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GreenCharge Project Deliverable: D2.11

Pilot Component Preparation for Full-Scale Pilot (Bremen)

Authors:

Andi Dittrich, Bernd Günther, Markus Spiekermann
(Personal Mobility Center NordWest eG)

Nils Jakubowski, Lars Meyer (ZET GmbH, formerly Move-About GmbH)

www.civitas.eu

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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: Joe Gorman, joe.gorman@sintef.no

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

Executive Summary

In this description the various components that are needed for prototyping the use cases in the Bremen pilot are listed and assessed regarding their level of importance for the pilot, their respective readiness, and the options that are envisaged for their integration, when the full-scale pilot starts in September 2019.

The components are described in the following 2 sections:

- h/w (Hardware) comprising charging stations, EV fleet (incl. CarSharing computers), and electric energy supply via on-site solar power and buffer battery storage;
- s/w (Software) comprising 2 backend solutions (SmartCharge, gridctrl.ENCORE), a CarSharing booking App (GTS), and Software for automatic data collection (GTS and OtaKeys).

Regarding h/w, the most important items are the 6 charging stations, which partially still need upgrading to participate in the demonstration process. Adaptable backend- and frontend-s/w (SmartCharge) has to be integrated and must connect to the energy management system and the in-car services provided by the EV-fleet operator.

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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List of Abbreviations

Table 1 List of abbreviations

Abbreviation	Explanation
API	Application Programming Interface
BEV	Battery(-operated) Electric Vehicle
CMS	Charge Management System
CP	Charging Point (as a connecting part to a charging station)
CPO	Charging Point Operator
CS	Charging Station (comprising 1 or multiple charging points)
EV	Electric Vehicle
GDPR	General Data Protection Regulation
GTS	Good Travel Software is a s/w-backend solution for the CarSharing operator
LDAP	Lightweight Directory Access Protocol
NFC	Near-Field Communication
OCPP	Open Charge Point Protocol – an open protocol/specification to connect charge points to a backend system
RADIUS	Remote Authentication Dial-In User Service
RES	Renewable Energy System
s/w and h/w	Software and Hardware
SC	Scenario (described in the "Description of Work" of the GreenCharge project)
SIM	Subscriber Identity Module
SLB	Second-Life Battery (used automotive traction battery applied for stationary energy storage)
UC	Use Case (see also chapter 4.3 in D2.9, where the 4 use cases for the Bremen pilot have been defined)
VPN	Virtual Private Network – a "private" connection between multiple peers carried over an existing network (e.g. internet)
VRF	Virtual Routing and Forwarding
WAN	Wide Area Network

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1 About this Deliverable

1.1 Why would I want to read this deliverable?

This deliverable gives you information about all the components that have been selected, tested and assessed to prepare the Bremen pilot. We indicate the different systems/ components that are going to be used both at the software and hardware level.

1.2 Intended readership/users

This deliverable should be of interest to all participants within the project consortium, who are in charge of implementation and testing the prototypes for the 3 pilots. It is particularly useful for the “software partners”, who are providing smart solutions to GreenCharge electric vehicles. It is also of interest to an external reader who wants to know which components will be used in the Bremen pilot.

1.3 Other project deliverables that may be of interest

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

- **D2.1 Initial Strategic Plan for Pilots -** This deliverable D2.11 is input to the strategic plan.
- **D2.9 Description of the Bremen Pilot and User Needs** – Describes the Bremen pilot in terms of challenges, user needs, use cases, scenarios, stakeholders and locations involved and the baseline.
- **D2.10 Implementation Plan for Bremen Pilot** – Describes the planning of the tests to be carried out at the pilot site. It includes scenarios to be demonstrated, time schedules, stakeholders and locations selected, users selected for workshops and for testing, hardware and software to be installed, tests to be run, data to be collected, together with supporting measures.
- **D2.5 and D2.18 Pilot Component Preparation for Full-scale Pilot (Oslo and Barcelona, resp.)** – "Sister deliverables” describing the respective preparation part for s/w and h/w for the Oslo and Barcelona pilot.
- **D4.3 / D4.4 / D4.5 Initial/revised/final version of Integrated Prototype** -
The s/w and h/w components described in this D2.11 are adapted in the integrated prototype.

1.4 Other projects and initiatives

Some h/w-components that are being used in the Bremen pilot originate from the initiative “Modellregion Elektromobilität Bremen/Oldenburg”, which was funded by the federal ministry for transportation and infrastructure BMVI in Germany in 2010-2015.

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2 Table of Pilot-Site Components

Table 2 in this section presents an overview of all the s/w- and h/w-components to be used in the Bremen pilot for the various charging stations (CS#1-6). Charging stations CS#1-4 are operated by PMC, whereas charging stations CS#5-6 are operated by ZET GmbH (partner MOVA). Each component is specified in more detail in section 3 "Pilot-Site Software Components" and in section 4 "Pilot-Site Hardware Components". It should be mentioned that s/w-components are identified for both employed backend solutions (ENCORE and SmartCharge) to integrate with roaming platform.

