Grant number: 769016
Project duration: Sept 2018 - Aug 2021
Project Coordinator: Joe Gorman, SINTEF

HORIZON 2020: Mobility for Growth
MG-4.2-2017
Supporting Smart Electric Mobility in Cities
Project Type: Innovation Action

greencharge2020.eu

GreenCharge Project Deliverable: D2.18

Pilot Component Preparation for Full-scale Pilot (Barcelona)

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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 electromobility.

For more information

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Executive Summary

This deliverable presents the components that are going to be integrated in the full-scale implementation for the Barcelona pilot. The needed components and their role in the pilot have been extracted from work presented on deliverables *D2.16 Description of Barcelona Pilot and User Needs* and *D2.17 Implementation Plan for Barcelona Pilot*.

The table below lists all the components. It indicates for each component the demonstrators in which it will be used (there are three demonstrator sites). It also indicates the "*Test result*" for each component as follows:

- New development (RED). The component does not yet exist and needs to be developed from scratch in the course of the project.
- Needs adaptation (YELLOW). Testing of the component has been carried out and identified that some adaptations are needed for successful use in the pilot.
- Approved (GREEN). The component has been tested and found to be suitable for full-scale implementation in the pilot; some work may be needed to integrate fully with other components.

Sub-system role	Component name	Demonstrator	Test result	Responsible partner
EV In-vehicle system	Atlantis Fleet app	e-bike sharing	New development	ATLANTIS IT
	Scooter shared services app	MOTIT	Needs adaptation	MOTIT
	Journey planner app	Eurecat, e-bike sharing	Needs adaptation	EURECAT
	Data logger and GPS tracker devices	e-bike sharing	Approved	ATLANTIS IT
Fleet management system	Atlantis Fleet platform	e-bike sharing	Needs adaptation	ATLANTIS IT
	Scooter shared services fleet management	MOTIT	Approved	MOTIT
Charge management system (CMS)	Algorithm for vehicle autonomy calculation	Eurecat	Needs adaptation	EURECAT
	Battery swapping in hub	MOTIT	Approved	MOTIT
	Charging point (Eurecat)	Eurecat	Needs adaptation	EURECAT
	Charging point (St. Quirze)	e-bike sharing	Needs adaptation	MILLOR ENERGY
	Booking system	Eurecat	New development	EURECAT
	Charge management system	All	New development	EURECAT
Neighbourhood energy management system (NEMS)	SEM scheduler	All	Needs adaptation	EURECAT
	SEM forecaster	All	Needs adaptation	EURECAT
Local renewable energy source	PV panels	Eurecat	Approved	EURECAT
	PV panels	e-bike sharing	Approved	MILLOR ENERGY
Local battery storage	Stationary battery	e-bike sharing	Needs adaptation	MILLOR ENERGY

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List of Abbreviations

Table 1: List of abbreviations

Abbreviation	Explanation
API	Application Programming Interface. A set of clearly defined methods of communication among various components.
CMS	Charge Management System
DoA	Description of Action
ESN	Energy Smart Neighbourhood
GPS	Global Positioning System
HW	Hardware
NEMS	Neighbourhood Energy Management System. An ICT system implementing the smartness of an energy smart neighbourhood.
POI	Point of Interest
PV	Photovoltaic
RES	Renewable Energy Systems
RFID	Radio Frequency Identification
SEM	Smart Energy Management
SoC	State of Charge
SW	Software
TRL	Technology Readiness Level

List of Definitions

Table 2: List of definitions

Definition	Explanation
RFID Card	An RFID card is an electronic card that exchanges data with a RFID reader through radio waves.
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, a scenario is a higher level of description of the system and can be modelled using one or several use cases
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

1 About this Deliverable

1.1 Why would I want to read this deliverable?

This deliverable gives you information about all the components that are going to be used in Barcelona pilot both at the software and hardware level. We explain the role of each component in the pilot, the tests carried out to assess that its operation is correct and matches its role and, where appropriate, the necessary adaptations that must be carried out in a component so that it can be used successfully in the pilot. The deliverable also identifies some cases where components will need to be developed from scratch.

1.2 Intended readership/users

This deliverable should be of interest to all participants within the project consortium in charge of implementation and testing the prototypes for all the 3 pilots. It will also be useful for organizations that want to implement some of the scenarios treated in the pilot and want to know the components used in Barcelona pilot.

