Grant number: 769016
Project duration: Sept 2018 - Feb 2022
Project Coordinator: Jacqueline Floch, 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: D2.6

Full-Scale Pilot Implementation in Building Block

Authors: Patrycjusz Bubilek (OSLO), Paal Mork (OSLO), Nils Jakubowski (ZET), Dennis Look (ZET), Terje Lundby (ESMART), Vitor Schwaab (FORTUM), Sofia Stadler (FORTUM), Arjun Subramanian (HUBJ), Frida Josefin Sund (OSLO/ESMART), John Einar Thommesen (SINTEF), Runar Søråsen (OSLO)

www.civitas.eu

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

About GreenCharge

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

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

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

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

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

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

For more information

Project Coordinator: Jacqueline Floch, Jacqueline.Floch@sintef.no

Dissemination Manager: Reinhard Scholten, reinhard.scholten@egen.green

Executive Summary

This document describes the implementation of the Oslo pilot. The Oslo pilot comprises three demonstrators, OSL.D1, OSL.D2 and OSL.D3, which collectively with this document is deliverable D2.6. All demonstrators in the Oslo pilot are associated with Røverkollen housing cooperative. The Røverkollen housing cooperative comprises several building blocks with apartments.

OSL.D1 demonstrates optimised charging of private EVs, where the grid power load is balanced through time-shifting of charging, utilisation of locally produced renewable energy from solar panels, added up with a stationary battery. Off-the-shelf-hardware is combined with software solutions developed by the project.

OSL.D2 demonstrates booking and roaming of shared and public charge points. Standard hardware and software solutions are modified and used in new ways, and dedicated software and user interface are developed for booking functionality not available on the market.

OSL.D3 is not a conventional demonstrator, but a supplement to OSL.D1. In OSL.D3 data is collected from heating and cooling devices, in addition to total consumptions of the apartments. The data collected enables simulation of a full energy smart neighbourhood.

At the time of the release of this document all hardware has been installed at the pilot site, the demonstrations are up and running, with the exception of the integration of the stationary battery in OSL.D1. Therefore, for the time being, the solar panels can only be utilized to charge the EVs directly.

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

Table of Contents

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

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

Table of Figures

List of Tables

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

List of Abbreviations

Table 1: List of abbreviations

Abbreviation	Explanation
AAA	Authentication-Authorization-Accounting
AI	Artificial Intelligence
API	Application Programming Interface
App	Application
Auth	Authentication
BMS	Battery Management System
CDMC	Charge & Drive Management Cloud (Fortum's system)
CDR	Charge Detail Record
CMS	Charge Management System
CPO	Charge Point Operator
DoA	Description of Action
EMP	Electric Mobility Provider
ESN	Energy Smart Neighbourhood
EV	Electric Vehicle
EVSE	E-vehicle supply equipment
GCMT	GreenCharge Management Tool
ICT	Information and Communication Technologies
IoT	Internet of things
MaaS	Mobility-as-a-Service
MNO	Mobile network operator
NEMS	Neighbourhood Energy Management System
OSL.D1, OSL.D2, OSL.D3	Oslo demonstrator 1, 2 and 3
OCP	Optimal Capacity Plan
OCPP	Open Charge Point Protocol
POI	Point of interest (in this case EVSE)
PV	Photovoltaics

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.

Abbreviation	Explanation
SaaS	Software-as-a-Service
SoC	State of Charge
TCP	Transmission Control Protocol

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

List of Definitions

Table 2: List of definitions

Definition	Explanation
Application Programming Interface	Application Programming Interface is a set of clearly defined methods of communication among various components
Artificial Intelligence	Artificial Intelligence is intelligence demonstrated by machines in contrast to natural intelligence which are demonstrated by humans and animals
Charge & Drive Management Cloud (CDMC)	Charge & Drive Management Cloud is a Fortum cloud-based backend system and operates as the CMS in GreenCharge
Charge Management System	The Charge Management System balances the load between the connected chargers and keeps within the OCP generated by Neighbourhood Energy Management System (NEMS). Fortum Charge & Drive Management Cloud operates as the Charge Management System in GreenCharge
Charge Point Operator	Fortum is the Charge Point Operator in GreenCharge and manages the charge points in the parking garage
Description of Action	Part of the formal "Grant Agreement" between the consortium and the funding authority, defining in detail the work to be carried out and the results to be produced
Gateway	Joins two networks so the device on one network can communicate with the device on another network
GreenCharge Management Tool (GCMT)	Application developed for GreenCharge to register user data and create interfaces between software systems. Part of the backend-system developed by ZET.
Local Reference Groups	Group comprising relevant stakeholders (citizens and businesses in ESN, city representatives, interest groups, etc.). The group where actively involved in the project through business model workshops, surveys, interviews, etc. to provide input to needs, requirements and feedbacks for the project development, evaluation and exploitation.
Mobility-as-a-Service	Mobility-as-a-Service (MaaS) integrates various forms of transport services into a single mobility service accessible on demand[1].
Neighbourhood Energy Management System	Neighbourhood Energy Management System. An ICT system implementing the smartness of an energy smart neighbourhood

[1] See https://maas-alliance.eu/homepage/what-is-maas/

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

Definition	Explanation
Optimal Capacity Plan	The Optimal Capacity Plan (OCP) is generated by NEMS (eSmart) and sent to CMS (Fortum) to perform load balancing between the connected chargers in the garage
Photovoltaic	Photovoltaic panels (solar cell panels) convert light into electricity using semiconducting materials
Radio Frequency Identification Tags	An RFID tag is an electronic tag that exchanges data with an RFID reader through radio waves
Roaming / eRoaming	Roaming enables users with contract with one operator to access charge points from other operators
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
Uptake Cities Group	Group comprising of cities, which are not partners in the project, but with interest in the project's outcome. They have contributed with user needs and feedback from a variety of urban contexts across Europe. The Uptake Cities where selected considering representative distribution over Europe.
Use Case	A use case describes how a system will be used and is a tool for modelling requirements of a system.

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

1 About this Deliverable

1.1 Why would I want to read this deliverable?

This document describes the implementation of the Oslo pilot. The Oslo pilot comprises several demonstrators, which collectively with this document is deliverable D2.6. All demonstrators in the Oslo pilot are associated with Røverkollen housing cooperative. The Røverkollen housing cooperative comprises several building blocks with apartments.

The demonstrators show indoor charging solutions that balances charging of EVs with local electricity use and production, and bookable outdoor chargers accessible by roaming agreements. To implement the demonstrators, it was necessary to integrate existing components (both software and hardware) with new software developments. This document contains descriptions of the installation and configuration of the demonstrators and the full test.

1.2 Intended readership/users

This document will be of interest to the partners within GreenCharge, especially the solution developers of each demonstrator. In addition, as a public demonstrator it will also be of interest to a larger audience, especially those that want to replicate some of the results in other, but similar contexts. This includes the Local Reference Group for Oslo, the wider Uptake Cities Group and potentially other innovators and organizations:

- Housing cooperatives
- City and district administrates
- Software developers for energy smart management
- Charging Point Operators (CPO)
- Electric Mobility Providers (EMP)
- Distribution System Operators (DSO)

1.3 Structure

The Oslo pilot is divided into three demonstrators, all situated at the Røverkollen housing cooperative:

- OSL.D1: Energy Smart Neighbourhood Charge Point Demo (private charge points inside the parking garage)
- OSL.D2: Charge Point Operations Demo (public charge points outside)
- OSL.D3: Energy Measurement of Energy Smart Neighbourhood (ESN) apartments Demo

This document is structured accordingly, with sections providing descriptions of all demonstrators, components used, overall architecture, software systems integrated, installation and configuration and full test of the demonstrator.

1.4 Other project deliverables that may be of interest

The following public project deliverables might be useful for the reader to get a more comprehensive view on the conditions and relationship of the Oslo pilot.

The hardware and software components presented in this document are based on inputs from the following deliverables:

- *D2.3 Description of Oslo Pilot and User Needs* - this document describes the Oslo pilot in terms of challenges, user needs, use cases, scenarios, stakeholders and locations to be involved and the baseline.

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.

- *D2.4 Implementation Plan for Oslo Pilot* - this document 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)* - deliverable describing the deployment and the testing of software and hardware components to be used in the pilot, to prepare for the full-scale pilot implementation.

The two other pilots have provided similar deliverables describing user needs, implementation plans and pilot components. The so-called “sister" deliverables are:

- Bremen: *D2.12 Full-Scale Pilot Implementation of Car Sharing* - “Sister” deliverable describing the integrated smart charging solution installed for car-sharing, including charging infrastructure and 2nd use EV-battery storage.
- Barcelona: *D2.19 Full-Scale Pilot Implementation for Smart Charge and EV Fleet Management* - “Sister” deliverable describing the integrated smart charging solution installed, prepared for integrating battery swapping hub and shared homeowner charging points solution with smart planning, booking and billing solutions and balanced with local energy use and electricity production.

