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GREEN CHARGE

greencharge2020.eu

GreenCharge Project Deliverable: D2.19

Full-Scale Pilot Implementation for Smart Charge and EV Fleet Management

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2020 CiViTAS Cleaner and better transport in cities

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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 implementation of each demonstrator of the Barcelona Pilot. The components used were previously described on the deliverable *D2.18 Pilot Component Preparation for Full-scale Pilot (Barcelona)*.

All the developments and adaptations needed for the integrated prototypes for the first iteration have been done for the 3 demonstrators, although the hardware installation has been delayed for some of the demonstrators.

The table below shows the status of each demonstrator per 9 April 2021, indicating when fully completed (green colour) or work is still on progress (yellow colour).

Demonstrator	Task	Comments	Status
MOTIT	Software development/adaptation	Communication issues with battery management system caused delays on implementation	
	Hardware installation		
	Configuration		
	Full tests		
	Start data acquisition	Automatic data collection: on going	
Eurecat	Software development/adaptation		
	Hardware installation	Hardware installation completed in Cerdanyola premises. Additional premises are planned for 2nd iteration	
	Configuration		
	Full tests		
	Start data acquisition	Static baseline: on going Automatic data collection: on going	
e-bike sharing	Software development/adaptation		
	Hardware installation	Bike batteries, charge points, PV panel and stationary battery are all installed.	
	Configuration		
	Full tests		
	Start data acquisition	Pending service reopening due to COVID19.	

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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.

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Table of Figures

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List of Tables

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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.
BCN.D1	Barcelona Pilot Demonstrator 1. In previous deliverables referred as BCL.D1
BCN.D2	Barcelona Pilot Demonstrator 2. In previous deliverables referred as BCL.D2
BCN.D3	Barcelona Pilot Demonstrator 3. In previous deliverables referred as BCL.D3
CAN	Controller Area Network
CEL	Cellular
CMS	Charge Management System
CPO	Charging Point Operator
DC	Direct Current
EMP	Electromobility Provider
GNSS	Global Navigation Satellite System
GSM	Global system for Mobile communications
GPS	Global Positioning System
GUI	Graphical User Interface
HW	Hardware
KPI	Key Performance Indicator
LTE	Long Term Evolution
NEMS	Neighbourhood Energy Management System. An ICT system implementing the smartness of an energy smart neighbourhood.
EVSE	Electric Vehicle Supply Equipment
OTA	Over The Air
PV	Photovoltaic
PWR	Power
SEM	Smart Energy Management
SMS	Short Message Service
SoC	State of Charge
SoH	State of Health
SW	Software
TCP	Transmission Control Protocol
UDP	User Datagram Protocol

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List of Definitions

Table 2: List of definitions

Definition	Explanation
CAN bus	The CAN bus (Controller Area Network bus) is a communication standard for vehicles. It allows microcontrollers and devices inside or outside vehicle to communicate with each other.
SAE J1939	Society of Automotive Engineers standard SAE J1939. is the vehicle bus recommended practice used for communication and diagnostics among vehicle components over CAN bus.

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1 About this Deliverable

1.1 Why would I want to read this deliverable?

This deliverable gives you an overview of the components (hardware and software) installed as an integrated prototype in each demonstrator of Barcelona pilot and the full tests carried out to ensure that all components are correctly installed and they interact well with each other. The deployment described in this document is the first iteration of the integrated prototype (as described on *D4.3 Initial Version of Integrated Prototype*). Modifications and/or updates to current components will be done in next iterations and documented in *D4.4* and *D4.5*. All the updates will be deployed in the demonstrators and will be reported in the final report for pilot (*D2.21 Final Report for Barcelona Pilot: Lessons Learned and Guidelines*).

1.2 Intended readership/users

This delivery is mainly targeted to readers with technical knowledge on eMobility solutions design and implementation.
Inside GreenCharge project partners involved on design, develop or deploy of pilots should read this deliverable in order to understand the current implementation and find potential cross-demo integrations for next iterations.
Other intended readers are **external stakeholders** planning to deploy eMobility solutions with smart and green charging and also component providers that want to design components that fits the GreenCharge architecture.

1.3 Structure

The Barcelona Pilot takes place in various demonstrators, specifically 3:

- MOTIT (optimize charging process and incentivize users)
- Eurecat (booking and charging)
- St. Quirze e-bike sharing (charging profiles and strategies)

Based on this, we have structured this document based on demonstrators. We have included a first section that shows a summary of the components involved in the pilot and then a section for each demonstrator with specific information about each one.

1.4 Other project deliverables that may be of interest

Public deliverables:

- **D1.1 Data Management Plan** – Describes the internal procedures for dealing with the collection and handling of data from the pilots in order to make them as open research data, including the necessary permissions for handling private data, and the necessary forms of informed consent and documentation of technical solution for secure data storage.
- **D2.16 Description of Barcelona Pilot and User Needs** – Describe the Barcelona pilot in terms of challenges, user needs, use cases, scenarios, stakeholders and locations to be involved and the baseline.
- **D2.18 Pilot Component Preparation for Full-scale Pilot (Barcelona)** – Deployment and testing of software and hardware components to be used in the pilot, to prepare for the full-scale pilot implementation.
- **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

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the data collected. Describe lessons learned and guidelines for replicability of the services tested.

- **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.

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2 Pilot site components overview

An overview of the components to be used in the Barcelona pilot can be seen in Figure 2-1 where the overall architecture of GreenCharge is shown (this architecture is presented on *D4.1 Initial Architecture Design*).

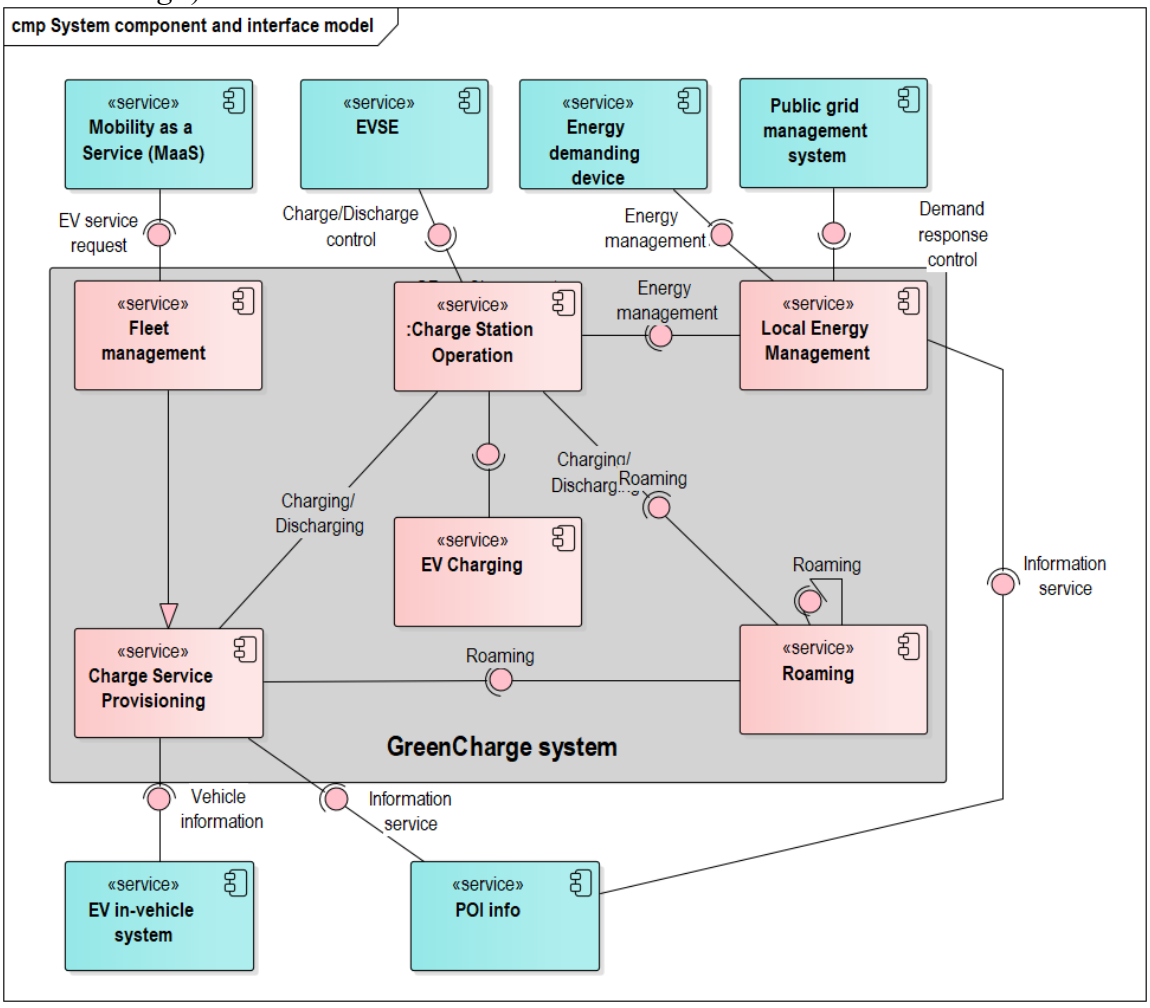

Figure 2-1: Overall GreenCharge architecture (from D4.1)

Although this is the general GreenCharge architecture, specific instances derived from this general architecture are used for each pilot and demonstrator. In the Barcelona pilot we have 3 demonstrators each one with its concrete architecture. We have assigned an abbreviation to each demonstrator for better reading of the document:

- BCN.D1 - "MOTIT" (e-scooter charging)
- BCN.D2 - "Eurecat" (corporate charging and booking)
- BCN.D3 - "St. Quirze e-bike sharing" (e-bike sharing)

The table 1 shows the components used and their role in the pilot. It has been extracted from work presented on deliverable *D2.18 Pilot Component Preparation for Full-scale Pilot (Barcelona)*.

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

Service	Component name	Description	Section	Demo site	Type	Partner
EV In-vehicle system	Atlantis Fleet app	It's the user interface with the e-bike sharing service. It allows to find an e-bike available, track it in real time and read the SoC.	5.2.1	BCN.D3	SW	ATLANTIS IT
	Scooter user's mobile app	It's the user interface with the scooter sharing service. It allows to find a scooter available, lock/unlock it, open the trunk, track it in real time and read the SoC.	3.1	BCN.D1	SW	MOTIT
	GPS tracker devices	GPS tacker device to get the e-bike/e-scooter location. It has both digital and analogue inputs and also CAN BUS input to collect data.	3.2.2 5.2.3	BCN.D1 BCN.D3	HW	MOTIT ATLANTIS IT
Charge Service Provisioning	Journey planner app	Help users to drive or ride to their destination.	5.2.2	BCN.D2 BCN.D3	SW	EURECAT
	Booking system	Enables Eurecat employees to book a charging point in Eurecat premises.	4.2.4	BCN.D2	SW	EURECAT
Fleet management	Atlantis Fleet platform	It's the interface with service administrator to manage the fleet. It collects data from e-bikes and GPS trackers.	5.2.4	BCN.D3	SW	ATLANTIS IT
	Scooter shared services fleet management	It's the interface with service administrator to manage the fleet. It allows service operator to receive information about the e-scooters that need to be charged and plan an optimized battery swapping	3.1	BCN.D1	SW	MOTIT
EVSE	Battery swapping in hub	The battery swapping hubs allow to centralize and optimize the battery charging process.	3.2.1	BCN.D1	HW	MOTIT

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Service	Component name	Description	Section	Demo site	Type	Partner
	Charging point (Eurecat)	Charging point installed in Eurecat premises that will be used by Eurecat employees.	4.2.1	BCN.D2	HW	EURECAT
	Charging point (St. Quirze)	Charging point for e-bikes installed at parking & charging station.	5.2.6	BCN.D3	HW	MILLOR ENERGY SOLUTIONS
Charge Station Operation & EV Charging	Charge management system (CMS)	Control the charging process of a charging station.	4.2.1	All	SW	EURECAT
Local energy Management	SEM scheduler	Calculate the optimal schedule of all loads and local RES for the optimization criteria defined and user preferences/needs.	4.2.5	All	SW	EURECAT
	SEM forecaster	Forecast of the energy demand 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.	4.2.5	All	SW	EURECAT
	PV panels	PV panel to provide green energy locally produced at premises site.	4.2.2	BCN.D2	HW	EURECAT
	PV panels	PV panel to provide green energy locally produced at e-bike charging station.	5.2.7	BCN.D3	HW	MILLOR ENERGY SOLUTIONS
	Stationary battery	This battery stores the electric energy generated by the PV panels in order to be used on the charging point.	5.2.8	BCN.D3	HW	MILLOR ENERGY SOLUTIONS

The following sections show the concrete architecture for each demonstrator inside Barcelona pilot.

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3 MOTIT (BCN.D1)

3.1 Overall architecture and components involved

The Figure 3-1 shows the concrete architecture for the MOTIT demonstrator.

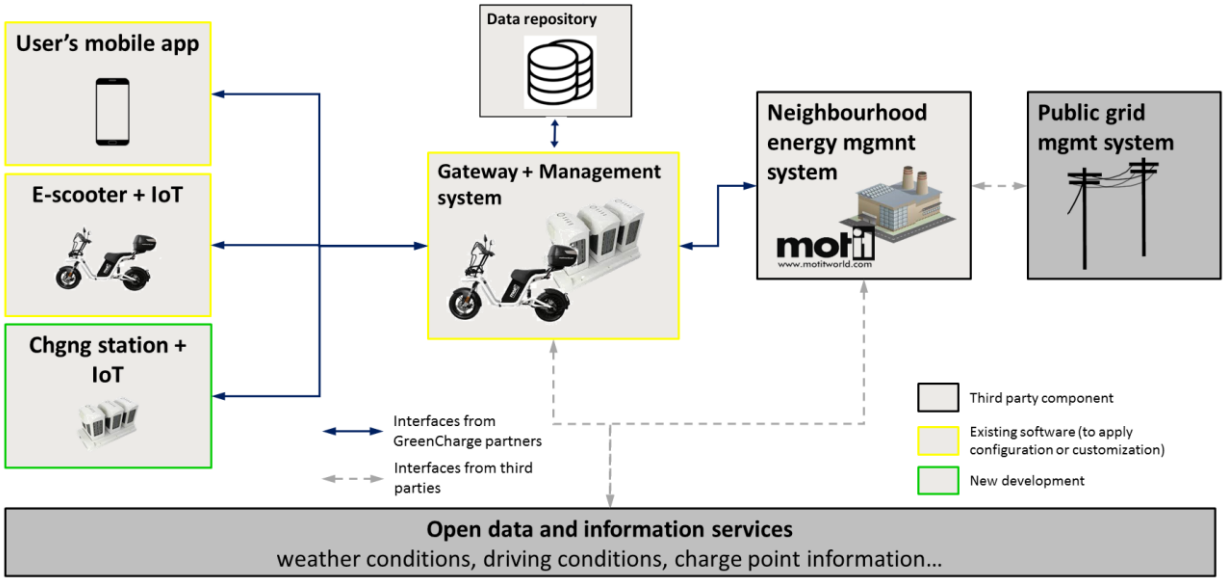

Figure 3-1: GreenCharge architecture in MOTIT demonstrator

The components deployed in the demonstrator are:

- Charging station + IoT: a communications device per charging slot, connected through CAN-BUS proprietary protocol with the battery's control board. Power supply from an additional 12V output from the charger.
- A data repository (mySQL database) to store all gathered information and allow applications to retrieve historical data.

Apart from that, some components were already in place, which needed adjustments:

- E-scooter + IoT: Vehicle GNSS tracking devices, which needed new firmware configuration
- Charging stations, which needed new wirings to connect the chargers and batteries to the communications devices.
- Gateway + management system: this is the Scooter shared services fleet management component.
- The Fleet management system connects with the Neighbourhood energy management system component that uses the SEM scheduler and SEM forecaster Eurecat developed.

The scooter user's mobile app is already in production. Adaptations for the different business models and promotions have been done for the demonstrator.

3.2 Adaptations done for the demonstrator

3.2.1 Charging stations

Six charging stations has been equipped with the communications device and are transmitting the information regarding the battery that is being charged to the data repository.

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Figure 3-2 Batteries connected to a three-slot charger station

3.2.2 Vehicle tracking device

The vehicles are equipped with a tracking device (the IoT part of the "E-scooter+IoT" component in Figure 3-1), but a new configuration is needed to collect information regarding accelerometers, that wasn't used in the service.
This information is needed to trace the user's behaviour during driving the e-scooter and reward a safer and greener driving style, according to the business model defined in the deliverable D3.3.
The selected device is Teltonika TFT-100 and its main features can be found in appendix B.1.

Figure 3-3 In-vehicle tracking device

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3.2.3 SEM scheduler

The SEM Scheduler software used is the same developed for Eurecat demonstrator. See section 4.2.5.

3.2.4 SEM forecaster

The SEM Forecaster software used is the same developed for Eurecat demonstrator. See section 4.2.5.

3.3 Installation and configuration of the demonstrator

3.3.1 Communications device

An out-of-the shelf device has been selected to be connected to the charging stations (one per charging slot). These devices equipped in the charging slots are the same as the ones integrated in the scooters, so they share communication protocols and information that can be collected. Its main features can be found in appendix B.1.

Figure 3-4 Communications device

3.3.2 Electronic control board

The information that can be collected form the batteries, both while charging and in running condition include, among information from the scooter:

- Serial Number of the battery (S/N)
- Time (GMT)
- State of Charge (percentage and mA·h counter)
- Battery voltage
- HiCell voltage / LowCell voltage
- State of Health (SoH)
- Temperatures (battery, BMS, etc)

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Figure 3-5: Battery provided with electronic board

3.3.3 Data repository

A new MySQL database has been deployed, prepared to collect the information related to the batteries connected to the charging stations. Further details about this component can be found in the deliverable D4.3.

3.4 Full test for the demonstrator

After placing successful laboratory tests related to the charging stations the solution has been deployed in six charging stations that are responsible of the fleet charging operations.
The e-scooters have started transmitting accelerometer information and this information is collected by the system. There is a data analysis software module running that analyses the drivers' behavior.

