlier, most part of the population is disperse on multiple detached housing districts. The population growth over 32% between 2001 and 2011. Most of the population came from other neighbouring towns like Sabadell, Terrassa and Barcelona itself. There were families looking for big houses with gardens for their children. Although the population pyramid shows the same pattern as in the rest of Catalonia, aging population, an increase on the range between 5-14 years old is observed, due to the above mentioned migration.

The disperse nature of the population is a challenge for public transport mobility, since the critical mass is low for a meshed transport network. Most journeys are done by private car, but bicycles are also a good option, especially is electrical assisted.

Eurecat

Eurecat has over 640 employees and it is expected to grow up to 1700 employees in 2025. The balance is 57% male, 43% female, easily explained by a higher presence of men in technological jobs, 21% of the staff have a PhD degree and most of them have a university degree. The profile of the staff is very "techie", always eager to test new technologies. Thus there is a small population of EV early adopters, as well.

Not all the centres have the same size. Barcelona, Cerdanyola and Manresa are the biggest ones as shown in Table 3.

Table 3: Distribution of Eurecat staff

Centre	Employees	Distance to Barcelona
Barcelona (headquarters)	189	-
Cerdanyola del Vallès	167	15
Manresa	99	70
Mataró	61	30
Reus	48	125
Vilaseca	28	126
Lleida	17	181
Tarragona	5	125

[3] https://www.barcelonaturisme.com/uploads/web/estadistiques/190225_Provisional_Anual2018.pdf

[4] http://habitatge.gencat.cat/ca/dades/estadistiques_publicacions/indicadors_estadistiques/estadistiques_de_construccio_i_mercat_immobiliari/mercat_de_lloguer/lloguers-barcelona-per-districtes-i-barris/

[5] http://content.portdebarcelona.cat/cntmng/guestDownload/direct/workspace/SpacesStore/5df63492-b5d4-48d2-9821-91bbb8ecd233/PortBcnTrafic2018_12_es.pdf

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

Centre	Employees	Distance to Barcelona
Girona	5	100
Canet	4	45
Amposta	3	195

The exchange between different teams is reinforced by the aim to provide an added-value offering to the customers aggregating the know-how from different research units. This fact fosters frequently journeys of the employees between the different premises.

2.3 Challenges at the pilot site

The main challenge of the Barcelona pilot site is the low penetration of EVs that in turn affects also the charging infrastructure. Some regulations related to energy jeopardize the penetration of RES.

Culturally, ownership is the preferred option, and it applies in many scopes: housing ownership versus rent, car ownership versus sharing. The number of motorbikes per inhabitant is one of the highest in Europe. In Barcelona 12.6%[6] of daily trips are done by motorbikes and scooters. Since for many inhabitants this is the usual mean of transportation, they already own a motorbike. That is the main reasons why the MOTIT sharing service is more successful in Madrid than in Barcelona; in Barcelona bikers already own the vehicle.

Low penetration of EVs

The share of EVs in Barcelona, but also in Catalonia and the whole country is lower compared to other countries in Europe, especially compared to Norway. However, the figures are increasing in the last years. Among the reasons, the most important ones are:

- Cost: Some subsidies for the purchase of an EV have been put in place, but still the price of an EV is substantially higher than the price of an ICE vehicle. The economic crisis affecting the country since 2008 does not help and medium class families postpone high investments like the purchase of cars and their choice is either second-hand cars or mid-range vehicles. Recently, the number of diesel cars have decreased due to some policy announcement related to environmental impact and pollution regulation. It is being said, that in the long term, the maintenance and operation costs of an EV payoffs the extra cost in the purchase, but the buying decision is most affected by the short term perspective, especially for families; the uncertainty of what will happen with the cost of energy, how long will an EV last, and so on. For commercial use, the long term figures are more likely to be taken into account, but then there is the uncertainty about charging infrastructure.
- Range anxiety: Although the average length of trips in less than 50 km, drivers still fear not to reach home with an EV because the battery goes flat. The cars with highest range autonomy are still the most expensive, and cost is a barrier. Range anxiety might explain why people thinking on buying an electric car because of environmental concerns end up buying a hybrid car. The Toyota Prius had (and still has) a great success not only among families but also among Barcelona taxi drivers.
- Access to charging infrastructure: the uncertainty to access public charging infrastructure, sometimes not properly maintained, and the need to have a fix (linked) charging point either at home or at work, limits the number of potential e-car owners to those that have a parking spot, either on an individual parking garage or on a community garage. Regulations have been modified to ease the installation of individual charging points in community garages, but still when the user of the parking space is not the owner of the parking space and/or does not live in the same building, it still remains as an issue and requires the cooperation and sensibility of the owner of the community garage.

[6] https://www.barcelona.cat/mobilitat/es/medios-de-transporte/moto

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

According to a survey done by Idescat (Catalan Institute of Statistics) between 2006 and 2009, 62.4% of the population was in favour of setting up a tax for pollutant fuels and 46.9% were in favour of setting measures to restrict private transport means. However, at individual level, the purchase decision seems not to be aligned to the environmental concern.

Charging infrastructure

The municipalities and, especially Barcelona city council, started the deployment of public slow charging points on-street. The use of these charging points is free of charge, and drivers usually have to request a card to get access to them (some charging points work with a QR code). However, due to low penetration of EVs and the non-profitability of the charging points, the maintenance of the infrastructure is poor: it often happens that a user goes to the charging point and it is not working or there is a non-electric car parked in the parking space.

Lately, the policies have changed and the envisioned approach is to install slow charging points off-street and keep a reduced number of fast and ultra-fast charging points for “emergency” situations. The slow charging points off-street are meant to be linked to EVs for daily charges, mainly at night. By regulation, all parking garages newly built need to deploy charging infrastructure for at least 2% of parking slots.

For community parking garages in blocks of apartments, the owner of a parking spot does not need the consent of all the community to deploy a charging point in his/her spot. The electricity wiring to supply the charging point comes from their flats. Thus, there is an extra cost for the charging installation that has to be covered by the owner and that it is added to the extra cost of buying an electric vehicle. Some subsidies for the purchase of EVs have been replaced by subsidies for the installation of charging infrastructure.

The use of the most of the public charging points (all of them, to the knowledge of the writer) are free of charge. Apart from being an incentive from public administration to foster the penetration of EVs, there was a legal barrier to be overcome to exploit commercially a charging infrastructure. Until very recently the organization willing to exploit commercially the charging infrastructure has to be set legally as a ‘charge manager’ which also implies they operate as energy retailers. Thus most of the charging point operators are electricity utilities. However the regulation was revised in October 2018 and, the ‘charge manager’ entity has disappeared. It is expected the market will be open now to a wide variety of stakeholders.

Penetration of renewable energy sources, demand response and Vehicle-to-Grid

Although the weather conditions in Spain are favourable to a high penetration of renewable energy sources, especially photovoltaic panels, the deployment of such infrastructures has not have the same success as in other European countries. After a high increase in such installations, mainly motivated through attractive economical incentives, the growth stopped abruptly once the incentive policy and the corresponding regulation framework has been changed. The Spanish government decided to change the incentive schemes for renewable sources in place, even for the ones already deployed, and add a tax to such installations, the so called “sun tax”. Also, the administrative process to legalize such installations became much more cumbersome and slow, especially for installations over 10 kW. This new regulation, allegedly forced by the big electric utility lobby, has jeopardized the achievement of 20-20-20 goals. Currently, on average 40% of the energy mix comes from green energy from big wind farms (off-shore and on-shore) and hydro power plants in the mountains.

The legal framework of the electric market and the capacity of the grid (the available installed generation capacity is higher than load demand) results in the non-existing need for demand response schemes, that would have a valuable impact on the development of load side-management, including the charging of EVs and the exploitation of their storage capacity for V2G approaches.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

3 E-mobility at the start of the project

3.1 Vehicle ownership and EV penetration

Vehicle pool

The average car ownership indicator is 1.5 vehicles per household in Catalonia. Over 70% of households have at least 1 vehicle, 43.7% of households have only 1 vehicle, 22% of households have 2 vehicles and 6% of households have 3 or more vehicles.[7]

It is noticeable the percentage of scooters and motorbikes in Barcelona is almost 15% while the average in Spain is barely 10%. Traffic congestion is one of the reasons that explain it, but not the only one. The share in Madrid, a city as congested as Barcelona is lower. Mild climate and past relevant motorbike manufacturers in the region might have fostered a motorbike culture.

The total share of EVs is very low, but increasing in recent years. The table below shows the vehicle pool for 2018 at country level, region level and city level. The data comes from DGT (Dirección General de Tráfico, the National Traffic Authority).

Table 4: EV share at national, regional and local level

		Spain	Catalonia	Barcelona
Scooters	Total	23878	4714	3811
	Electric	2006	1089	1073
	Share of EVs	8.40	23.10	28.16
Motorbikes	Total	144905	38243	30604
	Electric	2707	389	330
	Share of EVs	1.87	1.02	1.08
Cars	Total	1344794	225836	178052
	Electric	7067	1460	1273
	Share of EVs	0.53	0.65	0.71
Vans	Total	111062	17509	13484
	Electric	856	211	186
	Share of EVs	0.77	1.20	1.38
Buses	Total	4037	543	387
	Electric	39	6	6
	Share of EVs	0.10	1.10	1.55
Trucks < 3500 kg	Total	63362	10578	7996
	Electric	198	52	41
	Share of EVs	0.31	0.49	0.51

[7] Idescat: Survey Households and environment – Transport and Mobility, 2008 https://idescat.cat/pub/lma/7.1.1.1

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

		Spain	Catalonia	Barcelona
Trucks > 3500 kg	Total	9709	1973	1528
	Electric	8	4	4
	Share of EVs	0.08	0.20	0.26
Others	Total	26298	3643	2072
	Electric	2	2	1273
	Share of EVs	0.00	0.09	0.71

Economic insights – Price and incentives

Using a Spanish car seller web-portal[8], we have built a table of the price of different electric car models and the price of the corresponding or similar non-electric model, when possible. As it can be seen in Table 5, the corresponding electric model is over 10,000 k€ more expensive in most cases.