The adaptation and integration of the components presented in this document shall be compliant with the architecture and interoperability specification defined in the following deliverables:

- *D4.1 Initial Architecture Design and Interoperability Specification*: this document 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*: this document describes the final version of the GreenCharge architecture and the specification of interfaces and protocols for interoperability. This is the refined version of architecture based on feedbacks and lessons learned from pilots and evaluations.

This document describes the installation, configuration and deployment of the integrated prototype. The integrated prototype itself is described in the following deliverables:

- *D4.3 Initial Version of Integrated Prototype* – deliverable describing the initial version of the integrated prototype based on D4.1. Describing the software implementation and development in more detail.
- *D4.4 Revised Version of Integrated Prototype* - Refined and extended version of the integrated prototype based on evaluations.

1.5 Other projects and initiatives

The INVADE Horizon 2020 project seeks to solve the challenges our electrical infrastructure is facing in the coming years, i.e. aging infrastructure and the need for greater share of renewable energies. By combining existing technology, a cloud-based flexibility management system integrated with EV’s and batteries for energy storage, INVADE increases the share of renewables in the smart grid (INVADE H2020, 2019).

ESMART is an INVADE project partner and the *eSmart Connected Prosumer* is a flexibility management system made for and in INVADE as a continuation of experiences from the EMPOWER Horizon 2020 project. Historical values and correlating information, such as weather, forms the basis for predictions utilizing the ESMART artificial intelligence (AI) capabilities. The system combines properties and topology with contract pricing and parameters, giving the input to optimization on site (household or commercial building) or zone (neighbourhood or other type of area).

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

This software, with required adjustments, forms the basis of the Neighbourhood Energy Management System (NEMS) for the Oslo Pilot and is a part of ESMART's input to the GreenCharge project. The adjustments made in the platform for the GreenCharge H2020 project will be described in this deliverable.

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

2 Overview Oslo Pilot

In the National Transport Plan 2018-2029 for Norway, the Norwegian Government announced that all new cars will be zero-emission vehicles from 2025. The municipality of Oslo has a defined policy to promote e-mobility and has identified that the main barrier for continued growth of e-mobility is the lack of charging infrastructure. Approximately 70% of the inhabitants of Oslo live in flats and apartments, in older housing associations with old infrastructure making it challenging to facilitate home charging of EVs.

The main focus of the Oslo pilot is providing cost efficient home charging facilities in places with local grid limitation. For demonstrating different scenarios and use cases among inhabitants living in blocks of flats, the Røverkollen housing cooperative has been chosen as the pilot site. A more detailed description of the Pilot site can be found in *D2.3 Description of Oslo Pilot and User Needs.* In addition to demonstrating smart charging in an energy smart neighbourhood (ESN), the Oslo pilot will demonstrate booking on public charge points, roaming, priority charging for privately owned charge points and prediction-based load balancing within the neighbourhood, utilising locally produces energy and storage.

In order to fulfil the purpose, the pilot demonstrates four different use cases and four innovation scenarios, divided into two segments:

1. Use cases for private charging in ESN, and
2. Use cases relevant for public users and visitors

In the first segment (1) the increased demand of home charging facilities is considered, utilising renewable energy sources and storage facilities to schedule the most optimal way of charging EVs, reducing peak loads and grid limitations, implementing priority charging and an app interface. As an additional flexible resource, EVs can be utilised as a stationary battery (V2G-technology). V2G was not planned to be demonstrated but to be validated through simulations. The second segment (2) addresses charging at public parking spaces employing functionality for roaming, booking and payment combined in an app interface, making it easier for vehicle owners to access services of all providers. The charging spot will be reserved upon arrival!

The Oslo pilot comprises the following demonstrators (see Figure 1):

1. OSL.D1 - “Energy Smart Neighbourhood Charge Point Demo” – this covers the first segment described above
2. OSL.D2 - “Charge Point Operation Demo” – this covers the second segment described above
3. OSL.D3 - “Measurement of ESN apartments Demo” – this does not directly cover any of the above defines segments, but is used to collect data to enable simulations for impact assessment of ESN

These demonstrators are further described in chapter 3, 4 and 5 in this deliverable.

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.

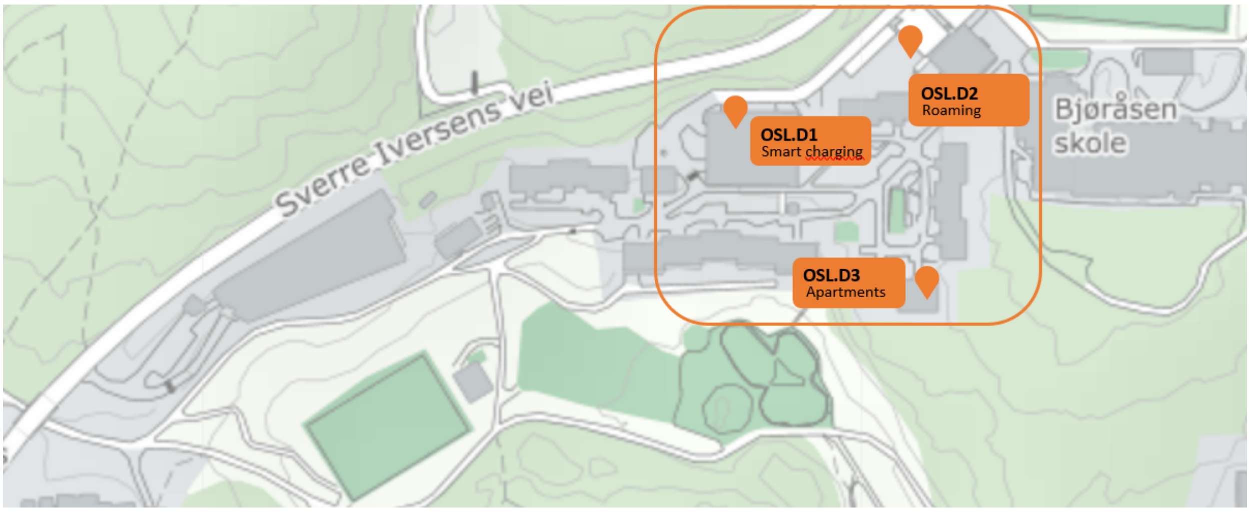


Figure 1: The demonstrators at the Oslo Pilot

2.1 Pilot site components

In order to meet the requirements of the three demonstrators in the Oslo pilot, different components from different providers needed to be developed or modified, installed and integrated. This section gives an overview of these components. The preparation of the different components is part of and described in deliverable *D2.5 Pilot Component Preparation for Full-scale Pilot (Oslo).*

For integration of the different component, an UML component model was developed by the project. This UML component model is shown in Figure 2 and illustrates the high-level logical components of the GreenCharge system, the external components they interact with, and the interfaces used for communication. This model and description of the related different services are part of deliverable *D4.1 Initial Architecture Design*.

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.

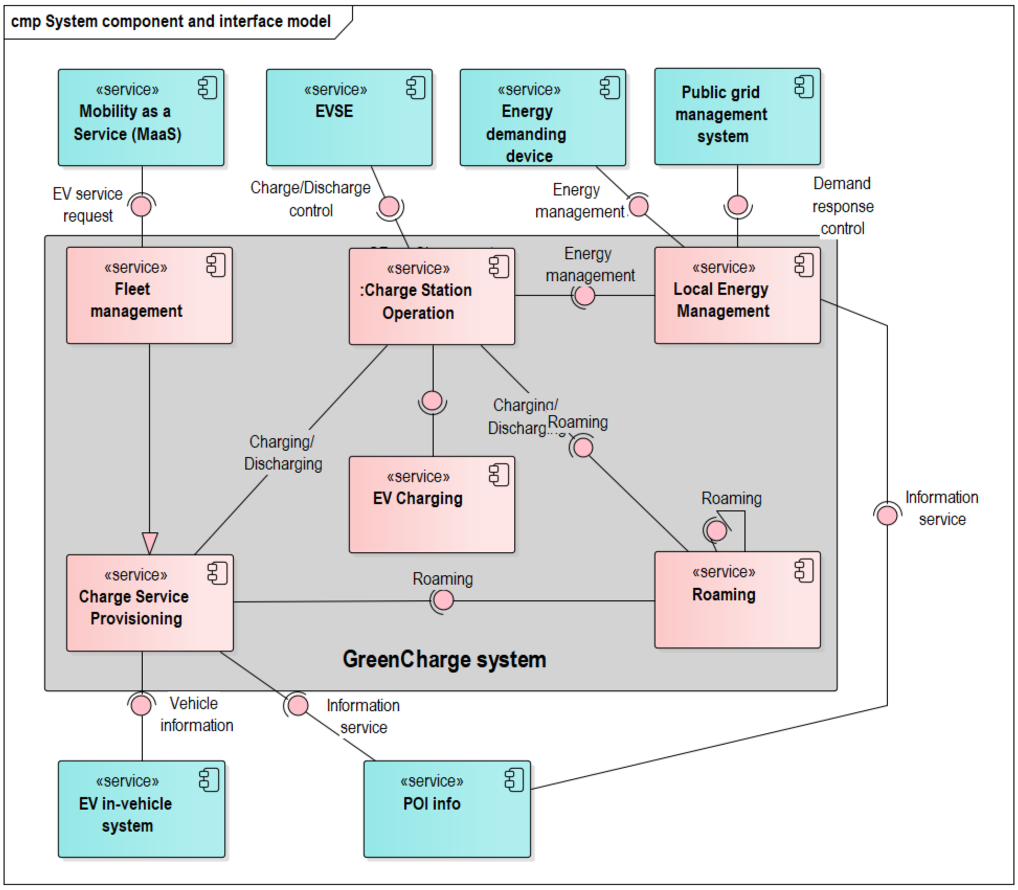


Figure 2: High level logical components and interfaces (from D4.1)

