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GreenCharge Project Deliverable: D5.5 & D6.4

Final Result for Innovation Effects Evaluation / Stakeholder Acceptance Evaluation and Recommendations

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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 charge points, grid investment reductions, and policy and public communication measures for accelerating uptake of electromobility.

For more information

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Executive Summary

This combined report for deliverable D5.5 and D6.4 presents the final evaluation results from the GreenCharge project. It describes the approach and results from the evaluations of seven GreenCharge demonstrators and simulation scenarios.

Each demonstrator implements a set of new measures from a set of measure groups:

- **EV fleet:** Shared electric vehicles (EVs), Shared EVs integrated with public transport, and Shared EVs in new housing cooperatives.
- **Charging:** Private charge points (CPs), public CPs, shared CPs, roaming, advance booking, battery swapping & charging, flexible charging, priority charging, and priority access to CP.
- **Smart energy management:** Local RES, Local storage, and Optimal and coordinated use of energy.
- **Business aspects:** Rewarding eco driving, payment for sharing EVs, penalizing priority in Energy Smart Neighbourhood (ESN), rewarding flexibility in ESN, payment for shared CPs, penalizing blocking of CP, rewarding prosumers, and rewarding desired consumption pattern.

The evaluation approach builds on the CIVITAS evaluation framework and includes:

1. **Impact evaluations addressing the impact of the measures implemented.** An indicator framework defines the indicators to be used to represent the situations before and after the new measures. The indicators are established by means of research data collected in the demonstrators and through simulations.
2. **Process evaluations addressing the measure implementation processes:** Input from stakeholders is collected and barriers, drivers, lessons learned, risks, and recommendations are identified to support learning and to identify issues that should be considered by the impact evaluation.

In addition to the above, a hybrid approach with simulations is applied to support the impact evaluation. The simulations address demonstrator extensions with respect to size, diversity, and dimensioning of the included measures. The simulations are configured by research data from the demonstrators.

The impact evaluation results show that the acceptance and the awareness of the services varies between the demonstrators. An EV sharing service in Bremen has struggle with the acceptance of both e-mobility and car sharing. A B2B eScooter sharing service in Barcelona has, on the other hand, been very popular due to the COVID situation, since the scooters were used in food deliveries. The e-mobility acceptance has also been high in a housing cooperative in Norway where charging has been integrated with smart energy management.

More than 80 charge points are established by the project, and more than 5500 charging session are carried out. For charging at work and at private charge points, the EVs are connected for longer periods than is required for charging. Thus, the inherent flexibility is high and arrange for smart energy management. This, and the use of PV panels in combination with stationary batteries and optimisation of the energy use arrange for increased self-consumption of the energy produced by the PV panels, charging with a higher share of green energy, reduction of peaks powers, and cost reductions.

The combination of e-mobility and smart energy management also contributes to a reduction of CO_2 emissions. Depending on the CO_2-intensity of the electricity in the public grid, the CO_2-savings in the demonstrators varies from 9 to more than 100 g CO2eq/kWh.

The process evaluation results highlight the importance of stakeholder involvement and business models. Extensive challenges regarding the integration of the systems (new and existing) in the ESNs are also addressed. Due to the lack of standards and standardised interfaces, the establishment of an ESN and the integration of charging into an ESN is today a very demanding task. There is for example no standards for the integration of charging with local energy management, and there are no open interfaces for access to the current state of charge (SoC) from the EV batteries.

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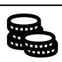
List of Abbreviations and symbols

Table 0-1 List of abbreviations and symbols

<table>
<tr><th>Abbreviation/ symbol</th><th colspan="2">Explanation</th></tr>
<tr><td>CP</td><td colspan="2">Charge Point</td></tr>
<tr><td>CPO</td><td colspan="2">Charge Point Operator</td></tr>
<tr><td>DoA</td><td colspan="2">Description of Action – formal plan describing the activities to be carried out in the project and the concrete results to be produced.</td></tr>
<tr><td>EMP</td><td colspan="2">Electric Mobility Provider</td></tr>
<tr><td>ESN</td><td colspan="2">Energy Smart Neighbourhood</td></tr>
<tr><td>EST</td><td colspan="2">Earliest start time</td></tr>
<tr><td>EV</td><td colspan="2">Electric Vehicle</td></tr>
<tr><td>KPI</td><td colspan="2">Key Performance Indicator</td></tr>
<tr><td>LEV</td><td colspan="2">Light Electric Vehicles</td></tr>
<tr><td>LFT</td><td colspan="2">Latest finish time</td></tr>
<tr><td>MaaS</td><td colspan="2">Mobility as a Service</td></tr>
<tr><td>RES</td><td colspan="2">Renewable Energy Source, e.g., a solar plant.</td></tr>
<tr><td>SoC</td><td colspan="2">Status of Charge</td></tr>
<tr><td>sota</td><td colspan="2">State of the art</td></tr>
<tr><td>ToU</td><td colspan="2">Time of use</td></tr>
<tr><td>V2G</td><td colspan="2">Vehicle to Grid</td></tr>
<tr><td>WP</td><td colspan="2">Workgroup</td></tr>
<tr><td></td><td rowspan="4">Measure groups</td><td>EV fleet measure</td></tr>
<tr><td></td><td>Charging measure</td></tr>
<tr><td></td><td>Smart energy management measure</td></tr>
<tr><td></td><td>Business aspects measures</td></tr>
<tr><td></td><td rowspan="5">Impact categories</td><td>Society and people</td></tr>
<tr><td></td><td>Transport system</td></tr>
<tr><td></td><td>Energy</td></tr>
<tr><td></td><td>Environment</td></tr>
<tr><td></td><td>Economy</td></tr>
</table>

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List of Definitions

Table 0-1 List of Definitions

Definition	Explanation
Energy Smart Neighbourhood	A microgrid composed of smart buildings, charging stations and other energy consumers and producers that use an ICT infrastructure and a centralized or distributed energy management systems to optimize energy usage.
Electric Vehicle	By opposition to internal combustion engine (ICE) vehicles, electric vehicles use an electric engine and a battery to provide the needed energy. They include several types of vehicles: specific types e-bikes (electric bicycles), e-scooter (electric scooters), e-car (electric cars), among others
GreenCharge concept	This is that electric vehicles, charge management and local energy management work together to facilitate a transport system running on green energy. Users of electric vehicles get charging support, and peaks in the power grid and grid investments are avoided through a balance of power. When many vehicles are plugged into the grid around the same time (e.g. on returning home from work), the energy management balances demand with available supplies. Supplies from local renewable energy sources and batteries in connected vehicles not in use may also be utilised. The concept also includes viable business and price models rewarding charging behaviour contributing to peak reductions.
Impact Evaluation	Evaluation of a wide range of technical, social, economic and other impacts of the measures (focused measures or groups of measures) arising from implementation by cities.
Indicator	Well defined indicator used to quantify the impact of a measure. May be a KPI or an indicator addressing other aspects of the impact.
Key Performance Indicator	An indicator that is crucial for the evaluation of the impact of GreenCharge.
Measure	Action, feature, or support implemented to improve sustainable mobility. Note: The word "measure" sometimes causes confusion because it sounds like a way of "measuring" something. In the context in which it is used here, it does not refer to any way of measuring, or metrics. The extent to which a measure succeeds in achieving its objective is assessed through impact evaluations using indicators – see below.
Process evaluation	Evaluation of the processes of preparation, implementation, and operation of measures, including the roles of information, communication, and participation.
Smart Energy Management	System optimising the use of energy adapted to energy availability and demands. May also take predictions of future energy availability and demand into account.
Vehicle to Grid	Vehicle to Grid (V2G) is the capability of an electric vehicle to behave as a stationary battery, returning accumulated energy to the grid

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1 About this Deliverable

This single document provides the final evaluation results from the GreenCharge and covers the content expected for two deliverables (D5.5 and D6.4). The decision to provide the content of both deliverables in a single document was based on the following:

1. There are significant overlaps and dependencies between the two deliverables.
2. Both deliverables build on a common evaluation approach.
3. It was considered most efficient to work on the content in a single document to avoid the overhead of ensuring consistency between two documents and to provide a single source of information for other tasks in the project that will use the information.
4. A combination of the two deliverables is also considered advantageous to the reader to provide a complete overview of the evaluation approach and results.

For simplicity, this combination of D5.5 and D6.4 will in the following be referred to as "the deliverable".

1.1 Why would I want to read this deliverable?

The deliverable is relevant to readers interested in knowledge gained from the evaluations in the GreenCharge project.

The deliverable is also relevant to readers that are interested in evaluation approaches for e-mobility as well as smart and green charging. This includes the measures that are evaluated for e-mobility and smart and green charging, and a related indicator framework. This also includes the use of a hybrid approach where the demonstrator evaluations are combined with simulations.

1.2 Structure

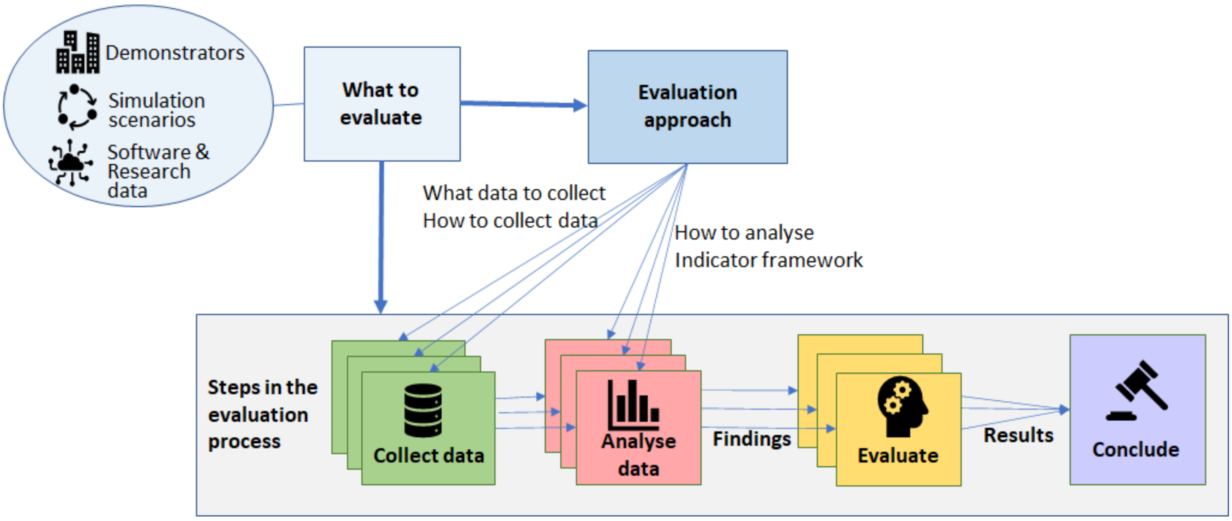

Figure 1-1 Overview of steps in the evaluation approach, covered by the deliverable content

The structure of this document can be linked to the elements in Figure 1-1, which provide an overview of the generic evaluation process. The symbols and the colour coding in the figure will be used throughout this document to link the content to the overall steps.

The aspects addressed in the deliverable are:

- **What to evaluate.** The "what to be evaluated" is defined. In the case of GreenCharge these are:
  - Real-life demonstrators – the impact of measures implemented and the implementation processes.
  - Simulation scenarios – "what if" scenarios that cannot be demonstrated in real life are evaluated.

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  - Software & research data – the capabilities of the software developed, and the quality and completeness of the research data collected from demonstrators are assessed.
- **Evaluation approach.** The approach is adapted to "what to evaluate". The following is defined:
  - Research data collected and how they are collected.
  - How the data are analysed, and when relevant, the indicator framework used.
- **The steps of the actual evaluation process.** For all evaluations, the steps are
  - Collect data: The research data is collected, as described by the defined approach.
  - Analyse data: The research data are analysed, as described by the defined approach. For an impact evaluation, the findings should preferably describe a before and an after situation.
  - Evaluate: The findings from the data analysis are analysed and evaluation results are described.
  - Conclude: The conclusion is found based on one or more evaluation results.

Chapter 1 provides overall information about the deliverable. Table 1-1 provides an overview of the additional content of this document – related to the elements in Figure 1-1.

Table 1-1 Overview of document content

	Demonstrators	Simulation scenarios	Software & Research data
What to evaluate details	**Section 2.1 describes:** - Overview of measures for smart and green charging. **Chapter 3 describes:** - Measures in each demonstrator. - Implementation of the measures	**Section 2.1 describes:** - Overview of measures for smart and green charging. **Chapter 4 describes:** - Demonstrator extensions	**Annex A.1 and A.2 describe:** - The research data to be assessed. **0 and 0 describe:** - Requirements for software at demo sites, simulator and optimizer
Evaluation approach	**Section 2.2 describes <u>in general</u>:** - Impact evaluation approach - Indicator framework to be used **Section 2.3 describes <u>in general</u>:** - Process evaluation approach **Chapter 4 describes <u>for each demonstrator</u>:** - Use of indicator framework - Data collection/analysis plan	**Section 2.2 describes:** - Indicator framework to be used **Section 2.4 describes:** - Hybrid approach with simulations	**Chapter 6 describes:** - Overall approach in general - Demo software assessment approach - Research data assessment approach - KPI-calculator, simulator, and optimizer assessment approach
Collect data	**Annex** A.1 and **A.2 describe:** - Research data from demos - Data collection plan per demo **Annex C and Annex D describe:** - Surveys, interview guides, etc. for impact evaluation - Interview guide, process eval-	**Annex A.1 describes:** - Research data produced by simulations.	**0 and 0 describe:** - Demo software requirement fulfilments - Simulator and optimizer requirement fulfilments **Annex A.2 describe:** - Research data completeness and quality overview
Analyse data	**Annex B describes:** - Indicator calculation details **Chapter 5 describes per demo:** - Indicator findings	**Annex B describes:** - Indicator calculation details **Chapter 5 describes indicator findings from simulations of:** - Demo extensions	**Chapter 6 describes:** - The assessment findings
Evaluate	**Chapter 5 describes per demo:** - Impact evaluation results - Process evaluation results	**Chapter 5 describes per demo:** - Impact evaluation (simulation extensions included)	**Chapter 6 describes:** - Results from software and research data assessments - Possible effects on impact evaluations

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Conclude	**Chapter 7 describes:** - Impact evaluation conclusion across demos and simulations - Process evaluation conclusion across demos - Evaluation confidence assessment (taking software capabilities and research data quality into account) - Appraisal of evaluation approach and recommendations

1.3 Intended readership/users

The deliverable should be read by actors interested in the GreenCharge evaluation approach and results. Table 1-2 shows which parts of the deliverable that are of most interest to the different actors.

Table 1-2 Intended readership of the individual chapters

Section	Topic	Content	May be of interest to
Chapter 1	Introduction	Overview of deliverable and what to read	**Scientists and others interested in** - Measures for smart and green charging - Indicator framework for evaluations of smart and green charging - Hybrid evaluation approaches including simulations
Chapter 2	**Demonstrators** **Simulation scenarios**	Overview of measure groups and measures	
		Approach in general - Overall impact evaluation strategy - Process evaluation strategy - Hybrid approach combining demos and simulations	
Chapter 3	**Demonstrators**	Per demo: What to be evaluated - Objectives and measures - Measure implementation	**Scientists and others interested in** - Measures implementations - GreenCharge demonstrators
Chapter 4		Per demo: Detailed approach - Data collection and analysis - Simulation extensions - Use of indicator framework	**Scientists and others interested in** - Evaluations approaches and use of indicators framework for measure groups
Chapter 5		Per demo: Data analysis and findings - Impact evaluation findings - Process evaluation findings	**Scientist and others interested in** - Final evaluation results regarding smart and green charging and energy smart neighbourhoods (ESNs).
		Per demo: Evaluation results	
Chapter 6	**Software & Research data assessment**	Software and research data assessment approach	**Scientists and others interested in** - Software assessment aspects. - Research data assessment aspects - Related confounding factors
		Results regarding confounding factors to be considered in impact evaluation regarding: - Demo software capabilities - Research data quality and completeness - Simulator, optimizer, KPI-calculator capabilities	
Chapter 7	**Evaluation conclusions**	Conclusion - Conclusion from impact evaluations - across demonstrators and simulations - Conclusion from process evaluations – across demonstrators - Evaluation confidence assessment - Appraisal of the evaluation approach	**Scientists and others interested in** - Evaluations of smart and green charging and ESNs - Re-use of evaluation approach

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1.4 Other project deliverables that may be of interest

This report combines deliverable D5.5 and D6.4, and the content is based on input from other deliverables on *data requirements and approaches to be followed*:

- D1.1 – Data Management Plan [1]: The document describes the guiding principles, the legal framework set by the GDPR, an overview of the data gathered and processed in the project and how it will be stored to guarantee security and ethical aspects.
- D9.1 POPD - Requirement no. 1 [2]: This documents provides the ethics guidelines regarding research data.
- D4.2 – Final Result for Innovation Effects Evaluation / Stakeholder Acceptance Evaluation and Recommendation [3]: This document define requirement to systems in a full-fledged ecosystem for smart and green charging. These requirements are used in the assessment of the software running at the demo sites.
- The combined D5.1 – Evaluation design and D6.1 – Stakeholder acceptance Evaluation Methodology and Plan [4]: This document provides descriptions of the initial versions of the method used for the evaluation. This includes initial versions of the indicators to be used and the measures to be evaluated.
- D5.3 – Simulation and Visualisation Tools (revised version) [5]: This document provides a specification of the simulator to be used in the simulation evaluation and also the software and tools needed for indicator calculations and for visualisation of indicators - both in ordinary evaluations and in simulations.
- D5.6 – Open Research Data [6]: This deliverable specifies the research data delivered from the demonstrations used in the data analysis. The data requirements provided are used in the assessment of the data completeness and quality.
- D6.2 – Data Collection and Evaluation Tools: The document contains a description of the tools chosen for data collections and evaluation of stakeholder acceptance, as well as the rationale for the selection.

The following deliverables providing information on *the demonstrators to be evaluated*:

- D2.8/D2.15/D2.21 – Final reports from Oslo/Bremen/Barcelona Pilots: Lessons Learned and Guidelines: These deliverables describe what the demonstrators have implemented and related lessons learned [7] [8] [9].

This report (the combined D5.5 and D6.4 deliverable) provides refined versions of the measures and indicators specified in D5.1/D6.1 [4]. The main refinements are as follows:

- A new, common set of reference measures is defined and replaces the measures from D5.1 and D6.1. The new measures provide a holistic view upon measures needed for smart and green charging.
- It is described how subsets of common measures are deployed by the different demonstrators. The same measure may however be implemented in different ways to facilitate learning about different implementation strategies.
- The indicators descriptions are improved, and the detailed approaches to be followed to calculate the indicators by means of research data are specified.
- The use of the indicators in evaluations of measures is described in a more mature way. The selection of the indicators to use is for each demonstrator is adapted to the goal of the demonstrator, the ability to get research data, and the ability to establish baseline indicators.

1.5 Other projects and initiatives

GreenCharge is a project under the CIVITAS umbrella of projects and is using the CIVITAS process and impact evaluation framework [10] as a basis for the evaluation. This is reflected in the approach described in Chapter 2 and 4.

Because of the above, the content and structure of this deliverable is guided by the SATELLITE report "Measure reporting on evaluation approach and evaluation findings - RIA projects" [11]. Some extensions and adjustments are however suggested, as described in section 7.2.

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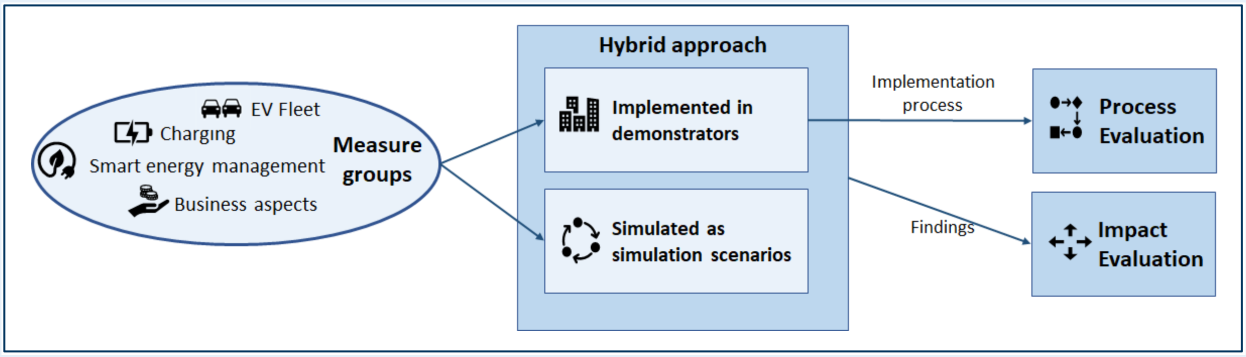
2 Overall evaluation plan and strategy



This chapter summarises the overall plan and strategy for the evaluation of the GreenCharge demonstrators and the simulation scenarios. The evaluation approach is guided by the **CIVITAS evaluation framework** [10].

The following aspects are addressed:

- **Measure groups with measures** to be evaluated. The measures are implemented in the demonstrators and included in the scenarios that are simulated.
- **Overall process evaluation strategy** for evaluations of measure implementation processes.
- **Overall impact evaluation strategy** regarding the evaluation of the impact of the measure groups and measures, the use of an indicator framework used included.
- **The hybrid approach** where the demonstrator impact evaluations are extended and refined through simulations of scenarios.

A measure is an action taken or a solution. In the case of GreenCharge, the measures are linked to the GreenCharge concept. The measures are intended to cause a change towards increased eMobility and more sustainable charging of electric vehicles.

The GreenCharge concept is that electric vehicles, charge management and local energy management work together to facilitate a transport system running on green energy. Users of electric vehicles get charging support, and peaks in the power grid and grid investments are avoided through a balance of power. When many vehicles are plugged into the grid around the same time (e.g., on returning home from work), the energy management balances demand with available supplies. Supplies from local renewable energy sources and batteries in connected vehicles not in use may also be utilised. The concept also includes viable business and price models rewarding charging behaviour contributing to peak reductions.

Further details on the implementation of measures in the individual demonstrators are provided in Chapter 3, and more details on the impact evaluation approaches for the individual demonstrators are provided in Chapter 4.

Note: The plan is adapted to what the demonstrators have been able to implement and demonstrate, as described in D2.8/D2.15/D2.21.

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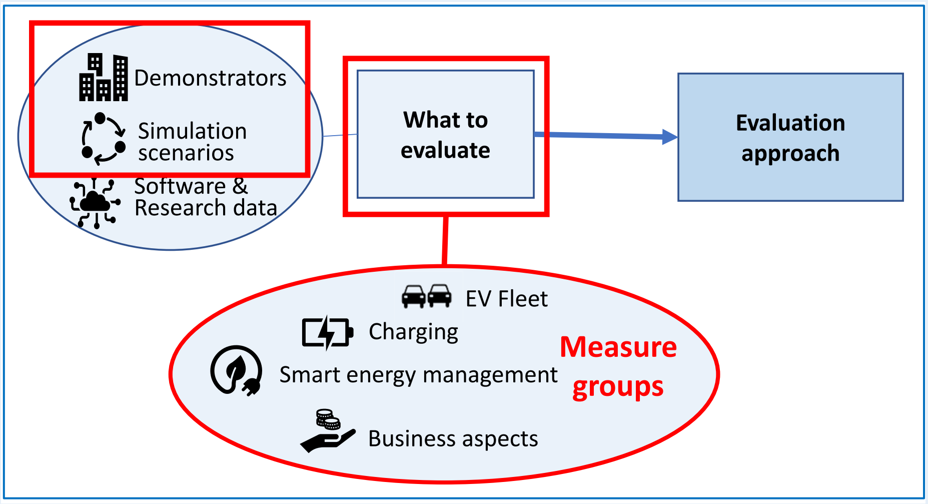
2.1 Measures in demonstrators and simulation scenarios



This section addresses **"what to evaluate" in the GreenCharge demonstrators and simulation scenarios,** with reference to Figure 1-1 in section 1.2. This is the set of **measures in measures groups** targeting EV fleets, EV charging, Smart energy management, and Business aspects

An overview of the measure groups with measures are provided as well as the selection of those to be implemented for each demonstrator.

Table 2-1 provides and overview of all GreenCharge measures, i.e., the new actions or solutions that implements the GreenCharge concept. They are grouped into measure groups (electric vehicle fleets, charging, smart energy management, and business aspects). All measures within a group in general address the same target group and the same objectives, and all measures within the group are evaluated as a whole. The use of measure groups also eases the further description of the demonstrators and the evaluation approach.

The measures are in general of two types:
(1) Measures that are **state-of-the-art** (sota). These measures are today commonly implemented and in operation, or they are tested in demonstrators. The measures may however not be evaluated in the contexts represented by the GreenCharge demonstrators.
(2) Measures that go **beyond state-of-the-art** (beyond sota). These measures are today not commonly implemented and not evaluated. They represent an innovation potential.

The motivation for the implementation of sota measures (1) is that they facilitate innovations such as new combination of several sota measures as well as the measures that go beyond sota (2). The latter are in many cases depending on one or more sota measures. The public charge point (CP) measure is an example of (1). Such charge points exist, but they are needed to demonstrate and evaluate the booking of charge point measure. In the same way, private charge points facilitate the evaluation of measures of type (2), e.g., those within the smart energy management group.

Table 2-1 shows the combinations of measures implemented by seven demonstrators in Oslo, Bremen, and Barcelona. For one demonstrator, the measures are adapted to the local context and needs, and the impact of the measure groups and the implementation processes are evaluated in this context. We use the following notation to describe the evaluations carried out:

- "I" indicates that an impact evaluation is performed.
- "I*" indicates that the impact evaluation is carried out through simulations or calculations.

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- "P" indicates that a process evaluation is performed. If just a "P" is provided and no "I", this means that the measure is implemented and testes and that it works, but it has not been possible to collect a sufficient amount of research data to carry out an impact evaluation

Table 2-1 Overview of measures and the demonstrated for each demonstrator

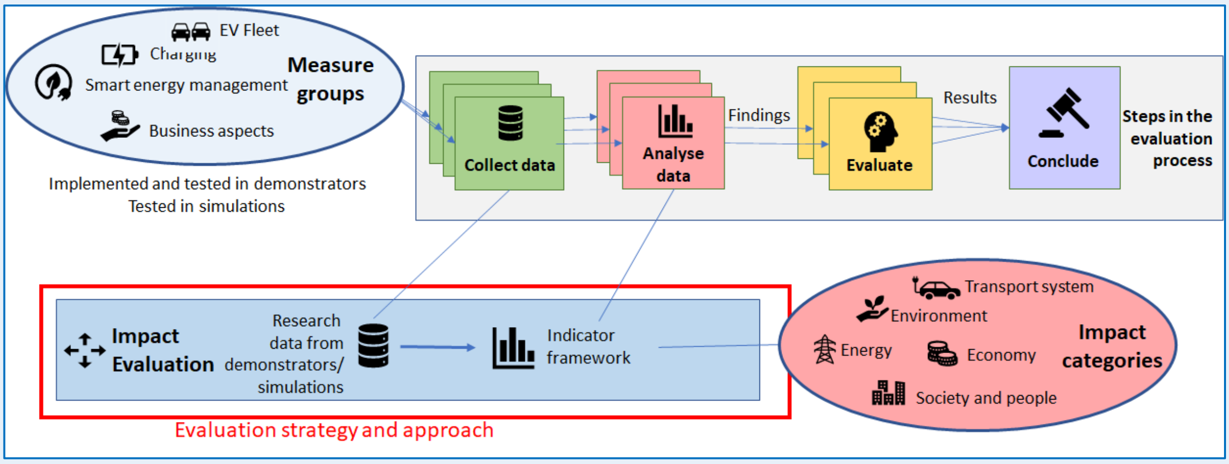
Measure group	Measure (1) – sota (2) – beyond sota	Description	Demonstrators						
			Oslo		Bremen		Barcelona		
			D1	D2	D1	D2	D1	D2	D3
EV fleets	Shared EVs (1)	A fleet of EVs shared among several users.				IP	IP		IP
	Shared EVs integrated with public transport (2)	A fleet of shared EVs is integrated with public transport.							IP
	Shared EVs in new housing cooperative (2)	A fleet of shared EVs is available to residents in *a new* housing cooperative to reduce the need for parking spaces/garage				IP			
Charging	Private CPs (1)	CP is owned and used by the CP owner, or someone approved by the owner.	IP		IP	IP			IP
	Public CPs (1)	CP can be used by the public.		IP					
	Shared CPs (1)	CP is shared with others when not needed by the owner.		IP				IP	
	Roaming (1)	EV users with a contract with one Electric Mobility Provider (EMP) can use the services of other EMPs/Charge Point Operators (CPOs).		P				IP	
	Advance booking (2)	A time slot for use of a CP is booked in advance. Planned arrival and departure time and initial and target SoC are provided at booking time.		P				IP	
	Battery swapping and charging (1)	Depleted EV batteries are swapped with fully charged ones.					IP		
	Flexible charging (2)	Charging is done at any time within a given time window as long as the requested amount of energy is provided.	I*P		I*P		I*	IP	IP
	Priority charging (2)	If there is not enough energy available to satisfy all charging sessions, priority sessions will be satisfied at the expense of non-priority ones.	I*P		I*P				
	Priority access to CP (1)	EV users have a prioritised access to CPs.						IP	
Smart energy manage-ment	Local RES (1)	Local renewable energy sources (RES) are exploited	IP		IP		I*P	IP	IP
	Local storage (1)	Energy is stored locally in stationary batteries for later use when it is advantageous.	I*P		I*P				IP
	V2G (2)	Ability to exploit discharging of EVs connected for charging, within constraints set by user and beneficial for optimal demand profile of building or neighbourhood[2].							
	Optimal and coordinated use of energy (2)	Energy demands (charging included) are coordinated with energy availability to reduce peaks and expenses. EV users' needs and other needs are considered.	I*P		IP			IP	IP
Business aspects	Rewarding Eco driving (2)	The customers using shared EVs are rewarded if they accomplish Eco driving				IP	IP		
	Payment for sharing EVs (1)	Citizens pay for eMobility services.				IP	IP		I*
	Penalizing priority in ESN (2)	EV users requesting priority are penalised or not rewarded.	I*P						
	Rewarding flexibility in ESN (2)	EV users offering flexibility are rewarded. This may also include those allowing V2G.	I*P						
	Payment for shared CPs (2)	CP owners are compensated for offering CPs to others.		I*P					
	Penalizing blocking of CP (2)	EV users not using booked time slots (no show or late arrival) or connected too long (blocking) are penalised.		I*P				IP	

[2] V2G requires EVs and CPs supporting discharging and an energy management system able to exploit it. None of the demonstrators include EVs and CPs supporting V2G, so the potential impact can only be investigated in simulations.

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.

Measure group	Measure (1) – sota (2) – beyond sota	Description	Demonstrators						
			Oslo		Bremen		Barcelona		
			D1	D2	D1	D2	D1	D2	D3
	Rewarding prosumers (2)	ESN benefits from being a prosumer by means of a positive Feed-in tariff or self-consumption.	IP						
	Rewarding desired consumption pattern (2)	Energy tariffs may reward lower peaks or use of energy outside peak hours. The use of energy is adapted to reduce the energy costs.	I*P				IP		

2.2 Impact evaluation strategy for demonstrators and simulations



In this section we present the overall impact evaluation strategy and approach by describing

- **Research data collection.** Overall description of the research data needed in the impact evaluation.
- **The indicator framework**. It defines the indicators to be used to evaluate the impact.
- **Expected impact.** This is how the different indicators are expected to be linked and how several indicators together may provide knowledge on certain aspects. This is an overview of generic influencing factors as seen before we do the formal impact evaluation.

Note: The same indicator framework is used in the impact evaluation of both the demonstrators and the simulation scenarios.

The indicator framework is composed of a sub-set of the impact indicators suggested by the CIVITAS evaluation framework [10] (adapted to the needs in GreenCharge) and new indicators defined by GreenCharge to support impact evaluations related to t e-mobility and smart charging.

The indicators in the indicator framework support the evaluation of the measure groups (see section 2.1), with respect to the impact categories defined by CIVITAS. These impact categories and measure groups are:

- **Society and people:** EV fleet measure group, Charging measure group, Smart energy management measure group, and Business aspects
- **Transport system:** Charging measure group
- **Energy:** Smart energy management measure group
- **Environment:** Charging measure group and Smart energy management measure group
- **Economy:** Business aspects measure group

2.2.1 Indicator framework for impact evaluation

The purpose of the indicators

The indicators in the indicator framework are to support the assessment of the impact of measures or to provide a context for the assessment. For each measure or measure group, one or more indicators may be of relevance. The mappings between the measures/measure groups and the indicators that may be of relevance are listed in Table 2-2.

The impact evaluation is in general done along two approaches:

1. **Analysis of the before (baseline) and after situation:** This is the ideal situation. As illustrated in Figure 2-1 [10], indicators are established for the situation before and after the implementation of the measures. The differences will show the possible impact, but an analysis of the result must also take other influencing factors into account.
2. **Analysis of after situation:** When a baseline cannot be established, indicators for the situation after the implementation of the measure groups are analysed to provide insight and learning.

In GreenCharge, approach 2 is in many cases a necessity since there was no comparable situation before the implementation of the measures., and a comparison of the before and after situation is not possible. It is however still interesting to analyse indicators to learn about the after situation, e.g., the awareness and acceptance among stakeholders and the effects of the measures, e.g., how the new infrastructure is used and how energy availability is affected.

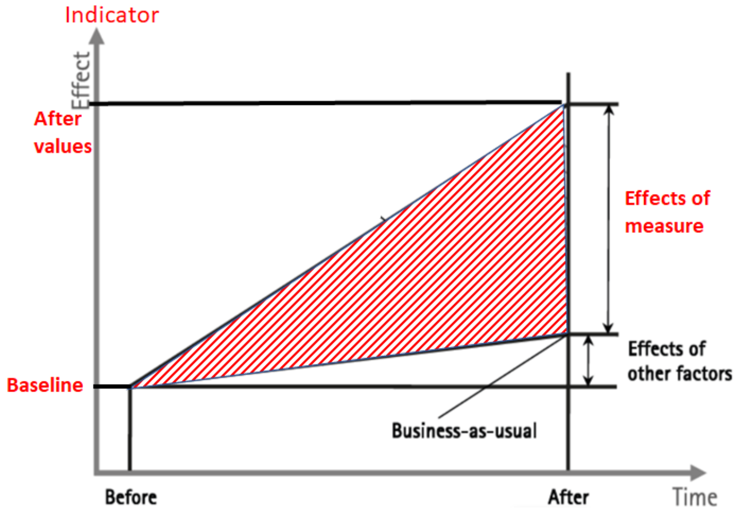


Figure 2-1 Impact evaluation using before and after situation [10]

Indicator overview and use

Table 2-2 provides an overview of the measures in the measure groups, as described in section 2.1, the indicators and sub-indicators of relevance for evaluation of the groups, and how the indicators are used in the evaluation of the individual demonstrators. Details on the indicators, sub-indicators, and indicator calculations are described in Annex A.2.

Several dependencies must be taken into account when the indicator values are evaluated:

- Within one measure group, the measures and the associated indicators may affect each other. Together they define a context, and this context must be taken into account when the indicators are evaluated. As a consequence, *all measures within a measure group are evaluated as a whole.*
- The measures within one measure group may also define a context for another group, and this context must also be considered during evaluations. The effect of the business model measures in the business aspects group must for example be considered when the charging group is evaluated, e.g., how economic incentives may affect the charging behaviour.
- Depending on the demonstrator and the measure group, the indicators may have different roles. Some provide the context for other indicators. Others are key performance indicators providing the core evaluation results. This will be discussed in section 5.