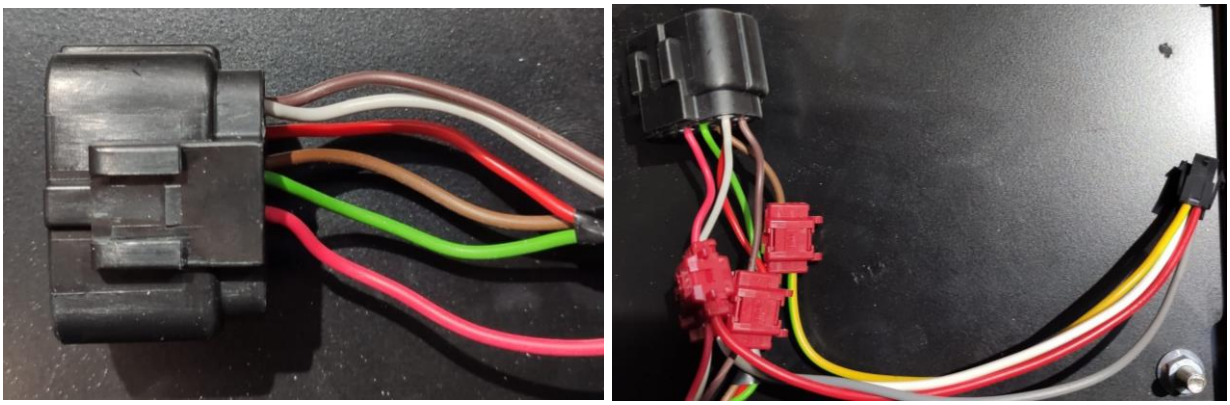

Figure 3-6: IoT connection detail

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Wiring description:

- Brown: CAN-L
- White: CAN-H
- Red: red LED
- Brown: GND
- Green: green LED
- Red: auxiliary 12VDC

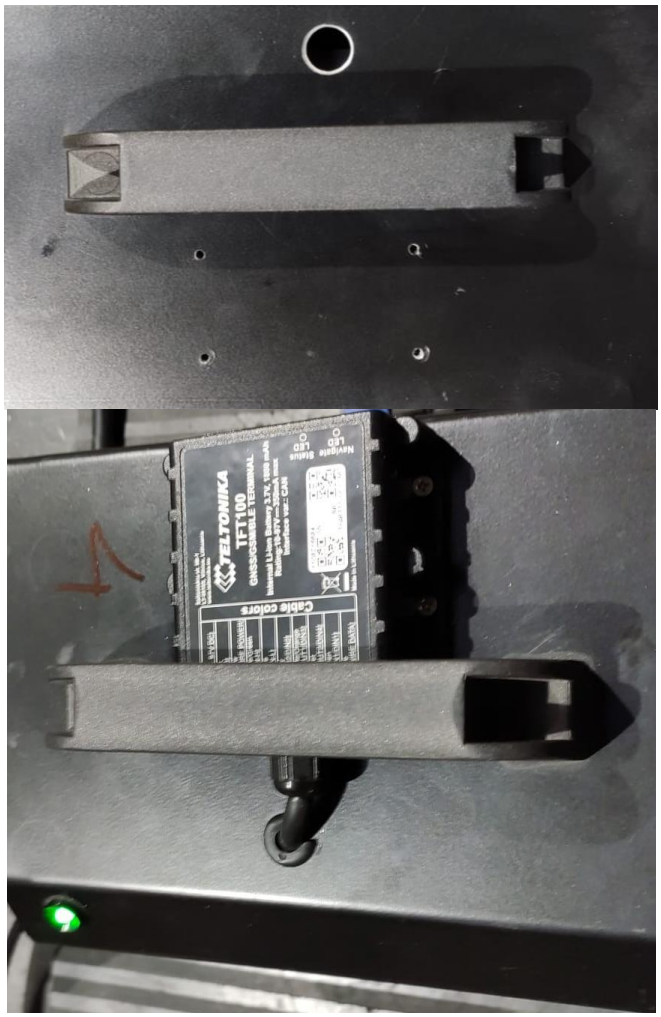

Figure 3-7: IoT mounting detail

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Figure 3-8: Detail of the rental scooters used

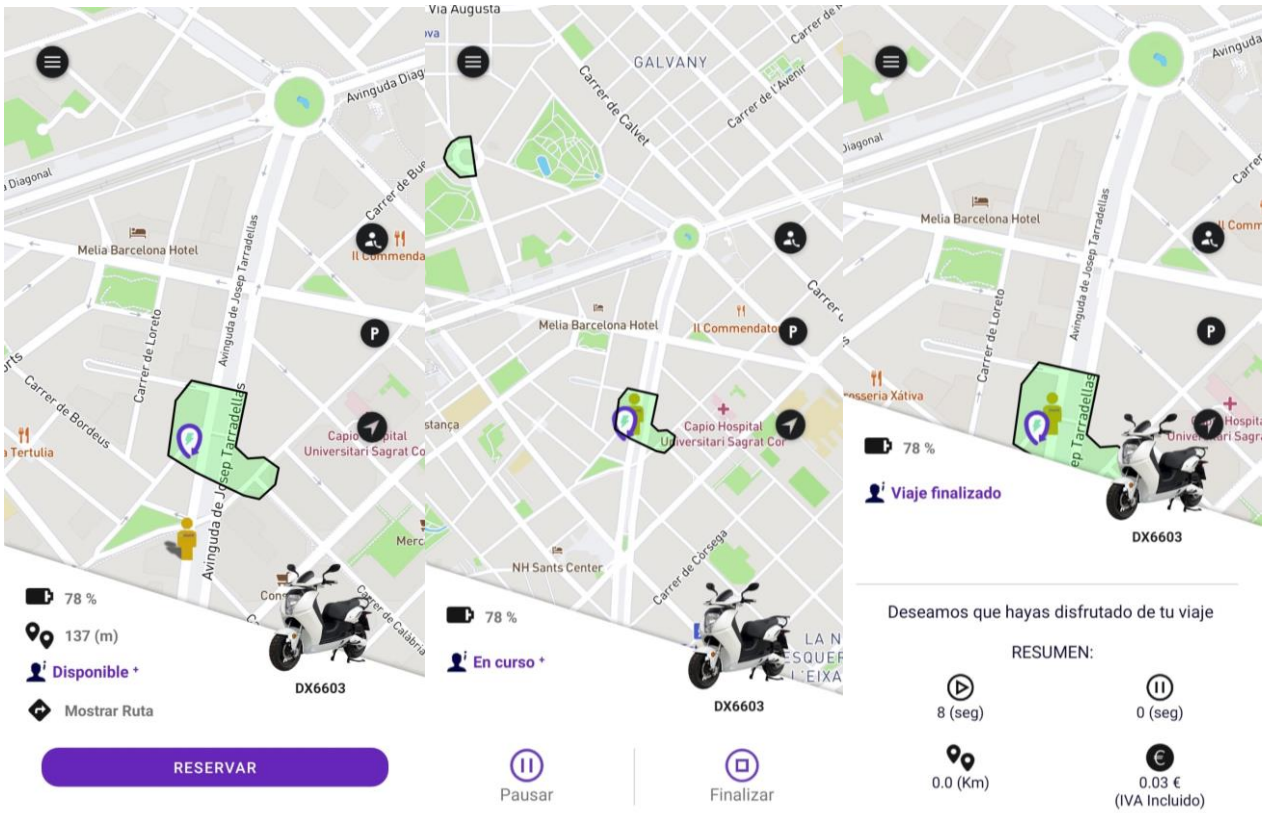

Figure 3-9: App reservation process

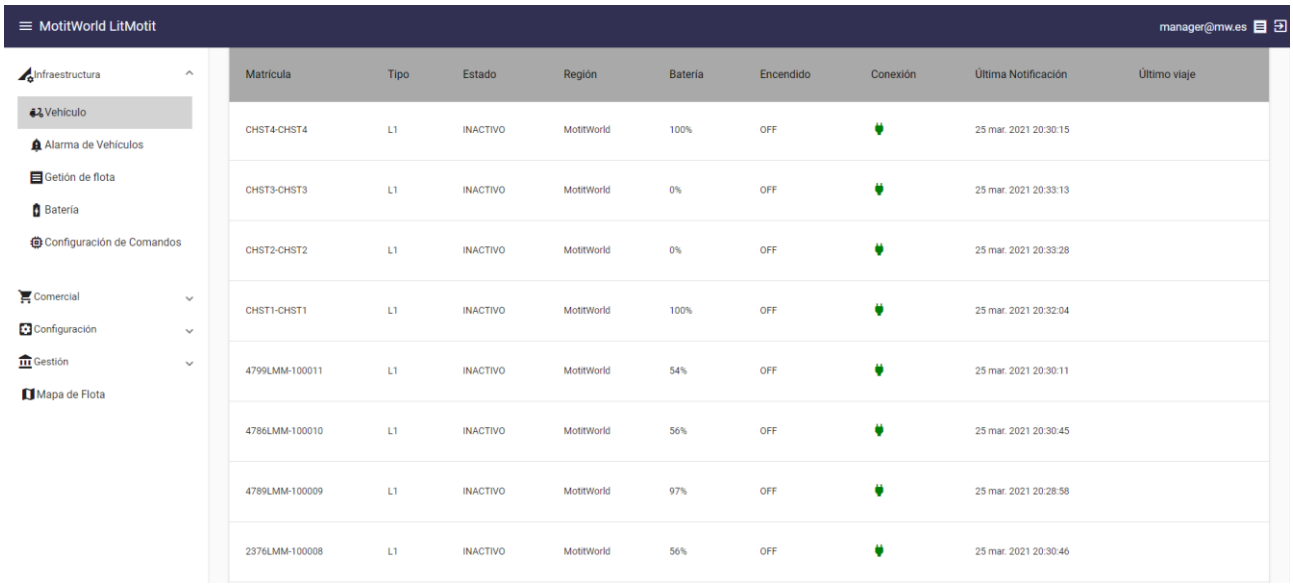

Figure 3-10: Back-end fleet detail

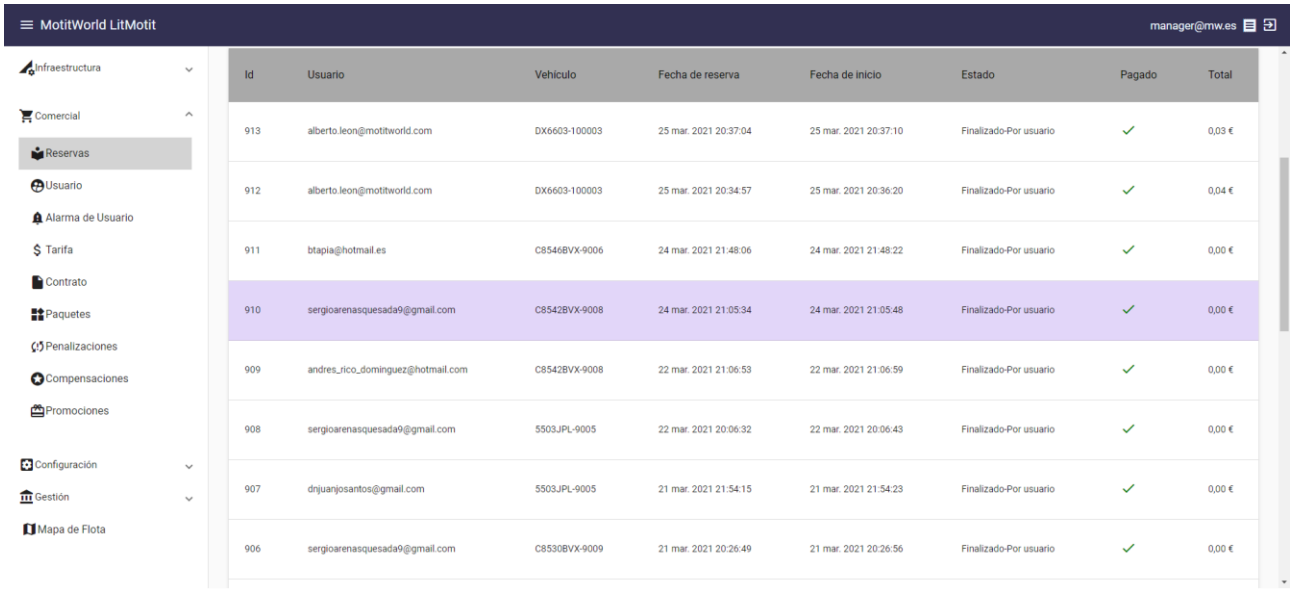

Figure 3-11: Back-end reservations detail

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4 EURECAT (BCN.D2)

4.1 Overall architecture and components involved

The Figure 4-1 shows the concrete architecture for the Eurecat demonstrator.

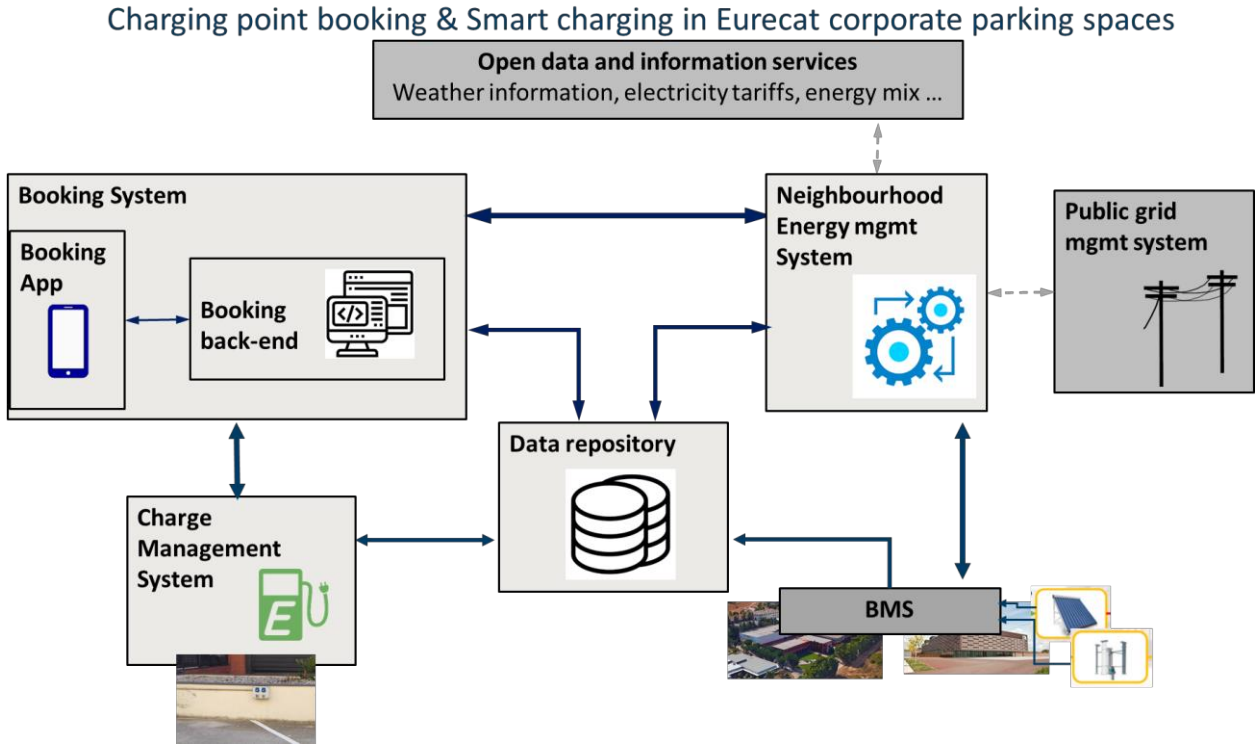

Figure 4-1: GreenCharge architecture in Eurecat demonstrator

The components deployed in the demonstrator are:

- A booking system formed by an app opened to Eurecat employees and a back-end system for the facility manager
- A charge management system to monitor and control the sockets of the charging points (comprises a software module, actuators to switch on/off the charging points, network analysers to measure energy consumption and a data hub to enable remote communication)
- A Neighbourhood Energy Management System (NEMS) composed by Energy Optimizer (SEM Scheduler) and a load demand forecaster (SEM Forecaster)
- A central data repository to store all the data gathered and generated by the different systems, needed for the applications (load forecaster) as well as for KPI calculations and open research data

Apart from that, some components were already in place and only some connectors to interact with them have been implemented. Namely:

- PV panels in Eurecat Manresa premises
- Mini-wind turbines
- A Building Management System (BMS) in Eurecat Manresa premises to get energy consumption

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4.2 Adaptations done for the demonstrator

The technical details on the software components can be found in deliverable D4.3. Here, the focus is set in the adaptations needed and the hardware components deployed.

4.2.1 Charge management system

The charging facilities are split into two different spaces: the outdoor parking space and the underground parking space. We will open first to employees for charging the outdoor parking space since the control access is easier. Besides all the spots in the indoor parking space are already allocated and only one employee drives occasionally a plug-in hybrid car; he has committed to use the outdoor parking space when so.

Charging spots

In the outdoor parking space, there were already two spots with charging capabilities, but they did not include any monitoring or control capabilities. Each charging spot has associated a parking space. Some adaptations have been done on site to enable the demonstration of the functionalities envisioned by GreenCharge. Each charging point has an associated QR code to be scanned by the app.

Figure 4-2: Charging spots in the outdoor parking space at Eurecat premises

Electrical installation

Regarding the electrical connection, the adaptations done can be summarized in the following table:

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Table 4: Adaptations for the outdoor parking space energy supply at Eurecat premises

Element	Before GreenCharge	After GreenCharge
Sockets	2 Schuko + Type C connector	2 Schuko + Type C connector (No changes)
Wiring	1 single wire to supply both sockets	An independent wire to supply each
Energy Monitoring	A network analyser not working	2 single-phase network analysers (Circutor CVM 1D) 1 Energy Management system (Circutor EDS)
Energy Control	No control	2 double-pole contactors activated through the Energy Management system (Schneider Acti9 iDT40 CT)
Communications	No LAN or Wi-Fi coverage	Ethernet connection to Eurecat LAN and connection to the internet

The equipment installed in the electrical cabinet to monitor and control energy supply can be seen in Figure 4-3.