Components of the GreenCharge system:

- **Charge service provisioning:** The eMobility Providers (EMPs) or a third party (for example a Mobility-as-a-Service (MaaS) operator, a Fleet Operators or similar) provides a charge service to EV users as a stand-alone service or integrated with other services (e.g. MaaS, car sharing, etc.).
- **Fleet management:** Fleet operators operate EV fleets that needs charging (not demonstrated in Oslo).
- **Charge station operation:** Charge Point Operators (CPOs) receives the charging requests and controls the actual charging. The aim is optimal charging adapted to the EV users' needs and the energy availability.
- **Local energy management:** Local Energy Managers provide smart energy management for optimal use of energy. The use of energy in charging is adapted to the energy availability and to other energy demands. This service may collaborate with other similar services in a hierarchy of local energy management services.
- **EV charging:** The EV user is supported when the charging starts and during the charging (provision of status information, etc.), and billing and payment is handled.
- **Roaming:** Roaming Operators provide roaming services, i.e. allowing users with contract with one operator to access charge points from other operators.

External components that interact with the GreenCharge system:

- **MaaS management system**: Such systems may communicate with EV Fleet Operators offering mobility services.

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.

- **Electric Vehicle Supply Equipment** (EVSE): The equipment delivers electric energy to electric vehicles connected to the charge points.
- **Energy demanding devices**. This may be any kind of devices, and they may communicate with the GreenCharge solution through standardised or proprietary interfaces. The purpose is to coordinate charging with other energy demanding equipment (heating, cooling, hot water etc.).
- **Public grid management system**: This system does demand response control.
- **EV in-vehicle system:** This is in-vehicle information and communication systems, typically integrated in the vehicle by the EV manufacturer.
- **Point of interest (POI) information**: Various information sources (both open and paid) provide data and information services that are needed when smart and green charging is planned and accomplished. Relevant data include location and capacity of charge points, cost of charging, meteorological information, etc. These services may have various interfaces and may be provides by different actors.

Table 3 below shows how each service of the UML component diagram shown in Figure 2 has been implemented by software or hardware artefacts in the three demonstrators of the Oslo pilot.

Table 3: Components used and implemented in the full-scale Oslo pilot

Service	Component name	Description	Section	Demo site	Type	Partner
Charge Service Provisioning	ZET.Charge	The GreenCharge application ZET.Charge is the digital interface towards the user	3.2.3 4.2.3	OSL.D1 OSL.D2	SW	ZET
	Payment system	System for billing and payment of charging sessions	3.2.1 4.2.3	OSL.D1 OSL.D2	SW	FORTUM ZET
	Booking system	Enables visitors to pre book a time slot for a charge point via App	4.2.4	OSL.D2	SW	ZET
Roaming	HUBJ eRoaming	eRoaming between FORTUM CPO system and ZET EMP system via eRoaming	4.2.5	OSL.D2	SW	HUBJ
Fleet management system	N/A	-	-	-	-	-
EVSE	Charge point infrastructure in garage	Charging points installed at privately owned parking spots in the parking garage. Will be used by residents of the housing cooperative	3.3.1	OSL.D1	HW	OSLO
	Outdoor public charging station	Charging points installed outdoors, to be shared/used by visitors	4.2.2	OSL.D2	HW	OSLO

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.

Charge station operation & EV charging	Charge mgmt. System (CMS)	Fortum Charge & Drive (CDMC)	3.2.1 3.2.3	OSL.D1 OSL.D2	SW	FORTUM
	Algorithm for Smart Charging	ZET algorithm for smart charging Local control system managing the charging process of a charging station based on input from NEMs	3.2.4	OSL.D1	SW	ZET
Local energy management	eSmart Connected Prosumer	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 Calculates the optimal schedule of all loads and local RES for the optimization criteria defined and user preferences	3.2.2	OSL.D1	SW	ESMART
	Local Renewable energy source	PV panels installed on the roof of the parking garage. To enable locally produced energy. Will be stored in the stationary battery	3.3.2	OSL.D1	HW	OSLO
	Local battery storage	The stationary battery stores the electric energy generated by the PV panels. To be used e.g. when charging EVs	3.3.3	OSL.D1	HW	OSLO
	Battery mgmt. system	Battery mgmt. System to be integrated with NEMS in order to push meter values for PV and battery and to receive control signals from NEMS	3.3.3	OSL.D1	SW	OSLO

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

3 Energy Smart Neighbourhood Charge Point Demo (OSL.D1)

3.1 Overall architecture and components involved

Figure 3 shows the software and hardware architecture of OSL.D1 in more detail. This includes the interaction between the different components (the components themselves are described in Table 3 above):

1) Third party components (shown with black boxes in the figure): Open data and information services (i.e., weather data, energy mix etc.), public grid, hardware and the battery management system (BMS)
2) Existing software (the yellow boxes): NEMS and charge management system (CMS) modified (configurated or customized) to be integrated in the pilots
3) The required new software (the green boxes): ZET.Charge and the GreenCharge Management Tool

The lines in the figure highlights the interfaces between components, grey lines for third party interfaces and blue lines for interfaces between project specific components.

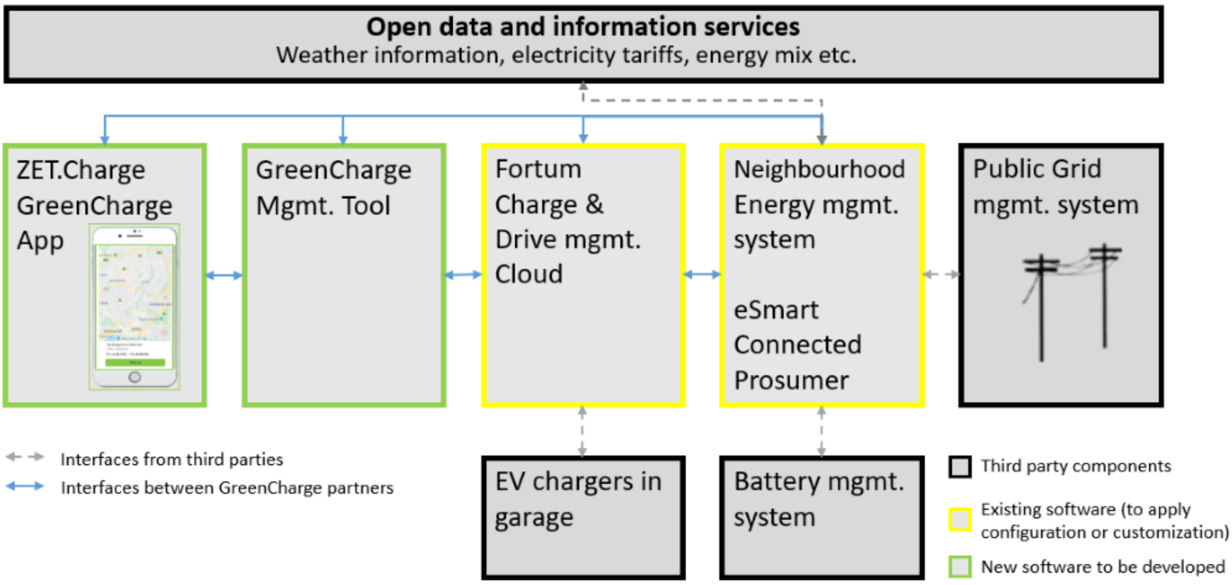


Figure 3: OSL.D1 Energy Smart Neighbourhood software components

The project ecosystem and its main components are described in section 1.3.1 in the DoA. Figure 3 above is based on the project ecosystem but adapted to suit the Oslo demo cases.

