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Full-Scale Pilot Implementation for Car Sharing

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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 is about the Full-Scale Pilot implementation in Bremen. The Bremen Pilot separates into two different demonstrators:

- GreenCharge@work demonstrator BRE 1 (PMC)
- eCar Sharing demonstrator BRE 2 (ZET)

The used components of both demonstrators are described in D2.11 *Pilot Component and Preparation for Full-Scale Pilot (Bremen)*. This deliverable portrays mainly the installation and configuration of the different components involved.

In the BRE1 demonstrator, the hardware setup including solar panels, inverters, battery systems as well as the gridctrl charging infrastructure system are the central components. The gridctrl charging infrastructure system allows the user to be guided within a set of different charging stations. At the time of writing, the setup and development of this key component is delayed. The version of the system that currently exists can:

- Provide charge services with fixed grid power limit
- Aggregate charging session data

A second development stage will follow, to provide a full operable demonstrator.

The BRE2 demonstrator is ready to collect the needed research data. The existing CarSharing system was replaced by the newly developed ZET system. This includes the change of the in-vehicle system within the EVs, the development of a new fleet management system and the deployment of a new CarSharing customer frontend (ZET App).

The new system is able to:

- Collect baseline research data
- Provide an optimized CarSharing Service to Customers
- Provide real-time information about Public Transport to CarSharing users

As of November 2019 – after a series of adjustments - a real-time dataflow test between all system components had been successfully implemented. Since then the BRE2 demonstrator can be described as fully operable.

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List of Abbreviations

Table 1: List of abbreviations

Abbreviation	Explanation
AAA	Authentication-Authorization-Accounting
App	Application
Auth	Authentication
BMS	Battery Management System
CDR	Charge Detail Record
CMS	Charge Management System
CPO	ChargePoint Operator
EMP	Emobility Provider
EV	Electric Vehicle
EVSE	E-vehicle supply equipment
ICT	Information and Communication Technologies
IoT	Internet of things
MNO	Mobile network operator
NEMS	Neighbourhood Energy Management System
OCPP	Open Charge Point Protocoll
OTA Key	
POI	Point of interest (in this case EVSE)
PV	Photovoltaics
SaaS	Software-as-a-Service
SC	Scenario
SoC	State of Charge
TCP	Transmission Control Protocol
UC	Use case

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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.
Demonstrator	Site for testing hardware and software solutions in the GreenCharge project.
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
Photovoltaic	Photovoltaic panels (solar cell panels) converts light into electricity using semiconducting materials
Scenario	A scenario describes a specific use of a proposed system by illustrating some interaction with the proposed system as viewed from the outside, e.g., by a user, using specific examples. In GreenCharge, a scenario is a higher level of description of the system and can be modelled using one or several use cases.
Use Case	A use case describes how a system will be used and is a tool for modelling requirements of a system. In GreenCharge, a scenario is a higher level of description of the system and can be modelled using one or several use cases.

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1 About this Deliverable

1.1 Why would I want to read this deliverable?

This deliverable describes the implementation of the two demonstrators at the Bremen pilot, i.e. the solutions developed for charging at work at BRE D1 and car-sharing at BRE D2. The deliverable gives an overview of hardware and software, new development and the integration of the different components for the demonstrators. The report also contains descriptions of the installation and configuration of the demonstrators.

1.2 Intended readership/users

This deliverable is mainly targeted to readers with technical knowledge on design and implementation of e-Mobility and / or car-sharing solutions.

The GreenCharge project partners involved on design, development or deployment 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 e-Mobility solutions with smart and green charging and also developers of car-sharing concepts and software for such solutions. Additional readers should be component providers that want to design components that fits the GreenCharge architecture.

1.3 Structure

The deliverable has a simple structure, reflecting the two different demonstration scenarios to be demonstrated in Bremen:

BRE.D1 – "GreenCharge@work" Charging preferably from on-site RES combined with stationary battery storage. Priority charging for certain EV-drivers, such as visitors and business EV's.
BRE.D2 – "eCar-Sharing in a residential neighborhood". Station-based CarSharing featuring more convenient and smarter way of booking and charging of the shared EVs.

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:

- D2.9 Description of Bremen Pilot and User Needs - this document describes the Bremen pilot in terms of challenges, user needs, use cases, scenarios, stakeholders and locations to be involved and the baseline.

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- D2.10 Implementation Plan for Bremen 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.
- D2.14 – Intermodal On-street Car Sharing Stations in New Housing Development – this document describes the new generation intermodal car sharing station with electric charging in low car- and low carbon.

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

- Oslo: D2.6 Full-Scale Pilot Implementation in Building Block - “Sister” delivery 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” delivery 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 deliverable describes the installation, configuration and deployment of the integrated prototype developed and 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.

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2 Overview Bremen Pilot

The Bremen pilot comprises the following 2 demonstrators:

I. BRE.D1 – "GreenCharge@work"
II. BRE.D2 – "eCar-Sharing in a residential neighborhood".

The sub-sections below provide a high-level description of the architecture of the two demonstrators. The two chapters which follow then provide full details of each of the two demonstators.

2.1 Architecture of GreenCharge@Work (BRE.D1)

The demonstrator BRE.D1 consists of a set of charging sites with different h/w specifications that can be managed together with the proprietary "gridctrl" charging system. This allows users to be guided to different charging stations depending on the occupancy status of the preferred station.

2.2 Architecture of eCar Sharing (BRE.D2)

BRE.D2 consists of one core system and two additions. The core system includes the In-Vehicle-System, the fleet management system and a customer car sharing frontend (CS-Frontend). Supplementing the core system with an interface for the local public transport system constitutes part of the CS#6 pilot site. The plan of installing a "Smart-Charge"- Backend changed, so this component was replaced. Read more about it in Chapter 4.1.

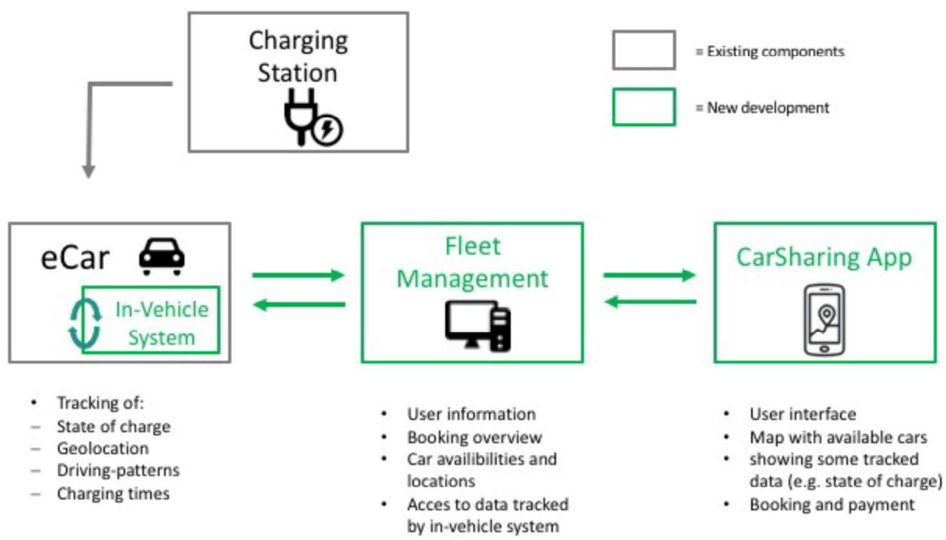

Figure 1: Architecture of demonstrator BRE.D2 ("eCar Sharing in a residential neighbourhood")

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3 GreenCharge@work demonstrator BRE.D1

The demonstrator BRE.D1 consists of a set of charging sites (CS#1-CS#4) with different specifications that can be managed with the proprietary "gridctrl" charging system. It's provided by one of the local stakeholders including custom extensions made for GreenCharge. The charging stations are divided into 3 functional groups to analyze different aspects of the charge@work showcase which is targeted to commuters who are recharging their private electric cars during the business hours:

Technology prototype CS#3

Including second life batteries, solar panels and advanced energy management. This site is completely re-engineered within GreenCharge project.

Derived technology prototype CS#1

Using the same technology as CS#3, but without storage or pv capabilities (to be integrated into an existing building with pv as prospective extension).