Table 2 Components to be used and implemented in the Full-scale Bremen pilot

	Component name	**type**	**Cha pter**	**Scenario (SC) Use case (UC) (see Appendix)**	**Test status**	**respon-sible partner**	
	gridctrl.ENCORE (backend)	s/w	3.1	SC#4 UC#1,2	Requires minor adjustments	PMC	
	gridctrl.aggregator (component)	s/w h/w	3.2	SC#4 UC#1,2	Requires new development	PMC	
	CS#1 ("PARKALLEE") (display-CS)	h/w	4.1	SC#4 UC#2	To be tested with ENCORE	PMC	
	CS#2 ("GALILEO")	h/w	4.2	SC#4 UC#2	In the status of being upgraded	PMC	
	CS#3 ("IFAM-1") with solar power system	h/w	4.3	SC#4 UC#2	Requires adjustments (upgrade from 1-phase to 3-phase system)	PMC	
	2 wallboxes (part of CS#3)	h/w	4.3	SC#4 UC#2	Minor work to put in place	PMC	
	3 battery storage modules (part of CS#3)	h/w	4.4	SC#4 UC#2	Tested individually; to be stacked to comprise a storage capacity of >60kWh	PMC	
	CS#4 ("IFAM-2") dc-(fast-)charging	h/w	4.3.4	SC#3 UC#1	Running system; agreement with owner (IFAM) achieved	PMC	
	CS#5 ("KISSINGER")	h/w	4.6	SC#7 UC#4	Running system; minor work needed for adjustment with SmartCharge backend	MOVA	
	CS#6 ("RICARDA-HUCH")	h/w	4.6	SC#7 UC#3	Running system; agreement with stakeholder SWB still pending (CPO)	MOVA	
	Miveo	s/w	3.3	n.a.	Will be replaced by the combined usage of OTA-Key and GTS	MOVA	

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	OTA-Key	s/w	3.7	SC#7 UC#3,4	Required new development	MOVA	
	SmartCharge (CMS for CS#5 and CS#6)	s/w	3.5	SC#7 UC#3,4	Required new development	MOVA	
	RFID-interface	s/w	3.6	SC#7 UC#3,4	Necessity will be decided by 10/2019 and depends on the availability of mobile applications	MOVA	
	EV-fleet	h/w	4.5	SC#7 UC#3,4	Running EV's (Nissan-Leaf)	MOVA	
	Car computer	h/w	4.5	SC#7 UC#3,4	Running system; already built-in and tested	MOVA	
	GTS	s/w	3.4	SC#7 UC#3,4	Required new development	MOVA	

Current status (09/2019) indicated as follows:		
		Nearly ready to go for usage in Full-scale Pilot
		Minor/routine work to be done to adopt for Full-Scale Pilot
		h/w: upgrade/redesign key parts --- s/w: update with re-design to adopt for Full-Scale Pilot
		Usage of this option is not decided yet OR it will be replaced with an alternative

The above s/w- and h/w-components are needed for a system that will prototype the use cases as defined in detail in D2.9. The use cases (UC#1-4) and the respective scenarios (SC#3, 4, 7 from the DoW) are outlined in the Appendix 6.1 and 6.2, respectively.

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3 Pilot-Site Software Components

3.1 gridctrl.ENCORE

This component represents a combined charge-point infrastructure and energy management system owned by one of the stakeholders (Aenon Dynamics - a member company of PMC eG).