3.2 Adaptations done and new development for OSL.D1

3.2.1 Charge management system (CMS)

The charge management system (CMS) is a software platform that allows Charge Point Operators (CPOs) to control EV chargers remotely. FORTUM calls its CMS for *Charge & Drive Management Cloud* (CDMC), and a simplified structure of this is illustrated in Figure 4. For this project, the system can be simplified and described in four parts:

- A charger-server bridge, that enables the communication between the chargers and FORTUM's servers;
- Authentication and payment services, that enables users to register, add payment method and start and stop charging with RFID

- A web admin portal, that provides the CPO with information regarding charger status and charging sessions, and need for maintenance and customer support;
- A smart charging API, which is exposing session data (starts, stops and metering values) to the other partners (ESMART and ZET). The smart charging API was developed specifically for the GreenCharge project.

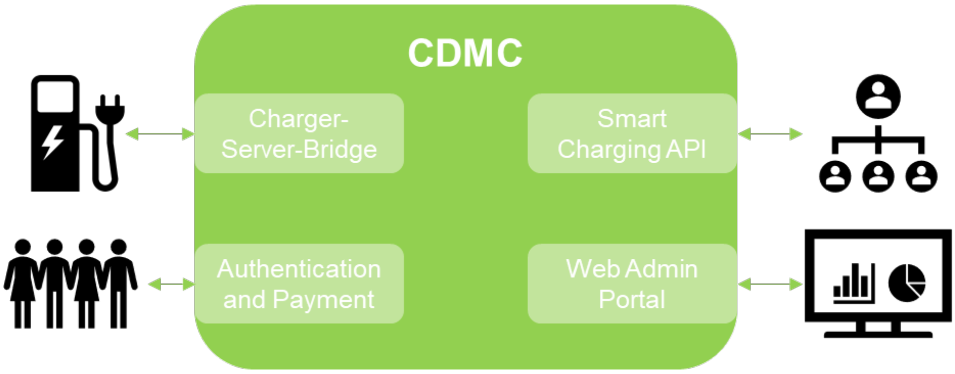


Figure 4: Simplified structure of CDMC

The main adoption/update done for CDMC for GreenCharge OSL.D1 is the development and implementation of the Smart Charging API:

- Send session information through the API: Start charging, stop charging and metering values, with relevant charger, session and transaction parameters.
  - Integration with ESMART and ZET.
- Receive specific values of current (Ampere) for specific charging stations through the API. CDMC thereafter send through the steering commands to each charging station.
  - Integration with ZET.

3.2.2 Neighbourhood energy management system (NEMS)

The purpose of the NEMS in OSL.D1 is to perform optimization to reduce peaks in the power grid by load balancing the EV chargers with total consumption by the housing cooperative. Historical values and correlating information, such as weather, form the basis for predictions leveraged by AI capabilities. The system combines properties and topology with pricing and other parameters to provide input to optimization at the pilot site. The output from optimization is a plan for the coming 48 hours for the EV chargers in the garage and how to utilize the stationary battery.

When NEMS is installed at new sites, there are several steps which need to be performed:

1. Establish a production environment
2. Configure an asset hierarchy (The asset hierarchy for OSL.D1 is shown in Figure 5 below)
3. Establish and configure interfaces to import relevant external data as weather data, energy prices and grid tariffs
4. Needed integrations with third party systems
5. Develop and analyse site specific prediction models (forecasting)
6. Configure necessary calculations and optimization models

In addition to the above, several adaptations have been done to the NEMS as part of the implementation in the OSL.D1 pilot:

- Receive and implement EV charge bookings from the GreenCharge app ZET.Charge
- Improved EV charging predictions
- Optimisation of flexibility usage on several levels of the asset hierarchy

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.

- User interface change to enable review of historic predictions and control plans

Receive and implement EV charge bookings from the GreenCharge app ZET.Charge

Through the ZET.Charge app, especially developed for GreenCharge, the users will book charging and input charging start, charging stop, battery state of charge at the start of the charging and required charging amount at end of charging session. This information is forwarded to the NEMS and overrides the prevailing forecasted charging energy if different. Should the user not turn up, or should the user decide to disconnect before the booking period is over, the booking is automatically deleted.

Improved EV charging predictions

Predicting future EV charging is a challenge. The pattern is often non-regular and volatile. Time-of-day and the state of charge when charging starts varies from day to day. As part of the implementation in the OSL.D1 pilot, a new AI based EV prediction methods have been developed and trained. This has been tested as part of the pilot.

Optimize flexibility on several levels of the asset hierarchy

In the garage in OSL.D1, the charge points are organised in four zones within each floor (1-4) in the garage, where each zone have a fixed maximum capacity of supplied electricity. This limits the maximum charging which can take place within each zone. The garage itself also has a maximum capacity of supplied electricity, which cannot be exceeded. The optimization of flexibility therefore must take place at several levels in the garage. The NEMS algorithms was improved to incorporate this functionality.

User interface change to enable review of historic predictions and control plans

To enable evaluating of the forecasting performance in the OSL.D1 pilot, it was necessary to implement new functionality with associated user interface that enabled the review of the whole forecasting history and resulting control plans.

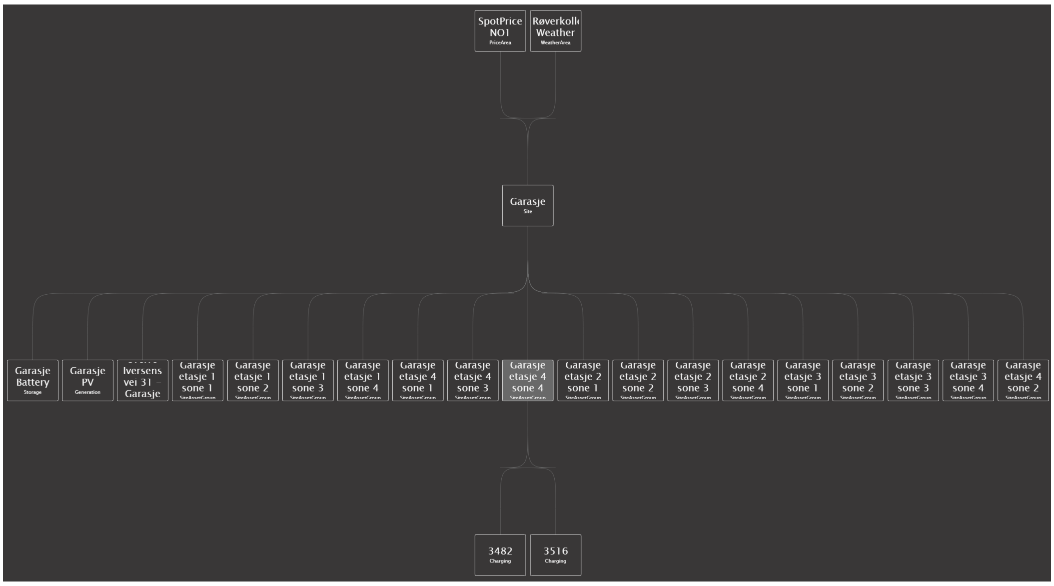


Figure 5: Asset hierarchy in OSL.D1 pilot (etasje = floor, sone = zone)

3.2.3 GreenCharge app, ZET.Charge for OSL.D1

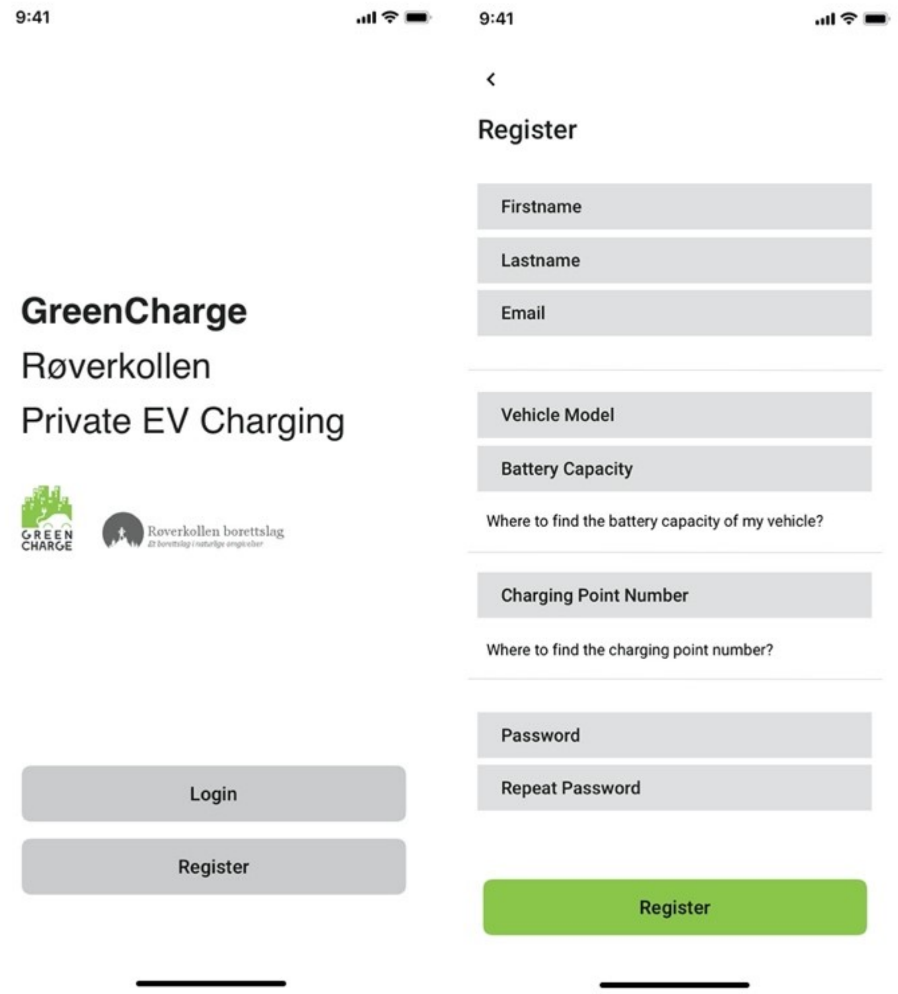
The ZET.Charge application has been specifically developed for this project's purposes and will be the EV user interface for both OSL.D1 and D2. For D1 it allows the users, together with the GreenCharge Management Tool (see section 3.2.4 below), to enable smart charging sessions on their private charge points.