1.3 Other project deliverables that may be of interest

You may find it useful to refer to the following project deliverables:

- **D2.1 Initial Strategic Plan for Pilots** – This deliverable is input to the strategic plan.
- **D2.16 Description of Barcelona Pilot and User Needs** – Describe Barcelona pilot in terms of challenges, user needs, use cases, scenarios, stakeholders and locations to be involved and the baseline. It defines the context under which the components will be used for implementation of the scenarios/use cases in different demonstrators.
- **D2.17 Implementation Plan for Barcelona Pilot** – Describes 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.
- **D2.5 Pilot Component Preparation for Full-scale Pilot (Oslo)** – "Sister" deliverable describing the preparation for Oslo pilot.
- **D2.11 Pilot Component Preparation for Full-scale Pilot (Bremen)** – "Sister" deliverable describing the preparation for Bremen pilot.
- **D4.1 Initial Architecture Design and Interoperability Specification** – Describes the initial version of the GreenCharge architecture and the specification of interfaces and protocols for interoperability.
- **D4.2 Final Architecture Design and Interoperability Specification** – Describes the final version of the GreenCharge architecture and the specification of interfaces and protocols for interoperability. Built on D4.1 and refined based on feedbacks and lessons learned from pilots and evaluations.
- **D4.3 Initial Version of Integrated Prototype** – Initial version of the integrated prototype based on D4.1. The software components described in this deliverable will be integrated in the integrated prototype.
- **D4.4 Revised Version of Integrated Prototype** – Refined and extended version of the integrated prototype based on evaluations.
- **D4.5 Final Version of Integrated Prototype** – Final version of the integrated prototype including refinement and extensions integrated during the pilots.

2 Pilot Site Components

The table in this section presents an overview of all the software and hardware components to be used in the Barcelona pilot. The table contains the components name, type (SW/HW), the responsible partner and in which scenarios the components are relevant.

The Barcelona pilot has 3 different demonstrator sites with components that are used in all demonstrators and others only used in some of them. Each component is further specified in section 3 *Pilot Site Software Components* and section 4 *Pilot Site Hardware Components*. The components and their role in the pilot have been extracted from work presented on deliverables D2.16 Description of Barcelona Pilot and User Needs and D2.17 Implementation Plan for Barcelona Pilot. Test results are summarized in section 5 *Conclusions*. Appendix A provides a summary of the scenarios and use cases defined in D2.16.

Table 3: Components to be used and implemented in the Full-scale Barcelona pilot

Sub-system role	Component name	Section	Demonstrator	Component type	Responsible partner	Scenarios (as def. in D2.16)
EV In-vehicle system	Atlantis Fleet app	3.1	St. Quirze e-bike sharing	SW	ATLANTIS IT	7
	Scooter shared services app	3.2	MOTIT	SW	MOTIT	7
	Journey planner app	3.3	Eurecat, St. Qurize e-bike sharing	SW	EURECAT	1
	Data logger and GPS tracker devices	4.1	St. Quirze e-bike sharing	HW	ATLANTIS IT	7
Fleet management system	Atlantis Fleet platform	3.5	St. Quirze e-bike sharing	SW	ATLANTIS IT	7
	Scooter shared services fleet management	3.6	MOTIT	SW	MOTIT	7
Charge management system (CMS)	Algorithm for vehicle autonomy calculation	3.4	Eurecat	SW	EURECAT	7
	Battery swapping in hub	4.2	MOTIT	HW	MOTIT	7
	Charging point (Eurecat)	4.3	Eurecat	HW	EURECAT	2, 3, 4
	Charging point (St. Quirze)	4.4	St. Quirze e-bike sharing	HW	MILLOR ENERGY SOLUTIONS	7

	Booking system	3.10	Eurecat	SW	EURECAT	1
	Charge management system (CMS)	3.9	All	SW	EURECAT	4, 7
Neighbourhood energy management system (NEMS)	SEM scheduler	3.7	All	SW	EURECAT	4, 7
	SEM forecaster	3.8	All	SW	EURECAT	4,7
Local renewable energy source	PV panels	4.7	Eurecat	HW	EURECAT	4
	PV panels	4.5	St. Quirze e-bike sharing	HW	MILLOR ENERGY SOLUTIONS	7
Local battery storage	Stationary battery	4.6	St. Quirze e-bike sharing	HW	MILLOR ENERGY SOLUTIONS	7

3 Pilot Site Software Components

The software components that will be used in the pilot are described below.

3.1 Atlantis Fleet app

3.1.1 Purpose of component

This app will be developed to allow users to find an e-bike available and lock/unlock it as described in use cases 6 and 7 (ref. Appendix A). The vehicle will be tracked on real time using a GPS tracker and all data will be sent to Atlantis Fleet platform (ref. section 3.5). The app will show the battery level for charge planning and will be connected with CMS (ref. section 3.9).