Figure 4-3: Equipment installed in the electrical cabinet for the charging management at Eurecat premises

Access control

Regarding the access control, currently there is an entrance barrier that can be opened using an RF remote control (employees with assigned parking spot) or an intercom and camera controlled by the

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receptionist (occasional users). The employees from other sites with a booking will be considered occasional users. However, it is envisioned to be installed a biometric system like the one already in place for the indoor parking garage. Users can be authorized on demand according to their bookings.

Figure 4-4: Access to outdoor parking space at Eurecat premises

System management

Apart from the hardware components, a software module has been developed to manage the system. The module is deployed in a virtual machine in Eurecat central data centre, in Eurecat headquarters in Barcelona (reachable through Eurecat LAN). Its functionalities are:

- To monitor the energy consumption of the charging points
- To detect if a vehicle is connected to the charging point
- To report on the status of the charging point (on/off)
- To apply the energy plan provided by the NEMS
- To detect any deviation from the plan
- To apply flexibility, if possible, to amend any deviation from the plan
- To notify the NEMS in case local flexibility is not enough to amend deviations from the plan

It has been configured to monitor signals in a 1-minute based.

4.2.2 Renewable energy sources

Eurecat premises in Manresa already had some renewable energy sources (RES) that complement the energy exported from the grid. The energy locally produced is consumed in the installation. In Figure 4-5, there is a scheme of the different energy sources and system available, designated as Energy Hub.

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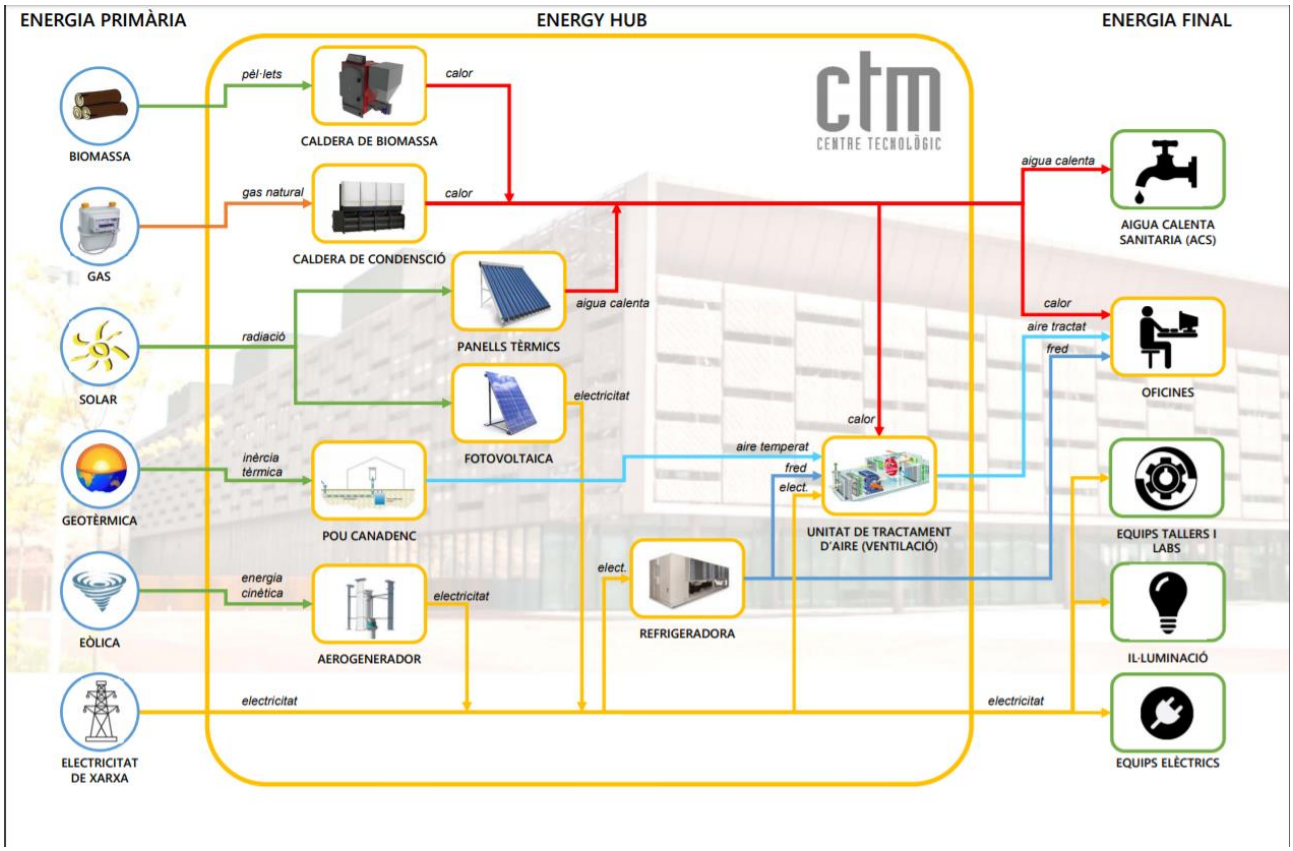

Figure 4-5: Scheme of Energy Hub in Eurecat-Manresa premises

The following table shows the characteristics of the RES elements on site.

Table 4: RES at Eurecat premises (Manresa)

Element	Characteristics
PV panel 1	6.48 kWp
PV panel 2	1.35 kWp
Thermal solar panel	2.33 m^2
Mini-wind turbine	1 kW
Storage	4.8 kWh

4.2.3 Building Management System

At Eurecat premises in Manresa there was already a Building Management System (BMS) in place that monitors the consumption and production of the elements of the energy hub (Figure 4-5). The information provided by this BMS can be seen on a big monitor in the reception of the building by employees and visitors.

The work done by some researchers of the Sustainability group in Eurecat has enabled the retrieval of this information through a connector in Python. The information is meant to be used by the NEMS and will be stored in the local GreenCharge repository (data base) and later provided as open research data.

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.

4.2.4 Booking system

The booking system has been developed for the project. It consists on an app available for Eurecat employees and a back-end system to manage the bookings and communicate to the NEMS. In this section we provide an overview of the functionalities, while in Appendix A.1 a full manual description is provided. The technical details on the implementation can be found in D4.3.
It is important to notice that the users are requested to introduce the state of charge (SoC) when they arrive and the energy desired when booking. To ease the process, we have introduced to the system the make and models of electric cars in the market and their battery capacity. Furthermore, the current SoC to be provided is discretised in 5 levels.
User App:

- **Sign Up view:** The user has to provide credentials, and vehicle description, namely make and model, battery capacity (pre-defined using make and model but editable), plate number.
- **Reservation view:** The user can view a list of available Eurecat locations with charging capabilities and choose a location and time slot, and pre-set charging regimes (fast, normal or slow). Furthermore, the booking can be set to be periodical (every day, week, month).
- **Charging view:** The user notifies the SoC at arrival and can monitor the progress of the charging
- **Historical record:** A list of previous bookings and energy supplied in each one as well as carbon footprint and cost (even if it has been agreed with the organisation that they will not pay during the piloting phase)
- **Contact form:** A channel to contact the responsible party to report faults, suggestions or praises.

The figure shows the reservation view.

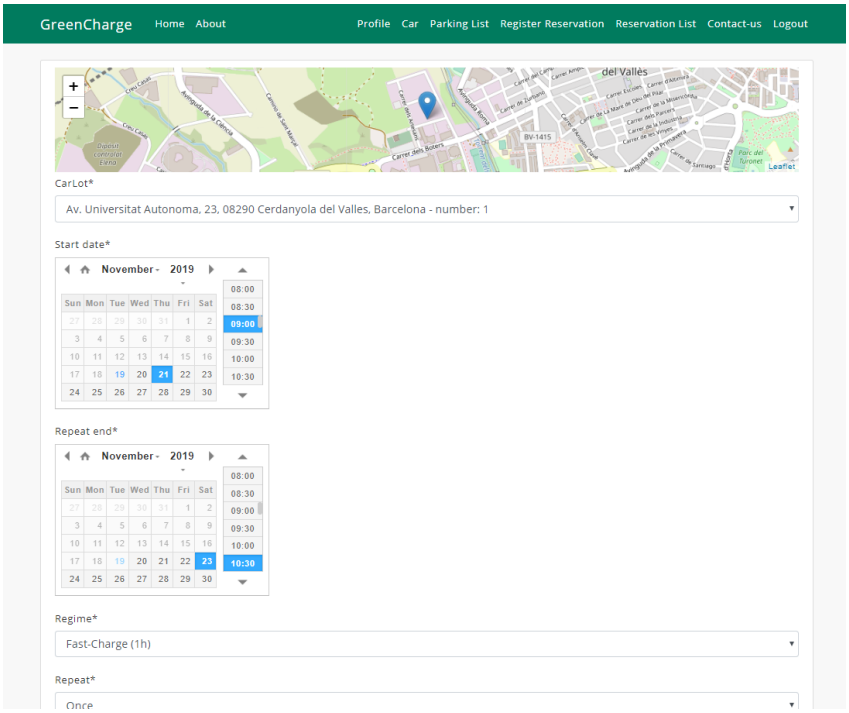

Figure 4-6: View of reservation form in the booking app

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Administration Application (CPO-EMP)

A back-end system with a GUI to set-up and manage the system has been developed as well. The user of this application is meant to be the infrastructure department responsible at Eurecat. The main functionalities are

- **Charging spot registration:** To add a new charging point available to Eurecat employees
- **Reservation management**: To enable the viewing of active bookings, acceptance, change or rejection.

As an example the figure below shows the form to register a new charging spot.

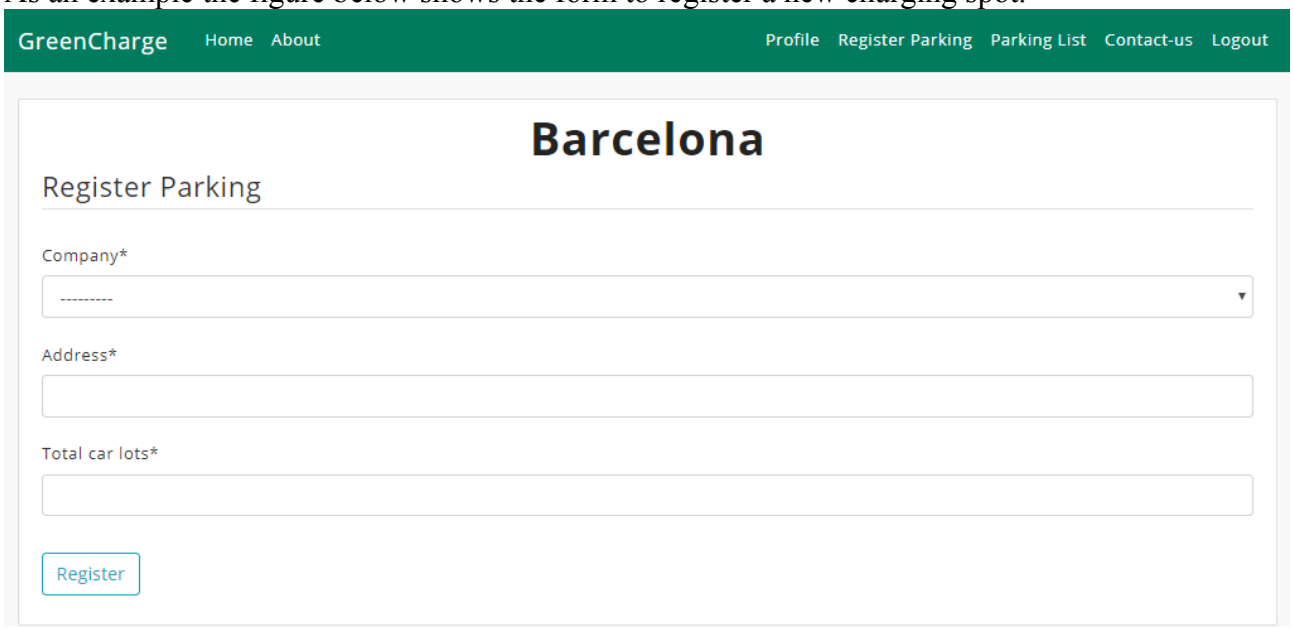

Figure 4-7: View of registration of a new charging spot at Eurecat

4.2.5 Neighbourhood Energy Management System

The NEMS is a modular application composed by different modules with specific functionalities, as described in the following list:

- Connector to weather information: The weather information, current and forecasted, is obtained from darksky[1] using an API. It triggers a request every 15 minutes to get updated information, which is stored in a database (Influx DB)
- Connector to energy mix: The energy mix is published by the TSO (REE) every hour. This information can be accessed from the pan-European platform Entso-e[2] through an API. The energy mix expresses the amount of energy generated by each of the generation technology types. For wind and solar energy, the forecasted energy (24 hour ahead) is also provided. This information is used to calculate the carbon footprint of the energy consumed, as well as to calculate the optimal energy plan making used of as much renewable energy as possible.
- Connector to energy prices: In the evenings the energy market operator (OMIE[3]) publishes the energy prices for the following day. This information is captured to calculate the optimal energy plan according to energy price, that changes hourly.

[1] https://darksky.net/dev
[2] https://transparency.entsoe.eu/content/static_content/Static%20content/web%20api/Guide.html
[3] https://api.esios.ree.es/

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.

- Connector to BMS: In Manresa premises there is already a BMS that monitors energy consumption and production. A connector extracts this information regularly and stores it in the Influx data base.
- Connector to the booking system to get the charging bookings that will be used for the calculation of the optimal energy plan
- Connector to the charging system to deliver the optimal energy plan for the charging points and to get any deviation from the calculated plan
- Energy forecaster (SEM Forecaster): To forecast local energy demand and production according to historical energy data, weather forecast and calendar.
- Scheduler (SEM Scheduler): Taking into account the energy forecast, prices and energy mix calculates the optimal energy plan according to the goal function defined.

The summary of adaptations done for the integration in GreenCharge project are described in Table 5.

Table 5: Adaptations for the Neighbourhood Energy Management System

Element	Before GreenCharge	After GreenCharge
Scheduler	Configuration read from files	Configuration stored in database GUI to configure some parameters Meteorological information, energy mix and prices updated regularly
Load forecaster	Stand-alone algorithm No interaction with other modules	Triggered by message Inputs and outputs stored in a database
BMS	Data accessible only by facility manager and some researcher on site	Connector to extract data from BMS to be used in NEMS and stored in the data repository
Energy Control	No automatic control	Control over charging points and eventually the HVAC system

4.3 Installation and configuration of the demonstrator

The installation of the equipment and the configuration of the systems are done. Additional configuration related to individual users is on hold due to the lock-down since workers work from home.

4.4 Full test for the demonstrator

Laboratory test have been done successfully. Full test has been done and detected issues were fixed.

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5 St. Quirze e-bike sharing (BCN.D3)

5.1 Overall architecture and components involved

The Figure 5-1 shows the concrete architecture for the St. Quirze e-bike sharing demonstrator.

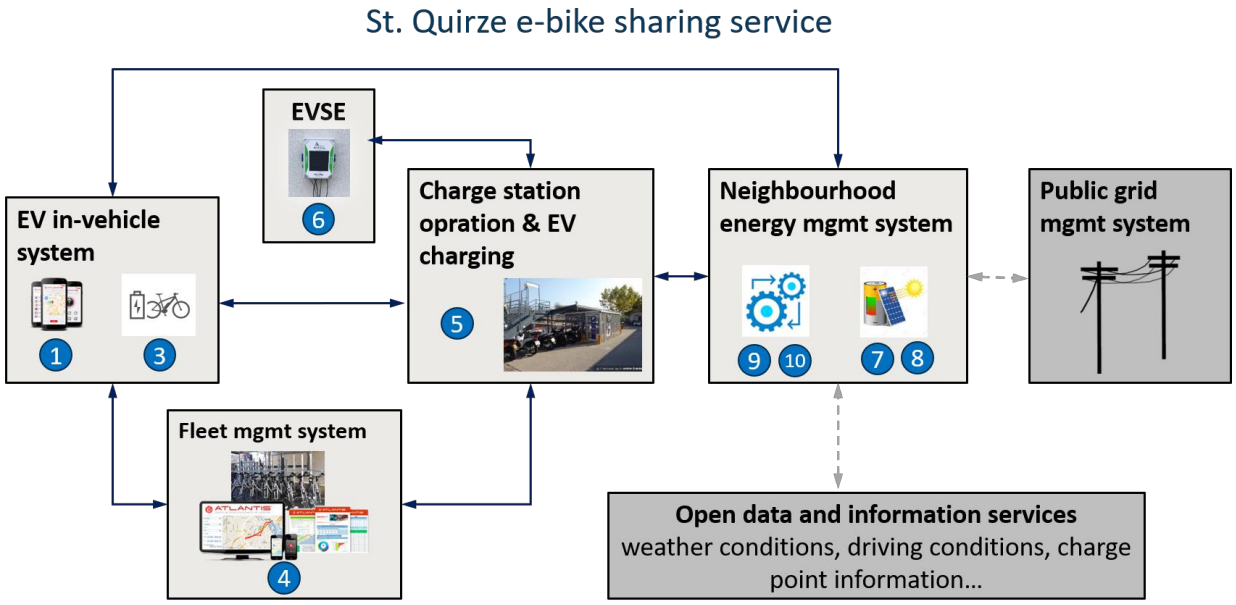

Figure 5-1: GreenCharge architecture in St. Quirze e-bike sharing demonstrator

The following components have been implemented in this demonstrator:

1. Atlantis Fleet app
2. Journey planner
3. GPS tracker devices
4. Atlantis Fleet platform
5. Charge management system
6. Charging points
7. PV panel
8. Stationary battery
9. SEM scheduler
10. SEM forecaster

5.2 Adaptations done for the demonstrator

5.2.1 Atlantis Fleet app: Atlantis eMobility

This is a new development carried out by Atlantis IT. The app is the user interface with the e-bike sharing service in the EV in-vehicle system. The main functionalities are:

- ✓ Find an e-bike available
- ✓ Geo-positioning the e-bike in real time
- ✓ Read the SoC
- ✓ Get riding time
- ✓ Get the route history
- ✓ Get directions to the charging station

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- ✓ Return the e-bike

It is available for both iOS and Android smartphones on corresponding app stores:

- iOS: https://apps.apple.com/us/app/atlantis-emobility/id1498934785
- Android: https://play.google.com/store/apps/details?id=com.atlantis.emobility

The following figures show the main screenshots of the app:

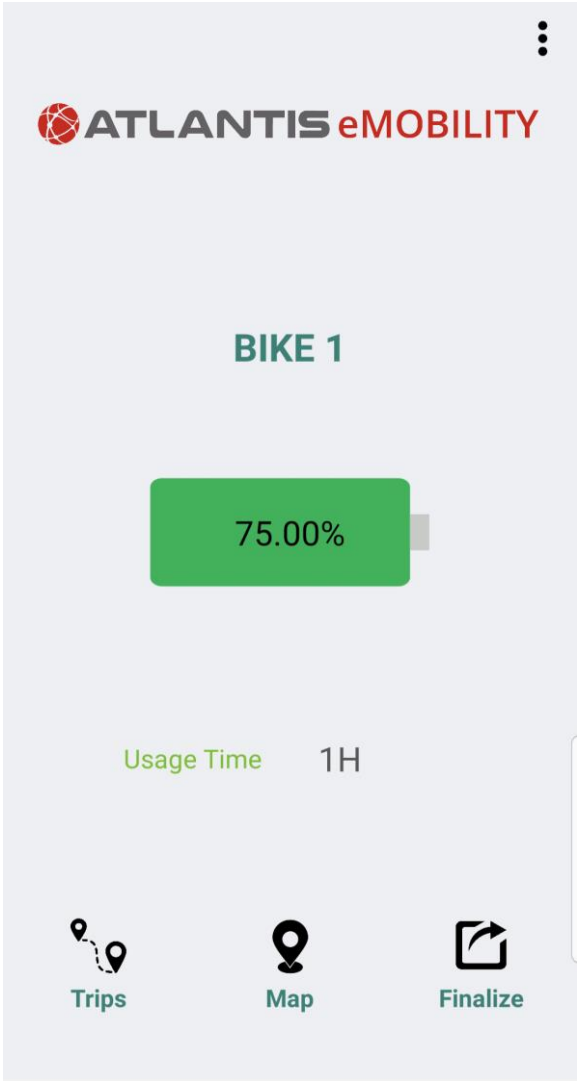

Figure 5-2: e-bike SoC and usage time

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Figure 5-3: Map with e-bike real time location and charging station

A more detailed description and screenshots of the app can be found at Appendix A.2.
The app communicates with the Fleet Management system backend via the proprietary Atlantis Fleet API (see details on deliverable *D4.3 Initial Version of Integrated Prototype*). It also communicates with the CMS but not directly, using the API mentioned above to communicate with the CMS via the Atlantis Fleet backend.
At this stage the app will not provide lock/unlock functionality because this is not a requirement of the municipality in charge of the e-bike sharing service. We can add this functionality later if we think that it can bring some change at business models level.

5.2.2 Journey planner

In the original planning of the pilot site demonstrator (D2.18), it was envisioned to include a journey planner. However, the added value for such an application was not clear to the partners involved in the demonstrator. In order to gather the real user needs and decide if such functionality was really of interest of users, a survey was conducted in July 2019. All the users replied that they always did the same route and there was no need for a journey planner, or in any case they could

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use Google Maps. Thus, the journey planner has not been implemented for the moment, as it has not been identified as an added-value for the users.

5.2.3 GPS tracker devices

As described on previous deliverable *D2.18 Pilot Component Preparation for Full-scale Pilot (Barcelona)*, we have done some tests with different GPS devices in order to use the one that fits better with our requirements and can communicate with the e-bike battery management system (BMS) to get battery information (mainly the SoC).
The selected GPS device is GV350 from Queclink. Some of its technical specifications are detailed in appendix B.2.
We have selected this device because we can use CAN bus interface SAE J1939 to collect data from e-bike BMS. This is a commercial device so no adaptation was necessary.

5.2.4 Atlantis Fleet platform

The Atlantis Fleet platform is operating in production environment since 2014. We have made some Adaptations done to communicate with other components:

- Update Atlantis Fleet API: Atlantis has updated the proprietary API in order to allow Atlantis Fleet app to communicate with the backend
- Integrate GV350 GPS device (Section 5.2.3): the selected GPS device GV350 was not integrated in the platform, but as it is a product derived from the GV300 and they use a very similar protocol, we have integrated it into the backend without much effort

We have not made any adaptations to allow the lock/unlock functionality because as explained in 5.2.1 it is not a requirement of the municipality in charge of the e-bike sharing service. We can add this functionality in the future.

5.2.5 Charge management system

The Charge Management System software used is the same developed for Eurecat demonstrator. See section 4.2.1 System Management.
Previously, there was no such charging management system: the user usually connected the bicycle to the power supply and the charge started immediately. There was no means to monitor the energy consumption apart from the monthly energy bills or to control the charging process.
The charging management system integrated for the GreenCharge demo will enable to monitor and control the charging process. The differences to the charging management system from Eurecat only concern the connector to gather energy usage from the charging point (current and voltage sensors in the charging point and the current sensor in the batteries) and the switches to control the relay of the charging point which are from a different manufacturer from those from Eurecat and will be controlled by an API provided by Atlantis.

5.2.6 Charging points

Five charging points have been installed. Each charge point consists of the following elements:

- Magnetothermal Curve C 16A 2P
- Differential switch A class 16A 2P
- Monophasic Contactor 16A

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- Battery Regulator 42V 2A
- Communication board with 3G

The system will be powered at 230V by inverter output.
The charging management system will communicate with the charge point to activate and deactivate it using a contactor using a digital signal. The command to switch on/off each charging point will be provided as an output of the NEMS, according to the optimal scheduled planning.

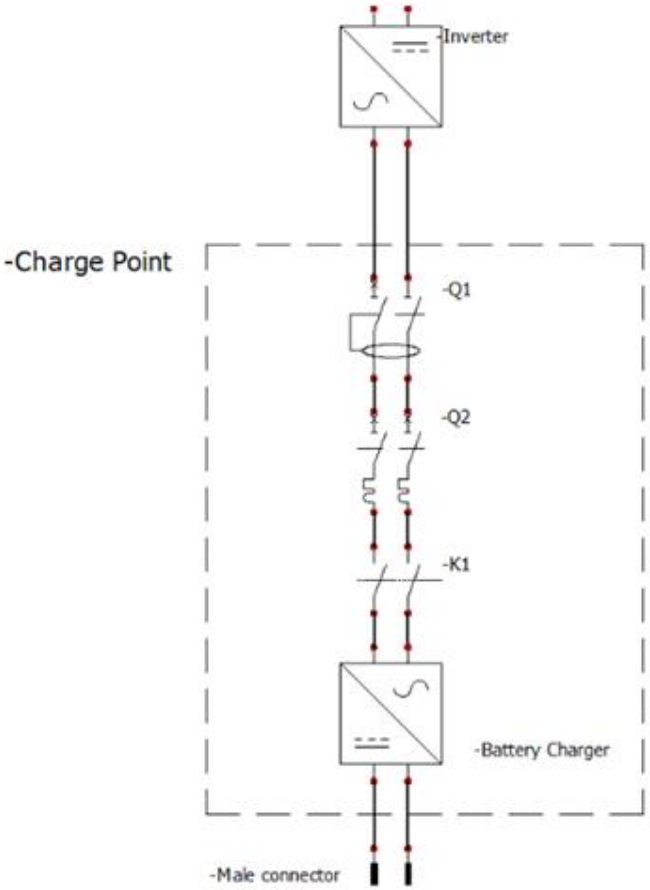

Figure 5-4: e-bike Charge Point scheme

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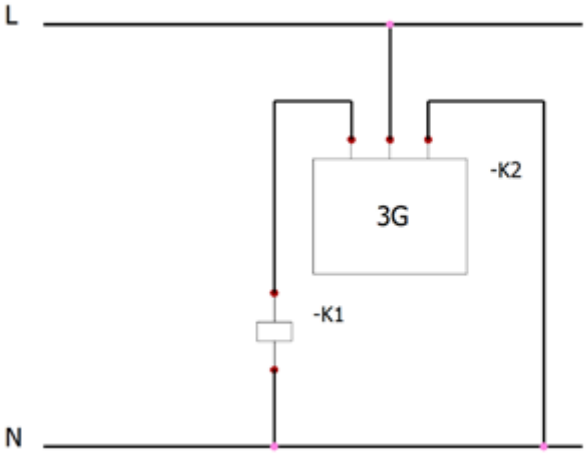

The charge point will have a male connector connected directly at the output of the contactor, inside the charge point to avoid possible theft of it.
Example of SMART charging point solution with an integrated male connector:

Figure 5-5: Smart charge point solution

5.2.7 PV panel

No adaptation was needed for the PV panel as it is considered an off the shelf product. External sensors to measure the current and voltage are included to compute the energy production of the solar panel.

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Figure 5-6: PV panel used on e-bike Charge Station

5.2.8 Stationary battery

The stationary battery used is provided by Millor Battery, one of the partners in the Barcelona Pilot. Sensors to control energy flow are installed.

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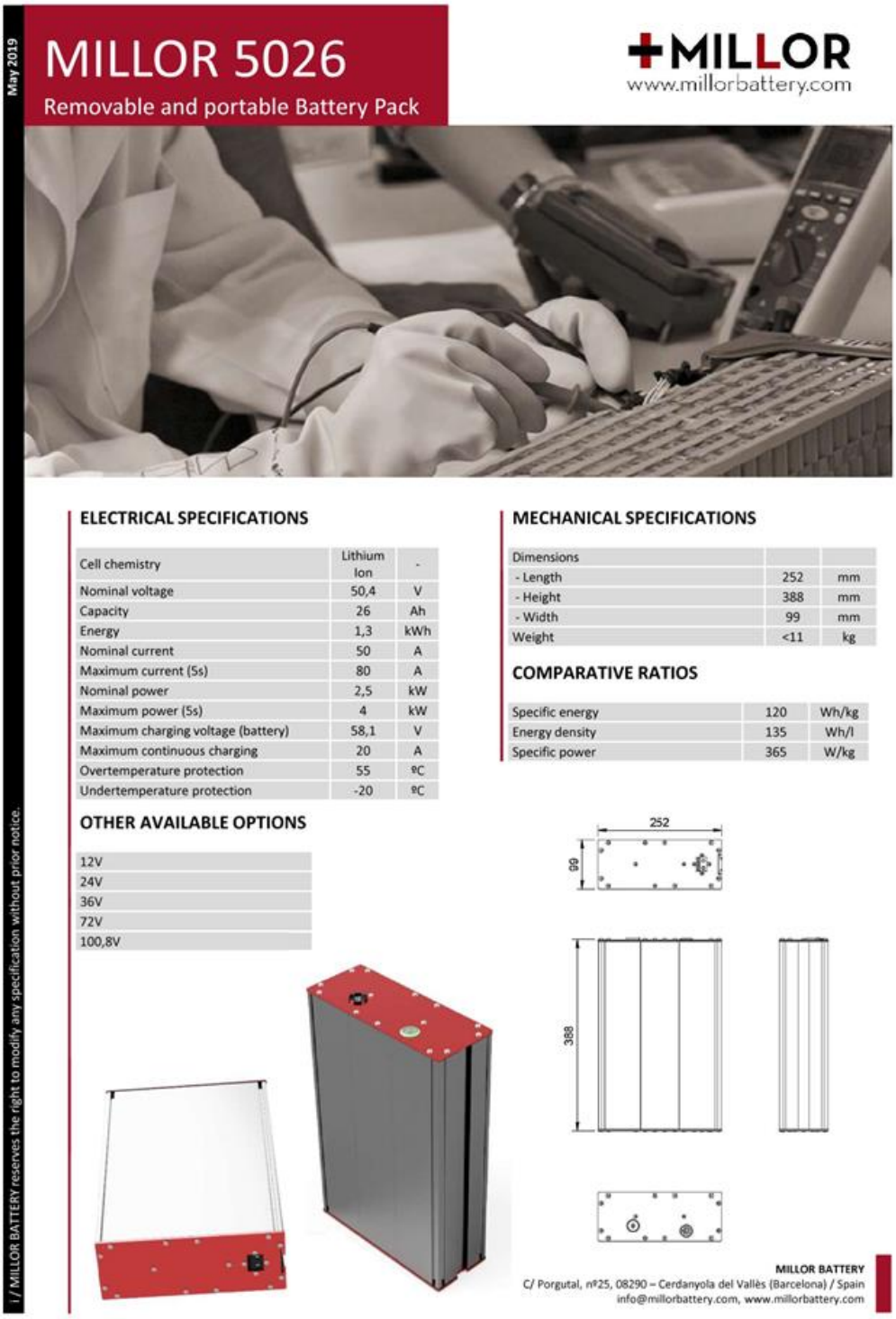

Figure 5-7: Stationary battery

5.2.9 SEM scheduler

The SEM Scheduler software used is the same as developed for Eurecat demonstrator. See section 4.2.5 .

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5.2.10 SEM forecaster

The SEM Forecaster software used is the same as developed for Eurecat demonstrator. See section 4.2.5 .
Inside this module we use an algorithm for better estimate the vehicle range as it is necessary to know the energy needs of each battery to forecast the energy demand.

5.3 Installation and configuration of the demonstrator

5.3.1 Description

The installation consists of 5 charging points with integrated hose with specific terminal for bicycles. The feeding of these points is carried out by a photovoltaic system or the grid system. This system consists of a photovoltaic cell, a battery regulator, a second life Lithium battery and an electric inverter. The installation has been carried out in accordance with current regulations for charging point installations for electric vehicles, the ITC BT-52 (in Spain).

This installation has been executed in its entirety within the perimeter marked by the current fencing intended for the loading and storage of electric bicycles. Both at ground level and on the roof.

A photovoltaic cell has been installed on the roof, ensuring enough support to prevent its detachment and possible fall during its useful life. An electrical distribution panel has been placed inside the fence where the electrical box (second life battery, regulator and inverter)can be found.

5.3.2 Croquis of the installation

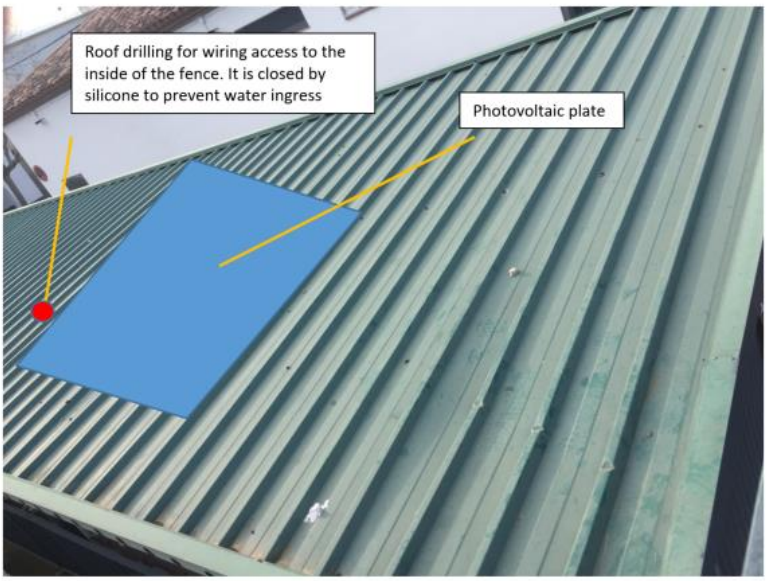

Figure 5-8: PV panel installation

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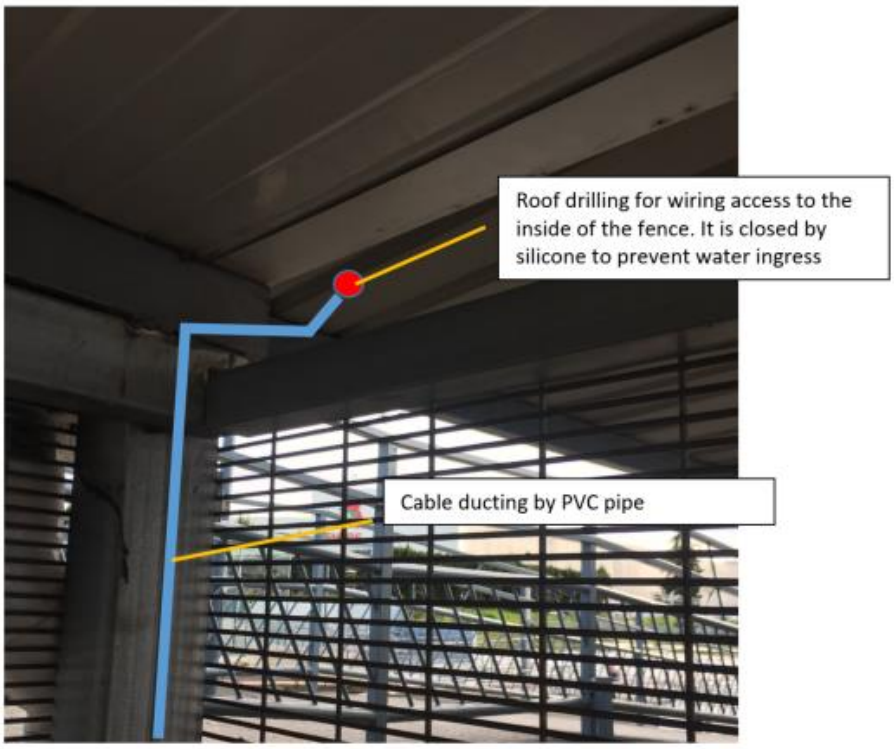

Figure 5-9: Installation cables

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.