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.

Necessary information for the energy management is provided by the user through this user interface: 1) initial state-of-charge (SoC), 2) requested SoC, 3) estimated departure time and 4) request for priority.

The following functionality has been developed for OSL.D1:

- A white labelled[2] end user application for GreenCharge
- It prompts user to add information about EV battery size and EV make and model at registration
- It prompts user to fill in the current SoC of their EV when arriving at the charge point
- It prompts user to fill in the desired departure time
- It gives the user the possibility to choose between standard and priority charging
- It enables the user to start/stop the charging
- It adds relations between user and charger



[2] White labeling is when a product or service removes their brand and logo from the end product and instead uses the branding requested by the purchaser

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.

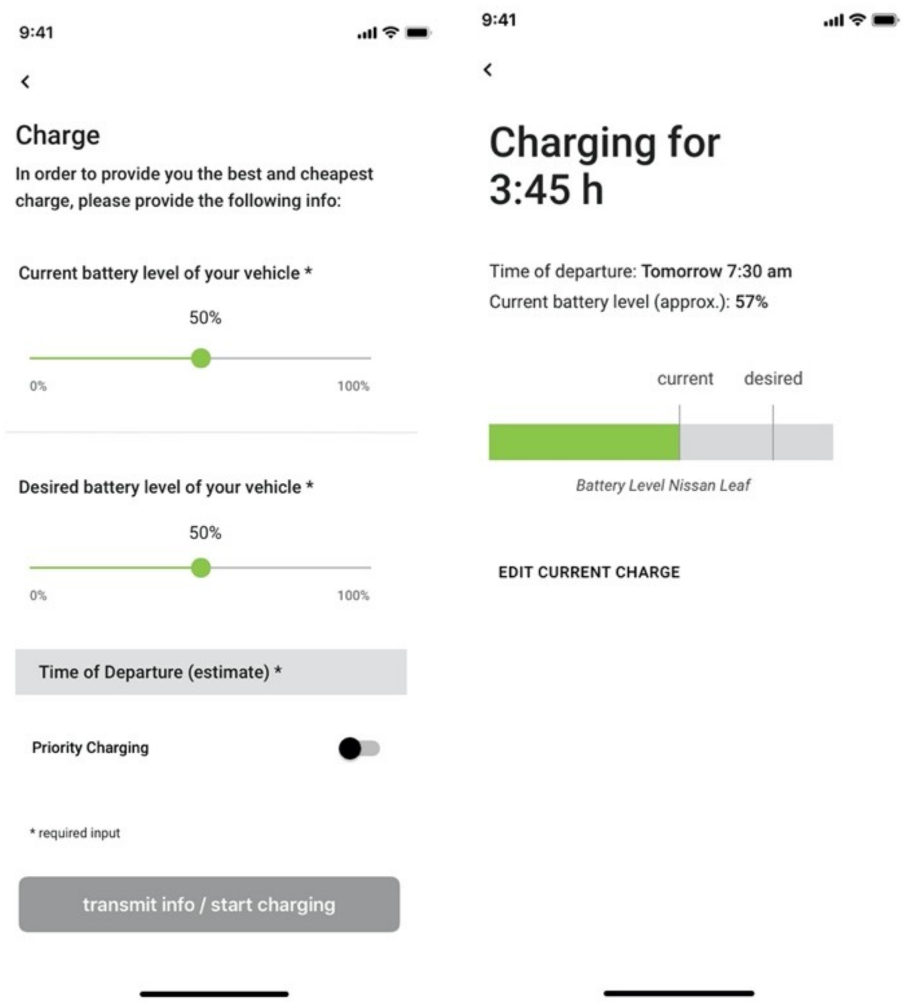


Figure 6: Screenshots of the GreenCharge App (ZET.Charge) for OSL.D1

3.2.4 GreenCharge Management Tool (GCMT)

The GreenCharge Management Tool (GCMT) is part of the backend-system developed by ZET. It combines, integrates and processes information from the different GreenCharge systems using defined APIs. The implemented algorithm will control the demand-based energy provision.

The new GCMT features:

- Data handling to be able to receive session information and meter values from FORTUM
- Data handling to be able to receive overall steering plan for the whole garage from ESMART
- Algorithm to define charging profile for each connector
- Sending of charging profile per charger through API to FORTUM

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 7: Screenshot of the ZET database interface

3.2.5 Battery management system (BMS)

The company OneCo is a sub-supplier of the City of Oslo and delivers the battery management system (BMS) for the Oslo pilot. This system is considered an off-the shelf product but required integration with the NEMS at the pilot, i.e. ESMART's *Connected Prosumer*. The integration of BMS and NEMS was done via a web-based REST API with JSON as data carrier.

The purpose of the BMS is to manage the local photovoltaics (PV) panels and the stationary battery installed at Røverkollen, in addition to the communication to and from the NEMS.

Description of integration and dataflow/timeseries implemented between the BMS and the NEMS:

Stationary Battery (BMS to NEMS):

- The BMS is pushing data on "EnergyLevelMeterReading " (State-of-Charge) of the battery to the NEMS with a 15-minute interval
- The BMS is pushing charging and discharging meter readings. These series increase incrementally, and based on these, the NEMS is calculating data on "charging" and "discharging"

Control Signals (NEMS to BMS)

- Every 15th minute, the NEMS generates a plan for the next 48 hours, with 15-minute resolution, telling the stationary battery to either charge or discharge during the next 48*4 = 192 quarters. The plan is made available for the BMS through a "NetStoragePowerRegulation" series. This data series is pulled by the BMS from the NEMS every 15th minute

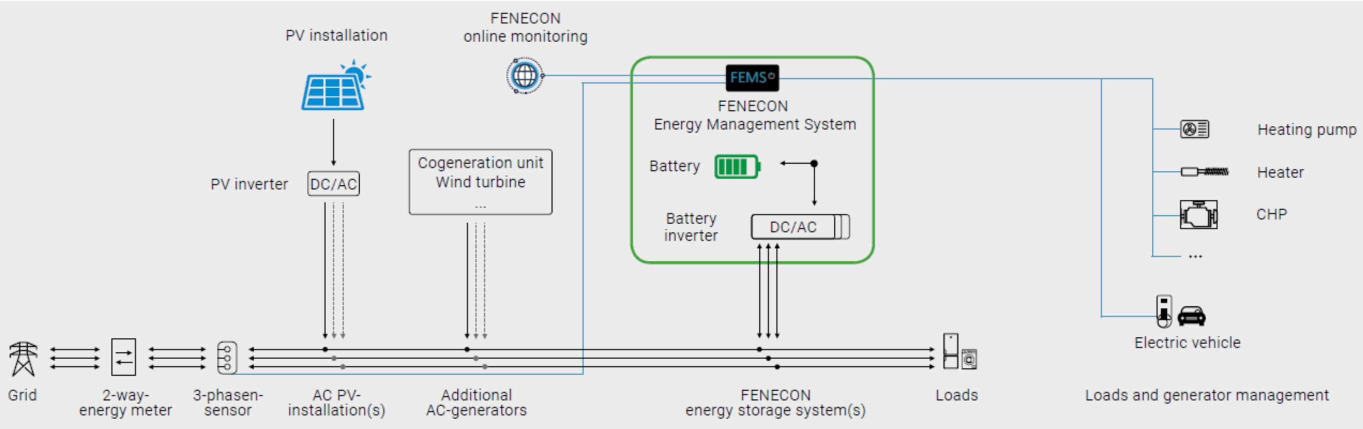


Figure 8: Technical structure at Røverkollen

Figure 8 shows the technical structure for the implementation. The implemented solution gives a complete overview of how power flows, how much power is used from the grid, how much is stored in the battery bank and how much the PV panels generates. The system will also illustrate how big the consumption is, see Figure 9 for a screenshot from the system.