Table 5: Comparison of prices for electric and non-electric cars

Brand/Model	Official Price (k€)	Range (km) (WLPT)	Battery capacity (kWh)	Equivalent ICE model	Official price for equivalent ICE model (k€)
Renault Twizy	4.9	-			
Citroen e-Mahari	24.2	150			
Peugeot iOn	26.4	150		Peugeot 108	13-16
Citroen C-zero	26.6	150	16.0	Citroen C1	12-14
Mitshubishi i-MIEV	30.5	150		Mitsubishi Space star	12.5-13.5
Smart ForFour Electric Drive	23.9	155	17.6		
Smart ForTwo Electric Drive	23.3	160	17.6		
Volkswagen e-up	28.0	160		VW Polo	15-22
BMW i-3	38-46	200	27.2	BMW Serie 1	27-33
Kia Soul EV	23.9	200	30.0	Kia Stonic	17-24
Volkswagen e-Golf	38.0	230		VW Golf	20-32
Renault Zoe	30-37	240	22.0	Renault Clio	13-20
Hyndai Ioniq Electric	29.9	250	28.0	Hyndai Ioniq	25-40
Nissan Leaf	33-37	270	40.0	Nissan Qashqai	22-36
Audi e-tron	82.4	400	95.0	Audi Q5-Q7	41-64
Hyndai Kona EV	36.1	480	64.0	Hyndai Kona	20-32
Jaguar I-Pace	37-70	480			
Tesla Model 3	59.1		75.0		

[8] https://www.quecochemecompro.com/

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

Brand/Model	Official Price (k€)	Range (km) (WLPT)	Battery capacity (kWh)	Equivalent ICE model	Official price for equivalent ICE model (k€)
Tesla Model S	113-150	400	75.0	Mercedes Clase C Audi A4	41-54 33-53
Tesla Model X	116-164	460	75.0	BMW Serie 3 Volvo S60	35-59 42-56

A similar exercise has been done for motorbikes and scooters and presented in Table 6. Although in percentage the difference between electric and non-electric motorbikes might be similar to cars, in absolute terms, by an extra 500-1000 € one can drive a LEV, which might explain why the penetration of this type of vehicles is higher than the penetration of e-cars.

Table 6: Comparison of prices for electric and non-electric scooters and motorbikes

Brand/Model	Official Price (€)	Range (km) (WLPT)	Battery capacity (kWh)	Equivalent ICE model	Official price for ICE model (€)
BMW C Evolution A1	14990	100	8.0	Suzuki Burgman 400	7799
BMW C Evolution A2	16612	160	8.0	Suzuki Burgman 600	11199
NIU N-series	2899	60	1.4	Kymco Agility 50	1399
NIU M-series	2499	65	1.25	Honda Vision 110	2250
Silence S02	4180 5120 5725	50 75 100	2.0 4.0 6.0	Piaggio New Liberty 125	2299
Torrot MUVI L1	3521	100	3.8	Kymco Agility 50	1399
Torrot MUVI L3	3824	100	3.8	Piaggio New Liberty 125	2299
Vectrix VX-1 Li	7300 12120 14470	125 180 250	7.2 10.8 14.4	Suzuki Burgman 200	4499
Vectrix VX-2	4900 6700 8300	50 90 120	2.25 4.5 6.0	Honda SH 125 2018	3389
Zero Motorcycles S 2017	12260	193	14.4	Yamaha Tracer 700 2019	8299

Public administration is incentivizing the purchase of alternative energy vehicles, including electric vehicles, with several plans over time, as well as the installation of charging infrastructure.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

LEV sharing fleets

In Barcelona there are several mobility operators offering e-scooter sharing services. MOTIT, partner of GreenCharge, is one of these operators. Its fleet accounts 200 scooters. The particularity of the scooters is that they are manufactured by the company and they have been especially designed for this service (robust and with few “breakable” parts), integrated navigation system and space for the helmet, as shown in Figure 3-1.

Figure 3-1: e-scooter from MOTIT sharing service

Other e-motorbikes fleet operating in the city and their corresponding fleet is shown in Table 7.

Table 7: e-scooter operators in Barcelona

Operator	Fleet (# scooters)
eCooltra	1150
Scoot	500
Yego	450
Muving	350
MOTIT	**200**
AccionaMobility	50

Barcelona city council operates a bike sharing service called Bicing. It has been updated recently reaching 519 stations and 6000 bicycles, 1000 of them are electric. Over 100,000 users are subscribed to the service, paying an annual fee of 50 €. For e-bikes, an extra 0.35 €/30 minutes have to be paid.

Eurecat EV drivers

At the moment of writing this report, they have been identified 5 employees of Eurecat that drive e-cars (FEV and PHEV); several more drive hybrid cars. The share is lower than regional average; however the figures might change when a more formal poll will be conducted and for employees replacing their cars. Unfortunately, the number can also be reduced by employees leaving the company. This is a risk already identified.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

Sant Quirze bicycle sharing service

The e-bike sharing service operated by Sant Quirze del Vallès municipality accounts 6 e-bikes. The service was put in service 2 years ago open to workers from factories in the industrial area. The approach of the municipality is to offer the service to a company at a time for a limited time period (3 months). The final goal is that after successfully testing the acceptance of users, the factories themselves will buy more bicycles as part of their mobility plans (enterprises over a certain number of employees are obliged to define a mobility plan for their workers). To use the service, users get a key to access the "Bicibox" (seen in Figure 3-2) where the bicycles are parked and charged. The service is meant to cover the last mile between the train station and the factories in the several industrial areas in the town. At the moment, the service is free of charge.

Figure 3-2: St.Quirze e-bike sharing service station

3.2 Existing charging infrastructure

Barcelona and surroundings

As mentioned before the development of the public charging infrastructure started with the deployment of slow charging points. There are multiple sites and apps to check the location of the charging points, but the most commonly used is electromaps[9] (electromaps.com) that covers Europe. As seen in the map in Figure 3-3, the highest concentration of charging points is in Barcelona.

[9] http://electromaps.com

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

Figure 3-3: Distribution of public charging points in Spain extracted from electromaps

The above mentioned website allows to search by location, type of point, type of socket and operator. There is a smartphone app that allows to interact to some of the charging points interoperable with the app or and RFID key ring.

When available, the status is also displayed, either because the charging point is equipped with a communication module or because a user has notified that it is out of order or it is occupied by himself/herself.

The ICAEN (Catalan Institute for Energy), in charge of the development of the PRIVEC (Strategic Plan for Deployment of Charging Infrastructure for Electric Vehicles in Catalonia) also provides real time information of the charging points in Catalonia, except for Barcelona city (see Figure 3-4).

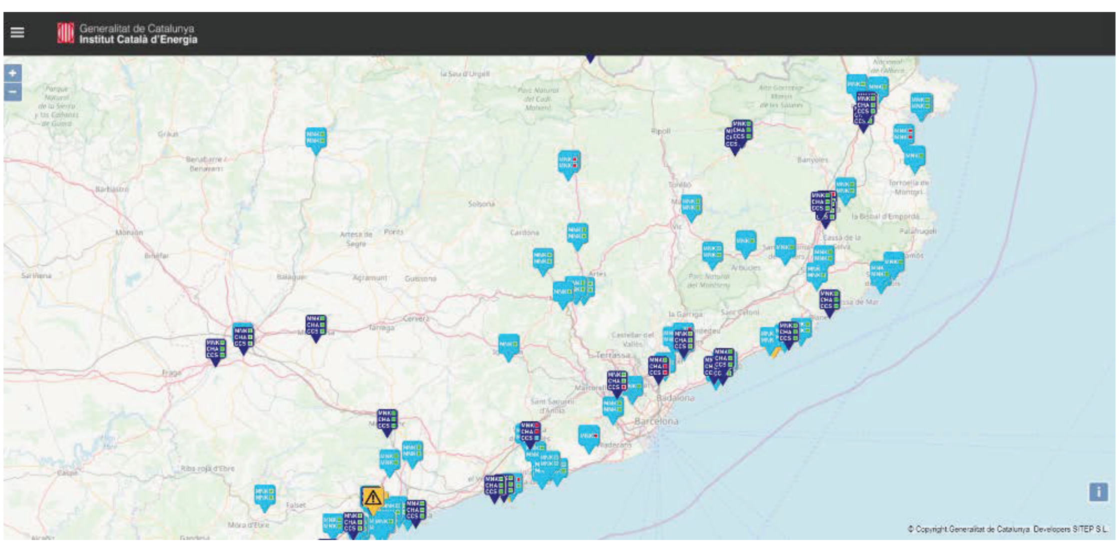

Figure 3-4: Distribution of public charging points in Catalonia extracted from ICAEN web portal

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

Similarly, AMB (Barcelona Metropolitan Area) also provides a map (Figure 3-5) with real-time information of the 10 fast charging points managed by the organization. The particularity of these charging points is that they can be booked 15 minutes in advance.

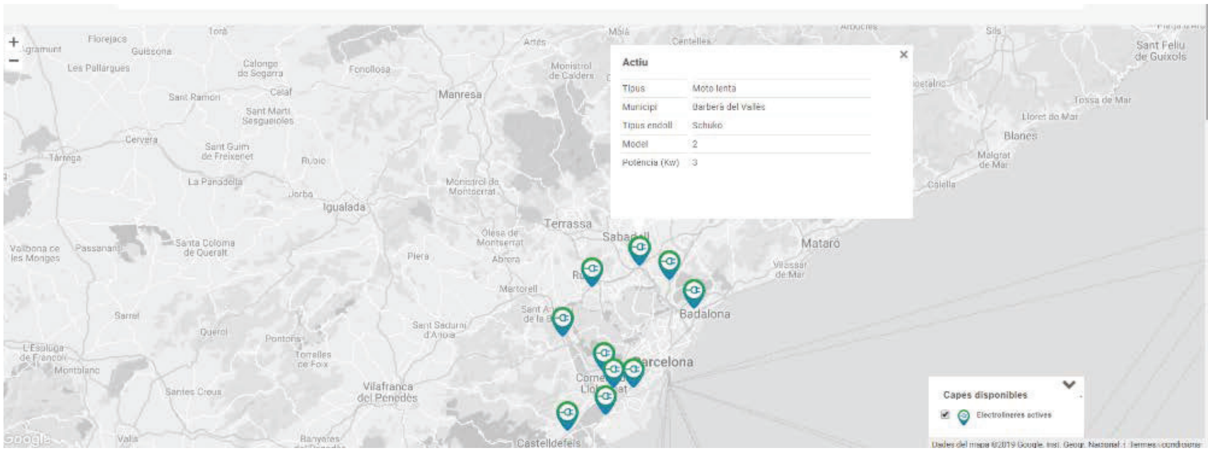

Figure 3-5: Distribution of public charging points operated by AMB

The summary is that there are multiple web sites to locate public charging points, and unfortunately, they are not always consistent or complete.

At the moment of writing this report, we have not been able to identify a data source to provide the figures on private charging point infrastructures.

In general, slow charging points are not bookable and the use is free of charge. However, there are also some fast charging point networks: Barcelona deployed a network of 14 fast charging points addressed to cover the need of e-taxis; AMB owns a network of 10 fast charging points, bookable up to 15 minutes in advance.