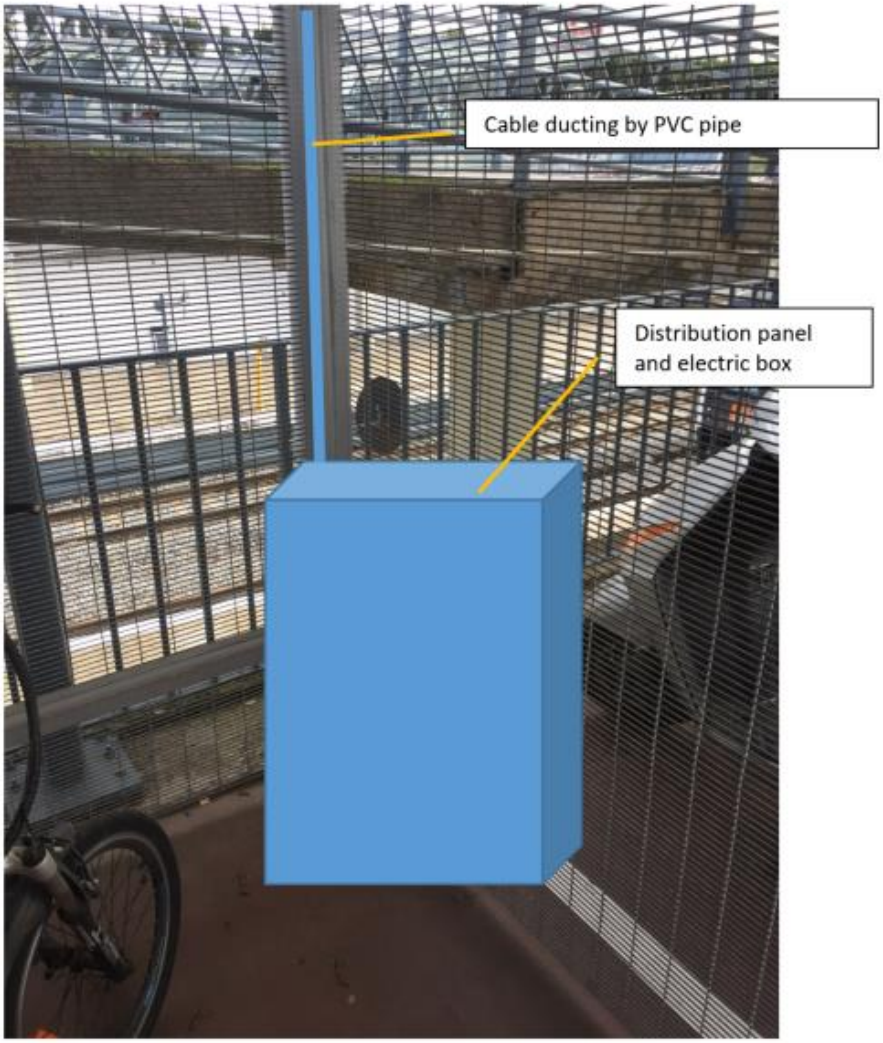

Figure 5-10: Distribution panel

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Figure 5-11: New Charge Points

Figure 5-12: Detail of the Charging station

5.3.3 Electrical Scheme

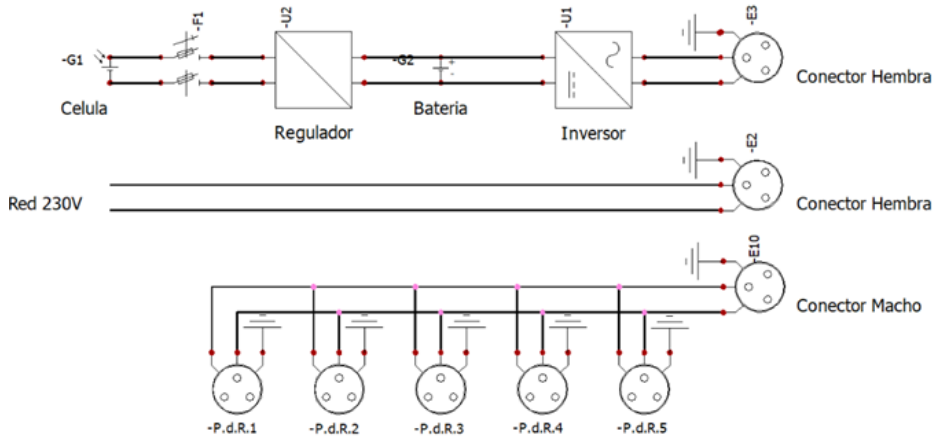

Figure 5-13: Electric scheme

5.3.4 Electric parameters of the installation

- Maximum solar panel power: 60W
- Maximum regulator power: 2080W (48V)
- Maximum inverter power: 1000W
- Maximum power regulator bicycles: 414W
- Maximum recharge current per point: 1.8 A
- Phase-Neutral inverter voltage: 230V

5.4 Full test for the demonstrator

Laboratory test have been done successfully and full test with e-bikes have also been done successfully. Full tests with PV panel and Charge Points have also been done after some delays due to the delay on legal agreements with service providers (municipality and train operator). Some issues have been detected with vandalism at charging station. We are in contact with railway provider (the charging station proprietary) in order to change the access system and prevent the vandalism.

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 eRoaming

For the Barcelona pilot, the eRoaming implementation has no sense for 2 of the demonstrators, those who are dealing with sharing services and light electric vehicles. The eRoaming is being implemented in Eurecat demonstrator to be piloted in the second iteration using the Hubject eRoaming platform, although in this case the eMobility Provider and the Charging Point Operator are the same.

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.

7 Further Work

The implementation described in this document is the first iteration of the integrated prototype. This will be refined in next iterations. During the design and implementation of the pilot we have identified different changes or improvements that we can introduce in the next iteration:

- In the MOTIT demonstrator we are gathering data from different sensors. This data will be analysed in the next months and in second iteration, the user driving profiles will be attached to the pricing schemes and the service provider will reward the more efficient and sustainable behaviours. New fares and discounts will be implemented, and the clients will be moving between fares while improving their driving style.
- At Eurecat premises at Cerdanyola el Vallès the charging spots included in the demonstrator in the first iteration are the ones in the outdoor parking lot because access control is easier. In next iteration we will try to include also the 8 charging spots in the underground parking garage, if necessary to satisfy employees charging needs.
- In Eurecat demonstrator, the eRoaming system will also be implemented in future iterations as a proof of concept and to prepare the system for interoperability with other platforms and mobility providers.
- The St. Quirze electric bicycle sharing demonstrator is obtaining data on battery behaviour in different environments, both at the route and driver level. The analysis of this data will allow us in a second phase to make recommendations of driving style, route and even how it is better to charge the battery. Thanks to this analysis we will also be able to show in the app the approximate remaining driving time according to the behaviour of the battery and the user driving profile.
- The e-bike sharing service can be upgraded adding e-bike lock/unlock functionality in order to increase the security of the system. This is not a requirement for the service provider at this stage but this can change during the pilot.

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Appendix A Software screenshots

A.1 EURECAT booking system

The booking system developed by Eurecat is a web-app based application meant to be used by Eurecat employees. The users are categorised in three groups:

- Drivers: Eurecat employees who drive an electric car and might use a parking spot with a charging point
- Office manager: S/he is in charge of the on-site facility management and will create, modify or delete parking spots with associated charging points, monitor the booking and accept or reject according any constraint that may occur (such as temporary power limitation or faults)
- System administrator. This is the role of a super-user who has access to any page in the GreenCharge admin area, as well as permissions to Create, Read, Update and Delete any type of model record available.

According to their group, the views and functionalities they can access are different, and can be found in the following subsections.

A.1.1 Driver's profile

A.1.1.1 Sign Up, Login and Logout

The first time any user accesses the application they have to register. The registration process, or Sign Up, is meant to set the credentials to later login as well as some details about their vehicles in order to ease the booking process.
Regarding the user identification, the form to be completed is shown in Figure 0-1.
Some checks are done regarding the choice of password and user name:

1. Password not too short. It must contain at least 8 characters.
2. Password not too common.
3. Password not entirely numeric.
4. Password not similar to the first name.
5. Password not similar to the last name.
6. Correct email.
7. Username doesn't already exist.

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.

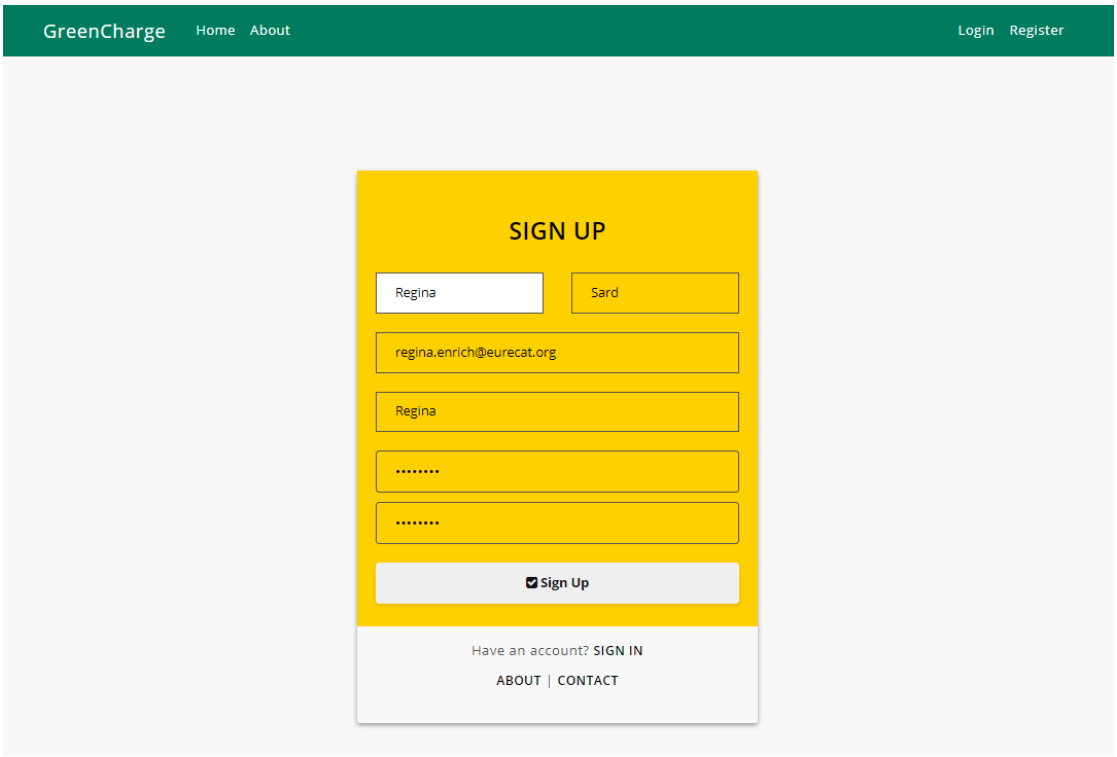

Figure 0-1: Eurecat Booking app: Sign up view

Once the credentials are set, the user should provide some basic information about the car. This information refers to the vehicle plate number, the car make and model and the battery capacity. The plate number enables to auto-complete the car make and model using an open data source. Similarly, the make and model allows to set the battery capacity according to a pre-defined list obtained by exploring the specifications of electric cars manufacturers. However, if the users feel the battery capacity pre-set is not accurate enough, they can modify it. The view of the car configuration is shown in Figure 0-2.

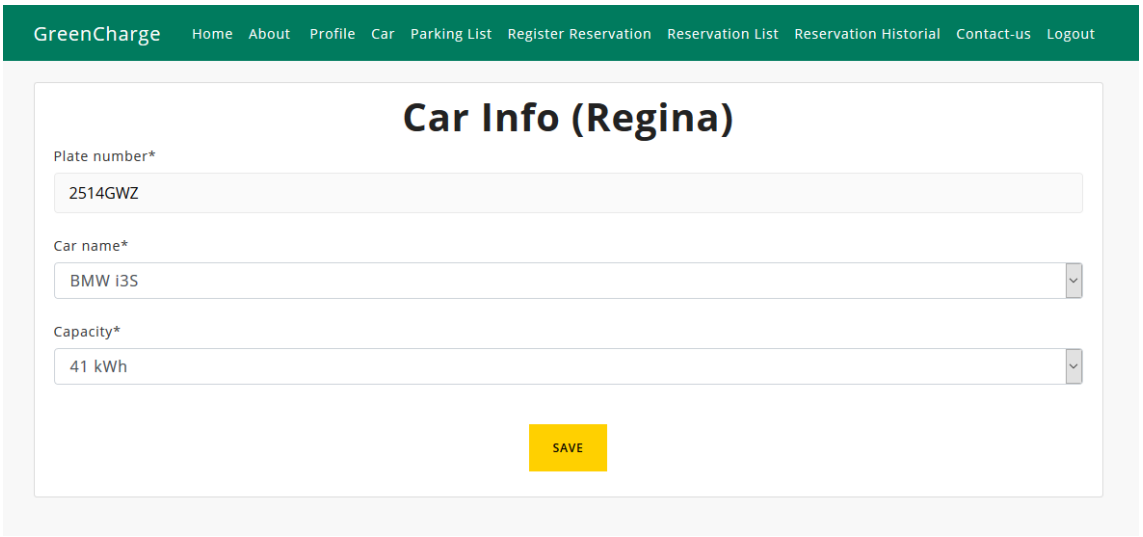

Figure 0-2: Eurecat booking system: Car info configuration page

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The user can modify his/her profile at any time (once logged into the application), as shown below.

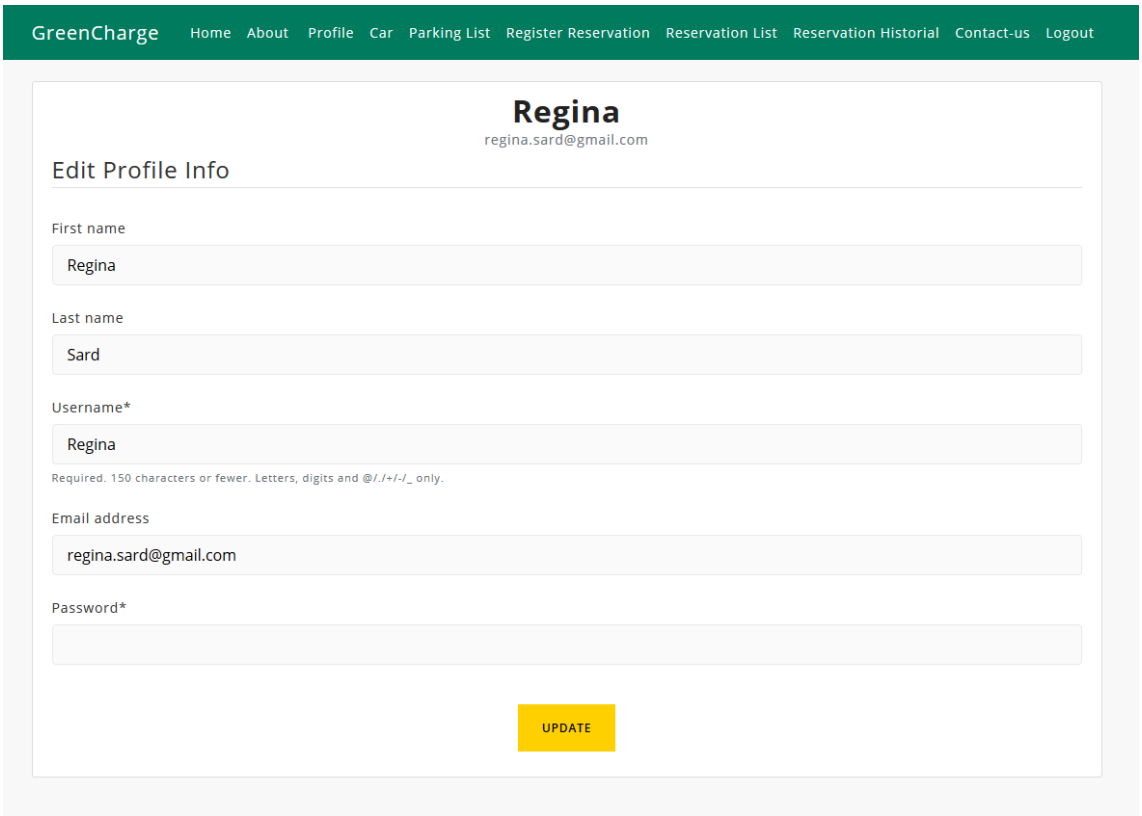

Figure 0-3: Eurecat booking system: Update user Profile view

After a success authentication in the application the user is redirected to the home page (Figure 0-4). The upper panel in this home page (menu)is visible in all other pages. The available options are:

- Home
- About
- Profile
- Car
- Parking list
- Register reservation
- Reservation list
- Reservation history
- Contact-us
- Logout

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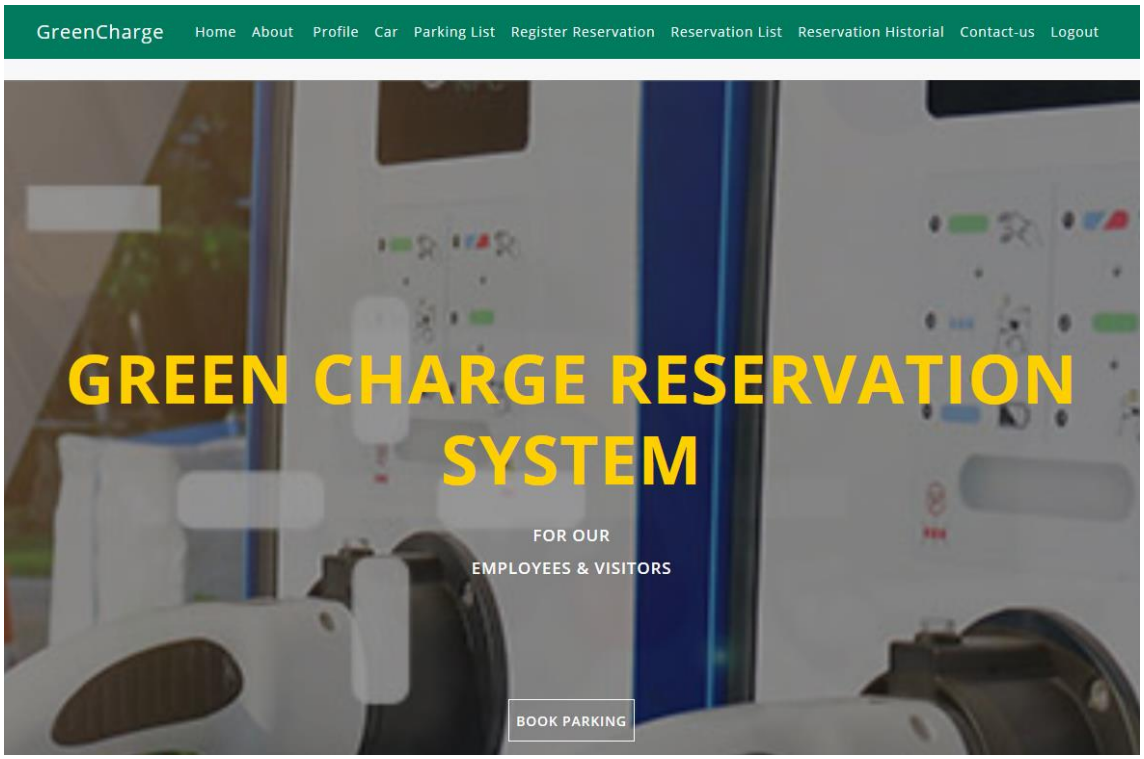

Figure 0-4: Eurecat Booking system home page

A.1.1.2 Booking a spot

To book a parking spot with charging capabilities, the user has to access the **Parking List** option. Then, the list of parking facilities and the available charging spots will appear (see Figure 0-5).

