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

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

GREEN CHARGE

greencharge2020.eu

GreenCharge Project Deliverable: D2.9

Description of Bremen Pilot and User Needs

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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

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Executive Summary

Within the GreenCharge project, Bremen is one out of 3 pilot sites, where the interoperability of key components for “green charging” of electric vehicles, esp. for CarSharing purposes, will be developed and demonstrated. To meet the involved challenges, a dedicated group of stakeholders has been constituted and involved in the process of defining innovative business models related to e-CarSharing.

In this report, the Bremen pilot site is described in its current situation regarding economic, societal, and environmental aspects of electric mobility. Since the greater Bremen region was chosen “Modellregion Elektromobilität” in 2010, its character as a living lab for implementation of electric mobility has been demonstrated in some previous projects. From these the following status regarding electric mobility in Bremen can be derived:

- The Bremen-specific “mobil.punkt”-concept has been designed and is promoted by the city of Bremen. It is very effective in reducing the number of cars in the city center. Its core-element is the combined usage of CarSharing and public transport making own cars redundant for many citizens. In this way the main objective can be met, i.e., the reduction of the overall number of cars in the city center.
- Electric busses (2) for public transport have been tested successfully in the past 2 years by the local operator BSAG stimulating a swift procurement process to end up with a fleet of more than 55 busses for public transport by 2025.
- Neither e-scooters nor electric trucks/vans for delivery-purposes are playing a significant role in Bremen and therefore will not be considered for piloting at this site.

Currently, the overall charging infrastructure for EV’s in Bremen is diversified, the main player being the local utility SWB, which delivers 100% “green” electricity to their public charging stations. The charging infrastructure that will be used in the GreenCharge project has been chosen as a mixture of public and private stations in order to prototype the following use cases:

- Booking enforcement for priority charging in business areas;
- Commuters charging at work via PV energy supply;
- EV-CarSharing combined with public transport at the “mobil.punkt”-stations;
- EV-CarSharing in a residential neighbourhood.

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List of Abbreviations

Table 1: *List of abbreviations*

Abbreviation	Explanation
PT	Public transport
SUBV	Senator Umwelt, Bau und Verkehr / (Ministry for the environment, construction and transportation / Bremen)
PMC	Personal Mobility Center NordWest eG
CS	Charging Station (with 1 or more charging points)
SrV	"System repräsentativer Verkehrsverhaltensbefragungen" (System of representative traffic behaviour surveys)
SoC	State-of-Charge (of battery storage – EV or stationary)
ICT	Information and Communication Technology
LRG	Local Reference Group (stakeholders)
w/o	without
esp.	especially

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1 About this Deliverable

1.1 Why would I want to read this deliverable?

This deliverable describes the current situation in Bremen regarding the specific topic of how to reduce the number of cars via sharing electric vehicles (EV's). Typical users of charging infrastructure are commuters, through-travellers, and hop-on/hop-off drivers using the so-called mobility hubs. User needs and typical use cases for such (piloted) infrastructure in Bremen are described in order to understand the promotional effects of CarSharing business, when it is run with EV's.

1.2 Intended readership/users

- Project partners, esp. those providing input to WP2 (from other pilot sites) and to WP4;
- Developers of quarters responsible for mobility concepts that include public charging stations;
- Developers and technical management of business areas with hundreds of commuters travelling to work in the morning, who want to have a charged EV in the evening.

1.3 Other project deliverables that may be of interest

- **D3.1 Stakeholder Analysis Report** – Describes the result of the stakeholder analysis, identifying the concerns and needs from all stakeholders relevant for GreenCharge;
- **D2.10 Implementation Plan for Bremen Pilot -** Describes the planning of the tests and the combination of different modules of a green charging infrastructure. Included are different scenarios, users selected for (stakeholder-)workshops, descriptions of h/w and s/w to be implemented, etc.;
- **D2.15 Final Report for Bremen Pilot: Lessons learned and Guidelines** – Describes the Bremen pilot, including the implementation, operation, the prototype tests, and the data collected. Describes lessons learned esp. for the EV CarSharing business;
- **D2.3 and D2.16 Description of Oslo/Barcelona Pilots and User Needs -** "Sister" deliveries describing the specific situation in the Oslo and Barcelona pilots describing esp. the charging in large parking garages near apartment buildings and dealing with EV-scooter business, respectively.

1.4 Other projects and initiatives

Bremen is also involved in the H2020 project "STARS". launched in October 2017 and standing for "Shared mobility opportunities and challenges for European cities", STARS aims at exploring the diffusion of CarSharing in Europe, its connections with technological and social innovations, as well as its impact on other transport modes (private car, bike, walk, taxi, public transport, …).

A focus of STARS is to explore the dynamics of individual preferences, behaviours and lifestyles influencing the use and non-use of CarSharing. With results stemming from STARS, a policy toolkit is designed that provides European mobility stakeholders and policymakers with a support tool. It will include guidelines and recommendations to support them in making the right decisions and develop the best strategies for environment-friendly and cost-effective CarSharing services in European cities.

There is also a cooperation between the H2020 project "MEISTER" (launched 2018), in which the consortium of 10 institutions investigates and implements e-mobility business models in the cities of Malaga, Gothenburg, and Berlin. MEISTER specifically investigates the current status of e-mobility implementation in several cities belonging to city networks such as EnergyCities, POLIS, EUROCITIES via a questionnaire. With this the various preconditions and frameworks in cities are identified regarding the deployment of electromobility concepts. The questionnaire's target group will include representatives of local city administrations having a good background in e-mobility strategies.

Bremen is also a member city of CIVITAS and one of the living lab cities. The Bremen SUMP integrated e-mobility as one of the necessary measurements for improving sustainable mobility in the city.

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2 Introduction to the Bremen pilot site

Bremen is a city of ca. 560.000 inhabitants, located in Northwest Germany. The number of car-free households in 2013 was 29% compared to 36% in 2008 (SrV, 2017). This growth indicates that car ownership is still an option for the citizens of Bremen – rather on the periphery than in the central neighbourhoods with car ownership being fairly low.

There were about 240.000 cars registered in Bremen by 2018 and congestion remains a problem in Bremen's historic and narrow streets.

Parking

Currently there are enough parking spaces in Bremen's city centre. The majority of these are in publicly-owned parking garages. The street parking spaces are likewise almost entirely pay parking. Many parking garages built in the 1950s and 60s are located very centrally in the old town — with all of the associated advantages and disadvantages. The real-time parking information showing available spaces is well established. However, these centrally-located garages are responsible for much of the traffic in the central area of the old town. Because of its location and the unsatisfactory accessibility of the central parking garage — particularly at busy shopping times — there are tailbacks and delays for both pedestrians and car drivers. Many improvement options were examined within the city centre plan (Bremen City Centre 2020). Both the parking supply in city centre garages and the price of parking in Bremen are comparable to other similar-sized cities. In relation to its retail space, Bremen is well-supplied with parking.

In Bremen there are over 4,310 parking spaces at park&ride stations, which can be increased to as many as 10,900 for major events such as soccer games. There is, however, not enough supply at all access points. The occupancy rate at the different locations varies. Sometimes more spaces are needed even in locations where there is already a large supply.

Particularly in the areas near the city centre, Bremen is characterised by dense and small-scale construction. This applies especially in areas with so-called "Bremen houses" (tall, narrow row houses with very small or no front gardens) as are found in the new town or the eastern periphery. These areas have a high population density and very limited parking on private property. This results in high parking pressure in these neighbourhoods, where it is normal to see cars half-hoisted on sidewalks to the extent that emergency access, pavements and intersections are blocked.

In some neighbourhoods high parking demand is caused by users from outside the neighbourhood such as office employees, customers, and visitors.

Resident parking regulations currently exist in several neighbourhoods of the city near the city centre, but also in 2 more distant neighbourhood centres. A very effective way to solve these problems is the implementation of CarSharing service.

Car Sharing

CarSharing offers a mobility service that focuses on the environmentally-friendly use of cars and puts car use ahead of ownership. A distinct advantage of CarSharing is that it relieves public street space of parked cars — thus promoting higher quality local mobility in densely populated neighbourhoods. Regular customer surveys of CarSharing operators have shown that 31% of those surveyed had got rid of a personal car. Given the statistical average of 45 users per CarSharing vehicle, this means roughly up to 16 private cars are replaced by each CarSharing vehicle (Ref.: team read, "Analysis of impacts of car-sharing in Bremen", Germany, 2018).

CarSharing offers a comparatively inexpensive means to reduce parking pressure, particularly in central neighbourhoods, and to help create better conditions for local mobility. The "mini mobility points" enhance this approach on a small scale through a dense network of 2-car stations in densely populated neighbourhoods.

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The growth rate and the interest from car manufacturers show that CarSharing is gaining importance, above all at the local level.

With its CarSharing Action Plan, the City of Bremen supports the further development of CarSharing and has set itself an ambitious goal of 20,000 CarSharing users by 2020 (compared to 11,000 users in 2015).

Through new stations in public street space, the station network will be further developed and densified. The action plan is independent of any CarSharing operator, however any operator that would like to use parking spaces in public street space must fulfil the standards of the German Blue Angel environmental label and provide proof that they are relieving the car burden in public space. The amendment of the parking regulations is an important step toward being able to integrate CarSharing into new construction projects from the beginning. The existing station distribution and planned network densification are geared toward neighbourhoods close to the city centre, whereas neighbourhoods in the outskirts are connected selectively or not at all to car sharing.

Based on the characteristics of the well-connected CarSharing neighbourhoods (high resident density, low car density), some areas that are not yet developed show potential for CarSharing stations. In these neighbourhoods, the potential stations should be oriented towards important destinations such as neighbourhood centres or full-service grocery stores in combination with good public transport accessibility so that accessibility of the vehicles can be ensured, even over comparatively large catchment areas.

The idea of CarSharing in Bremen is closely linked to the “mobil.punkt station”, which is supported by the Senator for Environment, Construction and Transport. Mobil.punkte are CarSharing stations in public street space that can be easily reached by walking, biking, or public transport. So, CarSharing and public transport may complement each other. Holders of annual subscription tickets for public transport receive discounts on the Bremen CarSharing providers.

Current statistics: ~ 17.000 current users, 5000 substituted cars, car substitution rate (45 users per car/ 1:16) 112 stations, 344 vehicles (source: City of Bremen and operators, date: January 2019).

Modal split

Two surveys carried out in 2008, provided a detailed picture of Bremeners’ transport behaviour. Bremen is a very bicycle friendly city with 420,000 bicycle trips per day. 52% of the population rely on public transport, biking or walking (SUBV, 2014). Still, city planners are convinced that there is still room for improvements in Bremen’s historic and narrow streets, where it is normal to see cars half-hoisted on sidewalks.

Figure 1 shows Bremen’s modal split in 2008 and the differences in transport mode choices among different age groups. For example, over 44% of children younger than 6 years old and adults from 25-64 years old drive by private cars. This choice changes mainly during teenagerhood, when 51% of the trips are made by bike. The modal split of private mobility modes in the city of Bremen shows 48% car usage, 15% walking, 20% biking, and 17% public transport.