Figure 9: Screenshot of energy table

3.3 Installation and configuration of the demonstrator

3.3.1 Charge point infrastructure

The specification and choice of charge point infrastructure is described in *D2.5 Pilot Component Preparation for Full-scale Implementation*. The charge point infrastructure was installed in the parking garage in September 2019 and comprises:

- Charge points: Off-the-shelf *EVlink Smart WallBox* from Schneider
- Load balancing: *EVlink Controller* from Schneider - managing the fuses and enabling communicating with the CPO. As GreenCharge is developing its own load management systems (LMS) the LMS included by Schneider must be deactivated.

The charge points support both 400V TN network and 230V IT network. In the garage they were connected to 32 A, 3-phase supply on the 230V IT-network.

In October 2020 the goal of having 64 charge points installed was reached.

Figure 10: One of the charge points mounted inside the garage for OSL.D1

3.3.2 Photovoltaic system

The company OneCo is a sub-supplier of the City of Oslo and delivers the battery management system (BMS) for the Oslo pilot. This system is considered an off-the shelf product but required integration with the NEMS at the pilot, i.e. ESMART's Connected Prosumer. The integration of BMS and NEMS was done via a web-based REST API with JSON as data carrier.

The purpose of the BMS is to manage the local photovoltaics (PV) panels and the stationary battery installed at Røverkollen, in addition to the communication to and from the NEMS. The stationary battery was delivered by Fenecon and installed by OneCo.

The PV panels (from provider Canadian Solar and delivered by sub-supplier OneCo) were installed at the demo site in September 2019. The total peak capacity (Watt peak) of the installed PV system is 70 kWp. The PV system was connected to the local power network inside the garage (230V IT network) through PV inverters provided by INVT (also delivered by OneCo).

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 11: Photovoltaic panels on the garage roof at Røverkollen

3.3.3 Battery storage and battery management system

The stationary battery was installed at the demo site in September 2019. The battery has a capacity of 50 kWh. The battery was delivered by Fenecon and installed by OneCo. Because no suitable inverter that supports 3-phase 230V IT-network, a transformer upgrade was necessary. This transformer was installed in front of the inverters of the battery.

Figure 12: Battery rack

3.3.4 Main meter

To enable the GreenCharge system to calculate the total energy consumption from the grid, a connection was made from the main meter in the parking garage to the NEMS. The reading from the main meter also includes the energy consumption by the automatically controlled heating cables in the driveway. The

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.

connection to the main meter was done through the smart meter's HAN port. This port provides input to the NEMS on a 15-minute resolution[3].

3.4 Full test of the demonstrator

A first site acceptance test was performed 3 March 2021. This was not fully successful. A follow-up test was done December 2021, January 2022 and February 2022. The test cases and results are summarized in Table 4 below. The following functionality were tested:

- Booking of charging via the ZET.Charge app
- Access to data needed for the optimization algorithms: Data from ZET, FORTUM, OneCo, main meter, together with open data used for predictions.
- Flexibility management optimization.

Table 4: List of test cases and results OSL.D1

Test case	Date	Description	Status
OSL.D1 – Energy request (frontend)	21.12.2021	In the ZET.Charge App the user enters the current SoC of his vehicle, desired end time of charging session, and desired SoC after the session. Test Case: Select vehicle, enter end date and desired SoC. Submit a request.	success
OSL.D1 – Energy request (backend)	21.12.2021	GCMT uses the submitted energy request (from App) as well as the transmitted authentication (CPO) to create an energy request and send it to NEMS. Test Case: Submit energy request via app and use the RFID Chip for authentication. Check message exchange with NEMS.	success
OSL.D1 – Charging plan (ESMART algorithm)	21.12.2021	NEMS receives data from different sources and coordinates the energy assigned per zone. The assigned energy is transferred as a charging plan to GCMT every 15 minutes and is adapted to incoming energy requests. Test Case: Set default charging value to 0A and start a session. Submit an energy request via app. Create and send a new charging plan to the GCMT.	success
OSL.D1 – Charging plan (ZET algorithm)	21.12.2021	Based on charging plan from NEMS the GCMT calculates the energy amount allocated to each charger based on the requested charging mode from the user (standard or priority). Test Case: Set default charging value to 0A and start a session. Submit an energy request via app. Receive	success

[3] HAN - Home Area Network

			a new charging plan and calculate a new charging value. Send value to CPO's system.	
	OSL.D1 – Steering command request charger	03.02.2021	The FORTUM CPO system is able to send steering commands to the charge point and control the amount of energy made available by each charge point. Test Case: Set default charging value to 0A and start a session. Submit an energy request via app. Receive a new charging plan and calculate a new charging value. Send steering command to charger. It was discovered that the charger did not provide the correct current level. Quick fix in place, working on a long-term solution.	failure
	OSL.D1 – Battery management plan	06.01.2021	NEMS is able to generates a charge/discharge plan for the stationary battery. Test Case: A full test case was not developed since it was discovered that the eSmart Connected Prosumer was not able to read SoC from the battery. This has been identified as a malfunction of the battery controller (part of battery management system supplied by Fenecon)	failure

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 Charge Point Operation Demo (OSL.D2)

OSL.D2 consists of four charge points. The charge points outside are meant for guests of the residents of the housing cooperative or staff of nearby businesses – people stopping by for a short time, parking and charging their EV.

4.1 Overall architecture and components involved

Figure 13 shows the software and hardware architecture of OSL.D2 in more detail. This includes the interaction between the different components (the components themselves are described in Table 3 on (page 13)):

1) Third party components (shown with black boxes in the figure): Open data and information services (i.e., weather data, energy mix etc.), public grid, hardware
2) Existing software (the yellow boxes): Roaming and charge management systems (CMS) modified (configurated or customized) and integrated in the pilots
3) The required new software (the green boxes): ZET.Charge extended version for OSL.D2 including the specially developed GreenCharge booking tool

The lines in the figure highlights the interfaces between components, grey lines for third party interfaces and blue lines for interfaces between project specific components.

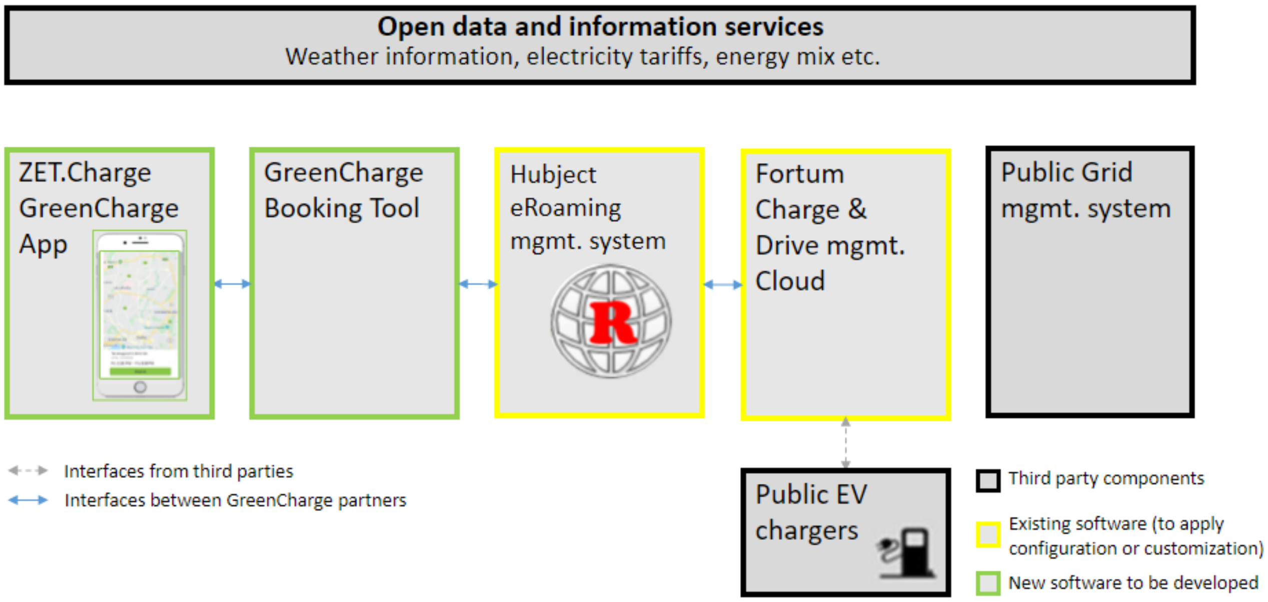


Figure 13: OSL.D2 Charge point operation demo software components

The project ecosystem and its main components are described in section 1.3.1 in the DoA. Figure 14 above is based on the project ecosystem but adapted to suit the Oslo demo cases.