3.1.2 Initial status

This is a new development.

3.1.3 Component testing

This is a new development so test will be done after development.

3.1.4 Conclusions, assessments, and adaptations

This app will be developed and tested during the following months and it will be ready for the full-scale pilot.

3.2 Scooter shared services app

3.2.1 Purpose of component

This MOTIT app allows the users to find an e-scooter available, lock/unlock it and open the trunk. The vehicle is tracked (including its position and battery's state of charge (SoC)) using an IoT device, and the data collected is sent to MotitWorld fleet management platform (ref. section 3.6).

3.2.2 Initial status

APP and servers are currently deployed and running.

3.2.3 Component testing

APP needs to be modified in order to foster the users to leave the e-scooter near the charging hub. Tests will be placed during and after the development.

3.2.4 Conclusions, assessments, and adaptations

All the developments needed to make the current ones completely useful for the project will be placed during the following months and will be ready for the full-scale pilot.

3.3 Journey planner app

3.3.1 Purpose of component

The journey planner aims at helping the users to drive or ride to their destination, so it is a component from EV In-vehicle subsystem.

The MOTIT scooters already have a navigation system integrated in their in-vehicle system. The interaction with the journey planner for the MOTIT sharing service is out of the scope of the use cases to be demonstrated, except for maybe the addition of the battery hubs as POI.

For the Eurecat demonstrators, the charging point is right at destination, thus it only makes sense to help user to reach the charging spot in the corporate garage. It will probably be implemented with a static map with the spot highlighted. The actual navigation in underground spaces cannot be done by GPS and it is not foreseen to use any other indoor positioning technique that will be a project in itself.

For the St. Quirze e-sharing service demonstrator it is been considered to customize a journey planner for bike riders taking into account safety as an optimization parameter (bicycle lanes, low-speed streets, …). However, it involves quite an effort and the usefulness to the users is quite limited since the commuters usually go the same way every day. It is been considered to build an intermediate solution to show the safest ways in the area without actual dynamic navigation.

3.3.2 Initial status

Eurecat has a journey planner based on OpenTripPlanner. It has to be customized to introduce information about bicycle lanes and maximum speed limit in Sant Quirze and surrounding area and optimize the trip according to safety criteria.

3.3.3 Component testing

Need to be tested after customization tasks are done.

3.3.4 Conclusions, assessments, and adaptations

This application needs to be customized, but before doing that, it must be further discussed if it is really relevant for the use case.

3.4 Algorithm for vehicle autonomy calculation

3.4.1 Purpose of component

This algorithm will help us to better estimate the vehicle range. There are many variables that affect battery autonomy and that is why it is important to study the batteries themselves, the driving conditions as well as the charging/discharging conditions to generate these algorithms that allow us to better estimate the range.

This algorithm will not be integrated in the In-vehicle subsystem because there is no available API to interact with the system. But the development of the algorithm and its results will be used to make recommendations on the improvement on the calculation of the vehicle range.

3.4.2 Initial status

On the one hand, Eurecat has a framework to apply different machine learning algorithms to model any kind of process. Using data from historical trips it can be trained to select the best technique for further real validation.

On the other hand, Eurecat has a lab for battery testing. Batteries can be charge and discharge with different current intensity to measure their response. This way any driving condition can be tested to validate range estimation.

3.4.3 Component testing

Testing will be done after algorithm implementation.

3.4.4 Conclusions, assessments, and adaptations

The algorithm will be implemented in a later stage. It is needed to get historical trips data and to analyse the batteries behaviour in order to refine the algorithm.

3.5 Atlantis Fleet platform

3.5.1 Purpose of component

The core system of Atlantis Fleet will be in charge of collecting data from e-bikes in use cases 6 and 7 and allow service administrator to manage the fleet. A connection with Atlantis Fleet app (ref. section 3.1) will be needed in order to collect the data and exchange information. This component also needs to connect with GPS tacker devices (ref. section 4.1) to collect the location data and to interact with device digital outputs to lock/unlock the e-bikes. Interaction with CMS (ref. section 3.9) will be needed for charge planning purposes.