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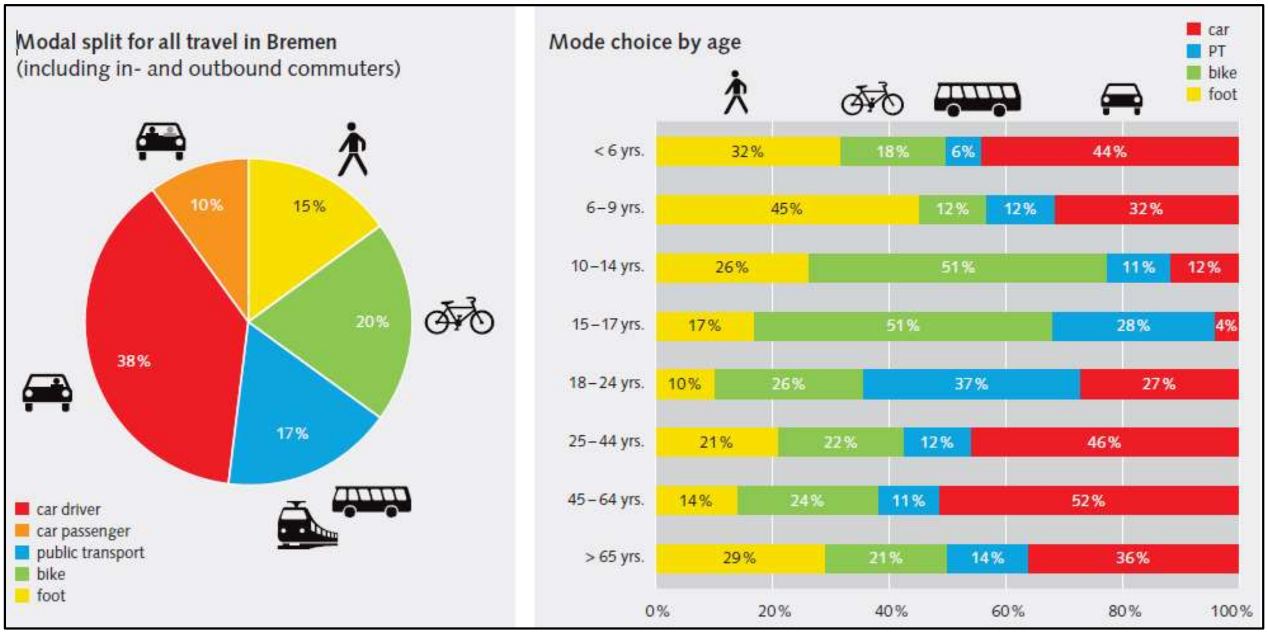

Figure* 1*: modal split for all journeys in Bremen by mode and choice by age*, *SUMP 2017

2.1 Geographical location

The Free Hanseatic City of Bremen has a strong political backing for the subject of sustainable urban transport. The Senate Department for Environment, Construction and Transport (SUBV) is the responsible authority for urban development and planning, for transport and for environment, climate protection and energy.

The City of Bremen with its ca. 560,000 inhabitants is a typical European city – undergoing a structural change from basic and traditional harbour industries towards a modern city with a mix of old and new industry, research and services. Besides this structural transformation, significant parts of the town have developed into centres of technological competence and innovation.

The city of Bremen has an area size of ~237 km^2. However, commuter traffic within the greater Bremen region is rising and contributes considerably to congestion and parking demand (figure 3)

***Figure 2: Bremen location within Germany** (source: Wikipedia)*

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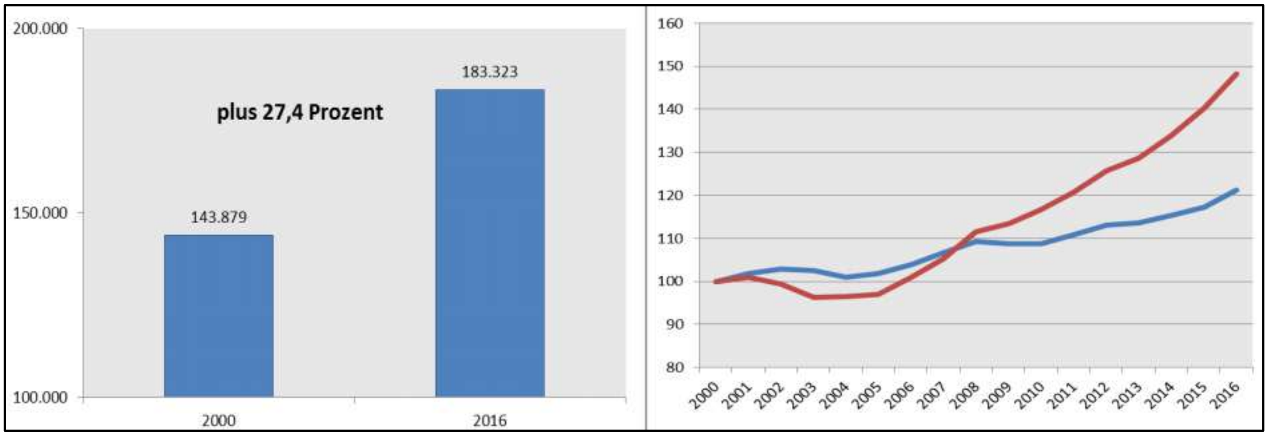

***Figure* 3**: *Commuters from year 2000 to 2016 in Bremen, blue=inbound, red = outbound, source: figures by Arbeitnehmerkammer Bremen 29.03.2017, data: Statistisches Landesamt Bremen (2017), Bundesagentur für Arbeit am 30.06.2016*

2.2 Demographic data

In terms of urban development, Bremen is undertaking a sensitive regeneration policy, with a strong focus on sustainability. The ambitious Bremen Climate and Energy Program sets a framework to reduce drastically the overall greenhouse gas emission, with an overall target of a 40% reduction (against the 1990 level).

Today's modal split of the Bremen citizens shows a good starting point – with a share of about 60% of all trips done by the sustainable modes (public transport, cycling and walking) – which shall be extended.

The relatively high density of housing and workplaces, the tendency to trans-regional transport (particularly transport of goods) and Bremen's role as a regional centre in the northwest of the state of Lower Saxony have decidedly shaped transport activity in Bremen. As the tenth largest city in Germany, Bremen is the cornerstone of the registered European metropolitan region Bremen/Oldenburg in the Northwest, where it serves as a regional centre. Bremen also has international importance as a seaport.

Bremen is also the central transport node within the transport association Bremen/Lower Saxony. The lines of both regional and trans-regional rail traffic are aligned with this node. Bremen is connected to long-distance rail travel via its main station. Bremen also serves as a central node in the network of national motorways.

The Bremen metropolitan area of roughly 325 km^2 lies on both sides of the Weser River and stretches almost 38 km from southeast to northwest. The urban structure is distinguished by its form as a linear city. As is characteristic of linear cities, the settlement areas of Bremen are oriented along the major roads, along the rail line and along the Weser River so that the accessibility (including by public transport) is relatively easy to provide. Also typical of linear cities, the green spaces and open areas in Bremen are closely associated to the individual settlement areas.

Suburbanisation is a growing trend which influences the demographic pattern of Bremen citizens. Particularly striking are the migration losses among the 30-65 year olds to the surrounding area of Bremen adding to commuter numbers.

Along with the city centre (the historic, economic and cultural centre of Bremen), the city has a polycentric structure, as is typical of a linear city, too. As compared to cities with a compact urban structure, Bremen has relatively long travel times for connections between its settlement areas (see the accessibility analyses below).

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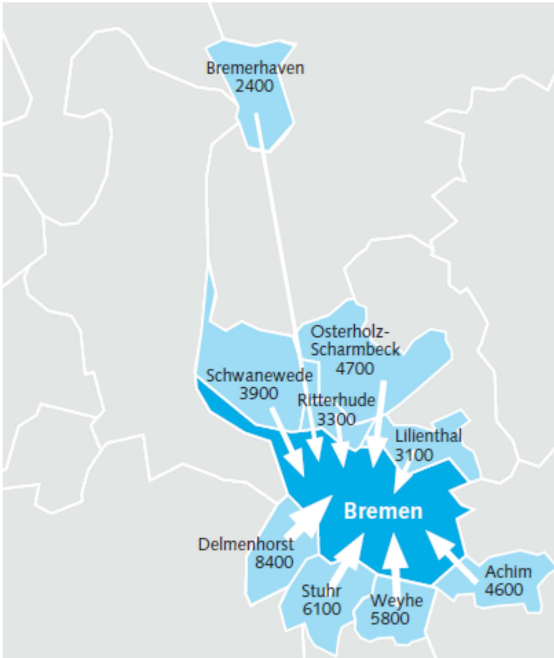
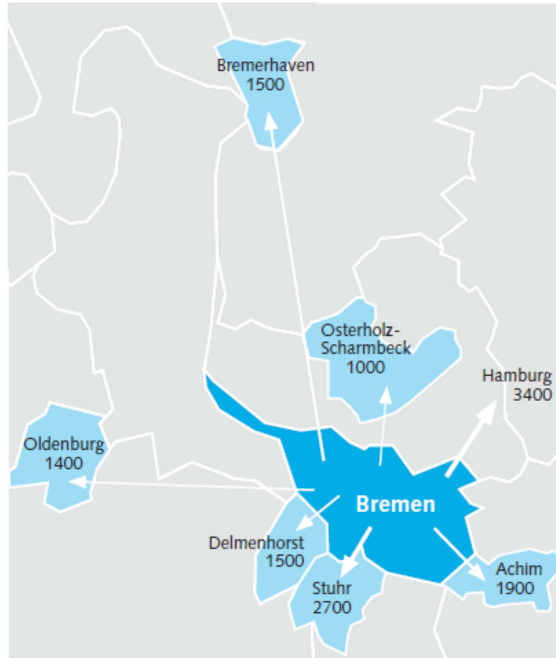


Inbound commuters to Bremen in 2010 (communities with more than 3,000 inbound commuters)



Outbound commuters from Bremen in 2010 (communities receiving more than 1,000 outbound commuters)

Figure 4: inbound and outbound commuter overview 2010 (source: SUMP 2014, SUBV, City of Bremen)

There are around 13.200 inbound and 52.300 outbound commuters per day (data: Statistisches Landesamt Bremen, 2017) with a rising trend. Around 80% of them use their private car for commuting.

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3 E-mobility in Bremen at start of project

According to the national register[1], in Bremen there are at least 50 publicly accessible chargers with more than 102 charging points. Most of them are distributed throughout the city centre. Furthermore, there are 3 CarSharing companies active in the city of Bremen:

- MOVE-ABOUT GmbH,
- CAMBIO GmbH and
- FLINKSTER

All of them offer **station-based CarSharing** service, i.e., currently there are no free-floating CarSharing activities in Bremen (status 12/2018).