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The indicators used and the origin of the indicators are provided in the table

- "C" indicates that the indicator is based on an indicator defined by the CIVITAS evaluation framework
- "GC" indicates that the indicator is defined by GreenCharge
- "C/GC" indicates that the indicator builds upon a CIVITAS indicator but that it is adapted to e-mobility.

The indicators are established in different ways in different demonstrators, as indicated in the table:

- "M" indicates that the research data needed is manually established, e.g., through surveys and interviews.
- "A" indicates that the data are automatically collected by the software systems involved (see descriptions of this datasets in Annex A) or data provides according to technical specifications.
- "S" indicates that further analyses are done through simulations of relevant simulation scenarios (see details in 2.4). This may for example be done to show the effects scale ups, or the use of artificial energy tariffs and price models.
- "A+S" or "M+S" are combinations of the above.

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Table 2-2 Overview of measures, relevant indicators, and data collection – used in impact evaluations of demonstrators and simulation scenarios

Measure groups	Measures	Indicators and sub-indicators used (Origin: C, GC, or C/GC)		Oslo		Bremen		Barcelona		
				D1	D2	D1	D2	D1	D2	D3
EV Fleet	• Shared EVs • Shared EVs integrated with public transport • Shared EVs in new housing cooperatives	GC 6.1 Awareness level (C)	1. Share of people within different awareness levels 2. Qualitative study of awareness				M	M		M
		GC 6.2 Acceptance level (C)	3. Share of people within different acceptance levels 1. Qualitative study of acceptance				M	M		M
		GC 6.3 Perception level of physical accessibility (C)	1. Index of "accessibility perception" 2. Qualitative study of accessibility					M		M
		GC 6.4 Operational barriers (C)	1. Qualitative study of barriers				M	M		M
Charging	• Private CPs • Public CPs • Shared CPs • Roaming • Advance booking • Battery swapping and charging • Flexible charging • Priority charging • Priority access to CP	GC 6.1 Awareness level (C)	See above	M	M	M		M	M	
		GC 6.2 Acceptance level (C)	See above	M	M	M		M	M	
		GC 6.3 Perception level of physical accessibility (C)	See above	M				M	M	
		GC 6.4 Operational barriers (C)	See above	M	M	M		M	M	
		GC 5.1 Number of EVs (C/GC)	1. Number of EVs	A		A	M	M	M	M
			2. Share of EVs	M				M	M	
			3. Number of specific EVs				M			
			4. Number of planned EVs	M				M	M	M
		GC 5.2 Number of CPs (GC)	1. Number of CPs	A	A	A	M		M	M
			2. Share of CPs	M			M		M	
			3. Number of private CPs	A						
			4. Number of shared CPs		A				M	
		GC 5.3 Utilization of CPs (GC)	1. Share of connected time	A+S		A+S		A	A	A
			2. Share of charging time	A+S		A+S		A	A	A
			3. Energy per time unit	A+S		A+S		A	A	A
			4. Number of charging sessions	A+S		A+S		A	A	A
		GC 5.5 Charging availability (GC)	1. Energy availability			A+S		A		A
			2. Demand fulfilment			A+S		A		A
			3. Share of no show							
			4. Average delay							
			5. Share of late plug out							
			6. Delay of plug out							
		GC 5.13 Charging Flexibility (GC)	1. Offered flexibility	A+S		A+S				
			2. Actual flexibility	A+S		A+S		A	A	
			3. V2G flexibility							
		GC 5.12 CO2 Emissions (C)	1. Average CO2 emission per vehicle km	A+S		A+S		A		A
			2. Average CO2 emission per kWh used	A+S		A+S			A	A
			3. CO2 Emission				M			

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.

Measure groups	Measures	Indicators and sub-indicators used (Origin: C, GC, or C/GC)		Oslo		Bremen		Barcelona		
				D1	D2	D1	D2	D1	D2	D3
Smart energy manage-ment	• Local RES • Local storage • V2G • Optimal and coordinated use of energy	GC 6.1 Awareness level (C)	See above	M		M		M	M	M
		GC 6.2 Acceptance level (C)	See above	M		M		M	M	M
		GC 6.4 Operational barriers (C)	See above	M		M			M	M
		GC 5.10 Peak to average ratio (GC)	1. Maximum peak power	A+S		A+S		A	A	A
			2. Average power demand	A+S		A+S		A	A	A
		GC 5.14 Self-consumption (GC)	1. Energy self-consumption	A+S		A+S			A	A
			2. Share of self-consumption	A+S		A+S			A	A
		GC 5.9 Share of green energy (C/GC)	1. Share of green energy	A+S		A+S		A	A	A
		GC 5.12 CO2 emissions (C)	1. Average CO2 emission per vehicle km	A+S		A+S		A		A
			2. Average CO2 emission per kWh used	A+S		A+S		A	A	A
			3. CO2 emission	M			M			
		GC 5.4 Share of battery capacity for V2G (GC)	1. Average amount of energy	S		S				
			2. Share of battery capacity	S		S				
Business aspects	• Rewarding Eco driving • Payment for sharing EVs • Penalizing priority in ESN • Rewarding flexibility in ESN • Payment for shared CPs • Penalizing blocking of CP • Rewarding prosumers • Rewarding desired consumption pattern	GC 6.1 Awareness level (C)	See above	M	M		M	M		
		GC 6.2 Acceptance level (C)	See above	M	M		M	M		
		GC 6.5 Relative cost of the service (C)	See above					M		M
		GC 5.6 Average operating costs (GC)	1. Total average operating costs				M	M		M
			4. Average energy costs	M			M	A		M
			5. Maintenance costs					A		MA
			6. Service payment to CPO	M	M					M
		GC 5.7 Capital investment cost (C)	1. Capital investment costs	M	M	M		M		M
			2. Preparation and design costs					S		M
		GC 5.8 Average operating revenue (C)	1. Revenue from normal operation	M	M		M	M		M
			2. Revenue from penalties	M	M			A		S

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2.2.2 Expected impact

This section presents generic hypotheses regarding the impact and dependencies that should be considered during the evaluation. The aspects addressed are:

- Hypotheses regarding the possible impact related to individual measures – see Table 2-3.
- Hypotheses regarding how measures might have effect other measures within the same measure groups as well as other measure groups – see Table 2-4.

The measures are expected to contribute to the GreenCharge concept. As described in 2.1, the measure groups will be evaluated as a whole for each demonstrator, since it is difficult to isolate and quantify the effects of each single measure. In the simulations it might however be possible to study the effects on the measures one by one.

Table 2-3 The expected impact of the individual measures

<table>
<tr><th>Measure group</th><th>Measures</th><th>Hypotheses – Expected type of impact</th></tr>
<tr><td rowspan="3">EV fleets</td><td>Shared EVs</td><td>• Increased number of shared EVs
• Reduced number of private cars
• Reduced operating costs (for housing cooperative)</td></tr>
<tr><td>Shared EVs integrated with public transport</td><td>• New customers
• Increased acceptance (user satisfaction)
• Reduced emissions (replace ICE vehicles trips)
• Increased awareness (of sharing services)</td></tr>
<tr><td>Shared EVs in new housing cooperatives</td><td>• New customers
• Increased awareness (of sharing services)</td></tr>
<tr><td rowspan="8">Charging</td><td>Private CPs</td><td>• Reduction of operational barriers (regarding charging)
• Increased number of CPs
• Increased number of EVs
• Increased acceptance
• Increased awareness
• Reduction in emissions</td></tr>
<tr><td>Public CPs</td><td rowspan="2">• Increased number of CPs
• Increased number of EVs
• Reduction of investments costs
• Increased physical accessibility (more CPs available)</td></tr>
<tr><td>Shared CPs</td></tr>
<tr><td>Roaming</td><td>• Increased number of EVs
• Increased acceptance
• Increased physical accessibility (more CPs available)</td></tr>
<tr><td>Battery swapping and charging</td><td>• Increased number of EVs.</td></tr>
<tr><td>Flexible charging</td><td rowspan="2">• Increased acceptance of charging flexibility (facilitating ESN)
• Increased utilization of CPs (energy per time unit)
• Increased charging availability (energy demand fulfilment)
• Increased acceptance of flexible charging
• Reduced operational costs
• Reduced emissions
• Higher share of green energy</td></tr>
<tr><td>Priority charging</td></tr>
</table>

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.

Measure group	Measures	Hypotheses – Expected type of impact
	Priority access to CP	• Increased acceptance of charging flexibility (facilitating ESN)
	Advance booking	• More predictable access to charging/increased availability
Smart energy manage-ment	Local RES	• Increased self-consumption • Higher share of green energy
	Local storage	• Increased self-consumption • Increased flexibility
	V2G	• Increased flexibility • Reduced emissions • Reduced operational costs (incomes from selling energy)
	Optimal and coordinated use of energy	• Lower peaks • Higher share of green energy • Increased self-consumption • Reduction in emissions
Business aspects	Rewarding Eco driving	• Reduction in maintenance costs for fleet operator • Reduction in energy costs for fleet operator • Increased awareness
	Payment for sharing EVs	• Increased revenue for fleet operator
	Penalizing priority in ESN	• Increased acceptance of charging flexibility • More optimal use of energy • Higher share of green energy • Reduction in average operation costs linked to energy
	Rewarding flexibility in ESN	
	Payment for shared CPs	• Increased revenue
	Penalizing blocking of CP	• Increased acceptance of a non-blocking behaviour • Increased utilization of CPs • Increased availability • Increased average operating revenue
	Rewarding prosumers in ESN	• Increased acceptance of RES • Reduction in average operation costs linked to energy
	Rewarding desired consumption pattern	• Increase investments in ESN • Reduction in future grid investments • Reduction in average operation costs linked to energy

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Table 2-4 The expected impact across measures

Measure groups	EV fleet group	Charging group	Smart energy management group	Business aspects group
EV fleet group	**EV fleet indicators affect other EV fleet indicators:** Shared EVs facilitate the different deployments, among others • Shared EVs in housing cooperatives • Shared EVs integrated with public transport.	**EV fleet indicators affect charging indicators:** EV fleet measures may • Increase the awareness/acceptance of the charging measures and e-mobility • Increase the number of EVs • Reduce CO2 emissions	**EV fleet indicators affect smart energy management indicators:** The charging of EV fleets in an ESN may • Use of surplus energy from RES and increase self-consumption	**EV fleet indicators affect business aspect indicators:** EV fleets in among others housing cooperative may: • Reduce operating costs (due to less tax on parking spaces)
Charging group	**Charging indicators affect EV fleet indicators:** Shared EV fleets may: • Increase acceptance of e-mobility and thus Increase the number of EVs and CPs Charging of EV fleets may • Increase CP utilization • Be prioritised through priority access to CPs and priority charging.	**Charging indicators affect other charging indicators:** High awareness on e-mobility in general and CP booking, and few operational barriers may • Increase acceptance • Increase the number of EVs • Reduce CO2 emissions. • Increase CP utilization High awareness/acceptance of the need for flexibility may • Increase the charging flexibility. Low CP availability (e.g., due to blocking, lack of energy, etc.) and operational barriers may • Lower the acceptance • Lower the CP utilization (low fulfilment of demands)	**Charging indicators affect smart energy management indicators:** High awareness/acceptance of the need for flexibility and few operational barriers will probably • Increase the acceptance of the smart energy management measures. High charging flexibility will probably • Reduce the peaks loads • Increase the self-consumption • Decrease the CO2 emissions.	**Charging indicators affect business aspect indicators:** High awareness/acceptance of charging flexibility and few operational barriers may • Increase the awareness and acceptance of the business aspect measures. • Reduce the operating costs if the energy tariffs arrange for it. • Reduce the relative cost of service. • Increase the revenue (for commercial services) High utilization of CPs will: • Increase the revenue (for commercial services)
Smart energy management group	**Smart energy management indicators affect EV fleet indicators:** Optimal and coordinated use of energy for EV fleet charging may:	**Smart energy management indicators affect charging indicators:** High awareness/acceptance of smart energy management and few operational barriers will probably: • Increase the acceptance of flexible charging. • Increase the charging flexibility.	**Smart energy management indicators affect other smart energy management indicators:** Operational barriers in energy management will probably: • Lower the acceptance. Increased use of RES should: • Increase self-consumption.	**Smart energy management indicators affect business aspect indicators:** Increased self-consumption should: • Reductions in operating costs. A reduction in peak loads should (if the energy tariffs arrange for it):

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	• Increase the acceptance of shared EVs. • Increase the establishment of shared EV services.	Reductions in peak loads may: • Increase the number of CPs. • Increased the number of EVs. • Increase CP utilization. • Increase charging availability (energy included). • Reduce CO2 emissions. Operational barriers in energy management may: • Reduce the acceptance of flexible charging and there by • Reduce charging flexibility	• Give a higher share of green energy • Reduce CO2 emissions. Reductions in peak loads may: • Increase the acceptance of the smart energy management measures. • Reduce CO2 emissions.	• Reductions in operating costs. • Reductions in the cost of the service.
Business aspects group 	**Business aspect indicators affect EV fleet indicators:** Business measures like rewarding eco driving may: • Increase the acceptance of shared EVs Payment for sharing EVs is essential for • Shared EV fleets • Shared EVs integrated in public transport • Shared EVs in housing cooperatives	**Business aspect indicators affect charging indicators:** High acceptance of business measures (e.g. rewarding and penalties) may: • Increase the number of EVs and CP, • Reduce the CO2 emissions. • Increase charging flexibility. • Increase CP availability (e.g., prohibit blocking). • Increase CP utilization (e.g., through flexibility). Low awareness/acceptance of the business aspect measures may: • Become operational barriers for the charging measures like flexible charging and booking.	**Business aspect indicators affect smart energy management indicators:** Capital investment costs and high acceptance of the business aspect may will facilitate: • The implementation of the smart energy management measures, and thereby • Reduction of peaks loads. • Increased self-consumption. • Reduction of CO2 emissions. Low awareness/acceptance may become: • Operational barriers for smart energy management measures. Reductions in operating and charging costs may: • Increase the acceptance of smart energy management measures.	**Business aspect indicators affect other business aspect indicators:** Investment costs will facilitate: • Reductions in operating costs. • Reductions in the cost of the service. The relative cost of the service is: • Linked to the operating costs.

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2.2.3 Research data collection

This section provides an overview of the research data needed in the impact evaluation.

The data collection and storage follow the data management plan (deliverable D1.1 [1]) and ethics guidelines (deliverable D9.1 [2]).

In general, two types of research data are collected:

- **Research data collected manually through surveys:** The data are collected through interviews and questionnaires targeting EV users, residents, employees, and other relevant stakeholders. The questionnaires (see Annex C) have been designed to minimise the number of personal questions (i.e.: age in ranges rather exact age, no questions about incomes, …), but still the research data cannot be considered as anonymous, and the data are not published as open research data. The data are input to qualitative data analysis.
- **Research from demonstrators meant for automated processing:** The data are provided according to detailed data structures and technical specifications provided in GreenCharge deliverable D5.6 [6]. Annex A.1 provides an overview of the datasets, and Annex A.2 provides an overview of the data collection for all demonstrators. The data is anonymous, and thus they are published as open research data as described in D5.6. The research data describe:
    - **The setup of the demonstrators**, i.e., the devices included (stationary batteries, solar plants, EV models, and other devices), price models used, etc. These data are in general manually defined.
    - **Events and sessions.** These data are collected or generated automatically by the software running in the demonstrators.

2.3 Process evaluation strategy

According to the CIVITAS evaluation framework [10], the aim of the process evaluation is to identify factors of success, and strategies to overcome possible barriers during the implementation phase, by analyses of relevant information supporting the:

- Understanding of why measures have succeeded or failed.
- Understanding of the roles of supporting activities.
- Validation of the impact of the measures. The impact indicators must be analysed taking influencing factors into account, and the effects of supporting activities must be understood.

The process evaluation addresses the stages of the demonstrator implementation processes. In GreenCharge, these were mainly the design and implementation stages since the operational stages were too limited in extent and duration. Some operational aspects are however included when this is relevant. The definitions of the stages are as follows:

- **In the design stage,** the measures addressed in the GreenCharge proposal were elaborated further, planned, and designed. Engagement activities for stakeholders were used to collect input on concerns and to identify and manage potential barriers at an early phase and to achieve acceptance. The implementation and integration of the technologies and systems at the demo sites were planned.
- **In the implementation stage,** the measures were realised and deployed. Technology was developed or adapted to meet the requirements, equipment was installed, and systems were integrated and deployed. In addition, information activities for stakeholders about the implementation were arranged to inform about effects and the upcoming operational stage (awareness and information campaigns).
- **In the operational stage,** the measures were in operation. Information and communication campaigns were carried out to bridged information gaps.

The demonstrators include several measures, and the work on the different measures has not always been synchronised. Thus, activities carried out have in some cases covered several stages at the same time.

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The research data collection for the evaluation of the implementation processes includes:

1. **A pre-analysis** of which stakeholders that have a significant role in the implementation and their specific role, as well as possible implementation risks, barriers, and drivers.
2. **Monitoring and assessment of all relevant actions and events** to understand what has happened and why. The monitoring will identify:
   - **Supporting activities that contributed in a positive way.** These are activities aiming to make the implementation of the measure/measure group better, easier, more efficient and/or increasing the impact of the measure/group. Examples of such activities are communication, planning or decision-making methods, stakeholder involvement and engagement activities.
   - **Barriers** encountered during the work and actions taken to overcome the barriers.
   - **Drivers** that have supported the work and actions taken to make use of the drivers
3. **Other activities that have affected the implementation process**. This is among others the implementation of the automatic research data collection needed in the impact evaluation (done by the software systems). Correct and complete data collection had to be addressed during the design, implementation, and operational stages. This was a complex and comprehensive task. Many discussions and actions were required. The process evaluation must take the "noise" from these activities into consideration when the implementation of the measures is evaluated.
4. **Involvement of the stakeholders.** Input was collected from minutes from meetings and logs where the stakeholder involved document challenges, events and decisions during the implementation process. Focus groups were also used to get input to point 2 above.

Note: The input to the process evaluation for point 1 and 2 above is summarised in Annex E.

2.4 Hybrid approach strategy

Due to regulatory and budgetary constraints, and the limited duration of the project, the demonstrators have limitations. They are

- rather few and implemented in small scale,
- heavily affected by the Covid situation,
- limited with respect to number of users and use,
- not necessarily representative of a future with a much higher density of EVs and a more ubiquitous and smarter charging infrastructure and energy supply system than we see today.

Due to the above, the ability to collect research data is limited, and the research data collected may not be sufficient for complete and reliable impact evaluations.

To broaden the basis for more complete impact evaluation, we therefore apply a **hybrid approach where we combine demonstrator evaluations and simulation.**

Simulations will support evaluations that cannot be done in the real-life demonstrators. This includes additional functionality, scale up, and extensions that facilitate further learning on how different factors contribute to different effects.

These simulation strategies from the demonstrator extensions are described in Chapter 4, and the related simulation results are provided together with the demonstrator evaluation findings and results in Chapter 5.

The overall approach to the simulations is illustrated in Figure 2-2. The simulation scenarios are evaluation using the following tools:

- **A KPI calculator** calculates the indicators of relevance for the demonstrators.

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- **A discrete event simulator** simulates on a detailed level the electric energy demand of the consuming devices of a neighbourhood, the production of local energy producing devices, and demand response signals from the electric grid, and computes an optimal demand schedule within the given demand flexibility. The simulator calculates many of the same indicators as the KPI calculator, of relevance to the simulations. More details about the simulation facility are provided in D5.3.
- **An optimizer** optimises a variety of different energy consumption events.

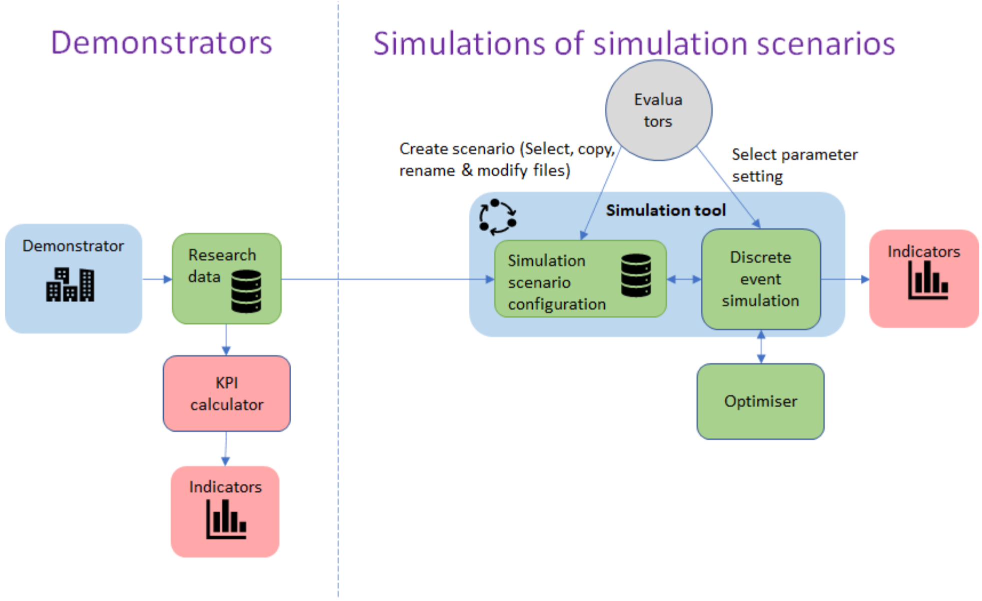

Figure 2-2 Overall evaluation approach through use of simulations

A scenario is defined by means of research data from one or more demonstrators. The data describes the setup of the demonstrator (location, devices/equipment, price models, etc.) and dynamic events that are energy demanding/supplying activities. The scenario is input to the discrete event simulator, and the simulation is configured through the setting of parameters (e.g., the share flexibility provided by the EV users). The simulations use the optimizer and will generate additional research data.

3 Measures implemented by demonstrators

Section 2.1 provides an overview of the measure groups and measures to be implemented in each demonstrator.

This chapter describes for each demonstrator:

- **Measure groups and measures** implemented and the related objectives and expected outputs
- **Implementation** strategies for each measure group.
- **Interactions/dependencies** between measure groups and measures

Note: Due to the relatively small scale of the demonstrators, we cannot define overall, generic, and quantitative demonstrator objectives. Thus, **the main objectives of the demonstrators are to facilitate learning about possible effects and the implementation.** The indicators calculated from the simulations that extend the demonstrators (see section 2.4) will provide more insight into potential impacts.

3.1 Oslo Demo 1 – Charging in ESN: Measure descriptions

The following subsections describe the objectives of the measure group and expected outputs, the implementation of the measures in each group, and dependencies between measures within and across groups.

3.1.1 Measures and related objectives

The demo addresses a housing cooperative where the residents have their own, private parking space in a common garage. In total the garage contains 230 parking spaces. All housing cooperative residents that are EV users now have private charge points in their parking garage to charge their EVs.

Measures: The demonstrator covers the following measures:

- Charging measure group: Private CPs, Flexible charging, and Priority charging
- Smart energy management measure group: Local RES, Local storage, and Optimal and coordinated use of energy
- Business aspects measure group: Penalizing priority in ESN, rewarding flexibility in ESN, Rewarding prosumers, and Rewarding desired consumption pattern.

The following business-as-usual scenario describes what the situation would be with no further implementation of the measures:

- There will be no smart energy management. All electric vehicles start charging from the moment they plug in, and the available energy is shared equally among all plugged in electric vehicles.
- Capacity problems in the local grid may occur during peak hours, and residents that need their electric vehicle fully charged in a short time may experience that the electric vehicle is just partly charged.
- The EV users get no support for a desired charging behaviour. If they want to postpone the charging to a time when the load is low, they must do so manually, either by plugging in the car later or setting the charge plan in the EV itself (most EVs have possibility to do this in settings).
- There are no economic incentives for a desired charging behaviour since load balancing is not possible.

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 following GreenCharge scenario describes the situation when the measures are implemented:

- Flexible charging arranges for smart energy management. The default is flexible charging but if needed, the residents may ask for priority charging.
- Smart energy management is supported, i.e., optimal distribution of the energy use over time (for charging as well as other use of energy in the garage), adapted to energy availability, and to individual energy demand regarding the amount of energy requested as well as when the energy has to be delivered. Due to the use of local RES, the energy used will be greener. The plugged-in electric vehicles may be charged at any time before the latest finish time defined by the EV user.
- The EV users may get an economic penalty for non-desired charging behaviour (i.e., to use priority charging). Flexible charging will, together with use of RES, stationary batteries, and optimisation of the energy use, reduce the energy costs. The reduction of peak loads reduces the need for expensive grid investments. Business models for prosumers facilitate return on RES investments.

Objectives

Table 3-1 defines the overall objectives of the demo.

Table 3-1 The Objectives of Oslo Demo 1

Measure group	Overall objectives	Detailed objectives	Target group
Charging	Replace fossil mobility by eMobility	• Provide private CPs to all residents in housing cooperative that want one • Increased the number of EVs (owned or leased) among the residents by at least 100 % • Increase number of CPs to cover at least 25 % of the parking spaces • Reduce CO2 emissions by at least 10 %	Housing cooperative Residents
	Learn about the use of CPs	Answer the following questions: • How long are the EVs connected? • How much of the connected time is used for charging? • How much energy is on average charge per connected time unit?	Housing cooperative Residents
	Learn about the charging flexibility of the EV users	Answer the following questions: • How much flexibility are EV users willing to provide? • What is the actual flexibility that the system could have utilised? • What is the effect of economic incentives?	Housing cooperative Residents
Smart energy management	Learn about the effects of the measures	Answer the following questions: • How much is the peak level reduced? • What is the self-consumption achieved with the current solar plant and stationary battery? • What are the effects on the share of green energy? • What is the effect on CO2 emissions?	Housing cooperative Residents
Business aspects	Learn about the effect of the business aspect measures	Answer the following questions: • What is the effect on the charging behaviour (e.g., flexibility and use of priority)? • What are the economic benefits for the housing cooperative?	Housing cooperative Residents with EVs

Expected outputs

The expected outputs from charging measures are:

- New charge points in the garage makes charging easy and predictable for residents.
- Flexible charging arranges for smart energy management.
- Increased share of electric vehicles, and thus a reduction of CO2 emissions

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 expected outputs from smart energy management measures are:

- The distribution of available energy is fair and adapted to individual needs.
- Load balancing reduces the peaks, and it is possible to charge more electric vehicles without grid extensions due to a reduction of peak loads.
- Smart use of energy from local RES and use of stationary battery storage make the share of green energy higher.

The expected outputs from business aspect measures are:

- The return of investment and a possible profit for the housing cooperative will be facilitated: 1) The share of the payments from the EV users that is returned from the CPO to the housing cooperative as payment for the use of energy; 2) The extra fees paid by EV users for priority charging; and 3) A reduction of the operational costs related to energy use (see below).
- The operational costs related to energy use will be reduced: 1) The use of energy from local RES will reduce the energy import from the public grid, and thus reduce all costs of type "price per kWh" to be paid to the DSO and the retailer; 2) The power tariff per kW per hour peak paid to the DSO will be reduces with a better load balance (the peaks and thus the costs will be reduced); and 3) Desired charging behaviour (i.e., low use if priority charging and more flexibility) will affect the costs in a positive way.

3.1.2 Implementation

All the planned measures were implemented but a few did not become operational. This is further described in the process evaluation. Independent of this, this section describes how the measure groups are implemented.

3.1.2.1 Implementation of Charging measures

The following hardware installations are done to facilitate the charging:

- **Charge points** at parking slots in the garage. All residents were offered to purchase charge points.

The software facilitating the charging measures are

- **App** used by the EV users to start the charging and to provide input on
  - User profile information such as information about the electric vehicle (registration number, electric vehicle model, battery capacity, etc.), the credit/debit card to be used for payment of the extra fee for priority charging, and default values to be used to simplify the charging requests.
  - Charging requests with charging constraints such as priority/no priority and flexibility. The flexibility is expressed through the latest finish time for the charging and the amount of energy requested.
- **App back end** facilitating
  - Integration with the CPO
  - Extended charge management functionality for the provision of information about charging demands to the smart energy management system.
  - Billing and payment in case of priority charging (extra fee)
- **Charge management system** (legacy system)

The implementation of the deployed charging measures is described in the Table 3-2.

Table 3-2 Details on the implementation of charging measures for Oslo Demo 1

Description of measure implementation
1. **Private CPs:** The CPs are installed, and the EV users can connect and charge at any time and stay connected as long as they want, also when they are not charging. a. The App is used to define the charging constraints. It provides information about priority (if needed) and the flexible provided.

Description of measure implementation
b. The EV user can monitor the charging by means of the App c. The App provides an overview of their charging history If the user for any reason does not use the App (i.e., that the charging is initiated by a RFID tag and the App is not used), the EV will be charged with a minimum amount of electric current (8 A) for 6 hours.
2. **Flexible charging:** The EV is charged at any time before the latest finish time, depending on energy availability, greenness, and price. a. This is the default charge option. b. The required input (current SoC, requested SoC, a minimum SoC, and the latest finish time) is provided via the App c. If the energy demand of all EVs charging in the garage cannot be fulfilled, the available energy is shared among the EVs according to their requests. At least, a minimum SoC must be reached. d. During the charging, the EV user can see the estimated SoC in the App based on the initial SoC and the charging plan from the local energy management system.
3. **Priority charging:** EV is charged prior to other EVs that have not chosen priority charging. The following principles are followed: a. The required charging constraints are provided via the App b. If there is a lack of energy, the charging will be done prior to charging of EVs with no priority. c. If many users request priority charging at the same time, and there is not sufficient energy to all, the available energy is shared among these users.

3.1.2.2 Implementation of Smart energy management measures

The following hardware installations are done to facilitate the smart energy management:

- **PV panels** on the roof of the garage (capacity of 70 kWh, 300 W per panel)
- **Stationary batteries** for storage of energy (capacity of 50 kWh)
- Integration with the local energy grid.

The software facilitating the energy management are:

- **Extended energy management** will
  - Monitor issues that may affect the energy availability and use (weather, RES production, stationary battery, charging demands with varying flexibility, heating cables, etc.).
  - Predict energy demands and availability (derived from monitored and historical data). Weather conditions may for example influence both the RES production and the energy demands.
  - Calculate and maintain a dynamic plan for optimal energy use, and control the use of energy from RES, and the use of the stationary battery capacity (charging and discharging) according to the plan.
- **Extended charge management** (implemented by the App back end) will
  - Manage charging sessions according to the dynamic plan for optimal energy use. The charging at individual charge points is started and stopped, and the amount of energy transferred is be controlled according to the plan.
- **Software** in connected devices (e.g., energy metres, PV panels, and stationary battery) will provide data. Some devices (e.g., the stationary battery) will also receive instructions regarding charging and discharging.

The implementation of the smart energy management measures is described in Table 3-3.

Table 3-3 Details on the implementation of smart energy management measures for Oslo Demo 1

Description of measure implementation
1. Local RES: PV panels are installed for local production of green energy, and the use of the energy from RES is optimised (e.g., storage vs immediate use) by the energy management system

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

Description of measure implementation
2. Use of stationary energy storage: A battery is installed to support the storage of energy surplus from RES production (i.e., when it cannot be used or when it is more optimal to store surplus energy that to sell it)
3. Optimal and coordinated use of energy a. Information on the charging demand is managed for each CP. This is: the energy demand, the latest finish time, the minimum SoC, and the charging option (priority or not). b. Data on energy availability, use and production for the whole garage is managed. This includes energy needed for charging and heating cables as well as the energy available from the grid, local RES and stationary battery. c. Optimal energy distribution among energy demanding activities, charging included, is dynamically calculated based on information on all energy demand, historical data, energy availability and production. **d.** The charging of individual EVs, use or storage of energy from local RES, and the use of energy from stationary batteries are scheduled for optimal load balancing and optimal use of energy from RES. e. The schedule is used to control the charging as well as other activities.

3.1.2.3 Implementation of Business aspect measures

The software facilitating the implementation of the business models is

- **Charge management system** of CPO handling the billing for charging in general.
- **App** used by residents to provide.
    - **I**nput on the charging demand (priority or not and flexibility).
    - Input on the debit/credit card to be used for payment of fees for priority charging.
- **App back end** doing the billing of the extra fee in case of priority charging.

The implementation of the deployed business aspect measures is described in Table 3-4.

Table 3-4 Details on the implementation of business aspect measures for Oslo Demo 1

Description of measure implementation
1. **Rewarding flexibility in ESN:** There is no extra fee for flexibility charging: - The price with for charging is in general set to 1.70 NOK per kWh. - The billing is managed by the CPO. The CPO will keep a share of the payment and transfer the rest to the housing cooperative as a payment for the energy used.
2. **Penalizing priority in ESN:** There is an extra fee on priority charging: - The price with priority is set to 2.50 NOK per kWh, i.e. an extra fee of 0.80 NOK - The billing of the extra fee is managed by the App back end
3. **Rewarding prosumer in ESN:** Energy from PV panels replaces energy from the public grid and the energy from the PV panels may also be sold. - The feed in tariff to be used if surplus energy from the PV panels is exported.
4. **Rewarding desired consumption pattern:** The energy costs is composed of several elements, among others a peak power tariff. - The energy costs are reduced when the smart energy management lowers the peaks

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.

3.1.3 Interaction with other measures

The measures are@ not independent on each other. Table 3-5 shows the dependencies within and between measure groups.

Table 3-5 Dependencies between measures in Oslo Demo 1

Measure groups	Charging group	Smart energy management group	Business aspects group
Charging group	• EV user must understand the importance of correct input on charging constraints. • With low understanding, little flexibility may be provided, and the effects of the "flexible charging" measure will be limited.	• The CPs facilitate testing of charging integrated with smart energy management. • "Flexible charging" facilitates more optimal load balancing. • The charging constraints provided by the App are needed by the "Optimal and coordinated use of energy" measure.	• The App will provide the input on which price model to use (e.g., priority charging). • "Flexible charging" facilitates the rewarding measures that are linked to more optimal use of energy.
Smart energy management group	• "Optimal and coordinated use of energy" will make use of the charging flexibility provided by the EV user.	• "Local storage" will increase the effect of "Local RES". Energy surplus can be stored and used when needed. • The measures mentioned above affect the "Optimal and coordinated use of energy" measure.	• "Optimal and coordinated use of energy" influence the rewarding measures that are linked to the use of energy.
Business aspects group	• "Penalising priority" measures is designed to encourage EV users to not use "priority charging" unless this is needed. • Rewarding measures linked to use of energy benefit from on flexible charging.	• "Rewarding prosumers" is linked to "Use of RES" and is facilitated by a positive feed in tariff. • The positive feed in tariff is always lower than the cost of imported energy. Thus, it is always better to use energy from local RES in the ESN. • "Rewarding desired consumption pattern" depends on energy tariffs and adaption to tariffs. • The rewarding is facilitated by "local RES", "local storage", and "optimal and coordinated use of energy measures"	• Rewarding and penalising measures must be a balance with the needs to arrange for high acceptance.

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 Oslo Demo 2 – Advance booking of CPs: Measure descriptions

The following subsections describe the objectives of the measure group and expected outputs, the implementation of the measures in each group, and dependencies between measures within and across groups.

3.2.1 Measures and related objectives

The demo address how a private actor like a housing cooperative can share their charge points with the public. In the demo, the housing cooperative share four charge points that are located outside the common garage.

Measures implemented: The demonstrator covers the following measures:

- Charging measure group: Shared CPs, Public CPs, Roaming, and Advance booking
- Business aspects measure group: Payment for shared CPs, and Penalizing blocking of CP

The following business-as-usual scenario No 1 describes the situation before GreenCharge:

- The residents of the housing cooperative had no private charge points in the garage, and they had to use four old charge points that were shared among the residents. The residents booked the charge points by means of a spread sheet.
- The shared charge points were just available to residents, and other EV users did not have access to them.
- They did the housing cooperative for use of the charge points.