In Barcelona city, public charging points (slow charge) can be accessed with the LIVE card. This card is granted to Barcelona citizens or companies that own an EV (registered in the city), upon request to the municipality on-line or on-site.

Other municipalities issue their cards for EV owners as well. To foster interoperability, the Alliance of Municipalities for Interoperability created a card that enable compatibility to use the public charge infrastructure of all the municipalities of the alliance. The initiative was promoted by ICAEN (Catalan Institute for Energy). Currently, the alliance includes 29 municipalities, including Barcelona city, Barcelona Metropolitan area, 4 public parking garage operators and a *comarcal* council (similar to a county).

Another method to access charging points is through QR codes and apps (see Figure 3-6). This is the case of the points managed by AMB (Metropolitan Area of Barcelona) or Granollers municipality.

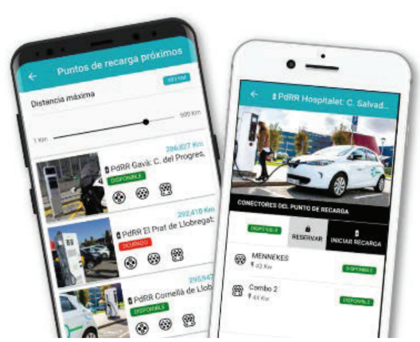

Figure 3-6: Screenshots from AMB app

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

Regarding utilization, the usage of the public charging infrastructure is very low, in general.

Eurecat charging infrastructure

The charging infrastructure in Eurecat is quite limited, but consistent with the low number of EV drivers. The headquarters in Barcelona have charging points in the parking garage of the premises. However, they are not managed by Eurecat; the offices of Eurecat-Barcelona are in a complex of buildings occupied by several companies, called The Corner Stone, and owned and managed by a third party. For employees based on Eurecat-Barcelona, some of them, according to their position, have access to a parking spot in the garage and if needed, with charging capabilities. Employees for other premises can book a parking spot for their visit, if available (there are few spots), but they do not have charging infrastructure in the premises. Apart from the community parking, it is possible to rent a parking slot in one public parking owned by BSM (Barcelona Municipal Services) that offers different tariff schemes (working hours, whole day, by time) and provides charging infrastructure for some slots, or access nearby public charging slots in 22@ district (as shown in Figure 3-7), the technological neighbourhood where the premises are located.. These charging points are located in time regulated parking spaces and drivers can park up to 2 hours (free of charge).

Currently there are two employees based in Barcelona with EVs. Both have access to the parking garage.

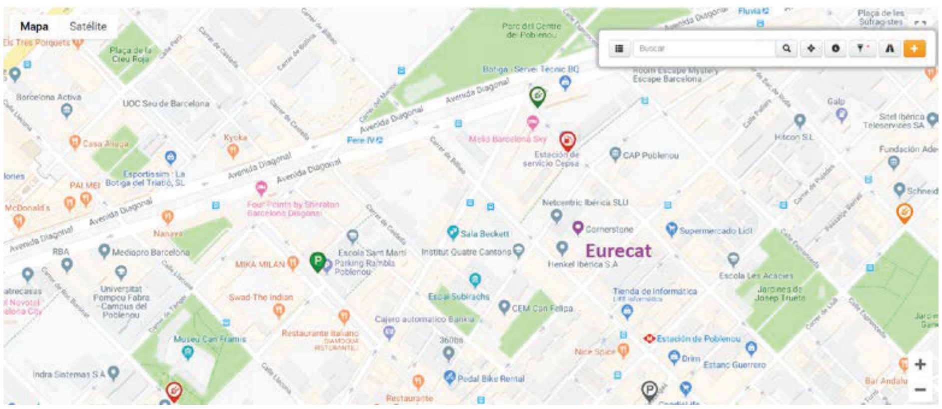

Figure 3-7: Charging facilities around Eurecat headquarters in Barcelona

In Cerdanyola del Vallès Eurecat premises, the building is owned and managed by Eurecat. It is one of the premises chosen to implement some of the use cases. There is a community parking garage accessible by some employees, according to their position. In the garage there are 8 sockets for charging purposes. Employees with access to the garage can request a card that enables the charge of the vehicle; the employee pays for the energy. There is a charging point in the visitor's parking space open to public use but currently is out of order. There are plans to install a charging point taking advantage of a subsidy plan to install fast charging infrastructure for public use. Employees visiting the premises in Cerdanyola with an EV should go to nearby towns like Sant Cugat, Sabadell or Sant Quirze to charge their EVs (5-10 km), as shown in Figure 3-8.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

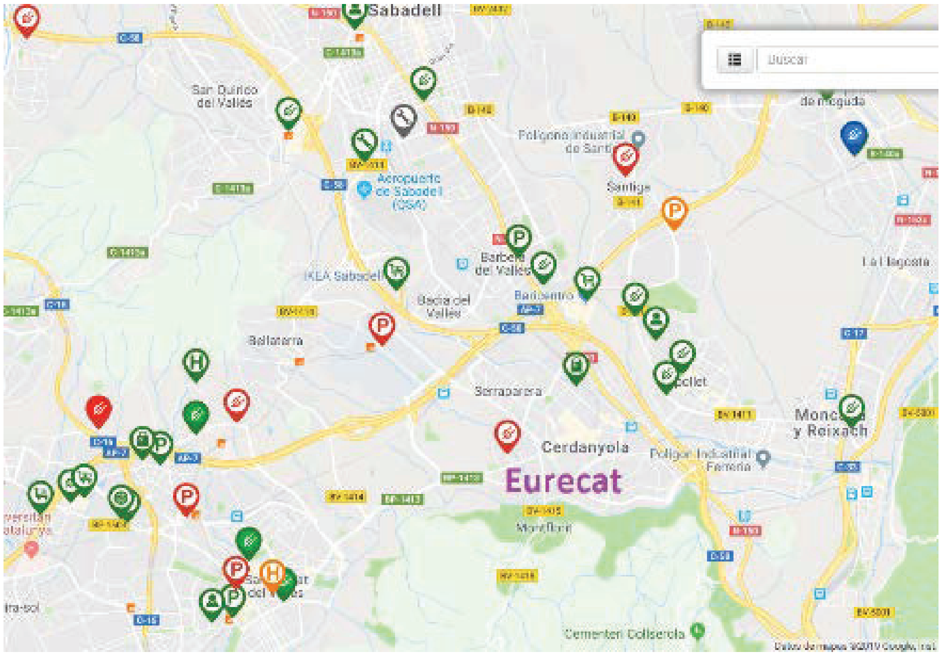

Figure 3-8: Charging facilities around Eurecat premises in Cerdanyola

Currently there is only one employee with a PHEV which has access to the parking garage. Some employees from other sites that visit Cerdanyola quite often are interested in using the charging infrastructure.

For the rest of offices there is no charging infrastructure and employees should search for public charging points located between 2 and 10 km away.

MOTIT charging infrastructure

The e-scooter sharing service operated by MOTIT in Barcelona and Madrid charge their vehicles swapping the batteries. In Barcelona they have 200 e-scooters and 240 batteries. Initially they charged the batteries in their headquarters in Hospitalet de Llobregat, but to increase efficiency they have 2 hubs spread all over Barcelona city. MOTIT staff go with MOTIT e-scooter to the location where the e-scooter with the empty battery is and replace the empty battery with a full one. They can carry up to 3 batteries in each trip. They take the empty batteries to the hubs where they are charged to full charge with slow charging.

Battery capacity is 2.1 kWh, providing a range of up to 60 km. On average, a battery is replaced every three days and serves 5 trips, which means a total mileage of 30 km. Batteries are usually replaced with 50% of SoC, to avoid the driver's range anxiety.

Sant Quirze e-bike sharing service

The bicycles of the service, 6 in total, are charged in the same parking spot where they are stored. To access the parking spot a key is needed. The users are responsible to plug the bicycles when they finish their trip. Most of bicycles are parked in the factories during the shift (8-9 hours) but due to the short trips (typically 3 + 3 km, round way) it is not needed for extra charge at the workplace.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

3.3 Energy and power situation

The Spanish Energy System

In Spain the price of energy is traded daily in the electricity market; retailers and producers bid in an auction, resulting in a price for electricity every hour[10]. The operator of the system (TSO) checks the physical feasibility of the offers, meaning that the grid is capable to transmit the energy from the producers to the consumers safely within the operation limits. The transmission and distribution of energy is a regulated activity; the TSOs and DSOs received a fixed amount of money defined by the government for the grid capacity and the energy transmitted. Consumers find in the energy bill four terms: 1) the cost of energy (including energy and the usage of the grid) pay by kWh, 2) the cost of contracted power (maximum kilowatts they are able to consume) pay by kW contracted per day, 3) the rental of the meter reader pay per day and taxes. Retailers offer different tariffs schemes to their customers: hourly based, two period-based (peak/off-peak fixed periods) and flat tariffs. Prosumers also pay for the usage of the grid, per peak power of the installation. While renewable energy was highly incentivized some years ago, the fees has drastically been reduced, jeopardizing the economic sustainability of many PV farms built with loans.

Apart from the daily bid, there are intra-day markets to cope with deviations (regulation markets). In those markets what is sold is flexibility, but only a small group of companies can participate.

The installed capacity of the system is above power needs, probably due to the combination of economic crisis and energy efficiency measures. Some power plants, the most costly to operate, like CHP plants, work few hours a year, typically when there are very high and very low temperatures to cope with cooling and heating demand. Locally, congestion in the grid is observed in some areas during summer season due to the high impact of tourism activities. Currently there are not demand response programs in place, and the only way to cope with congestion is load shedding.

Similarly, regulation does not allow V2G strategies, although as a result of research project it has been developed a charging point with V2G capabilities that is commercialize by one of the biggest energy utilities in Spain. It will happen first the V2H in the framework of self-consumption installations and NZEB.

The composition of the energy mix varies according to the energy market, but on average, 40% of the energy is produced by renewable sources[11] (see Figure 3-9).

Energy in Eurecat

As mentioned previously there are 11 different premises, each one with a different contract and energy consumption according to the size of the installation.

We will focus on the energy consumption of the site located in Manresa because it has in place a building energy monitoring system and some distributed energy resources. Figure 3-10 shows the main loads and production resources. The connection to the grid has a capability (contracted power) of 522 kW. There are 2 PV panel installations with a rated power of 6.48 kWp and 1.35 kWp. The thermal solar installation covers an area of 2.33 m^2. The mini wind turbine has a rated power of 1 kW and the storage capacity is 4.8 kW.

The energy locally produced is consumed in the installation. The annual production is around 9.3 MWh. On the other hand, the monthly consumption of the premises is on average 57.3 MWh. There is activity all year long; however on summer, especially in August most part of the personnel is on holidays. The tariff scheme is called 6.1A, which has 6 different time periods along the day and the year, with different prices depending on the period.