Off-the-shelf charging components CS#2, CS#4

Used as comparison to the prototypes (to provide reliable charging without having an impact to the users caused by the energy management).

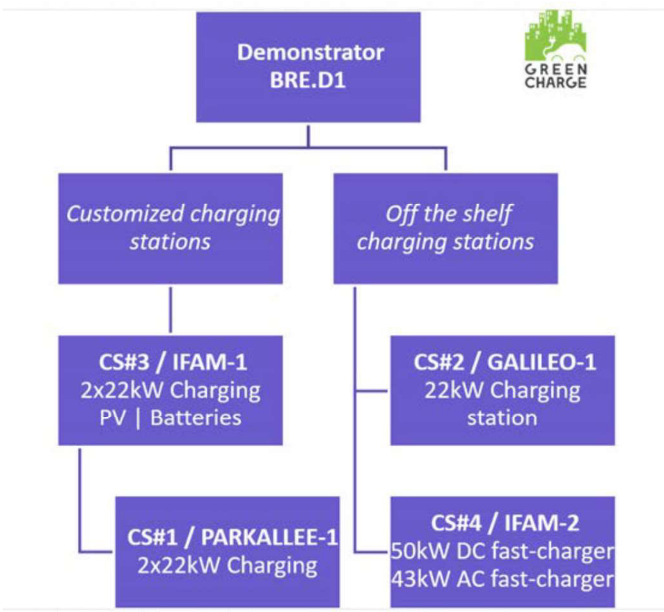

Figure 2: Comparison between customized and of-the-shelf components

3.1 Overall architecture and components involved

The following figure shows the top-level architecture of the demonstrator BRE.D1 including all charging stations, their connections and the global management system.

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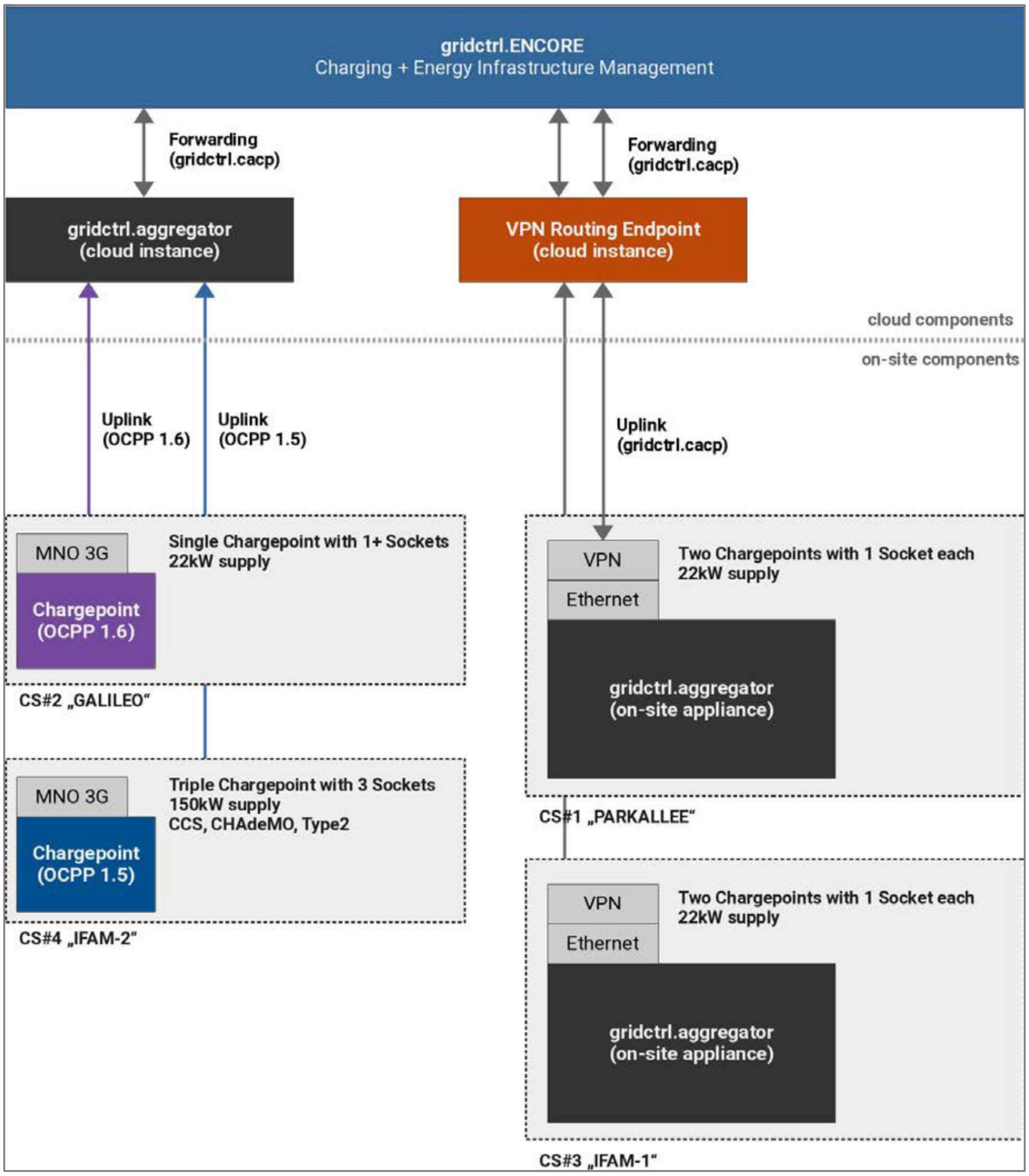

Figure 3: Architecture of the demonstrator BRE.D1 (GreenCharge@work)

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In this demonstrator GreenCharge@work the following core components are involved. The status and results from the tests of each component for integration in the demonstrator have been given in the table.

Component	Site	Type	Comment	Status
ZEBRA Battery System	CS#3	h/w	2 of 5 extracted batteries are operational	
PV Inverters	CS#3	h/w	Inverter is tested and operational	
PV Panels	CS#3	h/w	Panels are tested and in good condition	
Battery Inverters	CS#3	h/w	Inverters are not tested with the batteries yet	
Battery Chargers	CS#3	h/w	New chargers must be installed	
Smart Meters	CS#3	h/w	Smart meters are tested and operational	
Charge Controllers	CS#2,3	h/w	New charge socket controllers are tested, installed and operational	
Wallboxes (prototype)	CS#3	h/w	Wallboxes are installed, tested and operational	
DC Charger	CS#4	h/w	Station is operational but cannot record all the required datasets.	
Charging Station (residential student home)	CS#2	h/w	Station is operational but cannot record all the required datasets.	
Charging Station (parking garage)	CS#1	h/w	Uses the same technology as CS#3 for the charging outlets. Installation pending	
gridctrl.aggregator	ALL	h/w s/w	Initial version has been deployed to CS#3. Development version still in use	
gridctrl.ENCORE	ALL	s/w	Development version still in use	
Data Storage System	ALL	s/w	SQL based, distributed data storage system (MariaDB)	

Table 3: Components involved into the demonstrator BRE.D1

color-scheme: **no known issues**; **additional actions required for integration**; **major issues have raised**

3.1.1 ZEBRA Battery System (h/w component)

One major goal of the charging site #3 is the use of second-life-batteries as stationary energy storage. Most of the batteries used by this demonstrator are of the same type and extracted from "Think City" cars which were decommissioned due to various failures.

The "Think City" contains a high temperature, molten-salt, NaNiCl batterie of the type "ZEBRA", manufactured by "Fiamm SoNick". These batteries require an internal temperature of at least 240°C and do not have any self-discharge effects except for thermal losses caused by the thermal insulation.

Each battery was tested under laboratory conditions but only a very few of them passed all tests and were confirmed as operational. Currently there are only two batteries in full-operational state which can be used for the demonstrator. All other batteries need to be recycled by the manufacturer.