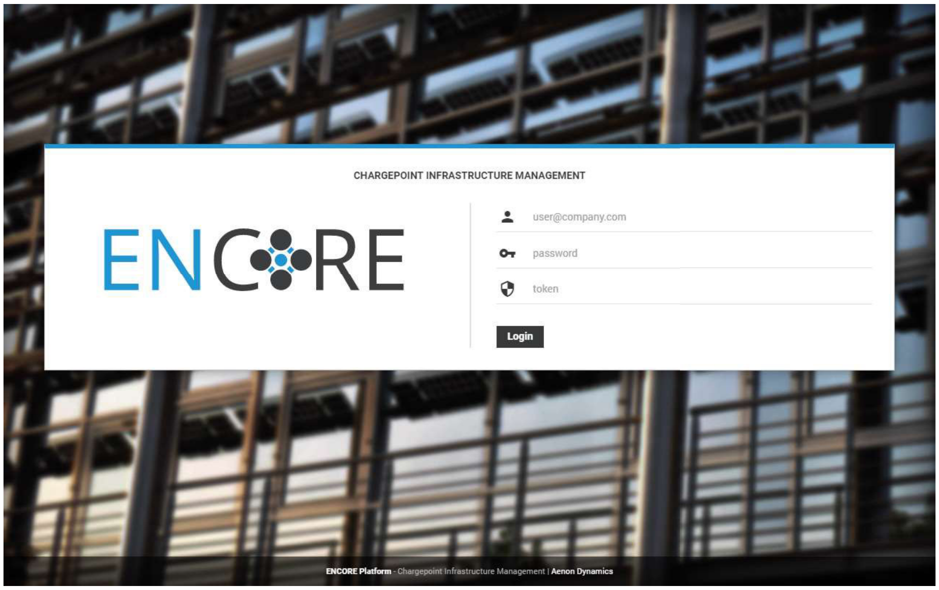
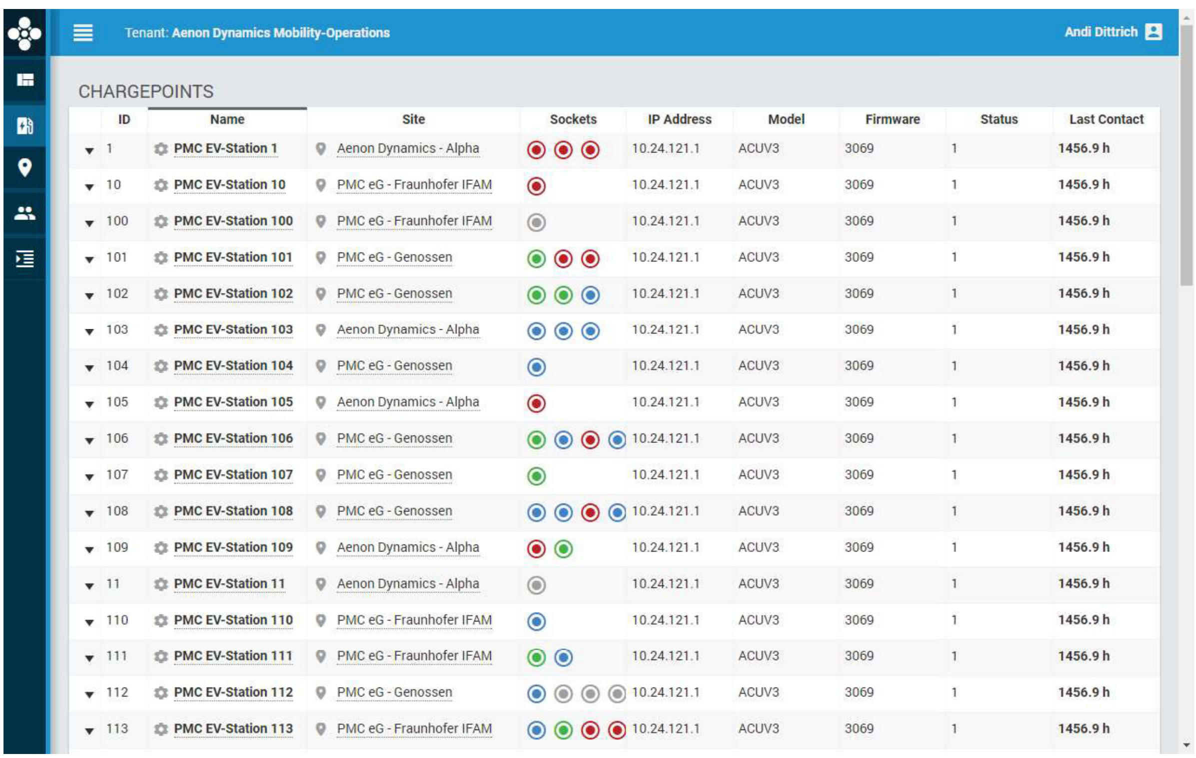


Figure 1: gridctrl.ENCORE user authentication



Tenant: Aenon Dynamics Mobility-Operations

Andi Dittrich

CHARGEPOINTS

ID	Name	Site	Sockets	IP Address	Model	Firmware	Status	Last Contact
1	PMC EV-Station 1	Aenon Dynamics - Alpha		10.24.121.1	ACUV3	3069	1	1456.9 h
10	PMC EV-Station 10	PMC eG - Fraunhofer IFAM		10.24.121.1	ACUV3	3069	1	1456.9 h
100	PMC EV-Station 100	PMC eG - Fraunhofer IFAM		10.24.121.1	ACUV3	3069	1	1456.9 h
101	PMC EV-Station 101	PMC eG - Genossen		10.24.121.1	ACUV3	3069	1	1456.9 h
102	PMC EV-Station 102	PMC eG - Genossen		10.24.121.1	ACUV3	3069	1	1456.9 h
103	PMC EV-Station 103	Aenon Dynamics - Alpha		10.24.121.1	ACUV3	3069	1	1456.9 h
104	PMC EV-Station 104	PMC eG - Genossen		10.24.121.1	ACUV3	3069	1	1456.9 h
105	PMC EV-Station 105	Aenon Dynamics - Alpha		10.24.121.1	ACUV3	3069	1	1456.9 h
106	PMC EV-Station 106	PMC eG - Genossen		10.24.121.1	ACUV3	3069	1	1456.9 h
107	PMC EV-Station 107	PMC eG - Genossen		10.24.121.1	ACUV3	3069	1	1456.9 h
108	PMC EV-Station 108	PMC eG - Genossen		10.24.121.1	ACUV3	3069	1	1456.9 h
109	PMC EV-Station 109	Aenon Dynamics - Alpha		10.24.121.1	ACUV3	3069	1	1456.9 h
11	PMC EV-Station 11	Aenon Dynamics - Alpha		10.24.121.1	ACUV3	3069	1	1456.9 h
110	PMC EV-Station 110	PMC eG - Fraunhofer IFAM		10.24.121.1	ACUV3	3069	1	1456.9 h
111	PMC EV-Station 111	PMC eG - Fraunhofer IFAM		10.24.121.1	ACUV3	3069	1	1456.9 h
112	PMC EV-Station 112	PMC eG - Genossen		10.24.121.1	ACUV3	3069	1	1456.9 h
113	PMC EV-Station 113	PMC eG - Fraunhofer IFAM		10.24.121.1	ACUV3	3069	1	1456.9 h