The following business-as-usual scenarios No 2 describes the situation with Oslo Demo 1 (private charge points in the garage), i.e., the situation after the implementation of Oslo Demo 1 but before the implementation of Oslo Demo 2:

- The residents have access to private charge and do not need the old charge points outside the garage.
- Due to the charge points in the garage, the residents will probably not or to a very little degree use the old charge points outside the garage.
- There are no mechanisms supporting the sharing of the charge points outside the garage with the public.

The scenario with GreenCharge measures is as follows:

- The old charge points are replaced by new charge points. The new charge points arrange for data collection and billing, and an App can be used to start the charging.
- The App support booking of a charge point and the payment for use of it. The booking may take place a short or a long time in advance (days) – to arrange for predictable access to charging.
- Everyone can download the App and book and use the shared charge points. The users may for example be visitors to the residents in the housing cooperative, utility vehicles visiting the area, employees and visitors at the nearby school, and any other EV user in the area.

Note: Due to Oslo Demo 1, the target group (i.e. the potential users of the shared charge points) is changed from residents to the public. Thus, the business-as-usual scenario No 1 cannot be used as a baseline. Business-as-usual scenario No 2 is a fictive scenario. If this is used as a baseline, the number of users is 0.

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.

Objectives

Table 3-6 defines the overall objectives of the demo.

Table 3-6 Objectives of Oslo Demo 2

Measure group	Overall objectives	Detailed objectives	Target group
Charging	Learn about the use of shared and pre-booked CPs	Answer the following questions: • How many charge sessions are there during a time frame? • The time EVs are connected during a time frame? • How much of the total connected time is used for charging during a time frame? • How much energy do the EVs on average charge per connected time unit?	Providers of shared CPs
	Learn about the charging availability provided by bookable charge points	Answer the following questions: • What share of booked time slots are not used? • What is the delay in plug in time compared with the booked time slot? • What share of EVs are not disconnected in time (i.e. connected longer than the booked time slot)?	Providers of shared CPs Potential users, e.g. visitors and any other EV users in in the area.
Business aspects	Learn about how price models can be used to achieve desired behaviour	Answer the following questions: • How can CP blocking be avoided through use of price models targeting this challenge? • How to can the utilization of the CPs be increase through use of price models targeting this challenge?	Housing cooperative Visitors
	Learn about business potential and return of investments regarding shared CPs.	Answer the following questions: • What is the potential for payback of the investment costs? • What price can be charged is a high utilization is desired?	Housing cooperative

Expected outputs

The expected outputs from charging measures are:

- 4 shared charge points are installed and available to the public.
- EV users can book charging time slots in advance and get predictable access to charging. The charging anxiety can be reduced.

The expected outputs from business aspects measures are:

- The housing cooperative will get paid for the use of the charge points and return of investments.
- The price models encourage a desired behaviour, e.g., in time cancellations and no blocking charge point. The price models also compensate the housing cooperative in case no shows and blockings, and the compensations are aligned with the expected payment if charge points were used for charging.

3.2.2 Implementation

All the planned measures were implemented but just the charge point themselves become operational. This is further described in the process evaluation. Independent of this, this section describes how the measure groups are implemented.

3.2.2.1 Implementation of Charging measures

The following hardware installations are done to facilitate the charging:

- Shared charge points at the parking spaces outside the garage

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The software facilitating the charging are

- An App facilitating charge point bookings and status updates to the EV user.
- Charge management system of CPO.
- Extended CPO functionality: Calendar system supporting the booking of charge sessions.
- Roaming platform supporting authentication and authorisation.
- App back end supporting the roaming.

The implementation of the smart energy management measures is described in Table 3-7.

Table 3-7 Details on the implementation of charging measures for Oslo Demo 2

Description of measure implementation
1. **Shared CPs/Public CPs:** Four CPs are installed outside the garage a. The CPs can be used by everyone. b. The CPs supports for data collection, and an App can be used to start the charging and to support the billing.
2. Advance booking: The CPs must be booked before they can be used. The booking is done via an App at any time before the charging starts. a. The EV user books a charge session. The booking defines the time slot and the energy request. The latter is provided indirectly by indication of the current and the wanted state of charge (SOC) (in the future, the current SOC can probably be collected automatically). b. Bookings can be cancelled at any time before the booked time slot. c. On arrival to the CP, the EV user must authenticate via the App and plug-in the EV. d. The EV must be plugged out before the end of the booked slot-time. Actions are taken to avoided blocking, deviations, and disadvantages for the CP owner: e. The EV user must be informed about cancellation conditions, no show conditions, and blocking fees. f. If the EV is not un-plugged at the end of the booked time slot, the charging is stopped. g. Notifications are sent to the EV user: - 15 minutes before the start of the slot time – to remind about the potential no show payment, and the cancellation deadline (before the start of the booked slot time). - 15 minutes before the end of the timeslot – remind about the end of the booked time slot and the blocking fee. - If an EV blocks the CP after the end of the booked time slot- to remind about the blocking fee. h. If another EV blocks the charge point when the time slot starts, the blocking can be reported, and the EV user blocking the CP should be notified.
3. **Roaming:** There is no contract between the CPO and the EMP, but both have a contract with the roaming operator. The following is implemented: a. The roaming operator authorise the charging. b. The CPO manages the charging. c. The EMP receives data about the charging from the CPO via the roaming operator.

3.2.2.2 Implementation of Business aspect measures

The software facilitating the implementation of the business models are:

- Charge management system of CPO (providing data on the charging – energy amount, etc.).
- App and back-end system offered by EMP managing the billing and, if relevant, also the penalties.
- Calendar system supporting the booking of charge sessions.
- Roaming platform supporting the exchange of data on the charging.

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The implementation of the business aspect measures is described in Table 3-8

Table 3-8 Details on the implementation of business aspect measures for Oslo Demo 2

Description of measure implementation
1. **Payment for sharing CPs** The EMP will do the billing and get the payment from the EV user a. When the EV user books a CP, a payment reservation on his/her credit card (via the App) is done for future payment to the EMP. i.The payment reservation will cover the costs in case of no show. i.Amount reserved: 12 NOK per hour booked. b. The CP booking can be cancelled: i.If the cancellation is done more than 1 hour before the booked time slot, the payment reservation is released. i.If the cancellation is done less than 1 hour before the booked time slot, one hour must be paid. The rest of the reserved payment (if more than one hour was booked) is released. c. Billing is supported i.Information (from CPO) on the connected time (time between plug in and plug out) and information (from EMP App) on the booked time slot is input to the billing. i.Price for charging – for the booked time slot: 3,5 NOK per kWh i.Price for no show: 12 NOK per hour d. The EMP will transfer money to the CPO (according to the agreement between the CPO and the housing cooperative) and to the housing cooperative. In addition, the housing cooperative will pay a monthly fee to the CPO and the energy bill. i.The CPO will receive payment from the EMP (direct payment) i.The CPO will receive from the housing cooperative: 1000 NOK per month. i.The housing cooperative will receive from the EMP: The payment received from the EV users minus the payment made to the CPO. v.The Retailer and DSO will receive payment for energy/use of grid from the housing cooperative: The price is defined by the tariffs used.
2. **Penalizing blocking of CPs** a. Blocking and the extend of the blocking are detected by combining information on among others the connected time (from CPO) and information on the booked time slot (from EMP App). The blocking fees are added to the bill. i. Blocking fee is: 25 NOK per hour connected after the end of the booked time slot

3.2.3 Interaction with other measures

The measures are not independent on each other. Table 3-9 shows the dependencies within and between measure groups.

Table 3-9 Dependencies between measures in Oslo Demo 2

Measure groups	Charging group	Business aspects group
Charging group	• The understanding of the booking procedures and the usability of the App will affect the willingness to book CPs in advance and the acceptance of the booking service.	• The possibility to book a CP in advance facilitate predictable charging, and EV users may be willing to pay for this.

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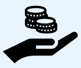
	• Operational problems may affect the willingness to book in advance and the acceptance. • The use of notifications may reduce the number of no shows, delays, and blockings, and thus also the acceptance – both for the CP owner and EV users.	• The App (booking interface) must communicate prices and conditions related to prices in a way that is easy to understand to increase the acceptance. • The App must support a behaviour that limit the costs for the EV user (notifications that support in time cancelations, avoids delays, etc.).
Business aspects group 	• The understanding of price models and conditions will affect the willingness to book CPs in advance. • An easy-to-understand price model (price per hour connected) arrange for acceptance and awareness. • The payment reservation and the penalty measure may affect the charging behaviour (e.g., avoid no show and blocking) • The blocking fee is higher than the normal price per hour since to avoid problems for other users.	• Price models must balance needs of the CP owner and the EV user with respect to revenues and costs. • The business and price models arrange for a proper income for the CP owner. ○ Price is per hour and not per kWh charged ensure a fair income – also when the booked period is several hours but only a little amount of energy is charged. ○ The payment reservation (when the CP is booked) will cover potential no show situations. The CP owner will get paid when the CP cannot be used by others. ○ The no show fee per hour is equal to the price per hour (as for hotels). • Cancellation rules must define payment conditions.

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.

3.3 Bremen Demo 1 – Charging at work: Measure descriptions

The following subsections describe the objectives of the measure group and expected outputs, the implementation of the measures in each group, and dependencies between measures within and across groups.

3.3.1 Measures and related objectives

Employers want to provide charging facilities to their electric vehicle fleet, to visitors and to employees. The charging is offered for free to users who are registered at the CPO and connected via the provided web-based App. Other users cannot connect..

Measures: The demonstrator covers the following measures:

- Charging measure group: Private CPs, Flexible charging, and Priority charging
- Smart energy management measure group: Local RES, Local storage, and Optimal and coordinated use of energy

The following business-as-usual scenario describes the situation before GreenCharge:

- Employees and visitors with electric vehicles can charge as much as they like at existing charge points.
- No energy management is needed since there are few electric vehicles and enough energy.
- With the expected increase of the number of electric vehicles, too little energy will be available.

The scenario with GreenCharge measures is as follows:

- The energy delivered to each electric vehicle is predicted and controlled according to rules to arrange for the charging of more electric vehicles.
    - Visitors and users of company fleets get priority. They can charge as much as they want up till a maximum.
    - Employees may use the shared charge points for free if the charge points are not used by visitors and company fleet, but they will just get the energy needed for their commuting.
- The charge and energy management system adapts the charging the electric vehicles with flexible charging to the available amount of energy. Energy from a stationary battery storage is used when this is needed.
- The stationary battery storage is charged during night when the energy prices are low.

Objectives

The demonstrator has a technology focus and not on business aspects. Thus, the business aspects are mainly addressing how the technology can contribute to a cost reduction. Table 3-10 defines the overall objectives of the demo.

Table 3-10 Objectives of Bremen Demo 1

Measure group	Overall objectives	Detailed objectives	Target group
Charging 	Learn about the use of CPs and the fulfilment of charging demands	Answer the following questions: • How long are the EVs connected? • How much of the connected time is used for charging? • How much energy do they on average charge per connected time unit? • What is the share of energy charged compared with the energy demand?	CPO – Charge point operator Employees
	Learn about the charging flexibility of the EV users	Answer the following questions: • How much flexibility do the EV users provide with respect to when the charging can be accomplished?	CPO – Charge point operator

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		• What is the actual flexibility that the system could have utilised?	
Smart energy management	Learn about the effects on of the measures and the technology needed	Answer the following questions: • How much is the peak level reduced? • What is the self-consumption achieved with the current solar plant and stationary battery? • What are the effects on the share of green energy? • What is the effect on CO2 emissions?	CPO – Charge point operator Employer

Expected outputs

The output from the charging measures is:

- Certain types of EV users can ask for priority charging.

The output from the smart energy management measures is:

- The infrastructure and management systems are prepared for a higher number of electric vehicles.
- Use of stationary battery storage provides flexibility when energy demand is high.
- A rule-based distribution of available energy to the electric vehicles, depending on which group they belong to (visitors, company fleet, or employee), will ensure enough energy to charge all according to the rules.

3.3.2 Implementation

The planned measures were implemented but the local storage did not become fully operational. This is further described in the process evaluation. Independent of this, this section describes how the measure groups are implemented.

3.3.2.1 Implementation of Charging measures

The following hardware installations are done to facilitate the energy management:

- 5 charge points are installed in the vicinity of the premises of the employer.

The software facilitating the energy management is

- WebApp collecting input on charging demand from EV users such as
  - Electric vehicle identifier and the properties of the electric vehicle (battery capacity, etc.)
  - Charging request with information on the time period in which the charging should be accomplished and the energy amount requested. EV users may also request priority charging.
- Charge and energy management system

The implementation of the charging measures is described in Table 3-11.

Table 3-11 Details on the implementation of charging measures for Bremen Demo 1

Description of measure implementation
1. **Private CPs:** a. One CP is reserved for company EV. b. One CP is reserved for visitors. c. Three CPs are offered to employees (first come, first served).
2. **Flexible charging:** a. EV users will get flexible charging if they do not request priority charging. b. The energy available for flexible charging is the total energy availability minus the energy needed for the priority charging. c. The available energy is distributed among the connected EVs depending on the energy request and the time window they have provided in the charging request.

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. **Priority charging:** a. EV users may request priority charging. b. With priority charging, the EVs are always charged with maximum charging speed.

3.3.2.2 Implementation of Smart energy management measures

The following hardware installations are done to facilitate the energy management:

- Charge points are installed in the vicinity of the premises of the employer.
- PV panels on the roof of charge station (4,7kWp and 12kWp, respectively),
- Stationary batteries for local energy storage. Some of these were secondary life batteries.

The software facilitating the energy management are:

- App collecting input on the charging option to be used (flexible or priority), time period for the charging and the energy requested.
- Charge and energy management system managing the stationary batteries and the optimisation of the charging with respect to the schedules and charging speeds to be used for the individual electric vehicles.

Table 3-12 Details on the implementation of smart energy management measures for Bremen Demo 1

Description of measure implementation
1. Local RES: a. PV panels are installed for local production of green energy. c. The energy produced by the PV panels is fed into the local grid and it is used in the neighbourhood.
2. Local storage: a. Stationary batteries are installed to store energy (taped from the grid). Some of these were secondary life batteries demounted from decommissioned EVs. b. The energy stored is used when extra energy is needed, i.e., when more than the maximum peak power is reached. d. The batteries are charged with energy from the grid.
3. **Optimal and coordinated use of energy:** a. Flexible charging arranges for more optimal use of energy. b. If the maximum peak power is reached, the energy stored in the battery is used. e. If energy from the grid and the battery storage is not sufficient, the charging power is reduced evenly for all EVs with flexible charging.

3.3.3 Interaction with other measures

The measures are not independent on each other. Table 3-13 shows the dependencies within and between measure groups.

Table 3-13 Dependencies between measures in Bremen Demo 1

Measure groups	Charging group	Smart energy management group
Charging group	• No dependencies detected	• The private CPs facilitate the testing of charging integrated with smart energy management. • Flexible charging facilitates the desired load balancing and use of energy adapted to grid capacity. • The App used to start the charging will provide the input needed for the realisation of the smart energy management such as the energy demand and latest finish time.
Smart energy management group	• No dependencies detected	• "Local storage" will affect the "Optimal and coordinated use of energy". RES and energy storage will facilitate the use of more green energy and provide flexibility with respect to when the green energy is used.

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.

3.4 Bremen Demo 2 – EV sharing: Measure descriptions

Bremen Demo 2 extends the scope of traditional car sharing services to address EV sharing linked to a housing cooperative. The housing cooperative have in total 158 apartments. In addition, there are approximately 290 apartments in a walking distance (not necessarily owned by housing cooperative).

The following subsections describe the objectives of the measure group and expected outputs, the implementation of the measures in each group, and dependencies between measures within and across groups.

3.4.1 Measures and related objectives

As described in section, the demonstrator covers the following measures:

- EV fleet measure group: Shared EVs, and Shared EVs in new housing cooperative
- Charging measure group: Private CP
- Business aspects measure group: Rewarding Eco driving and Payment for sharing EVs

The following business-as-usual scenario describes the situation without GreenCharge:

- Housing cooperatives must have a high share of parking spaces for their residents.
- If the number of parking spaces is limited, residents will have parking problems if they have a private car.
- The housing cooperative must pay a high tax due to the city for the land use due to the high number of parking spaces, and the tax makes the apartments more expensive.

The scenario with GreenCharge measures is as follows:

- Shared EVs are provided to residents in a new housing cooperative – as an alternative to private car ownership. Residents can manage without having a private car.
- The housing cooperative can limit their number of parking spaces, and the tax to the city can be reduced. Thus, the price of the apartments can be reduced.

Objectives

Table 3-14 defines the overall objectives of the demo.

Table 3-14 Objectives of Bremen Demo 2

Measure group	Overall objectives	Detailed objectives	Target group
EV fleet	Learn about the acceptance and potential of e-mobility services	Answer the following questions: • What is the potential of EV sharing services in new housing cooperatives? • How are the shared EV service accepted?	EV fleet operator Residents/Citizens
Charging	Learn about the use of the EVs involved	Answer the following questions: • To which extend are the EVs used and charged?	EV fleet operator Residents/Citizens

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.

Business aspects	Learn about the economic potential of the services offered	Answer the following questions: • Will such services be sustainable from an economic point of view?	EV fleet operator

Expected outputs

Expected results of the EV fleet measures:

- Housing cooperative residents can manage without a private car.
- Housing cooperative gets a tax reduction due to a reduced land use for parking spaces.
- Increased awareness and acceptance of electric vehicles among residents.

Expected results of the charging measures:

- Charge points at pickup and delivery locations (in this case in the premises of the residents).

Expected results of the business aspect measures:

- The rewarding of eco-driving encourages a driving behaviour the causes less ware on the electric vehicles and thus a reduction of maintenance and investment costs.
- The digitalisation of the electric vehicle sharing process (use of App, key-less access, remote validation of driving licence) reduce operating costs.
- Viable business model for shared electric vehicle services.

3.4.2 Implementation

This section describes how the measures of the demonstrator are implemented. All measures became operational.

3.4.2.1 Implementation of EV fleet measures

The following hardware installations are done to facilitate the charging:

- Fleet of electric vehicles
- electric vehicle station in the vicinity of housing cooperation

The software facilitating the energy management are:

- In-vehicle systems monitoring the status of the electric vehicle, among others the SoC and the mode in which the electric vehicle is used (eco-driving included).
- Fleet management system. In addition to supporting traditional fleet management operations, the system also interacts with the in-vehicle systems of the electric vehicles in the fleet.
- App supporting functions such as: EV booking, access to EV, and validation of driver licence.

The implementation of the EV fleet measures is described in Table 3-15.

Table 3-15 Details on the implementation of EV fleet measures for Bremen Demo 2

Description of measure implementation	When implemented
1. **Shared EVs:** A fleet of shared EVs are offered to the public. The service has the following characteristics: a. Station based EV sharing b. The EV has to be picked up and delivered at the same station An App is used to manage the interaction with the EV user. It supports c. Booking of EV d. Key-less access to EV	From: November 2019 To: November 2021

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.

e. Remote validation of driving licence The fleet management system monitors the EVs through interactions with the in-vehicle systems and uses the information received in the management of the fleet. The following is among others monitored: f. SoC g. The mode in which the EV is used (eco driving included) is monitored h. Driving distance	
2. **Shared EVs in new housing cooperatives:** Residents and citizens are offered the opportunity to use a fleet of shared EV. a. Charge points are installed in the vicinity of apartment blocks b. A fleet of EVs is parked at the CPs and offered to the residents App is supporting booking, payment, etc. as for shared EVs in general above, and the EVs are also monitored in the same way.	From: November 2019 To: November 2021

3.4.2.2 Implementation of Charging measures

The following hardware installations are done to facilitate the charging:

- Charge point equipment in the vicinity of housing cooperation.

The charge management is done outside the project. The SoC is however monitored by the fleet management system, as described for the EV fleet measures.

The implementation of the charging measures is described in Table 3-16.

Table 3-16 Details on the implementation of charging measures for Bremen Demo 2

Description of measure implementation	When implemented
1. **Private charge point:** The charge points can only be used by the EV fleet: a. The CPs are pickup and delivery point for the shared EVs. b. Since the CPs are dedicated to the shared EV fleet, no booking is required.	From: November 2019 To: November 2021

3.4.2.3 Implementation of Business aspect measures

The software facilitating the implementation of the business models are:

- **Fleet management system** handling the billing for use of electric vehicles
- **App** used by EV users.
- **On-board systems** monitoring the electric vehicle and reporting information about the use of the electric vehicle to the fleet management system.

The implementation of the business aspect measures is described in Table 3-17.

Table 3-17 Details on the implementation of business aspect measures for Bremen Demo 2

Description of measure implementation	When implemented
1. **Rewarding eco driving:** The EVs in the EV fleet are monitored, and the use of the eco mode is detected.: a. A price models that rewards eco driving will be tested in the demonstrator	From: Autumn 2021 To: November 2021
2. **Payment for sharing EVs.** The EVs are offered to residents in the housing cooperative. a. The EV users pay for the use of the EVs b. The housing cooperative pays the EV operator for offering the shared EVs in the vicinity of the apartment blocks.	From: November 2019 To: November 2021

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 shared EVs reduces the need for private car ownership among the residents, and thus the need for parking spaces on the land owned by the housing operative. The need for land is reduced, and thanks to this, c. The housing cooperative get a tax reduction that among others affect the prices for the apartments.	

3.4.3 Interaction with other measures

The measures are not independent on each other. Table 3-18 shows the dependencies within and between measure groups.

Table 3-18 Dependencies between measures in Bremen Demo 2

Measure groups	Charging group	Smart energy management group	Business aspects group
EV Fleet	• The sharing of EVs in settings with housing cooperatives and public transport give insight into user needs that may improve the service and increase acceptance and awareness.	• The shared EV service may increase the acceptance and awareness of e-mobility.	• The sharing of EVs in settings with housing cooperatives and public transport generates new business opportunities. • The digitalisation of the EV sharing service (App, key-less access, remote validation of driving licence) reduces the operating costs.
Charging group	• CPs at pickup and delivery location reduces the overhead and may increase the acceptance.	• NA	• The automated monitoring of SoC, mode (eco driving) and driving distance reduces the operating costs.
Business aspects	• The rewarding of eco driving may increase the acceptance. • The tax reduction housing cooperatives may get when replacing parking spaces with a shared EV fleet may increase the acceptance and awareness.	• NA	• The rewarding of eco driving may lower the operating costs

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.

3.5 Barcelona Demo 1 – eScooters battery swapping: Measure descriptions

The following subsections describe the objectives of the measure group and expected outputs, the implementation of the measures in each group, and dependencies between measures within and across groups.

3.5.1 Measures and related objectives

The demo addresses an e-scooter sharing service where citizens (location 1) and professionals (location 2) use scooters by minutes. The fleet manager has to guarantee that the energy in the battery is sufficient for the trip. The following subsections describe the objectives of the measure group, the implementation of the measures in each group, the expected output, the activities carried out to support the implementation of the measures, and the dependencies between measures within and across groups.

Measures: The demonstrator covers the following measures:

- EV Fleet measure group: Shared EVs
- Charging measure group: Battery swapping and charging, and Flexible charging
- Smart energy management measure group: Local RES, and Optimal and coordinated use of energy
- Business aspects measure group: Payment for sharing EVs, and Rewarding Eco driving

The following business-as-usual scenario describes what the situation would be with no further

- The professionals needing a scooter for delivery activities or citizens needing a trip own their vehicle. Since electric scooters are more expensive or owners do not have charging infrastructure, they will opt to buy a fossil fuelled scooter.
- EV fleet managers own charge point stations or make use of public charge points. The users must plug in the electric vehicle when they finish the use of the electric vehicle.
- Fleet managers operating an e-scooter sharing service focus the operation activity on having the batteries as full as possible to avoid user complaints if they cannot reach their destination. Thus, they plug the vehicles in, or they swap the batteries as soon as they are not in service and the charge starts right at the moment.

The following GreenCharge scenario describes the situation when the measures are implemented:

- The fleet manager has different battery hubs and more batteries than e-scooters. The manager replaces the depleted batteries by full batteries previously charged in the battery hub.
- According to estimated trip needs, the batteries can be charged at off peak hours or sequentially, to avoid peak prices and/or high peak power contracts by using optimal and coordinated used of energy
- EV sharing service can be branded as green or eco-friendly if apart from minimizing air pollution it uses renewable energy locally produced to charge the batteries with the support of smart energy management and battery storage capacity.
- The fleet manager rewards users that drive smoothly with no sudden breaking and acceleration, since smooth driving allows energy savings and longer battery lifespan. Incentives will engage users in a more sustainable driving pattern.

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.

Objectives

Table 3-19 defines the overall objectives of the demo.

Table 3-19 Objectives of Barcelona Demo 1

Measure group	Overall objectives	Detailed objectives	Target group
EV fleet	Learn about the acceptance of e-scooter service (B2B and B2C)	Answer the following questions: • What is the potential of EV sharing services combined with multilocation battery hubs? • How spread does the battery hub network need to be? • Free-floating versus station-based approach: acceptance and operational costs	EV fleet operator Professionals/Citizens not owning an e-scooter
Charging	Learn about predictability of charging needs Learn about the use of the EVs involved	Answer the following questions: • To which extend are the EVs used and charged? • Average energy user per trip?	EV fleet operator Users of the sharing service
Smart energy management	Learn about charging flexibility potential	Answer the following questions: • How flexible is the charging process: ratio time to charge/time to next battery use? • How much energy locally produced will contribute to reduce carbon footprint and size of connection to the grid	EV fleet operator
Business aspects	Learn if users are open to change their driving profile when incentives are put in place. Learn if smart charging and local RES helps in business exploitation	Answer the following questions: • How big has the incentive to be to persuade users to drive smoothly • How much maintenance costs are reduced due to more sustainable driving behaviour (less wear of the brakes, etc.)? • To which extend a RES installation pays back?	EV fleet operator EV users

Expected outputs

Expected outputs from the EV fleet and business aspects measures:

- Reduce operational cost
- Provide sufficient offer for EV users
- Keep level of satisfaction of users

Expected outputs from the charging and energy management measures are to find out that there is room for:

- Reduction of peak demand by sequencing battery charging
- Reduction of energy bill by charging at off-peak hours and using energy locally produced
- Reduction of carbon footprint by using greener energy

3.5.2 Implementation

This section describes how the measures selected for the demonstrator (see Table 2-1 on page 17) are implemented.

3.5.2.1 Implementation of EV fleet measures

The following hardware installations are done to facilitate the charging:

- **Battery hubs** deployed in different locations
- **Hardware** to enable energy metering in the battery hubs
- **E-scooters** to operate the service (some already in operation and a new model introduced)

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The software facilitating the fleet and charging management are:

- **In-vehicle systems** monitoring the status of the electric vehicle, position, speed, acceleration and energy use.
- **Fleet management system** (already in place). In addition, it supports the analysis of driving patterns.
- **App** supporting functions such as: electric vehicle booking, access to electric vehicle.

The implementation of the EV fleet measures is described below.

Table 3-20 Details on the implementation of EV fleet measures for Barcelona Demo 1

Description of measure implementation
1. **Shared EVs (B2C):** A fleet of shared EVs are offered to the citizens. The service has the following characteristics: a. Free floating b. The electric vehicle has to be picked up and delivered within specific areas An App is used to manage the interaction with the EV user. It supports a. Booking of EV b. Key-less access to EV The fleet management system monitors the EVs through interactions with the in-vehicle systems and uses the information received in the management of the fleet. The following is among others monitored: a. SoC b. The mode in which the EV is used (eco driving included) is monitored c. Driving distance
2. **Shared EVs (B2B):** Professionals are offered the opportunity to use a fleet of shared EV by minute. The main characteristics are: a. Station based b. Battery hubs points are installed in kiosks at different locations c. The e-scooters has to be returned to the same pick-up point App is supporting booking, payment, etc. as for shared EVs in general above, and the EVs are also monitored in the same way.

3.5.2.2 Implementation of Charging measures

The following hardware installations are done to facilitate the charging:

- **Battery hubs** at kiosks and fleet operator premises. Operation staff collects from e-scooters depleted batteries to be charged in the hub and takes charged batteries (swapping)
- **Energy meters:** battery hubs are equipped with sensors to measure electricity in the charging process

The software facilitating the charging measures are

- **Fleet back end**, already in place, and extended, to enable:
  - Monitoring of bookings to estimate charging needs
  - Extended charge management functionality for the provision of information about energy metering to be provided to the smart energy management system.
- **Charge management system**
  - Collection of energy usage during charging operations

The implementation of the deployed charging measures is described in the Table 3-21.

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Table 3-21 Details on the implementation of charging measures for Barcelona Demo 1

Description of measure implementation
1. **Battery swapping and charging (Battery hubs – B2B):** The battery hubs are installed in kiosks at several locations in the city and they are operated by the kiosk tenant. a. Tenants perform battery swap when the e-scooter is not in use. b. Tenants take care of the charging of the batteries in the battery hub. c. The EV user can go to a kiosk to swap battery if they need extra charge d. Users are charged by minute, not by energy
2. **Battery swapping and charging (Battery hubs – B2C):** The battery hubs are located at the premises of the mobility provider. The staff collects depleted batteries and replace them by full batteries. The depleted batteries are stored in the battery hub where they are charged. There is no specific equipment to control the charging process or to monitor the energy use. The utility energy meter will be used to extract energy.
3. **Flexible charging** The business-as-usual approach to charge the battery as soon as possible will be replaced by another strategy that takes into account following hours-days trips (estimated from historical records) to define plugging times longer than actual charging times

3.5.2.3 Implementation of Smart energy management measures

The following hardware installations are done to simulate the smart energy management:

- **Energy meters:** the battery hubs for the B2B operation are equipped with sensors to measure energy use during the charging process.
- **Battery Management System** located in the e-scooter provides energy usage and SoC during the trip
- PV and different grid connection configurations will be explored in the simulation scenarios, but they will not exist physically.

The software facilitating the energy management are:

- **Software** to extract energy usage and generate research data.
- **Simulator application:** The energy management will be implemented through the schedulers of the simulation.

The implementation of the smart energy management measures is described below.

Table 3-22 Details on the implementation of smart energy management measures for Barcelona Demo 1

Description of measure implementation
1. **Local RES:** Different PV panels configurations are defined for simulations purposes. Location of battery hubs are used for solar production estimation.
2. **Optimal and coordinated use of energy** a. Information on the energy use is obtained from the energy meters on the battery hubs and e-scooters. b. Information on the charging flexibility is obtained from the fleet management back-end that controls the bookings and the e-scooter usage c. Information on local RES availability is estimated using the PV parameters and location d. The charging of individual batteries is calculated through the schedulers of the simulation application under different configuration scenarios.

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.

Description of measure implementation
e. A posteriori analysis is done providing the flexibility potential and the ROI if a smart energy management approach is implemented.

3.5.2.4 Implementation of Business aspects measures

The software facilitating the implementation of the business models is

- **App** used by users of the sharing service:
  - To book the trips in advance
  - To receive messages incentivising eco driving
  - Input on the debit/credit card to be used for payment of fees for priority charging.
- **App back-end** used to bill the users according to the trips done or to do the pre-payments
- **Fleet management system** to select users to participate in the eco driving measure according to their driving profile.

The implementation of the deployed business aspect measures is described in the table below.

Table 3-23 Details on the implementation of business aspect measures for Barcelona Demo 1

Description of measure implementation
1. **Payment for sharing EVs (Pre-payment of EV sharing use – B2B):** - Users (professionals) willing to use the service purchase a voucher to use the e-scooter for a certain amount of time at the kiosk. The payment is done in advance to the usage - The kiosk tenant registers the voucher in the system.
2. **Payment for sharing EVs (Payment per minute – B2C):** - Users register to the service and provide a valid credit card number that will be used for billing - The user is charged for the trip according to the time of use
3. **Rewarding for eco driving:** User will be offered a discount if they change their driving pattern avoiding sudden breaks and accelerations

3.5.3 Interaction with other measures

The measures are not independent on each other. The table below shows the dependencies within and between measure groups.

Table 3-24 Dependencies between measures in Barcelona Demo 1

Measure groups	EV Fleet Group	Charging group	Smart energy management group	Business aspects group
EV fleet group	• Understanding of the user profiles and usage of the service is needed to shape the offer	• With low understanding, little flexibility may be provided, and the effects of the "flexible charging" measure will be limited	• Understanding that energy costs are part of the operation process is very relevant • Size of fleet and batteries will enable flexible charging	• The number of vehicles, spots and pricing needs to be according to user preferences and needs • Business sustainability will depend on investment and operational costs • Tariffication and usages is a key aspect to achieve sustainability

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.

Charging group	• The charging process has to take into account the fleet needs	• EV operator must understand the importance of correct input on charging constraints. • Operator needs to be open to change operation-as-usual (charge as soon as possible)	• "Flexible charging" facilitates more optimal load balancing. • Capacity charging introduce energy constraints.	• Variable electricity tariffs may provide a business case • Flexibility in charging process will enable energy bill • Electricity contracts have to be reviewed
Smart energy management group	• Fleet operators need to provide operational constraints according to fleet usage	• "Optimal and coordinated use of energy" will make use of the charging flexibility provided by the fleet.	• Explore different PV configurations (simulated) • Explore different fleet usage and battery hubs capability.	• Analyse cost of PV installations • Perform sensitivity analysis for different tariff schemes
Business aspects group	• Shape an offer attractive enough to engage users in changing their driving profile • Define a rewarding policy	• Energy needs are different according to driving style. • Battery degradation can be slow down with non-aggressive driving profiles	• Using energy locally produced (or at least green energy) can be linked to a marketing message. • Use actual battery capacity, according to ageing	• Rewarding measures must be a balance with the needs to arrange for high acceptance and not compromising incomes

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.

3.6 Barcelona Demo 2 – Charging in ESN at work: Measure descriptions

The following subsections describe the objectives of the measure group and expected outputs, the implementation of the measures in each group, and dependencies between measures within and across groups.

3.6.1 Measures and related objectives

The demo addresses the provision of charging infrastructure to Eurecat employees at different premises, avoiding the need to upgrade electric network and peak power contracts. The goal is achieved by enabling a booking system and an energy management system.

Measures: The demonstrator covers the following measures:

- Charging measure group: Shared CPs, Roaming, Advance booking, Flexible charging, and Priority access to CP
- Smart energy management measure group: Local RES, and Optimal and coordinated use of energy

The following business-as-usual scenario describes what the situation would be with no further implementation of the measures:

- Due to limited demand and lack of mandatory regulation for old buildings, the employer consider that it is not necessary to provide charging facilities to employees driving an electric car. Those employees should charge at home and/or search for a public charge point in the vicinity if the current energy stored in the battery is not enough to complete their trip.
- Other employers might consider to installed charge points. They will install a certain number of charge points and adapt the electric network to provide power to all charge points simultaneously. Most likely, the energy contract with the DSO needs to be updated to adjust to the new loads.
- In case of charging facilities, electric vehicle drivers will plug in their e-car at arrival and the charging process will start immediately and will conclude either when the battery is fully charged or the driver leaves.

The following GreenCharge scenario describes the situation when the measures are implemented:

- The facility manager (employer in this case) installed a limited number of charge points in several facilities owned by Eurecat that will be shared among e-car drivers. The overall electrical installation is not affected.
- A webapp application is deployed to allow users to book the charge point for a certain period and express their energy needs.
- A communication mechanism is established to address drivers not arriving or leaving when specified in the booking request.
- A rewarding/penalty scheme to be tested to incentivise users to observe the charging time slot and energy demanded (priority for "responsible" users).
- An energy management system is in place. It gathers information from energy usage from the Building Management System, the PV installation, the charging system and the booking app and calculates a schedule to charge the e-cars and eventually adjust HVAC set-points to fulfil all energy demand
- The facility manager gets insights on different scenarios of the charging infrastructure and local RES production to take informed decision to scale up.
- The facility manager gets insights on future charging capacity needs (intention of employees to buy an e-car in the future) and corporate policies for charging fee (cost of energy and investment, willingness to pay, branding).

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.