4.2 Adaptions done and new development for OSL.D2

4.2.1 Charge management system (CMS)

OSL.D2 uses the same CMS as OSL.D1. See section 3.2.1 for description.

The following configuration and/or adoptions where required to make it work with OSL.D2:

- Onboarding of the chargers to the FORTUM CDMC

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.

- Connecting CDMC to the HUBJ roaming platform, including onboarding of new CPO to HUBJ's eRoaming management system
- Connecting the booking tool to the HUBJ roaming platform

These modifications enable charging to be booked, started, stopped and paid through the (updated) ZET.Charge application.

4.2.2 Outdoor charging infrastructure

For OSL.D2 four new charge points was installed. These charge points are compliant with OCPP (Open Charge Point Protocol). The new chargers where then onboarded to the FORTUM Charge Management System.

4.2.3 GreenCharge app, ZET.Charge for OSL.D2

The ZET.Charge app used for OSL.D1 was adjusted, and some functionalities added to be able to use the same app for OSL.D2. ZET.Charge provides the user interface that allows EV users to reserve a charge point, book a desired time slot, and initiate charging.

The following functionality has been developed for OSL.D2:

- Registration of user, including prompt for personal data (e.g., name and address)
- Ask the user to choose a payment method
- Prompts the user for a desired booking time
- Confirm reservation of the charger
- Start/Stop charging
- Invoice user for a conducted session

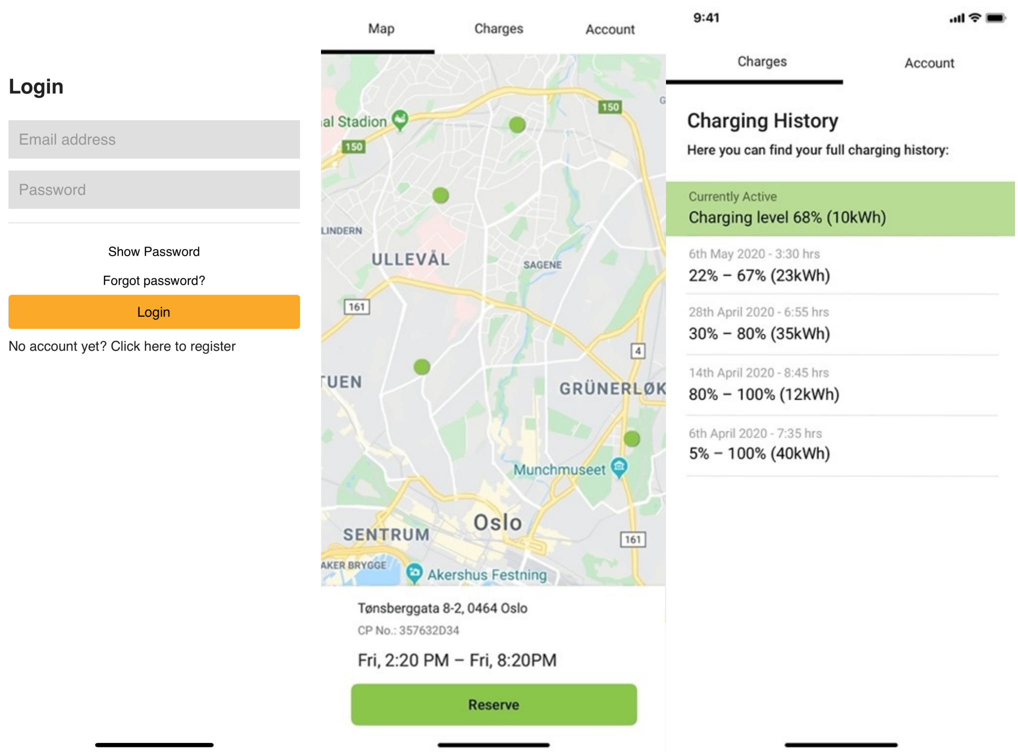


Figure 14: Screenshots of the GreenCharge App (ZET.Charge) for OSL.D2

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 GreenCharge Booking Tool

The GreenCharge Booking Tool is part of the backend-system developed by ZET. It combines and processes information from project partners through defined APIs.

GreenCharge Booking Tool is new for this project and includes:

- Integration with payment service provider
- Integration of ZET with HUBJ as an EMP
- Integration of FORTUM with HUBJ as a CPO
- Locally savings of booking requests

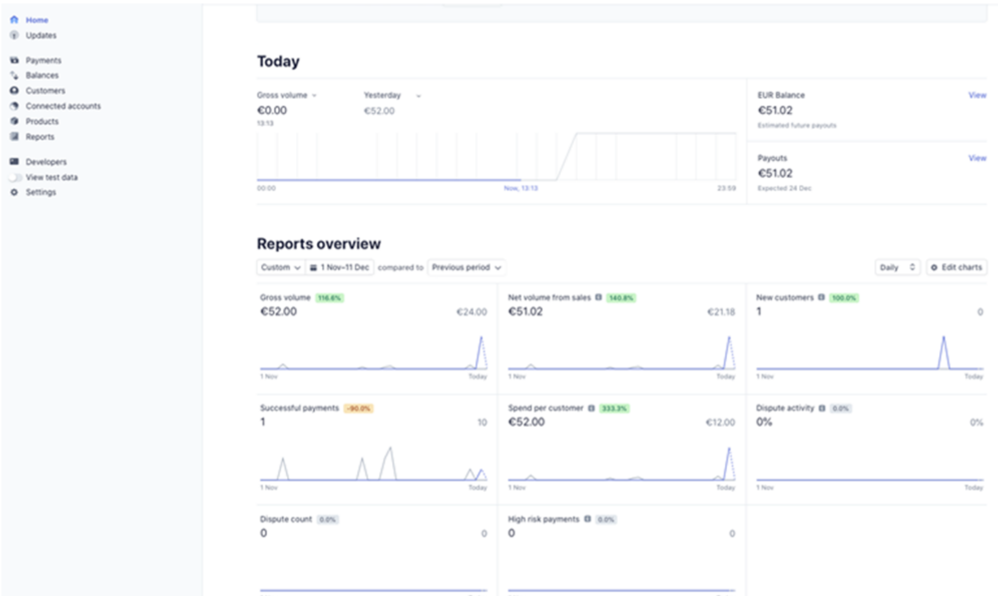


Figure 15: Reporting interface of the new ZET payment integration

4.2.5 Roaming

Roaming (or eRoaming) offers EV drivers the opportunity to charge their vehicles at all charging stations – regardless of any contracts with operators. The purpose of eRoaming in the GreenCharge project is to authenticate the users of the ZET.Charge application developed by ZET (the EMP), to get access to the Fortum (the CPO) chargers placed outdoor at Røverkollen (see Figure 16). After a verification process is completed, the user will be able to charge their vehicle. A connection with the back-end system of FORTUM allows ZET.Charge to know availability of the charging points and details about charging sessions (Charge Detail records).

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.

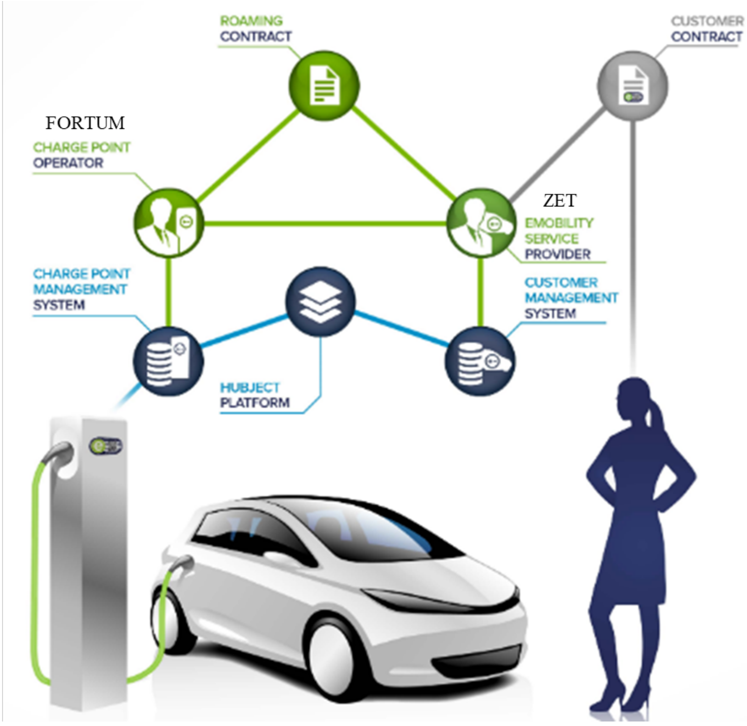


Figure 16: Interactions of OSL.D2

Implementation of the eRoaming:

- ZET GreenCharge EMP system and FORTUM Charge & Drive CPO system connects through HUBJ Roaming platform

4.3 Installation and configuration of the demonstrator

4.3.1 Charge point infrastructure

At the start of the project the plan was to use already existing semi-fast chargers (see deliverable *D2.4 Implementation Plan for Oslo Pilot*) but it was discovered that these chargers where not OCPP compliant. To enable the GreenCharge functionality planned for OSL.D2 the existing outdoor chargers was therefore replaced (see Figure 17). Four new charge points were installed for OSL.D2 at Røverkollen in August 2020. Basic specification of the outdoor charge points:

- Charging mode: Mode 3
- Connector: Type 2
- OCPP 1.6
- Power connection: 230 V, IT network, 32 A, 1-phase supply
- Charging capacity: 7.3 kW
- Authentication: RFID reader
- Communication: 4G mobile network

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 17: Old charge points vs. the new, OCPP compliant.