---

[10] There is a similar market to be put in place for gas energy

[11] https://www.ree.es/sites/default/files/11_PUBLICACIONES/Documentos/InformesSistemaElectrico/2019/presentacion-avance-informe-2018.pdf

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

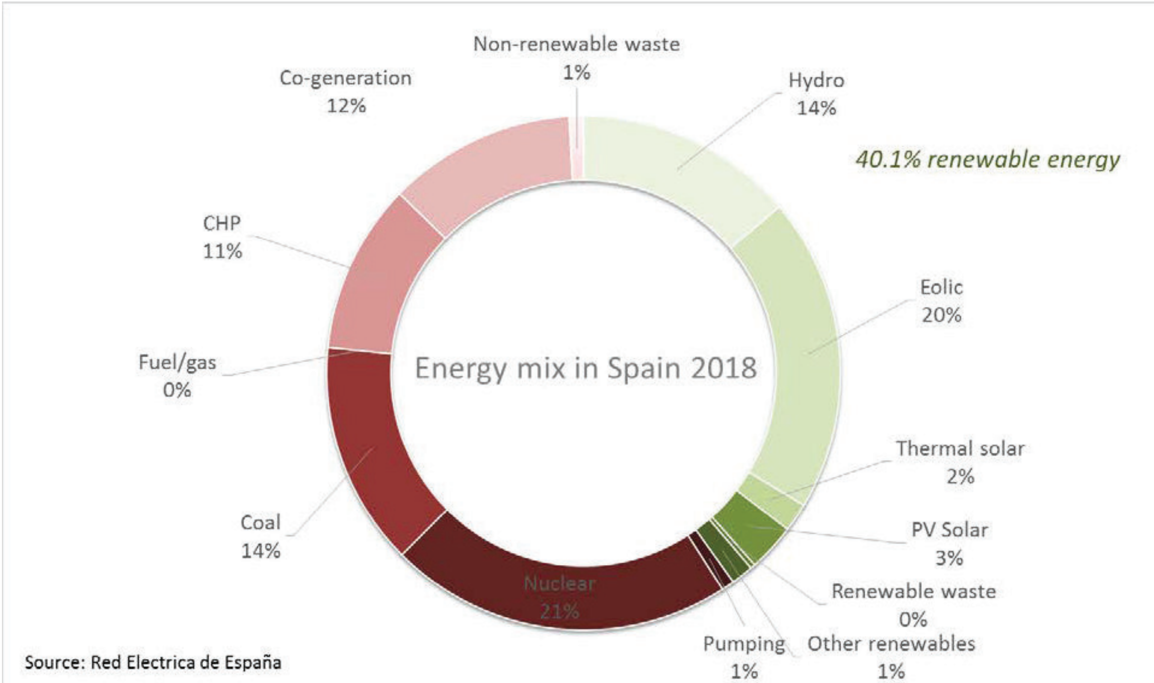

Figure 3-9: Energy mix in Spain, 2018 (provisional data Feb. 2019)

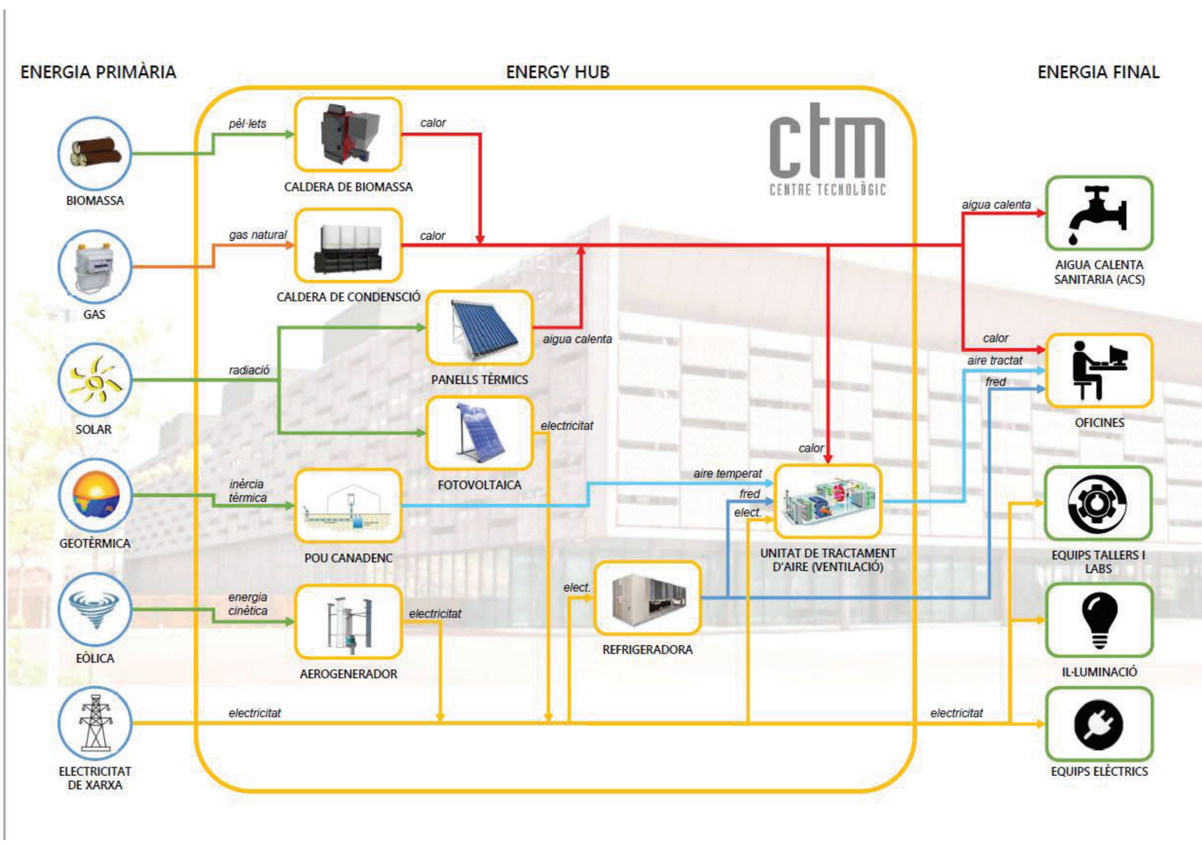

Figure 3-10: Energy schema exchange in Eurecat-Manresa building

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

This site will be used as demonstration for the ESN use case and the data regarding PV efficiency will be used in simulations for what-if scenarios in other premises (MOTIT and Eurecat Cerdanyola site).

Energy in MOTIT

The energy contract for MOTIT hubs was carried out having in mind the high consumption of the charging infrastructure. The infrastructure is 3-phase and the maximum power contracted is 34.65kW. Because of the particular locations of the hubs, the PV production is difficult (downtown buildings), but operation managers keep in mind this possibility for new locations.

On average, monthly consumption is 950kWh, which can provide energy for around 430 battery charges every month in the hubs.

Figure 3-11: Battery hub in MOTIT premises

3.4 ICT Systems and Interoperability in the Electro-mobility Landscape in Barcelona

The interoperability in Barcelona landscape is limited for the moment. The reason for it is the low penetration of EVs and the reservations of car manufacturers to provide information about the vehicle, such as state of charge, fearing that it can be misused by competitors. The infrastructure is growing according to different policies put in place and the interests of stakeholders.

Bearing in mind that recharging in public charging points is free of charge (due to several reasons presented previously), it has not appear the need for a payment and clearance system.

Regarding physical interoperability of the charging points, the charging infrastructure has adopted the market standards. Slow chargers use mainly Mennekes sockets and fast chargers uses Chademo. Many charging points are equipped with different type of sockets (Schuko, Mennekes).

Some e-cars have a non-standard system and require a specific charging point. This is the case of Tesla cars; the charging infrastructure can only be installed by authorized installers.

Regarding the accessibility to the charging point (to unblock the charging point to start charging), there are several systems; the most commonly used are RFID cards (or key-chains) and apps (QR code reader). For the cards, commonly issued by city councils, an alliance to create interoperable fast charging points accessible via cards or an app called EVCharge[12] has been created and is growing. The alliance, called AMTU (*Aliança de Municipis per a la Interoperabilitat* – Alliance of Municipalities for Interoperability). The current members are: Amposta, Barcelona, Balaguer, Cambrils, Cabrera de Mar, Calafell, Caldes de Malavella, Calella, Canyeles, Celrà, Cunit, Girona, Granollers, Lleida, Molins de Rei, Navarcles, Roses, Rubí, Olot, Santa Coloma Gramenet, Santa Coloma de Farners, Sant Fruitós del Bages, Sant Hilari Sacalm, Sant Pere de Ribes, Santa

[12] http://swetecnic.com/evcharge-2/

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

Perpètua de la Mogoda, Sitges, Tortosa, Vidreres and Vilafranca del Penedès municipalities, Consell Comarcal Baix Ebre (county) and the following public parking operators: BSM, GESTVIA, APARCAM and GRAMEPARK. As seen in Figure 3-12, the location of the interoperable fast charging points enables journeys along Catalonia.