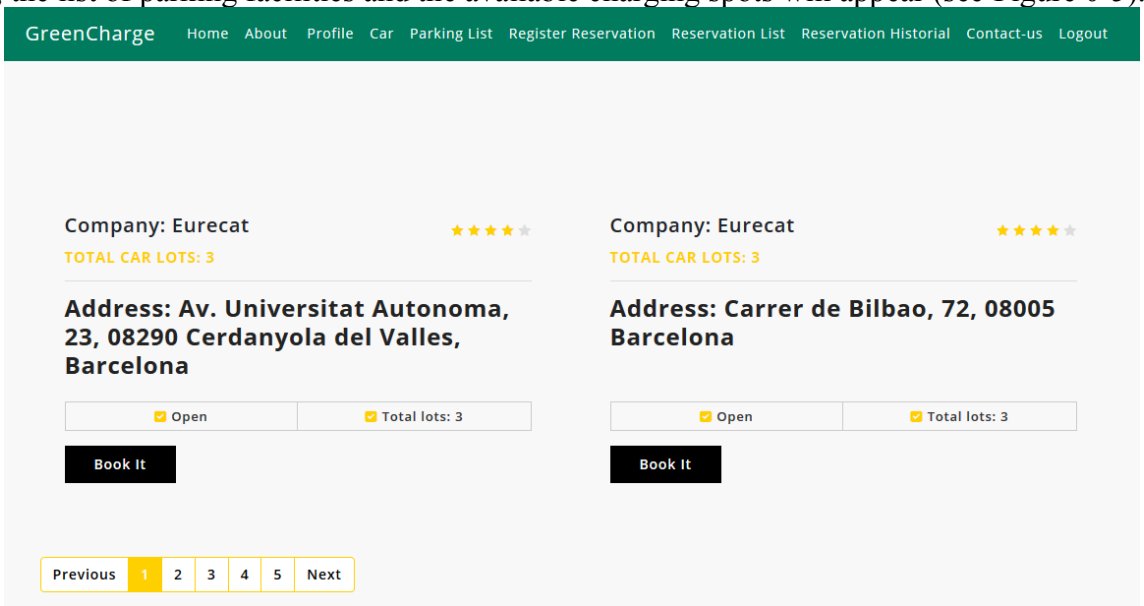

Figure 0-5: Eurecat Booking system: Parking lot list view

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By clicking the **Book it** button, a new form will enable to specify the details of the reservation which includes the time slot (date and hour for arrival and departure) and the flexibility offered expressed as charge regime:

- Fast Charge: For short stays or uncertain departure time (no flexibility)
- Normal Charge: for stays in the premises for half day (4 hours)
- Slow Charge: for stays in the premises the whole day (8 hours)

Additionally, the user can also program an automatic reservation (weekly, daily, or monthly) if s/he visit the premises regularly.

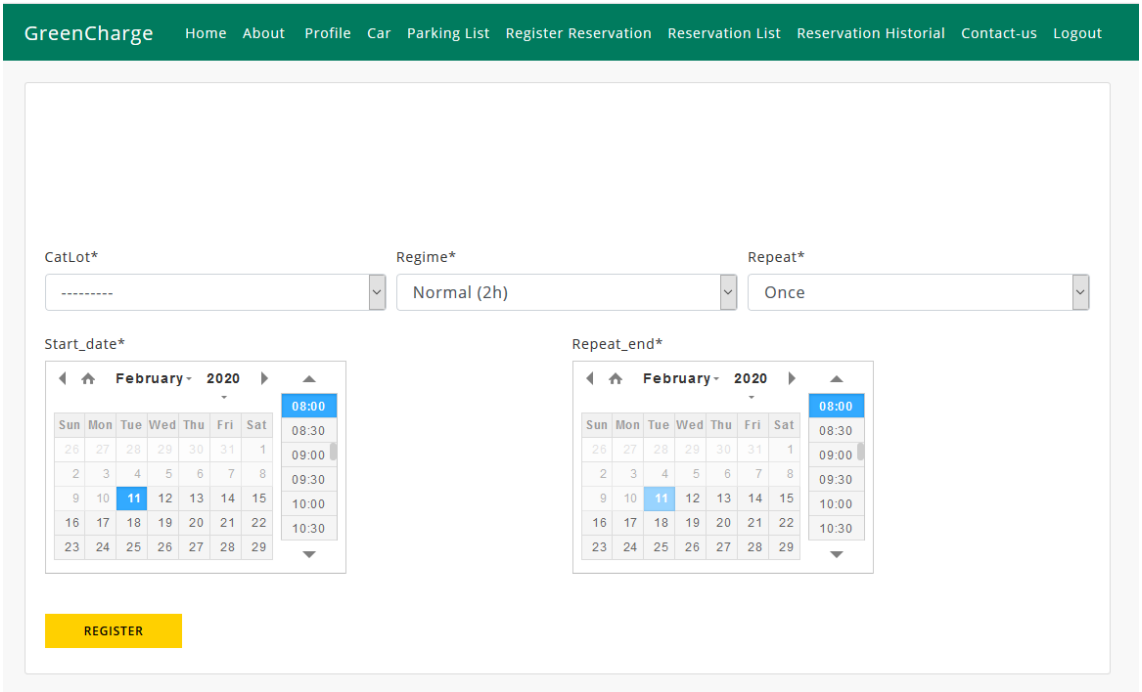

Figure 0-6: Eurecat Booking system Reservation view

The user might have more than one active reservation and can update them if needed. In any case, the user will receive a notification confirming or rejecting any reservation or change as constraints in the premises may arise. The list of active reservations may be seen in Figure 0-7, while the form to edit a reservation is shown in Figure 0-8 and Figure 0-9.

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.

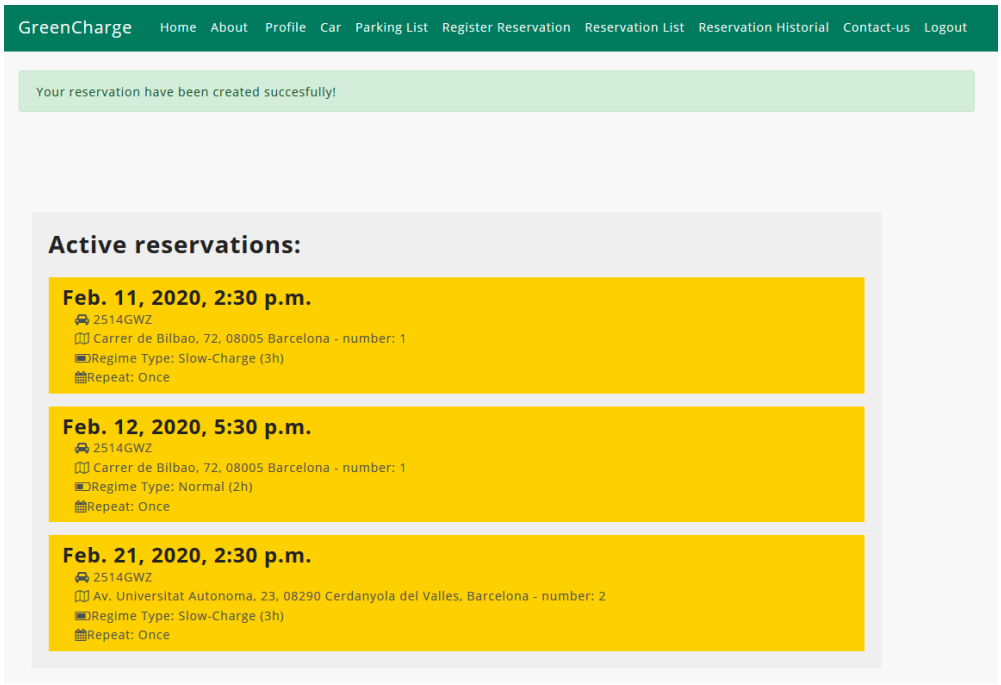

Figure 0-7: Eurecat Booking system Active Reservation list page

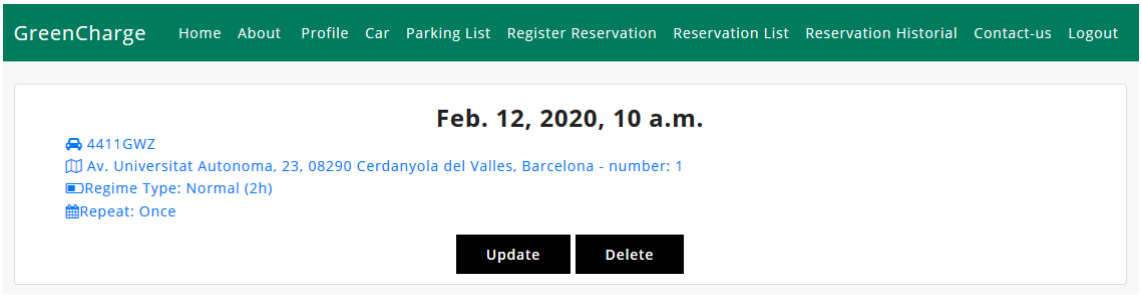

Figure 0-8: Eurecat Booking system Reservation details page

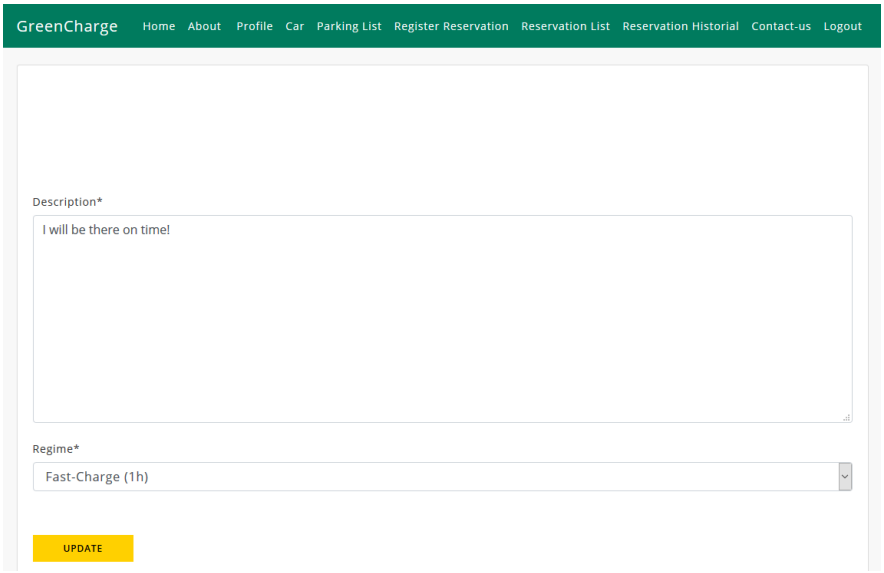

Figure 0-9: Eurecat Booking system: Reservation update page

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.

Afterwards the user may be able to review past reservations. For those that had been actually used, the record on the time, energy and CO2 emissions associated to the charging process will be shown. (Figure 0-10)

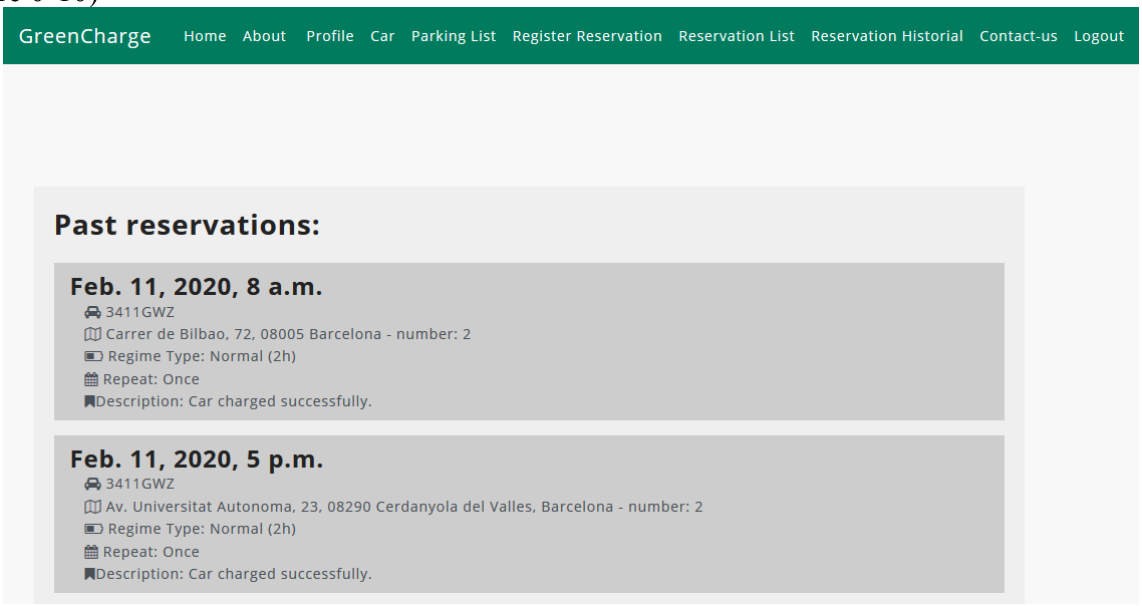

Figure 0-10: Eurecat Booking system: Reservation historical view

A.1.1.3 Charging at a spot

When the user arrives to the previously booked charging spot, s/he must notify the arrival and an estimation of the battery State of Charge. In order to make the process easier, 5 different levels have been defined. Shows an example.

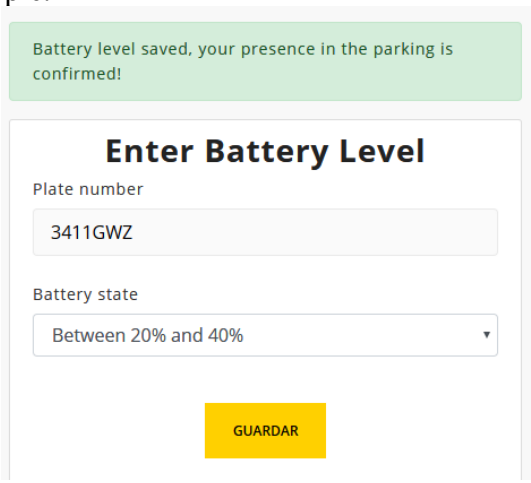

Figure 0-11: Eurecat Booking system: Providing current state of charge

A.1.1.4 Contact form and getting information

There is a contact form so the adminstrator can collect experience details, comments, and opinions in an efficient manner.

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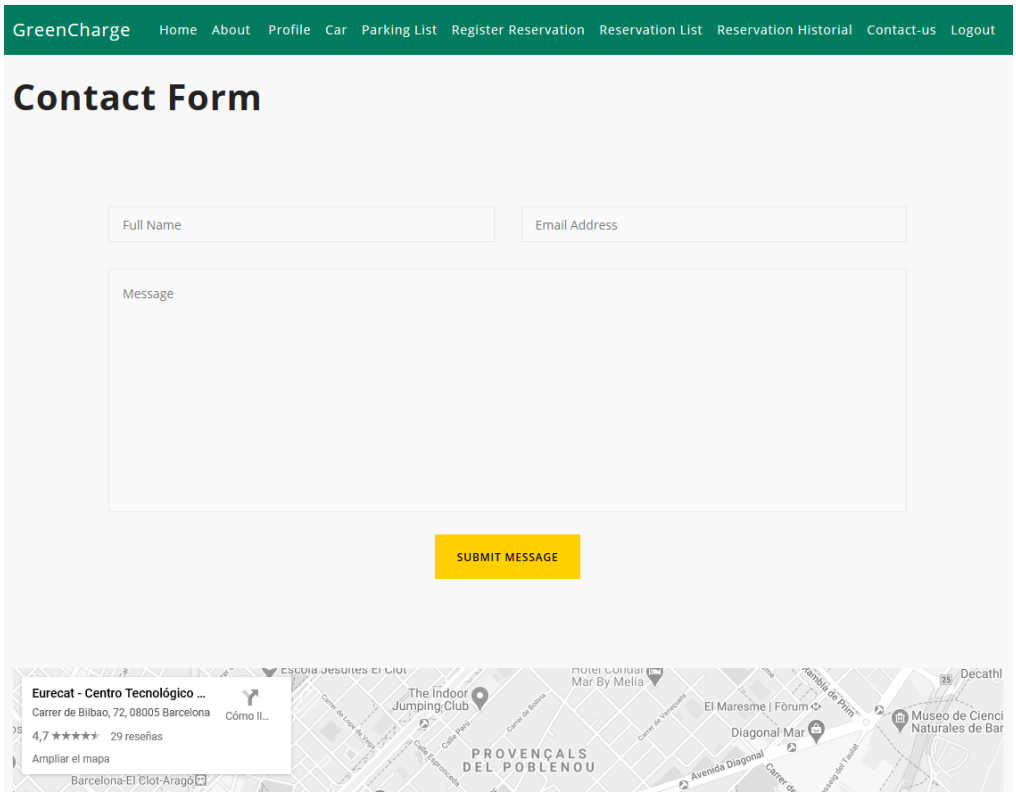

Figure 0-12: Eurecat Booking system Contact form page

Finally a "About us" option links to the GreenCharge web page to inform the user about the goals and progress of the project.