Figure 2: gridctrl.ENCORE charge-point monitoring and diagnostics (testing environment)

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3.1.1 Purpose of component

ENCORE is a charging infrastructure software platform providing user authentication and authorization management, charge-point monitoring, and energy meter data aggregation. It is used to manage the PMC operated charging stations CS#1-4.

3.1.2 Initial status

The system covers basic user authentication and authorization management, charge-point monitoring, and energy meter data aggregation. It works with open charge point protocol (OCPP 1.5) for standard charging stations and wall-boxes and has multi-tenant capability. It provides GPDR compliant information security and data protection (regarding confidentiality, integrity, availability). An experimental web-based user interface is being developed. Most of the sub-components do not require any graphical user interface.

3.1.3 Component testing

System tests will be continuously executed during pilot site operation (continuous integration, continuous delivery).

3.1.4 Conclusions, assessments and adaptations

The following adaptions will be made during GreenCharge:

- Hubject roaming connection for interoperability with external parties
- Export live metering data to external data storage systems (PMC infrastructure)
- Export live transaction data to external data storage systems (PMC infrastructure)
- External user authentication via LDAP/RADIUS (PMC infrastructure)
- Internal GDPR compliance audit
- Move OCPP connectivity to the aggregator.

3.2 gridctrl.aggregator

The gridctrl.aggregator is an autonomous network+energy gateway solution to connect the on-site-components (e.g., charging points, energy meters, energy storage systems) to the gridctrl.ENCORE backend via a unified communication interface (single link).

Figure 3: gridctrl.aggegator prototype

3.2.1 Purpose of component

The aggregator is used as a kind of physical (or even virtual) abstraction layer between the hardware components and the backend system. All components on a single charging site are connected to a dedicated gridctrl.aggregator appliance, which provides the backend connectivity for each component as well as local energy routing/load-balancing as part of a larger energy neighbourhood management system.

This unique design pattern eliminates the need for device-specific WAN communication interfaces (UMTS/LTE transceivers, SIM cards) and improves the system reliability including offline operation.

Due to its isomorphic architecture it can be run on-site as a stand-alone appliance (high availability and redundancy scenarios; to use non-network enabled components) or virtualized within a compute cloud environment.