In the following we do not further specify and consider rental car service (Sixt, Hertz, Avis, etc.), although in the midterm future these also could play an important role for enhancing the share of EV usage, i.e., in concepts to reduce CO_2 emission locally.

MOVE-ABOUT offers a fully electrified fleet with 15 passenger cars at 10 stations in total,

CAMBIO is running 101 car-sharing stations in Bremen, whereas 5 full electric vehicles are offered at just 4 of these stations.

FLINKSTER belongs to the Deutsche Bahn train operation (DB connect) and is offering 4 conventional cars (no electric vehicles) at 1 single station in Bremen located close to the train main station. However, via its network partners Vonovia and Hertz more conventional cars (currently 7) are shared and can be booked from FLINKSTER via booking-app or web-site (no EV's up to now!).

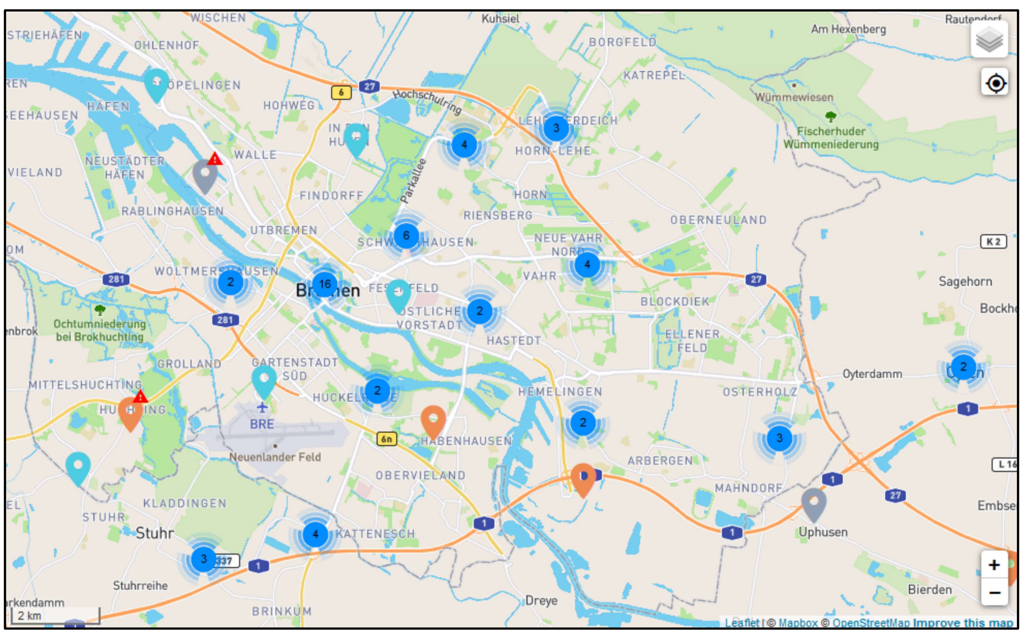

Figure 5: EV charging points in and around Bremen,
source: https://www.goingelectric.de/stromtankstellen/Deutschland/Bremen/

[1] https://www.bundesnetzagentur.de/DE/Sachgebiete/ElektrizitaetundGas/Unternehmen_Institutionen/HandelundVertrieb/Ladesaeulenkarte/Ladesaeulenkarte_node.html

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3.1 Vehicle ownership and EV penetration

3.1.1 Passenger cars

In the state of Bremen (one of the 16 German states, Bundesländer) the number of EV's in private/business ownership amounts to 307 plus 288 plug-in hybrid vehicles, out of a total of 290.188 in 2017[2] (i.e., a share of about ~0,10% for both segments).[3] For the City of Bremen, there are in total 240.790 registered vehicles, with 264 BEV (battery electric vehicles ~0,11%) and 252 plug-in hybrids (~0,10%).

3.1.2 Busses (public transport)

Further, currently there are 2 fully electric battery busses in operation owned by the local public transport company BASG.

Figure 6: articulated e-bus in Bremen, *source: Bremer Straßenbahn AG (BSAG)*

The Bremer Straßenbahn AG (BSAG) is the public transport operator offering mobility services within the Free Hanseatic City of Bremen and surrounding area. Mobility services are based on 7 tram lines (operated by 119 low-floor vehicles) and 44 bus lines (operated by 161 articulated and 49 standard buses - excluding the 2 operating electric buses) with a combined length of 600 km. The tram and buses are parked at 5 depots, one of them reserved for buses only.

In order to cope with the growing demand for environmental and resource-saving public transport operation, BSAG laid down a forward-looking concept approach to reduce fossil fuel consumption by electrifying their entire bus fleet.

In order to prove that electric buses with overnight slow-charging can already be deployed for everyday operation and can be operated economically BSAG tested 2 electric low-floor buses in regular operation at the main tram-bus depot.

To do so, BSAG carried out a tender for both a 12m and a 18m electric bus, based on the technical and operational specifications elaborated so far. Finally, SILEO has been awarded the contract. But instead of purchasing the 2 electric buses they were leased on basis of a full-service contract. Both busses are equipped

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[2] https://www.kba.de/DE/Home/home_node.html 1. Jan. 2018

[3] https://www.kba.de/DE/Statistik/Fahrzeuge/Bestand/Umwelt/2018_b_umwelt_dusl.html?nn=663524

with low-floor technology, ticket vending machines and air conditioning systems to maintain the usual standard for urban buses operated by BSAG.

The charging infrastructure is made available (leased) by both OEMs and can be used only for their own vehicle. The energy is supplied with power from the medium-voltage network of the local energy supplier and no energy from the existing DC tram infrastructure at the depot is used. Before the electric buses were put into operation, they had to undergo comprehensive quality assurance measures and approval procedures.

Results and lessons learned from the electric bus test operation:

In general, both the passengers and the drivers were satisfied with using and operating the electric buses. Noise generation, particularly while standing and during the bus stop approach could be reduced, whereas the driving noise of the electric bus wasn't lower compared to a diesel bus. The electric recharging at the depot requires different management from current refuelling procedure (diesel bus: 10min vs. E-bus: 5-8h). However, the charging infrastructure is easier to manage, if not located in a public space, since on private ground there are fewer regulations and statutory provisions that have to be taken into account. The availability of electric buses did not accomplish that of diesel buses: the 12m electric bus had run ca. 11,000km within 10 months compared to 68.000km for a diesel bus. Very little can be concluded about maintenance, since the electric buses are run on a full-service leasing basis

Future plans:

The two electric busses that are currently in operation will be returned to SILEO, when the leasing contract ends in 2019/2020. The overnight charging infrastructure at the depot will be dismantled at the same time. BSAG intends to begin the procurement of series electric busses from the end of 2019 onwards. The goal is to operate a fleet of more than 55 electric busses until the year 2025.

In cooperation with the housing company Gewoba and MoveAbout, BSAG also operates 4 mobility stations with EV CarSharing (see *Figure* 5 for all publicly available charging points for EV´s) and is preparing to extend its EV CarSharing service in cooperation with the company 'Move About'.

3.1.3 Trucks/vans (delivery logistics)

Currently there are no electric delivery vans operating in Bremen, e.g. for servicing retail business in the city centre, some are operating in the city's periphery ("StreetScooter"). However, it is expected that these types of EV's will enter the scene in the city centre in the coming years, too.

It is decided that within the GC-project the charging needs and use cases for this type of EV's will not be considered within the Bremen pilot.

3.1.4 Electric scooters (2-wheelers)

Electric scooters and pedelecs have been considered within the framework project "Modellregion für Elektromobilität Bremen/Oldenburg" funded by the federal ministry of transportation and infrastructure (BMVI) in 2010-2015. PMCeG had managed the sharing and usage of a fleet of more than 20 electric 2-wheelers. The outcome of these "prototype" activities within this Modellregion project can be summarized as follows:

- Low user acceptance - only very few users could be acquired to test the applicability in local traffic system;
- Diagnostic data could not be measured/evaluated, since no specific charging infrastructure could be assigned to the use cases in parallel;
- Many h/w failures experienced, since the used scooters were 1st generation electric 2-wheelers (from low volume production).

Due to lacking economic advantages needed for any business concept, the operation of the scooter fleet was stopped by the end of this project (2016ff). Further, since with the "sister" pilot site Barcelona a well-developed scooter-scene is prototyped within the project (see D2.16), there won't be any 2-wheelers considered for prototyping smart and green charging in the Bremen pilot site.

3.2 Existing Charging infrastructure

Since public charging stations in Bremen are mostly funded by federal ministries, the terms and conditions set by the Federal Ministry of Transport and Industry (BMVI)[4] for charging stations must be met in accordance with the LSV (”Ladesäulenverordnung”) and EmoG ("Elektromobilitätsgesetz"), i.e., charge point regulation and the federal law regarding electric vehicles, respectively.

Currently, most of the public charging stations in Bremen are operated by the local utility SWB delivering 100% "green" electricity to these sites. SWB is cooperation partner in the German network "ladenetz" (www.ladenetz.de). Customers of dc-stations are charged either time-based (€/min) or by a fixed amount. Payment in €/kWh is not allowed, since calibrated dc-stations are still lacking. In general, payment after invoice from SWB is made per direct debit.

In the following the charging infrastructure used by MOVA and PMC in the testing scenarios in Bremen will be described in more detail.

3.2.1 Public EV-CarSharing Stations

Move-About GmbH (GreenCharge partner "MOVA") operates various charging equipment at the different CarSharing stations. Currently this charging infrastructure is used by own CarSharing EV's only. Therefore, there is no specific payment system implemented so far. RFID technique is used for user authorisation, but within the Bremen pilot, authorisation via an App will be available, too.

At the CarSharing stations involved in the Bremen pilot the following charging equipment will be provided:

3.2.1.1 Site "RICARDA-HUCH"

Location: Ricarda-Huch-Straße

Capacity: 2 parking places

Technical Data

- Vendor: SWB
- OEM: EBG Compleo
- Series: AC charging station highline
- Outlets: 2x 22kW Type 2 Mode 3 Sockets
- Grid power limit: 30kW
- Load balancing: several programs with OCPP1.6 and 2.0, simple load balancing with 1.5 on some chargers.
- Backend communication protocol: OCPP 1.6-JSON
- Backend connectivity: 3G/APN
- Backend: SmartCharge
- Authentication: via RFID (integrated reader) or backend

4 https://www.bav.bund.de/DE/4_Foerderprogramme/6_Foerderung_Ladeinfrastruktur/4_Fragen_und_Antworten/4_Anforderungen/Fragen_zu_Anforderungen_node.html;jsessionid=18A3760E9F6DCE8B38032AF8D6050470.liv

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.