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Table 4: Overview of the second-life-batteries extracted from electric vehicles

Car	Battery status	Defective cells	Comment	Second life usability
Think City #1 (gen0)	Partially operational	20	High number of defective cells in a single string causes internal balancing currents (massively degrading system efficiency). Charging not possible without overriding the security systems.	**unusable**
Think City #2 (gen0)	Internal electrical isolation error	4	Emergency shutdown caused by the battery management system due to an internal electrical isolation error	**unusable**
Think City #3 (gen2)	Operational	0	Battery system (cells + containment + management) full operational	**perfect**
Think City #4 (gen2)	Operational	0	Battery system (cells + containment + management) full operational	**perfect**
Think City #5 (gen2)	Thermal insulation error	0	High thermal loss/dissipation must be compensated by using additional electrical energy (massively degrading system efficiency)	**usable**
Stationary Battery #6	BMI fault	N/A	The battery management interface is defective.	**unusable**

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Figure 4: Extraction of the ZEBRA battery system

Figure 5: Transport of the 300kg battery systems to CS#3

3.1.2 PV Inverter (h/w component)

Figure 6: SMA SunnyBoy single phase inverter

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3.1.3 PV Panels (h/w component)

No adaptions were required for pilot operation. The panels are in good condition and produce still enough energy.

3.1.4 Battery Inverters (h/w component)

Figure 7: SMA WindyBoy (for batteries) and SunnyBoy (for PV) inverters feeding into 3 phase system

3.1.5 Battery Chargers (h/w component)

3.1.6 Smart Meters (h/w component)

The technology prototype CS#3 has been equipped with state-of-the-art smart meters which enable a detailed collection of all electrical parameters for each phase of each charge-point. These smart-meters will also be added to the derived technology prototype CS#1.

Data acquisition capabilities:

- Per phase voltage/current/powerfactor
- Per phase power consumption (energy import+export)
- Total power consumption (energy import+export)
- Industrie standard Modbus-RTU over RS485 interface
- Live data acquisition with > 1Hz time resolution
- 40A/phase current limit

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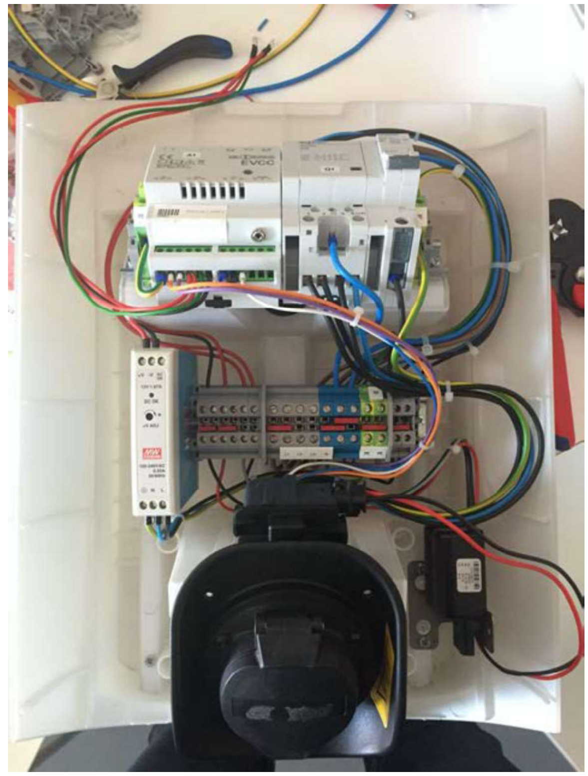
Figure 8: Bidirectional Smart Meter installed for each charging socket on CS#3

3.1.7 Chargepoint Controllers (h/w component)

3.1.8 Wallbox Prototype (h/w component)

	
Figure 9: Wallbox prototypes installed on CS#3	**Figure 10: Wallbox prototypes during laboratory testing**

3.1.9 gridctrl.ENCORE (s/w component)

This software component is briefly described in D4.3/D.4.4. As a proprietary component it can be only described in its overall functionality and not in detail.

The grid control aggregator is a new development that is under construction throughout the whole project. In its first (initial) version although being implemented it will not be able to extract data as needed.

The ENCORE backend still needs adjustments in the course of phase 1 comprising the following steps:

- Implement gridctrl.cacp protocol (required to connect to the aggregator instances)
- Added redundant, distributed database storage backend

3.1.10 gridctrl.aggregator (hw/ + s/w component)

This software component is briefly described in D4.3/D.4.4. As a proprietary component it can be only described in its overall functionality and not in detail.

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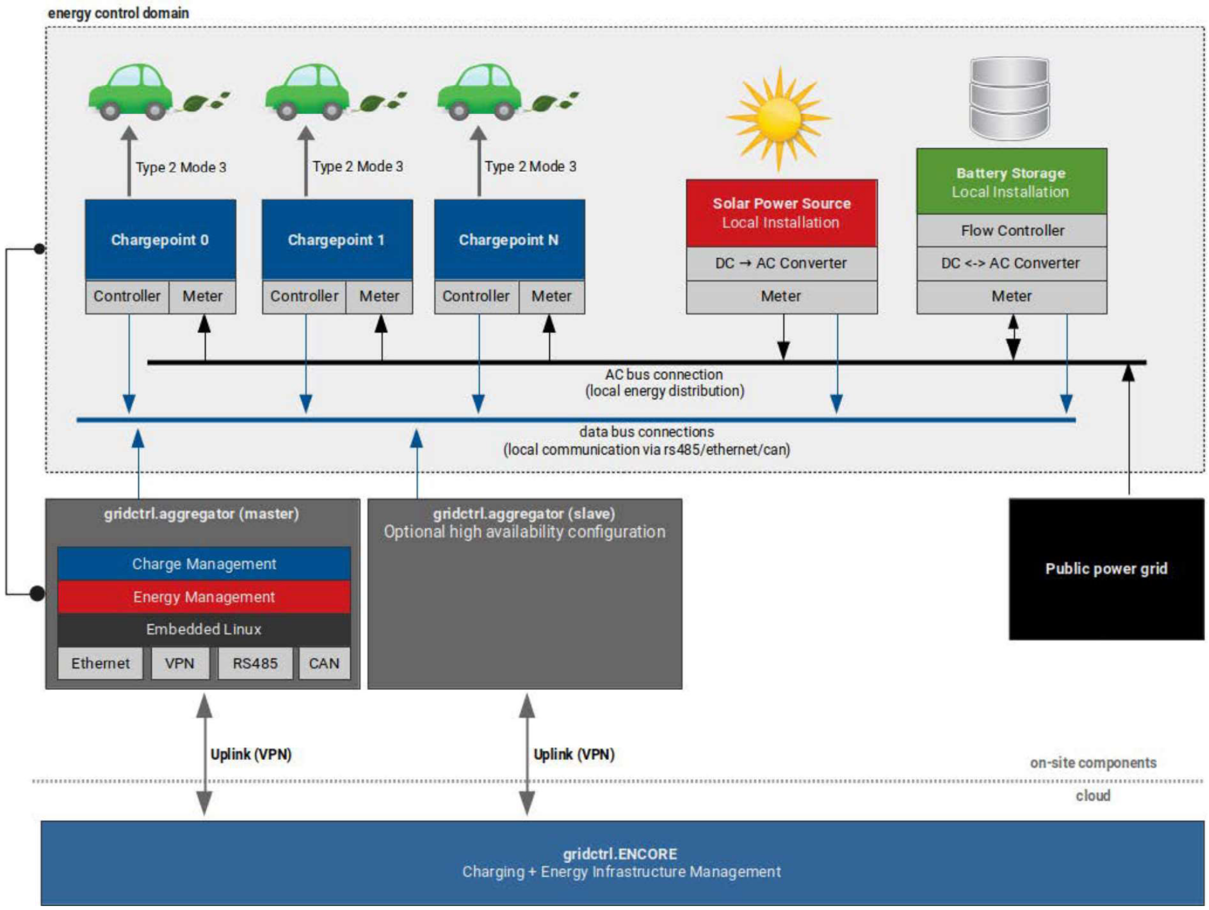

Figure 11: gridctrl.aggregator as the central management component of CS#3

Figure 12: gridctrl.aggregator operating system tests

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3.1.11 Data storage system

The real time data feeds are stored on a cloud instance of MariaDB (an open source sql database) using a distributed storage system as persistent media. This setup can be scaled up to a total 10TB storage space for each instance. In case the storage requirements may increase during the pilot operation the table space can be distributed over multiple instances. All software components used for this system are open source and just need a basic configuration. The cloud computing instances are provided by a german hosting provider which complies with all terms of the GDPR.