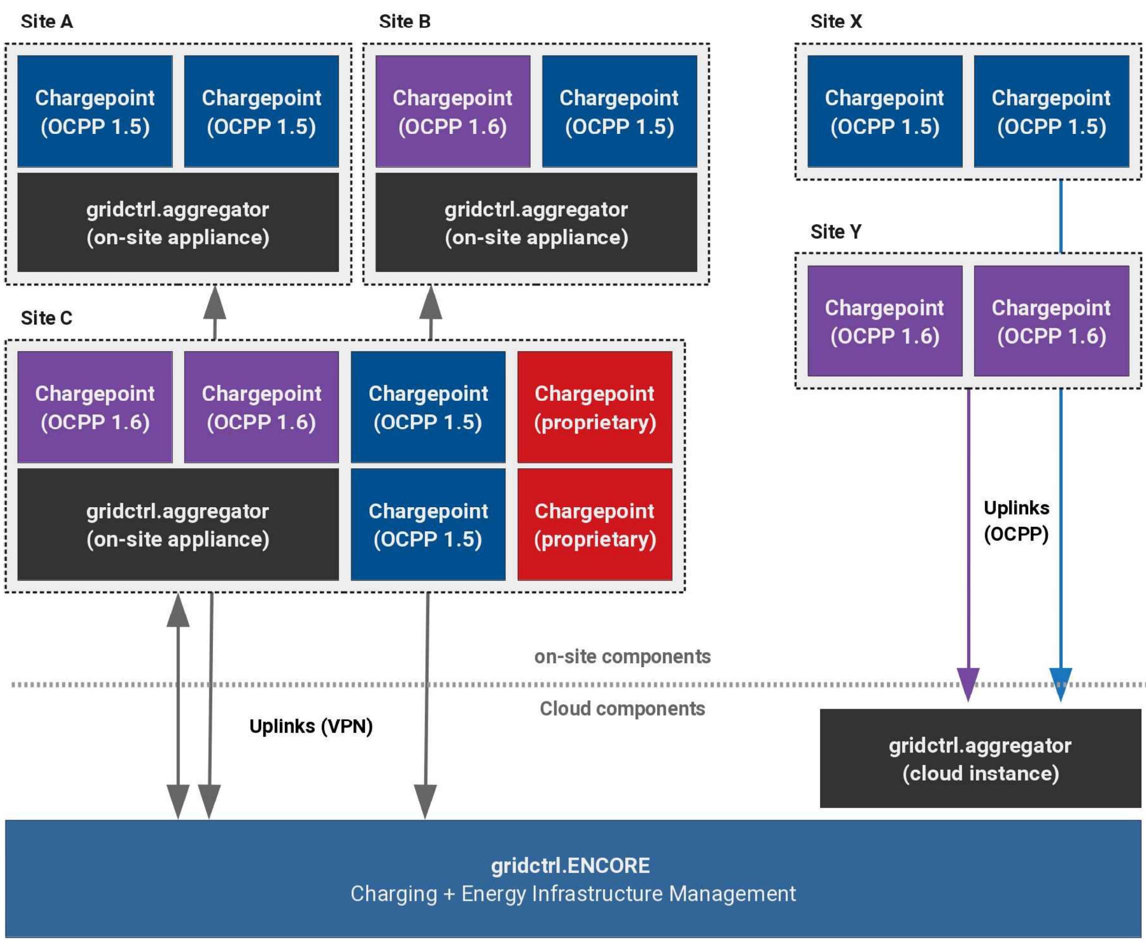

Figure 4: System components deployed on multiple charging sites using gridctrl.aggregator appliances combined with cloud instances

3.2.2 Initial status

This component is currently a lab-prototype based on an industrial gateway (pc). Upgrading the s/w is needed to meet the needs of the pilot. The h/w will be kept in its current version nearly unchanged.

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.

3.2.3 Component testing

System tests will be continuously executed during the first phase of the pilot site operation (continuous integration, continuous delivery).

3.2.4 Conclusions, assessments and adaptations

A hardware appliance acting as aggregator will be tested on #CS3 (IFAM-1) during the pilot site operation. Further development is required to integrate the additional system components (solar inverters, battery inverters, energy meters, proprietary wallboxes) of the charging site.

The virtual cloud instance will be used to connect the DC-Charger #CS4 and additional wall-boxes on #CS2 via OCPP to the backend. The protocol OCPP v1.6 needs to be implemented.

3.3 Miveo Software

3.3.1 Purpose of component

This s/w allows running the CarSharing business at ZET GmbH. It is based on the Miveo-cloud (https://www.miveo.se), which is an end-to-end CarSharing platform. At ZET, this software-solution has been used successfully for years. It connects to in-vehicle equipment, driver and operator interfaces, and a solid cloud-based backbone with booking, fleet management and reporting.

3.3.2 Initial status

Miveo used to be a CarSharing-s/w as a backbone in the ZET CarSharing business. Currently, it is not used any more and also in the foreseeable future, it cannot fulfil all the requirements involved in the use cases UC#3-4.

3.3.3 Component testing

Not needed, since it will be replaced within the full pilot (see description of GTS and OTA-Keys in 3.4 and 3.7, respectively).

3.3.4 Conclusions, assessments and adaptations

The Miveo cloud CarSharing platform will be replaced by a combination of OTA-Keys and GTS. This preparation phase will end in 10/2019 (see 3.4 and 4.7).

3.4 Good Travel Software (GTS)

3.4.1 Purpose of component

The GTS (Good Travel Software) is the s/w-backend solution for the CarSharing operator in the Bremen pilot, fulfilling all requirements needed to protype use cases UC#3 and UC#4 (see Appendix).

Because of its open API documentation, it is capable of being connected to both the timetables for public transportation (bus) and a CMS (Charge Management System), i.e. the SmartCharge backend-s/w (see section 3.5). Furthermore, customers can be categorized in several subgroups (e.g., residents, others).

3.4.2 Initial Status

Still to be implemented in 10/2019.

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3.4.3 Component testing

Tests are already in progress and will be completed by 10/2019.

3.4.4 Conclusions, assessments, and adaptations

We expect that after having linked GTS to CMS and public transport timetables, GTS will fully fit its role in this demonstration part.

3.5 SmartCharge backend

3.5.1 Purpose of Component

“SmartCharge” is the new backend-s/w for CS#5-6. It will operate as a CMS and communicate with GTS the CarSharing s/w-backend (section 3.4). Further, it is needed to give access to the charging infrastructure to any user.

3.5.2 Initial Status

The existing backend-s/w needs to be adjusted and implemented to CS#5-6 by Meshcrafts AS.

3.5.3 Component testing

The backend-s/w will be accommodated to CS#5 and CS#6 by 10/2019 and 11/2019, respectively. Thereafter, communication between CMS and CarSharing-s/w will be implemented. Testing will be completed only by 11/2019.