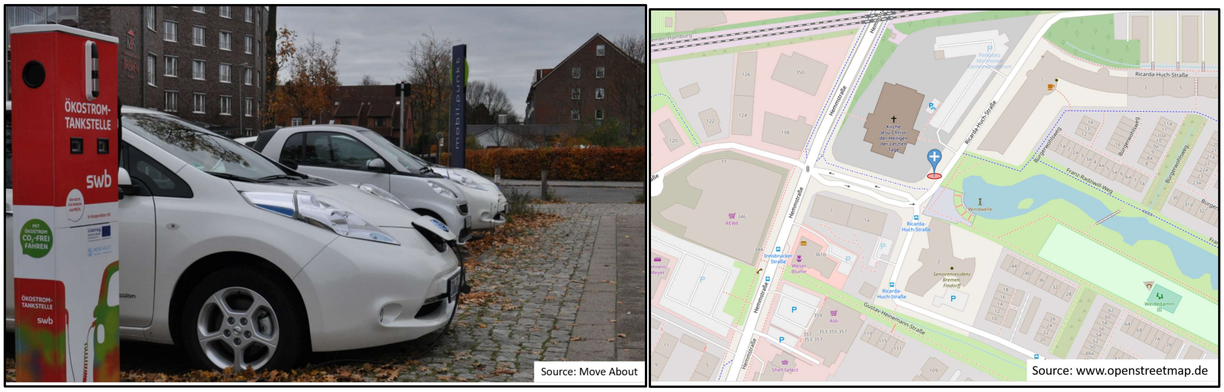


Figure 7 station "RICARDA-HUCH", *source: Move-About / www.openstreetmap.de*

3.2.1.2 Site "KISSINGER"

<u>Location:</u> Kissinger Straße / Utbremer Ring

<u>Capacity:</u> 5 dedicated outdoor parking spots

<u>Technical Data</u>

- Vendor: ABL SURSUM
- OEM: ABL SURSUM
- Series: Wallbox eMH3 Twin
- Outlets: 2x 22kW Type 2 Mode 3 Sockets
- Grid power limit: 30kW
- Load balancing: several programs with OCPP1.6 and 2.0, simple load balancing with 1.5 on some chargers.
- Backend communication protocol: OCPP 1.6-JSON
- Backend connectivity: 3G/APN
- Backend: SmartCharge
- Authentication: via RFID (integrated reader) or backend

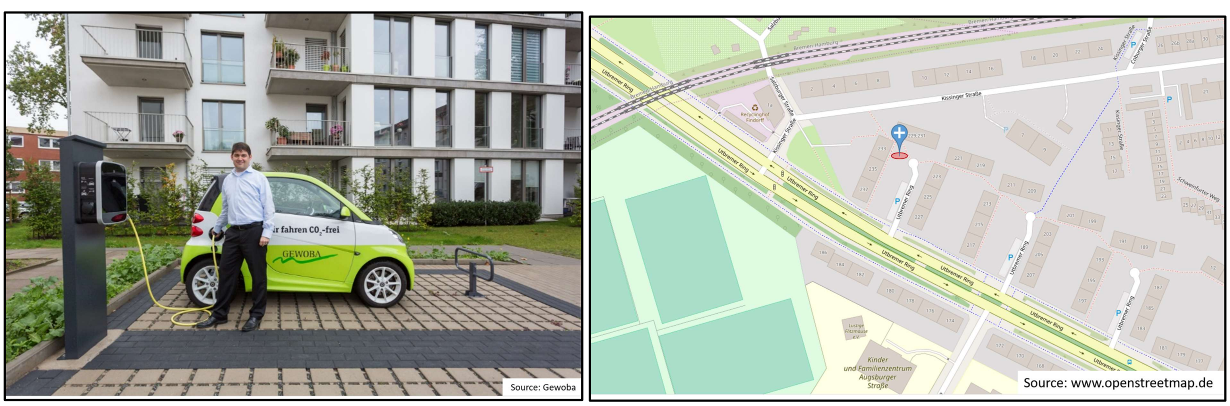


Figure 8 station "KISSINGER", *source: GEWOBA / www.openstreetmap.de*

The 2 sites operated by Move-About are separated by about 700m (10min walking distance).

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.

3.2.2 Corporate EV Charging Stations

As corporate CarSharing stations involved in the Bremen pilot and open to company employees only, the following PMC sites will be used. All stations are located on the campus of the University of Bremen within reach to the PMC office to provide minimal response times for project related tasks.

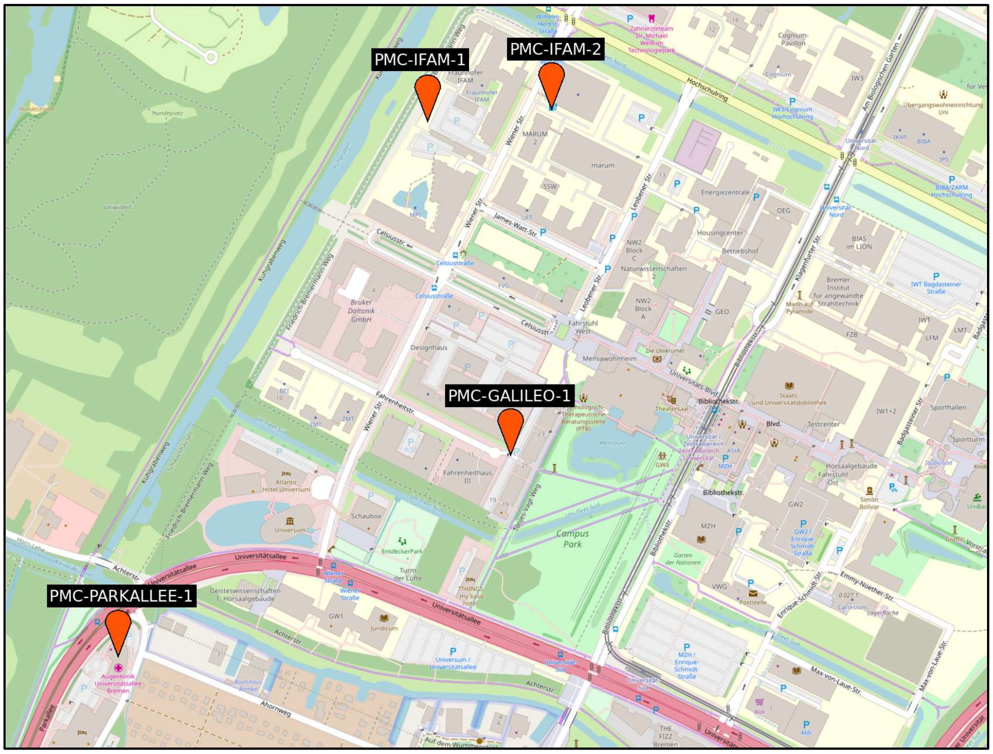


Figure 9 PMC Charging Stations at the campus of Bremen University;
Map source: OpenStreetMap - Open Database License 1.0; Datasource: PMC

3.2.2.1 Site "GALILEO-1"

The Galileo-Residenz Bremen is a private dormitory located in the campus centre of the University of Bremen. The PMC charging station includes two dedicated parking spots reserved for CarSharing vehicles equipped with a 2x22kW charge point. It is used basically by corporate customers working on the campus area.

Figure 10 Galileo-Residenz, Bremen; *Image source: PMC/Markus Spiekermann*

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.

Type**:** Dual Socket AC Wallbox

Location**:** private dormitory, Bremen, Fahrenheitstraße 19

Capacity**:** 2 shared outdoor parking spots

Status**:** operational – to be replaced with a modern version in Feb 2019; needed to allow data acquisition required in GreenCharge

Technical Data

- Vendor: SWARCO
- OEM: ICU
- Series: eVolt
- Outlets: 2x 22kW Type 2 Mode 3 Sockets
- Grid power limit: 30kW
- Load balancing: static configuration – future: realtime via encore.gridctrl
- Backend communication protocol: OCPP 1.6-JSON
- Backend connectivity: 3G/APN
- Backend: PMC tenant on encore.gridctrl
- Authentication: RFID (integrated reader) or Backend

3.2.2.2 Site "PARKALLEE-1"

This site is primarily used for development and testing purpose but can also be re-configured to run the production grade software. In this case it is targeted to employees of PMC to recharge cars on demand and providing general diagnostic maintenance on the EV's.

The charging station is also equipped with a 46" digital-signage display, which can be used to visualize charging instructions, advertisements or any kind of stored data.

Type: Quad Socket AC Charger with Digital Signage s/w capabilities

Location: underground car park, @Parkallee 301

Capacity: 5 dedicated parking spots

Status: maintenance/smart meter and controller upgrade required for GreenCharge by end of 03/2019

Technical Data:

- Vendor: SWARCO
- OEM: Technagon
- Series: Public46 MKII
- AC-Outlets: 2x 22kW Type 2 Mode 3 Sockets + 2x 3.7kW CEE 7/4 Sockets
- Grid power limit: 22kW
- Load balancing: static configuration – future: realtime via encore.gridctrl system
- Backend communication protocol: proprietary (gridctrl.cacp)
- Backend connectivity: 4G/VPN
- Backend: PMC tenant on encore.gridctrl
- Authorization/Authentication: RFID (integrated reader) and Backend

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.

3.2.2.3 Site “IFAM-1"

This site provides two parking spots with 22kW prototype charge points beneath a 4.7 kWp solar carport. It is used to recharge the cars of Fraunhofer-IFAM employees at work.

Figure 11: EMH2 Prototype; *Image source: PMC/Andi Dittrich*

Type**:** Single Socket AC Wallbox

Location**:** Fraunhofer-IFAM, main parking area @Wiener Straße 12

Capacity**:** 2 dedicated outdoor parking spots beneath a 4.7 kWp solar carport

Status**:** maintenance/smart meter update required for GreenCharge by end of 03/2019

Technical Data**:**

- Vendor: ABL
- Series: eMH2
- AC-Outlet: 22kW Type 2 Mode 3 Socket
- Grid power limit: 11kW
- Load balancing: static configuration – future: realtime via encore.gridctrl system
- Backend communication protocol: proprietary (gridctrl.cacp)
- Backend connectivity: Ethernet/VPN
- Backend: PMC tenant on encore.gridctrl
- Authorization/Authentication: Mechanical switch and Backend

3.2.2.4 Site “IFAM-2"

This site provides a station for fast-charging with 2 outlets as described below. Both AC and DC outputs can be used in parallel with a combined output power up to 100kW. Access is restricted to IFAM-employees only (access code and RFID authentication enforced).

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 12: DC Quick Charger; *Image source: PMC/Markus Spiekermann*

Type**:** Combined AC/DC Charger

Location**:** Fraunhofer-IFAM, building @Wiener Straße 17

Capacity**:** 2 dedicated outdoor parking spots

Status**:** operational

Technical Data**:**

- Vendor: DBT-CEV
- Series: Quick Charger
- AC-Outlet: 43kW Type 2 Mode 3 cable connector
- DC-Outlets: 50kW CCS and CHAdeMO cable connector
- Grid power limit: 100kW
- Load balancing: total power limit set to 100kW (static configuration)
- Backend communication protocol: OCPP 1.5-SOAP
- Backend connectivity: 3G/APN
- Backend: PMC tenant on encore.gridctrl
- Authorization/Authentication: RFID (integrated reader) and Backend

3.2.2.5 Site "IFAM-3" (upcoming)

In addition, usage of several charging stations installed at the parking ground of Fraunhofer-IFAM is considered. These are installed within the BMWi-funded project "LamA" (Laden am Arbeitsplatz) by 2020. The possibility to use these is still under debate. It would be an advantageous option for testing the use case "Priority Charging" (within scenario#3 - "Booking Enforcement") with a specified user group (employees who are driving shared EV's). Otherwise this use case must be tested with a very limited number of charging points.