3.2 Installation and configuration of the demonstrator

Off-the-shelf charging components CS#2, CS#4

The off-the-shelf chargers are fully operational, but are only capable of providing a very limited dataset (session-logging and recording the total amount of energy provided during a session). Installation of additional data acquisition equipment failed to limitations caused by their proprietary architecture or EMI (electromagnetic interference) issues within the fast-charge enclosure. Overall, this made it impossible to install external sensors or dataloggers to these stations.

3.2.1 Technology prototype CS#3

Scope: private station with PV and 2nd-life battery storage ("carport")

Status: Full rework/re-engineering of the existing system. New charging points, smart meters have been added and tested. The initial version of this site is fully operational.

Figure 13: Prototypes installed on CS#3

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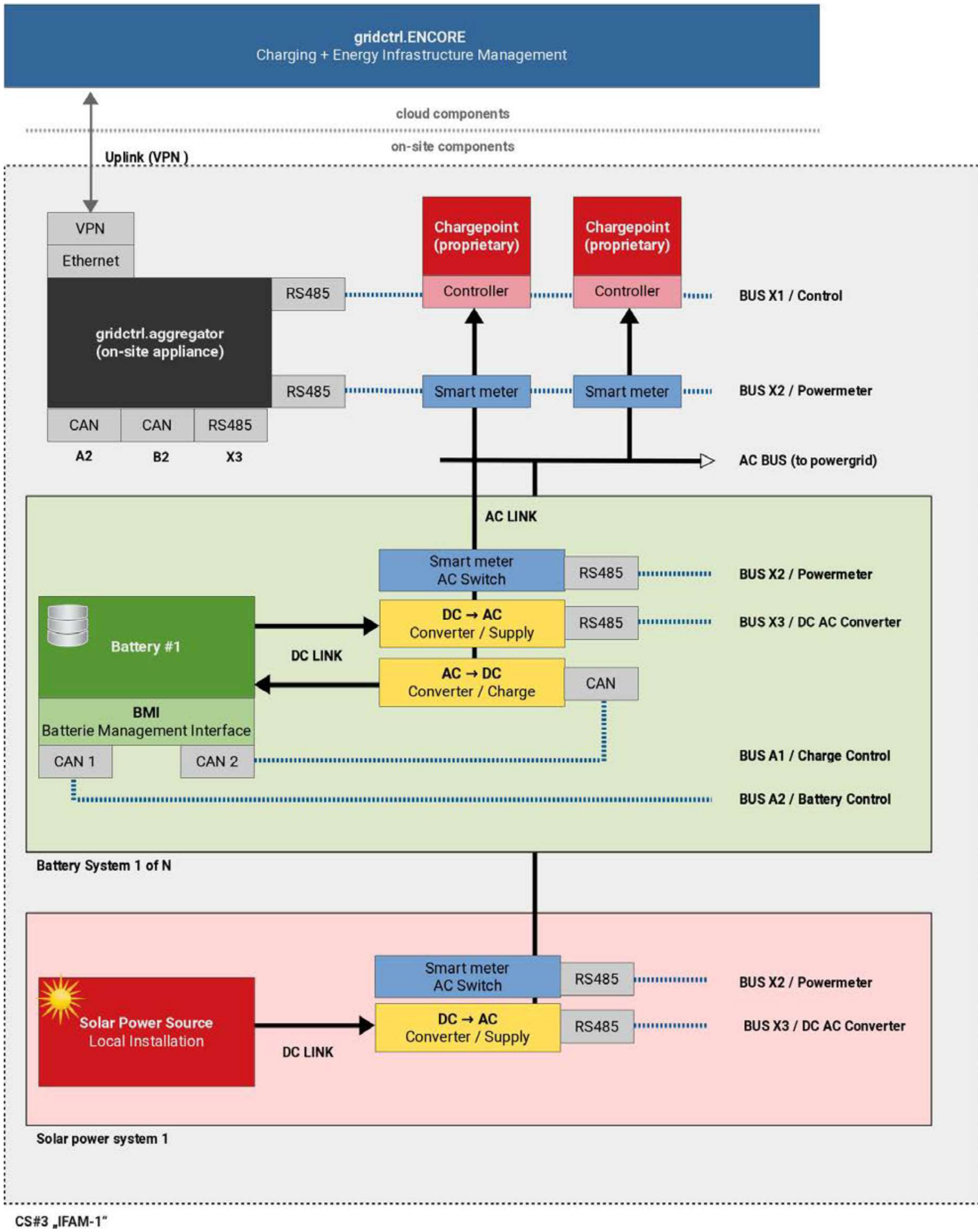

Figure 6: Systems architecture of the carport system (CS#3) comprising wallboxes, PV-panels, inverters and stationary 2nd life batteries and operated via ENCORE backend

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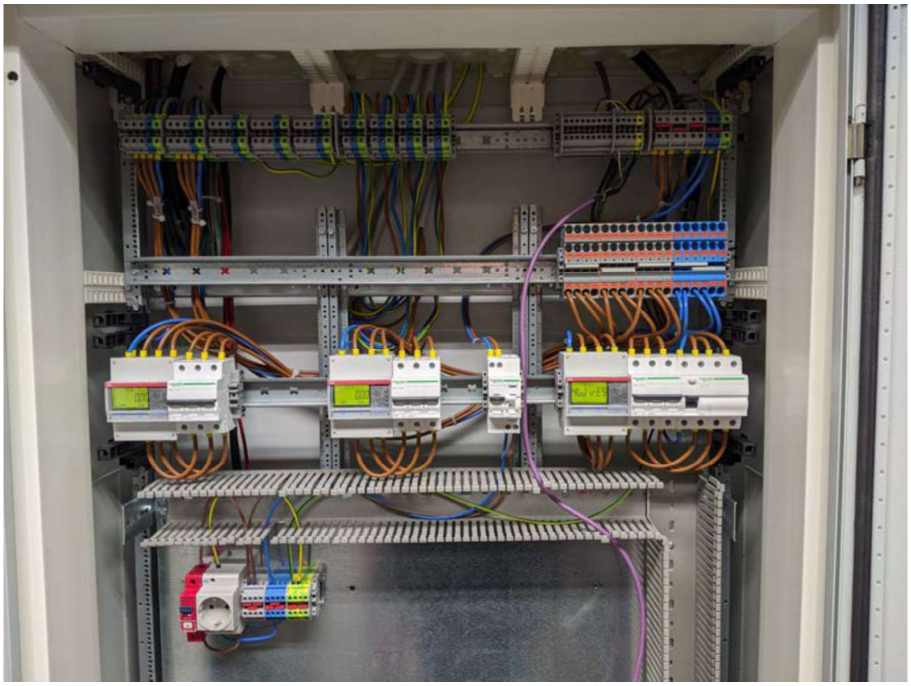

Figure 14: Phase 1 of rebuilding the electrical distribution system on CS#3

3.2.2 Derived technology prototype CS#1

Scope: a private charging station in an underground parking garage ("Parkallee").

Status: stock version is operational; the upgrade with the new components developed for CS#3 is pending.