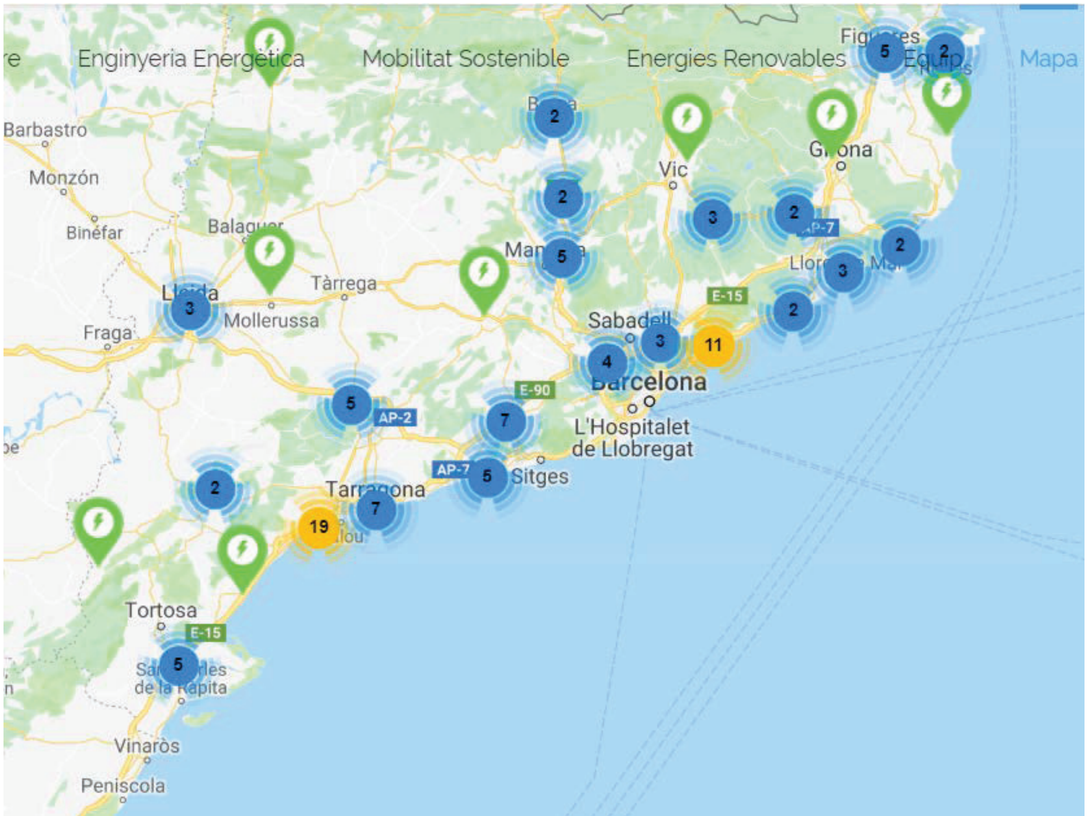

Figure 3-12: AMTU fast charging points network

As far as booking is concerned, only few charging points are bookable. Each network of "bookable" charging points provide its system, accessible through an app.

Finally, concerning the location and status of the charging points, there are several websites in place, but the most popular one has become electromaps. Charging point operators are invited to fill in a form for each new charging point installed. Users can also provide information about existing points and status. The charging points with communication capabilities can provide the status of the charging point in real time. Additionally, Barcelona city council has a platform called NOC, in the control centre. All charging points installed in the city by different operators should provide the description of the charging point in a specific format. For those with communication capabilities, they should provide their status periodically. The control centre receives also calls for users reporting issues with the charging points and manages the work orders for maintenance and fixing tasks.

The following operators have joined *intercharge* which should facilitate interoperability: Electromaps, Urbener, Estabanell Energía, Atos, GIC (ACS Group) and Circontrol.

3.5 Policy and incentives for e-mobility

Public administration at national, regional and local level have put in place several incentives to foster e-mobility. In general, incentives do not address explicitly electric vehicles, but low pollutant vehicles or zero emission vehicles. Of course, EVs are included in these groups. Recently, to those incentives some regulations are set to penalize the use of high pollutant vehicles, mainly diesel vehicles.

Incentives

The incentives may vary depending on the autonomic government (region) or municipality (local). Here are the most extended:

- Subsidies for the purchase of alternative fuelled vehicles[13]:

  The last plan approved by the Spanish government is called Plan VEA. The budget for this year 2019 is 66.6 M€, 50 M€ exclusively to subsidize the purchase of clean vehicles (Plan MOVEA). The success of this plan in previous years was that the requests for subsidies covered the budget in less than 24 hours. A total of 1,288 full electric vehicles (43% of the budget) were subsidised. The subsidies assigned to each type of vehicles is not known at the moment of writing this report. However as an illustration, the subsidies for Plan MOVEA 2018 range from 1500 € for motorbikes to 5000 € for vans, buses and trucks.

  Some regional governments and municipalities have additional subsidies. In the case of Catalonia, the current available subsidies targeted the purchase of EV for professional use and range from 4000 € to 4500 €.

  The Barcelona Metropolitan Area has granted subsidies of 250 € for the purchase of electric bicycles (1000 bicycles). Currently, the subsidy is not active but it is expected it will be available again in May. It also put in place the temporary lending of bicycles (electric and non-electric) to companies for their employees in order to shift from pollutant cars to cleaner transportation modes. The subsidy is not active at the moment; it is expected to reopen during 2019.

- Subsidies for the installation of private charging infrastructure: as an extension of the previous subsidy plan (Plan VEA), in 2019 16.6 M€ are assigned to subsidise the installation of a charging point for private use when they buy an EV. The subsidy is estimated to be around 1000 €.

- Tax reduction: city councils offer a 75% discount on the yearly tax for EVs. This tax is mandatory to be able to drive in the roads. The amount to be pay depend on the tax HPs of the vehicle. For cars it can range from 25 to 220 €.

- Toll reduction: different governments offer a toll reduction of gratuity in pay motorways and tunnels. For instance, a common motorway with tunnels used to access Barcelona and avoid the congested free motorway offers a discount of 30%, for a toll that cost 4.34 €.

- Free parking in time controlled areas: EVs are granted free parking for the maximum time a vehicle can remain parked in a time-regulated (type A or B: 2 hours, type C: 3 hours, type D: 4 hours). Often, they can charge at the same time, since most public charging points are located in these areas. In Barcelona the cost of this parking spots range from 2.5 €/h in type A to 1.08 €/h in type D.

- Free charging in public charging points: To charge the vehicle has no cost in public charging points. Most charging points are installed by city councils, utilities or car manufacturers and they are usually slow fast chargers. There are a few fast charging points also free of charge for public use.

[13] The government does not address specifically electric vehicles

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

- Use of HOV lanes: The HOV lane in C-58 motorway used by many commuters of the Valles area (Cerdanyola, Sabadell, Sant Quirze,…) to enter Barcelona city can be used by zero emission cars, even if they do not reach the minimum number of passengers (>2). It is in service since September 2014 and has a length of 6.8 km.

- Free ITV: The ITV is the technical inspection for vehicles over 5 years old. The cost depends on the type of vehicle and the region; for cars is about 45 € and for motorbikes around 20 €. It is free of charge for EVs.

Policies

- Ban high pollutant vehicles: Barcelona and its metropolitan area put in place in 2017 restrictions for high pollutant vehicles. For the moment it applies only during specific periods of time, when due to weather conditions (anticyclone) air pollution is high, but progressively it will become permanent. Vehicles are categorized depending on the fuel used and the year they were built (Zero, ECO, C, B, no tag). Similar measures apply to Madrid.
- Ban combustion vehicles by 2040: The Spanish government has announced recently the prohibition to manufacture any combustion vehicle by 2040. The announcement has caused strong reactions from car manufacturers and its application will rely very much on the party governing for the next years.

- Parking spots in new buildings: New buildings are required to build a certain number of parking spots, off-street. This pave the way to the installation of charging infrastructure in community parking garages and will minimize the number of EV drivers with no access to fix charging infrastructure.

- Charging infrastructure in public parking lots: new built parking spaces should provide at least 2% of the charging spots with charging infrastructure. This affects public charging garages, supermarkets, parking lots in train stations, etc., either underground or in open air.

- Permissions for the installation of private charging infrastructure: the regulation for community parking spaces was changed to avoid the veto of the community when any of the owners of a parking spot in a community parking garage wanted to install a charging infrastructure to charge their EV. The new regulation avoid asking for consensus as long as the electric supply for the installation come from their own household installation (not for the one from the community).

SUMPs

Most municipalities have developed their SUMPs including the shift to electro-mobility to achieve a more sustainable mobility. Barcelona city, although not explicitly mentioned, paved the way to electro-mobility already in the 2008 SUMP. The current SUMP includes it explicitly. The first priority is collective transport: buses, metro, tram. Barcelona is increasingly adding cleaner buses in its fleet, including gas, hybrid and full-electric buses. It is also of high importance to facilitate non-motorised journeys (walking, bicycle). It requires a holistic approach: to increase the journeys on foot it is required to have all services at walking distance. That is why they are testing the concept of superblocks (named *superilles*): the traffic circulates on the perimeter of the superblock, and journeys inside the superblock are done on foot. Finally, the last option is private mobility, that is still necessary in some cases; when so, some incentives previously mentioned aim at foster the purchase of low or zero emission vehicles.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

4 User needs for interoperability

4.1 Scenarios

Some target scenarios were already defined at proposal time. In this section we review how these scenarios are instantiated in Barcelona pilot site.

4.1.1 Scenario 1: Charge planning and booking

A booking system for charging points in Eurecat premises will be developed and offered to Eurecat employees. It will be demonstrated in the two premises directly owned and managed by Eurecat at Cerdanyola del Vallès and Manresa (see Figure 2-4).

The service is meant to be used by employees driving a plug-in electric car that are visiting other premises different from their usual workplace. For the charging in their workplace they should have access to a fixed charging spot (in the premises or in a parking garage with that offer).

The premises located in Cerdanyola del Vallès have already 8 charging points as shown in Figure 4-1. They are standard Schuko sockets activated with an RFID card. It is expected to upgrade these charging points to enable meter reading and remote on/off functionalities.

Figure 4-1: Charging points in Cerdanyola premises

The premises located in Manresa do not have a charging point yet. The installation of a standard pole charging point or a more low-cost solution will depend on access to a public subsidy for public charging point infrastructure. The interesting point of Manresa location is that there are DER on site.

4.1.2 Scenario 2: Charging at booked Charging station

The next step after scenario 1 is the actual charging at the charging point previously booked. This scenario will be realized in Eurecat premises at Cerdanyola and Manresa. The employees will have an app to do the booking and interact with the booking system for further updates. Once in the premises, the app will guide them to the allocated charging spot. Once there, they should be able to plug their car in the assigned spot until the charging process would be completed. It has to be decided yet if the car can stay in the spot as long as the user stays in the premises or if the user will have to take it away as soon as it is charged. Additional alternative situations may arise if the spot is occupied by another car (this situation is handled in Scenario 3) or if unexpected circumstances occur (a failure, an accident, …) that prevent the normal operation of the system.

4.1.3 Scenario 3: Booking Enforcement

This scenario is part of the situation that might arise from scenario 1 + scenario 2. In the same premises of Eurecat depicted previously, it can happen that a car spot in the garage is occupied by another vehicle when

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

the user that has booked the charging point arrives at the premises. The booking operator should find a solution to handle this situation. Since all the users of the parking garage are Eurecat employees, it is not foreseen to take harsh actions, especially during the first phase of the demonstration. However, the situation has to be handled somehow: identifying the user that has parked improperly in the parking space, assigning another spot to the user if it is available or other.

4.1.4 Scenario 4: Home charging in older (groups of) residential or working buildings with common internal grid and parking facilities, or at work in (groups of) buildings with similar limitations

The scenario will be demonstrated as such in Eurecat premises. Currently, there is no physical power limitation because the installation had been designed to supply the existing charging points. However, this exercise might serve to reproduce different situations:

- To explore the feasibility to reduce the maximum power contracted to the DSO (and potentially reduced the fixed term in the electricity bill)
- To explore the feasibility to multiplex charging processes according to availability of local energy sources
- To explore the flexibility offered in case of unplanned curtailment situations or future demand response schemes

The scenario might involve a negotiation process when it is applied to the case of a previously booked charging process if it is not possible to supply all users with the energy requested.