3.5.4 Conclusions, assessments and adaptations

“SmartCharge” is a promising s/w-backend solution for publicly accessible charging stations in the Bremen pilot. Accommodation, implementation and testing will verify the compatibility with the employed charging stations CS#5/6. This component will be further extended to support booking and roaming.

3.6 RFID-Interface

3.6.1 Purpose of Component

The RFID-interface allows to unlock the shared EV and to get it started. For this purpose it has to interact with the CarSharing s/w and therefore is part of the in-vehicle system.

3.6.2 Initial status

The RFID-interface is a running component - but it is not decided yet, whether or not this interface solution is really needed for CarSharing purposes within the pilot.

3.6.3 Component testing

Tests are not needed, component is readily available.

3.6.4 Conclusions, assessments and adaptations

Not decided yet on usage of RFID solution. As a more convenient alternative, a mobile application could be used instead as a realistic and versatile solution.

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3.7 OTA-Keys

3.7.1 Purpose of Component

OTA-Keys is a Joint Venture of Continental AG with the automotive service specialist D'leteren and is based in Brussels. As an end-to-end service, OTA-Keys provides a s/w-solution intended for keyless opening a pre-booked vehicle for CarSharing. No RFID is needed and no h/w-key. The virtual key is mirrored temporarily via a backend structure onto the user's smartphone and thus contributes to user comfort and CarSharing acceptance. For unlocking the car and getting started, the key is accepted by rf-receivers (mounted, e.g., in the car door) via NFC or Bluetooth.

3.7.2 Initial status

In the implementation phase.

3.7.3 Component testing

Tests are already in progress and will be completed by 10/2019.

3.7.4 Conclusions, assessments and adaptations

The combined system consisting of the s/w-backend SmartCharge, GTS, and OTA-Keys comprises a powerful set for providing a user-friendly CarSharing-service. Adaptations are still needed to meet all the requirements for demonstration in the Bremen pilot. First of all, OTA-Keys combined with GTS will be implemented in 05/2019. In a second step, SmartCharge needs to be connected to that s/w-combination.

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4 Pilot-Site Hardware Components

4.1 Display-charging station CS#1 - PARKALLEE

This station is needed for testing UC#2 (charging@work, see Appendix 6.1) addressing employees in an office building. The charging station with 2 CP's is positioned in an underground car-park, where parking is on a rental basis. Currently no power metering is involved.

4.1.1 Purpose

This CS#1 is combined with CS#2 as a multiple charging in an office/business area to test UC#2 (charging@work). Both are connected to the same backend-s/w (ENCORE, section 3.1).

4.1.2 Initial status

The CS is operable, currently on hold – no defined group of drivers is using the CS.

4.1.3 Component testing

Communication via OCPP 1.5 will be tested with gridctrl.ENCORE during 09/2019.

4.1.4 Conclusions, assessments, and adaptations

Charging station #1 is nearly ready for testing. Logged-in users will get charging information on the screen and/or on their smart phone App. An external smart power meter will be used to acquire charging data. If the backend connectivity test would fail, then the internal charge-controllers must be replaced.

4.2 Charging station CS#2 – GALILEO

4.2.1 Purpose

This charging station is needed for testing UC#2 (charging@work, see Appendix 6.1), which addresses employees and/or residents of the student dormitories - no public access to this CS is allowed.

4.2.2 Initial status

A wallbox with 1 CP (Charging Points) is available. Currently, the operator allows free-of-charge usage, since no calibrated charging is integrated. Up-grading this CS#2 with calibrated meters (per kWh) is part of the preparative work.

4.2.3 Component testing

Communication via OCPP 1.6 has to be tested with gridctrl.ENCORE after the hardware has been upgraded.

4.2.4 Conclusions, assessments, and adaptations

Charging station will be upgraded with calibrated meters (per kWh) to allow for payment-compliancy and communication via ENCORE-backend (section 3.1). Upgrading and testing will be finished by the end of 2019.

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4.3 Charging station CS#3 combined with solar power system

4.3.1 Purpose

This h/w is devoted to charging EV's on company ground from on-site RES combined with 2nd life (used) automotive batteries. It is intended to charge max. 2 EV's from a battery storage system that is slowly charged from grid (overnight) and/or from the solar car-port roof (e.g., over the weekend).

4.3.2 Initial status

Solar energy supply: PV-energy is supplied from an on-roof system and can be used in the pilot as is. It comprises 4,7 kWp PV-modules mounted to the roof of a car-port.

The Charging station itself with currently 2 CP's is supplied by an internal off-grid system (on single phase). It will be up-graded with another 2 wall-boxes, each furnished with one charging point.

4.3.3 Component testing

The system will be tested by 10/2019.