Type: Presumably dual socket AC Wallbox (decision ca. mid 2019)

Location: main parking ground of Fraunhofer-IFAM, Wiener Str. 12

Capacity: 8-10 charging 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.

Status: open call for tender.

The timeline for this set-up would end around 05/2020, i.e., far beyond M12, when the pilot is going to start. Nevertheless, given the chance this option can be used within the GC-project, we would include this new charging option to test the use case #1. In this case D2.9 will be updated accordingly.

3.3 Current usage of charging infrastructure

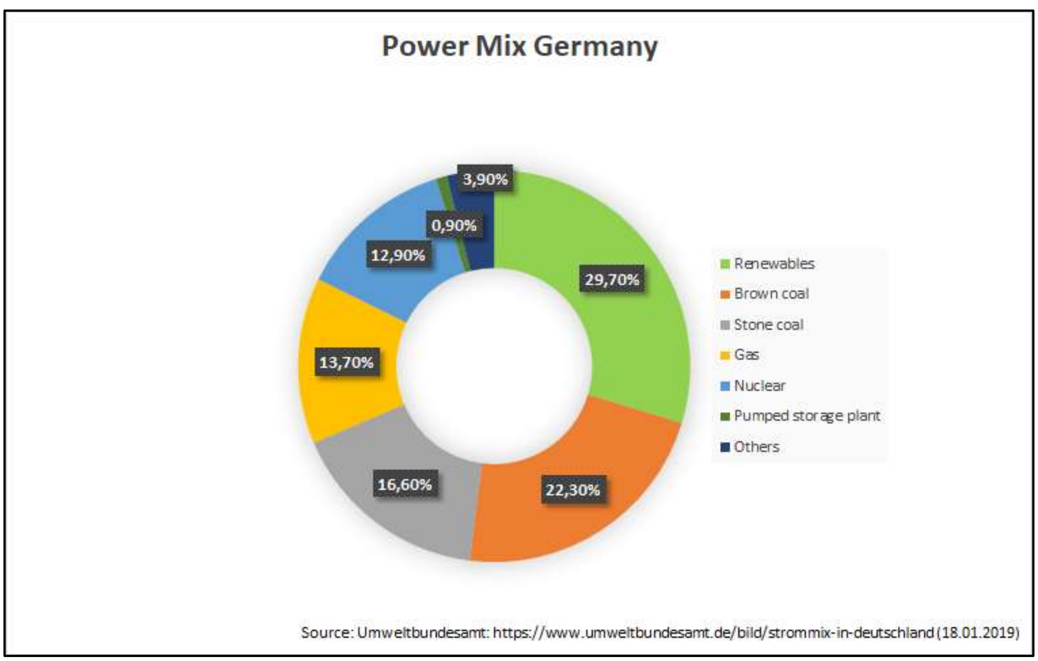
At the CarSharing stations serviced by MoveAbout, there is one charging point available for each vehicle registered at that station. Therefore, currently there is no particular booking process for chargers needed: For each EV registered for CarSharing there is a guaranteed parking lot at the respective charging point available. The frequency of use depends on the utilisation of each CarSharing station/vehicle and varies quite a lot from one site to the other. Currently, the general objective is to charge the EV immediately after each rental event.

The private EV charging infrastructure managed by PMC (as described in 3.2) is dedicated to restricted user groups, i.e., employees of PMC member entities. However, in order to prototype specific scenarios outside commuter traffic, other types of EV users must be acquired. In the current situation, pre-booking capability (app/web) of any of the charging-stations described in 3.2 is neither offered nor is it needed. This will have to change for testing the use cases described in chapter 4.1.

3.4 Electric energy and power supply

Germany's electricity supply has become ever "greener" throughout the last 2 decades, its share in gross electricity supply raising from about 6% in 2000 to nearly 30% in 2016 and over 40% in 2018.

The following diagrams provides an overview of both Germany's and Bremen's (Federal State) electric energy mix for the year 2016:



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.

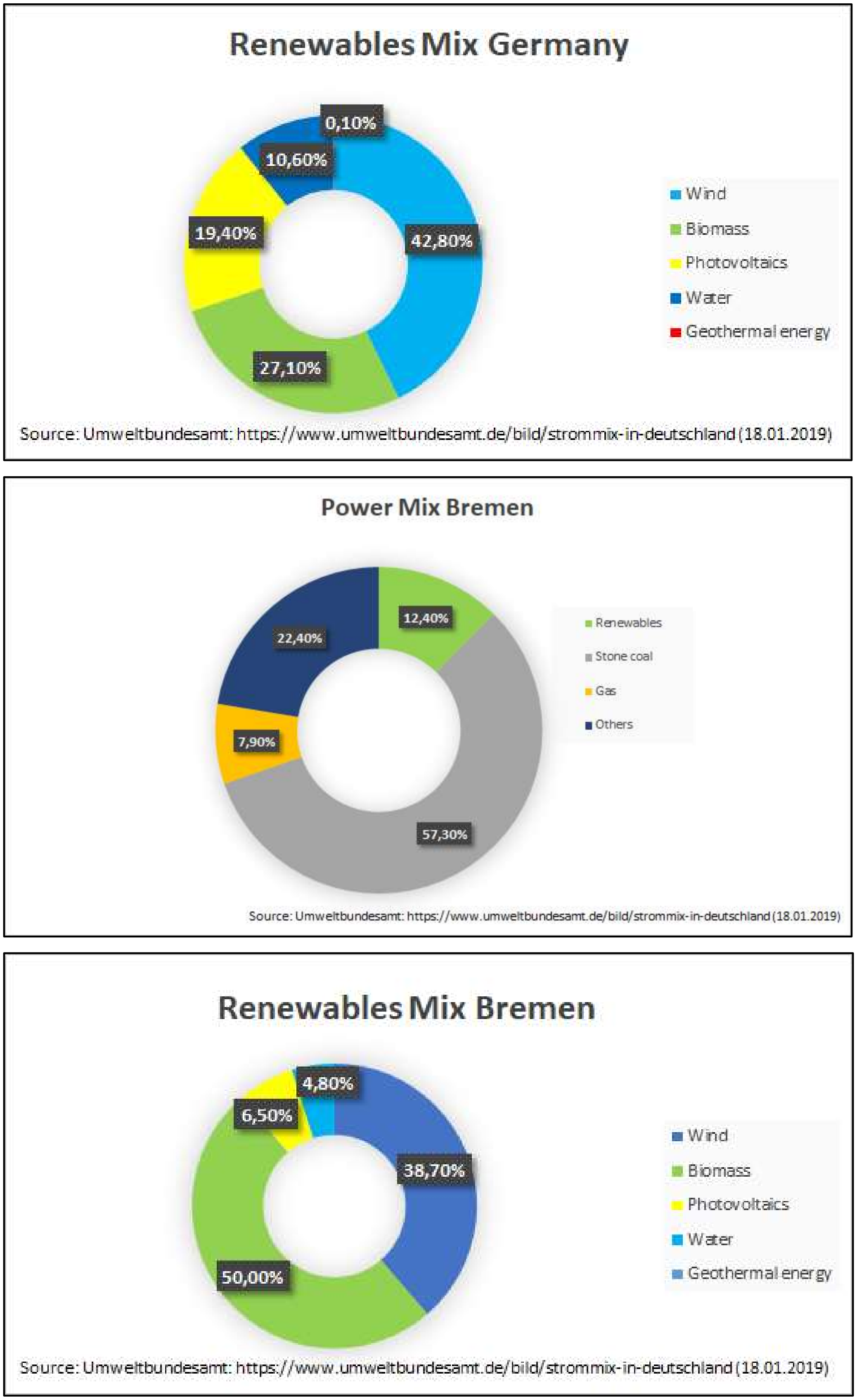


Figure 13: Electric power mix and Renewable Energy mix both in Germany and Bremen in the year 2016; *Source: Umweltbundesamt (from https//www.umweltbundesamt.de on 18.01.2019*

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.

For its charging stations, Move-About uses electric energy stemming 100% from renewable sources (wind, photovoltaic, biomass, and hydropower - "Öko-Strom") provided by the local utility SWB.

The charging stations managed by PMC are also supplied by the local utility SWB, but contracted with the "grey" Bremen electric power mix.

3.5 ICT Systems and Interoperability in the Electromobility Landscape in Bremen

3.5.1 Existing ICT systems in Bremen

The many-fold of usage options for public EV charging stations in Bremen is closely connected to the many-fold of operators. Access is usually granted to partners organized in fairly large networks. Public charging stations can be found via various Apps that also give the actual status of these stations (occupied, malfunction, etc.). However, enabling still occurs mostly via charging card issued by the operator or by a cooperating company (RFID key).

At Move-About, the implemented CarSharing-Boxes use the "Miveo"-system. Within this system each user must use RFID for opening and locking the shared car as well as for authorization at the existing charging stations of Move-About. The charging backend is provided by Meshcrafts AS (stakeholder in the LRG group). The running cooperation between Meshcrafts AS and Move-About is on a contractual basis and will be continued/extended for implementing the Bremen pilot in the GreenCharge project. Of course, within the GreenCharge project, Move-About will take responsibility for all items implemented by Meshcrafts.

PMC manages private charging infrastructure for some of its member entities, but also operates 3 own charging stations (described in 3.2.2.1/2/4). The backend software as well as the platform is provided by Aenon Dynamics (PMC member and stakeholder in the LRG group) as dedicated tenant.

3.5.2 Current interoperability of the ICT systems in Bremen

In Germany there are many operators of charging stations active with several 10 up to more than 10.000 units. Private networks are establishing selling own ID-cards to give access to charging stations registered in the respective network. Such nationwide cooperation between operators makes it progressively easier to go even on a long-distance trip with EV's using a single access mode.

Currently, the most relevant networks in Bremen (and throughout Germany) are:

- Plugsurfing (via App, RFID charge key)
- Intercharge / NewMotion
- Ladenetz.de (similar in size and connectivity as Intercharge)
- ChargeNow (BMW only)
- Allego (Alliander, NL)
- Bosch (web-based platform of Bosch Software Innovations).

In Bremen most of the public charging stations are run by the local utility SWB being partner of the charging network "Ladenetz". Meanwhile this roaming network allows access to ca. 13.000 charging points located all over Germany. Another large roaming network in Europe is "Newmotion" with over 80.000 charging points. Projects like "Intercharge" from Hubject connect more than 300 partners – Newmotion being one of them. To the best of our knowledge, this is the largest roaming network worldwide so far.