3.5.2 Initial status

This platform is deployed in cloud servers on production environment since 2014. It currently manages more than 4k GPS devices and it can support up to 10k GPS devices. The core functionalities of this component are:

- Vehicle location (with different tracking configurations from 10 seconds, to 1 minute and also combined with distance and heading)
- Driver identification
- Reports (route, km, stops, ...)
- Integrates multiple hardware from different manufacturers and different models
- Allow bidirectional communication with GPS devices

3.5.3 Component testing

As commented above, the Atlantis Fleet platform is in production environment (TRL 9) so no need for extra test. But we cannot test the lock/unlock functionality because it depends on hardware and this has not been yet decided. It is necessary to evaluate the different commercial locking systems that fits our needs with the constraint of low-cost. Once decided, adaptations on Atlantis Fleet platform will be needed to allow the locking functionality.

3.5.4 Conclusions, assessments, and adaptations

It needs some minor adaptations to allow the lock/unlock functionality.

3.6 Scooter shared services fleet management

3.6.1 Purpose of component

This is the fleet management system for the e-scooter sharing service. This component allows service operator to receive information about the e-scooters that need to be charged and plan an optimized battery swapping (ref. section 4.2). It is connected to the In-vehicle system in order to get the e-scooter location and battery's SoC and to the MOTIT app (ref. section 3.2) as user interface with service. In use case 8 the system must foster users to leave the e-scooters near the charging hub instead of leaving them anywhere.

3.6.2 Initial status

This service is deployed in production environment since the end of 2015. It currently has more than 17000 users and can support up 2500 to devices.

3.6.3 Component testing

As commented above, the scooter sharing service platform is in production environment (TRL 9). Adaption will be needed if data needs to be shared with other parties for the project purposes.

3.6.4 Conclusions, assessments, and adaptations

Minor adaptions will be needed for sharing data with project partners.

3.7 SEM scheduler

3.7.1 Purpose of component

This component is part of the Neighbourhood energy management system (NEMS) (SEM stands for Smart Energy Management). Its purpose is to calculate the optimal schedule of all loads and local Renewable Energy Systems (RES) for the optimization criteria defined (minimize energy cost, maximize use of green energy) while fulfilling technical requirements and user preferences (or needs). Interaction with CMS (ref. section 3.9) will be needed for charging optimization.

3.7.2 Initial status

The module is already developed. It has been developed in previous projects with a similar purpose.

3.7.3 Component testing

The component is ready to use but it has no interface with other components.

3.7.4 Conclusions, assessments, and adaptations

It will be adapted to define an API so that it can be called as a web-service. Further refinement in the algorithm can be considered after some initial tests. It can also be considered to align with the interface and data model of the simulator to be developed in WP5, to make results comparable.

3.8 SEM forecaster

3.8.1 Purpose of component

The module is part of the NEMS. The aim of the module is to forecast the energy demand, typically 1 day ahead. The forecasting of the energy demand is needed to properly plan the assets. The forecasting is done based on historical energy demand information and context variables such as weather forecast and calendar (holidays, events, …). Interaction with CMS (ref. section 3.9) will be needed for charging optimization.

The same module is also in charge of forecasting RES production. However, in this case it is based on modelling of the energy source (PV panel, mini-wind turbine) and weather information (irradiation, temperature, wind).

3.8.2 Initial status

The module is already developed as a stand-alone off-line module.

3.8.3 Component testing

A training process is needed to adjust the model used, so testing will be done while tuning the module.

3.8.4 Conclusions, assessments, and adaptations

The algorithm is based on data and different demand profiles will require different parameters. Further tuning will be needed for the demand forecast related to e-fleet charging based on usage profile.

Further adaptations are envisioned to use it as an on-line service (API definition).

3.9 Charge management system

3.9.1 Purpose of component

The module aims at controlling the charging process of a charging station. There will be three different instances in the three demonstrators, but the general functionality will be the same. It will connect with SEM modules (ref. section 3.7 and section 3.8) inside NEMS and with apps and fleet management platforms (ref. section 3.1 and section 3.5).

3.9.2 Initial status

For MOTIT demonstrator the battery hub (equivalent of the charging station) (ref. section 4.2) is already up and running (however some extra control is needed).

For Eurecat and St. Quirze it has to be developed. The current charging points are already working, but there is not an overall management system.

3.9.3 Component testing

This is a new development so test will be done after development.

3.9.4 Conclusions, assessments, and adaptations

A SW component has to be developed to properly control the charging points. Some extra HW needs to be deployed to enable the physical control of the energy flow and to monitor consumption with high time granularity.

3.10 Booking system

3.10.1 Purpose of component

To enable Eurecat employees to book a charging point in Eurecat premises.

3.10.2 Initial status

It does not exist. There is a similar mechanism to book a parking spot, but it is based on exchanging emails.