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.

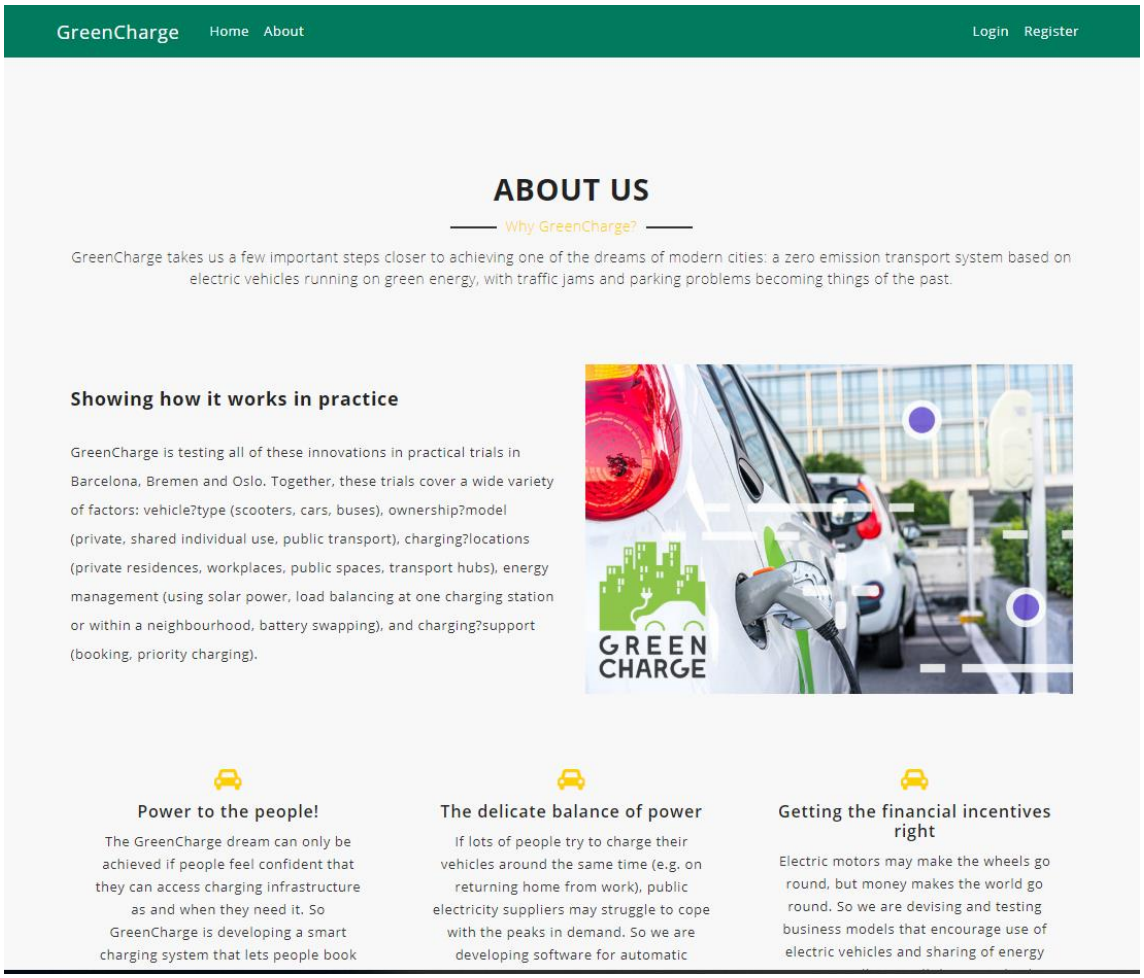

Figure 0-13: Eurecat Booking system: About us page

A.1.1.5 Languages

The web application offers its content in different languages, namely Catalan, Spanish and English, which are the languages typically used in Eurecat official communications.
The translation depends on the target language, and formatting usually depends on the target country. This information is provided by browsers in the **Accept-Language** header.
Figure 0-14 shows an example view for the three languages.

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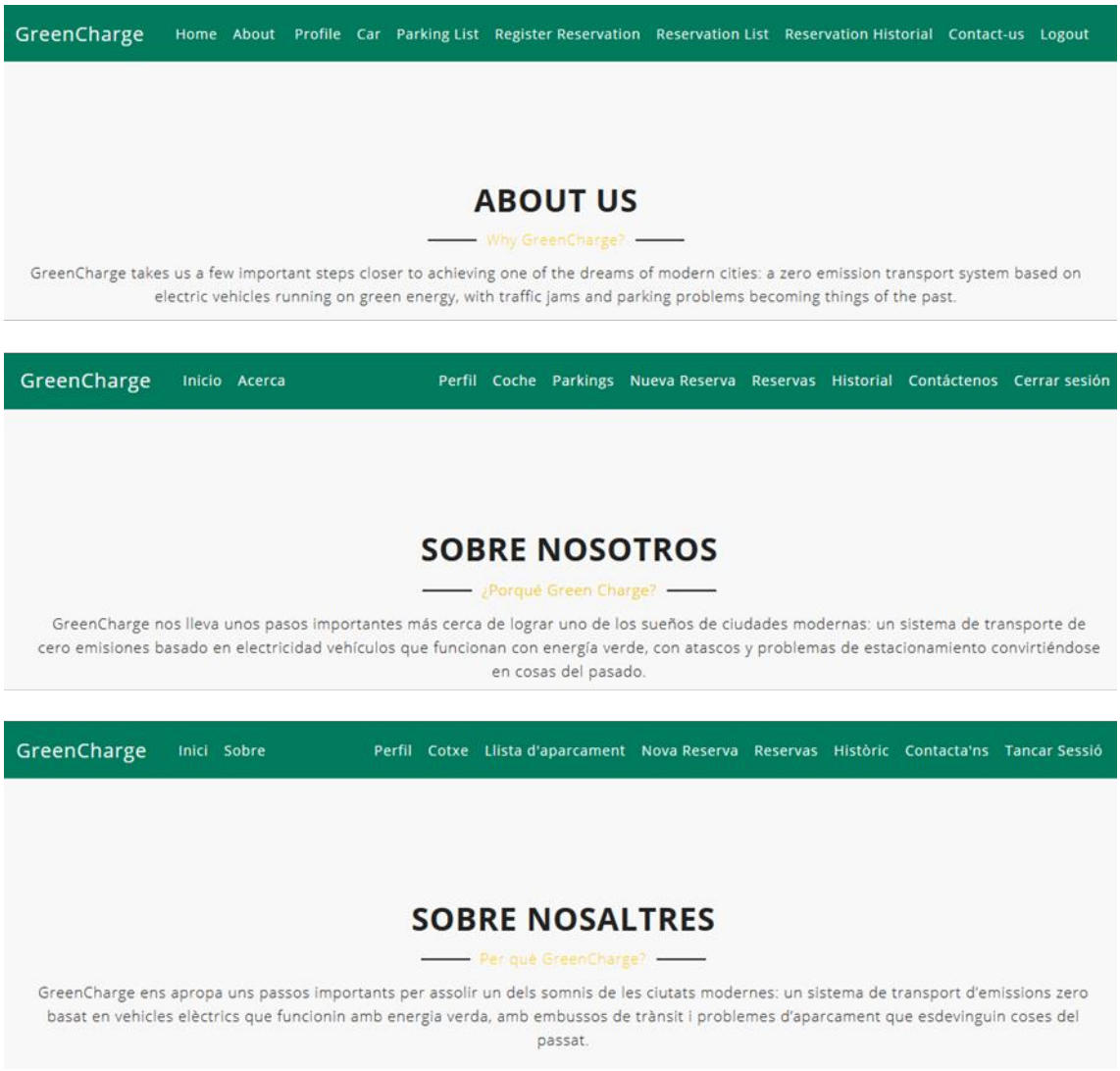

Figure 0-14: Eurecat Booking system: Multi-language capability

A.1.1.6 Notifications and alerts

Notifications and Alerts are essential parts to maintain user interaction and engage them with GreenCharge application.
The application informs the user about any unexpected error, provide some feedback about the result of an action and displays information about reservation: (confirmation, modification or assignation of specific car lot).
Some examples of such notifications can be seen in Figure 0-15:

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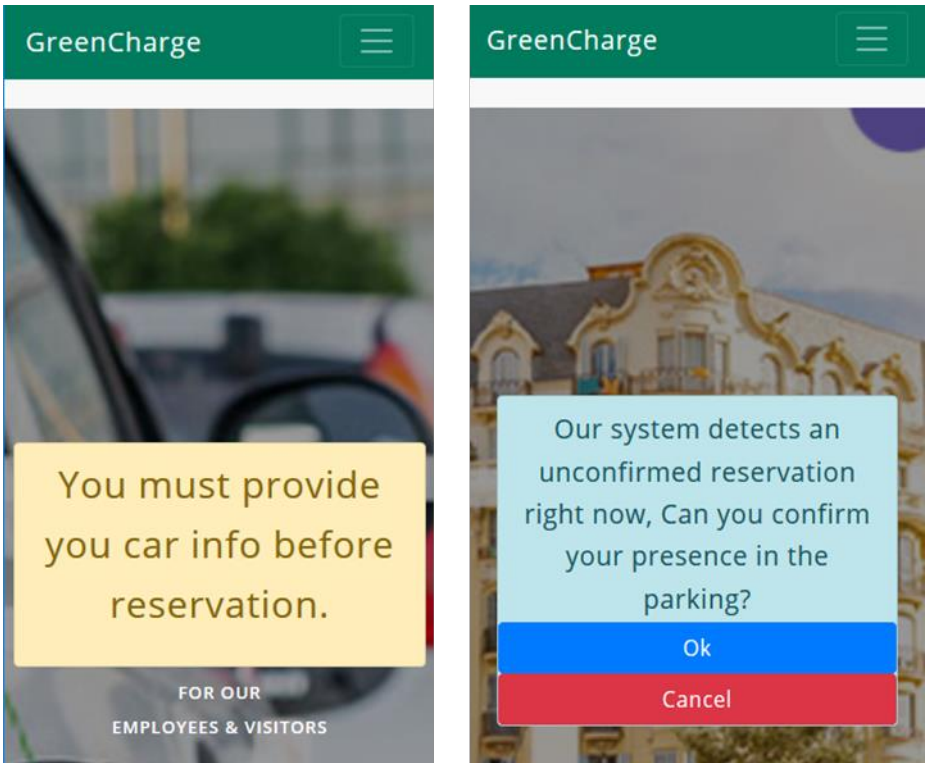

Figure 0-15: Eurecat Booking system: Notifications

A.1.2 Facility manager profile

A.1.2.1 Register a new Parking space with charging capabilities

Eurecat facility managers can list the of parking spaces and associates charging points, create a new one and assign charging points to it.
Below the view that this profile can use to create a new parking space and its charging points.

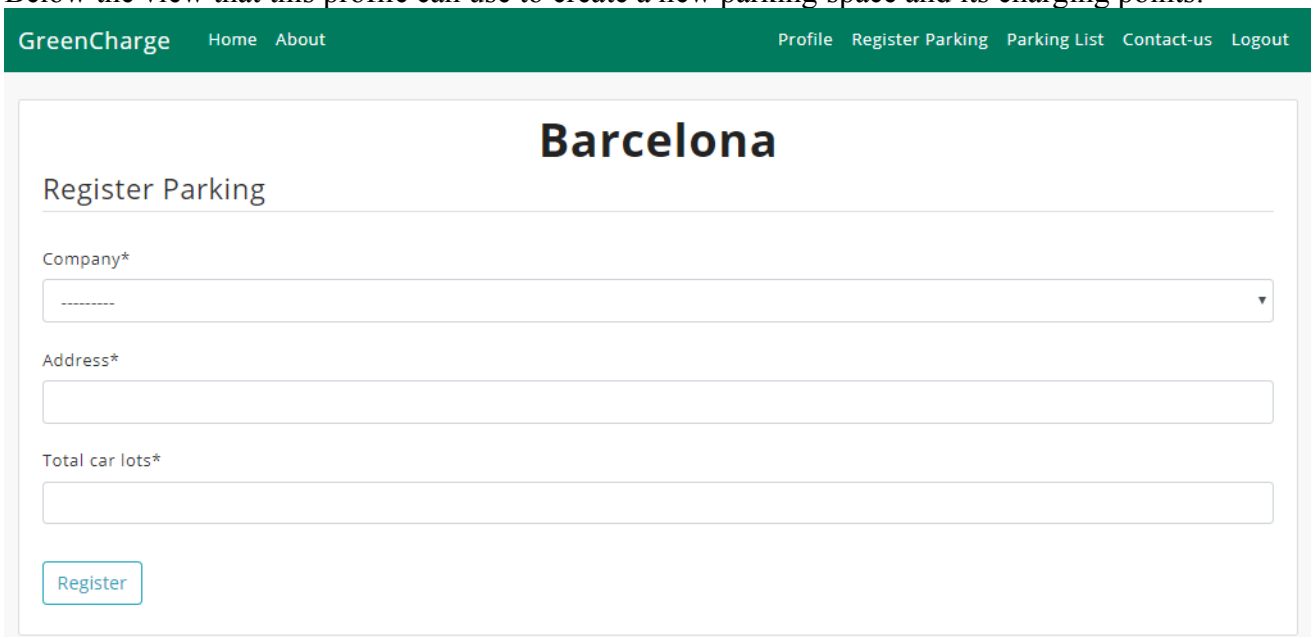

Figure 0-16: Eurecat Booking system: Register a new parking space view

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.

A.1.3 System administrator profile

The booking system has a web-based backend, this administrative interface, or admin for short, allows the super user to create, edit and publish content, manage site users and perform other administrative tasks. The main views for logging in (Figure 0-17), configuration of users, parking spaces and cars (Figure 0-18) and bookings updates (Figure 0-19) are shown below.

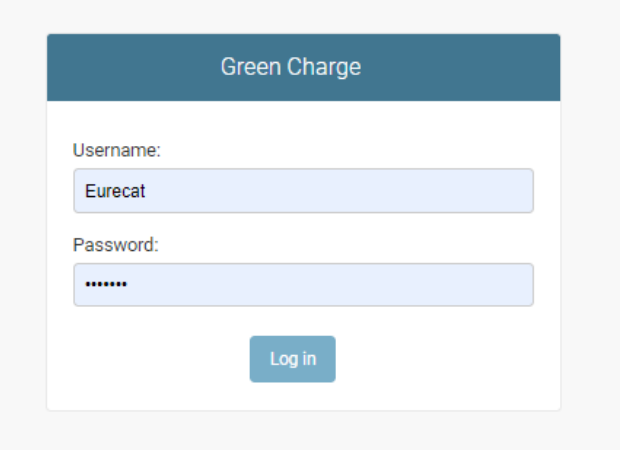

Figure 0-17: Eurecat Booking system: superuser login page

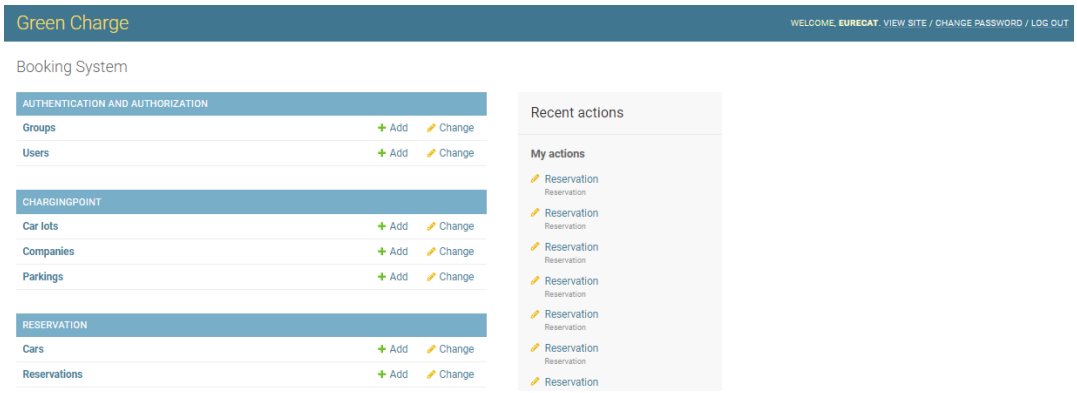

Figure 0-18: Eurecat Booking system configuration view

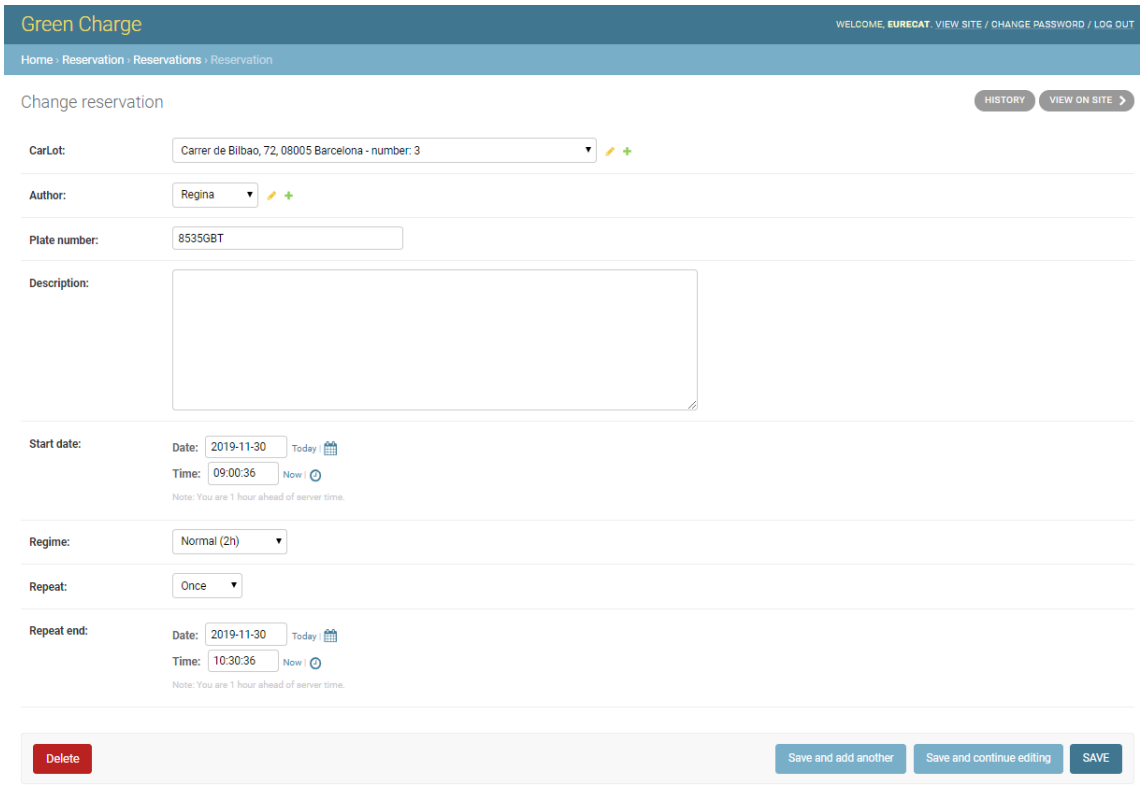

Figure 0-19: Eurecat Booking system change reservation admin view

A.2 E-bike sharing app: Atlantis eMobility

The e-bike sharing app has been developed by Atlantis IT in both Android and iOS platforms. As explained in previous sections the app is the interface between the user and the e-bike sharing service.
In this appendix we will show the different screens and functionalities of the app:

A.2.1 Login

As the e-bike sharing service is an authenticated service, the first screen is the *Login* screen where the user enters his credentials. There is also the possibility of recovering the password if it has been forgotten.