Move-About uses RFID cards to communicate with their charging stations, which are only accessible to EVs owned by Move-About itself. Further, the charging stations are not part of any charging network. Therefore,

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no other RFID cards are accepted so far. SmartCharge by Meshcrafts based on OCPP is used to monitor the charging stations.

PMC uses RFID cards, too, issued to EV users. No interoperability is employed.

Currently, no partner of the above charging networks are getting access to stations operated/managed by Move-About or PMC.

3.6 Policy and incentives for e-mobility

Bremen's SUMP is European SUMP Award winner 2015. The SUMP targets at well-functioning and environmentally friendly mobility in Bremen by an increase in social inclusion, higher level of traffic safety, optimisation of commercial traffic and accessibility of Bremen as a regional centre. Further, SUMP targets at more and better services for environmentally friendly modes of transport, linking of transport systems, strengthening of walking, cycling and public transport, including between the city and the surrounding region, fewer negative effects on people, health and the environment.

The outcome of the green city masterplan development as an update to the Bremen SUMP in 2018 has led to pursuing the electrification of public transport first.

Privileges for EV users are designated parking slots without paying for parking, only for charging, tolls are not available, taxes are on federal, not on city level. Additionally, there is a national funding scheme to encourage private byers of e-cars, of course applicable to Bremen customers, too.

Bremen uses a strategy to develop mobility-hubs, so called "Mobil.Punkt" on public space by combining public transport and bike parking together with CarSharing. These mobility stations have a specific appearance and are clearly visible in the city. Appropriate car-sharing sites will be equipped with the sign post "mobil.punkt" or "mobil.pünktchen" for smaller stations, thus enhancing recognition.

Figure 14: Bremen mobil.punkt station at Hohenlohestraße*; Image source: Michael Glotz-Richter*

Bremen built 8-10 mobil.punkt/mobil.pünktchen stations per year and intents to continue to do so in the coming years.

CarSharing spaces in public are generally prepared for electric charging, if street space allows. Thus, if a provider intents to install EV-charging, the grid connection is already in place.

As early as 2010, during the first phase of the German initiative "Modellregion Elektromobilität", Bremen became the first state in Germany that adopted the highway code, which allowed project partners within this initiative to install and operate charging stations on public parking ground.

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4 User needs

4.1 Scenarios

A scenario describes a specific use of a proposed system by illustrating some interactions 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.

The following 3 scenarios will be tested in the Bremen pilot site basically:

- Booking Enforcement (Scenario 3 from the DoW)..
- Charging at work in (groups of) buildings) with common internal grid (Scenario 4 from the DoW)
- E-mobility as an innovative MaaS - mobility as a service (Scenario 7 from the DoW)

4.1.1 Scenario 'Booking Enforcement'

For some specific types of EV (cars used for regular business trips, VIP owner, visitor cars, etc.) a priority charging is needed, i.e., a guaranteed parking/charging site must be available at a pre-booked time on the pre-determined site. This could be a charging-station on the own premises or on an external site that can be booked, when being on a long business trip.

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

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

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

3. Parking at a booked spot or leaving the vehicle by a charging post longer than agreed may cause punishment, e.g. a fine or higher price or blacklisting. A good strategy to avoid practical problems with booking, while still 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.

This scenario can be simulated at the Bremen pilot by combining priority charging on company premises and a dc-charging option.

Use case #1: Booking for priority charging at a company's site.

User needs: In business areas there are specific situations, for which Booking Enforcement is needed – even on own private ground. From a user perspective of the charging stations this comprises additional aspects.

- Visitors must be given priority via a pre-booked parking spot on arrival. This should be handled by the host ideally;
- Business EV's must be available fully charged always. On arrival from a trip they need priority charging – charging at other points must be adjusted accordingly.

4.1.2 Scenario 'Charging at work'

Charging at work in (groups of) buildings with common internal grid and parking facilities is a very common situation and an ever-growing field of services that could be realized both by the employing company itself or a contracted stakeholder for technical service, maintenance, and providing detailed statements. One of the main challenges here is to couple different charging stations at different places within a single backend system.

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

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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.

N.b.: 1(a) and 1(b) denote the same situation considering the charge management (charge planning, limitations in power supply) and similar user groups.

Use case #2: Commuter - Charging at work at various sites within a business area – ideally via photovoltaic energy supply combined to battery storage

User needs: A commuter driving to work by EV.....

- ….. needs to know whether charging at the employer's site can be used that day
- ….. needs to be sure that charge management system reserves enough power at an arbitrarily chosen charging point
- ….. wants to be informed via mobile application, if charging is interrupted
- ….. wants to charge green energy, even with no sun/wind being present.

4.1.3 Scenario 'Mobility as a Service (MaaS)'

This scenario is one of the most relevant for the Bremen pilot site. The overall objective here is to combine several services (usually offered from several stakeholders) in order to provide a comprehensive "mobility" package to potential users, e.g. to customers of the CarSharing provider.

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.

CarSharing in the Bremen pilot is offered as station-based system with a maximum of 1-2 EV's per station. The many boundary conditions that exist for operators and users of EV-CarSharing - as derived from experiences with customer inquiries - can be summarized as follows:

An EV-CarSharing operator...

- … needs to know the SoC of the shared EV's
- … needs to know, when the car is charging
- … needs to know how long each of the cars is on a trip (enables option to offer the charging infrastructure/parking spot to other users)

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- … needs to know how long the charging infrastructure/ parking spot will be used by someone else
- … needs to know the required power and amount of energy for load management
- … needs to know how many kWh have been charged.

An EV-CarSharing user...

- … wants to receive a fully charged car on request
- … wants to know optional charging sites, if being on a long-distance trip
- … wants to know the available km-range of the EV
- … wants to know the overall charging time (calculated/provided by the In-car system from SoC).

Use case #3: EV CarSharing combined with public transport ("mobil.punkt")

User needs: CarSharing combined with public transport offers even more flexibility in mobility.
The many boundary conditions that exist for users of EV-CarSharing can be summarized as follows:

An EV-CarSharing user of a mobil.punkt ....

- … wants to charge and ride
- … wants to have one single mobility ticket
- … wants to use one single Application instead of one for each service
- … wants to conduct optionally reservation of a required car.

Use case #4: EV CarSharing in a residential neighbourhood

User needs: CarSharing in a residential neighbourhood is open to everyone but should address the neighbourhood in a special way. The many boundary conditions that exist for users of EV-CarSharing - as derived from experiences with customer inquiries - can be summarized as follows:

An EV-CarSharing user from the neighbourhood...

- … wants to have attractive parking possibilities
- … wants to have an attractive pricing
- … wants to have the option to reserve/block a parking spot near his destination
- … wants to be sure that a towing service takes care of illegally blocked parking spots.

4.2 Stakeholders

A good mix of stakeholders have been acquired (and will be extended) to accompany and support the efforts and progress of the Bremen pilot partners during the GC project. These will actively contribute in the 3 workshops planned within WP3 (task 3.2).

In the following these entities are described with their respective relevance to the objectives pursued in the Bremen pilot site.

Table 2: *List of stakeholders engaged in the Bremen pilot site*

Stakeholders	Type	Description
MESHCRAFTS	Company	Meshcrafts is an Oslo-based company (A.S.) with a subsidiary in Bremen providing charging infrastructure backends that are used by MoveAbout charging points, too. In the framework of the Open Charge Alliance (OCA), Meshcrafts was the first platform with full integration of the OCPP 1.6 protocol

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		infrastructure and is also taking active part in the development of the next protocol, OCPP 2.0.
SWB	Company	The SWB AG ("Stadtwerke Bremen") is the local provider in the greater Bremen/Bremerhaven area for electric power, natural gas, drinking water and district heating with a turnover of 1500 Mio€. It is operating with its several daughter companies, e.g., "Wesernetz GmbH" (operator of the power, gas, water grids), SWB CREA GmbH (regenerative energy from regenerative sources wind, solar, hydropower, and biomass). In terms of sales of electric power and gas SWB Vertriebs GmbH is market leader in the city of Bremen. SWB manages grid operations in the medium/high voltage electric grid as well as the power connection to buildings and industrial sites and – increasingly - to public/private EV charging stations.
GEWOBA	Company	The Gewoba AG (Wohnen und Bauen) is the largest landlord-company in Bremen and is active in construction and operating buildings. Particularly important for the Bremen pilot are the activities of the GEWOBA Energie GmbH (a 100% daughter of Gewoba AG), dealing with technical equipment for heating and power supply. In addition, the Gewoba Energie GmbH is investing in installation of combined heat and power units (BHKW) in GEWOBA-flats via heat-and-power-cogeneration. This offers to residential tenants to buy not only environment-friendly produced heat, but also electric power at a reasonable price – so-called Mieterstrom -, which might be used for nearby EV-charging points in the future.
CAMBIO Bremen Carsharing	Company	Cambio Bremen GmbH (StadtAuto Bremen CarSharing GmbH) is by far the largest CarSharing provider in Bremen owning >90% of all shared cars in the Bremen area. Bremen is one out of 22 cities, where Cambio Germany operates station-based fleets. Since 03/17 there are also 4 EV's in the portfolio that can be rented at 4 out of 101 stations operated in Bremen. Cambio Bremen is planning to extend the share of EV's in the near future.
ECOTEC GmbH	Company	Ecotec GmbH is operating technical infrastructure of buildings (mostly offices) and takes on general facility management activities. It is operating buildings mainly at the university campus, but is active in large quarter development in the greater Bremen area, too. As the latest example, for the new building OCÜ Office Center Überseestadt Bremen, Ecotec was co-responsible for developing the energy concept, the implementation of technical infrastructure (heat/power) and controlling its realization. Increasingly, such energy concepts for new buildings include mobility concepts with EV's and e-bikes.
BSAG	Company	The BSAG ("Bremer Straßenbahn AG") is the largest local public transport provider operating 119 city trams and 230 busses. In addition, 2 battery electric busses were tested in the recent years. Unfortunately, extension of these activities regarding electrification of public bus transport is not foreseen during the GC project. However, to

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		increase mobility options for customers, EV car-sharing is combined with public transport in several mobility hubs.
SWARCO	Company	Swarco Traffic Systems GmbH is a supplier of charging infrastructure with business units urban/interurban traffic management, parking/emobility, and traffic detectors.
BREPARK	Company	Administration and servicing public parking space in Bremen, i.e., multi-storey car parks and parking-lots and many sites for hard-shoulder street-parking.
AENON DYNAMICS	Company	Aenon Dynamics UG is a start-up company located at the university campus and member of PMC. It is developing IT system architecture for small and medium-sized companies, EV charging infrastructure, and mobility concepts. Its proprietary backend solution ENCORE.gridctrl is used in some of the PMC charging stations.
UniBremenSOLAR eG	Company	managing and taking over the maintenance of solar panels on several buildings at the University campus (in total nearly 150kWp).
Gewoba-residents	Citizens	Beneficiaries of the charging stations
Neighbourhood	Citizens	Beneficiaries of the charging stations
Workforce	Employees	Beneficiaries of the charging stations

4.3 Use cases and user needs

Summarizing from Chapter 4.1 the following use cases derived from scenarios 3, 4, and 7 will be tested in the Bremen pilot (user needs are related to the required technology in Chapter 5.1). Detailed descriptions of the use cases are provided in Appendix.