3.10.3 Component testing

This is a new development so test will be done after development.

3.10.4 Conclusions, assessments, and adaptations

This component has to be developed. Currently, functionalities are discussed with Eurecat infrastructure management and will be ready for full-scale pilot.

4 Pilot Site Hardware Components

The hardware components that will be used in the pilot are described below.

4.1 Data logger and GPS tracker devices

4.1.1 Purpose

We will install in each e-bike a GPS tracker device to get the e-bike location every minute (the tracking interval can be adjusted during the pilot upon needs). We will use a commercial device to assure the correct operation.

These devices must send location data to Atlantis Fleet platform (ref. section 3.5).

4.1.2 Initial status

It is not yet decided which will be the hardware used but we will prioritize devices already integrated in Atlantis Fleet platform. Some of the candidates are device from following brands: Queclink Wireless Solutions (GV300, GV65, ...), Wonde Proud Technology (VT10), Shenzhen Concox Information Technology (ET25, WeTrack2, ...)

4.1.3 Component testing

The GPS devices used will be commercial ones of known brands and with which Atlantis has long experience. Test should apply if finally, we decide to use a device model that is not currently integrated on Atlantis platform.

4.1.4 Conclusions, assessments, and adaptations

As commented above, we will prioritize devices already integrated in Atlantis Fleet platform so there is no need for adaptation. If this is not possible, we will need to do some adaptations in Atlantis Fleet platform to support the selected device.

4.2 Battery swapping in hub

4.2.1 Purpose

The MOTIT service uses battery swapping hubs to centralize and optimize the battery charging process. Batteries with low SoC are replaced with charged ones and left in hub to be charged.

4.2.2 Initial status

MOTIT has 2 battery hubs in Barcelona, each one of this charging points allows charging up to six batteries at same time.

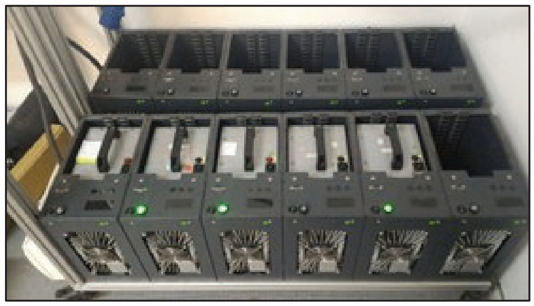

Figure 1: Battery hub of MOTIT service

This charging points has no intelligence, they only charge the connected batteries. There are no communication interfaces and nothing to measure the energy consumption during the charging process.

4.2.3 Component testing

No need for new tests on this multiple charging point as they are already working on production service. But we need to upgrade it by the integration of an IoT device for communications and energy metering. Data collection in the backend is also needed. Tests of the functionality will be placed during the development.

4.2.4 Conclusions, assessments, and adaptations

Integration of IoT devices and software development on the server side is needed to be ready for the full-scale pilot.

4.3 Charging point (Eurecat)

4.3.1 Purpose

These charging points are located at Eurecat premises at Cerdanyola del Vallès. They will be used only by Eurecat employees in use cases 2, 3, 4 and 5. This component must interact with CMS (ref. section 3.9) in order to allow/disallow charging according to booking and to allow smart charging.

4.3.2 Initial status

There are 8 charging points already installed and activated with an RFID card. The sockets are of Schucko type, which are compatible with the type of e-cars commonly used by Eurecat employees. The charge will be slow charge, up to 3.4 kW AC.

Figure 2: Charging point in Eurecat premises

4.3.3 Component testing

The test show that the charging point work as expected but currently they have no communications interface.

4.3.4 Conclusions, assessments, and adaptations

The charging points on Eurecat premises need to be upgraded with communications interface and need to provide energy metering and accept remote commands (for on/off functionalities).

4.4 Charging point (St. Quirze)

4.4.1 Purpose

In St. Quirze demonstrator there is a parking & charging station where we will test different use cases from scenario 7. The charging points will be connected to CMS (ref. section 3.9) and will get the electricity from a photovoltaic (PV) panel (ref. section 4.5) installed on the roof of the charging station through a stationary battery (ref. section 4.6).

4.4.2 Initial status

The charging station has already 8 charging points with standard plugs. Currently there is no communication interface.

4.4.3 Component testing

The charging points work as expected. The standard plug will be replaced with Millor Energy specific plug as a requirement from the service operator in order to avoid robberies. New tests must to be done after upgrading the components.