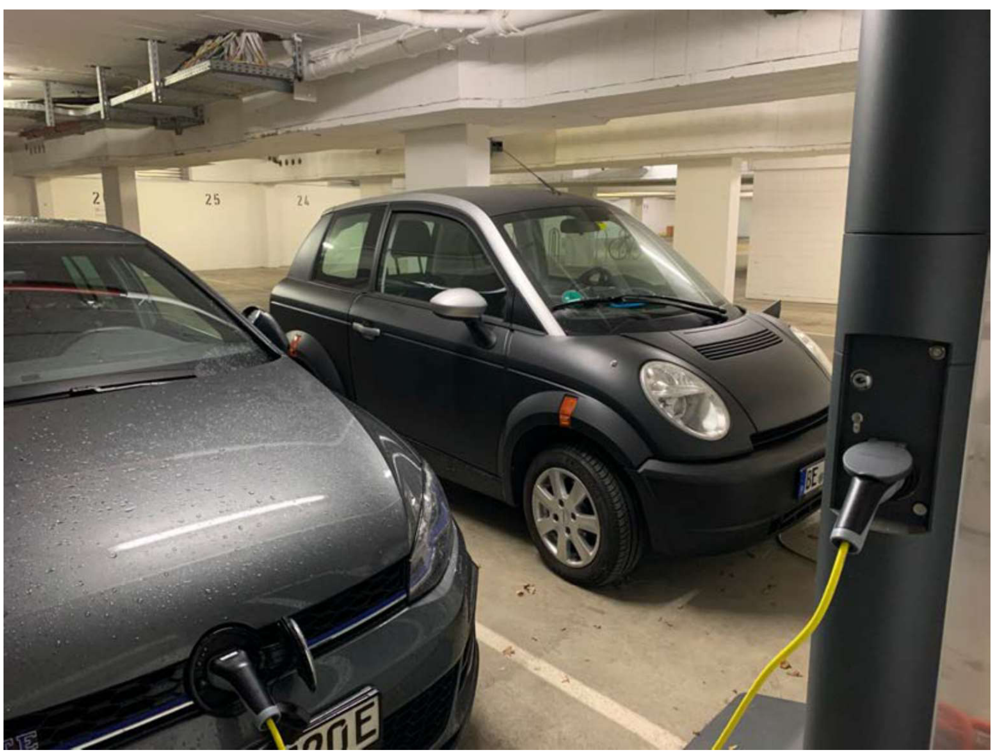

Figure 15: Electric car recharging on CS#1 using off-the-shelf configuration

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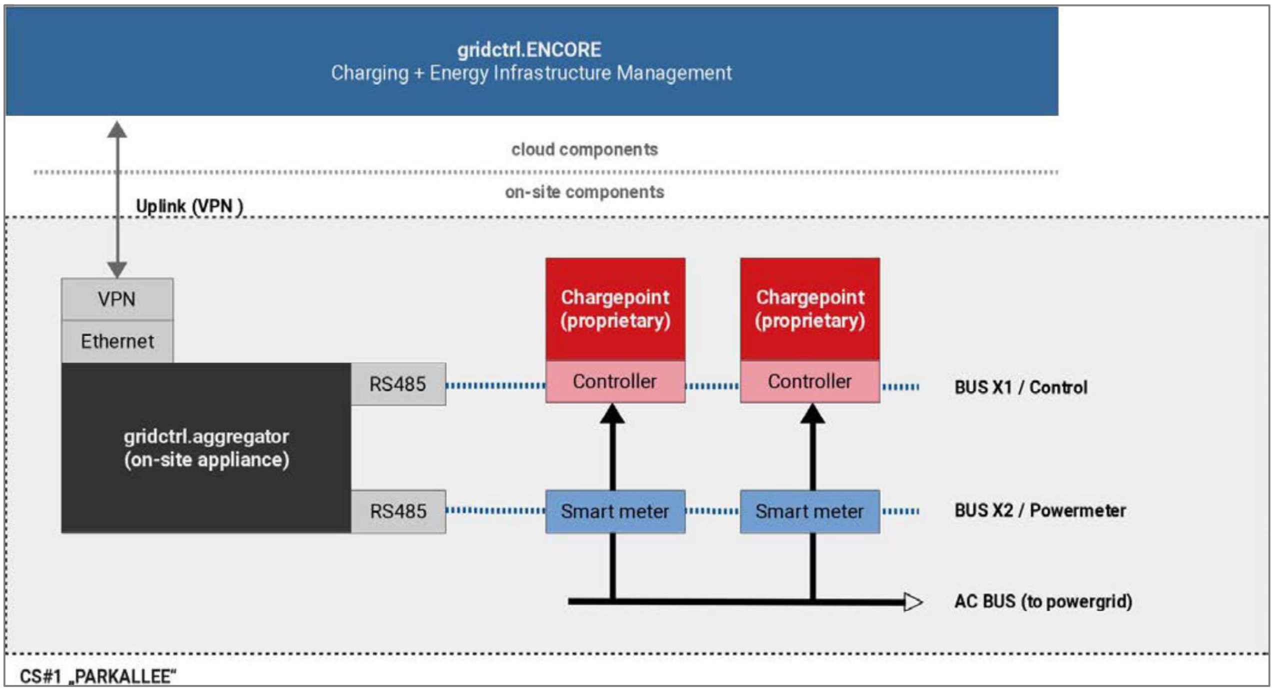

Figure 16: Architecture of the charging station CS#1 (underground parking garage)

3.2.3 Off-the-shell charging station CS#2

Scope: A private station on student apartment ground ("Galileo").

Status: The station is not operational yet due to contractual issues with the real owner, only tested/integrated under laboratory conditions. Subjected to be moved to CS#3 as an additional charging point.

Figure 17: Electric car recharging on CS#2

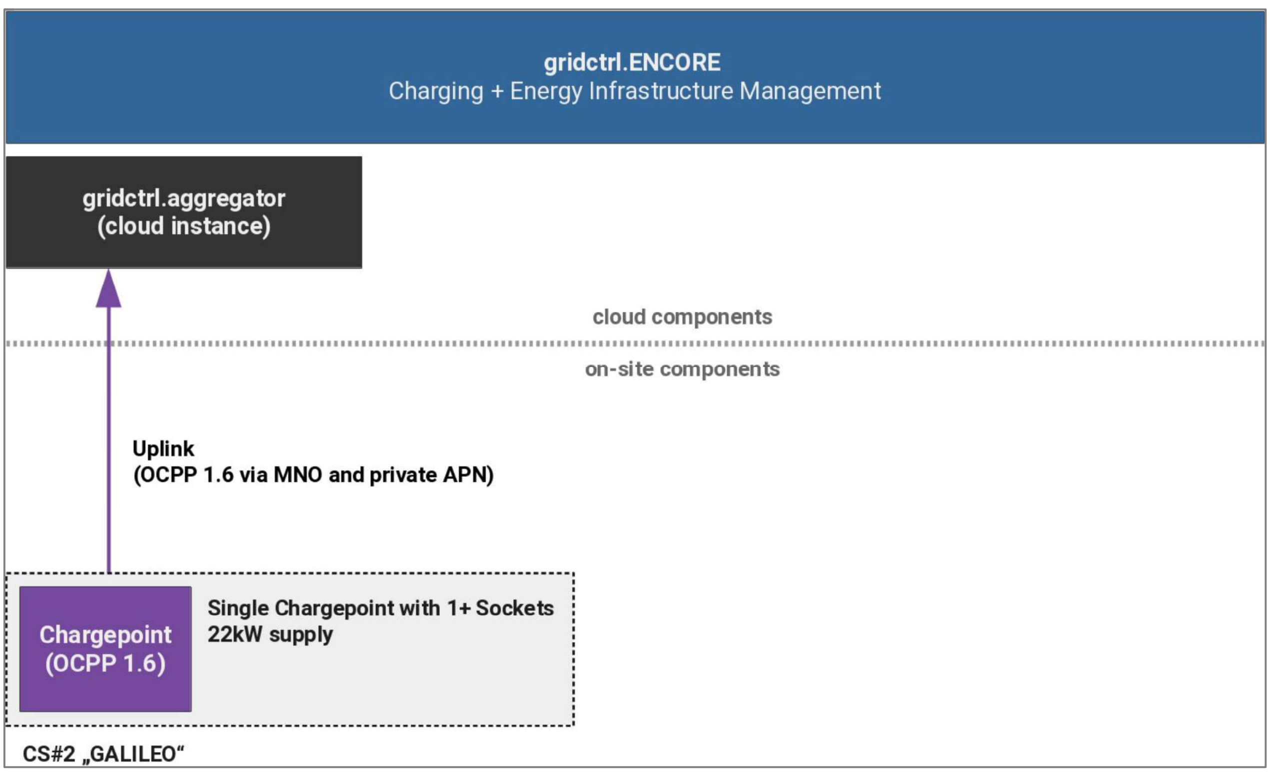

Figure 18: Architecture of the charging station CS#2 ("Galileo")

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.