4.3.1 Use case #1: Booking Enforcement for priority charging (in Scenario 3 (-> S3))

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.

4.3.2 Use case #2: Commuters charging at work via PV energy supply (-> S4)

Commuters have the chance to park & charge on their company's ground via PV and/or from electric energy buffered in 2^{nd}-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).

4.3.3 Use case #3: EV-CarSharing combined with public transport (-> S7)

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.

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.

4.3.4 Use case #4: <u>EV-CarSharing in a residential neighbourhood</u> (-> S7)

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.

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 Technological Requirements

The current situation in terms of usability of charging stations served by various stakeholders does not fulfil requirements for interoperability. In particular, the different backends that are employed for the various charging sites make a comprehensive performance in providing 'Mobility as a Service' inconvenient to potential users. On the other hand, interoperability is a requirement for testing the use cases in the above scenarios. Therefore 2 separate demos will be established to demonstrate and improve the usability of the various technological modules, when user needs are tackled in 4 well-defined use cases.

Charging during office hours (demo "Charge@work") needs a coordinated charging scheme to not exceed the given power limit taken from the company grid. In addition, implementing on-site PV power and storage battery modules further reduces the employer's cost of electricity. Giving priority to a certain group of users (e.g., visitors, VIPs) must be controlled by a suitable backend-software based on automatic data acquisition. The charging infrastructure employing the coordinated usage of the internal power grid, the on-site PV and a used battery storage would enable power peak-shaving and thus generate cost-savings for the employer.

Station-based eCarSharing (demo 2) is just one out of various options for user mobility. The acceptance of this option increases, if a reasonably good combination with public transport usage exists, e.g. via timetables, combined ticket and/or reservation options. This is currently not implemented and tested. Further, usage of charging points on public ground by private EV owners requires backend communication on the SOCs of the shared EV and the private EV requesting charge point usage.

More detailed descriptions of the interfaces to be implemented by the 2 Bremen demonstrators in relation to the 4 use cases is given in *D2.10 Implementation plan for Bremen pilot*.

The following Table 3 summarises the essential requirements for demonstrating the 4 defined use cases.

Table 3: *Technologies used to satisfy the user needs referring to use cases and demos*

Use Case (UC)	UC	Technology	Stakeholder(s) involved	Demos
Booking enforcement for priority charging	#1	Charging Management System (CMS) provides charging to the connected cars in normal operation; Charging Management System (software backend) decides the power distribution between the various charging points depending on pre-determined priority; relevant information on charging time is transferred to the user app.	PMC MoveAbout	Charge@work on company ground; eCarSharing stations
Commuters charging at work with PV	#2	Commuters give information for how long they are on-site (manually via mobile); Chargers are connected to backend system for management and operation of the charging station; CMS decides on the optimum power source depending on weather forecast and actual SOC of stationary storage battery; charging from internal power grid as least-preferred source option.	PMC	Charge@work on company ground with carport/PV

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.

EV-sharing combined with public transport	#3	The information from the public transport booking platform enabling ticketing, actual timetable, and reservation to be integrated in the eCarSharing software; Booking App integrates and visualises the options the users will have on using public transport and/or eCarSharing; Data from eCar parking site (occupied or unoccupied) to be acquired automatically and optionally proceeded to towing service.	BSAG (local public transportation provider) MoveAbout (eCarSharing)	eCarSharing stations (locations throughout Bremen)
EV-Sharing in a residential neighborhood	#4	Residents can book any EV that is available on the CarSharing station; the EV can be unlocked via an app that checks the authentication of the user; Reservation/blocking of an EV is realised by a booking platform for charging points and SmartCharge software; CMS of charging station should allow optional usage of charge points by private EV owners (currently not integrated). Charge data acquired automatically provide basis for billing the user.	Local landlord company MoveAbout	eCarSharing stations

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

From the above described situation of the Bremen pilot site, it can be concluded that there exist a vast variety of options on how to meet the challenges set by environmental issues on the one hand side and the citizens's mobility needs on the other. Future options in Bremen comprise, e.g., electric busses for public transport, replacement of delivery trucks/vans by electric versions, and privileging e-bikes in city traffic. Generally, there will always a compromise to be made between satisfying speed, cost, comfort, and environmental effect, when using the various mobility options.

Bremen was one of the first movers promoting/testing electric mobility issues in Germany. In GreenCharge, CarSharing will be the core element for the Bremen pilot, which will be enhanced by implementing selected tools to be described in detail in a forthcoming report. In a preceding project, this core element had been proven promising for reducing (voluntarily!) the number of car-owners among the fellow citizen by adding improved and convenient options for individual mobility.

However, a real "GreenCharge-effect" will mean not only to foster general CarSharing as a service, but to implement electric vehicles for this purpose. In this way both the local amount of airborne pollutants and the CO_2 footprint can be lowered even more effective. We are confident that by testing these options in selected situations and use cases we will achieve a major step in the direction of a sustainable green city Bremen.

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

A Appendix

A.1 Use Cases to be tested at the Bremen Pilot

A.1.1 Use Case #1 (PMC): Booking Enforcement for Priority Charging

1.1 Description

The energy demand of a charging site will be optimized by using pre-charge booking combined with task prioritization and selected user needs.

1.2 Actors

1.2.1 Primary Actor

3 Primary Actors are involved in this use case (either of them):

- A listed VIP or business EV driver gets to work and needs re-charging immediately, since he/she leaves in the next 2 hours.
- A pre-registered visitor to the company, who arrives during the day with nearly empty battery and needs recharging within 3 hours before he/she would leave again.
- A commuter arrives at work in the morning with 50% empty EV battery and would like to charge the battery to minimum 80% before he/she drives away after work.

1.2.2 Additional/Supporting Actors

Secondary Actors: a hosting employee in the case of a visiting guest.

1.3 Stakeholders

- Employer who want to obtain the energy demand of electric vehicle – data may be used to construct charging areas in the future;
- Charging infrastructure owner;
- Charging infrastructure operator;
- Virtual power plant operator;
- Fleet manager.
- Company responsible for the on-site energy management system, trying to keep peak energy demand as low as possible in order to prevent extra cost.

1.4 Preconditions

- A free parking spot must be available within the charge point area;
- The user has access to the booking website to book his charging session;
- The user's vehicle is registered within the backend including technical specifications (battery capacity, …);
- An optional in-vehicle data collection system will be installed in the EV to obtain real-time battery data. This precondition is required only, if the vehicle would require more than ~80% of the available power capacity of the local on-site grid;
- The driver has a charging demand.

1.5 Basic Flow

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.

1.5.1 Basic Flow: advanced charging infrastructure with authentication and pre-booking

1. The EV driver books his charging session spot via the booking website including a time schedule and energy demand;
2. The required charging point indicates priority by a busy sign to keep parking place free;
3. The EV driver parks the car on his dedicated parking spot and connects the car for charging;
4. The charge management systems transmits the energy demand and estimated schedule to the energy management system;
5. The energy management system controls the energy flow;
6. The charge management system observes the charging process and monitors the system health;
7. Advanced metering and usage data will be aggregated during the charging process to optimize the load balancing on the fly;
8. By disconnecting the car, the user will receive a notification including the amount of energy transmitted to the car.

1.6 Alternative Flows

1.6.1 Alternative Flow: legacy charging infrastructure with limited capabilities and RFID authentication

1. The EV driver parks the car on an available parking spot and connects the car for charging;
2. The driver uses a RFID card (e.g. a dedicated card or his employee badge) to authenticate himself with the charging point;
3. The driver has no special charging demand – static configured data will be used;
4. The charge management system observes the charging process and monitors the system health;
5. Basic usage data will be aggregated during the charging process;
6. By disconnecting the car, the user will receive a notification including the amount of energy transmitted to the car.

1.7 Extensions

1.7.1 Extension Flows

1.7.1.1 Basic Flow: driver changes his charging demand during charge

- 5. (extension). The user provides his charging demand (amount of energy; next trip reach or SoC; ETD - estimated time of departure) to the system via a website;
- 5.A The user will receive an immediate feedback if the goal can be reached;
- 5.B The energy management system will change the energy flow to reach the goal.

1.7.2 Exception Flows

N.b.: It is expected that the exception flow list will be further expanded during the pilot site operation. Respective up-dates will be included in the final report ("living" document)

1.7.2.1 Basic Flow: projected SoC cannot be reached – SoC too low

- 4. (raised exception). The start-of-charge SoC is too low to reach the projected SoC within the schedule;
- 4.A The user will be notified that the goal cannot be reached;
- 4.B The user has to decide to use a lower amount of energy as projected OR move the car to the DC fast-charger (if supported by the vehicle).

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.

1.7.2.2 Basic Flow: no free parking spot available in the charging area

- 1. (raised exception). All parking spots in reach of the chargers are occupied;
- 1.A The user cannot charge the car – manual interaction is required: blocking cars must be moved to another location by their drivers (contact them by telephone).

1.7.2.3 Basic Flow: charge point hardware fault (start-of-charge)

- 1 (raised exception). All parking spots in reach of the chargers are occupied;
- 1.A The user cannot charge the car – manual interaction is required: car must be moved to another location;
- 1.B Technical support must be contacted.

1.7.2.4 Basic Flow: charge point hardware fault (during charge)

- 6 (raised exception). The charge management system detects a hardware fault;
- 6.A The user cannot continue the charging – manual interaction is required; 6.B User receives a system notification including the SoC;
- 6.C car must be moved to another location to continue the charge OR the user decides to stop the charge based on SoC information.

1.7.2.5 Basic Flow: charge management system fault (start-of-charge)

- 2(raised exception). The charge point cannot communicate with the charge management system;
- 2.A The user cannot charge the car – manual interaction is required: car must be moved to another location;
- 2.B Technical support must be contacted.

1.7.2.6 Basic Flow: charge management system fault (during charge)

- 6 (raised exception). The charge point cannot communicate with the charge management system;
- 6.A The charge point will go into failsafe condition -> system shutdown; 6.B The user cannot continue the charging.

1.7.2.7 Basic Flow: projected SoC cannot be reached – grid power limit reached

- 6 (raised exception). The total energy demand of the charging site has changed and the energy management system cannot fulfill all the tasks;
- 6.A The user will be notified that his demand cannot be met;
- 6.B The energy management system will apply a prioritized load balancing algorithm with data provided by the charging management system. The priority is bound to the user identity and/or the next trip destination/reach.

A.1.2 Use Case #2 (PMC): Commuters charging at work with PV

1.1 Description

Commuting employees driving an electric vehicle (EV) want to charge their cars during business hours. Local load balancing is required to optimize the charging process and to provide the amount of energy, which is required for the up-coming trip.

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.

1.2 Actors

- Employees of PMC members (EV drivers);
- Employees of PMC.

1.2.1 Primary Actor

The Primary Actor is the EV driver within a corporate context.