Objectives

Table 3-25 defines the overall objectives of the demo.

Table 3-25 Objectives of Barcelona Demo 2

Measure group	Overall objectives	Detailed objectives	Target group
Charging	Learn about charging management complexity of shared CPs.	Answer the following questions: • How many users can be served? • How long do employees stay? • How rigorous users are on booking in advance, provide real charging needs and observe arrival and departure times • Which mechanisms (rewards/penalties) incentivise users to "behave" according to plan: is giving priority a good incentive? • To which extend including e-roaming is positive for private CPs?	Eurecat employees driving an e-car (or having plans to purchase one in the near future) Facility managers (they are also Eurecat employees)
Smart energy management	Learn about charging flexibility potential Learn about how local RES can support EV charging and other loads To find solutions to accommodate EV charging in existing buildings with limited grid capacity	Answer the following questions: • How flexible is the charging process: ratio time to charge/time parking? • To which extend local PV panels support load balancing and avoid extending grid connection • How much energy locally produced will contribute to reduce carbon footprint and size of connection to the grid • How beneficial would be to include V2G? Are users willing to provide battery storage capacity? Will the installation of a stationary battery be beneficial for that purpose?	EV fleet operator

Expected outputs

The expected outputs from charging measures are:

- Provide with charging capabilities Eurecat employees driving e-cars
- Minimize barriers for Eurecat employees considering buying an electric vehicle
- Minimize the investment on charging infrastructure and electricity network
- Demonstrate interoperability for future exploitation of charging system or integration of off-the-shelf charging infrastructure
- Increase charge point usage compared to the approach of installing as many charge points as e-cars
- High predictability on energy demand due to charging operations due to compulsory booking
- Gather knowledge about user requirements and acceptance on charging infrastructure and willingness to pay

The expected outputs from smart energy management measures are:

- Keep peak demand similar to the situation with no charging infrastructure
- Avoid peak pricing (shift loads to off-peak)
- Reduction of carbon footprint by using greener energy
- Define the best size of PV installation for return of investment, reduction of grid interconnection capacity and explore potential for participation in flexibility energy market

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.

3.6.2 Implementation

This section describes how the measures selected for the demonstrator (see Table 2-1 on page 17) are implemented.

3.6.2.1 Implementation of Charging measures

The following hardware installations are done to facilitate the implementation of the charging measures:

- **Energy meters** have installed to monitor individual energy consumption of each charge point (in an electric cabinet).
- **Remote Control Outlets:** Switches allowing remote control have been installed for each charge point to enable starting and stopping the charging process.
- **Server on a virtual machine:** deployed to monitor, control and stored information for the charging installation.
- **Socket:** A new socket has been installed to plug the e-cars. Two additional sockets where available but had been upgraded.
- **Electric wiring:** Electric connections and cabinet have been deployed to enable supply and protections to the charge points (sockets).
- **Communication wiring:** Ethernet connections have been installed to enable communication between the electric cabinet (energy monitoring and control devices) and the corporate network where the server for charging management is installed.

The software facilitating the charging measures are:

- **Webapp for booking:** Application for Eurecat employees to book a charge point for a time slot, notify arrival and SoC.
- **Smartphone app:** At the time of writing this document, the option to use the same app as Oslo and Bremen demonstrator is being analysed, in terms of replicability showcase.
- **Booking back end:** application for the facility manager and system administrator to manage the charging infrastructure, disable charge points temporary, visualize records. It includes connection to Hubject roaming platform and the charging management system
- **Charging management front-end**: Graphical user interface to visualize charge points status, monitor record or apply manual control.
- **Charging management back-end**: Application to retrieve information from the charge points. It interacts with the charging management front-end, the energy management back-end and the roaming platform from Hubject.

The implementation of the deployed charging measures is described in the Table 3-26

Table 3-26 Details on the implementation of charging measures for Barcelona Demo 2

Description of measure implementation
1. **Shared CPs:** The charge points (2 in Cerdanyola and 1 in Manresa) are open to Eurecat employees. Initially no booking through the webapp is mandatory (also due to limitations to work in the offices; employees are requested to work from home until August, except for special activities that cannot be done at home) a. Availability of charge points have been communicated to users with an e-car and to facility managers and the head of infrastructure department b. Users willing to use the charge point had communicated to the head of infrastructure and to GreenCharge demo coordinator. c. Due to low occupancy, no further management to solve conflicts is needed d. Users don't pay for the charging, but a record of the charging sessions and the equivalent energy and CO2 impact will be provided as historical records

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

Description of measure implementation
2. **Roaming:** The integration with the roaming platform has been implemented in a second iteration. It does not affect Eurecat employee's interaction with charging process, although with roaming they are able to use another smartphone app (developed by ZET) to the booking and initiate the charging process. Thus EV users subscribing to services from one EMP can use the services of another EMP/CPO. This measure is aimed at demonstrating interoperability with other systems.
3. **Advance booking:** Users need to use the webapp to book a charging session a. If the charging slot is available, the booking is accepted b. Users have to provide estimated energy needed c. The user has to provide the actual State of Charge (SoC) when they plug in the vehicle d. If no SoC is provided, the socket remains off e. The user has no limitation on the number of bookings f. If a user books the charge point but then it does not use it, or arrive later than expected, it is registered in his/her profile
4. **Flexible charging:** The users accept flexible charging by default (in agreement with no fee pay for charging) a. The actual energy transferred will take place at any moment between the arrival and departure time b. The energy demand will not be fully satisfied if the time slot is not sufficient to transfer all energy required, the vehicle leaves before time, or any temporary constraint in the installation make it infeasible.
5. **Priority access to CP:** In case the demand for charging is higher than the actual capacity (many users willing to charge at the same time slot), priority will be given to those users with the best reputation. Reputation is achieved by complying with bookings (using the bookings accepted, arriving and leaving at designated times, providing accurate SoC, etc.). Yet exceptional cases may occur is a VIP visitor or employee (manager) need to access the charge point. In this case, priority if overwritten by Eurecat management.

3.6.2.2 Implementation of Smart energy management measures

The following hardware installations are done to simulate the smart energy management:

- **Energy meters** have installed to monitor individual energy consumption of each charge point (in an electric cabinet)
- **Remote Control Outlets:** remotely controlled switches have been installed for each charge point to allow starting and stopping the charging process.
- **Server on a virtual machine:** deployed to monitor and control energy use
- **Communication wiring:** Ethernet connections have been installed to enable communication between the electric cabinet (energy monitoring and control devices) and the corporate network where the server for charging management is installed
- **PV panels and inverter:** Legacy systems; they were already in place
- **Other energy meters:** Legacy system; one of the premises already had energy meters to measure HVAC system and background load in the building

The software facilitating the energy management are:

- **Booking back end:** application that provides estimates on energy demand linked to future charging sessions
- **Charging management back-end**: application to monitor energy demand in the charge points and to apply charging schedule according to optimal use of energy.

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- **Energy Smart Neighbourhood back-end:** application to forecast energy use based on historical records and bookings, and to schedule the optimal energy use according to energy tariffs, local RES and technical constraints**.**
- **Simulator application:** to scale-up charging demand, charge points and local RES and other scenarios such as V2G of stationary batteries.

The implementation of the smart energy management measures is described below.

Table 3-27 Details on the implementation of smart energy management measures for Barcelona Demo 2

Description of measure implementation
1. Local RES: Existing PV panels in Manresa being monitored. Currently all the production is self-consumed during working days. For the weekends, some surplus is injected to the grid.
2. Optimal and coordinated use of energy a. Information on the energy use in the building is obtained from the energy meters b. Information on the charging flexibility is obtained from the booking back-end c. Information on local RES availability is estimated using the PV parameters and location and historical records d. The charging of individual e-cars is calculated through the scheduler according to energy prices, local RES availability and energy mix and the rest of the building energy demand. e. HVAC set-points are calculated for better energy balance, not affecting users' comfort.
3. V2G (Simulated) a. Scenarios to be simulated according to more e-cars charging and potential installation of stationary batteries. **b.** Surveys to be conducted to analysed willingness to participate in V2G

3.6.3 Interaction with other measures

The measures are not independent on each other. The table below shows the dependencies within and between measure groups.

Table 3-28 Dependencies between measures in Barcelona Demo 2

Measure group	**Charging group**	**Smart energy management group**
Charging group	• Facility manager (acting as charge point operator) needs to keep up to date the installation constraints. • Operator needs to monitor and maintain the installation, even if low usage is initial registered, in order to keep it operational. • Strict booking policy should be maintained for good sharing of resources • Availability of RES or, prioritizing the use of green energy for charging, will enhance user acceptance for those EV owners who has shift to electric because of environmental concerns	• "Flexible charging" facilitates more optimal load balancing. • Capacity charging introduce energy constraints. • Using the booking, more charging operations can be performed keeping the investment of new charge points limited. This is a good convincing reason for the facility manager to open the shared charge point option
Smart energy management group	• "Optimal and coordinated use of energy" will make use of the charging flexibility provided by the charging energy demand. • Predictability to estimate future energy demand is needed (bookings requests should be communicated)	• Flexibility of other loads apart from charging will depend on feasibility (or authorization) to change set-points (i.e. HVAC) • Reduction of carbon footprint will depend on local RES and energy mix

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	• If power limitations are identified, constraints should be translated into charging capacity limitation (bookings restricted)	• Reduction on energy bill will depend on variability of electricity tariffs

3.7 Barcelona Demo 3 – eBike sharing: Measure descriptions

The following subsections describe the objectives of the measure group and expected outputs, the implementation of the measures in each group, and dependencies between measures within and across groups.

3.7.1 Measures and related objectives

The demo addresses the provision of an e-bike sharing service for commuters working in Sant Quirze industrial area where last mile public transport is not available. The service is station-based (only one station at the train station). The bike station is equipped with controllable charging points and PV panels and a stationary battery are installed to provision most of the energy demand requested. An app will enable users to access the station, notify the e-bike taken and monitor their trips.

Measures: The demonstrator covers the following measures:

- EV Fleet measure group: Shared EVs, and Shared EVs integrated with public transport
- Charging measure group: Private CPs, and Flexible charging
- Smart energy management measure group: Local RES, Local storage, and Optimal and coordinated use of energy
- Business aspects measure group: Payment for sharing EVs

The following business-as-usual scenario describes what the situation would be with no further

- Some workers choose to go to work with their own cars. Their trip is more flexible, and sometimes more comfortable, than travelling by train and covering last part of the journey on foot. However, it is more expensive, they generate pollution and traffic congestion, and they get stressed at rush hours. Other workers may decide to bring their personal mobility vehicle (bike or scooter) on board of the train. At peak hours fitting the bicycle in the train is quite annoying. And the purchase of an own e-bike is expensive.
- Some public transport operators include parking facilities for bikes. However, it is not safe to leave the bike overnight.
- Providing a sharing service does not necessary implies that the energy use is green.

The following GreenCharge scenario describes the situation when the measures are implemented:

- E-bike sharing service provided by the townhall is available for a set of employees working in the area. The group of employees change every few months to give the chance to try the service to as many employees as possible.
- The railway operator has deployed an e-bike station in the train station, making it convenient to combine public transport with a light vehicle sharing service.
- Smart charging is enabled by monitoring and controlling a new set of charging points (original charging points did not have this capability) and keeping track of SoC by means of IoT devices
- The energy management system enables charging the e-bikes with solar energy locally produced and stored in the stationary battery when the e-bikes are not in the station. Estimation of energy needs are based on historical records of SoC and trips.
- An app and a back-end systems enables a better control of the fleet and sets the basis for scaling-up and exploring a viable business model

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Objectives

The main objective of the demonstrator is to explore acceptance and viability of a e-bike sharing service to cover last mile for commuting coming from Barcelona metropolitan area to Sant Quirze industrial area to work. ICT included should pave the way to scalability and local RES should make the bike station self-sufficient, reducing the need for extending the grid connection.

Table 3-29 Objectives of Barcelona Demo 3

Measure group	Overall objectives	Detailed objectives	Target group
EV fleet	Learn about the acceptance of e-bike service Learn about operation and maintenance and sustainability	Answer the following questions: • How big is the target community that can become users of the e-bike sharing service? • How expensive is to operate the service? Can a sustainable business case be derived? As a stand-alone service or in combination with public transport operators? • How ICT enhance safety and security? (vandalism) • Will a booking system increase the number of users or number of trips? • Will it be possible to open the service to other group of users (i.e. during weekends)?	Public transport operator Employers Townhall Commuters
Charging	Learn about charging management complexity a sharing mobility service.	Answer the following questions: • How often do users not plug the bike when they finish the service? How can it be avoided? • How often need the bikes to be charged? • How predictable is the energy demand? • How feasible is to increase the use of charging points (open the infrastructure to other users with own bike that commute in the other direction)	Charging point operator e-mobility service provider Installation owner
Smart energy management	Learn about charging flexibility potential Learn about how local RES and stationary battery can support e-bike charging with or without grid connection	Answer the following questions: • How flexible is the charging process: ratio time to charge/ parking time? • To which extend local PV panels support e-bike charging • How much energy locally produced will contribute to reduce carbon footprint and size of connection to the grid • How is the payback of a smart energy approach with local RES and stationary battery	EV fleet operator Charging point operator
Business aspects	Learn if users are willing to pay for such a service	Answer the following questions: • How much are users willing to pay • Are other stakeholders willing to subsidise the service (employers, public transport operators, townhall)	EV fleet operator EV users Public authorities (town hall, regional administration,…)

Expected outputs

Expected outputs from the EV fleet measures:

- Increase of user acceptance for ICT enhanced functionalities (app, better maintenance)
- Increase fleet control (detection of usage and trips within authorised area)
- Minimize vandalism (users are registered and linked to a specific bike for each usage)
- Persuade stakeholders to keep the service running (employers, public transport operator)

Expected outputs from the charging and energy management measures

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- Minimise or avoid energy usage of the grid (self-consumption)
- Reduction of carbon footprint by using greener energy

3.7.2 Implementation

This section describes how the measures selected for the demonstrator (see Table 2-1 on page 17) are implemented.

The operation with real users has never taken place due the Covid situation and vandalism. The stationary battery has not operated in a continuous mode because the inverter was stolen, and the PV panels were disconnected for security reasons since there was no load demand. However, it has been possible to test the demonstrator with friends & family to get some charging profiles in January 2021 to be used in the simulator.

3.7.2.1 Implementation of EV sharing measures

The following hardware installations are done to facilitate the implementation of the sharing measures:

- **Geolocation trackers** with communication capabilities (based on IoT) to increase fleet controllability and scalability
- **Batteries** with CAN communication to monitor constantly SoC
- **Server on a virtual machine:** deployed to monitor, control and stored information for the charging installation
- **Electronic lock:** To minimize vandalism and enabling the access to the bike station with an app, an electronic lock and an IoT relay have been deployed
- **Charging points** needed for the sharing measures are not requested to be smart. Existing charging points (prior to GreenCharge) may suffice, but since the charging measures required smart charging, the new charging points are used also for EV sharing measures.

The software facilitating the sharing measures are:

- **Smartphone app:** Users will use the app to register to the service, to access the bike station, get the bike assigned to them for that trip and keep record of trips, as well as notify problems.
- **Fleet management back end:** a back-end application for the fleet manager (e-mobility provider) to keep track of the fleet and supervise the operation

The implementation of the deployed charging measures is described in the Table 3-30

Table 3-30 Details on the implementation of EV fleet for Barcelona Demo 3

Description of measure implementation
1. **Shared EVs:** The e-bikes are available to a group of commuters working in Sant Quirze area. The shared EV service does not differ from the Shared EVs integrated with public transport: the bike station is the same. Users are not forced to use the train, although the bike station is located conveniently in the train station. a. The employer signs an agreement with the townhall b. A group of users is selected to use the service c. Users get a key to access the bike station during the trial period (some of them lock the bike to ensure they always get the same bike) d. One the trial period is finished (3-6 months), users return the key
2. **Shared EVs integrated with public transport:** The measure is basically the same as for Shared EV, but it takes place after the upgrading of the bike station and deployment of an app for the user and a back-end system for the sharing operator. a. A group of selected users is authorized to use the service b. They register using the app and the authorisation is granted for a limited period of time c. Users get access to the bike station using the app to unlock the door of the station (tag reading using NFC) d. The system assigns a bike and controls whether the user takes that bike

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Description of measure implementation
e. The system monitors if the e-bike exits the authorised operating area. If this is the case a penalty is apply (authorisation temporary denied) f. The system monitors the trip g. The system controls if the bike is returned to its charging point and it is plugged in. Otherwise, the user will receive a notification h. Users can notify if there is a problem in the e-bike or the station

3.7.2.2 Implementation of Charging measures

The following hardware installations are done to facilitate the implementation of the charging measures:

- **IoT Sensors** with communication capabilities (wireless) to monitor energy consumption and production
- **Charging points:** with control capabilities that can be switched on/off remotely, according to charging scheduling or manually, by the charging operator
- **Server on a virtual machine:** deployed to monitor, control and stored information for the charging installation
- **Electric wiring:** Electric connections and cabinet have been deployed to enable supply and protections to the charging points (sockets)

The software facilitating the charging measures are:

- **Charging management back-end**: application to retrieve information from the charging points. It interacts with the energy management back-end and the fleet manager back-end.

The implementation of the deployed charging measures is described in the Table 3-31

Table 3-31 Details on the implementation of charging measures for Barcelona Demo 3

Description of measure implementation
1. **Private CPs** There are new 5 charging points with monitoring and control capabilities. There are 5 additional “dummy” charging points (not used at the moment) from a previous deployment, that might be used in case of failure or to extend charging capability. The number of operational charging points equals the number of e-bikes, each bike is assigned to a unique charging point (except if there is a failure and one is temporary out of order) a. The user should plug the e-bike at the charging point assigned by the app b. No booking is necessary c. No payment is involved
2. **Flexible charging:** The charging management system accepts a charging schedule coming from the ESN manager system. It switches on/off the individual charging points according to the schedule. The charging management system monitors that the energy flow is that expected. The charging management system sends the energy transferred to the ESN system

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

3.7.2.3 Implementation of Smart energy management measures

The following hardware installations are done to simulate the smart energy management:

- **Sensors** have installed to monitor individual energy consumption of each charging point, PV production and energy stored in the stationary battery
- **PV panels** to provide renewable energy locally produced and increase self-sustainability
- **Inverter** to control solar energy, energy stored in the stationary battery and energy coming from the grid
- **Stationary battery** to store solar energy when the e-bikes are not at the station or at fully charged**.**
- **Server on a virtual machine:** deployed to monitor and control energy use
- **Gateway** (Raspberry pi) to enable communications (4G) between the local equipment and the remote server

The software facilitating the energy management are:

- **Energy Smart Neighbourhood back-end:** application to forecast energy use based on historical records and weather information, and to schedule the optimal energy use according to energy tariffs, local RES and technical constraints**.**

The implementation of the smart energy management measures is described below.

Table 3-32 Details on the implementation of smart energy management measures for Barcelona Demo 3

Description of measure implementation
1. Local RES: Two PV panels have been deployed in the bike station roof. They will be connected to an inverter to control local energy inputs
2. Local storage: A stationary battery is deployed that stores energy produced by PV panels when the e-bikes are not at the charging points. During working days, the maximum production is produced when the e-bikes are away
3. Optimal and coordinated use of energy a. Estimation of solar production based on weather forecast and PV panel characteristics b. Estimation of energy demand based on historical records of e-bikes usability c. Information on SoC for stationary battery and boundary constraints d. Information on grid connection capability, energy mix and energy prices. e. Provision of charging schedule for the next 24-48 hours.

3.7.2.4 Implementation of Business aspects measures

No specific hardware or software has been deployed for these measures.

Currently, there is no payment involved, but business opportunities will be explored through surveys to determine the willingness of users to pay, and through analysis of charging flexibility and self-consumption.

Simulations will be performed to scale up and analyse the impact on the operation and maintenance costs.

Table 3-33 Details on the implementation of business aspects measures for Barcelona Demo 3

Description of measure implementation
1. Payment for sharing EVs: Surveys issues gathers willingness to pay of users, before service upgrading and after trials

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3.7.3 Interaction with other measures

The measures are not independent on each other. The table below shows the dependencies within and between measure groups.

Table 3-34 Dependencies between measures in Barcelona Demo 3

Measure groups	EV Fleet Group	Charging group	Smart energy management group	Business aspects group
EV fleet group	• Understanding the user profiles and usage of the service and external factors that might impact on usage	• Discover potential flexibility of charging operations to perform smart charging • If vehicles are not properly plugged, charging cannot be performed. If it happens quite often, actions in the form of penalties may be considered, or staff needs to be assigned to ensure proper operation	• Mobility patterns affects the potential of energy optimization	• Business sustainability will depend on investment and operational costs • Users' willingness to pay may help to keep the service in operation and scale-up
Charging group	• If the charging process is not performed correctly and the user cannot reach their destination, user acceptance will decrease	• EV operator must understand the charging constraints. • Operation and maintenance require supervision: personal efforts need to be assigned	• "Flexible charging" facilitates more optimal load balancing.	• Fee might be dependent on energy usage for the trips performed
Smart energy management group	• Energy optimization should fulfil users' needs for the next trip • Trips predictability helps to optimize energy	• "Optimal and coordinated use of energy" will make use of the charging flexibility provided by the fleet.	• Capabilities to overlap energy production and energy demand help in optimization. Alternative, storage should be used	• With bigger installations, exporting energy to the grid may provide additional incomes
Business aspects group	• Shape an offer attractive enough to engage users in paying for the service • Use user acceptance to explore willingness to pay of other stakeholders (municipality, public transport, employers)		• Explore "selling" flexibility as an alternative income source.	

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4 Evaluation approach for demonstrators

Starting from the overall evaluation strategies in Section 2.2 and 2.3, this chapter describes the detailed evaluation approaches for the GreenCharge demonstrators.

For the process evaluation, the approach outlined in 2.3 are used for all demonstrators, and the data collected are summarised in Annex E.

For the impact evaluation, the following is defined:

- **Baseline situation:** This is the situation before the measures were introduced or the situation when the measures are not in operation.
- **Data collection for baseline and after data:** The baseline data define baseline situation. The after data are from when the measures are taken. For both, the data collection strategy is defined.
- **Period to be evaluated:** This is relevant since the evaluation is about optimal energy management over time with variations in energy use, energy production, energy prices, etc.
- **Use of simulations:** Two demonstrators are extended by simulation, Oslo Demo 1 and Bremen Demo 1. Selected weeks are simulated. Additional measures are simulated, one by one, to generate the after situations where the cause of the impact is well defined.

Note: The data collection and the evaluation strategies were planned in advance for each demonstrator. Due to the complexity of the demonstrators and the data collection, these plans are adapted to the availability of research data, as described in section 6.3:

- The evaluation periods are set to periods with access to complete research data of good quality.
- The baseline and simulation strategies are defined based on the data availability.

4.1 Oslo Demo 1 (charging in ESN) impact evaluation approach

A hybrid approach is used for the evaluation of some measures, as described in section 2.4. The demonstrator is extended through simulations to facilitate an investigation of the effects of flexible charging, use of local energy storage, and smart energy management.

The automated data collected from the demonstrator are baseline data and represent a situation with no charging flexibility, no local energy storage, and no smart energy management. Simulations show the after situation, and the impact of flexible charging, use of local energy storage, and smart energy management is evaluated.

Baseline and after situation strategy

Most of the implemented measures have been operational. The operation times o varies from January 2021 (CPs), from June 2021 (PV panels), and from August 2021 till the end of the project. There are however some exceptions:

- The battery used as local energy storage did however stop working before the summer 2021, and we consider it to have no operation time.
- An App supporting flexibility and smart charging was, due to a delay, not tested until February 2022. The extent of the test is not sufficient to be included in the evaluation. The test did however facilitate the collection of research data on acceptance, awareness and accessibility regarding the App-solution.

Due to the above, the smart energy management is not demonstrated. A simple load balancing arranges for the fastest possible charging of all connected EVs (ready as soon as possible) is however in operation (the *earliest* optimisation criteria). This is state of the art and implemented by the charge management system.

The baseline and after situation strategies varies between the measure groups and indicators.

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For all groups: Acceptance, Awareness, Accessibility, Number of EVs and Number of CPs indicators:
- The baseline is the situation before the start of GreenCharge where there were no charge points in the garage, but some residents owned or used EVs.
- The after situation is when charge points are installed in the garage
- Note that an evaluation of the App is included. It was finalised and tested after the main evaluation period.

Charging measure group: Utilization of CPs, Charging flexibility, and CO2 emission indicators:
- The baseline from the demonstrator is charging with no flexibility and no smart energy management but PV panels are in operation.
- The baseline from simulation: See details below.
- The after situation is from simulations. See details below.

Smart energy management measure group: For all indicators, there are two baselines:
- The baseline from the demonstrator is charging with no flexibility and no smart energy management. PV panels are installed, and they produce energy, but the use of the energy is not adapted to the PV production (due to no smart energy management).
- From simulation: See details below.

Business aspects measure group: All indicators:
- The baseline is a situation when charge points are installed and used with no PV panels.
- The after situation is with use of the PV panels.
- The consequences of an introduction of flexibility, battery, and smart energy management are discussed.

Data collection and simulations

There are three approaches for data collection:
- **Research data from surveys:** The data are collected manually through interviews or questionnaires targeting the leaders of the housing cooperative and residents (see Annex C.1).
- **Research from demonstrators used in automated indicator calculations:** Annex A.2 provides an overview of the data collection and an assessment of the data.
  The period for data collection from the demonstrator is: **August 2021 – January 2022** (see section 6.3)
- **Simulations.** New research data are generated from the simulations as described below.
  The periods for simulations are **August 23-29, October 23-29, and December 13-19,** and all seasonal variations are included.

Simulations are used to extend the demonstrator. Different optimization criteria are used. Earliest is without additional optimisation (just the simple load balancing that is state of the art). Greenest means that the optimizer finds the greenest alternative.

Simulation scenarios extending demonstrator		Optimization criteria	Comment
S1	With no optimisation and no battery	Earliest (non)	Simulation baseline
S1b	With no optimisation and battery	Earliest (non)	To study effect of battery
S2	With optimisation and no battery	Greenest	Flexibility is configured. To study effects of smarter optimisation with without battery and scale ups.
S3	With optimisation and battery	Greenest	
S4	With optimisation with no battery and max power	Greenest	
S5	With optimisation, battery and max power	Greenest	

Table 4-1 shows that details on the measures:
- Green "O" means that the measure is operative, and data from the operation is collected..
- Yellow "S" means that the measure is simulated. The dates for the simulation period are provided.
- Pink "M" means that the effect of the measure is analysed and/or calculated manually

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Table 4-1 Operation/simulation periods for measures

Measure group	Measures	Comment	2021						2022
			Jul	Aug	Sept	Oct	Nov	Dec	Jan
Charging	Private CPs	Installed and used		O	O	O	O	O	O
	Flexible charging	Degree of flexibility is input to simulations.		S 23-29		S 23-29		S 13-19	
Smart energy management	Local RES	Operative		O	O	O	O	O	O
	Local storage	Simulated to study the effect batteries		S 23-29		S 23-29		S 13-19	
	Optimal and coordinated use of energy	Simulated to study the effect of different optimization criteria		S 23-29		S 23-29		S 13-19	
Business aspects	Penalizing priority in ESN	Manual calculations to see the effect of local RES.	M	M	M	M	M	M	
	Rewarding prosumers		O	O	O	O	O	O	
	Rewarding desired consumption pattern	Manual analysis of the effect of optimal and coordinated energy use	M	M	M	M	M	M	

Table 4-2 provides details on the baseline and after situation strategy, with reference to Annex A.2. "B and "A" are baseline and after data.

- Green cells with C indicate that data are collected from the demonstrator
  - B: C is that the baseline situation is established from demonstrator
  - B/A: C is that the baseline and after situation is the same and established from demonstrator data. The data provide a context for calculation.
- Yellow cells with S indicate that baseline and/or after data are generated by simulations.
  - B: -/S is that there is no baseline from the demonstrator, but a baseline is simulated.
  - B: C/S is that one baseline is established from the demonstrator, and another is simulated
  - A: S is that the after situation is simulated
- Pink cells with M indicate that the baseline and after situations are established and analysed manually from collected data.

Table 4-2 Baseline and after data

Datasets collected	Comment	2021						2022
		Jul	Aug	Sept	Oct	Nov	Dec	Jan
Booking of charge point/energy (flexibility, etc.)	Baseline: Simulation S1 (no booking) After: Simulation of S2, S3, S4, S5		B: -/S A: S			B: -/S A: S		B: -/S A: S
Charging sessions			B: C/S A: S	B: C	B: C	B: C/S A: S	B: C	B: C/S A: S
Energy production from local RES	Baseline: From demo and simulation S1 After: Simulation S4		B: C/S A: S	B: C	B: C	B: C/S A: S	B: C	B: C/S A: S
Use of stationary energy storage	Baseline: Simulation S1 After: Simulation of S1b, S2, S3, S4		B: -/S A: S			B: -/S A: S		B: -/S A: S
Energy characteristics	Context: Data from demo		B/A: C	B/A: C	B/A: C	B/A: C	B/A: C	B/A: C
Weather conditions			B/A: C	B/A: C	B/A: C	B/A: C	B/A: C	B/A: C
Economic data	Baseline and after: Manually collected data from demo + manual analysis	M	M	M	M	M	M	

Use of indicators

The indicators are selected from the indicator framework defined in section 2.2.1. Table 4-3 provides an overview of the indicators used and further details on data collection and baseline strategies.

The after findings are simulated for the following indicators: Utilization of CPs, CO2 emissions, Share of green energy, Peak to average ratio, and Self-consumption.

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Table 4-3 Overview of impacts indicators used – Oslo Demo 1 (charging in ESN)

Measure groups	Indicators and sub-indicators	Data collection methods, baseline/after situations, and simulations (when relevant)	Observed groups/areas
Charging	GC 6.1 Awareness level GC 6.2 Acceptance level GC 6.3 Perception level of physical accessibility of service GC 6.4 Operational barriers	• **Data collection method:** Interviews, meetings and questionnaires (see Annex C.1). Tests with App. • **Baseline:** Situation at start of GreenCharge: No charge points in the garage, but some residents owned or used EVs. • **After:** Charge points are installed in the garage.	Residents in housing cooperative Users of CPs Housing cooperative adm.
	Number of EVs: GC 5.1.1 Number of EVs GC 5.1.2 Share of EVs GC 5.1.5 Number of planned EVs	• **Data collection method:** Manually (baseline) and automatically. Interview with housing cooperative board (see Annex C.1) and number of EVs registered in software system. • **Baseline:** No charge points in the garage, but some residents owned or used EVs. • **After:** EVs owned or used.	Residents in housing cooperative
	Number of CPs: GC 5.2.1 Number of CPs GC 5.2.2 Share of CPs GC 5.2.3 Number of private CPs	• **Data collection method:** Manually – counting • **Baseline:** Baseline is 0 (no CPs before GreenCharge) • **After:** Charge points are installed in the garage.	Garage
	Utilization of CPs: GC 5.3.1 Share of connected time GC 5.3.2 Share of charging time GC 5.3.3 Energy per time unit GC 5.3.4 Number of charging sessions	• **Data collection method:** Data from software systems and simulations. See Table 4-2. • **Baseline:** Baseline from collected data – no flexibility and no smart energy management. • **After values:** Simulations with flexibility and smart energy management. See Table 4-2.	Charge points in garage
	Charging flexibility: GC 5.13.1 Offered flexibility GC 5.13.2 Actual flexibility	• **Data collection method:** Data from software systems and simulations. See Table 4-2. • **Baseline:** GC5.13.1: Baseline is 0 – no flexibility. GC5.13.2: Baseline from collected data. • **After values:** Simulations with flexibility and smart energy management. See Table 4-2.	
	CO2 emissions GC 5.12.1 Average CO2 Emission per driven km GC 5.12.3 CO2 emission	• **Data collection method:** Data from open sources and software systems. See Table 4-2. • **Baseline:** 1) The emission from fossil vehicles driving a similar distance. 2) Emissions with EV, no flexibility and no smart energy management – from collected data. • **After values:** GC 5.12.1 Simulations with flexibility and smart energy management. See Table 4-2. GC5 5.12.3:Value from public Co2 calculator	EVs charged in garage
Smart energy	GC 6.1 Awareness level GC 6.2 Acceptance level	• **Data collection method:** Interviews/meetings and questionnaires (see Annex C.1). Tests with use of App facilitating smart energy management. • **Baseline/After:** Input from questionnaires and interviews (see Annex C.1)	Residents in housing cooperative

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.

Measure groups	Indicators and sub-indicators	Data collection methods, baseline/after situations, and simulations (when relevant)	Observed groups/areas
manage-ment	GC 6.4 Operational barriers		Housing cooperative adm.
	Share of green energy: GC 5.9.1 Share of green energy	• **Data collection method:** Data from open sources and software systems. See Table 4-2 • **Baseline:** 1) Public grid 2)From collected data – with PV but no flexibility/smart energy mgmt. • **After values:** Simulations with flexibility and smart energy management. See Table 4-2.	Garage
	Peak to average ratio: GC 5.10.1 Maximum peak power GC 5.10.2 Average power demand	• **Data collection method:** Data from software systems. See Table 4-2. • **Baseline:** Baseline from collected data – no flexibility and no smart energy management. • **After values:** Simulations with battery and smart energy management. See Table 4-2.	Garage
	Self-consumption GC 5.14.1 Energy self-consumption GC 5.14.2 Energy self-sufficiency		
	CO2 emissions GC 5.12.2 Average CO2 emission per kWh used	• **Data collection method:** Data from open sources and software systems. See Table 4-2 • **Baseline:** 1) With energy from grid. 2) No flexibility and no smart energy management. • **After values:** Simulations with flexibility and smart energy management.	EVs charged in garage
Business aspects	GC 6.1 Awareness level	• **Data collection method:** Interviews/meetings and questionnaires (see Annex C.1) • **Baseline/After:** Input from questionnaires, interviews, meetings (see Annex C.1)	Housing cooperative adm. Residents in housing cooperative
	GC 6.2 Acceptance level		
	Average operating cost GC 5.6.4: Average energy costs GC 5.6.6 Service payment to CPO	• **Data collection method:** Electricity bills, price lists/tariffs from external sources (varying energy prices). • **Baseline:** Costs with no PV panels, no smart energy management, no battery • **After:** Costs with PV panels – discussions for battery and smart energy management	Housing cooperative - Infrastructure in garage
	Capital investment cost GC 5.7.1 Capital investment costs	• **Data collection method:** Manually collection of investment costs. • **Baseline strategy:** Baseline is 0. No service before GreenCharge. • **After:** Cost of charging infrastructure, PV panels, battery	Housing cooperative – Infrastructure in garage
	Average operating revenue GC 5.8.1 Revenues from normal operations GC 5.8.2 Revenue from penalties	• **Data collection method:** Automatic data collection from software systems (use of CPs) • **Baseline:** Revenue with no PV panels, no smart energy management, no battery • **After:** Revenue with PV panels – discussions for battery and smart energy management	Housing cooperative

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

4.2 Oslo Demo 2 (advance booking of CPs) impact evaluation approach

Baseline situation

- **Charging:** The situation before GreenCharge cannot be compared with the situation after. Thus, the baseline is 0 or not available.
- **Business aspects:** The baseline is that there are no shared charge points available to the public, and baseline values for the indicators are 0 or not available.

Data collection approach and period covered by the data

The demonstrator is tested in an operational environment but not put into operation, and there is no data from the operation. Research data is however collected regarding the acceptance/expected acceptance and awareness, the number of CPs, and economic issues.

Use if indicators

The indicators are selected from the indicator framework (see 2.2.1). Table 4-4 provides an overview of indicators, data collection and baseline strategies.