3.2.4 Off-the-shelf fast-charging station CS#4

Scope: a private ac/dc fast-charger with 43kW AC output and 44kW DC output (CCS + CHAdeMO connector)

Status: The station is fully operational using the stock configuration. Installation of additional data acquisition equipment failed.

Figure 19: Electric car recharging on CS#4

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.

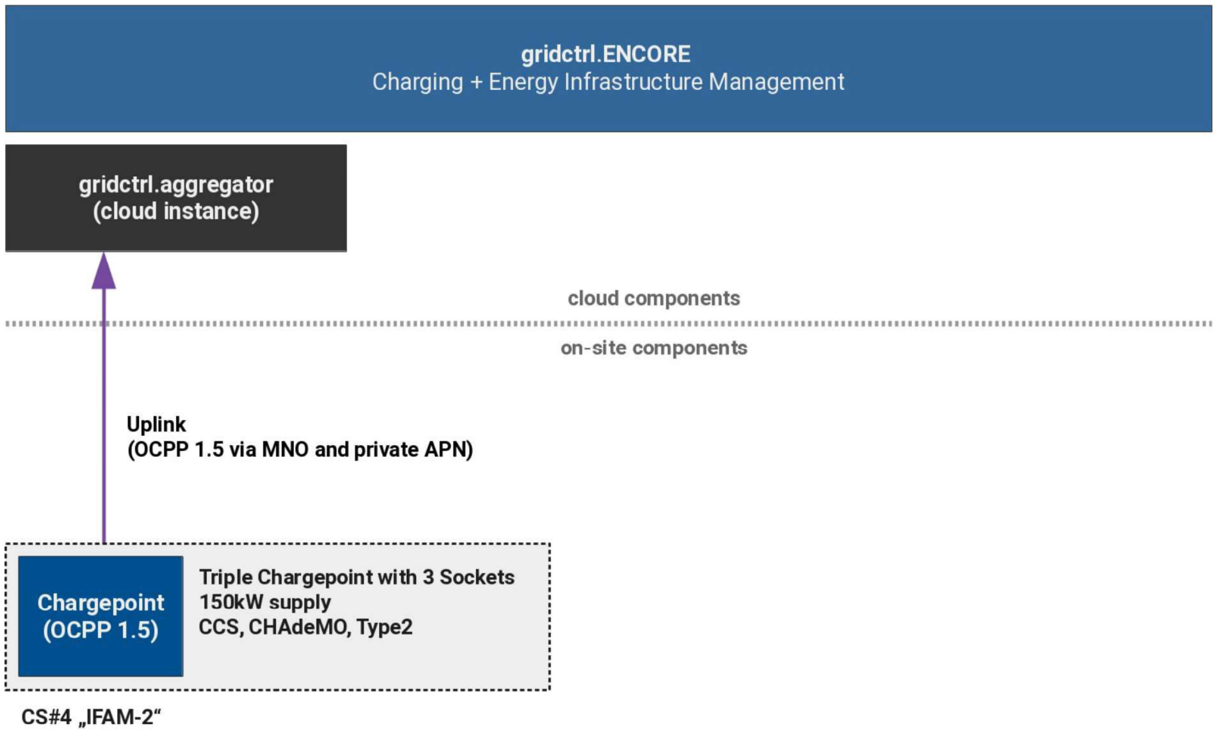

Figure 20: Outline of the combined ac/dc fast-charging station CS#4

3.3 Full test for the demonstrator

This action is pending until all components have been installed and tested (hardware+software) - estimated July/August 2020.

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4 eCar Sharing demonstrator BRE.D2

There are two different eCar-Sharing demonstrator sites delivering relevant research data to the project on two eCar-Sharing stations, where the components described in 4.1 are installed.

On CS#5/6? ZET is developing a solution to provide public transport data to their Car Sharing users, because we believe that the future of a mobility solution is an intermodal system. This development will increase the user experience to a new level. We are gathering data to analyse how this development increase the usage of public transport.

On CS5/6? ZET is providing together with local housing developers an exclusive Car Sharing solution for residents. In total ZET is handling up to four different housing stations across the city of Bremen. All stations are accessible for the public, residents are receiving a special discount. We are gathering data to analyse if opening the charging points to the public would be a business case.

4.1 Components implemented in the eCar Sharing demonstrator

Table 5: Overview of BRE.D2 components (source: Table 2 in D2.11 modified)

Component #no. / name	type	Test status	Owner / responsible
1) Miveo	s/w	Backup-System running	MOVA
2) Car computer	h/w	Backup-System running	MOVA
3) OTA-Key	h/w	System installed and running	MOVA
4) EV-fleet	h/w	Nissan Leaf	MOVA
5) Wallboxes	h/w	5 Wallboxes installed at parking slots. Access by RFID-interface	External / MOVA
6) Fleet management system	s/w	Backend system developed by ZET, initial version is running	MOVA
7) CS-Frontend	s/w	Application developed by ZET, testing in operational use	MOVA

Current status (10/2019) indicated as follows:	
green	(Nearly) Ready to go for usage in Full-scale Pilot
yellow	Minor/routine work to be done to adopt for Full-Scale Pilot
red	h/w: upgrade/redesign key parts --- s/w: update with re-design to adopt for Full-Scale Pilot
grey	Usage of this option is not decided yet OR it will be replaced with an alternative

The table shows the components in the current demo implementation. Compared to Table 2 in D2.11, some adaptions and updates have been introduced, which will be presented in Section 4.2. (Adaptations done for the demo)

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 Adaptions done for the eCar-Sharing demonstrator

1) s/w and h/w change

As denoted in Table 3 the items 2 and 3 are operating. The *miveo*-system was replaced and the OTA-Keybox installed in all EVs sending the following information to our fleet management backend:

- Vehicle-ID
- State of Charge (SoC)
- Charging Started/Ended
- Estimation of km-range
- Geolocation
- Driving patterns

Since already the in-vehicle-system delivers charging data, a “SmartCharge” backend will not be installed. The only relevant information of such a backend would have been the timestamps, when charging started/ended. Since the OTA Key Box sends this information as well, this solution allows an optimized return of investment.

2) RFID-interface

A RFID-interface with the vehicle is not needed anymore, because of the development of a smartphone App. This Application is the so-called Car Sharing (CS-) Frontend developed by ZET for enabling booking and payment of an EV via Smartphone. This App, together with the OTA-Key Box, replaces the mechanical vehicle key. This solution will probably improve the costumer’s experience and minimize the maintenance effort.

However, the start and the end of the charging process needs to be authorized. A RFID-interface is still the only opportunity to access the Charging Station. It is not possible to connect the existing charging infrastructure to the ZET Application so far.

3) EV-Fleet

The EV-Fleet is running in daily business in several spots all over Bremen. The old *miveo*-in-vehicle-system is replaced by the OTA-Key Box but is still serving as a backup system.

The GTS fleet management software is replaced by a self-developed fleet management software. This software is running and sending data between the in-vehicle-system (OTA-Key) and the user interface (CS-frontend). The new frontend (App) is available for *android* and iOS (more detailed information about the software is provided in D4.3.). The new Car Sharing App provides an optimized service to the customer as well as it delivers the needed research data to the GreenCharge Project.

4.3 Installation and configuration of the demonstrator

The OTA-Key box needed to be connected with the fleet management software and the CS-frontend developed by ZET (MOVA). OTA-Key provides a software development kit (SKD) to implement their box in different software solutions. The used car sharing system was built around a few interfaces by using the provided software library. More details are given in D4.3.