4.4 Full test of the demonstrator

The charge points for OSL.D2 were installed and made operative through onboarding with FORTUM's CDMC. A full test for OSL.D2 was performed 11 January 2022. The test cases and results are summarized in Table 5 below. The GreenCharge app, which is the user interface for the charge points was also tested as part for the full test for OSL.D1.

Table 5: List of test cases and results OSL.D2

	Testing	Date	Description	Status
	OSL.D2 – CP Map	11.01.2022	Charge Point location will be shared though the HUBJ platform. The platform connects the CPO and the EMP systems. Test case: Find charger on the ZET.Charge map	success
	OSL.D2 – Booking	11.01.2022	The Charge Point can be pre-booked bu user using the ZET.Charge app Test Case: Enter start and end date and submit a booking.	success
	OSL.D2 – Charging	11.01.2022	The charging process can be started via the ZET.Charge app. Authentication request transmitted from EMP system to CPO system. Test case: Start and stop a charging session.	success
	OSL.D2 – Payment I	11.01.2022	The charging session can be paid via credit card. Test case: Add credit card details to ZET.Charge account via the app.	success

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.

OSL.D2 – Payment II	11.01.2022	The charging session can be paid via credit card. For that a charge detail record are created in CPO system and transferred to EMP system via eRoaming platform. The EMP system charges the costumer credit card via a payment handler service (in this case Stripe) and creates an invoice. Test case: Pay a charging session via credit card and receive an invoice.	success

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

5 Energy measurement of ESN apartments Demo (OSL.D3)

5.1 Overall architecture and components involved

The OSL.D3 demonstrator is not considered a full demonstrator but complements OSL.D1 and OSL.D2 to demonstrate a complete ESN.

OSL.D3 was established since it was not possibly, due to physical constraints, to include energy consumptions from the apartments in the smart energy management of OSL.D1. The main purpose of OSL.D3 was to collect research data for simulation purposes, enabling the project to evaluate the effects of introducing a full ESN.

OSL.D3 collects data from sensors assigned with heating and cooling devices (temperature and energy consumption), in addition to power consumptions in apartments and hot water production. The data sources include:

- 12 electric water heaters in the housing cooperative. These are shared between several apartments.
- 9 apartments. These apartments were instrumented with energy meters and sensors

5.2 Installation and configuration of the demonstrator

5.2.1 Water heaters

Sensors were installed on 12 water heaters by sub-supplier Sodvin. Equipment used was *SPART energy meter*, an off-the-shelf-products from Sodvin. Data will be collected, and six files will be provided once a month.

5.2.2 Apartments

Nine apartments in the housing cooperative have been instrumented with meters and sensors from sub-supplier FutureHome. Equipment used is off-the-shelf-products, smart energy meters from Qubino, switches and sensors from Fibaro, in addition to Heathit-Z-TRM3 thermostats. Data will be extracted to Sintef's SFTP-server.

5.3 Full test of the demonstrator

As the demonstrator consists of off-the-shelf-products, the full test was limited to testing files containing data of usage. Test files were uploaded to an SFTP[4] server hosted by partner SINTEF. The content of the files was as expected. After testing, data is delivered on a regular basis, and the demonstrator is considered operative at the time of release of this deliverable.

[4] SSH File Transfer Protocol, a network protocol used for secure file transfer

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

6 Conclusions and Further Work

The Oslo pilot site demonstrates many of the results of GreenCharge. It includes both smart charging of EVs as well as optimised balancing of power consumption to avoid undesired peaks and overload of the power supply. Additionally, booking of shared charge points is demonstrated for public charging and data for energy smart neighbourhoods is collected for simulation purposes.

Implementing the technical functionality needed to demonstrate the solutions of GreenCharge proves that much of the technology is not available on the market. Consequently, solutions have been developed to reach the targets of GreenCharge.

Providing solutions for hardware, infrastructure and software systems depends on a combination of using products that already exists together, with technical development within the project. Some functionality has proven more demanding to develop; other features have required a combination of functionalities between existing solutions, which involved developing proper interfaces between the solution. Consequently, the implementation phase has taken more time than expected, resulting in a delay of the project.

At the release of this document, the three demonstrators of the Oslo pilot are technically operative, except integration of stationary battery in OSL.D1. The BMS is not providing data regarding the battery's SoC. Therefore, the NEMS is not able to utilize the stationary battery in the planning. This implies that the RES (the PV panels) are only charging the EVs directly. Even if the installed system succeeds in reducing the peaks in the power grid, enabling storage of energy would further increase the peak reduction capabilities of the system. *Status 08.02.2022: Sub-supplier OneCo is awaiting shipment of special measurement and diagnosis equipment needed to rectify the error.*

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

Members of the GreenCharge consortium

SINTEF	SINTEF AS (SINTEF) NO-7465 Trondheim Norway www.sintef.com	**Project Coordinator:** Jacqueline Floch, Jacqueline.Floch@sintef.no **Technical Manager:** Shanshan Jiang Shanshan.Jiang@sintef.no
eSmart systems	eSmart Systems AS (ESMART) NO-1783 Halden Norway www.esmartsystems.com	**Contact:** Susann Kjellin Eriksen susann.kjellin.eriksen@esmartsystems.com
HUBJECT	Hubject GmbH (HUBJ) DE-10829 Berlin Germany www.hubject.com	**Contact:** Jürgen Werneke juergen.werneke@hubject.com
eurecat Centre Tecnològic de Catalunya	Fundacio Eurecat (EUT) ES-08290 Barcelona Spain www.eurecat.org	**Contact:** Regina Enrich regina.enrich@eurecat.org
ATLANTIS TRACKING YOUR WORLD	Atlantis IT S.L.U. (ATLAN) ES-08013 Barcelona Spain http://www.atlantisit.eu/	**Contact:** Ricard Soler rsoler@atlantis-technology.com
enchufing	Millor Energy Solutions SL (ENCH) ES-08223 Terrassa Spain www.millorbattery.com	**Contact:** Baltasar López blopez@enchufing.com
motit www.motitworld.com	Motit World SL (MOTIT) ES-28037 Madrid Spain www.motitworld.com	**Contact:** Valentin Porta valentin.porta@goinggreen.es
Freie Hansestadt Bremen	Freie Hansestadt Bremen (BREMEN) DE-28195 Bremen Germany	**Contact:** Michael Glotz-Richter michael.glotz-richter@umwelt.bremen.de
ZET zero emission transportation	ZET GmbH (MOVA) DE-28209 Bremen Germany www.zet.technology	**Contact:** Dennis Look dennis@zet.technology

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.

	Personal Mobility Center Nordwest eG (PMC) DE-28359 Bremen Germany www.pmc-nordwest.de	**Contact:** Bernd Günther b.guenther@pmc-nordwest.de
	Oslo kommune (OSLO) NO-0037 Oslo Norway www.oslo.kommune.no	**Contact:** Patrycjusz Bubilek patrycjusz.bubilek@bym.oslo.kommune.no
	Fortum OYJ (FORTUM) FI-02150 Espoo Finland www.fortum.com	**Contact:** Jan Ihle jan.haugen@fortum.com
	PNO Consultants BV (PNO) NL.2289 DC Rijswijk Netherlands www.pnoconsultants.com	**Contact:** Francesca Boscolo Bibi Francesca.boscolo@pnoconsultants.com
	Universita Deglo Studi Della Campania Luigi Vanvitelli (SUN) IT-81100 Caserta Italy www.unicampania.it	**Contact:** Salvatore Venticinque salvatore.venticinque@unicampania.it
	University of Oslo (UiO) NO-0313 Oslo Norway www.uio.no	**Contact:** Geir Horn geir.horn@mn.uio.no
	ICLEI European Secretariat GmbH (ICLEI) DE-79098 Freiburg Germany www.iclei-europe.org	**Contact:** Stefan Kuhn stefan.kuhn@iclei.org **Innovation Manager:** Reggie Tricker reggie.tricker@iclei.org
	EGEN B.V. NL.2289 DC Rijswijk Netherlands www.egen.green	**Contact:** Simone Zwijnenberg Simone.zwijnenberg@egen.green

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.