4.4.4 Conclusions, assessments, and adaptations

The 8 charging points need to be upgraded with the specific plug used by the Millor Energy batteries used in e-bikes. A communication interface will also be added. New tests will be done after components upgrade and will be ready for full-scale implementation by September 2019.

4.5 Photovoltaic panel (St. Quirze)

4.5.1 Purpose

The purpose of photovoltaic panel is to provide green energy locally produced at e-bike charging station. The energy generated through the PV panels at daytime will be stored in the stationary battery and used when e-bikes require charging. The PV panel will be integrated with the stationary battery (ref. section 4.6) and the charging points (ref. section 4.4) into a local NEMS and will be connected with the CMS (ref. section 3.9).

4.5.2 Initial status

This component is considered an off the shelf product. We will use 2 PV panels with following specifications:

- PV size: 1956x992x40 mm
- PV maximum power of 660W
- Inverter size: 272x355x100 mm
- Inverter maximum power of 3kW
- Daily energy generation: between 2kWh and 4kWh

It requires no changes or adaptations and are fully ready to be implemented at the pilot site.

4.5.3 Component testing

No individual testing will be conducted by the project. The PV panels are considered successfully tested by the manufacturer.

4.5.4 Conclusions, assessments, and adaptations

No required adaptations for the PV panels are identified at this stage. The component will be included in the testing of all demonstrator components once they are integrated, before full-scale implementation in September 2019.

4.6 Stationary battery (St. Quirze)

4.6.1 Purpose

The stationary battery will store the electric energy generated by the PV panels (ref. section 4.5) in order to be used on the charging points (ref. section 4.4) upon charging needs. The battery will be integrated with the PV panels (ref. section 4.5) and the charging points (ref. section 4.4) into a local NEMS and will be connected with the CMS (ref. section 3.9).

4.6.2 Initial status

This component is considered an off the shelf product. We will use a battery from Millor Energy (a Barcelona pilot partner) with following specifications:

- size: 400x300x160 mm
- maximum power: 1kW
- energy: 1,3 kWh

4.6.3 Component testing

No individual testing will be conducted by the project. The battery is considered successfully tested by the manufacturer but it has no communication interfaces.

4.6.4 Conclusions, assessments, and adaptations

The component needs to be upgraded with communications interface and need to provide energy metering. This will be implemented for the full-scale pilot in September 2019 and it will be included in the testing of all demonstrator components once they are integrated.

4.7 Photovoltaic panel (Eurecat)

4.7.1 Purpose

The purpose of photovoltaic panel is to provide green energy locally produced at premises site (only in Eurecat-Manresa offices). It will communicate with SEM Scheduler (ref. section 3.7).

4.7.2 Initial status

These panels are up and running. There are 2 PV panel installations with a rated power of 6.48 kWp and 1.35 kWp. They are being monitored and there is historical data available for evaluation purposes.

4.7.3 Component testing

Only data information exchange has to be tested.

4.7.4 Conclusions, assessments, and adaptations

It is required the implementation of an automatic process to extract data and provide it to the SEM Scheduler.

5 Summary of Assessments of Components

This chapter summarises the assessments made of all the components, as reported in more detail in the earlier chapters. The table shows all the components (shown previously in the table at the start of chapter 2). The assessments are summarised in column "Test result" as follows:

- New development (RED). The component does not yet exist and needs to be developed from scratch in the course of the project.
- Needs adaptation (YELLOW). Testing of the component has been carried out and identified that some adaptations are needed for successful use in the pilot.
- Approved (GREEN). The component has been tested and found to be suitable for full-scale implementation in the pilot; some work may be needed to integrate fully with other components.

In September 2019 the components shall be upgraded and integrated for the full-scale pilot. During the pilot some components can be revised or refined based on feedback, lessons learned and intermediate evaluations.

Table 4: Summary of assessment of components

Sub-system role	Component name	Details in section	Test result	Adaptation(s) needed	Responsible partner
EV In-vehicle system	Atlantis Fleet app	3.1	New development		ATLANTIS IT
	Scooter shared services app	3.2	Needs adaptation	User interface with battery hub points	MOTIT
	Journey planner app	3.3	Needs adaptation	Customization tasks	EURECAT
	Data logger and GPS tracker devices	4.1	Approved		ATLANTIS IT
Fleet management system	Atlantis Fleet platform	3.5	Needs adaptation	Add lock/unlock function for e-bikes	ATLANTIS IT
	Scooter shared services fleet management	3.6	Approved		MOTIT
Charge management system (CMS)	Algorithm for vehicle autonomy calculation	3.4	Needs adaptation	Get historical data, test batteries and refine algorithm	EURECAT
	Battery swapping in hub	4.2	Approved		MOTIT
	Charging point (Eurecat)	4.3	Needs adaptation	Communication interface and energy metering	EURECAT
	Charging point (St. Quirze)	4.4	Needs adaptation	Update plug, add communication interface	MILLOR ENERGY
	Booking system	3.10	New development		EURECAT