4.3.4 Conclusions, assessments, and adaptations

The upgraded CS#3 will demonstrate a typical situation found in many residential and company environments. The coupling to an energy storage facility fed from RES (Renewable Energy Systems) provides additional benefit as described below in section 4.4

In addition, the ac/dc- (fast) charging station CS#4 is ready to use. It is described in detail in D2.9 chapter 3.2.2.4. Important here is to mention its backend functionality using OCPP1.5-SOAP, connectivity via 3G/APN, authorization via integrated RFID-reader+backend, and with PMC-tenant on encore.gridctrl.

4.4 Energy storage system comprising used traction batteries

4.4.1 Purpose

The usage of SLB's (2nd-Life Batteries) for charging BEV's (Battery Electric Vehicles) is particularly attractive for companies working in the field of electric mobility. There typically automotive batteries are available for second-life usage as intermediate storage for electric energy from own RES. Later on, it will be demonstrated that the usage of any other functional traction battery from EV's comprises an attractive option in combination with RES.

4.4.2 Initial situation

Currently, the battery storage system at CS#3 consists of a bank of lead-acid starter batteries. They will be replaced by used automotive batteries, namely 2 ZEBRA batteries with [Na | Ni/NaCl]-chemistry. They are stemming from Th!nk-EV's, which have been taken out of service by PMC recently. In addition, 2 used Li-ion traction batteries will be employed.

4.4.3 Component testing

Individual used traction battery packs (in total 4) have been tested in lab via standard electrochemical cycling procedure – for 3 of them the results were positive enough for the intended usage. Tests in integrated status will be running until 10/2019.

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.

4.4.4 Conclusions, assessments, and adaptations

Integration of the CS/PV/SLB-system needs to be done during Sep/Oct 2019 before starting the pilot. The stacked h/w should provide at least 60kWh electric energy.

A useful option that will be tested is a) slow charging the SLB from the internal grid and/or from on-roof PV energy supply and b) semi-fast discharging for connected EV's. Mounting a reasonable number of used batteries allows charging several EV's during the day. A minimum capacity of 60kWh is considered reasonable for piloting UC#2.

4.5 EV's with CarSharing computer

4.5.1 Purpose

The electric cars will be used for testing the fleet management and the charge management within use cases UC#3 and UC#4. Car computers must be built into each individual CarSharing car. They are provided, e.g., by OTA-Keys (see http://www.otakeys.com).

4.5.2 Initial situation

3 EV's (type: Nissan-Leaf) are available on-site and used by ZET customers.

4.5.3 Component testing

EV's are serviced and running; compatibility with OTAkeys will be tested as described in section 4.7.

4.5.4 Conclusions, assessments, and adaptations

Meanwhile, the EV-fleet has been updated with OTA-Keys (section 4.7) and GTS (section 3.4) - 3 EV's are operational for the project.

4.6 Charging station CS#5-6

4.6.1 Purpose

For the integrated solution of the Bremen pilot, those 2 charging stations can be shared with private EV owners which, if they are temporarily not occupied by CarSharing EV's. To accomplish this, both charging stations must be re-configured with the new CMS (Charge Management System).

4.6.2 Initial situation

Both charging stations are already installed and in operation. A new CMS has been implemented.

4.6.3 Component testing

The CMS backend-s/w has been accommodated to CS#5 and CS#6 and tested. Communication between CMS and CarSharing-s/w is currently in the implementation phase. Testing this CS-system is expected to end during 10/2019.

4.6.4 Conclusions, assessments, and adaptation

The charging stations are in operation and working. Connecting to the new CMS is a pre-requisite for finally implementing them in the full-scale pilot.

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5 Conclusion

Notwithstanding the fact that most of the described components that are to be implemented in the integrated pilot are in existence already, many upgrades and adaptations are needed to test the proposed use cases in the Bremen pilot. In particular, the backend- and frontend-s/w components need specific attention in order to ensure a safe and reliable communication for data collection and to provide a convenient user interface (App) that can be handled easily and in a self-evident manner.

Part of the demonstrators are dependent on a good cooperation with the stakeholders SWB (local utility) and IFAM (private entity), which allows to test the 2 use cases dealing with CarSharing @mobility-hubs ("mobil.punkt") and charging@work from RES (+ priority charging), respectively.

Future work must focus on integration of the h/w and s/w, which especially these 2 charging sites in the Bremen pilot are offering.

Finally, we anticipate that in the course of the project, additional charging stations can be employed to demonstrate even better 2 of the 4 defined use cases in the full-scale Bremen pilot.

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6 Appendix

6.1 Use Cases to be tested in the Bremen pilot (UC#1-4)

Use case #1: <u>Booking Enforcement for priority charging</u> (in Scenario 3 (-> SC#3))

Some predetermined type of EV's need charging on arrival immediately (independent of their respective SoC). At a company's site this situation could apply, e.g., for EV business cars, VIP-owned cars, and visitors. Booking any of the charging points (not a specific parking place) should be possible at least 1h before arrival via mobile app/web.

Use case #2: <u>Commuters charging at work</u> via PV energy supply (-> SC#4)

Commuters have the chance to park & charge on their company's ground via PV and/or from electric energy buffered in 2nd-life batteries. PV supply and SoC's of both EV and buffer battery have to be synchronized for the working period of time. A warning should be returned to the commuter, if this cannot be handled until end of work due to, e.g., low power giving time to reconnect to an alternate charging point (w/o PV).