4.1.5 Scenario 5: V2G

This scenario will not be tested in Barcelona pilot, as we do not expect vehicles with this capability to be available during the time period that the pilot will be conducted.

4.1.6 Scenario 6: Reacting to Demand Response (DR) request

This scenario is not tested as so in terms of DR requested by the grid, but the DR request comes from the premises themselves (ESN) to foster self-consumption of renewable energy.

The scenario can be demonstrated in the three different demonstrators:

- premises of Eurecat in Manresa: smart management of charging of EVs (from employees) and the rest of loads of the building combined with availability of energy coming from PV panels and mini-wind turbines
- e-bike station in Sant Quirze: it is foreseen to install a PV panel and a stationary battery that would enable the realization of the smart charging according to availability of local energy and e-bike usage extracted from utilization patterns
- MOTIT premises: it will be simulated off-line since there are not local RES. The aim is to analyse the business model prior to the purchase of the equipment

4.1.7 Scenario 7: E-Mobility in innovative 'mobility as a service' (MaaS)

This scenario will be realized in two different demonstrators: the MOTIT e-scooter sharing service and the e-bike sharing service for commuters in Sant Quirze train station.

MOTIT e-scooter sharing service

The aim of MOTIT is to improve the operation of it e-scooter sharing service searching for a reduction of operational costs while maintaining or increasing customer satisfaction. The activities can be grouped into two sub-scenarios:

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

- Smart management of battery hubs including analysis of impact of current intensity in battery health, flexibility for future deployment of RES (based on simulation results) or enrolment in DR campaigns (when available in Spain)
- Incentivise users to drop/take e-scooters in battery hubs to reduce time and energy needed to replace flat batteries spread all over MOTIT operation area. This will slightly alter the pure free-floating operation scheme to a hybrid scheme including both free-floating and station-based options to users to whom incentives are attractive enough.

Sant Quirze e-bike sharing service

The current operation of the sharing service is not ICT based. The aim is to upgrade the system to increase user satisfaction and provide insights to the service operator (municipality).

The measures include the development of a smartphone app (and corresponding back-end platform) to establish a link between the user and the bicycle. Currently, the user has a key to access the bike station and can take any available bicycle. There is no traceability on how often or how long the bicycles are used. Additionally, a locking system will be added to increase security and minimize theft.

The smart management system to be used in Scenarios 4 and 6 will also be included with the installation of a PV panel and a stationary battery. This will impact on the usage of greener energy, of special interest of commuters that have taken the decision of using public transport to reduce their carbon footprint.

Finally, and similar to the case of MOTIT, different charging profiles will be analysed in Eurecat Battery Lab to investigate the impact on batteries health to extend their lifespan. The results will be included as charging strategies in the charging management system.

4.2 Stakeholders

The following relevant stakeholders have been identified:

- Charging station owner: the individual or entity that has pay for the installation of the charging station
- Charging system operator: the individual or entity that takes care of the daily operation of the charging infrastructure
- Booking system operator: the entity that provides a system that enables the reservation in advance of a charging point.
- Facility owner: the individual or entity that owns the premises with the charging installation and/or building infrastructure.
- E-sharing operator: the entity that operates an e-sharing service, meaning that users of the service can use a vehicle that they do not own.
- Energy manager (ESN system operator): the person that takes care of the management of an installation from the energy perspective. In the project will be the person in charge of operating the optimization module of the ESN.
- EV driver: the person that drives an electric vehicle; they do not necessarily own the vehicle, like the user of a sharing service.
- EV owner: the person that owns an electric vehicle; they do not necessarily drive the vehicle, like a sharing operator
- ICT provider: an entity that provides a software application and/or other ICT equipment like a server, trackers, …

In the following table, the stakeholders with the actual entities in the three demonstrators are mapped.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

Table 8: Stakeholders in the demonstrators

	MOTIT demonstrator	EURECAT demonstrator	Sant Quirze demonstrator
Facility owner	MOTIT (headquarters) Other third party (2 battery hub locations)	Eurecat	Regional railway operator FGC
Charging system operator	MOTIT	Eurecat infrastructure department	Municipality
Booking system operator	N/A	Eurecat infrastructure department	N/A
e-sharing operator	MOTIT	N/A	Municipality
Energy manager	MOTIT	Eurecat infrastructure department	Municipality/Eurecat SMS department
EV driver	MOTIT customer	Eurecat employees	Wo0rkers/Commuters
EV owner	MOTIT	Eurecat employees	Municipality
ICT provider	MOTIT Third party	Eurecat Enchufing	Atlantis Enchufing Eurecat

4.3 Use cases and user needs

The scenarios previously defined include one or several use cases (see List of definitions for use case definition) that are described in this section.

4.3.1 Use case 1: Booking of charging point

4.3.1.1 Description

An Eurecat employee driving a plug-in electric car has scheduled a meeting in another Eurecat office, different of her/his usual working place and wants to recharge her/his car during the visit. The EV user provides the estimated arrival and departure time and the estimated SoC at arrival and departure.

4.3.1.2 Actors

The main actors involved are:

- EV driver (Eurecat employees): All Eurecat employees driving a plug-in electric car are candidates to use the booking service when accessing different premises from their usual working place. For the usual working place they should have a fix charging point.

Secondary actors are:

- Eurecat Infrastructures Manager (or Deputy): They are in charge of the operation and maintenance of the charging infrastructure, the garage and the access control system.
- Eurecat IT Department: They provide the IT infrastructure to run the back-end booking system. They will be notified when the server is not running or there is a failure in communications.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

- Eurecat Human Resources Department: They are in charge of defining the policy for the cost of the charging service and the payment procedure. In the past, the payment for the cost of the energy has been done as a payment in kind to be recorded in the pay check.

The energy provider is kept out of the scope of this use case since they are not directly involved in the realization of the use case.

4.3.1.3 Preconditions

The following pre-conditions are required:

- The e-car driver has access to the app to do the booking
- The e-car driver has been registered to the system (s/he is an Eurecat employee and/or has received the approval from Eurecat to access the service)
- The charging points are on service and the garage is accessible
- The socket type is compatible with the e-car plug

4.3.1.4 Basic flow

1. Danny, an employee working in Barcelona premises has arranged a meeting in Eurecat Cerdanyola premises and will stay there for the day. He logs into the app and inserts a new booking selecting the premises, the time slot (arrival and departure) and the estimated energy needed
2. The booking system, managed by Eurecat, checks for availability of spots taking into account temporary restrictions that might apply (maintenance work, …)
3. The booking system sends to Danny a notification confirming the booking has been accepted
4. The booking system sends to Danny a reminder some hours before the booked time

4.3.1.5 Alternative flows

A change in conditions occurs, such as limitation on energy or parking spot blocked by another user with higher priority

4. The booking system sends a notification to the user requesting a change on the booking: i.e. reduced SoC at leaving, reduced time in the charging spot or booking cancellation

The user cancels the booking

4. Danny logs into the app and cancels the booking
5. The booking system de-allocates the resources (charging spot)
6. The booking system sends a notification confirming that the booking has been cancelled

The user needs to modify the booking

4. Danny logs into the app and modify the existing booking, changing the time slot
5. The booking system cancels the existing booking
6. The booking system creates a new booking with the new parameters and goes to step 2

4.3.1.6 Exception flows

The user is not authorized to use Eurecat installation

2. Danny cannot log into the app. The approval has not yet being granted by the organization

The user has not a compatible smart phone to use the app

2. Danny cannot run the app in his smartphone

The system is not running

2. Danny tries to log into the app but the system is not responding.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

3. Danny call or put a ticket in the ticketing system to notify the issue

There are not available charging points or some maintenance works are going on

4. Danny receives a notification rejecting any booking option

There is not any available charging point at the requested time

4. Danny receives a notification rejecting the booking

There is not availability for the requested conditions, but it can be if there is a re-arrangement with other booking requests

5. Danny receives a notification that his booking is on-hold
6. The booking system initiates a negotiation with other users to reallocate some slots (leave the charging spot earlier o connect to the charging spot later)
7. Danny receives a notification confirming or rejecting the booking according to the result of the negotiation

4.3.2 Use case 2: Charging at a booked charging point

4.3.2.1 Description

A Eurecat employee who has previously booked a charging point for a specific time slot, drives to the premises to charge his/her e-car. This is the situation that follows Use case 1. At arrival the SoC of the battery is x%. The app will display the location of the spot in the parking garage for the active booking.

4.3.2.2 Actors

The main actors involved are:

- EV driver: All Eurecat employees driving a plug-in electric car are candidates to use the booking service when accessing different premises from their usual working place. For the usual working place they should have a fix charging point.

Secondary actors are:

- Eurecat Infrastructures Manager (or Deputy): They are in charge of the operation and maintenance of the charging infrastructure, the garage and the access control system.
- Eurecat IT Department: They provide the IT infrastructure to run the back-end booking system. They will be notified when the server is not running or there is a failure in communications.
- Eurecat Human Resources Department: They are in charge of defining the policy for the cost of the charging service and the payment procedure. In the past, the payment for the cost of the energy has been done as a payment in kind to be recorded in the pay check.

The energy provider is kept out of the scope of this use case since they are not directly involved in the realization of the use case.

4.3.2.3 Preconditions

The following pre-conditions are required:

- The e-car driver has access to the app to do the booking
- The charging points are on service and the garage is accessible
- The socket type is compatible with the e-car plug
- The user has previously booked a charging point and the booking has been accepted

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

4.3.2.4 Basic flow

Following the case story of Danny, the Eurecat employee in Use case 1.

1. Danny parks the car in the allocated spot, plugs the car in and introduces the current SoC and the minimum SoC required at departure time.
2. Danny confirms the car is ready to charge.
3. The charging point transfers the data to the booking system so that the action is recorded and the current status of the charging point is updated
4. The booking system transfers the data to the charging management system so that it can schedule the charging accordingly
5. The charging point detects when the requested SoC is achieved and sends a notification to the booking system. The detection is done based on an estimation of the energy actually transferred and the initial SoC introduced by the user.
6. The booking system sends a notification to Danny to inform that the charging has been completed
7. The booking system updates the information adding the total energy transferred and its cost
8. Danny goes to the garage, unplugs the car from the socket and leaves the garage.
9. Danny can check the cost of the energy for this booking or any other.