	Charge management system	3.9	New development		EURECAT	
Neighbourhood energy management system (NEMS)	SEM scheduler	3.7	Needs adaptation	Add API	EURECAT	
	SEM forecaster	3.8	Needs adaptation	Customization tasks	EURECAT	
Local renewable energy source	PV panels	4.7	Approved		EURECAT	
	PV panels	4.5	Approved		MILLOR ENERGY	
Local battery storage	Stationary battery	4.6	Needs adaptation	Communication interface and energy metering	MILLOR ENERGY	

Appendix A Scenarios and use cases for Barcelona Pilot

A.1 Summary of Innovation Scenarios

In the project description DoA (section 1.3.1) seven innovation scenarios are presented. The scenarios give examples of how GreenCharge technology and business models may work in typical situations. 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. The seven innovation scenarios are:

1. Charge planning and booking
2. Charging at booked Charging station
3. Booking Enforcement
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
5. V2G (vehicle-to-grid)
6. Reacting to Demand Response (DR) request
7. E-Mobility in innovative 'Mobility as a Service' (MaaS)

In GreenCharge, a scenario is a higher level of description of the system and can be modelled using one or several use cases.

For the Barcelona pilot, the relevant scenarios are 1, 2, 3, 4 and 7. They are presented shortly in the following table and described more detailed for the Barcelona pilot in *D2.16 Description of Barcelona Pilot and User Needs.*

Scenario #	Scenario name	Description
1	Charge planning and booking	***Scenario 1: Charge planning and booking*** 1. An EV driver needs to take a trip that exceeds the range of the vehicle (with its current state of charge - SOC), and thus needs to fast-charge underway. EV in-vehicle system gets destination from user (a) and plans the route. 2. EV in-vehicle system gets data from Open data and information services (f) regarding weather, driving conditions and charging opportunities along the route, computes expected progress and selects possible charging stations. 3. EV in-vehicle system sends charge request to Charge management system of selected charging stations via Roaming management system (b,i). 4. Charge management system sends power request to Neighbourhood energy management system (n). 5. Neighbourhood energy management system allocates power and returns offer via Roaming management system (i,b). 6. EV in-vehicle system evaluates offers, selects best fit and returns accept/reject to offer providers (c/b,i); The selection criteria should include suitable time, local RES, short detour, suitable surroundings (for spending waiting time, see below), etc. 7. Charge management system cancels power requests for rejected offers (n). 8. During the trip the EV in-vehicle system monitors progress and if the deviation from the predicted progress exceeds the threshold, the EV in-vehicle system re-computes expected progress and re-plans and rebooks the charging stop.
2	Charge at booked Charging station	***Scenario 2: Charging at booked Charging station*** 1. EV approaches booked charging station and sends an approaching message to the Charge management system.

		2. Charge management system sends guiding info to the EV in-vehicle system (c) who displays it to driver to assist the navigation to the booked charging point. This could include a detailed map of the charging facility, with indication of route to the booked charging post, the location of the EV and audio directions, like the navigation system normally works. Ideally this functionality would be seamlessly integrated with the navigation system. 3. The EV parks at the booked charging post and the EV in-vehicle system authenticates the EV (g) to the Charge management system. The Charge management system controls the charging, making sure to obey the constraints provided in the booking, and in collaboration with the Neighbourhood energy management system leveraging any flexibility.
3	Booking Enforcement	***Scenarios 3: Booking Enforcement*** An inherent practical problem of implementing booking of charging spots is that other cars may park at and block the allocated charging spot. Physical obstacles that can be controlled remotely exists but are expensive. Other solutions may be: 1. Charge management system instructs Charging post to display clearly the availability/non-availability for drop-in customers and blocks charging for other EVs in booked time slots. 2. Drop-in customers must also indicate the time-slot they will be parked by the selected charging post, and the Charge management system may enforce restrictions in busy periods with many bookings. 3. Parking at a booked spot, or leaving the vehicle by a charging post longer than agreed may cause punishment, e.g. a fine or higher price or blacklisting. A good strategy to avoid practical problems with booking, while still ens uring good utilisation of the charging equipment, may be to have more p arking spots with connectors (cheap) than chargers (expensive). The final assignment of charging post for booking customers could be p ostponed until arrival time, leaving more flexibility to sell free slots in b etween bookings to drop-in customers.
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	***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 internal electricity distribution grid in older (groups of) buildings often have limitations that cause problems when inhabitants want to charge EVs at home. Installing a *Neighbourhood Energy Management System (NEMS)* for the (group of) buildings and a *Charge management system (CMS)* supporting booking for the charging facilities, would avoid overloading and ensure optimal use of the available capacity, and if desirable, take care of the distribution of cost among the users. It would also open the possibility to sell excess capacity to outsiders, which if the facility is conveniently located, could recover the investment.
7	eMobility in innovative 'mobility as a service' (MaaS)	***Scenario 7: eMobility in innovative 'mobility as a service' (MaaS)*** Car sharing as a fleet-based service is used as innovative element of SUMPs to reduce the consumption of space for parked cars – and to introduce electric vehicles. Car sharing can widely replace car ownership –makes more efficient use of transport / parking infrastructure. Users have access to the cars of the fleet via electronic reservation and access. There are different business cases involved: for the cities, for the users/citizens,