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Table 6: List of implementation issues - dates and testing results

Testing	Date	Description	Status
Installation of test-vehicle key in OTA-Key Box	10.05.2019	EV-key sent to OTA-Key. Incorporation, installation and registration of EV- key.	Success.
Installation OTA-Key to EV (Nissan-Leaf)	15.05.2019	First connection of OTA Key Box to EV by OBD2.	Success.
Connection of OTA-Key Box and CS-System	15.05.2019	First connection of OTA-Key Box and CS-System. Testing of key functionality.	Failed Adaption needed.
Connection of OTA-Key Box and CS-System (2)	20.05.2019	Cconnecting OTA-Key Box and CS-System. Testing of key functionality.	Success.
Send and receive data to/from EV	31.05.2019	Connection of OTA-Key Box and CS-System	Success
Installation of all vehicle keys in OTA-Key Boxes	03.06-24.06.2019	Vehicle keys send to OTA-Key. Incorporation, installation and registration of vehicle keys.	Success
Re-equipment of EV-fleet	29.06.-05.07	Connecting OTA Key Box to vehicle by OBD2.	delayed
Connection of OTA-Key Boxes and CS-System	08.07.2019	Connection of OTA-Key Boxes and CS-System. Testing of key functionality and dataflow	3 error reports. Adaptions needed.
Connection of OTA-Key Boxes and CS-System (2)	12.07.2019	Connection of OTA-Key Boxes and CS-System. Testing of key functionality and dataflow	2 error reports. Adaptions needed.
Connection of OTA-Key Boxes and CS-System (3)	20.07.2019	Connection of OTA-Key Boxes and CS-System. Testing of key functionality and dataflow	Success.
Connection Frontend to OTA-Key.	12.08.2019	Testing of booking via Application	Failed. Adaption needed

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 Frontend to OTA-Key (2)	19.08.2019	Testing of booking via Application	Registration failed. Database error.
Connection Frontend to OTA-Key (3)	09.09.2019	Testing of booking via Application	Success.
Implantation of public transport live data	30.09.2019	Testing the availability of live data	Success.
(Internal) User experience	01.10.2019-31.10.2019	Testing of usability in real live scenarios	Success.
Real-time dataflow	12.11.2019	Testing of real-time dataflow according to concert GreenCharge requirements	Success.
Product launch / data collection	14.11.2019		

4.4 Full test for the demonstrator BRE.D2 (eCar Sharing)

4.4.1 Connection of in-vehicle- and fleet management system

As described in section 4.3, one of the main issues according the installation and configuration of the pilot, is the connection between the OTA-Key in-vehicle system and the fleet management backend system. The OTA-Key box sends multiple data to the backend, which allows a databased management and maintenance of the EV fleet.

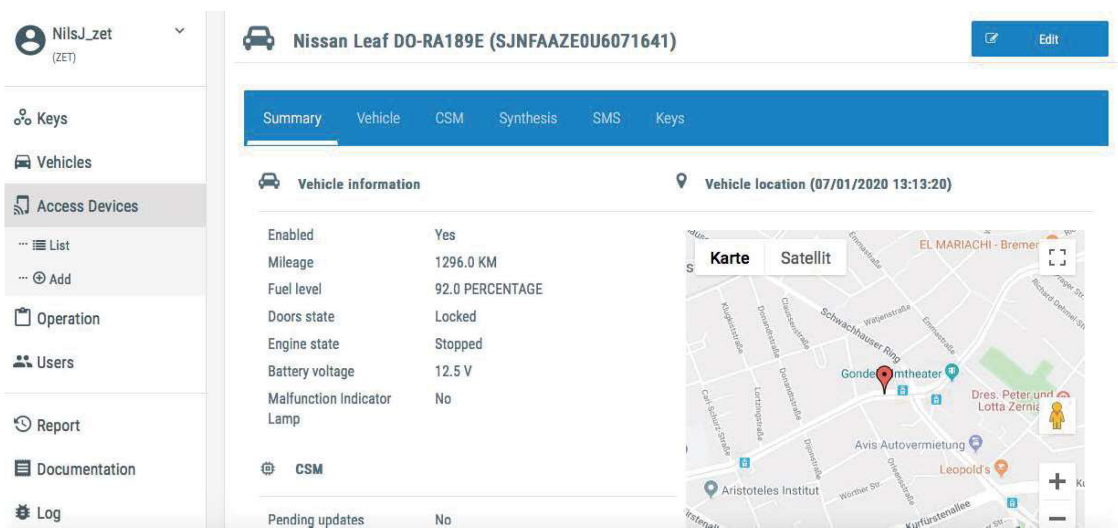
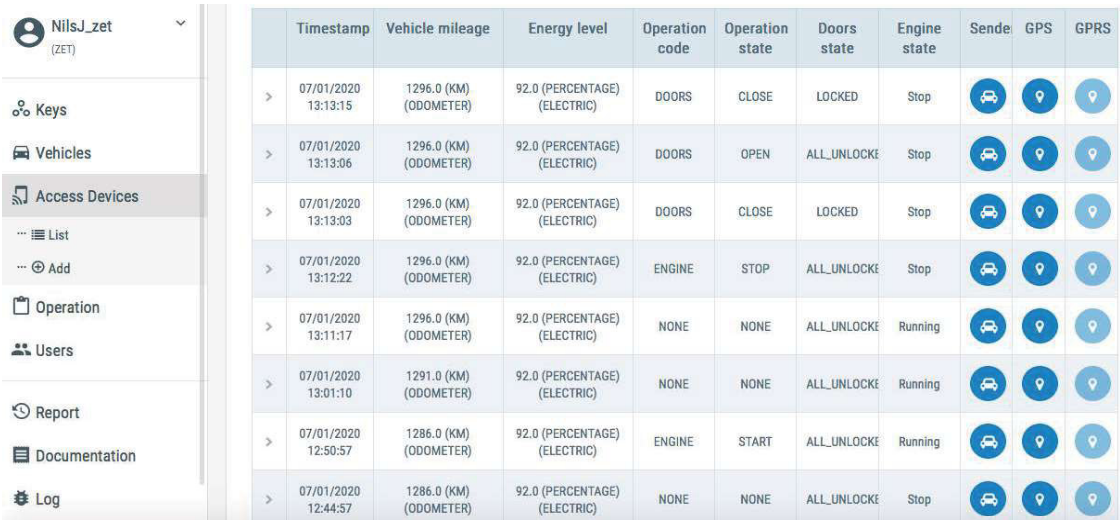


Figure 8, Screenshot fleet management system

The fleet management system provides a detailed overview about management relevant vehicle data like e.g. the geolocation of the vehicle (Figure 8) or the nearly real-time energy level (Figure 9).



	Timestamp	Vehicle mileage	Energy level	Operation code	Operation state	Doors state	Engine state	Sende	GPS	GPRS
>	07/01/2020 13:13:15	1296.0 (KM) (ODOMETER)	92.0 (PERCENTAGE) (ELECTRIC)	DOORS	CLOSE	LOCKED	Stop			
>	07/01/2020 13:13:06	1296.0 (KM) (ODOMETER)	92.0 (PERCENTAGE) (ELECTRIC)	DOORS	OPEN	ALL_UNLOCKE	Stop			
>	07/01/2020 13:13:03	1296.0 (KM) (ODOMETER)	92.0 (PERCENTAGE) (ELECTRIC)	DOORS	CLOSE	LOCKED	Stop			
>	07/01/2020 13:12:22	1296.0 (KM) (ODOMETER)	92.0 (PERCENTAGE) (ELECTRIC)	ENGINE	STOP	ALL_UNLOCKE	Stop			
>	07/01/2020 13:11:17	1296.0 (KM) (ODOMETER)	92.0 (PERCENTAGE) (ELECTRIC)	NONE	NONE	ALL_UNLOCKE	Running			
>	07/01/2020 13:01:10	1291.0 (KM) (ODOMETER)	92.0 (PERCENTAGE) (ELECTRIC)	NONE	NONE	ALL_UNLOCKE	Running			
>	07/01/2020 12:50:57	1286.0 (KM) (ODOMETER)	92.0 (PERCENTAGE) (ELECTRIC)	ENGINE	START	ALL_UNLOCKE	Running			
>	07/01/2020 12:44:57	1286.0 (KM) (ODOMETER)	92.0 (PERCENTAGE) (ELECTRIC)	NONE	NONE	ALL_UNLOCKE	Stop			

Figure 9, Screenshot fleet management system

4.4.2 Connection of fleet management system and CS-frontend

The fleet management system is the link between all system components. The fleet management system uses the data delivered by the in-vehicle system to provide information about booking opportunities to the CS-frontend and in this way to the customer.

Is an EV ready to be booked, it appears on the interactive map within the ZET application. With a click on the icon, a customer can book the chosen vehicle.