4.3.2.5 Alternative flows

The user leaves before the departure time

6. Danny leaves the premises before it was planned. Danny goes to the garage, unplugs the car from the socket and leaves the garage The required SoC can or cannot be reached
7. The booking system notifies the charging station of the new situation so that the charging can be re-arranged
8. The booking system updates the information adding the total energy transferred and its cost
9. Danny can check the cost of the energy for this booking or any other

4.3.2.6 Exception flows

The socket is not compatible or the user has no cable.

1. Danny parks the car in the allocated spot. He cannot plug the car because he has no wire to do it.

There is a car is his spot. This situation will be handled in Use Case 3.

There is no power or it is limited, either when he comes or at any moment during the charging operation.

6. The booking system sends a notification to Danny to inform that the SoC will not be reached due to unforeseen constraints
7. The booking system updates the information adding the total energy transferred and its cost
8. Danny goes to the garage, unplugs the car from the socket and leaves the garage (or stays longer to reach the desired SoC).
9. Danny can check the cost of the energy for this booking or any other.

The system is not running

2. Danny tries to log into the app but the system is not responding.
3. Danny call or put a ticket in the ticketing system to notify the issue

4.3.3 Use case 3: Enforcement at a booked charging point

4.3.3.1 Description

A Eurecat employee who has previously booked a charging point for a specific time slot, drives to the premises to charge his e-car and finds that the charging point allocated to him is occupied by another vehicle. This is the situation that follows Use case 1.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

4.3.3.2 Actors

The main actors involved are:

- EV driver: All Eurecat employees driving a plug-in electric car are candidates to use the booking service when accessing a different premises of their usual working place. For the usual working place they should have a fix charging point.
- Booking operator: The person in charge of managing the booking system and the parking lot and the access control system

Secondary actors are:

- Another driver: The driver of the car that is parked in the spot assigned to the booked charging spot

4.3.3.3 Preconditions

The following pre-conditions are required:

- The e-car driver has access to the app to do the booking
- The charging points are on service and the garage is accessible
- The socket type is compatible with the e-car plug
- The user has previously booked a charging point and the booking has been accepted

4.3.3.4 Basic flow

Following the case story of Danny, the Eurecat employee in Use case 1.

In general, the notification flow can be realized through the app and the booking system, but in the initial phase the most likely approach will be through human interaction.

1. Danny arrives at the spot and see there is another car parked in the spot assigned to him.
2. Danny called the booking operator (Eurecat infrastructure service) and notifies the event
3. The booking operator checks if there has been an error on the assignment or someone has parked without authorization and provide a solution to Danny
4. Danny is instructed to park in another spot (there were others available) (If not, he has to wait until the driver is found and takes his vehicle away)
5. The booking operator finds the driver and request to remove the vehicle

4.3.3.5 Alternative flows

The two drivers can charge for a shorter time slot but they both can reach the minimum SoC to reach their next destination.

4. Danny must wait until the other driver takes his car away
5. The booking system notifies Danny when the charging point is free
6. Danny drives until the assigned spot, plugs the car in and starts charging

4.3.3.6 Exception flows

The booking operator cannot be reached

2. He cannot park and has to find a public charging point

The driver of the car that occupies the charging point cannot be found or cannot take the car away

4. Danny goes to a public charging point on his way home or during lunch time

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

4.3.4 Use case 4: Optimal charge planning

4.3.4.1 Description

A charging infrastructure is managed through a smart charging management system. The system calculates the optimal activation of every charging point of the infrastructure according to the optimization criteria previously defined. The planning operation is triggered either manually or by an automatic signal (time, the arrival of a new vehicle, a deviation in the forecasted inputs, …). The result of the operation is a schedule comprising the signals to switch on and off each charging point, and the current to be supplied (if the charging point supports this feature).

4.3.4.2 Actors

If the operation is done manually, the main actor is the charging station operator. Otherwise, the main actor is the charging management system itself.

4.3.4.3 Preconditions

The following pre-conditions are required:

- The charging management system has been configured
- The charging management system has access to the input data needed

4.3.4.4 Basic flow

1. The charging station operator or manager triggers the planning calculation (it can be triggered automatically by another system)
2. The charging management system calculates the optimal plan taking into account the input data and configuration parameters
3. The charging management notifies the plan has been successfully calculated. The plan is accessible to the charging station operator
4. (If the automatic charging process is enabled) The plan is transferred to the dispatcher process that will apply it.

4.3.4.5 Alternative flows

There are two flows depending on the level of automation. If it works in manual mode or off-line, as part of a simulation, the receiver of the information is a person. However, if it is part of an automatic charging station manager system, the result of the optimization will be applied to the charging points.

4.3.4.6 Exception flows

The charging management system is not working

1. The operator cannot launch an optimization process

Some information is missing

2. The charging management system notifies the operator about the missing information
3. The operator introduces the information (or restore the process aiming at providing this information) and launch the optimization again (back to step 2)

The result of the optimization is unsuccessful

3. The charging management notifies that the plan could not be calculated
4. The operator modifies some constraints or parameters and launch the optimization again (back to step 2)

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

4.3.5 Use case 5: DR request

4.3.5.1 Description

Either for an electrical limitation or for flexibility analysis, the energy manager limits the maximum power allocated to the installation to a certain threshold for a given time period. The Energy Neighbourhood management system will provide the optimal set-points for the charging station and the rest of the loads to fulfil the limitation.

4.3.5.2 Actors

The main actor is the energy manager of the premises. In a proper DR scenario, the grid operator, the retailer or an aggregator will also be involved, but in this use case the DR is virtually triggered.

4.3.5.3 Preconditions

The following pre-conditions are required:

- The ESN is properly configured
- The ESN has access to the input data needed

4.3.5.4 Basic flow

1. The energy manager triggers a DR by introducing the limits and duration of the campaign.
2. The ESN calculates the flexibility for the different loads taking into account current conditions (weather and user constraints).
3. The ESN provides a provides an schedule for the devices which set-points have to be modified
4. If needed, the energy manager applies the schedule

4.3.5.5 Alternative flows

There are two different situations: 1) the DR request is triggered to analysis flexibility (study), 2) the DR request models a situation where there is a real need to reduce energy or power. In the first situation, the results are for reporting purposes, whereas in the second situation the schedule will be applied either manually or in an automatic manner.

4.3.5.6 Exception flows

The ESN system is not working

1. The operator cannot launch a DR calculation process

Some information is missing

2. The ESN system notifies the operator about the missing information
3. The operator introduces the information (or restore the process aiming at providing this information) and launch the calculation again (back to step 2)

The result of the calculation is unsuccessful

3. The ESN notifies that the plan could not be calculated
4. The operator modifies some constraints or parameters and launch the DR request again (back to step 2)

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

4.3.6 Use case 6: Take an e-bike from the sharing service

4.3.6.1 Description

An e-bike sharing service in available for commuters arriving at Sant Quirze train station to cover the last mile to the industrial areas of Sant Quirze. A user previously registered to the system arrives at the train station, opens the app and approaches one of the bikes anchored in the bike station. He unlocks the bicycle and rides to his destination.

4.3.6.2 Actors

The main actor involved is the bike rider. A secondary actor is the bike sharing operator.

4.3.6.3 Preconditions

The following pre-conditions are required:

- The user is registered to the service
- The user has a smartphone able to run the app (some features are needed)

4.3.6.4 Basic flow

Maria is a commuter. She lives in Barcelona and works in a factory in Sant Quirze. When the weather is fine she always goes to work by train and takes a bike in the station to reach her working place.

1. Maria approaches the bike station and uses the key to open the door and enter
2. She identifies a bike that fits her and initiates the booking process: she approaches the bike and scan the QR code on the app to select it. She introduces when she expects to drop the bike back (optional)
3. The sharing management system validates the user is authorized to take the bike and unlocks it.
4. Maria takes the bike, exits the station and closes the door
5. Maria parks the bike in the garage and checks the distance ridden and the SoC of the battery . This information is available through the geolocation system and the charging station.

4.3.6.5 Alternative flows

The bike does not work properly

4. Maria returns the bicycle to the station
5. Maria uses the app to notify the problem with the bike
6. The sharing management system sends a notification to the operator
7. Maria selects another bike (back to step 2)

4.3.6.6 Exception flows

The door cannot be opened (Maria has forgotten the key)

1. Maria waits another user to come

There are no bikes in the station

The best option is to walk, take the bus or a taxi. If it is an unusual situation, she can call the operator to get some insights before taking a decision.

The app does not work

1. Maria notifies it to the operator

The bike is not release

4. Maria uses the app to notify it

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

5. Maria selects another bike (if any) and goes back to step 2

Last time, she used the bicycle outside the operation area (or worse, she didn't return the bicycle back).

3. The system does not authorize Maria to use the bicycle. A message appears in the app. Maria will have to accept the penalization/fine.

4.3.7 Use case 7: Return an e-bike from the sharing service

4.3.7.1 Description

An e-bike sharing service is available for commuters arriving at Sant Quirze train station to cover the last mile to the industrial areas of Sant Quirze. A user that has taken a bike in the morning, goes back to the station after her shift to take the train back home. She rides to the sharing station and drops the bike there. She uses the app to complete the process.

4.3.7.2 Actors

The main actor involved is the bike rider. A secondary actor is the bike sharing operator.

4.3.7.3 Preconditions

The following pre-conditions are required:

- The user is registered to the service
- The user has a smartphone able to run the app (some features are needed)
- The user has taken the bike from the sharing station

4.3.7.4 Basic flow

Maria is a commuter. She lives in Barcelona and works in a factory in Sant Quirze. In the morning, she has taken a bike from the sharing station next to the train station. Now that her shift has finished, she rides back to the station to catch the train.

1. Maria approaches the bike station and uses the key to open the door and enter
2. She anchors the bike in an available slot and scans the QR code on the app to check in.
3. The sharing management system validates the operation and notifies Maria the service has been completed successfully.
4. The sharing management system sends the information about the SoC to the charging management system
5. Maria exits the station and closes the door

4.3.7.5 Alternative flows

Maria cannot return the bicycle to the station (it is raining heavily, she has been injured, she has to stay longer and it is dark,…)

1. Maria notifies the operator
2. The sharing operator agrees on a solution
3. The sharing operator updates the information in the system so that the bicycle is not considered missing

4.3.7.6 Exception flows

The door cannot be opened (Maria has forgotten the key)

1. Maria waits another user to come

The app does not work

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

1. Maria notifies it to the operator

The bike cannot be anchored

3. Maria uses the app to notify it
4. Maria selects another slot (if any) and goes back to step 2

The bike is not returned when expected

1. The sharing operator sends a message to Maria to inquiry the reasons

4.3.8 Use case 8: Change drop location

4.3.8.1 Description

MOTIT has put in place an incentive scheme to foster that the e-scooters are taken and dropped close to a battery hub. Albert has taken a scooter to go to his office today. The traffic was fine and he is not in a hurry. He remembers MOTIT has notified that if he leaves the e-scooter in certain spots he will be rewarded. So, he changes his mind: instead of leaving the e-scooter in front of his office, he decides to leave it in the battery hub, 1 block away, to achieve extra minutes to be used in his next trip.