1.2.2 Additional/Supporting Actors

Secondary Actors: none for this use case.

1.3 Stakeholders

- Employer who want to obtain the energy demand of electric vehicle – data may be used to construct charging areas in the future;
- Charging infrastructure owner;
- Charging infrastructure operator;
- Virtual power plant operator;
- Fleet manager.

1.4 Preconditions

- A free parking spot must be available within the charge point area;
- RFID tag of the employee's ID badge is registered in the backend as GreenCharge user;
- The user's vehicle is registered within the backend including technical specifications (battery capacity, …);
- An optional in-vehicle data collection system will be installed in the EV to obtain real-time battery data. This precondition is required only, if the vehicle would require more than ~80% of the available power capacity of the local on-site grid;
- The driver has a charging demand.

1.5 Basic Flow

1.5.1 Basic Flow: advanced charging infrastructure with authentication and real-time in-vehicle data link

1. The EV driver parks the car on his dedicated parking spot and connects the car for charging.
2. The in-car system of the EV establishes a connection to the charge point and sends both its SoC and vehicle-ID to the backend;
3. The driver has no special charging demand – static data will be used;
4. The charge management systems transmits the energy demand and estimated schedule to the energy management system;
5. The energy management system controls the energy flow;
6. The charge management system observes the charging process and monitors the system health;
7. Advanced metering and usage data will be aggregated during the charging process to optimize the load balancing on the fly;
8. By disconnecting the car, the user will receive a notification including the amount of energy transmitted to the car.

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.

1.6 Alternative Flows

1.6.1 Alternative Flow: legacy charging infrastructure with limited capabilities and RFID authentication

1. The EV driver parks the car on an available parking spot and connects the car for charging;
2. The driver uses a RFID card (e.g. a dedicated card or his employee badge) to authenticate himself with the charging point;
3. The driver has no special charging demand – static configured data will be used;
4. The charge management system observes the charging process and monitors the system health;
5. Basic usage data will be aggregated during the charging process;
6. By disconnecting the car, the user will receive a notification including the amount of energy transmitted to the car.

1.6.2 Alternative Flow: advanced charging infrastructure without authentication

1. The EV driver parks the car on his dedicated parking spot and connects the car for charging;
2. The driver presses a button on the charging station to start it;
3. The drivers/vehicle-ID is resolved from the dedicated charging point;
4. The driver has no special charging demand – static configured data will be used;
5. The charge management system transmits the energy demand and estimated schedule to the energy management system;
6. The energy management system controls the charging process energy flow;
7. The charge management system observes the charging process and monitors the system health;
8. Advanced metering and usage data will be aggregated during the charging process to optimize the load balancing on the fly;
9. By disconnecting the car, the user will receive a notification including the amount of energy transmitted to the car.

1.7 Extensions

[Document alternate flows and exceptions to the main success scenario. Extensions are branches from the main scenario, and numbering should align with the step of the success scenario where the branch occurs.]

1.7.1 Extension Flows

1.7.2.1 Basic Flow: driver provides charging demand via Smartphone/Tablet

- 3. (extension). The user provides his charging demand (amount of energy; next trip reach or SoC; ETD - estimated time of departure) to the system via a website;
- 3.A The user will receive an immediate feedback, if the demand can be met;
- 3.B The energy management system will change the energy flow to meet the demand.

1.7.2.2 Basic Flow: driver changes his charging demand during charge

- 5. (extension). The user provides his charging demand (amount of energy; next trip reach or SoC; ETD - estimated time of departure) to the system via a website;
- 5.A The user will receive an immediate feedback if the goal can be reached;
- 5.B The energy management system will change the energy flow to reach the goal.

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.

1.7.2 Exception Flows

N.b.: It is expected that the exception flow list will be further expanded during the pilot site operation. Respective up-dates are included of the final report ("living" document)

1.7.2.1 Basic Flow: projected SoC cannot be reached – SoC too low

- 4. (raised exception). The start-of-charge SoC is too low to reach the projected SoC within the schedule;
- 4.A The user will be notified that the goal cannot be reached;
- 4.B The user has to decide to use a lower amount of energy as projected OR move the car to the DC fast-charger (if supported by the vehicle).

1.7.2.2 Basic Flow: no free parking spot available in the charging area

- 1. (raised exception). All parking spots in reach of the chargers are occupied;
- 1.A The user cannot charge the car – manual interaction is required: blocking cars must be moved to another location by their drivers (contact them by telephone).

1.7.2.3 Basic Flow: charge point hardware fault (start-of-charge)

- 1 (raised exception). All parking spots in reach of the chargers are occupied;
- 1.A The user cannot charge the car – manual interaction is required: car must be moved to another location;
- 1.B Technical support must be contacted.

1.7.2.4 Basic Flow: charge point hardware fault (during charge)

- 6 (raised exception). The charge management system detects a hardware fault;
- 6.A The user cannot continue the charging – manual interaction is required; 6.B User receives a system notification including the SoC;
- 6.C car must be moved to another location to continue the charge OR the user decides to stop the charge based on SoC information.

1.7.2.5 Basic Flow: charge management system fault (start-of-charge)

- 2(raised exception). The charge point cannot communicate with the charge management system;
- 2.A The user cannot charge the car – manual interaction is required: car must be moved to another location;
- 2.B Technical support must be contacted.

1.7.2.6 Basic Flow: charge management system fault (during charge)

- 6 (raised exception). The charge point cannot communicate with the charge management system;
- 6.A The charge point will go into failsafe condition -> system shutdown; 6.B The user cannot continue the charging.

1.7.2.7 Basic Flow: projected SoC cannot be reached – grid power limit reached

- 6 (raised exception). The total energy demand of the charging site has changed and the energy management system cannot fulfill all the tasks;
- 6.A The user will be notified that his demand cannot be met;

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- 6.B The energy management system will apply a prioritized load balancing algorithm with data provided by the charging management system. The priority is bound to the user identity and/or the next trip destination/reach.

A.1.3 Use Case #3 (MOVA): EV-Sharing combined with Public Transport

1.1 Description

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 EV drivers looking for a re-charging option.

1.2 Actors

- Customer
- Public transport provider
- CarSharing provider
- Additional EV drivers looking for a charging point

1.2.1 Primary Actor

The Primary Actor is the CarSharing customer.

1.2.2 Additional/Supporting Actors

- Public transport provider
- CarSharing provider
- Additional EV drivers looking for a charging point

1.3 Stakeholders

- *C*arSharing customer
- Public transport provider
- CarSharing provider
- Additional EV drivers looking for a charging point.

1.4 Preconditions

CarSharing customer and other EV-drivers have a user account for the GreenCharge App.

The EV driver has previously configured the GreenCharge App with information about his/her EV and the default settings for charging:

- maximum battery capacity,
- minimum charging level demand,
- EV registration number (only needed,if priority charging is granted for extra cost),
- contact information.

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 EV-driver has got a charging demand.

Public transport timetable must be implemented in Greencharge App.

Information about booking periods for CarSharing must be implemented in the system so the charging site can be used by EV-drivers.

1.5 Basic Flow

1. The customer books a shared car.
2. For the booked car the App offers a connection to the CarSharing station.
3. The customer uses public transport to get to the reserved car.
4. The customer uses the App for identification at the station.
5. The customer drives away with the booked car to reach destinations, which are not served by local public transport.
6. During the booked period the charging site is available for other EV drivers looking for a charging point.
7. The EV driver opens the GreenCharge App.
8. Finding a suitable charging point the App informs about available charging time.
9. The EV driver books it via App.
10. Arriving at the charging point the EV driver connects car and charging point.
11. The App calculates the energy needed for charging and communicates the charge request to the "Charge management system".
12. The "Charge management system" charges the EV according to the schedule of the charging point during the absence time of the shared EV.
13. The "Charge management system" calculates the charging cost and registers under user's account.

1.6 Extensions

1.6.1 Alternative Flows

Pre-booking period for the shared EV is too short to enable the charging point

If the customer returns back earlier than booked, the charging point is occupied and thus not available for other EV drivers.

1.6.2 Exception Flows

The data needed is not provided with the App: 4.1. and 9.1 System displays a warning message

A.1.4 Use Case #4 (Move-About): EV-Sharing in a Residential Neighbourhood

1.1 Description

The EV-driver arrives at home with almost empty EV battery and would like to charge the battery to minimum 70% before driving away in 3 hours

1.2 Actors

1.2.1 Primary Actor

The primary actor is the CarSharing customer.

1.2.2 Additional/Supporting Actors

- Additional EV driver
- Landlord company

1.3 Stakeholders

- Customer
- Additional EV driver
- Landlord company

1.4 Preconditions

- Charge management system is integrated in App;
- The driver has a user account for the GreenCharge App;
- The driver has previously configured the GreenCharge App with information about the EV and the default settings for charging: maximum battery capacity, minimum charging level demand, EV registration number (needed for priority charging for extra cost), contact information (for notifications, e.g., in case charging cannot be provided);
- The driver has a charging demand.

1.5 Basic Flow

1. The EV driver parks the car in the garage and connects the car for charging.
2. The driver opens the GreenCharge App.
3. The driver gives input to the GreenCharge App that the required charge level is x%, and the charging should end in 3 hours.
4. The App will calculate the energy needed for charging to x% and communicates the charge request to the "Charge management system".
5. The "Charge management system" communicates the energy demand to the "Neighbourhood energy mgmt. system".
6. The "Neighbourhood energy mgmt. system" schedules the charging according to the total energy demand, the availability of energy and energy price.
7. The "Neighbourhood energy mgmt. system" sends the charge schedule (the charge periods with energy amount, price and energy source for each period) to the "Charge management system".
8. The "Charge management system" charges the EV according to the schedule.
9. The "Charge management system" calculates the charging cost and registers under user's account.

1.6 Extensions

1.6.1 Alternative Flows

- The SOC is below the minimum charge level demand, when the EV is plugged in.

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.

4.1 The App provides a charge request with immediate charging demand to reach the minimum charge level demand.

- The "Neighbourhood energy mgmt. system" needs to reschedule the charging due to changes in the neighbourhood energy demand, energy availability and energy price.

7.1 The "Neighbourhood energy mgmt. system" recalculates the schedule and sends it to the "Charge management system".

8.1 The "Charge management system" charges the EV according to the updated schedule.

1.6.2 Exception Flows

The data needed is not provided with the App:

3.1. System displays a warning message

3.2. Actor enters additional data.

The grid is overloaded and local renewable energy system production is not sufficient:

6.1 The "Neighbourhood energy mgmt. system" fails to schedule the charging according to the total energy demand and the availability of energy.

6.2 The "Neighbourhood energy mgmt. system" prioritizes the energy use and updates the charging schedule according to the priorities. Some charging demands may need to be rejected.

7.1 The "Neighbourhood energy mgmt. system" communicates the new schedule to the "Charge mgmt. system".

8.1 In case charge rejection, the "Charge mgmt. system" notifies the user according to the provided contact information.

3.1 In case of charge rejection, the user updates the priority setting and sends new charging request.

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