Table 4-4 Overview of impacts and indicators used – Oslo Demo 2 (advance booking of CPs)

Measure group	Indicators and sub-indicators	Data collection methods and baseline calculation	Observed groups/areas
Charging	GC 6.1 Awareness level GC 6.2 Acceptance level	• **Data collection method:** Stakeholder involvement. Process evaluation input. • **Baseline strategy:** Baseline is not available.	Housing cooperative adm./ residents Potential users
	Number of CPs: GC 5.2.1 Number of CPs GC 5.2.4 Number of shared CPs	• **Data collection method:** Manually • **Baseline strategy:** Baseline is 0.	Outside garage in housing cooperative
Business aspects	GC 6.1 Awareness level GC 6.2 Acceptance level	• **Data collection method:** Stakeholder involvement. Process evaluation input. • **Baseline strategy:** Baseline is not available.	Housing cooperative administration Potential users
	Capital investment cost GC 5.7.1 Capital investment cost	• **Data collection method:** Manually collection of investment costs. • **Baseline strategy:** Baseline is 0.	Housing cooperative – Shared CPs
	Average operating revenue GC 5.8.1 Revenues from normal operation	• **Data collection method:** Manually based on developed price lists. • **Baseline strategy:** Baseline is 0. • **After value:** From price lists	Housing cooperative
	Average operating cost GC 5.6.4: Average energy costs GC5 .6.6 Service payment to CPO	• **Data collection method:** Manually based on developed price lists. Estimates. • **Baseline strategy:** Baseline is 0. • **After value:** prom price lists	Housing cooperative (i.e. the cost per kWh and not the price the EV user has to pay)

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 Bremen Demo 1 (charging at work) impact evaluation approach

A hybrid approach is used for the evaluation of some measures, as described in section 2.4. The demonstrator is extended through simulations to address the limited availability of research data and to facilitate an investigation of the effects of flexible charging, use of local energy storage, and smart energy management.

The automated data collected from the demonstrator are baseline data and represent a situation with no exploitation of charging flexibility, no local energy storage, and no smart energy management. Simulations allows for the evaluation of the impact due to flexible charging, the integration of additional local energy storage, and smart energy management.

Baseline situation

The baseline strategy varies between the groups:

- **Charging:** The baseline indicators are calculated based on the collected data and will be compared with the after findings from the simulations. The baseline include flexibility recorded in booking data and EV charge sessions, even if EV users have always selected the priority option (charge at full speed).
- **Smart energy management:** The baseline will be simulated using collected data about PV production, no batteries and *earliest* criteria for charging sessions. In the simulated baseline, there will be neither flexibility usage nor battery installation neither in CS#5 (P2D1L3) nor in CS#3 (P3D1L1).

Operation period: All measures, except for the local storage, are operative, but all measures are not used (e.g. the flexible charging). Data about charging sessions have been collected since 11/2020 as test files, but they are available as research data from July 2021 to December 2021. Based on the research data assessment in section 6.3, **the evaluation period is set to September 2021 till December 2021.**

Data collection and period covered by the data

Research data manually collected: Data are collected manually through meetings and talks with the stakeholders.

Research data from demonstrators meant for automated processing: Annex A.2 provides an overview of the data collection.

Simulations are used to extend the demonstrator. Different optimization criteria are used. Earliest is without additional optimisation (just the simple load balancing that is state of the art). Greenest means that the optimizer finds the greenest alternative.

Simulation scenarios extending demonstrator		Optimization criteria	Comment
S1	With no optimisation and no battery	earliest	Simulation baseline
S1b	With no optimisation and battery	earliest	To study the effect of the battery
S2	With optimisation and no battery	greenest	Flexibility is configured. To study effects of smarter optimisation with without battery and scale ups.
S3	With optimisation and battery	greenest	
S4	With optimisation and scaled PV and battery	Greenest	
S5	With optimisation andV2G (no battery)	greenest	

Table 4-5 provides further details on the operation of the measures that are evaluated.

- Data are collected from three locations: L1 and L3.
- Green "OLn" means that data is collected form an operative measure at Location Ln.
- Yellow "S" means that the measure is simulated.

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Table 4-5 Operation/simulation periods for measures

	Measures	Comment	2021			
			Sept	Oct	Nov	Dec
Charging	Private CPs		O: L1 O: L3	O: L1 O: L3	O: L1 O: L3	O: L1 O: L3
	Flexible charging	Simulations will use the degree of flexibility as input to the optimisation.	S 5-12			
Smart energy management	Local RES	Simulations are used to study the effect of PV and PV scale ups	S 5-12			
	Local storage	Simulations are used to study the effect batteries	S 5-12			
	Optimal and coordinated use of energy	Simulations are used to study the effect of different optimization criteria	S 5-12			
	V2G	Simulation: V2G will be used to avoid or to reduce the battery size	S 5-12			

Table 4-6 provides details on the data collection, with reference to Annex A.2. "B and "A" are baseline and after data collection. "C" or " S" indicate whether data are collected or generated by simulations. For data just providing a context, the baseline and the after data are the same (B/A). Green indicates that alle data are collected. Yellow lines with S indicate that baseline and/or after data are generated by simulations.

Table 4-6 Baseline and after data collection

Datasets collected	Comment	2021			
		Sept	Oct	Nov	Dec
Booking of charge point/energy (flexibility, etc.)	Baseline is simulated using collected data on charging session, PV production, no batteries and earliest criteria for charging sessions. Simulation will generate after data on • Flexibility variations improving the results of the optimization strategy • PV scale ups producing the energy required to satisfy the charge demand. • Use of stationary battery • Local EMS uses a greenest optimization strategy • V2G will be used to avoid or to reduce the battery size	B:C/S A: S	B: C	B: C	B: C
Charging sessions		B:C/S A: S	B: C	B: C	B: C
Energy production from local RES		B:C/S A: S	B: C	B: C	B: C
Use of stationary energy storage		B: - A: S			
Energy characteristics	Context: Energy import/export and grid mix.	B/A: C	B/A: C	B/A: C	B/A: C

Use of indicators

The indicators are selected from the indicator framework defined in section 2.2.1. Table 4-7 provides an overview of the indicators used and related details on data collection and baseline strategies.

In demonstration, the Local EMS was not able to use the batteries installed in CS#3 (P1D1L1) and also the flexibility was not used as planned, because also not eligible used charged at full power. For this reason, the values of indicators computed in demonstration represent a baseline for the single charge stations, such as charge flexibility, utilization of charge points and self-consumption.

The simulation of the same scenario, using the *earliest* optimization strategy by the Eurecat optimizer, allow us to compute KPIs values for the joint Charge Stations CS#3 (P2D1L1) and CS#5 (P2D1L3)

This scenario will be used as a baseline to be compared with variation applied in simulation, which will provide the after values for the following indicators: Utilization of CPs, Charging availability, Charging flexibility, CO2 emissions (per vehicle km), Share of green energy, Peak to average ratio, Self-consumption, CO2 emissions (per kWh used), and Capital investment cost.

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

Table 4-7 Overview of impacts and indicators used – Bremen Demo 1 (Charging at work)

Measure groups	Indicators and sub-indicators	Data collection methods and baseline calculation	Observed groups/areas
Charging	GC 6.1 Awareness level GC 6.2 Acceptance level GC 6.4 Operational barriers	• **Data collection method:** Questionnaire. Data inspections showing use of service. • **Baseline:** GC 6.1/6.2: No/Low GC6.4: Not available	Employees EV users
	Number of EVs: GC 5.1.1 Number of EVs **Number of CPs:** GC 5.2.1 Number of CPs	• **Data collection method:** Automatic data collection from software systems • **Baseline:** 0 (this is a technology demonstrator. The number is due to decisions on EV involvements/CP establishments in the project and not due to impact). • **After:** Number at end of demo.	EVs accessing Shared CPs Shared CPs
	Utilization of CPs: GC 5.3.1 Share of connected time GC 5.3.2 Share of charging time GC 5.3.3 Energy per time unit GC 5.3.4 Number of charging sessions	• **Data collection method: D**ata from software systems and simulations. See Table 4-6 • **Baseline:** Baseline from collected data – no flexibility and no smart energy management. • **After values:** Simulations with flexibility and smart energy management. See Table 4-6	Shared CPs
	Charging availability: GC 5.5.1 Energy availability GC 5.5.2 Demand fulfilment		Shared CPs
	Charging flexibility: GC 5.13.1 Offered flexibility GC 5.13.2 Actual flexibility		Shared CPs
	CO2 emissions GC 5.12.1 Average CO2 emission per km driven	• **Data collection method: D**ata from software systems and simulations. See Table 4-6 • **Baseline:** 1) The emission from fossil vehicles driving a similar distance. 2) Emissions with no flexibility and no smart energy management – from collected data. • **After values:** Simulations with flexibility and smart energy management. See Table 4-6	EVs charged in Shared CPs
Smart energy management	**Share of green energy:** GC 5.9.1 Share of green energy	• **Data collection method:** Public data. **D**ata from software systems and simulations. See Table 4-6 • **Baseline:** 1) Public grid 2)From collected data – with PV but no flexibility/smart energy mgmt. • **After values:** Simulations with flexibility and smart energy management	Shared CPs
	Peak to average ratio: GC 5.10.1 Maximum peak power GC 5.10.2 Average power demand	• **Data collection method: D**ata from software systems and simulations. See Table 4-6 • **Baseline strategy:** Baseline from collected data – no flexibility and no smart energy management. • **After values:** Simulations with battery and smart energy management. See Table 4-6	Shared CPs
	Self-consumption: GC 5.14.1 Energy self-consumption GC 5.14.2 Energy self-sufficiency		Neighbourhood

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.

Measure groups	Indicators and sub-indicators	Data collection methods and baseline calculation	Observed groups/areas
	CO2 emissions GC 5.12.2 Average CO2 emission per kWh used	• **Data collection method:** Data from open sources and software systems. See Table 4-6 • **Baseline:** 1) With energy from grid. 2) No flexibility and no smart energy management. • **After values:** Simulations with flexibility and smart energy management.	Shared CPs
Business aspects	**Capital investment cost** GC 5.7.1 Capital investment cost	• **Data collection method:** Manually collection of investment costs. • **Baseline strategy:** Baseline is 0. No service before GreenCharge.	Shared CPs

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

4.4 Bremen Demo 2 (EV sharing) impact evaluation approach

Baseline situation: The baseline strategy varies between the groups:

- **EV Fleet:** The baseline is the situation before the start of GreenCharge. There were no shared EVs available at the locations involved.
- **Charging:** For most indicators, the baseline is 0 as there was no EV fleet available to the residents in the housing cooperative.
- **Business aspects:** There is no baseline available, or the baseline is 0.

Data collection and period covered by the data

- **Research data from surveys:** The data are collected manually through counting, work on price models, and questionnaire targeting residents.
- **Research data from fleet management system: Data on km driven and EV operations.**
- **Operation period:** June 2020 – December 2021

Use of indicators

Table 4-8 provides and overview of the indicators used and the related research data collection methods, the baseline strategies, and the observed groups/areas.

Table 4-8 Overview of impacts and indicators used – Bremen Demo 2 (EV sharing)

Measure groups	Indicators and sub-indicators	Data collection methods and baseline calculation	Observed groups/areas
EV fleet	GC 6.1 Awareness level (M) GC 6.2 Acceptance level (M) GC 6.4 Operational barriers (M)	• **Data collection method:** Survey • **Baseline: GC 6.1/6.2:** Low. GC 6.4: NA	Housing cooperative Users of service City
Charging	**Number of EVs:** GC 5.1.2 Share of EVs GC 5.1.3 Number of specific EVs	• **Data collection method:** Manually collected from Fleet operator/residents • **Baseline:** Baseline is 0	Shared EVs offered to residents
	Number of CPs: GC 5.2.1 Number of CPs GC 5.2.2 Share of CPs		Vicinity of housing location
	CO2 emissions GC 5.12.3 CO2 emission	• **Data collection method:** Driven km from fleet management system. • **Baseline:** The emission from fossil vehicles driving the same distance. • **After:** Use of emission factors/calculator.	EVs in fleet
Business aspects	GC 6.1 Awareness level (M) GC 6.2 Acceptance level (M)	• **Data collection method:** Survey • **Baseline:** No/ low	Residents in housing cooperative
	Average operating cost GC 5.6.1 Total average operating costs GC 5.6.4 Average energy cost	• **Data collection method:** Manual data collection from Fleet operators. • **Baseline:** 0	Fleet operator

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

Measure groups	Indicators and sub-indicators	Data collection methods and baseline calculation	Observed groups/areas
	Average operating revenue GC 5.8.1 Revenues from normal operations	• **Data collection method:** Manual data collection from Fleet operators. • **Baseline:** 0	Fleet operator

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

4.5 Barcelona Demo 1 (eScooters battery swapping) impact evaluation approach

Baseline situation and after situation

The baseline strategy varies between the groups:

- **EV Fleet:** The baseline is the situation just before the evaluation period
- **Charging:** The baseline is the situation without smart charging: the batteries are charged as soon as they are plugged in the battery hub
- **Smart energy management:** The aim is to investigate the effects of smart energy management if the charging strategy were smart and there was local RES. Thus, the baseline situation is with no local RES, all energy coming from the grid and the batteries are charged as soon as they are plugged in.
- **Business aspects:** The baseline is the situation before the implementation of the measure (smart charging and eco driving).

Data collection and period covered by the data

There are two approaches for data collection:

- **Research data from surveys:** The data are collected manually through interviews (see Annex C.4).
- **Research from demonstrators used in automated indicator calculations:** Annex A.2 provides an overview of the data collection and an assessment of the data. The data quality is considered good for the period August 2021 till September 2021.

Use of indicators

The indicators are selected from the indicator framework defined in section 2.2.1. Table 4-9 provides and overview of the indicators used to evaluate the impact and the related research data collection methods, the baseline strategies, and the observed groups/areas.

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

Table 4-9 Overview of impacts and indicators used – Barcelona Demo 1 (eScooter battery swapping)

Measures groups	Indicators and sub-indicators	Data collection methods and baseline calculation	Observed groups/areas
EV Fleet	GC 6.1 Awareness level (M) GC 6.2 Acceptance level (M)	• **Data collection method:** Surveys • **Baseline strategy:** Based on answers from survey	Users of the EV sharing service
	GC 6.3 Perception level of physical accessibility of service (M)	• **Data collection method:** Comments from users through service support call centre • **Baseline strategy:** Based on answers from survey	Users of the EV sharing service
	GC 6.4 Operational barriers (M)	• **Data collection method:** Survey • **Baseline strategy:** Not existing before the launching the service	Users of the EV sharing service
Charging	GC 6.1 Awareness level (M)	• **Data collection method:** Interview fleet operator • **Baseline strategy:** Results obtained from the first interview: partially aware	Fleet operator
	GC 6.2 Acceptance level (M)	• **Data collection method:** Interview fleet operator • **Baseline strategy:** Acceptance level very low	Fleet operator
	GC 6.3 Perception level of physical accessibility of service (M)	• **Data collection method:** Interview fleet operator • **Baseline strategy:** Based on reaction: difficult	Fleet operator
	GC 6.4 Operational barriers (M)	• **Data collection method:** Interview fleet operator • **Baseline strategy:** Based on reaction: high	Fleet operator
	Number of EVs (GC.5.1) GC.5.1.1 Number of EVs (M) GC.5.1.4 Number of planned EVs(M)	• **Data collection method:** Manually collected from Fleet operator • **Baseline strategy:** Number at the beginning of the monitoring period	Fleets involved in the trials
	Utilization of CPs (GC 5.3) GC.5.3.1 Share of connected time (A) GC.5.3.2 Share of charging time(A) GC.5.3.3 Energy per time unit(A) GC.5.3.4 Number of charging sessions(A)	• **Data collection method**: Automatic and simulation • **Baseline strategy**: Based on data collected before smart charging	Charging premises for the EV fleet
	Charging Flexibility (GC 5.13) GC.5.13.2 Actual flexibility (A)	• **Data collection method**: Simulation • **Baseline strategy**: Flexibility is 0 before the measure	Charging premises for the EV fleet
	CO2 Emissions (GC 5.12) GC 5.12.1 Average CO2 emission per vehicle km (A) GC 5.12.2 Average CO2 emission per kWh used (A)	• **Data collection method**: Automatic data collection for km driven and energy used per km, and simulation to obtained share of green energy with smart charging strategy • **Baseline strategy**: Values obtained in the demo (no smart charging)	Charging premises for the EV fleet
Smart energy	GC 6.1 Awareness level	• **Data collection method:** Interview fleet operator • **Baseline strategy:** Results obtained from the first interview: partially aware	Fleet operator
	GC 6.2 Acceptance level (M)	• **Data collection method:** Interview fleet operator	Fleet operator

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manageme nt		• **Baseline strategy:** Acceptance level very low	
	GC 5.10 Peak to average ratio (A)	• **Data collection method:** Automatic data collection for situation with no smart energy management • **Baseline strategy:** Values obtained for actual situation	Charging premises for the EV fleet
	Self-consumption (GC 5.14) GC 5.14.1 Energy self-consumption (A) GC 5.14.2 Energy self-sufficiency (A)	• **Data collection method:** Automatic data collection for situation with no smart energy management or local RES installed and additional data extracted from simulation for different scenarios • **Baseline strategy:** Baseline value is 0	Charging premises for the EV fleet
	Share of green energy (GC 5.9) GC 5.9.1 Share of green energy (A)	• **Data collection method:** Automatic data collection for situation with no smart energy management or local RES installed and additional data extracted from simulation for different scenarios • **Baseline strategy:** Baseline value is share of green energy from the national grid	Charging premises for the EV fleet
	CO2 Emissions (GC 5.12) GC 5.12.1 Average CO2 emission per vehicle km (A) GC 5.12.2 Average CO2 emission per kWh used (A)	• **Data collection method**: Automatic data collection for km driven and energy used per km, and simulation to obtained share of green energy with smart energy management and simulated local RES • **Baseline strategy**: Values obtained without smart energy management	Charging premises for the EV fleet
Business aspects	GC 6.1 Awareness level (M)	• **Data collection method:** Surveys • **Baseline strategy:** Based on answers from survey, basically awareness is 0 (it didn't exist before)	Users of the EV sharing service Fleet operator
	GC 6.2 Acceptance level (M)	• **Data collection method:** Surveys and usage • **Baseline strategy:** Willingness to adopt this type of measure	Users of the EV sharing service Fleet operator
	GC 6.5 Relative cost of the service (M)	• **Data collection method:** Manual data collection; comparison of cost of incentives versus reduction of operational costs • **Baseline strategy:** Cost (per km) with no incentives applied	Fleet operator
	Average operating costs (GC 5.6) GC 5.6.1 Total average operating costs (M) GC 5.6.4 Average energy costs (A) GC 5.6.5 Maintenance costs (M)	• **Data collection method:** Manual data collection, automatic data collection for energy cost and simulated data collection for different scenario for average energy costs and maintenance costs • **Baseline strategy:** Cost before the measure is applied	Fleet operator
	Capital investment cost (GC 5.7) GC 5.7.1 Charge investment costs (M) GC 5.7.2 Preparation and design costs (M)	• **Data collection method:** Manual and based on estimations (for potential equipment to be deployed) • **Baseline strategy:** Actual cost is 0	Fleet operator
	Average operating revenue (GC 5.8) GC 5.8.1 Revenue from normal operation (M)	• **Data collection method:** Manual data collection for actual costs and translation to the simulated scenarios. • **Baseline strategy:** Income (per km) with no incentives or smart energy management applied	Fleet operator

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

4.6 Barcelona Demo 2 (charging in ESN at work) impact evaluation approach

Baseline situation

The baseline strategy varies between the groups:

- **Charging:** Prior to GreenCharge, although some charging point existed, there was not monitoring system to know what the usage was. To get more insights, some of the indicators use as baseline the situation where there is not smart charging, and the vehicle is charged as it arrives.
- **Smart energy management:** The aim is to investigate the effects of smart energy management combining the charging of EVs and the predictability provided by the booking system, the rest of the building energy demand and the production of local PV panels (existing ones and simulated ones). Thus, the baseline situation is no control and predictability in the charging sessions, no control on the HVAC system and limited local production.
- **Business aspects:** There are no specific business aspects defined for this demo since no payment is involved, but analysis in terms of energy savings with smart energy management when scale-up will be analysed through simulated scenarios.

Data collection and period covered by the data

There are two approaches for data collection:

- **Research data from surveys:** The data are collected manually through a survey (see Annex C.4).
- **Research from demonstrators used in automated indicator calculations:** Annex A.2 provides an overview of the data collection and an assessment of the data.
- **Evaluation period:** The data quality is considered good for the period September 2021 till October 2021.

Use of indicators

The indicators are selected from the indicator framework defined in section 2.2.1. Table 4-10 provides and overview of the indicators used to evaluate the impact and the related research data collection methods, the baseline strategies, and the observed groups/areas.

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

Table 4-10 Overview of impacts and indicators used – Barcelona Demo 2 (Charging in ESN at work)

Measures groups	Indicators and sub-indicators	Data collection methods and baseline calculation	Observed groups/areas
Charging	GC 6.1 Awareness level (M)	• **Data collection method:** Survey for all employees, interviews for EV charging users, facility managers and human resources manager • **Baseline strategy:** Baseline is 0; it did not exist before	Eurecat employees Facility managers at Eurecat premises Human resources manager
	GC 6.2 Acceptance level (M)	• **Data collection method:** Survey for all employees, interviews for CP users, facility managers and human resources manager • **Baseline strategy:** Based on results from an initial survey and interviews	Eurecat employees Facility managers at Eurecat premises Human resources manager
	GC 6.3 Perception level of physical accessibility of service (M)	• **Data collection method:** Questionnaire for CP users • **Baseline strategy:** Baseline is 0; it did not exist before	CP users
	GC 6.4 Operational barriers (M)	• **Data collection method:** Questionnaire for CP users • **Baseline strategy:** Baseline is 0; it did not exist before	CP users Facility managers at Eurecat premises
	Number of EVs (GC.5.1) GC.5.1.1 Number of EVs (M) GC 5.1.2 Share of EVs (M) GC.5.1.4 Number of planned EVs (M)	• **Data collection method:** Survey for all employees • **Baseline strategy:** Based on results from an initial survey	Eurecat employees
	Number of CPs (GC.5.2) GC 5.2.1. Number of CPs (M) GC 5.2.4. Number of shared CPs (M)	• **Data collection method:** Manual counting • **Baseline strategy:** Operational charging points before GreenCharge	Eurecat proprietary premises
	Utilization of CPs (GC 5.3) GC.3.1 Share of connected time (A) GC.3.2 Share of charging time(A) GC.3.3 Energy per time unit(A) GC.3.4 Number of charging sessions(A)	• **Data collection method**: Automatic and simulation • **Baseline strategy**: Based on data collected without smart charging	Eurecat premises (Manresa and Cerdanyola)
	Charging Flexibility (GC 5.13) GC 5.13.2 Actual flexibility (A)	• **Data collection method**: Automatic and simulation (V2G) • **Baseline strategy**: Non existing before GreenCharge	Eurecat premises (Manresa and Cerdanyola)
	CO2 Emissions (GC 5.12) GC 5.12.2 Average CO2 emission per kWh used (A)	• **Data collection method**: Automatic data collection for kWh energy used • **Baseline strategy**: Values obtained without smart charging	CP users
Smart energy	GC 6.1 Awareness level (M)	• **Data collection method:** Survey for all employees, interviews for EV charging users, facility managers • **Baseline strategy:** Baseline is 0; it didn't exist before	Eurecat employees Facility managers at Eurecat premises

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manageme nt	GC 6.2 Acceptance level (M)	• **Data collection method:** Survey for all employees, interviews for CP users, facility managers • **Baseline strategy:** Based on results from an initial survey and interviews	Eurecat employees Facility managers at Eurecat premises
	GC 6.4 Operational barriers (M)	• **Data collection method:** Questionnaire for CP users and facility managers • **Baseline strategy:** Baseline is 0; it didn't exist before	CP users Facility managers at Eurecat premises
	Peak to average ratio (GC 5.10) GC 5.10.1 Maximum peak power (A) GC 5.10.2 Average power demand (A)	• **Data collection method:** Automatic data collection and simulation for scaling • **Baseline strategy:** Values obtained for situation without GreenCharge	Eurecat premises (Manresa)
	Self-consumption (GC 5.14) GC 5.14.1 Energy self-consumption (A) GC 5.14.2 Energy self-sufficiency (A)	• **Data collection method:** Automatic data collection for situation with no smart energy management and local RES installed and additional data extracted from simulation for different scenarios • **Baseline strategy:** Data available before GreenCharge	Eurecat premises (Manresa and Cerdanyola -S)
	Share of green energy (GC 5.9) GC 5.9.1 Share of green energy (A)	• **Data collection method:** Automatic data collection and additional data extracted from simulation for different scenarios • **Baseline strategy:** Baseline value is share of green energy before GreenCharge	Eurecat premises (Manresa and Cerdanyola -S)
	Share of battery capacity for V2G (GC 5.4) GC 5.4.1 Average amount of energy GC 5.4.2 Share of battery capacity	• **Data collection method: S**imulation for different scenarios • **Baseline strategy:** Baseline is 0	Simulations based on Eurecat premises (Manresa and Cerdanyola)
	CO2 Emissions (GC 5.12) GC 5.12.2 Average CO2 emission per kWh used (A)	• **Data collection method**: Automatic data collection for kWh energy used • **Baseline strategy**: Values obtained before smart energy management	Eurecat premises (Manresa and Cerdanyola -S)

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4.7 Barcelona Demo 3 (eBike sharing) impact evaluation approach

Baseline situation

The baseline strategy varies between the groups:

- **EV Fleet**: Prior to GreenCharge the fleet was managed in a very manual way. Users were assigned to use the bike for a period of time and there was not any kind of logging to know the usage of the bikes (if used at all) or the region of movement (some could leave the town and it was impossible to know). No information on energy or km made is available. Thus, the base line data has to be extracted from surveys, considered to be 0 o extracted from initial usage of the bikes ones the ICT devices had been installed.
- **Charging**: Prior to GreenCharge, although some charging point existed, there was not monitoring system to know what the usage was. Energy meter (from DSO) aggregates the energy consumed in the charging points and the energy of the train station. It has monthly granularity and is difficult to disaggregate consumptions. To get more insights, some of the indicators use as baseline the situation where there is not smart charging, and the bikes are charged as they arrive.
- **Smart energy management**: The aim is to investigate the effects of smart energy management combining the charging of e-bikes with local RES and storage in a stationary battery to increase energy self-sufficiently and reduce carbon footprint. Before GreenCharge, no PV panels or stationary battery were present, and the charging of the e-bikes occurred as soon as they were plugged in. Thus, the baseline situation is no control and emissions were assumed to be the ones derived from the grid mix.
- **Business aspects:** There is no actual payment involved, but some business cases are analysed based on capital investment, maintenance and operational costs and willingness to pay by users deduced from surveys.

Data collection and period covered by the data

There are two approaches for data collection:

- **Research data from surveys:** The data are collected manually through a survey (see Annex C.4).
- **Research from demonstrators used in automated indicator calculations:** Annex A.2 provides an overview of the data collection and an assessment of the data.
- **Evaluation period:** The data quality is considered good for the period August 2021 till September 2021.

Use of indicators

The indicators are selected from the indicator framework defined in section 2.2.1. Table 4-11 provides and overview of the indicators used to evaluate the impact and the related research data collection methods, the baseline strategies, and the observed groups/areas.

For most indicators, there is no baseline available as the situation before GreenCharge cannot be compared with the situation established by GreenCharge.

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Table 4-11 Overview of impacts and indicators used – Barcelona Demo 3 (eBike sharing)

Measures groups	Indicators and sub-indicators	Data collection methods and baseline calculation	Observed groups/areas
EV Fleet	GC 6.1 Awareness level (M)	• **Data collection method:** Surveys • **Baseline strategy:** Based on answers initial from survey	Users of the EV sharing service
	GC 6.2 Acceptance level (M)	• **Data collection method:** Surveys • **Baseline strategy:** Based on answers initial from survey	Users of the EV sharing service
	GC 6.3 Perception level of physical accessibility of service (M)	• **Data collection method:** Surveys • **Baseline strategy:** Based on answers from survey and feedback from townhall	Users of the EV sharing service Townhall
	GC 6.4 Operational barriers (M)	• **Data collection method:** Survey • **Baseline strategy:** Based on interview with townhall	Users of the EV sharing service Townhall
Charging	**Number of EVs** (GC 5.1) GC 5.1.1 Number of EVs (M) GC 5.1.4 Number of planned EVs (M)	• **Data collection method:** Manual • **Baseline strategy GC5.1.1:** Number of EVs in the fleet before GreenCharge • **Baseline strategy GC5.1.3:** Number of planned EVs according to townhall roadmap at the beginning of the project	Bike station
	GC 5.2.1 Number of CPs (M)	• **Data collection method:** Manual • **Baseline strategy:** Number of EVs in the fleet before GreenCharge	Bike station
	Utilization of CPs (GC 5.3) GC.3.1 Share of connected time (A) GC.3.2 Share of charging time(A) GC.3.3 Energy per time unit(A) GC.3.4 Number of charging sessions(A)	• **Data collection method**: Automatic • **Baseline strategy**: Data obtained in the first week of operation	Bike station
	CO2 Emissions (GC 5.12) GC 5.12.1 Average CO2 emission per vehicle km (A) GC 5.12.2 Average CO2 emission per kWh used (A)	• **Data collection method**: Automatic data collection for km driven and energy used per km, and simulation to obtained share of green energy with smart charging strategy • **Baseline strategy**: Values obtained before smart charging with share of green energy coming from the grid Hypothesis: the EV user does not charge outside the bike station	EV fleet and bike station
Smart energy manageme nt	GC 6.1 Awareness level (M)	• **Data collection method:** Surveys and Interviews fleet operator • **Baseline strategy:** Results obtained from the first survey and interviews when asking knowledge on energy management	EV users Townhall Bike station owner
	GC 6.2 Acceptance level (M)	• **Data collection method:** Surveys and Interviews • **Baseline strategy:** Not known for users	EV users Townhall

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			Bike station owner
	GC 6.4 Operational barriers (M)	• **Data collection method:** Questionnaire to bike station operator • **Baseline strategy:** Baseline is 0; it didn't exist before	Bike station owner Enchufing Eurecat
	Peak to average ratio (GC 5.10) GC 5.10.1 Maximum peak power (A) GC 5.10.2 Average power demand (A)	• **Data collection method:** Automatic data collection • **Baseline strategy:** Values obtained for situation without GreenCharge	Bike station
	Self-consumption (GC 5.14) GC 5.14.1 Energy self-consumption (A+S) GC 5.14.2 Energy self-sufficiency (A+S)	• **Data collection method:** Automatic data collection and simulation for different scenarios • **Baseline strategy:** Baseline value is 0	Bike station
	Share of green energy (GC 5.9) GC 5.9.1 Share of green energy (A)	• **Data collection method:** Automatic data collection and additional data extracted from simulation for different scenarios • **Baseline strategy:** Baseline value is share of green energy before GreenCharge	Bike station
	CO2 Emissions (GC 5.12) GC 5.12.1 Average CO2 emission per vehicle km (A+S) GC 5.12.2 Average CO2 emission per kWh used (A+S)	• **Data collection method**: Automatic data collection for km driven and energy used per km, and simulation to obtained share of green energy with smart energy management and simulated local RES • **Baseline strategy**: Values obtained before smart energy management	Bike station
Business aspects	GC 6.5 Relative cost of the service (M)	• **Data collection method:** Manual data collection. • **Baseline strategy:** Cost (per km)	Technology providers (Enchufing, Atlantis, Eurecat)
	Average operating costs (GC 5.6) GC 5.6.1 Total average operating costs (M) GC 5.6.4 Average energy costs (A) GC 5.6.5 Maintenance costs (M)	• **Data collection method:** Manual data collection, automatic data collection for energy cost and simulated data collection for different scenario for average energy costs and maintenance costs • **Baseline strategy:** Cost before the measure is applied	Technology providers (Enchufing, Atlantis, Eurecat)
	Capital investment cost (GC 5.7) GC 5.7.1 Charge investment costs (M+S) GC 5.7.2 Preparation and design costs (S)	• **Data collection method:** Manual and based on estimations (for potential equipment to be deployed) • **Baseline strategy:** Actual cost is 0	Technology providers (Enchufing, Atlantis, Eurecat) Townhall Bike station owner
	Average operating revenue (GC 5.8) GC 5.8.1 Revenue from normal operation (S)	• **Data collection method:** Manual data collection for actual costs and translation to the simulated scenarios. • **Baseline strategy:** 0	Technology providers (Enchufing, Atlantis, Eurecat)

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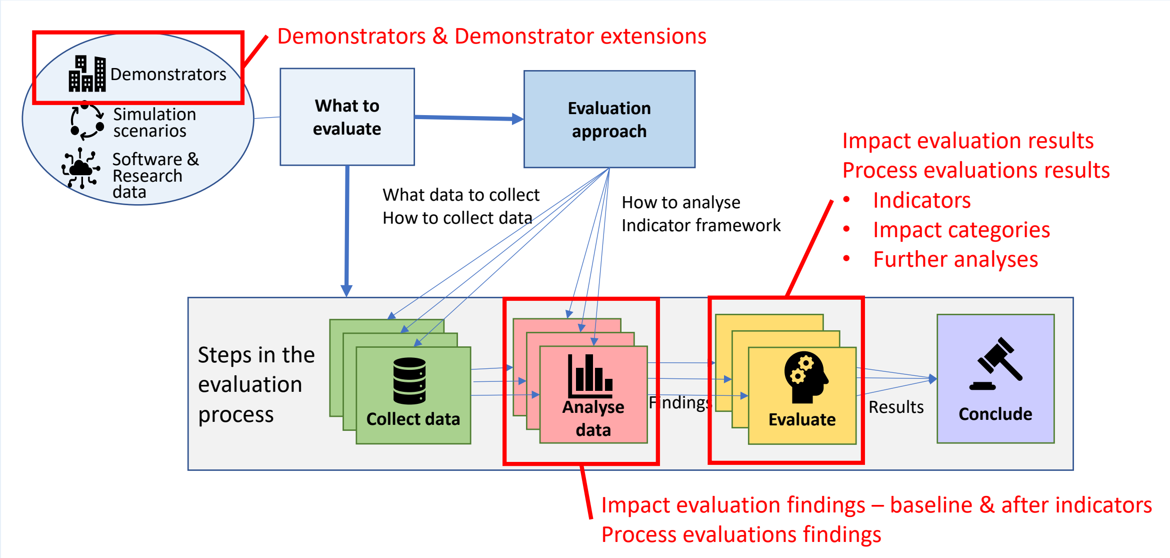
5 Evaluation results from demonstrators



This chapter provides, for each demonstrator:

- An assessment of the fulfilment of the objectives and expected outputs defined in Chapter 3.
- Findings and results from the process evaluation, established as described in section 2.3.
- Findings and results from the impact evaluation, using the indicator framework defined in section 2.2.1.

The process evaluations provide knowledge that can support re-implementations of the measures demonstrated and may also address issues that can affect impact evaluation findings.

The impact evaluations provide knowledge on the impact of smart and green charging. For Oslo Demo 1 and Bremen Demo 2, simulations extend the demonstrators (see section 2.4).

The conclusions from the evaluations as a whole, across all demonstrators and demonstrator extensions, are provided in Chapter 7.

Note: Different optimization criteria are used.
For the simulations, two optimization criteria are tested:

- **Earliest:** This is that charging is done as early as possible with the energy available. This is state of the art today, and these simulations are used as a baseline for comparison with the greenest optimization criteria.
- **Greenest:** This is that charging is done with as much green energy as possible. When the maximum power is reached, the power peaks are decreased. Thus, this optimisation criteria may also affect the power peaks.

In addition to the above, other approaches are implemented in the demonstrators:

- **Lowest peak:** This is relevant when the capacity of the grid is limited and/or when the energy fees depend on the peal power levels.
- **Lowest cost:** This is relevant when the energy process varies over time.