4.3.8.2 Actors

The main actor involved is the MOTIT user.

4.3.8.3 Preconditions

The following pre-conditions are required:

- The user is registered to the service
- The user is aware of the incentive scheme
- The user has a mean to know where the battery hubs are

4.3.8.4 Basic flow

Albert decides to leave the e-scooter in the battery hub and walk to his final destination. He will receive extra minutes to be used in his next trip.

1. Albert locates the closest battery hub to his destination, drives there and parks the e-scooter in an authorized place
2. Albert ends its trip as usual, using the dashboard
3. The sharing management systems identifies that the e-scooter is parked within the range of the battery hub, and awarded the user (Albert) that has left it there with extra minutes.
4. Albert receives a notification that he has been awarded with extra minutes.

4.3.8.5 Alternative flows

A similar scheme will be applied to pick-up the e-scooter from a battery hub.

4.3.8.6 Exception flows

The e-scooter is not left close enough to the battery hub (i.e. there is no way to park)

3. The sharing management systems identifies that the e-scooter is not within the range of the battery hub, and does not award the user.

The e-scooter is left close enough to the battery hub but the incentive does not appear in Albert's account

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

3. Albert calls MOTIT to notify the issue
4. The sharing operator checks the information for the trip and grants Albert with the extra minutes if the conditions are met (or informs the user why the conditions were not fulfilled)

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

5 Technological requirements

The critical technological requirements identified refers to the interoperability of the systems and the need to exchange information between them.

The scheme of the architecture shown in Figure 5-1 depicts the numerous interactions existing from the several components; each letter from *a* to *p* represents an interface between components that has to be defined and implemented. This diagram was developed as part of project proposal preparation, and is part of the Grant Agreement. A more detailed descriptions of the interfaces to be implemented by each demonstrator is presented in *D2.17 Implementation plan for Barcelona pilot*. Besides, a more specific work on the architecture definition is being performed in WP4. The results will be provided in *D4.1 Initial Architecture Design*.

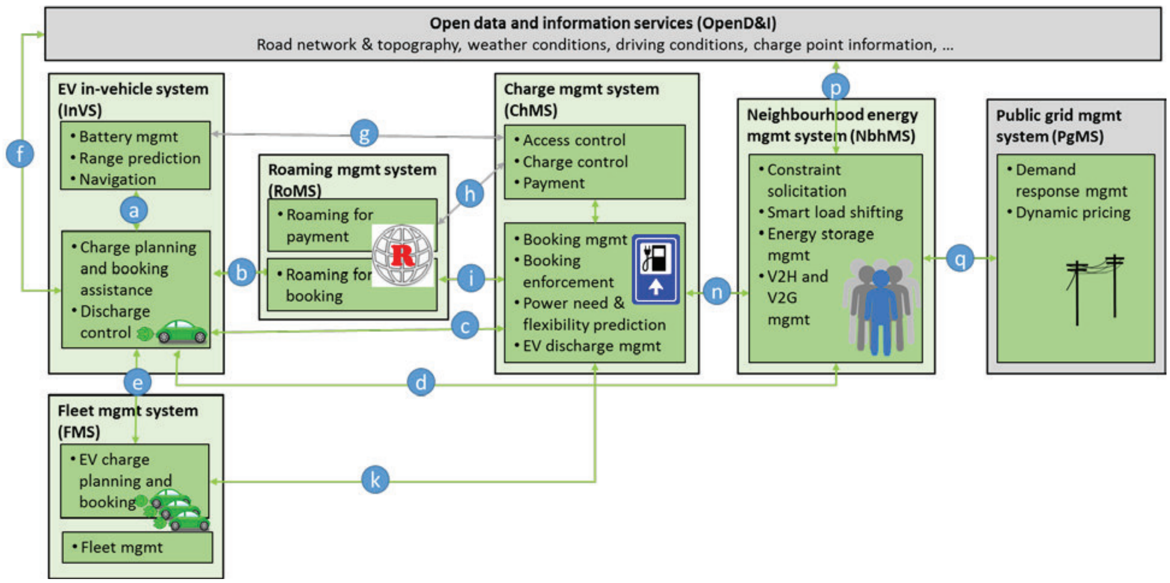

Figure 5-1: GreenCharge interfaces (from Grant Agreement)

At another level, the charging infrastructure needs to be compatible with the charging needs of the vehicles. In the case of the sharing services, MOTIT and St. Quirze e-bike sharing service, the charging infrastructure was designed by the service. An issue of incompatibility would arise if the battery hub was offered to third parties that use different batteries or if the e-sharing station was open to individuals that park and charge their bicycles. These scenarios are out of the scope of GreenCharge.

Finally, there is a technological use coming from the side of the user. The main interaction with the user is performed through apps. Thus, the users are required to have smartphones. The apps will be developed to support Android and iOs operating systems, which covers most of the market share. The features of the smartphone required are very basic (3G/4G communication, camera and potentially GPS).

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

6 Conclusions

GreenCharge will be demonstrated in three different demonstrators in Barcelona province, beyond the city limits.

The geographical location, with some hilly areas and mild climate sets a proper environment for the development of electro-mobility, especially for that based on light electric vehicles. However, the economic situation and some cultural bias towards ownership rather than sharing services have made that the penetration of EV is significantly lower than other European Northern countries.

To foster electro-mobility public authorities have put in place several incentives schemes, from free charge and park in public charging points to subsidies for vehicle and charging infrastructure purchase. Yet, the price of an electric car is much higher than the price of a combustion car, and the impact of environmental concern is lower than economics in the purchase decision.

Sharing services, that would be an alternative to mitigate the cost of EV ownership, are struggling to get a market niche. Public policies constraining the use of public space for private use and the scarcity of on-street available free parking spaces add an extra difficulty in operating these type of businesses to that of strong ownership feeling.

Energy market oligopoly is another aspect that jeopardises the development of new business models around the exploitation of energy flexibility, such as aggregators. Some policies have also slowed down the penetration of renewable sources, especially at small scale, that would reinforce the development of energy management providers.

All the above reasons have an impact in the number of potential users participating in the trials. However, even if few, there are early adopters whose needs can be covered by GreenCharge tools. In the pilot site it will be possible to satisfy the charging needs at work for e-car drivers through a booking system, the needs for LEV fleet operators to optimize the management of the charging process in order to minimize costs and the needs of building managers to maximize the usage of available energy locally produced and minimize the need to upgrade the electrical installation despite the increasing number of e-cars.

In the following months, a thoroug discussion on the architecture and the interfaces between components will be performed to produce the reference GreenCharge architecture and to facilitate data exchange between modules. Similarly, further work needs to be done to select the new hardware and software components to realize all the use cases defined, as well as the data needed for further evaluation of the measures applied.

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

Members of the GreenCharge consortium

SINTEF	SINTEF AS (SINTEF) NO-7465 Trondheim Norway www.sintef.com	**Project Coordinator:** Joe Gorman Joe.Gorman@sintef.no **Technical Manager:** Shanshan Jiang Shanshan.Jiang@sintef.no
eSmart systems	eSmart Systems AS (ESMART) NO-1783 Halden Norway www.esmartsystems.com	**Contact:** Frida Sund Frida.sund@esmartsystems.com
HUBJECT	Hubject GmbH (HUBJ) DE-10829 Berlin Germany www.hubject.com	**Innovation Manager:** Sonja Pajkovska sonja.pajkovska@hubject.com
eurecat Centre Tecnològic de Catalunya	Fundació Eurecat (EUT) ES-08290 Barcelona Spain www.eurecat.org	**Contact:** Regina Enrich regina.enrich@eurecat.org
ATLANTIS TRACKING YOUR WORLD	Atlantis IT S.L.U. (ATLAN) ES-08013 Barcelona Spain www.atlantisit.eu	**Contact:** Ricard Soler rsoler@atlantis-technology.com
enchufing	Millor Energy Solutions SL (ENCH) ES-08223 Terrassa Spain www.millorbattery.com	**Contact:** Gerard Barris gbarris@enchufing.com
motit www.motitworld.com	Motit World SL (MOTIT) ES-28037 Madrid Spain www.motitworld.com	**Contact:** Valentin Porta valentin.porta@goinggreen.es
Freie Hansestadt Bremen	Freie Hansestadt Bremen (BREMEN) DE-28195 Bremen Germany	**Contact:** Michael Glotz-Richter michael.glotz-richter@umwelt.bremen.de

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.

MOVE ABOUT Zero Hassle - Zero Emissions	Move About GmbH (MOVA) DE-28359 Bremen Germany www.move-about.de	**Contact:** Nils Jakubowski nils.jakubowski@move-about.de
pmc personal mobility center	Personal Mobility Center Nordwest eG (PMC) DE-28359 Bremen Germany www.pmc-nordwest.de	**Contact:** Bernd Günther b.guenther@pmc-nordwest.de
	Oslo kommune (OSLO) NO-0037 Oslo Norway www.oslo.kommune.no	**Contact:** Sture Portvik sture.portvik@bym.oslo.kommune.no
fortum	Fortum OYJ (FORTUM) FI-02150 Espoo Finland www.fortum.com	**Contact:** Jan Ihle jan.haugen@fortum.com
PNO Connecting Ambitions	PNO Consultants BV (PNO) NL.2289 DC Rijswijk Netherlands www.pnoconsultants.com	**Contact:** Arno Schoevaars arno.schoevaars@pnoconsultants.com
V: Università degli Studi della Campania Luigi Vanvitelli Scuola Politecnica e delle Scienze di Base Dipartimento di Ingegneria Industriale e dell'Informazione	Universita Deglo Studi Della Campania Luigi Vanvitelli (SUN) IT-81100 Caserta Italy www.unicampania.it	**Contact:** Salvatore Venticinque salvatore.venticinque@unina2.it
UiO : Universitetet i Oslo	University of Oslo (UiO) NO-0313 Oslo Norway www.uio.no	**Contact:** Geir Horn geir.horn@mn.uio.no
I.C.L.E.I Local Governments for Sustainability	ICLEI European Secretariat GmbH (ICLEI) DE-79098 Freiburg Germany www.iclei-europe.org	**Contact:** Stefan Kuhn stefan.kuhn@iclei.org

The research leading to these results has received funding from Horizon 2020, the European Union's Framework Programme for Research and Innovation (H2020) under grant agreement n° 769016.