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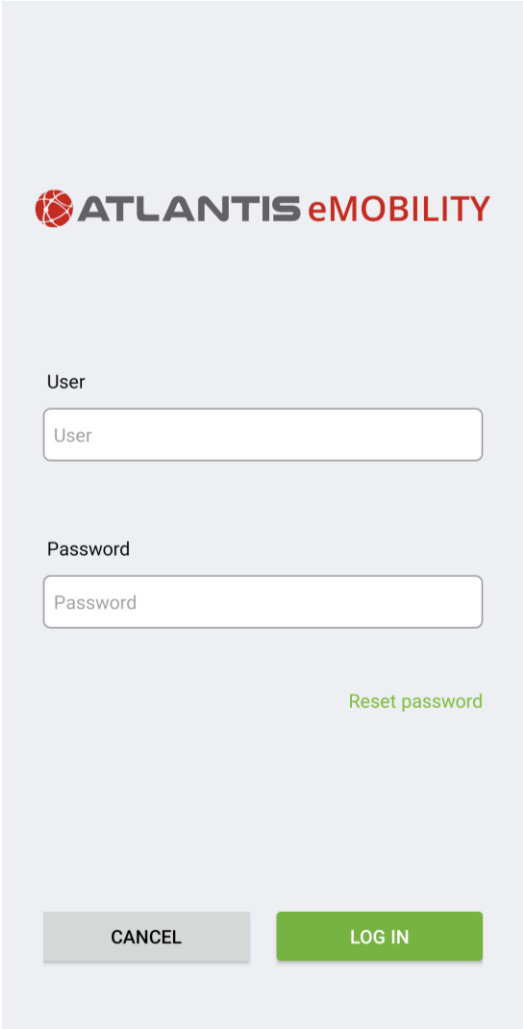

Figure 0-20: Atlantis eMobility Login

A.2.2 Start screen

After get logged the user enters the main screen where it has 3 options:

- scan the QR code of an e-bike
- see previous trips
- get a map with user location and charge point locations

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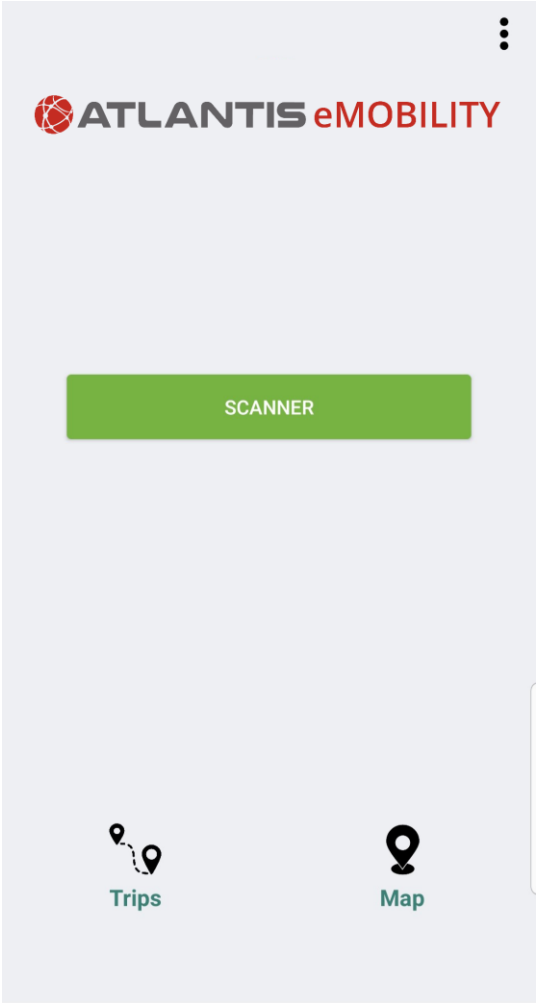

Figure 0-21: Atlantis eMobility start screen

When the user presses the scan button, a photo camera screen appears where the QR code of the e-bike to be taken must be focused. Adhesive QR codes have been pasted on the e-bikes like the one shown below:

Figure 0-22: QR code identifying an e-bike

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The Atlantis Fleet system processes the code below the QR and if it is correct (i.e. the code exists and it is not used by another user) and starts an e-bike session between the user and the e-bike.

A.2.3 Session started

Once the user has taken the e-bike, the application shows the battery SoC and the usage time.

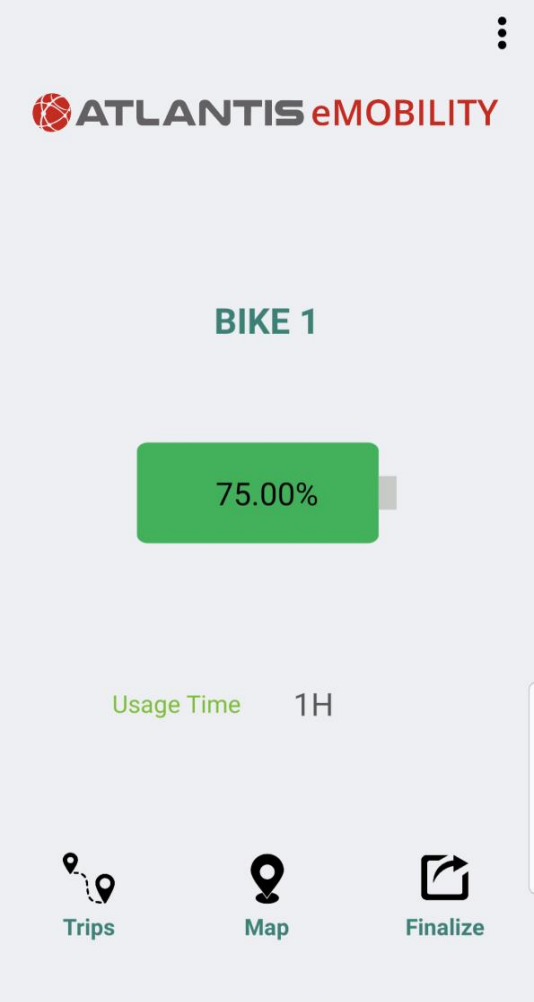

Figure 0-23: Atlantis eMobility e-bike SoC

A.2.4 Activity report

By trips button the user can see the previous activity done with shared e-bikes. First the user is prompted to select a period of time for the report and then the activity summary is shown:

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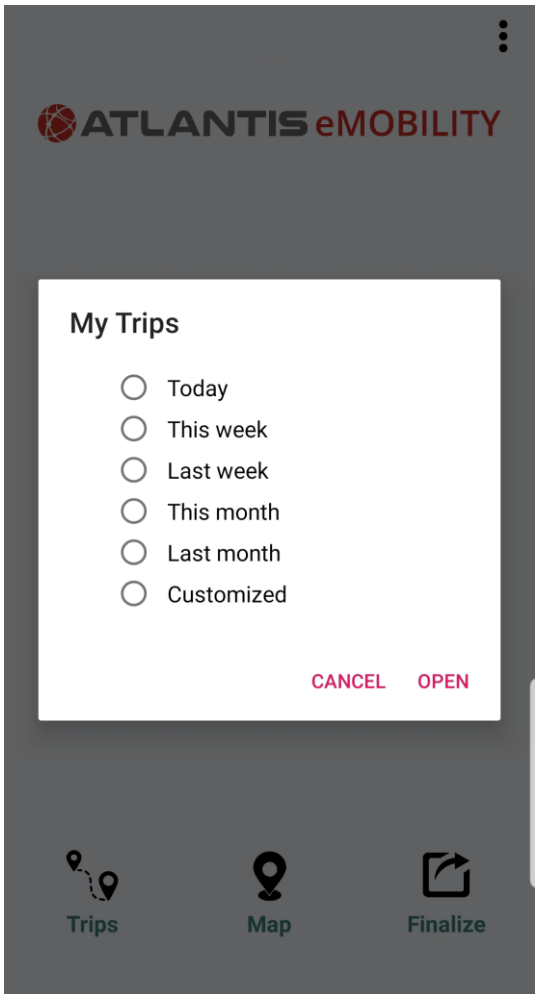

Figure 0-24: Atlantis eMobility report period

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.

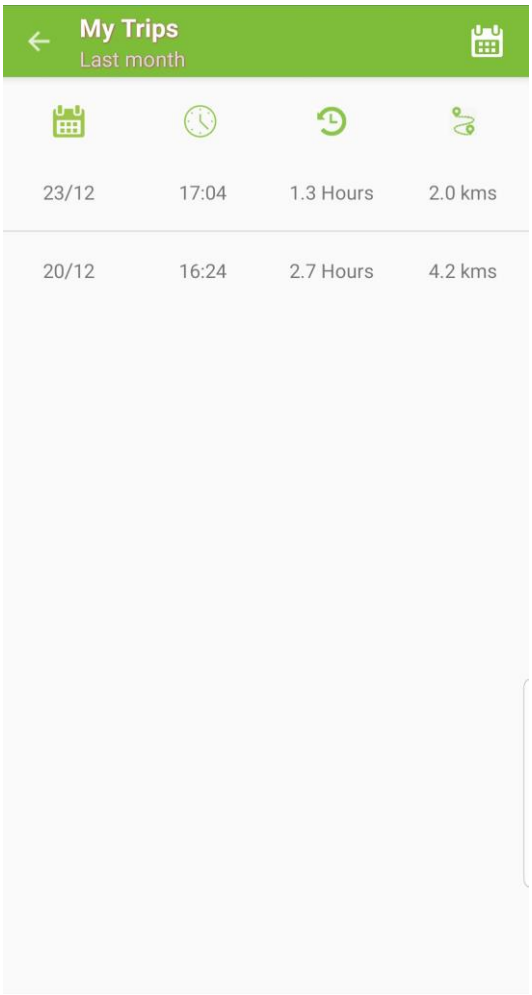

Figure 0-25: Atlantis eMobility activity summary

A.2.5 Location map

By pressing *Map* option, a map will be shown with the location of different assets:

- Real time location of e-bike 
- Real time location of user smartphone (if the user has given the corresponding permission)
- Location of charge stations 

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Figure 0-26: Atlantis eMobility real time location map

A.2.6 Finalize

By pressing the F*inalize* button, the user finalizes the activity and the bike is marked as being charged on charge station. Before finalizing, the user is asked to rate the service and if they want to introduce any problem with the possibility of adding photos.

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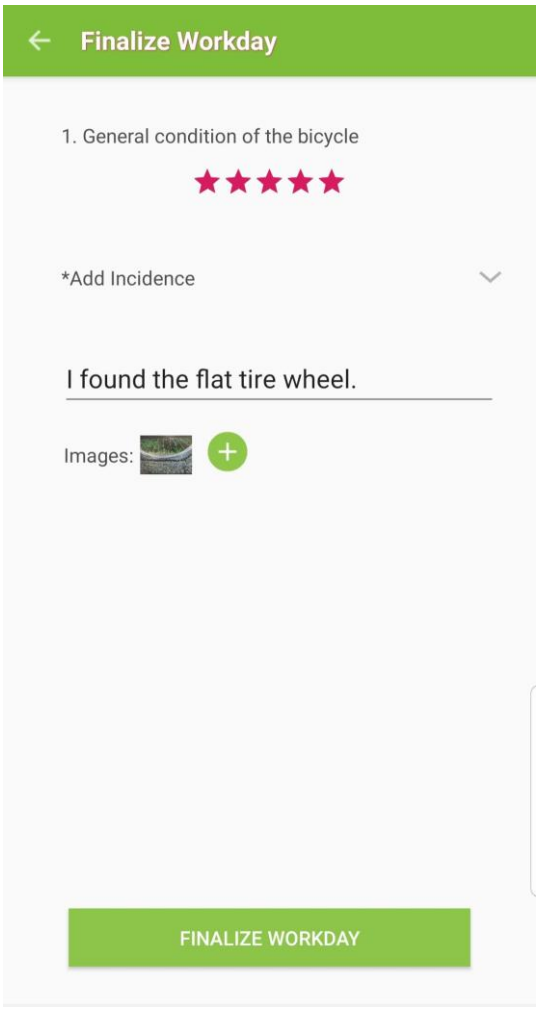

Figure 0-27: Atlantis eMobility finalize activity

A.2.7 About us

The *About us* screen shows all the partners providing the service as well as the partners involved in this project.

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Figure 0-28: Atlantis eMobility About Us screen

B Technical specifications

B.1 MOTIT tracking device and charge station IoT device specifications

Technical specifications of the selected tracking device Teltonika TFT100:

- Compact dimensions
- CANBus / FMS 2.0 / OBD2 interface
- Very low idle power consumption – virtually zero battery drain on a parked vehicle
- Teltonika TM2500 GNSS, supporting GPS, GALILEO, GLONASS, BeiDou, SBAS, QZSS, DGPS, AGPS
- 8 channels GNSS receiver, -165dBm sensitivity
- Teltonika TM2500 Quad-band modem (GPRS)
- Internal back-up 1800mA·h battery – 5 hours continuous, 5 days in hourly update mode
- IP67 enclosure
- 3 axis MEMS based accelerometer for driver behavior reporting + motion detection
- 10-97VDC voltage range with overvoltage protection

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.

- Up to 4 analog/digital inputs
- Up to 2 digital outputs, using open-drain MOSFET switches
- Bluetooth 4.0 + LE
- 1-wire communication
- microUSB connector for configuration and debugging
- External LED status indicators
- RFID/NFC card reader option for driver ID
- Simple and flexible user configuration by desktop application
- Over the air firmware update – fast and reliable, typically 2-3 minutes to complete
- Modular communications protocol codec8, codec8E

B.2 E-bikes GPS tracker device specifications

Technical specifications of the selected GPS device GV350 from Queclink:

- Dimensions : 80mm(L) x 48mm(W) x 25mm(H)
- Weight : 75g
- Backup battery: Li-Polymer, 250 mAh
- Operating Voltage: 8V to 32V DC
- Operating Temperature : -30℃ ~ +80℃
- GSM Frequency: 850/900/1800/1900 MHz
- GNSS Type: u-blox All-in-One GNSS receiver
- GNSS Sensitivity: cold start: -145 dBm / tracking: -161 dBm
- Digital Inputs: 1 positive trigger input for ignition detection & 3 negative trigger inputs for normal use
- Digital Output: 1 digital output, open drain, 150 mA max drive current
- Latched Digital Output: 1 digital output with internal latch circuit, open drain, 150 mA max drive current
- Configurable Input/Output: 1 special I/O can be configured as a 0V-32V analogue input or an open drain digital output with 150 mA max drive current
- Serial Ports: 2 RS232 serial ports on 16 pin Molex type connector, for external devices
- CAN Bus Interface: CAN 2.0A/B, SAE J1939
- 1-wire Interface: support 1-wire temperature sensor (maximum 8 channels)
- Cellular Antenna: internal only
- GNSS Antenna: internal patch antenna and optional external antenna (SMA type connector)
- LED Indicators: CEL, GNSS, PWR
- Mini USB Interface: used for upgrading and debugging
- Transmit Protocol: TCP, UDP, SMS
- Scheduled Report: report position and status based on pre-set time intervals, distance, mileage or a combination of these settings
- Geo-fences: geo-fence alarm, support up to 20 circular and 20 polygon geo-fence regions
- Power on Report: report when the device is powered on
- Tow Alarm: based on internal 3-axis accelerometer
- Driving Behaviour Monitoring: aggressive driving behaviour detection, including harsh braking, acceleration, etc.
- Crash Detection: accident data collection for reconstruction and analysis

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.

- Special Alarm: special alarm based on digital inputs
- Remote Control: OTA control of digital outputs

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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.