For the demonstrators, the following optimization criteria are implemented:

- Oslo Demo 1: A combination of lowest peak and lowest cost (did not become operative)
- Bremen Demo 1: Earliest

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- Bremen Demo 1: Earliest
- Barcelona Demo 2: A combination of lowest cost and greenest energy (did not become operative)
- Barcelona Demo 3: Maximization of consumption of energy locally produced (equivalent to reduce energy imported from the grid) (did not become operative)

5.1 Oslo Demo 1 (charging in ESN) evaluation

This section summarises the findings and results from the evaluation of the Oslo D1 demonstrator.

All measures described in section 3.1.2 are implemented, they are tested in the garage, and they work. Most measures have also been operational for 6 months or more. For some measure, problems are however experienced (see details in the process evaluation input in Annex E.1), and they are not put into operation. This is the case for the following measures:

- **Local storage:** The battery seemingly worked for a period spring 2021. Inspections of the research data do however indicate that something was wrong, and in June 2021, the battery stopped working. After a long period with testing, hardware errors were detected. They could not be fixed in time.
- **Flexible charging and Priority charging:** The App providing input on flexibility and priority was not operational until February 2022. Thus, the functionality could not be operational, and related research data could not be collected.
- **Optimal and coordinated use of energy:** This measure depends on flexibility and cold due to this could not be operational.

To cope with the above, extensions of the demonstrator are simulated, as described in Chapter 4.

5.1.1 Fulfilment of objectives and expected outputs

Note: Due to the relatively small scale of the demonstrator, the demonstrator objectives are not overall, generic, and quantitative (as stated in Chapter 3). Thus, the assessments of the fulfilment of the objectives are mainly about learning effects. The objectives are fulfilled if there are findings of evaluation results that facilitate learning.

The tables below provide a compact overview of the fulfilment of the demonstrator objectives and expected output related to the expectations defined in section 0. Colour codes indicates the fulfilment (green = fulfilled, yellow = partly fulfilled, red = not fulfilled).

In general, most objectives were fulfilled, as described by the table below. Note that many objectives are about learning and not quantitative goals.

Measure group	Overall objectives	Detailed objectives	Fulfilment/Answer
Charging	Replace fossil mobility by eMobility	Provide private CPs to all residents in housing cooperative that want one	All were invited to get a CP.
		Increased the number of EVs (owned or leased) among the residents by at least 100 %	> 100%
		Increase number of CPs to cover at least 25 % of the parking spaces	The number was increased by 26%
		Reduce CO2 emissions by at least 10 %	The emission per km driven reduced. (See GC.5.12 CO2 Emission)
	Learn about the use of CPs	How long are the EVs connected?	The EVs were in average connected only 20% of the time, and during much of this time they are charging. This charging behaviour is not
		How much of the connected time is used for charging?	
		How much energy is on average charge per connected time unit?	

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.

Measure group	Overall objectives	Detailed objectives	Fulfilment/Answer
			advantageous with respect to flexibility and future V2G implementations. The EVs received on average charge 0.82 KW per hour. (See GC 5.3 Utilisation of CPs)
	Learn about the charging flexibility of the EV users	How much flexibility are EV users willing to provide? What is the effect of economic incentives?	Due to the delay of the App, we cannot answer these questions. The offered flexibility does however provide some indications. The EVs are not charged very often, and they are not connected for long periods. Thus, the flexibility is lower than expected.
		What is the actual flexibility that the system could have utilised?	The actual flexibility (based on plug-in and plug-out times) is surprisingly low (< 50%) due to the charging behaviour (low share of connected time, charging of much energy when connected). The flexibility must be increased to get a maximum effect of the smart energy management (see GC 5.13 Charging flexibility)
Smart energy manage ment	Learn about the effects of the measures	How much is the peak level reduced?	The PV panels, local storage and optimal use of energy has positive effects, especially when a max power threshold is reached. The peaks are reduced, and the self-consumption is increased, especially when a stationary battery is used (see GC 5.10 Peak to average ratio, GC 5.14 Self-consumption, GC 5.9 Share of green energy, GC 5.12 CO2)
		What is the self-consumption achieved with the current solar plant and stationary battery?	
		What are the effects on the Share of green energy	
		What is the effect on CO2 emissions?	
Business aspects	Learn about the effect of the business aspect measures	What is the effect on the charging behaviour (e.g., flexibility and use of priority)?	Due to the delay of the App, we could not test the economic incentives on real users.
		What are the economic benefits for the housing cooperative?	The goal has not been to earn money on the charging of the residents' EVs. The PV panels reduces the costs int three ways: 1) access to "free" energy; 2) and reduction of peak loads; and 3) revenue from export. The first two are most important. The income can be adjusted by means of the price model (see GC 5.8 Average operating revenue)

All expected outcomes were fulfilled, as described by the table below.

Measure Group	Expected output	Fulfilment
Charging	• New charge points in the garage makes charging easy and predictable for residents. • Flexible charging arranges for smart energy management. • Increased share of electric vehicles, and thus a reduction of CO2 emissions	Yes to all
Smart energy management	• The distribution of available energy is fair and adapted to individual needs. • Load balancing reduces the peaks and makes it possible to charge more electric vehicles Smart use of energy from local RES/stationary battery storage make the share of green energy greener.	Yes to all
Business aspects	The return of investment and a possible profit facilitated through: • The share of the payments from the EV users. • The extra fees paid by EV users for priority charging. • A reduction of the operational costs related to energy use (see below). The operational costs related to energy use will be reduced: • The use of energy from local RES. • The power tariff per kW per hour peak paid to the DSO is reduced • Desired charging behaviour	Yes to all

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.

5.1.2 Process evaluation

This section provides the findings and results from the process evaluation for the implementation of the Oslo D1 measures. The measures are implemented as described in Chapter 3. The input to the evaluation is summarised in Annex E.1.

Most measures have been operational for more than 6 months. The local energy storage did however stop working due to hardware errors, and some measures were just tested for a short period due to delays.

Lessons learned from supporting activities

Here we summarize the supporting activities that contributed in a positive way.

Involvement of the housing cooperative administration and residents: The housing cooperative administration and residents were involved through workshops and meetings, and through communication initiatives like videos, information letters, and launch events. The intention was to arrange for dialogues around the solutions and to get input. The input was collected through interviews and questionnaires for two purposes: 1) To collect research data for the evaluation activities; and 2) To get input on needs and possibilities and views upon flexible charging, need for priority charging, etc.

In the last part of the project, there were frequent meetings with the housing cooperative administration on a weekly or even daily basis to exchange status information, plan testing activities, solve problems, etc. Due to the positive attitude in the housing cooperative administration, the following are achieved:

- It has been easy to involve the leaders and the residents
- A good relation is established.
- The housing cooperative/residents provided input on their needs.
- The housing cooperative was informed about and involved in plans and decisions.
- The housing cooperative gained knowledge through the participation in the project.
- We consider the approach to be a success even though there have been problems.

Daily (core group) and weekly (larger group) follow up meetings:
All partners involved in the implementation and roll out of the demonstrator participated. The meeting contributed to a tight follow up compared with the more overall workpackage meetings, which addressed all demonstrators. The reason for the positive effect was:

- Problems were identified and addressed at a detailed level (and not just at an overall level as done in the meetings that were common to all demos).
- All partners with a role were present, and decisions on actions could be taken.
- Use of video conferences with the video switch on ensured focus from all participants.
- The expert participants communicated good about complex problems and created a common understanding that inspired to dedicated work to solve problems

Workshop on business models: The main actors in the business model participated (EMP and housing cooperative) and the partners doing the technical development participated in a workshop. The aim was to re-design the business models and to decide the price models. We consider the approach to be a success.

- The discussions were concrete, addressing aspects of importance regarding decisions on prices
- The money flows between actors were clarified.
- The prices for normal charging and priority charging were decided.
- Economic incentives for desired behaviour were decided

Live testing at the demo location: In total the project arranged 5-7 test event with participants from all partners involved in the implementation to test charging of EVs and related software and hardware. Reasons for the positive effect:

- All partners experienced and identified the error through real-time debugging
- All partners could agree on responsibilities and actions to fix the problems

Lessons learned from implementation of measures

Charging measure group: The key lessons learned of importance for future e-mobility strategies are that flexible charging can be implemented, provided that the charge management system and the charge point equipment can be integrated and controlled in a detailed and flexible way. The ability to control the individual charge point is crucial. It must be possible to start and stop the charging of individual charge points and to charge with different power from different charge points.

Smart energy management measure group: The key lessons learned of importance for future e-mobility strategies and strategies for energy smart neighbourhoods (ESN) are that the implementation of an ESN is a huge challenge. Today, this is not done by easy plug and play. Off the shelf components from different providers cannot easily be combined due to the lack of standards and standardized interfaces. It may be difficult to control the systems and equipment involved (charge points included).

Business aspects measure group: The key lessons learned of importance for future e-mobility business strategies are that business models should address more than just the money flows. Price models may for example be used to encourage the desired charging behaviour. Flexibility should be rewarded.

Recommendations

Recommendation on stakeholder involvement: Several types of actions must be considered to engage stakeholders, to get input and to involve/provide information. Relevant actions are for example workshops and meetings, information letters to EV users, launch events creating publicity, interviews, and questionnaires. Users must also know how they can find information and how they can get support.

Affected stakeholders (housing cooperative administration, residents, EV users, and actors in the value chain) must be involved whenever this is relevant, e.g., regarding purchase of hardware, decisions regarding the functionality supported by the technology (e.g., App functionality), and the design of business and price models.

Recommendations regarding the design and implementation of business models and price models: The business and price models must be designed in collaboration with all partners involved. The needs of the property owner (i.e., housing cooperative) must be addressed, and the housing cooperative administration must be involved in the decisions.

The traditional approach to business models is not sufficient. It must be recognised that the value proposition is not just about the economy. It is also about sustainability with respect to environmental and societal aspects, e.g., to reduce energy peaks.

The business models and price models must be aligned with the work on the technical solutions. The right combination of technical solutions, business models, and price models has the potential to motivate to a desired behaviour and to handle business related problems. The technology may for example support the implementation of economic instruments for desired behaviour, e.g., penalties like an extra fee put on priority charging.

Recommendations regarding the follow up of the design and implementation: The coordinator/leader of the demonstrator activities must have high technical expertise. The energy management issues must be understood, and software knowledge is needed to follow up and interpret the status reporting from the technical partners involved. It is not always easy to detect potential problems regarding software and integration.

The implementation must be followed up at a weekly basis. All partners involved must participate in weekly meetings. Blockers, problems and potential problems must be identified at a detailed level, actions must be decided, and responsibilities must be assigned. Blockers and actions must be followed up.

Recommendation regarding the purchase of hardware and equipment for ESNs: The needs must be specified in detail. Thus, it may be good to not wait until the detailed requirements are decided before the purchase process is initiated.

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Statements from the providers regarding the ability of the devices cannot be trusted unless they are based in a detailed specification of the needs. In general, it cannot be expected that the provider has a complete understanding of the needs related to an ESN.

The integration with the energy management system and the ability for equipment control must be emphasized and verified. The integration of the charge point equipment with the energy management system is critical. The ability to control the individual charge points must be emphasized and verified. Many charge points are today provided with an in-built solution for simple load balancing that may cause problems in an ESN. The local energy management in the ESN may not be able to control the charge points as required. Such needs must be specified in detail and discussed with the provider of the software controlling the charge points. Statements from the providers regarding the ability of the charge points cannot always be trusted unless they come from those with detailed knowledge on the software controlling the charge points.

Involvement of experts is crucial. Considering the problems described above, most building/property owners should use external expertise on the design and development of the total ESN solution.

Recommendations regarding policy, standardization, and harmonization issues: Regarding SoC: Charging protocols must provide the current SoC to facilitate optimal charge planning in ESNs.

Regarding charge planning: Navigation systems must in the future support automated charge planning and booking where the charging constrains are adapted to the needs, e.g., based on planned trips or artificial intelligence using input on the EV user's habits.

Regarding charge point equipment and other devices: Providers of charge point equipment must arrange for integration with local energy management in ESNs to facilitate an extended load balancing that takes predictions and the needs of the whole ESNs into account. Providers of devices such as stationary batteries must recognise the needs in ESNs and support the control mechanisms required.

Regarding software integration: The integration between local energy management and charge management must be standardized.

5.1.3 Impact evaluation

This section provides a summary of findings and results from the impact evaluation for each measure group of relevance to the demonstrator (see section 2.1), organized according to the impact categories defined by the CIVITAS evaluation framework [10].

The findings are the indicators of relevance are defined in section 4.1.

The impact results are a comparison and a judgement of the baseline and the after findings.

Note: Some after findings are established through simulations.

Simulation variants extending demonstrator		Optimization	Comment	Simulation periods and context
S1	With no optimisation and no battery	Earliest (non)	Simulation baseline for calibration with the demo (not included below)	The simulations are carried out for one summer, autumn, and winter week: • Summer: August 23-29 • Autumn: October 23-29 • Winter December 13-19 **Context:** • Number of EVs: 18 • Number of charging sessions: 18 • Connection time: 3.94
S1b no opt, bat	With no optimisation and battery	Earliest (non)	To study effect of battery compared with baseline	
S2 opt, no bat	With optimisation and no battery	Greenest	To study effects of smarter optimisation with and without battery and scale ups.	
S3 opt, bat	With optimisation and battery	Greenest		
S4 opt, pw lim	With optimisation with no battery and max power limit	Greenest		

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S5 opt, bat, pw lim lim	With optimisation, battery and max power limit	Greenest		• Charge time: 15.01 • Average power: 0.52 • Charging availability: 1.16 • Flexibility: 0.82

5.1.3.1 Key impact – Measure group Charging

The tables below summarise the findings and results within the relevant impact categories.

Impact category Society and People

The baseline is the situation before GreenCharge where the residents shared 4 charge points that had to be manually booked for a time slot in a spread sheet. The after values are from when the charge points in the garage were operative.

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Society and People	**Awareness**	GC 6.1 Awareness level	Low	High (Residents/EV users)	Residents and EV users are aware of the new solution. They sometimes feel overwhelmed with information.
	Acceptance	GC 6.2 Acceptance level	High (e-mobility) Low (flexible charging)	High (Residents/EV users/Housing cooperation adm.)	In general, the acceptance of e-mobility has been high both before and during the project. Trials confirm that the acceptance of a new App is high – see details below.
	Accessibility	GC 6.3 Perception level of physical accessibility of service	High	High (EV users/ Housing cooperation adm.)	The charging infrastructure gives a feeling of making EV more available and increases the accessibility for the residents.
		GC 6.4 Operational barriers	Low	Medium (EV users) High (Housing cooperation adm.)	Compared to the previous solution, the new system is perceived as more convenient, and it gives more freedom. The system is easy to use and practical. In case of charging error, it was difficult to find information about whom to contact.

Input from interview with the chairman of the board in February 2022 and from the testing of the App:

The project has persuaded several residents to get EVs (and install CPs at their parking space), so there has been an increase in both CPs and activated CPs. Some residents planned to get an EV before GreenCharge, and therefore got an CP at their parking space. The CP was activated when the bought an EV.

Early in development there were questions about "what's the point of the App?", and "why it is so expensive to charge?". These questions are now gone, mostly due to the high energy prices[3] and higher degree of knowledge about how the use of the App may influence the peaks in energy use and costs.

The users have been given a lot of information and there have been several information meetings, but overall, there has not been much feedback. First the residents reported that it was easier to only use the RFID tag to

[3] In Norway, the energy prices have increased with several hundred percent in 2021, and it is expected that they will remain high. This has affected the acceptance of the App.

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.

start the charging. When the residents were informed about the positive effects of the App on the energy use, no further questions were asked.

The EV users know that if they do not charge with the App (only use RFID tag to start the charging), they always get a minimum charge current of 8 A. This has been a failsafe all along. Charge on 8A is usually enough on a daily basis for most.

Impact category Transport System

The baseline findings for the number of EVs and CPs indicators are the situation before the start of GreenCharge where there were no charge points in the garage, but some residents owned or used EVs. The after values are from February 2022.

The baseline findings for the other indicators are charging with no flexibility. The after findings are for some indicators from simulations of the variants listed in the introduction of section 5.1.3.

For all indicators, the evaluation period is August 2021 – January 2022.

Impact category	Indicators and sub-indicators		Demonstrator Baseline findings	After findings from demonstrator/simulations	Impact results
Transport system	**Number of EVs**	GC 5.1.1 Number of EVs	15	47	31 more EVs, and the share of EVs is increased by 14 %-points.
		GC 5.1.2 Share of EVs	15/230 = 6 %	47/230 = 20 %	
		GC 5.1.5 Number of planned EVs	Planned: 12 In 2 years: 17	230 (potential)	
	Number of CPs	GC 5.2.1 Number of CPs	0	In total: 64 (46 are activated, 30 are actively included in evaluation)	64 more CPs in the garage. Not all are active. The share of CPs is increased to 26 %.
		GC 5.2.2 Share of CPs	0	64/230 = 26%	
		GC 5.2.3 Number of private CPs	0	64	
	Utiliza-tion of CPs	GC 5.3.1 Share of connected time	Aug-Jan: 21.11 % Summer 28.22 Autumn 21.11 Winter 25.86	Unchanged	Not relevant. Mainly the baseline that is of interest with respect to charging behaviour..
		GC 5.3.2 Share of charging time	Aug-Jan: 26.46 % Summer 26.11 Autumn 27.99 Winter 33.79	Not relevant	
		GC 5.3.3 Energy per time unit	Aug-Jan: 0.83 kW Summer 0.65 Autumn 1.09 Winter 0.92		
		GC 5.3.4 Number of charging sessions	Aug-Jan: 2079 Summer 59 Autumn 65 Winter 92	Unchanged	Not relevant. If the baseline had been before GreenCharge, the impact would have been > 5000 charging sessions (not all within the evaluation period)
	Charging flexibility	GC 5.13.1 Offered flexibility	0 (no flexibility)	Context for simulations	Not relevant. The indicator is more a context.

		GC 5.13.2 Actual flexibility	Aug-Jan: 0.488 Summer: 0.482 Autumn: 0.427 Winter: 0.382	Not relevant	Not relevant.

Some comments to the results in the table:

- **Charging behaviour:** The share of connected time is surprisingly low (just above 20%), and the share of charging time is around 25 %. This shows that people do not plug in their EV every day, and they charge a quite high share of the time when they are connected. *This charging behaviour could have been better.* The EVs provide a relatively low flexibility, and if V2G is going to be implemented, this charging behaviour must be changed.
- **Charging flexibility:** The motivations for the sub-indicators are to define the context for other indicators (to see the flexibility that can be utilised) and the potential, and not to measure an impact. The Offered flexibility (i.e. the EV User's willingness to provide flexibility) could not be tested due to the delay of the App. The Offered flexibility does however provide information on the actual flexibility that could have been utilised by the smart energy management.

Impact category Environment

There are two baseline findings: 1) The energy from the public grid is used as it is; and 2) The energy the public grid and energy from local RES are used with no local energy storage and management.

The after findings are from simulations of the variants listed in the introduction of section 5.1.3.

The evaluation period is August 2021 – January 2022.

Impact category	Indicators and sub-indicators		Demonstrator Baseline findings	After findings from simulations[4]					Impact results
Environ-ment	CO_2 emissions	GC.5.12.1 Average CO2 Emission per vehicle km	Fossil vehicle: 135 gCO_2/vkm[5] Aug-Jan: 64 gCO_2/vkm[6]	S1b no opt, no bat	S2 opt, no bat	S3 op, bat	S4 opt, pw lim	S5 opt, bat, pw,	The savings is about 60 g CO2/vkm
				4.54	4.54	4.54	4.54	4.54	
		GC 5.12.3 CO2 Emission	19 100 kg CO_2 with Euro 6 (energy charged is 29954 kWh, corresponding to 149 770 km driven)	0 (assuming no emission)					19 100 kg CO_2 are saved by means of 30 charge points

5.1.3.2 Key impact – Measure group Smart energy management

The tables below summarise the findings and results within the relevant impact categories. The following comments apply to the table content:

Impact category Society and People

[4] GC 5.12.2 multiplied with 0.20 kWh/vkm

[5] From Norwegian Statistics Authority (2020) https://www.ssb.no/natur-og-miljo/forurensning-og-klima/artikler/mer-utslipp-for-hver-kilometer-reist/tabell-1.co-utslipp-per-person-passasjerkilometer-fordelt-pa-kjoretoy-og-drivstoff-g-co-pkm.2010-2020: about 75 gCO2/pkm, about 1,8 pkm/vkm, 135 gCO2/vkm (pkm = person km, vkm = vehicle km)

[6] 320 g CO2 eq /kWh and 0.20 kWh/vkm accounting for electricity product declaration (see https://www.nve.no/energi/virkemidler/opprinnelsesgarantier-og-varedeklarasjon-for-stromleverandorer/varedeklarasjon-for-stromleverandorer)

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The baseline is the situation before GreenCharge with no PV panels, no local storage, and no optimal use of energy. The after values are from when the smart energy management was operative.

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Society and People	Awareness	GC 6.1 Awareness level	Low	Medium (Residents)	Residents are aware of the new charging infrastructure but not so aware of the existence of PV panels. See details below the table.
	Acceptance	GC 6.2 Acceptance level	Medium	High (Residents/ Housing cooperative adm.)	The smart energy management and the solar panel can be seen as an extra service in the cooperative and looked at as something very positive. It can also be seen as a way to spreading knowledge and environmental awareness to the residents and may have a positive impact beyond just the residents with EV.
	Accessibility	GC 6.4 Operational barriers	NA	High (Housing cooperative adm.)	The battery has hardware errors and is not used.

Input from interview with the chairman of the board in February 2022:

There are PV panels on the roof of the garage that supply the garage with energy on sunny days. Energy not used are supposed to be transferred to the battery to be use later (the battery is however not working). There has been some question about how much the PVs produces, but generally people are unaware. It has been communicated in the annual report that we produce 55000 kWh, and that this helps to keep the energy bill lower. Energy not used are sold back to the grid and can be written up as income. We think that the PVs are useful and "fun" and, in that respect, it is a shame that they are not so visible. They can only be seen from high above. We do have a monitor outside of the garage showing data on PV and energy production, however most people do not understand it.

Impact category Energy

For the "share of green energy" there are two baselines: 1) with energy from the public grid; and 2) with energy from public grid and local RES. For the other indicators, the baseline findings are with no local energy management and no local battery storage.

The after findings are for some indicators from simulations of the variants listed in the introduction of section 5.1.3.

For all indicators, the evaluation period is August 2021 – January 2022.

Impact category	Indicators and sub-indicators		Demonstrator Baseline findings		After findings from simulations					Impact results
Energy	Share of green energy	GC 5.9.1 Share of green energy	From grid: 97 %		S1b no opt, bat	S2 opt, no bat	S3 op, bat	S4 opt, pw lim	S5 opt, bat, pw,	Demo: Use of RES increases share of green energy with 0.82% See details below on the simulations.
			Aug-Jan: 97.82 %							
			Summer	98.53	98.20	98.14	98.23	98.08	98.23	
			Autumn	97.82						
			Winter	97.62						
	Peak to average ratio	GC 5.10.1 Maximum peak power	Aug-Jan: 104 kW		S1b no opt, bat	S2 opt, no bat	S3 op, bat	S4 opt, pw lim	S5 opt, bat, pw lim	The optimisation and the battery, and especially the power limitations in S4 and S5 have a positive effect on the peaks.
			Summer	49.22	46.24	46.24	46.24	37.9	37.9	
			Autumn	70.49						
			Winter	94.96						
		GC 5.10.2 Average	Aug-Jan: 5.26 kW		S1b no opt, bat	S2 opt, no bat	S3 op, bat	S4 opt, pw lim	S5 opt, bat, pw,	

Impact category	Indicators and sub-indicators		Demonstrator Baseline findings		After findings from simulations					Impact results
		power demand	Summer	3.47	6.32	4.90	6.36	4.86	6.36	
			Autumn	5.53						
			Winter	6.23						
	Self-consump-tion	GC 5.14.1 Energy self-consumption	Aug-Jan: 56.19 %		S1b no opt, bat	S2 opt, no bat	S3 op, bat	S4 opt, pw lim	S5 opt, bat, pw,	With a stationary battery and smart energy management, the self-consumption has increased. See details below.
			Summer	48.18	73	61	74	58	75	
			Autumn	84.82						
			Winter	100						
		GC 5.14.2 Energy self-sufficiency	Aug-Jan: 11.56 %		S1b no opt, bat	S2 opt, no bat	S3 op, bat	S4 opt, pw lim	S5 opt, bat, pw,	See details below.
			Summer	44.61	40	38	41	34	41	
			Autumn	8.56						
			Winter	0.35						

GC 5.14.1 Energy self-consumption and GC 5.14.2 Energy self-sufficiency: As expected, adding the battery (S1b) has a significant effect on the self-consumption.

The optimizer used in the simulations optimizes self-consumption, so as expected, adding optimization without including the battery (S2) also have an effect, but smaller. It appears that although the flexibility is generous, the typical charging behaviour is to connect in the afternoon close to sunset and disconnects in the morning before or shortly after sunrise. Therefore, the best scheduling is to immediately as in the baseline to exploit the local PV production before it falls to 0. However, if the EVs disconnect after sunrise, the optimizer shifts whole of part of the charging to the morning, and thus achieves an improvement in the self-consumption.

Adding both battery and smart energy management (S3), gives only a small improvement over battery only, both for self-consumption and self-sufficiency, so we may conclude that, in this context (charging in residential area), smart energy management to some extent replace stationary battery capacity which is expensive.

In other contexts, for example in contexts where people work and is connected for charging during the day, this is likely to be different.

GC 5.9.1 Share of green energy: The impact on share of green energy is too small to be visible in this case, because the energy mix in the grid is already 97%, so replacing some of the energy consumption with PV does not make much difference in Norway. In other European countries where the share of green energy in the grid mix is around 50% one would see a bigger impact. The small differences we see may as well be due to inaccuracies in the computation caused by low resolution in some of the log data used.

GC5.10.1 Max Peak Power: There is also a reduction of peak power by adding both battery and smart energy management, although reducing peak power was not the prime optimisation criterion of the optimiser. In variants S4 and S5 we limited the max power in the connection to the grid and the optimiser then accommodated the given charging traffic with lower peaks as can be seen in the table above. This would correspond to the results from changing the optimisation criterion to put more emphasis on lowering peak power, and also to an optimization criterion minimising energy cost together with a power tariff punishing high peaks.

Impact category Environment

There are two baseline findings: 1) The energy from the public grid is used as it is; and 2) The energy the public grid and energy from local RES are used with no local energy storage and management.

The after findings are from simulations of the variants listed in the introduction of section 5.1.3.

For all indicators, the evaluation period is August 2021 – January 2022.

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Impact category	Indicators and sub-indicators		Demonstrator Baseline findings		After findings from simulations					Impact results
Environ-ment	CO_2 emissions	GC 5.12.2 Average CO_2 Emission per kWh used gCo2 eq/kWh	From grid: 31.38 Aug-Jan: 30.14		S1b no opt, bat	S2 opt, no bat	S3 op, bat	S4 opt, pw lim	S5 opt, bat, pw,	From demo: The PV panels save on average 1.24 g CO2eq/kWh For simulations – see discussion below.
			Summer	30.84	22,27	22,25	22,27	22,27	22,27	
			Autumn	28.75						
			Winter	31.27						

The CO_2 savings are quite low since the grid mix in Norway already is quite green (due to a high degree of hydro power).

5.1.3.3 Key impact – Measure group Business aspects

Impact category Society and People

The baseline is the situation before GreenCharge.

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Society and People	Awareness	GC 6.1 Awareness level	Low	High (housing cooperative)	The housing cooperative was involved when the business and price models were established. Thus, the awareness is high. Compensations for flexibility need to be high enough (according to interviewees).
	Acceptance	GC 6.2 Acceptance level	Low	High (housing cooperative) High (EV users)	Economic incentives are a driver for flexibility acceptance and the dissuasive mechanism for priority charging. The definition of the prices to be paid has needed many iterations to come with a proposal that was understandable. The main challenge was to decide how to reward the desired charging behaviour is rewarded. At the end, the business and price models were accepted by all stakeholders involved. The prices for charging are in general low. The aim is not to earn money (the housing cooperative has to serve the residents) but to cover the operation costs and minimize the costs for the residents.

Input from interview with the chairman of the board in February 2022:

There are many residents in the housing cooperative that does not have an EV. They often wonder if they subsidise the EV owners and their CP. When cooperative installed the first charger the individual EV owners had to pay for their charge point. The situation is different now because legislation dictates that all housing cooperatives must facilitated infrastructure to EV charging. All residents must now pay even though they don't have parking space. This is however how housing corporations operate. The board sees that CPs are a benefit to the housing cooperative. It is important to cover all the expenses, and the price for charging at your own CP is therefor set to 1.7 NOK/kWh. This has been enough to cover the expenses even though the energy prices vary from day to day.

Some months the income is negative, but so far we have had positive income. Several housing cooperatives in the neighbourhood have however recently increased their prices due the high energy prices in the market. We have not done that yet because we believe the prices may go down again.

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With new price models (demand tariff) it is cheaper to charge when there is no peak in energy use. This is an important aspect of the smart charging, and we must give the resident incentives to choose charging when there is no peak in energy use. This is usually at night. Priority charging is more expensive because you can charge regardless of the peak energy. The cheapest option is to use the App and let the smart charging system calculate the optimal charge speed and time (no priority charging). Regular charging like this is for the best of all. If you choose priority it should cost. This information is however very import to communicate.

Impact category Economy

The baseline is a situation when charge points are installed and used with no flexibility, no priority charging, no PV panels, no battery, and no smart energy management. <u>Note: The period used in July 2021 – December 2021 to include all seasonal variations with respect to the PV production.</u>

Impact category	**Indicators and sub-indicators**		**Baseline findings**	**After findings**	**Impact results**
Economy	**Average operating cost**	GC 5.6.4: Average energy cost	Charging costs with no PV: 46094 NOK, this is 1.539 NOK per kWh	Charging cost with PV: 41582 NOK, this is 1.388 NOK per kWh	In 6 months, the PV panels reduces the costs for the provision of the charging services by **4512 NOK, 0.151 NOK per kWh. This is a reduction of about 10 %.**
		GC 5.6.6 Service payment to CPO	62.5 NOK per month + 0.085 NOK per kWh	Same as baseline	No difference.
	Capital investment cost	GC 5.7.1 Capital investment cost	• Charging infrastructure: 1 289 600 NOK (Subsidies: 644 800 NOK) • 64 chargers: 943 800 NOK (paid by residents 543 800 NOK) In total: 2 233 400 NOK	In addition to baseline: • PV and battery installation: 64 000 NOK • PV: 658 085 NOK • Battery: 658 085 NOK • Baseline In total: 3 613 570 NOK	**Extra costs for PV and battery: 1 380 170 NOK** (138 000 Euros) Subsidies: 2 424 970 NOK Paid by housing cooperative: 644 800 NOK Paid by residents: 543 800 NOK
	Average operating revenue	GC 5.8.1 Revenues from normal operations	From PV charging: 48 376 NOK	From PV charging: 48 376 NOK From export of PV energy: 8191 NOK	Revenue from charging is unchanged (price models are independent of costs). **Extra revenue with PVs is 8191 NOK** See also discussion below.
		GC 5.8.2 Revenue from penalties	0	Assuming 20 % of the energy is priority charging: 4793 NOK	This is not tested. A **priority charging fees (0.80 NOK/kWh) for 20 % of the energy charged will increase the revenue with 4793 NOK.**

Profit elements	**July**	**August**	**September**	**October**	**November**	**December**	**TOTAL**
Revenue charging	6754 NOK	7389 NOK	8156 NOK	8661 NOK	8708 NOK	8708 NOK	48 376 NOK
Charging cost	1340 NOK	2497 NOK	5868 NOK	8275 NOK	12510 NOK	11092 NOK	41 581 NOK
Profit	5414 NOK	4891 NOK	2288 NOK	387 NOK	-3802 NOK	-2384 NOK	6 794 NOK

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Influencing factors							
Price kWh import	0.753 NOK	0.883 NOK	1.371 NOK	1.563 NOK	2.320 NOK	2.057 NOK	
Charging kWh	4182 kWh	4575 kWh	5050 kWh	5363 kWh	5392 kWh	5392 kWh	29 954 kWh
PV production	9090 kWh	8020 kWh	4130 kWh	1600 kWh	469 kWh	0 kWh	23 309 kWh
Revenue from PV energy export	3334 NOK	2935 NOK	1717 NOK	203 NOK	2 NOK	0 NOK	8 191 NOK
Total energy use	9090 kWh	10894 kWh	10262 kWh	12899 kWh	16384 kWh	34214 kWh	93 743 kWh
Peak power costs	884 NOK 22 per kW	1135 NOK 22 per kW	832 NOK 22 per kWh	1439 NOK 22 per kW	8563 NOK 67 per kW	14976 NOK 120 per kW	

The table above provides further details on the after situation with PV production. The charging costs are reduced due to revenue from export of surplus energy from PV production. The following can be observed:

- **Energy prices are increasing:** There has been a huge change in the electricity prices in Norway the last few months of 2021. The high prices are expected to last.
- **Profit reduction:** The profit varies a lot, and it is even negative in November and December. This is mainly due to the increase in the energy prices. In total for 2021, the profit on the charging was 49567 NOK (not included in the table). Due to the increased process, the contribution for the second half of the year was limited to 6794 NOK.
- **Seasonal variations:** The PV production and the revenue from the PV production export varies over the year. The production was low in November, and in December, the PV panels were covered by snow and the energy production was 0.
- **Peak costs are high:** The peak power cost is for all energy used (not just the charging) and the costs increase when the power peaks are high. For November and December the tariffs are higher, and for November and December, much energy is also used for the heating cables in the entrance (to reduce icing), and the peaks are high. In August and September, the PV production might have contributed to a reduction of the peak costs (it is difficult to tell).

The imported energy is in general more expensive than the payment received from the export of surplus energy from the PV panels. Since the PV production also lowers the peak costs, it is always better to use as much of the PV production locally instead of exporting it.

From section 5.1.3.2, we see that the self-consumption is around 50%. With a stationary battery that is working and/or more EVs in the garage (today just 30 of 64 charge pints are activated today), it should be possible increase the self-consumption to close to 100 %. With more EVs, it might also be that the stationary battery is not needed for an increase of the self-consumption to 100 %. In such a case there will be no revenue from the export of energy from the PVs, but the reduction of charging costs and peak costs will more than compensate for this.

An advanced, local energy management of the type implemented in the demonstrator (but not demonstrated), will move the energy use (charging included) to times when the varying price costs are low and also lower the peaks. The cost saving potential is large, also for periods when the total energy use is high, and the PV production is low.

With the high energy prices the return of investment for PV panels will improve.

The capital investment costs paid by the housing cooperative are considerably reduced by subsidies. In general, it is reasonable that the costs for the 64 charge points, which are owned by the residents, are not paid by the housing cooperative. The remaining costs would under normal circumstances have been investments made by the housing cooperative.

The business model for the demonstrator is adapted to a low-profit policy. The main objective is to provide the residents with access to convenient, green, and cheap charging. Some profit is however needed to ensure the return of investment. Due to the subsidies, a lower profit is needed. The charging price paid by the EV users can easily be adapted to increased energy prices, and there is probably an acceptance for this. **Thus, it**

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seems that the business model of the housing cooperative with respect to charging is sustainable, and it can be even more sustainable with optimal energy management.

5.1.3.4 Further analyses of findings and results

An analysis of the findings and results are provided below. "+" indicates that the result probably is "too good". "-" indicates that the result probably is "too bad". "+/-" indicates that there is an uncertainty. The reasons might be that other factors than GreenCharge or confounding factors might have influenced the result.