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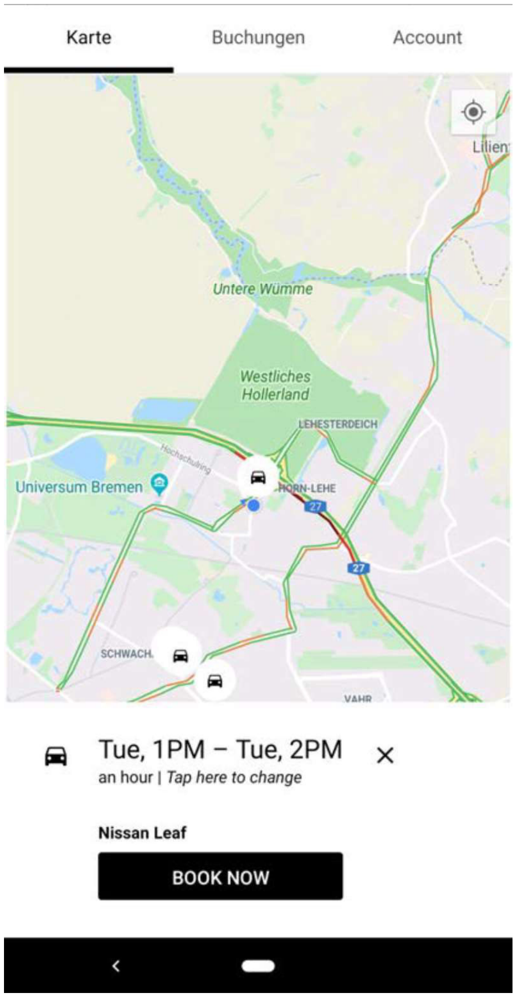

Figure 21: Interactive map for booking of vehicle

4.4.3 Registration, booking and payment

The new CS-frontend makes it much easy for the costumer to sign in for the car sharing service. According to the German law, a car sharing provider needs to check license of a customer and save a copy of it. The new App allows the customer to take a photo of its driving license and upload it directly, so the registration in done within minutes.

In this step, the costumer also needs to choose the preferred payment method. Payment can be done by a credit card or by PayPal.

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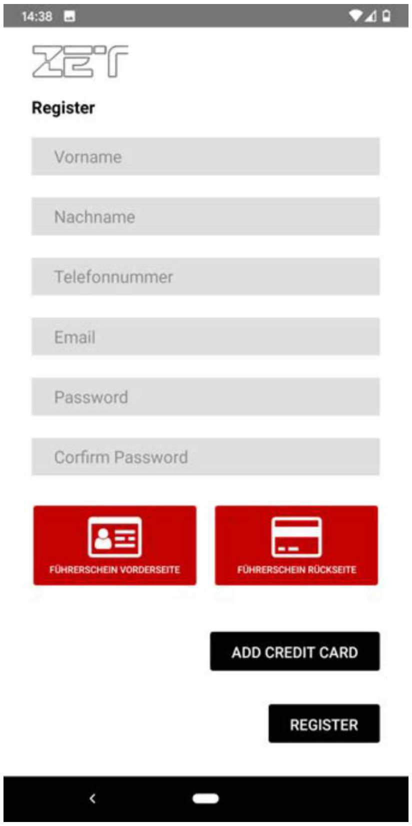

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5 Further Work

5.1 GreenCharge@work demonstrator BRE 1 (PMC)

The development and engineering of the second live battery storage system (CS#3) took much more resources and effort as initially projected. On the other hand, this site is the only one which provides the ability to test innovative technologies which can reduce grid power usage and optimize self-consumption in context of electric vehicle charging with full renewable energies.

Therefore, we have focused our project activities on this site with its enhanced data recording capabilities due to the full customized hardware. The Other (stock) charging stations are only providing a very limited dataset which doesn't fulfill the data recording requirements made in the project.

5.1.1 eRoaming Implementation

"Currently there is no eRoaming system implemented in this demonstrator. As a prospective extension within the project, the Hubject HBS eRoaming system can be integrated to enable temporary access to the corporate charging infrastructure to visitors without the requirement of dedicated charging-vouchers or guest accounts." (Source: D4.3)

The figure below shows a proposal which components need to be customized to enable the eRoaming. This affects primarily the gridctrl charge management 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.

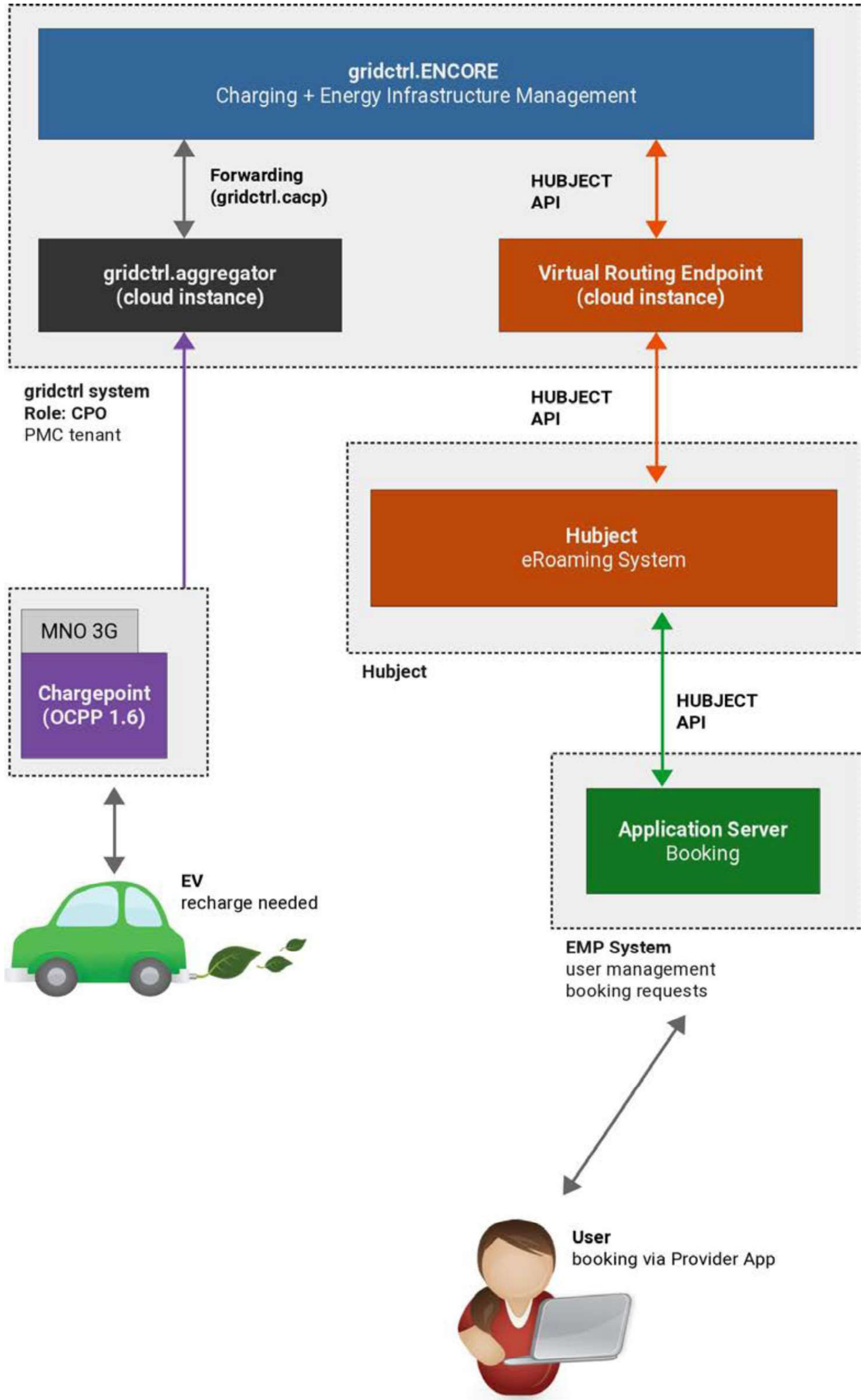

Figure 22: Components involved into a prospective eRoaming approach

An implementation of this approach is not decided, as it is not fully clear whether sufficient resources will be available.

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.

5.2 eCar Sharing demonstrator BRE 2 (ZET)

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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