		for car sharing operators, for recharging infrastructure operators, for housing companies. It needs proper communication between cars and the fleet management system e.g. about the state of the battery in order to optimise the charging of the cars in relation to the next reservations of cars at the very car sharing station. For satisfied customers, it is necessary to provide cars with sufficient battery charge for the planned trip. 1. With the reservation, the user tells that he wants to go a certain distance (e.g.100 kilometers) with the e-car. 2. The reservation system checks whether the available cars have a sufficient state of battery at the pick-up time. 3. During the trip, the car communicates the state of battery to allow the management system planning the charging for the follow-up reservation

A.2 List of Use Cases related to Scenarios and demonstrators in Barcelona pilot

In the following table (extracted from *D2.17 Implementation Plan for Barcelona Pilot*) a summary of the use cases to be implemented in Barcelona pilot site is correlated to the scenarios described in GreenCharge proposal and the demonstrators where they will be tested. A full description of the scenarios and use cases can be found in the deliverable *D2.16 Description of Barcelona pilot and user needs*.

Table 5: List of use cases, scenarios and demonstrators in Barcelona pilot site

Use Case	Scenario	Demonstrator	Short description
UC1: Booking of charging point	SC1-Charge planning and booking	Eurecat demonstrator	A Eurecat employee driving a plug-in electric car books a charging point to recharge her/his car during the visit to other Eurecat premises.
UC2: Charging at a booked charging point	SC2-Charging at booked charging station	Eurecat demonstrator	A Eurecat employee who has previously booked a charging point drives to the charging station to charge his/her e-car at the allocated charging point in the garage.
UC3: Enforcement at a booked charging point	SC3-Booking enforcement	Eurecat demonstrator	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. The charging station operator handles the situation.
UC4: Optimal charge planning	SC4-Home charging in working buildings with common internal grid and parking facilities	Eurecat demonstrator	The smart charging management system calculates the optimal activation of every charging point of the infrastructure taking into account price tariffs, technical and user constraints and availability of renewable energy locally produced.
	SC7: E-Mobility in innovative 'mobility as a service'	MOTIT demonstrator	The smart charging management system calculates the optimal recharge of every battery connected to the hub taking into account price tariffs, technical and operational constraints. In simulation mode, the optimization will take into

			account energy coming from a potential renewable source.
	SC7: E-Mobility in innovative ‘mobility as a service’	St. Quirze demonstrator	The smart charging management system calculates the optimal activation of every charging point of the infrastructure taking into account price tariffs, technical and operational constraints based on utilization of the bikes as well as availability of renewable energy locally produced and stored.
UC5: DR request	SC4:Home charging in working buildings with common internal grid and parking facilities	Eurecat demonstrator	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.
UC6: Take an e-bike from the sharing service	SC7: E-Mobility in innovative ‘mobility as a service’	St.Quirze demonstrator	A user previously registered to the e-bike sharing service 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. The sharing management platform will monitor the location of the bike and the SoC to plan the optimal charging of the fleet.
UC7: Return an e-bike from the sharing service	SC7: E-Mobility in innovative ‘mobility as a service’	St.Quirze demonstrator	A user who 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. The sharing management platform updates the status of the fleet and will activate the charging as planned.
UC8: Change drop location for e-scooter	SC7: E-Mobility in innovative ‘mobility as a service’	MOTIT demonstrator	A user who has finalised his trip with a MOTIT e-scooter change 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.

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