Effects of factors outside the control of GreenCharge

Such effects are illustrated in illustrated in Figure 2-1. This is relevant for the following indicators:

- **Awareness and acceptance (+):** The e-mobility in Norway is among the highest in the world, and this has probably impacted the indicators. The awareness and acceptance regarding the benefits of charging flexibility is however still in general low even though there are commercial services offering to adapt time of charging to the varying energy price. New legislation that dictates that all housing cooperatives must facilitated infrastructure to EV charging may have influenced the acceptance in a positive way.
- **Number of EVs and CPs (+):** These numbers have increased significantly in Norway since the start of the GreenCharge project, and especially in the Oslo area. Most EV owners do however probably not live in housing cooperatives. But even in housing cooperatives, it has however become quite normal to have an EV and a charge point if the housing cooperative has a garage. It is likely that the housing cooperative would have had an increase in the number of EV and charge points also without GreenCharge.
- **Utilization of CPs (-):** The COVID situation may have increased the connection time of the vehicles since the mobility has been low and many vehicles have stayed connected in the garage for longer periods (on average the reduction of the driving distance was 4.6 % in 2020[7]). For this reason, the energy demand, the share of charging time, and the number of charging sessions are probably reduced.
- **Charging flexibility (-):** Due to the factors mentioned for the utilisation of the CPs, the actual flexibility has been increased. The vehicles have been connected for long periods and charged little.
- **Peak to average ratio and self-consumption (-):** In case of a lower utilisation of the charge points, the baseline findings for the peaks and the self-consumption are probably decreased, and the effects of smart energy management is also reduced.
- **Average operating cost (-):** The energy costs in Norway have increased several hundred precents in in the last part of 2021 and start of 2022, and the high costs are expected to last. Thus, the operating costs are higher than expected.

Confounding factors

These factors may be caused by the software functionality and capability, the research data quality and completeness (see Chapter 6), and the process evaluation findings. In addition, other project specific issues may have caused other effects:

- **Number of CPs (+):** Due to the subsidies provided to the establishment of charge points, we consider the number of charge points to be affected to be higher than it would have been without the subsidies.
- **Awareness and acceptance (+):** The subsidies may also have affected the acceptance and the awareness. The fact that all charge points are not activates also indicates this but confirms a high degree of e-mobility awareness and acceptance. Many residents have concrete plans for a replacement of their fossil vehicles with electric vehicles.
- **Charging flexibility (+/-):** The App intended to be used was delayed to the extent that it could not be used, and data on the actual flexibility could not be provided. Also with the App, the actual flexibility would have been uncertain due to uncertainty about the correctness of the manual input of initial SoC, timeslot, etc., as pointed out by the software assessment section 6.2. This is however of no relevance when

[7] https://www.ssb.no/transport-og-reiseliv/artikler-og-publikasjoner/mindre-bilkjoring-i-koronaaret

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the App is not used. The actual flexibility had to be defined in the simulations. It was set to the offered flexibility (based on the actual connection time). This value may however not be correct, but we do not know whether it is too high or too low. In addition, as pointed put in the software assessment in section 6.2, there might be a reduced flexibility due to the software workaround regarding the control of the charge points.

- **Utilisation of CPs (+/-):** This indicator is also affected by the lack of the App. Without the App, every vehicle is fully charged every time (when energy is available). With the App, the amount of energy requested might have been lower. Thus, the energy demand and the share of charging time might also have been lower. It is however impossible to judge the affect.
- **Peak to average ratio and Self-consumption (+/-):** These indicators are affected by the charging flexibility. With uncertainty about flexibility used in the simulations, there is also an uncertainty about the effects on the indicators.
- **Capital investment cost (-):** Subsidies from the municipality to both the housing cooperative and to residents have de creased the investment costs. More charge points are for example installed than those used.

Other observations

These observations can be the explained by process evaluation findings and dependencies between measures and measure groups (see Table 2-4):

- **Awareness and acceptance:** These indicators have in general improved a lot. This is probably partly due to the high degree of stakeholder involvement, as pointed out by the process evaluation.
- **Capital investment cost:** These costs have enabled the smart energy management and contributed to positive effects on peaks and emissions.

5.2 Oslo Demo 2 (advance booking of CPs) evaluation

This section summarises the findings and results from the evaluations of the Oslo Demo 2.

The measures described in section 3.2.2 are implemented, they are tested, and they work. Delays have however prohibited the roll-out of the demonstrator (see details in the process evaluation input in Annex E.2), and the following measures were not put into operation: Roaming, Advance booking, Payment for shared CPs, and Penalizing blocking of CP.

Despite of not being operational, the implementation process has facilitated important learning.

5.2.1 Fulfilment of objectives and expected outputs

Note: The demonstrator objectives are not overall, generic, and quantitative (as stated in Chapter 3). Thus, the assessments of the fulfilment of the objectives are mainly about learning effects. The objectives are fulfilled if there are findings of evaluation results that facilitate learning.

The tables below provide a compact overview of the fulfilment of the demonstrator objectives and expected output related to the expectations defined in section0. Colour codes indicates the fulfilment (green = fulfilled, yellow = partly fulfilled, red = not fulfilled).

In general, all expected outcomes were delivered. Many objectives were however not met since the App that was needed for many of the measures was rolled out too late. Learning has however been possible to some extend for the business aspects.

Measure group	Overall objectives	Detailed objectives - See section 0	Fulfilment/Learning
		How many charge sessions are there during a time frame?	
		The time EVs are connected during a time frame?	

Charging	Learn about the use of shared and pre-booked CPs	How much of the total connected time is used for charging during a time frame?	The demonstrator was not started due to delays with release of App.. It is not possible to answer these questions.
		How much energy do the EVs on average charge per connected time unit?	
	Learn about the charging availability provided by bookable charge points	What share of booked time slots are not used?	
		What is the delay in plug in time compared with the booked time slot?	
		What share of EVs are not disconnected in time (i.e. connected longer than the booked time slot)?	
Business aspects	Learn about how price models can be used to achieve desired behaviour	How can CP blocking be avoided through use of price models targeting this challenge?	Business models were defined taking this into account, but not testes.
		How to can the utilization of the CPs be increase through use of price models targeting this challenge?	
	Learn about business potential and return of investments regarding shared CPs.	What is the potential for payback of the investment costs?	Desktop analyses show that the market potential is a good if information about the CPs reach potential users. We have however not been able to test this.
		What price can be charged if a high utilization is desired?	

Measure Group	Expected output	Fulfilment/ Learning
Charging	• 4 shared charge points are installed and available to the public. • EV users can book charging time slots in advance and get predictable access to charging.	Yes
Business aspects	• Housing cooperative will get paid for the use of the charge points and return of investments. • The price models encourage a desired behaviour and compensate in case no shows and blockings.	Yes. The CPs are in operations

5.2.2 Process evaluation

This section provides the findings and results from the process evaluation for the implementation of the Oslo D2 measures. The measures are implemented as described in Chapter 3. The input to the evaluation is summarised in Annex E.2

Despite of not being operational, the implementation process has facilitated important learning.

<u>**Lessons learned from supporting activities**</u>

Here we summarize the supporting activities that contributed in a positive way.

Involvement of the housing cooperative administration and residents:

The housing cooperative administration were involved through:

- Meetings and informal talks
- Interviews with members of the administration to get insight into needs and opportunities.
- Videos

Due to the positive attitude in the administration of the housing cooperative, it has been easy to involve them, and we consider the approach to be a success. The following are achieved:

- A good relation was established.
- The housing cooperative administration provided input on their needs.
- The housing cooperative administration was informed about plans and decisions, and they have provided input that is taken into consideration.

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.

Workshop on business models:
The main actors in the business model participated (EMP and housing cooperative) participated in a workshop as well as the partners doing the technical development. The aim was to re-design of the business models and to decide the price models. We consider the approach to be a success.

- The discussions were concrete, addressing aspects of importance regarding decisions on prices (prices for comparable services, how to ensure income in case of blocking, etc.) as well as the actual prices.
- The money flows between actors were clarified.

Weekly follow up meetings:
All partners involved in the implementation and roll out of the demonstrator participated. The meeting contributed to a tight follow up compared with the more overall workpackage meetings, which addressed all demonstrators. The reason for the success was:

- Problems were identified and addressed at a detailed level (and not just at an overall level as done in the meetings that were common to all demos).
- All partners with a role were present, and decisions on actions could be taken.

Focus group addressing the design and implementation stage:
A focus group was arranged with all actors involved in the demo to investigate the barriers and drivers encountered and the effect of the supporting activities. A neutral facilitator asked open questions, and the participants discussed. The input was analysed. The input provided is summarized in Annex E.

<u>**Lessons learned from implementation of measures**</u>

Charging measure group: The key lessons learned of importance for future e-mobility strategies are that the demonstrator was more complex than foreseen. In particular, it was not expected that the administrative issues linked to the opening of APIs, contract, and the onboarding into the roaming platform would take so much calendar time. For a long time, these issues were blockers.

Business aspects measure group: The key lessons learned of importance for future e-mobility strategies are that business models should address more than just the money flows. Price models may for example contribute to a desired behaviour. Blockings must be panelised. No show (no cancellation) must also be panelised.

<u>**Recommendations**</u>

Recommendation on stakeholder involvement:
Several types of actions must be considered to get input and to involve/provide information. The actions may for example be meetings and interviews with charge point owner to get input on needs and opportunities; information letters to contact points for potential EV users that may use the charge points (e.g., other housing cooperatives in the area, and a school in the area); and information provided to the e-mobility association so that they can promote the charge points via their channels (Web-site showing charge points, Newsletters, etc.). Users must be able to find information and how they can get support. Information measures at charge points, etc. must be considered.

Affected stakeholders (housing cooperative administration, residents, EV users, and actors in the value chain) must be involved whenever this is relevant, e.g., regarding purchase of hardware, decisions regarding the functionality supported by the technology (e.g., App functionality), and the design of business and price models.

Recommendations regarding the design and implementation of business models and price models:
The business and price models must be designed in collaboration with all partners involved. The needs of the property owner (i.e., housing cooperative) must be addressed, and the housing cooperative administration must be involved in the decisions.

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 traditional approach to business models is not sufficient. It must be recognised that the value proposition is not just about the economy. It is also about the charging behaviour. The work on technical solutions and business models must integrated to arrange for synergies. The right combination of technical solutions, business models, and price models has the potential to motivate to a desired behaviour, e.g., to prevent blockings of the charge point and to handle no shows.

Recommendations regarding the follow up of the design and implementation:
The implementation must be followed up at a weekly basis. All partners involved must participate in weekly meetings. Blockers, problems and potential problems must be identified at a detailed level, actions must be decided, and responsibilities must be assigned. Blockers and actions must be followed up.

Administrative and formal issues (opening of APIs, roaming onboarding, contracts, etc.) must be planned and addressed in a way that does not delay the implementation: The administrative activities needed must be identified at an early stage, the time it will take to carry them out must be estimated, and these activities must be planned and handled in parallel with the technical implementation.

5.2.3 Impact evaluation

This section provides a summary of findings and results from the impact evaluation for each measure groups of relevance to the demonstrator (see section 2.1), organised according to the impact categories defined by the CIVITAS evaluation framework [10].

The findings are the indicators of relevance, as defined in section 4.2.

The impact results are a comparison and a judgement of the baseline and the after findings.

5.2.3.1 Key impact – Measure group Charging

Impact category Society and People

Baseline is the situation before GreenCharge. Then, there were no public and bookable charge points available and no awareness and acceptance.

The charge points were not operational during the project. As a consequence, *it is not possible to collect data on the real awareness and acceptance among external users*.

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Society and People	Awareness	GC 6.1 Awareness level	NA	High (residents) Low (Potential users)	Residents are aware of the existence of the outdoor charging points and will recommend them to visitors. Communication activities to raise awareness among potential external users have been planned but are not conducted. In addition, the outdoor charging points are not visible for the general public, and they are not easy to find. Thus, the awareness level among external users is *assumed* to be low.
	Acceptance	GC 6.2 Acceptance level	NA	High (housing cooperative) Expected acceptance: High	The service was established in collaboration with the housing cooperative, and with high acceptance from them. They want to offer charging to visitors and EV users in the neighbourhood. The *expected* acceptance among external EV users is assumed to be high as there are few public charge points

				(Potential users)	in the area. In addition, the advance booking facilitates predictable access to charging.

Impact category Transport System

The baseline is the situation before GreenCharge. No bookable charge points were shared with the public.

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Transport system	Number of EVs	GC 5.1.1 Number of EVs	0	0	The CPs have not been used by external partners
	Number of CPs	GC 5.2.1 Number of CPs	0	4	4 New CPs. This is however more a decision than an impact since the CPs were installed by the project and not due to an independent decision.
		GC 5.2.4 Number shared CPs	0	4	

5.2.3.2 Key impact – Measure group Business aspects

Impact category Society and People

Baseline is the situation before GreenCharge. Then, there were no business model for the sharing of bookable charge points with the public, and no awareness and acceptance.

The charge points were not operational during the project, but the business and price models were established and implemented by the software. The after values represent the *housing cooperative's awareness and acceptance* of these business and price models, and not the EV user's acceptance and awareness.

Impact category		Indicators and sub-indicators	Baseline findings	After findings	Impact results
Society and People	Awareness	GC 6.1 Awareness level	No	High (housing cooperative adm.)	The housing cooperative was involved when the elaboration of the business and price models. Thus, the awareness is high.
	Acceptance	GC 6.2 Acceptance level	No	High (housing cooperative adm.) Expected acceptance (Potential users): High	In collaboration with the housing cooperative, and with high acceptance from them, it was emphasized that the price model should ensure a revenue also in case of un-desired charging behaviour (no show, blocking, etc.). The compensation for such behaviour was set to be high enough. The EV users' expected acceptance is assumed to be high since the price level is lower the at other public chargers. In addition, they get predictable access to charging.

Impact category Economy

Baseline is the situation before GreenCharge. Then, there were no public and bookable charge points, and the baseline values are 0. The after value tagged with (E) is an estimate. Those with (P) are based on the business and prise models defined.

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.

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Economy	Capital investment cost	GC 5.7.1 Capital investment cost	0	• Charging infrastructure: 85 000 NOK • 4 chargers: 60 000 NOK (subsidies 60 000 NOK) In total: 145 000 NOK	Charging infrastructure and 4 charge points: 145 000 NOK Subsidies: 60 000 NOK Paid by housing cooperative: 85 000 NOK
	Average operating revenue	GC 5.8.1 Revenues from normal operations	0	3,5 NOK per kWh (P)	After value based on price model.
		GC 5.8.2 Revenue from penalties	0	No show fee: 12 NOK Blocking fee: 25 NOK per hour	Penalties are for blockings and no show and are designed to compensate for not being able to offer the service to others. Thus, it can be neglected.
	Average operating cost	GC 5.6.4: Average energy costs	0	1.8 NOK per kWh (E)	In total this is 1.885 NOK per kWh + 1000 NOK per month
		GC 5.6.6 Service payment to CPO	0	0.085 NOK per kWh (P) 1000 NOK per month (P)	

5.2.3.3 Further analyses of findings and results

An analysis of the findings and results are provided below. "+" indicates that the result probably is "too good". "-" indicates that the result probably is "too bad". "+/-" indicates that there is an uncertainty. The reasons might be that other factors than GreenCharge or confounding factors might have influenced the result.

Effects of factors outside the control of GreenCharge

Such effects are illustrated in illustrated in Figure 2-1. This is relevant for the following indicators:

- **Awareness and acceptance (+):** The e-mobility in Norway is among the highest in the world, and this has probably impacted the indicators.
- **Number of CPs (+):** The number might have been unchanged without GreenCharge since the housing cooperative originally had 4 charge point for use among the residents. The sharing of these charge points with the public would however have been a challenge due to the lack of an App, and it would not have been possible to book the charge point unless the use of a manual management of the booking.

Confounding factors

These factors may be caused by the software functionality and capability, the research data quality and completeness (see Chapter 6), and the process evaluation findings. In addition, other project specific issues may have caused other effects:

- **Awareness and acceptance:** The subsidies mentioned above have made the business models more viable and thus influenced the acceptance of the establishment of the charge points.
- **Number of EVs (-):** Since the demonstrator was not operational, there are no EVs. It is likely that the number of EVs would have much been higher if the charge points were operative. The concern on the lack of publication of charge point information, as addressed in the software assessment in section 6.2, might however have played a role if the demonstrators had been in operation. Plans related to this was however established, but not implemented due to the status of the demonstrator.

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- **Number of CPs (+):** The number of CPs in the demonstrator was more a decision than an impact. The number might have been lower without the subsidies.

Other observations

These observations can be the explained by process evaluation findings and dependencies between measures and measure groups (see Table 2-4):

- **Awareness and acceptance:** Despite the failure with respect to getting operative, these indicators are in general high. This is probably partly due to the high degree of stakeholder involvement, as pointed out by the process evaluation. Advance booking is a new service that mainly is relevant when the acceptance is high and the number of EVs is high (and the pressure on charging infrastructures is high). Thus, the findings with respect to the expected acceptance and awareness are relevant even though charge points have not been operational.

5.3 Bremen Demo 1 (charging at work) evaluation

This section summarises the findings and results from the evaluation of the Bremen D1 demonstrator.

All measures described in section 3.4.2 are implemented. Most measures have also been operational. For some measure, problems are however experienced, and they are not put into operation (see details in the process evaluation input in Annex E.3), or they are not used, or the implementation is less advanced. This is the case for the following measures:

- **Local storage:** The 2nd hand EV battery stopped working.
- **Flexible charging:** All EV users used the priority option and not flexible charging.
- **Data about PV production:** are not always available for all the locations.
- **Optimal and coordinated use of energy:** Just a simple load balancing was implemented and not an optimisation based on predictions..

To coped with the above, extensions of the demonstrator are simulated, as described in Chapter 4.

5.3.1 Fulfilment of objectives and expected outputs

Note: Due to the relatively small scale of the demonstrator, the demonstrator objectives are not overall, generic, and quantitative (as stated in Chapter 3). Thus, the assessments of the fulfilment of the objectives are mainly about learning effects. The objectives are fulfilled if there are findings of evaluation results that facilitate learning.

The tables below provide a compact overview of the fulfilment of the demonstrator objectives and expected output related to the expectations defined in section 3.3.1. Colour codes indicates the fulfilment (green = fulfilled, yellow = partly fulfilled, red = not fulfilled).

In general, all expected outcomes were delivered. Some objectives were not fulfilled in demonstrations because of technical problems, but they were evaluated by simulation.

Measure group	Overall objectives	Detailed objectives - See section 3.3.1	Fulfilment/Answer
Charging	Learn about the use of CPs and the fulfilment of charging demands	How long are the EVs connected? How much of the connected time is used for charging? How much energy do they on average charge per connected time unit? What is the share of energy charged compared with the energy demand?	The results are affected by the Covid-situation. There are few charging sessions, and they may not be typical. In general, the connection times are not very long. Thus, the share of charging time is quite long. (see GC 5.3 Utilisation of charge point, unit, GC 5.5 Charging availability)

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	Learn about the charging flexibility of the EV users	How much flexibility do the EV users provide with respect to when the charging can be accomplished?	(see GC 5.13 Charging flexibility)
		What is the actual flexibility that the system could have utilised?	
Smart energy management	Learn about the effects on of the measures and the technology needed	How much is the peak level reduced?	(see GC 5.10 Peak to average ratio, GC 5.14 Self-consumption, GC 5.9 Share of green energy, GC 5.12 CO2 Emission)
		What is the self-consumption achieved with the current solar plant and stationary battery?	
		What are the effects on the Share of green energy?	
		What is the effect on CO2 emissions?	

Measure Group	Expected output	Fulfilment
Charging	• Certain types of EV users can ask for priority charging.	Yes
Smart energy management	• The infrastructure and management systems are prepared for a higher number of electric vehicles. • Use of stationary battery storage provides flexibility when energy demand is high. • A rule-based distribution of available energy to the electric vehicles, depending on which group they belong to (visitors, company fleet, or employee), will ensure enough energy to charge all according to the rules.	Yes

5.3.2 Process evaluation

This section provides the findings and results from the process evaluation for the implementation of the Bremen D1 measures. The work is carried out as described in section 2.3.

Most measures have been operational for several months. For the "local storage" measure, serious problems were however experienced due to hardware errors in the secondary EV batteries (see details on barriers in Annex E.3). One battery was however operational.

Lessons learned from supporting activities

The following conclusions and lessons learned concerning the supporting activities are drawn:

Questionnaire: The questionnaire gave useful information on the perspective of potential users (commuters): A rough estimate of the needed charging energy per day could be derived.

Technical meetings: These monthly meetings with technical eMobility staff were focused on follow-up actions to implement the demonstrator. In-depth discussions on specific problems allowed to path the way to practical solutions – in particular during the implementation phase.

PMC-staff is also active in advanced training for professionals. This gave the opportunity to implement some of the GreenCharge objectives into lecture modules, e.g., charging infrastructure, e-mobility, RES, etc., which might develop into additional business opportunities for PMC as a CPO in the near future.

Lessons learned from implementation of measures

Charging measure group: The key lessons learned of importance for future e-mobility strategies are that the modifications of the charger hardware setup was more complex than foreseen. An unexpected switch from a pre-determined site to another site incurred a multitude of technical modifications. Additional manpower and investment were needed, but no planned resources were available.

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Taking the role of both a CPO and developer of backend S/W was beneficial. This allowed PMC to adjust or even modify the OCCP compatible communication standard without the need to solve contractual issues with providers of CP-H/W and backend control experienced by other demonstrators.

Smart energy management measure group: The key lessons learned of importance for future e-mobility strategies are that the integration of 2^{nd}-life EV-batteries into the charging station caused problems. Employing deinstalled batteries from old and/or wrecked EVs appears unsafe for this purpose. 2^{nd}-life EV-batteries should be still on the market and provided by an existing OEM or a contracted supplier. This market does however not existent yet, but it will certainly evolve in the coming years, making this option still viable. By then a preferred option is definitely to involve battery specialists acting as re-sellers for used traction batteries including well-defined communication interfaces.

Business aspects measure group: The key lessons learned of importance for future e-mobility strategies are that the business models must be emphasized. The incentive for a company (PMC's potential customer) to invest in the charge@work options for their employees must be highlighted – by doings so the need for local grid extension will be reduced as well as additional retention of employee to their management.

Recommendations

Recommendation on stakeholder involvement:
Affected stakeholders must be involved, in particular the electrician, whenever the local grid is affected.

Charge point users must have easy access to information on how they can get immediate support on malfunction of App and/or charge point. This can best be ensured by providing the information needed directly at the charge point.

CPO as a service provider must be available. However, for cost reasons, running a hotline access point could be realised only with existing and experienced staff member. Ideally these should have access to the S/W backend.

Recommendations regarding the design of price models (although currently no money flow is involved in Bremen Demo 1):
Intern of investment is a challenge. The charge@work service will be beneficial to the commuting employee only, if cost for charging is less than when charging at home. This makes it difficult for a CPO to get a return of investment in a reasonable period of time. Thus, financial support by the employer (owner of the parking lot) is needed to attract an external CPO to set up a smart charging system with a monthly all-in service fee per CP. A survey with its employees is strongly recommended before starting such an investment.

Recommendations regarding the follow up of the design and implementation
There is a need for regular meetings and/or telcos. The contractor for charge@work (private entity) must be involved on a cooperative basis via short but regular meetings (monthly) to identify potential problems in relation to on-site grid aspects (electrician and/or IT expert).

5.3.3 Impact evaluation

This section provides a summary of findings and results from the impact evaluation for each measure group of relevance to the demonstrator (see section 2.1), organised according to the impact categories defined by CIVITAS evaluation framework [10].

The findings are the indicators of relevance are defined in section 4.3.
The impact results are a comparison and a judgement of the baseline and the after findings.

Note: The after values for some indicators are established through simulations that extend the capability of the demonstrator.

Simulation variants extending demonstrator		Optimization criteria	Comment	Simulation periods
S1	With no optimisation and no battery	Earliest (non)	Simulation baseline. The results are just used for calibration with the demo (not included below)	The simulations are carried out for one summer, autumn, and winter week: • Week From September 5th – to September 12th
S1b no opt, no bat	With no optimisation and battery	Earliest (non)	To study effect of battery compared with the baseline	
S2 opt, no bat	With optimisation and no battery	Greenest	Flexibility is configured. To study effects of smarter optimisation with and without battery and scale ups.	
S3 opt, bat	With optimisation and battery	Greenest		

5.3.3.1 Key impact – Measure group Charging

Impact category Society and People

The baseline is the situation before GreenCharge. Charging services were available, but EV users had no or low awareness and acceptance regarding the need for flexible charging.

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Society and People	**Awareness**	GC 6.1 Awareness level	No/Low	Low (Employers/EV users)	From inspections of data, we see that all users have chosen priority charging. Thus, the awareness about the need for flexibility is still low.
	Acceptance	GC 6.2 Acceptance level	No/Low	App: High (EV users) Flexibility: Low (EV users)	From informal talks with employers and EV users, the service is perceived as good. The App for accessing the service is ready since 07/2021 and is well-accepted by the users. The meaning and consequences for charging behaviour by choosing "priority charging" in the App had to be explained in more detail to user, but still all users have chosen priority charging. Thus, the acceptance of flexibility charging is low.
	Accessibility	GC 6.4 Operational barriers	NA	Low	The main operational barrier is that temporarily there were no users because of home-office policies due to

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					COVID-19 issues. By 11/2021 there are 11 registered users – nearly all EV drivers working on-site.

Impact category Transport System

The baseline findings for the number of EVs and CPs indicators are the situation before the start of GreenCharge. The after values are from the operation period.

The baseline findings for the other indicators are charging with no flexibility. The after findings are for some indicators from simulations of the variants listed in the introduction of section 0.

The indicators are reported monthly for Bremen location D1L1 and D1L3 from September to December. For D1L1 there are not usable data in October.

Impact category	**Indicators and sub-indicators**		**Demonstrator Baseline findings**			**After findings from demo/simulations**			**Impact results**
	Number of EVs	GC 5.1.1 Number of EVs	10						No changes
	Number of CPs	GC 5.2.1 Number of CPs		L1	L3				
				3	2				
	Utilization of CPs	GC 5.3.1 Share of connected time		L1	L3	**S1b** no opt, no bat	**S2** opt, no bat	**S3** opt, bat	Increase is due to the selection of a week of higher utilization.
			Sep.	3.67	15.83	34.9	34.9	34.9	
			Oct.	-	10.98				
			Nov.	3.46	6.96				
			Dec.	4.92	12.03				
		GC 5.3.2 Share of charging time		L1	L3	**S1b** no opt, no bat	**S2** opt, no bat	**S3** opt, bat	Higher values are due to the fact that the EMS, to match PV energy delays the charge
			Sep.	36	35.2	34.9	86.2	36.4	
			Oct.	-	35.38				
			Nov.	64.94	40.23				
			Dec.	64.94	40.04				
		GC 5.3.3 Energy per time unit		L1	L3				
			Sep.	3.5	2.2				
			Oct.	-	3.1				
			Nov.	6.1	3.6				
			Dec.	4.8	3.6				
		GC 5.3.4 Number of charging sessions		L1	L3	**S1b** no opt, no bat	**S2** opt, no bat	**S3** opt, bat	Because of the Covid emergency we find a underutilization of CPs.
			Sep.	4	26	10	10	10	
			Oct.	-	24				
			Nov.	11	34				
			Dec.	12	26				
	Charging avail-ability	GC 5.5.1 Energy avail-ability		L1	L3	**S1b** no opt, no bat	**S2** opt, no bat	**S3** opt, bat	The value is always greater than 1 in the demonstrator because the ESM charges the battery until full and beyond the booked energy demand. In simulation the battery always increase energy availability, but
			Sep.	1	9.12	1.16	0.86	1.02	
			Oct.	-	4.21				
			Nov.	5.02	5.05				
			Dec.	3.35	3.61				

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									not much more than the demand.
		GC 5.5.2 Demand fulfilmen		L1	L3	**S1b** no opt, no bat	**S2** opt, no bat	**S3** opt, bat	The lack of the battery does not affect much energy availability, but many EVs do not charge completely
			Sep.	1	1	1	0.2	1	
			Oct.	-	1				
			Nov.	1	1				
			Dec.	1	1				
	Charging flexibility	GC 5.13.1 Offered flexibility		L1	L3	**S1b** no opt, no bat	**S1b** no opt, no bat	**S2** opt, no bat	Offered flexibility is larger than 0 because employees set an estimated departure time that is longer than the time needed to charge. Offered flexibility is larger than actual flexibility because employees leave the EV longer than the time set in the booking app.
			Sep.	0.79	0.74	0.54			
			Oct.	-	0.71				
			Nov.	0.79	0.58				
			Dec.	0.68	0.69				
		GC 5.13.2 Actual flexibility		L1	L3	**S1b** no opt, no bat	**S1b** no opt, no bat	**S2** opt, no bat	
			Sep.	0.49	0.41	0.38			
			Oct.	-	0.38				
			Nov.	0.50	0.36				
			Dec.	0.54	0.36				

GC 5.3.1 Share of connected time is very low. It increase in simulation because we selected the time period with higher number of charge session.

Employees leave always before the time they set on booking, this motivates a lower value for ***GC 5.13.1 Offered flexibility*** than ***GC 5.13.1 Actual flexibility.***

GC 5.3.2 Share of charge time in demonstrator is related to the EMS that charge at full power and does not exploit flexibility. We see in simulation that EMS by the greenest policy try to continue to charge the EV when green energy is available, exploiting flexibility and extending the charge time.

GC 5.5.2 Demand fulfilment is always 100% and ***GC 5.5.2 Demand fulfilment is greater than 1 f***or the same reason in the demonstrator. The demo does not work according to the specification, not demonstrating a smart management, and also the employees always ask for charging at the maximum speed. But in demonstrator, only when there is no battery, in order to use only green energy, there is a reduced energy availability. Not all the EVs are charged until the demanded energy, but the global demand is satisfied at 86%.

Impact category Environment

There are two baselines: 1) The energy from the public grid is used as it is. 2) The energy the public grid and energy from local RES are used with no local energy storage and management. The after values are form simulations with local energy storage and management.

Impact category	Indicators and sub-indicators		Baseline findings	After findings from simulations	Impact results
			Fossil vehicle: 135 gCO_2/vkm[8]		

[8] From Norwegian Statistics Authority (2020) https://www.ssb.no/natur-og-miljo/forurensning-og-klima/artikler/mer-utslipp-for-hver-kilometer-reist/tabell-1.co-utslipp-per-person-passasjerkilometer-fordelt-pa-kjoretoy-og-drivstoff-g-co-pkm.2010-2020: about 75 gCO2/pkm, about 1,8 pkm/vkm, 135 gCO2/vkm (pkm = person km, vkm = vehicle km)

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.

Impact category	Indicators and sub-indicators		Baseline findings	After findings from simulations	Impact results
Environ-ment	CO2 emissions	GC.5.12.1 Average CO2 Emission per vehicle km	Sep. – Dec.: 117.4 gCO_2/vkm[9]		
		GC 5.12.3 CO2 Emission		0 (assuming no emission)	

5.3.3.2 Key impact – Measure group Smart energy management

Impact category Energy

For the "share of green energy" there are two baselines: 1) with energy from the public grid; and 2) with energy from public grid and local RES. For the other indicators, the baseline findings are with no local energy management and no local battery storage.

The after findings are for some indicators from simulations of the variants listed in the introduction of section 5.1.

Impact category	Indicators and sub-indicators		Demonstrator Baseline findings			After findings from simulations			Impact results
Energy	Share of green energy	GC 5.9.1 Share of green energy	From grid: 59.28 Sep-Dec: 61.37 (L3)			S1b no opt, no bat	S2 opt, no bat	S3 opt, bat	Both greenest optimization and batteries contributes to increment the grid mix. In particular when self-sufficiency increases, which also occurs here with less energy charge.
						67	87	76	
	Peak to average ratio	GC 5.10.1 Maximum peak power		L1	L3	S1b no opt, no bat	S2 opt, no bat	S3 opt, bat	Both the battery and optimisation contribute to improve this KPI.
			Sep.	11.9	16.36	38,5	22	26.03	
			Oct.	-	17.26				
			Nov.	12.2	19.64				
			Dec.	24.99	16.66				
		GC 5.10.2 Average power demand		L1	L3	S1b no opt, no bat	S2 opt, no bat	S3 opt, bat	The limited number of charges in demonstrator produces very low values. Without battery (S2), the smart energy management system charges when there is PV production and the total charged energy decreases.
			Sep.	0.13	0.7	2.95	1.2	3.2	
			Oct.	-	0.6				
			Nov.	0.43	1.23				
			Dec.	0.47	0.86				
	Self-consump-tion	GC 5.14.1 Energy self-consumption		L1	L3	S1b no opt, no bat	S2 opt, no bat	S3 opt, bat	PV data in L1 are not available and the battery does not work, while in L3 there is a background load that consume all PV production. Only in simulation we can observe The battery has a higher impact on self-consumption, but the EMS contributes to improve it.
			Sep.	0	100	0.61	0.41	0.68	
			Oct.	-	100				
			Nov.	0	100				
			Dec.	0	100				

[9] 320 gCO2/kWhel and 0.20 kWh/vkm accounting for electricity product declaration (see https://www.nve.no/energi/virkemidler/opprinnelsesgarantier-og-varedeklarasjon-for-stromleverandorer/varedeklarasjon-for-stromleverandorer)

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.

Impact category	Indicators and sub-indicators		Demonstrator Baseline findings			After findings from simulations			Impact results
		GC 5.14.2 Energy self-sufficiency		L1	L3	**S1b** no opt, no bat	**S2** opt, no bat	**S3** opt, bat	In S2, without battery, the EMS charges only if there is PV energy available. Thus the total charged energy decreases and the KPIs value is higher.
			Sep.	0	11.15	0.44	0.75	0.59	
			Oct.	-	6.31				
			Nov.	0	2.21				
			Dec.	0	0.9				

It has been observed that the measures operated in simulation allowed to obtain high values of self-consumption, above all when both the greenest optimization and the batteries are used.
In particular we observed that the current configuration, with the two working second life batteries is correctly dimensioned and it does need to scale.

The ***GC 5.10.1 Maximum peak power*** can increase a lot when more EVs are charging, but even if the operated measures do not have as an objective its minimization, its value and the **GC 5.10.1 Peak to average** benefit both of the greenest optimization strategy as a side effect.

Impact category Environment

There are two baselines: 1) The energy from the public grid is used as it is. 2) The energy the public grid and energy from local RES are used with no local energy storage and management. The after values are form simulations with local energy storage and management.

Impact category	Indicators and sub-indicators		Baseline findings	After findings/ Simulations			Impact results
Environ-ment	**CO2 emissions**	GC 5.12.2 Average CO2 Emission per kWh used	From grid: 189	**S1b** no opt, no bat	**S2** opt, no bat	**S3** opt, bat	The usage of PV production has a relevant impact on CO2 emission, above all in those scenarios where a high value. Both battery and greenest optimization have a big impact on co2 emission.
			Sep-Dec: 58.7 (L3)				
			Sept 5th – 12th	40.09	53.45	45.9	

5.3.3.3 Key impact – Measure group Business aspects

Impact category Economy

The baseline is a situation when charge points, infrastructure and batteries are not installed.

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Economy	**Capital investment cost**	GC 5.7.1 Capital investment cost	0	105 000 Euros	Charge points 15 000 Euros Infrastructure 40 000 Euros Battery storage 50 000 Euros

The demonstration has a technology focus, and the business aspects are not emphasized. In the course of the project, PMC is adapting, operating and evaluating the charging infrastructure and is paying a flat-rate fee since 01/2020. This situation will however change after the project, when business aspects come into play: The company owning the CPs would lease them out to the CPO on a monthly flat-rate basis. Vice versa a service fee is paid to the CPO depending on the number of CPs.

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.