Use case #3: <u>EV-CarSharing combined with public transport</u> (-> SC#7)

This use case is closely connected to the "mobil.punkt", which is a Bremen-specific activity to support CarSharing. Bremen citizens w/o own car want to go shopping in a large shopping centre outside Bremen or go on a recreation trip. Arriving at a mobil.punkt by public transport and after identification, the customer can take a pre-booked fully charged EV from the charging site. The charging point gives a "free" sign for other customers looking for a re-charging option.

Use case #4: <u>EV-CarSharing in a residential neighbourhood</u> (-> SC#7)

A citizen living in a neighbourhood at a maximum distance from a CarSharing station of ca.300m, wants to take from that CarSharing station a fully charged EV on a monthly trip for shopping and wants to charge at a pre-booked charging point at the shopping centre.

6.2 Scenarios (copied from DoW) covered by the Use Cases #1-4 described in 6.1

<u>From DoW: Scenario 3 - Booking Enforcement</u>
<u>An inherent practical problem of implementing booking of charging spots is that other cars may park at and block the allocated charging spot. Physical obstacles that can be controlled remotely exists but are expensive. Other solutions may be:</u>

1. Charge management system instructs Charging post to display clearly the availability/non-availability for drop-in customers and blocks charging for other EVs in booked time slots.

2. Drop-in customers must also indicate the time-slot they will be parked by the selected charging post, and the Charge management system may enforce restrictions in busy periods with many bookings.

3. Parking at a booked spot or leaving the vehicle by a charging post longer than agreed may cause punishment, e.g. a fine or higher price or blacklisting. A good strategy to avoid practical problems with booking, while still ensuring good utilisation of the charging equipment, may be to have more parking spots with connectors (cheap) than chargers (expensive). The final assignment of charging post for booking customers could be postponed until arrival time, leaving more flexibility to sell free slots in between bookings to drop-in customers.

<u>From DoW: Scenario 4(b) - Charging at work in (groups of) buildings with common internal grid and parking facilities</u> (in addition to 4(a): Home charging....)

1(a). In the afternoon, many people return home and connects their EV to their home charging point.
1(b). In the morning, many people come to work and connect their EV to a charging point provided by the employer.
2. Those who need the car soon again indicate that to the charge planning assistant.
3. Rather than starting the charging of all the cars immediately after connection, the ESN management system, possibly in collaboration with a local charge management system, schedules the charging of the different vehicles according to

their expected future use and SOC, so as to exploit as far as possible locally produced electric energy, while also considering other tasks that need electric power in the neighbourhood.

The internal electricity distribution grid in older (groups of) buildings often have limitations that cause problems when inhabitants want to charge EVs at home Installing a neighbourhood energy management system for the (group of) buildings and a Charge management system supporting booking for the charging facilities, would avoid overloading and ensure optimal use of the available capacity, and if desirable, take care of the distribution of cost among the users. It would also open the possibility to sell excess capacity to outsiders, which if the facility is conveniently located, could recover the investment.

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

Car sharing as a fleet-based service is used as innovative element of SUMPs to reduce the consumption of space for parked cars – and to introduce electric vehicles. Car sharing can widely replace car ownership – makes more efficient use of transport / parking infrastructure. Users have access to the cars of the fleet via electronic reservation and access.

There are different business cases involved: for the cities, for the users/citizens, for car sharing operators, for recharging infrastructure operators, for housing companies. It needs proper communication between cars and the fleet management system, e.g. about the SoC (state-of-charge of the battery) in order to optimise the charging of the cars in relation to the next reservations of cars at the very same car sharing station. For satisfied customers, it is necessary to provide cars with sufficient SoC for the planned trip.

1. With the reservation, the user tells that he wants to go a certain distance (e.g.100 km) with the e-car.
2. The reservation system checks whether the available cars have a sufficient SoC at the pick-up time.
3. During the trip, the car communicates the state of battery to allow the management system planning the charging for the follow-up reservation.

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Members of the GreenCharge consortium

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

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	ZET GmbH (MOVA) DE-28209 Bremen Germany www.zet.technology	**Contact:** Nils Jakubowski nils@zet.technology
	Personal Mobility Center Nordwest eG (PMC) DE-28359 Bremen Germany www.pmc-nordwest.de	**Contact:** Bernd Günther b.guenther@pmc-nordwest.de
	Oslo kommune (OSLO) NO-0037 Oslo Norway www.oslo.kommune.no	**Contact:** Sture Portvik sture.portvik@bym.oslo.kommune.no
	Fortum 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:** Arno Schoevaars arno.schoevaars@pnoconsultants.com
	Universita Deglo Studi Della Campania Luigi Vanvitelli (SUN) IT-81100 Caserta Italy www.unicampania.it	**Contact:** Salvatore Venticinque salvatore.venticinque@unina2.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

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