5.3.3.4 Further analyses of findings and results

An analysis of the findings and results are provided below. "+" indicates that the result probably is "too good". "-" indicates that the result probably is "too bad". "+/-" indicates that there is an uncertainty. The reasons might be that other factors than GreenCharge or confounding factors might have influenced the result.

Effects of factors outside the control of GreenCharge

Such effects are illustrated in illustrated in Figure 2-1. This is relevant for the following indicators:

- **In general (-):** The COVID situation has had a huge effect on the demonstrator. People have been told to work from home. As a consequence, the demonstration period shrank due to delays, and there have been very few users.
- **Awareness and acceptance (-):** In general, the acceptance of e-mobility is low in Germany. Thus, it is likely that the awareness and acceptance are affected in a negative way.
- **Utilization of CPs (-):** As a consequence of the COVID situation, the utilisation is probably lower than it would have been under more normal circumstances.
- **Energy availability and Demand fulfilment (+):** As a consequence of the above, these indicators have probably been higher than they would have been under more normal circumstances.
- **Peak to average ratio:** Due to the lower utilisation of the charge points, the baseline findings for the peaks and the self-consumption are probably decreased, and the effects of smart energy management is also reduced.

Confounding factors

These factors may be caused by the software functionality and capability, the research data quality and completeness (see Chapter 6), and the process evaluation findings. In addition, other project specific issues may have caused other effects:

- **Charging flexibility, Utilization of CPs, and Charging availability CPs (+/-):** As described for the software assessment in section 6.2, the SoC cannot be provided from the in-vehicle systems. The value is manually provided via an App, and the input may be inaccurate or faulty. This may affect the charging flexibility in one way or another and thereby also the charge point utilisation and the charging availability. The demonstrator design, with an equal distribution of energy, might also have affected the indicators.
- **Share of green energy and Self-consumption (-):** As described in the process evaluation, there were problems with the 2nd life batteries, and surplus energy from the PV panels could not be stored. Thus, the share of green energy and the self-consumption is thus lower than it could have been. This was however handled through simulations.

Other observations

These observations can be the explained by process evaluation findings and dependencies between measures and measure groups (see Table 2-4):

- **Awareness and acceptance:** These indicators are in general low. This is probably partly due to that the demonstrator mainly is a technology demonstrator. The stakeholder involvement has in general been low, as shown by the process evaluation.

5.4 Bremen Demo 2 (EV sharing) evaluation

This section summarises the findings and results from the evaluation of the Bremen D2 demonstrator.

All measures described in section 3.4.2 are implemented. The problems experienced are described in the process evaluation input in Annex E.4.

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

5.4.1 Fulfilment of objectives and expected outputs

Note: Due to the relatively small scale of the demonstrator, the demonstrator objectives are not overall, generic, and quantitative (as stated in Chapter 3). Thus, the assessments of the fulfilment of the objectives are mainly about learning effects. The objectives are fulfilled if there are findings of evaluation results that facilitate learning.

The tables below provide a compact overview of the fulfilment of the demonstrator objectives and expected output related to the expectations defined in section 0. Colour codes indicates the fulfilment (green = fulfilled, yellow = partly fulfilled, red = not fulfilled).

In general, all objectives are met. All expected outcomes were not delivered, but the demonstrator facilitated learning of relevance to all of them.

Measure group	Overall objectives	Detailed objectives - See section 0	Fulfilment/Answer
EV fleet	Learn about the acceptance and potential of e-mobility services	What is the potential of EV sharing services in new housing cooperatives? How are the shared EV service accepted?	Low utilization rates due to low e-mobility acceptance in Germany and high possession of own vehicles. Maybe the EV sharing should be located in an area where car ownership is lower, and people are more willing to make use of shared cars.
Charging	Learn about the use of the EVs involved	To which extend are the EVs used and charged?	Covid-19 restrictions has caused less mobility. A marketing strategy is needed to promote car sharing usage. People should be aware of the benefits of EV sharing.
Business aspects	Learn about the economic potential of the services offered	Will such services be sustainable from an economic point of view?	Economies of scale is needed to create a financially viable business model. Fixed costs are a bottleneck and a large part of the total costs for car sharing operators. About 75% of the costs are related to vehicle leasing and insurance. Other fixed costs like parking costs are also high (about 10%). This could be avoided by stimulating car sharing through making parking freely available for car sharing companies. To be financially viable, revenues must increase to the double in a break-even business model. - EV sharing price cannot be increased to cover the gap – the service will be too expensive. - EV utilisation must be much higher. But then the availability of shared EVs could be scarce. Frequent users of shared cars want to have a guaranteed availability.

Measure Group	Expected output	Fulfilment	Learning
EV fleet	Housing cooperative residents can manage without a private car.	Few users, but very positive feedback from the users on the reliability of the service. Users, once registered, become regular users very fast. Feedback that one user sold his car due to the service.	Yes
	Housing cooperative gets a tax reduction due to a reduced land use for parking spaces	More important than tax reductions: They can build 20-40% fewer parking spaces. Building the parking areas often makes up to 15% of the total construction costs. Instead of paying a redemption fee to the city – for not building enough parking spaces - they are Buy EV sharing services.	Yes
	Increased awareness and acceptance of electric vehicles among residents.	For many residents, the EV sharing service is the first contact point with EVs. Especially before and during the first booking, there is a high need for support regarding EV specific questions. After the first few rides, people enjoy using EV a lot. However, the use of an EV is a big hurdle for many	Yes

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		potential users which we think is one of the reasons for the low number of users.	
Charging	Charge points at pickup and delivery locations.	The residents have charge points just outside their door.	Yes
Business aspects	The rewarding of eco-driving encourages a driving behaviour the causes less ware on the electric vehicles and thus a reduction of maintenance and investment costs.	Hard to answer because of the generally low usage of the vehicles. But also from a fleet management perspective, it is unlikely that eco-driving will lead to a reduction of maintenance costs. Firstly, maintenance cost for EVs is in general low, and secondly, the EVs are regularly changed due to the leasing contract. There might be a bigger impact if sharing companies own the shared EVs and have to maintain them over +5 years. In general, we don't see any impact on the investment costs.	Yes
	The digitalisation of the electric vehicle sharing process (use of App, key-less access, remote validation of driving licence) will hopefully reduce operating costs.	Absolutely. The service can hardly be performed without digital processes. The new build software / operation processes led to a reduction of operating cost by 14% comparing operation in 2018 and 2021.	Yes
	Viable business model for shared electric vehicle services.	Currently, EV sharing in Germany is a difficult business. Many additional revenue streams are established (cooperation with the housing association + additional marketing contract with the housing association) but still the utilisation of the EV is the key for building a successful business. In Germany, as still most people prefer owning a car - the number of private owned cars in Germany is on a record high. So, first of all, people have to be convinced to use shared cars and in a second step they also need to be convinced to use shared EVs. This might me one hurdle too much to overcome. Therefore, we think it might take some more years to make EV sharing a reliable business model, as in the coming years more people will get in touch with EVs.	Yes

5.4.2 Process evaluation

This section provides the findings and results from the process evaluation for the implementation of the Bremen D2 measures. The measures are implemented as described in Chapter 3. The input to the evaluation is summarised in Annex E.4.

The demonstrator has been operational for more than 1.5 years.

Lessons learned from supporting activities

The meetings in the EU Booster service were useful but the requirement on openness towards all participants was challenging. It should have been possible to keep business secrets in a more closed group.

Exploitation activities on new market channels will hopefully be fruitful in the future.

Lessons learned from implementation of measures

EV fleet measure group: The key lessons learned of importance for future e-mobility strategies are that more knowledge is needed. The EV fleet operator needs more knowledge on mobility in general. Technology competence must be complemented with insight into mobility challenges. The city also has too little knowledge on EV sharing, possibilities and barriers. More knowledge on business models is also needed.

Business aspects measure group: The key lessons learned of importance for future e-mobility strategies are that the economic sustainability of the business models is a challenge, and for a small company, it is difficult to plan the business models at the same time as the technology is developed.

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The operating costs of the EV sharing is high. When e-mobility acceptance in Germany in general is low, the utilization of the EVs will also be low.

Subsidies from the city make the EV provider less dependent on the use of the EVs.

Recommendations

Recommendations regarding the design and implementation of business models:
Business models must be emphasized: Expert support should be used if needed.

A sufficient acceptance level for both car sharing and e-mobility must be ensured. Today it is a challenge to get enough customers. Fixed costs are a bottleneck and a large part of the total costs for car sharing operators, and they depend on a high degree of utilisation of the EVs. People must be willing both to use a shared car and to use an electric car.

Fleet operators and the city must collaborate with EV fleet operator. They need parking and charging spaces for the EVs, and they need support like e-mobility incentives and EV sharing incentives.

5.4.3 Impact evaluation

This section provides a summary of findings and results from the impact evaluation for each measure group of relevance to the demonstrator (see section 2.1), organised according to the impact categories defined by the CIVITAS evaluation framework [10].

The findings are the indicators of relevance are defined in section 4.4.

The impact results are a comparison and a judgement of the baseline and the after findings.

5.4.3.1 Key impact – Measure group EV fleet

Impact category Society and People

The baseline is the situation before the start of GreenCharge. There were no shared EVs available at the locations involved and few in the city of Bremen in general.

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Society and People	Awareness	GC 6.1 Awareness level	Low	Medium (Residents)	The awareness has raised. However, the use of an EV is a big hurdle for many potential users which we think is one of the reasons for the low number of users. To raise awareness the EVs should be seen all the time in the parking lot (but it was not economically sustainable). There is a lack of information in the charging point itself, which might be considered an operational barrier.
	Acceptance	GC 6.2 Acceptance level	Low	High (Users of service) Low (residents in general) High (city)	For many, the service is the first contact point with EVs. After the first few rides, people enjoy using EV a lot. There are few users, but they use the services on a regular basis. Those that use the service have provided positive feedback, and we the acceptance has raised a lot and is now high. Acceptance of the app used is high among the users.

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					The acceptance among those that are not users is still low. Use of an EV is a big hurdle for many potential users. The city of Bremen has a very high acceptance of shared vehicles in general and shared EVs in particular. Shared EV fleets in one of their preferred measures towards sustainable transport.
	Accessibility	GC 6.4 Operational barriers	NA	Low (Users of service) Low (Fleet operator)	There are very few operational barriers. The residents have charge points with EVs just outside their door. Since the service may be the first contact point with EVs, there is a need for support regarding EV specific questions the first time the service is used. After that, there are very few barriers. Digital fleet management tools have reduced the operating cost by 14% comparing operation in 2018 and 2021.

5.4.3.2 Key impact – Measure group Charging

Impact category Transport System

For the number of EVs and CPs, the baseline is the situation before GreenCharge. There was no access to a shared EV fleet and charge points for the residents. The after values are for November 2021.

Indicators and sub-indicators		Baseline findings	After findings	Impact results
Number of EVs	GC 5.1.1 Number of EVs	0	4 or more	4 or more. One extra EV and one Hybrid have requested use of the CP (but may not be owned by resident)
	GC 5.1.3 Number of specific EVs	0	4 (shared EVs)	4 new shared EVs
Number of CPs	GC 5.2.1 Number of CPs	0	4	4 new CPs
	GC 5.2.2 Share of CPs	0	4/32= 12,5%	Less than 12,5 % It is difficult to know the total number of parking spaces but at least 28 belongs to one building (with 100 of 158 apartments)

Impact category Environment

The baseline is the situation before the start of GreenCharge. No shared EVs were available, and fossil vehicles were used. Thus, the baseline is the CO2 emission with use of fossil vehicles for the same driving distance. The after value is the emission from the EV fleet. The date used in the calculations are:

Location of shared EV	Period	Total distance driven by EV
LP#1	2020.06 -2021.12	5957 km
LP#2	2020.06 -2021.12	6308 km
EURO#1	2020.06 -2021.12	7042 km
EURO#2	2020.06 -2021.12	8225 km

CO_2 emission factors are[10]:

- 168,1 g/km (Euro 4)
- 129,2 g/km (Euro 6)

[10] Emission factors – See page 54 - *NEFZ* (English New European Driving Cycle (NEDC)) .https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/2020-06-29_texte_116-2020_tremod_2019_0.pdf

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.

TOTAL	**27532 km**	

We do a manual calculation of emission, not including the emissions caused by the production of the vehicles. Emission from EV is set to 0. There are several alternatives for the emission caused by fossil vehicles:

- Using emission factor for Euro 4: 168,1 g/km * 27532 km = 4628 kg CO_2
- Using emission factor for Euro 6: 129,2 g/km * 27532 km = 3557 kg CO_2
- Using the calculator provided by the Norwegian Environment Agency[11]: 3500 kg CO_2

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Environ-ment	**CO2 emissions**	GC 5.12.3 CO2 Emission	Euro 4: 4628 kg CO_2 Euro 6: 3557 kg CO_2 Calculator: 3500 kg CO_2	0	More than 3500 kg CO_2 are saved.

5.4.3.3 Key impact – Measure group Business aspects

Impact category Society and People

The baseline is the situation before the start of GreenCharge. There were no EV sharing service available at the locations involved, and no or very low awareness and acceptance of the business models for such services.

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Society and People	**Awareness**	GC 6.1 Awareness level	No/Low	Medium (housing cooperatives) High (city)	City regulations might have contributed to higher awareness about business models and shared EVs among housing cooperatives. Instead of paying a redemption fee to the city – for not building enough parking spaces – housing cooperatives may buy EV sharing services. Through involvement in the project, the city of Bremen has become much more aware of the business-related challenges related to shared EV fleets.
	Acceptance	GC 6.2 Acceptance level	No/Low	Medium (housing cooperative) Low (Users of service)	The city regulations mentioned above may also have contributed to higher acceptance among housing cooperatives. Due to the shared EV fleet, the housing cooperative can cope with 20-40% fewer parking spaces. This may reduce the total construction costs with 15%. The utilisation of the EV is low. EV sharing in Germany is a difficult business in Germany. It might take time to make EV sharing a reliable business model.

Impact category Economy

The baseline is the situation before the start of GreenCharge – no EV sharing service.

[11] https://www.miljodirektoratet.no/tjenester/klimagassutslipp-kommuner/beregne-effekt-av-ulike-klimatiltak/

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.

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Economy	**Average operating cost**	GC 5.6.1 Total average operating costs	0	2648 Euro	Leasing vehicles is really expensive. Around 73% of the operating costs are due to leasing vehicles and insurance. 9% is due to parking of the vehicles.
		GC 5.6.4 Average energy cost	0	288 Euro	11% of the total operating costs are due to energy consumption of the vehicles.
	Average operating revenue	GC 5.8.1 – Revenue from normal operation	0	1.642,31 Euro	The revenues are lower than overall costs. Resulting in negative earnings of 1.317 euro per month.

5.4.3.4 Further analyses of findings and results

An analysis of the findings and results are provided below. "+" indicates that the result probably is "too good". "-" indicates that the result probably is "too bad". "+/-" indicates that there is an uncertainty. The reasons might be that other factors than GreenCharge or confounding factors might have influenced the result.

Effects of factors outside the control of GreenCharge

Such effects are illustrated in illustrated in Figure 2-1. This is relevant for the following indicators:

- **Acceptance and awareness (-):** COVID-19 has caused social distancing, reduced mobility, and scepticism regarding the sharing of EVs with others. In addition, the general situation in Germany is that the acceptance and awareness of both e-mobility and car sharing are low. Most people prefer owning a car. So, first people have to accept to use shared cars, and in addition they must accept to use a shared EVs.

  The city of Bremen has independent of GreenCharge a focus on promoting car sharing services as an alternative to private cars ownership. The reductions in the redemption fee to be paid by the housing cooperatives to the city when the need for parking spaces is decreased may also have contributed to a higher awareness and acceptance.

- **Average operating revenue (-):** The COVID situation has influenced the acceptance, and thus probably also the revenue.

Other observations

These observations can be the explained by process evaluation findings and dependencies between measures and measure groups (see Table 2-4):

- **Average operating cost:** A change in the business models from owning EV to leasing EVs has moved costs from capital investments costs to operating costs. This have made the business model more viable.
- **Average operating revenue:** The low acceptance has caused few users, and low revenue. The business model challenges identified in the process evaluation have also contributed to the low revenue-

5.5 Barcelona Demo 1 (eScooters battery swapping) evaluation

This section summarises the findings from the data analysis, the evaluation results from the impact and process evaluations of Barcelona Demo 1.

All measures described in section 3.5.1 are discussed. They have been split between two locations: t

- Location 1 implements a B2C approach, has been able to gather data about trips to analyse driving profiles.

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.

- Location 2 implemented the B2B approach during the second half of the project and focuses on gathering data related to charging sessions. The new B2B business have been operational for 6 months or more, although the fleet and the number of trips is relatively small (starting step by step).

The implementation of incentives has been very limited and more as a proposal to a selected small number of users (see details in the process evaluation input in Annex **Error! Reference source not found.**); due i rregularity in the operation of the service, not bothering customers have been prioritise. However, analysis of driving patterns and feedback from users about of acceptance of such a scheme has been performed.

5.5.1 Fulfilment of objectives and expected outputs

The tables below provide a compact overview of the fulfilment of the demonstrator objectives and expected output related to the expectations defined in section 3.5.1. Colour codes indicates the fulfilment (green = fulfilled, yellow = partly fulfilled, red = not fulfilled).

Measure group	Overall objectives	Detailed objectives	Fulfilment/Answer
EV fleet	Learn about the acceptance of e-scooter service (B2B and B2C)	What is the potential of EV sharing services combined with multilocation battery hubs?	During the COVID-19 mobility restrictions, the B2B service was very demanded due to the increase of on-line shopping and take-away delivery. It is uncertain how it will evolve in the future. B2C suspension of the service and changes in regulation in Barcelona led to going out of business in the city, but not in other locations. It does not change big changes in usage.
		How spread does the battery hub network need to be?	As spread as possible. The costs of adding new hubs are small because third parties take care of the daily operation and there is no investment in infrastructure, apart from the battery hub itself.
		Free-floating versus station-based approach: acceptance and operational costs	Station-based approach is more convenient for the fleet operator; it reduces the cost and the need of staff. As more shop tenants join, the user may have a similar situation as free-floating in the city centre.
Charging	Learn about predictability of charging needs Learn about the use of the EVs involved	To which extend are the EVs used and charged?	Still not as much used as it should require a profitable business model.
		Average energy user per trip?	0.171 kWh/trip
Smart energy management	Learn about charging flexibility potential	How flexible is the charging process: ratio time to charge/time to next battery use	Batteries are not charged for every trip; on average every 6.5 trips. The flexibility is high because they could be charged at the end of one of the 6 trips
		How much energy locally produced will contribute to reduce carbon footprint and size of connection to the grid	Since every battery hub charges up to 6 batteries, a small PV installation can significantly reduce the capacity of the grid connection. The exact amount needs further calculations.
Business aspects	Learn if users are open to	How big has the incentive to be to	According to the surveys, users will only be willing to change behaviour if there is reward involved. The margin for offering rewards is quite limited

	change their driving profile when incentives are put in place. Learn if smart charging and local RES helps in business exploitation	persuade users to drive smoothly	at this phase of the business. Only operational costs are 40% of the revenue stream.
		How much maintenance costs are reduced due to more sustainable driving behaviour (less wear of the brakes, etc.)	Not able to compute yet
		To which extend a RES installation pays back?	Considering the scalation in price and the subsidies, the payback is claimed to be 5 years. A more conservative approach is to consider between 8-10 years, considering the maintenance of the installation.

Measure Group	Expected output	Fulfilment
EV fleet	• Provide sufficient offer for EV users • Keep level of satisfaction of users	Partially. The fleet is still rather small
Smart energy management	• Reduction of peak demand by sequencing battery charging • Reduction of energy bill by charging at off-peak hours and using energy locally produced • Reduction of carbon footprint by using greener energy	Estimations show the peak demand can be reduced. The energy bill was not affected because a flat tariff was in place. Reduction of carbon footprint has been achieved by contracting a green energy retailer
Business aspects	• Reduce operational cost	Not able to compute

5.5.2 Process evaluation

This section provides the findings and results from the process evaluation for the implementation of the Barcelona D1 measures. The work is carried out as described in section 2.3.

Lessons learned from supporting activities

Here we summarize the supporting activities that contributed in a positive way.

Workshop on business models:

- Joining together people with different background helps to bring new perspectives to address the challenges.

Participation in fairs (when it was possible):

- Presence in fairs in Barcelona (EVS, Expoelectric) of partners involved in the project creates a good opportunity to disseminate the project and get in contact with relevant stakeholders. The project is also an ice breaker for visitors to approach and know the activity of the partner.

Interviews to users and operators:

- Several interviews were held to get EV fleet operators' feedback and user's acceptance of the incentive scheme.

Lessons learned from implementation of measures

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 main lessons learned from the process evaluation are:

More data is needed:

- Data on charging profiles are needed to do calculations on the cost-benefit of implementing smart charging.
- Analysis of flexibility of the charging process and thinking out of the box to get a chance to smart charging is required to be able to convince about the benefits on doing so.
- Knowledge on business models is needed.
- Accuracy of the IoT sensors is very important to use the information to do smart management. The new sensors installed in the e-scooters do no perform as well as expected and show an erratic behaviour. They were selected because they were supposed to be more accurate than the previously used ones.

The economic sustainability of the business models is a challenge:

- The operating costs of the EV sharing are high.
- The operation and maintenance of an e-scooter service is complex.
- Ideally, to gain visibility, and a critical mass of customers, the fleet should be big. However, investment costs are unacceptable for a small company.

Recommendations

Recommendations regarding business modelling: Trying to find business sustainability only from the point of view of a single player will never succeed for EV sharing fleets when investment and operational costs are higher compared to other type of vehicles. Synergies have to be established with stakeholders that might benefit from the positive aspects of electromobility compared to ICE vehicles (noise, air pollution) including claiming for subsidies.

Recommendations regarding research: Data blocks any research activity. The knowledge obtained by the early analysis of datasets may even alter the final solution. However, the business survival was paramount and data gathering processed needs to adapt to reality.

5.5.3 Impact evaluation

This section provides a summary of findings and results from the impact evaluation for each measure group of relevance to the demonstrator (see section 2.1), organised according to the impact categories defined by CIVITAS evaluation framework [10].

The findings are the indicators of relevance are defined in section 4.5.
The impact results are a comparison and a judgement of the baseline and the after findings.

Note: Some findings (indicators) are established through qualitative analysis of the data obtained. It would have been interesting to define a set of simulations scenarios, that might be done in the future. At this moment, one can rely on the effect of simulations done in Oslo and Bremen pilots.

5.5.3.1 Key impact – Measure group EV fleet

Impact category Society and People

The baseline is the situation where the main concern for the fleet operator is to have the batteries ready for use and to do as many trips as possible.

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.

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Society and People	**Awareness**	GC 6.1 Awareness level	They know about the service by different means (social media, ads, friends)	No changes	For one of the location the figures of usage of the service are not representative because of mobility restrictions due to COVID-19. For the second location, the new service is operational at very low scale.
	Acceptance	GC 6.2 Acceptance level	Most users are satisfied with the availability and performance of the service	Affectation was observed (positive in the sense that they did not perceive a decrease of quality of service)	No real impact on acceptance level.
	Accessibility	GC 6.3 Perception level of physical accessibility of service	Not known	Mostly satisfied; some claims to have more vehicles available to get use to them	Measures had no impact on the B2C approach. The fleet size is still small. It is perceived that it could improve. During the COVID-19 restrictions, availability was 0. After that, it took some time to put them into operation again.
		GC 6.4 Operational barriers	-	When the service was restricted	No impact identified

5.5.3.2 Key impact – Measure group Charging

Impact category Society and People

The baseline is that the batteries charged as soon as they are plugged in. They are brought to the charging hub when they reach a certain SoC.

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Society and People	**Awareness**	GC 6.1 Awareness level	Partially aware	People are more aware of energy cost because it is every day on the media	Fleet operator does not see smart charging as an improve of fleet operation.
	Acceptance	GC 6.2 Acceptance level	Low	Low. There is a lack of trust, until the solution had been extensively tested	Acceptance level is low in the sense that the fleet operator is reluctant to made investments for smart charging with uncertain payback and a long period needed for integration, deployment and testing. The solution is not plug&play yet.
	Accessibility	GC 6.3 Perception level of physical	Low	Low	Not off-the-shell solutions available. Need time and money to have the system working.

		accessibility of service			
		GC 6.4 Operational barriers	High	Medium	The effort required is high enough to perceive it as an operational barrier and a physical (logistic) problem for organising battery swapping.

Impact category Transport System

The baseline is the situation without smart charging: the batteries are charged as soon as they are plugged in the battery hub.

Impact category	Indicators and sub-indicators		Baseline findings	After findings		Impact results
Transport system	**Number of EVs**	GC.5.1.1 Number of EVs	0 (for B2B)	8 (B2B) 50 (B2C)		The fleet number is small
		GC.5.1.4 Number of planned EVs	20-40	-		The situation and its evolution is uncertain
	Utilization of CPs	GC 5.3.1 Share of connected time	Not known	Aug	42.45	The connected time has not changed (no smart management applied). The KPI show 50% of the time the hub is free to receive additional charging sessions (more batteries to increase EV availability)
				Sep	53.58	
		GC 5.3.2 Share of charging time	Not known	Aug	88.11	Some flexibility can be obtained. Surprisingly, in August, the share of charging time is quite high. The fleet operator might apply a scheduling him/herself
				Sep	64.47	
		GC 5.3.3 Energy per time unit	Not known	Aug	0.16	The amount of energy needed is fairly small. There is no need for investment in extending local network capacity, thus investment costs are kept low.
				Sep	0.14	
		GC 5.3.4 Number of charging sessions	50-80	Aug	55	The number of charging session have been affected by the number of usages and not for the measure.
				Sep	67	
				Sep	-	
		GC 5.13.2 Actual flexibility		Aug	0.911	Flexibility to match local energy production or off-peak prices is relevant.
				Sep	0.914	

Impact category Environment

The baseline is the one that uses the energy from the public grid. The average CO2 emissions for 2021 are 138 g/CO2eq

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.

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Environ-ment	**CO2 emissions**	GC 5.12.1 Average CO2 Emission per km driven	7.5 g/CO2	1.2 g/CO2	The e-scooters have a ratio of 54 W/km and 171 W/trip. If only PV is used for charging, either from local production of from certified green energy, the emissions are much reduced.

5.5.3.3 Key impact – Measure group Smart energy management

The baseline is that the battery hub is connected to the grid and no smart management is done.

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Society and People	**Awareness**	GC 6.1 Awareness level	Partially aware	Aware	According to the feedback, they are aware of the charging process and the impact of different strategies.
	Acceptance	GC 6.2 Acceptance level	Low	Not relevant for them	In general, how the batteries are charged in not perceived as an added value.

Impact category Energy

The baseline situation is with no local RES, all energy coming from the grid and the batteries are charged as soon as they are plugged in (no smart energy management).

Impact category	Indicators and sub-indicators		Baseline findings	After findings		Impact results
Energy	**Share of green energy**	GC 5.9.1 Share of green energy	Equal to energy grid.	Aug Sep	(see impact)	The share of green energy could increase with the installation of PV panels. The energy produced by PV panels is greener than the average CO2 emissions for renewable energy from the grid (average emissions of RES in Spanish grid: ; CO2 emissions for PV solar energy:)
	Peak to average ratio	GC 5.10.1 Peak to average ratio	95.06 84.44	Aug Sep	(see impact)	The peak to average ratio is very high, because as presented above the share of connected time is aprox. 50% leaving to periods with a very low demand. Shifting charging using the flexibility will help to reduce the peak power (in many cases it will be the power demand of charging only one battery). The price paid for peak

Impact category	Indicators and sub-indicators		Baseline findings	After findings		Impact results
						demand will decrease, leading to constant savings.
	Self-consumption	GC 5.14.1 Energy self-consumption	0	Aug Sep	Not computed	Taking into account that there are spare batteries, the self-consumption will be very close to 100%
		GC 5.14.2 Energy self-sufficiency	0	Aug Sep	Not computed	If an appropriate location is found for PV installation, it is estimated that a hub with 6-10 batteries can reach a high degree of self-sufficiency
	Share of battery capacity for V2G	GC 5.4.1 Share of battery capacity for V2G	0	Aug Sep	281.76 286.67	A V2G approach is not of high relevance for this demonstrator since there are spare batteries to charge, unless the energy is sold to the grid for ancillary services or regulation.

5.5.3.4 Key impact – Measure group Business aspects

Impact category Society and People

The baseline is that there is no incentive plan to reward users to avoid over expenditure of energy in their trips and battery degradation.

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Society and People	**Awareness**	GC 6.1 Awareness level	Unknown	Higher	Some of the interviewees consider that they have an aggressive driving pattern that could be changed.
	Acceptance	GC 6.2 Acceptance level	Unknown	High	All interviewees were open to make a try on changing their driving pattern if they would be rewarded.
	Accessibility	GC 6.5 Relative cost of the service	Acceptable	Acceptable	According to the feedback from the interviews, one of the reasons for using MOTIT is that the cost of the service is affordable and similar to public transportation

Impact category Economy

The baseline is that the system operates with the minimum number of sensors for EV fleet control; not monitoring or controlling energy consumption in real time.

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Economy	**Capital investment cost**	GC 5.7.1 Capital investment cost		Cost of IoT sensors and actuators	There is an increase of capital investment due to

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.

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
					the new sensors installed and the hosting for data storage and computation. To be included also the cost of installation and maintenance of PV panels.
	Average operating cost	GC 5.6.1 Total average operating costs	4 € per battery swap 0.2 €/trip	The same	We expect this cost to be slightly lower, but we haven't gathered enough data to quantify it.
		GC 5.6.4 Average energy cost	0.4-0.8 €/trip	Not computed	The average energy cost may vary with different tariff schemes or by adding a PV panel. In the current situation, no tariff could have been more beneficial that the one in place. The addition of PV panels could produce some savings, but will require an initial investment to be redeemed.
		GC 5.6.5 Maintenance costs	125 €/VE.year	Not enough data to compute	The savings will appear in the mid-long term. In the case of the B2C business, the maintenance cost had increased because the batteries were spoilt during the inactivity of the service
	Average operating revenue	GC 5.8.1 – Revenue from normal operation	-	-	
		GC 5.8.2 – Revenue from Penalties	0	*	There are no penalties, but rewards.

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.

5.5.3.5 Further analyses of findings and results

An analysis of the findings and results are provided below. "+" indicates that the result probably is "too good". "-" indicates that the result probably is "too bad". "+/-" indicates that there is an uncertainty. The reasons might be that other factors than GreenCharge or confounding factors might have influenced the result.

Effects of factors outside the control of GreenCharge

Such effects are illustrated in illustrated in Figure 2-1. This is relevant for the following indicators:

- **In general (-):** The COVID situation has had a huge effect on the demonstrator. The sharing services were interrupted for many months due to mobility restrictions and other restrictions imposed to some non-essential activities. The first consequence, when the service was resumed, was that the ICT sensors in the batteries have drained all the power and they could not be restored. Major investments were needed to put the service into operation again. A temporary (+) consequence was that the delivery sector increased by on-line shopping and take-away meals.
- **Regulation (-**): Barcelona city council has limited the number of licences for sharing services, thus some of the operators have stopped its activity.

Confounding factors

These factors may be caused by the software functionality and capability, the research data quality and completeness (see Chapter 6), and the process evaluation findings. In addition, other project specific issues may have caused other effects:

- Acceptance of e-mobility and EV sharing among potential users.
- The price of the service compared to other transport services and other light vehicle sharing options.
- How easy it is to use the service.
- The economy of potential users of the service.
- The awareness about the service.
- The size of the fleet
- Policies introducing mobility constraints in certain areas

Other observations

These observations can be the explained by process evaluation findings and dependencies between measures and measure groups (see Table 2-4)

5.6 Barcelona Demo 2 (charging in ESN at work) evaluation

This section summarises the findings from the data analysis, the evaluation results, and the conclusions from the impact and process evaluations of Barcelona Demo 2.

5.6.1 Fulfilment of objectives and expected outputs

The tables below provide a compact overview of the fulfilment of the demonstrator objectives and expected output related to the expectations defined in section 3.6.1. Colour codes indicates the fulfilment (green = fulfilled, yellow = partly fulfilled, red = not fulfilled).

Measure group	Overall objectives	Detailed objectives	Fulfilment/Answer
Charging	Learn about charging management complexity of shared CPs.	How many users can be served?	
		How long do employees stay?	
		How rigorous users are on booking in advance, provide real charging needs and observe arrival and departure times.	

		Which mechanisms (rewards/penalties) incentivise users to "behave" according to plan: is giving priority a good incentive?	
		To which extend including e-roaming is positive for private CPs?	
Smart energy management	Learn about charging flexibility potential Learn about how local RES can support EV charging and other loads To find solutions to accommodate EV charging in existing buildings with limited grid capacity	How flexible is the charging process: ratio time to charge/time parking	
		To which extend local PV panels support load balancing and avoid extending grid connection	
		How much energy locally produced will contribute to reduce carbon footprint and size of connection to the grid	
		How beneficial would be to include V2G? Are users willing to provide battery storage capacity? Will the installation of a stationary battery be beneficial for that purpose?	

Measure Group	Expected output	Fulfilment
Charging	• Provide with charging capabilities Eurecat employees driving e-cars • Minimize barriers for Eurecat employees considering buying an electric vehicle • Minimize the investment on charging infrastructure and electricity network • Demonstrate interoperability for future exploitation of charging system or integration of off-the-shelf charging infrastructure • Increase charge point usage compared to the approach of installing as many charge points as e-cars • High predictability on energy demand due to charging operations due to compulsory booking • Gather knowledge about user requirements and acceptance on charging infrastructure and willingness to pay	
Smart energy management	• Keep peak demand similar to the situation with no charging infrastructure • Avoid peak pricing (shift loads to off-peak) • Reduction of carbon footprint by using greener energy • Define the best size of PV installation for return of investment, reduction of grid interconnection capacity and explore potential for participation in flexibility energy market	

5.6.2 Process evaluation

This section provides the findings and results from the process evaluation for the implementation of the Barcelona D2 measures. The work is carried out as described in section 2.3.

Lessons learned from supporting activities

Here we summarize the supporting activities that contributed in a positive way.

Involvement of Eurecat organisational departments:

The measures could not be applied without the support and approval of organisational departments such as infrastructure management (including facility managers), human resources department and communication department. The big facilitator has been the head of infrastructure department who has acted as a connector to the facility managers of the different buildings and to the top management of Eurecat to grant authorization for the actions to be performed. She has also shared the vision and roadmap of Eurecat in terms of electromobility and we have identified synergies, being GreenCharge a first step to test certain measures at small scale before growing. She has also redirected users interests in charging that were addressed to her.

In that respect, the achievements reached are:

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.

- To have a reference point to concentrate initiatives related to electromobility and energy management.
- To align Eurecat energy strategy and GreenCharge approach.
- Completion of installation of charging infrastructure with monitoring and control capabilities.

Contact with e-car drivers:
The community of e-car drivers at Eurecat is rather small but very active. As soon as someone become an e-car driver, it joins the “club” and exchange impressions. One of the main entry points to the community is the research unit in charge of the battery lab. This unit is involved in GreenCharge project; thus, they immediately mention the project and an exchange of opinions start. Knowing first-hand the initiative helps them to better understand the goals and to engage them in participating.

Two main mechanisms were used to reach e-car drivers:

- Questionnaire published in the internal newsletter to get a list of employees interested in participating, because they own a car or they plan to buy one in the near future.
- Informal talks to potential users, either met through the questionnaire of known beforehand.

Interviews with members of the local reference group and other suitable companies to deploy a smart energy management to:
Valuables insights on service provider and user experience, especially regarding to charging. Those insights had led to consider a simplification of the booking process. Initially, it was designed thinking more on the research interest that on the user interest.

Collaboration with other GreenCharge partners:
Most part of the design and work for Barcelona D2 demo was realised by Eurecat. However, W2 and W4 task workforce meetings had been very helpful to keep going and to learn from other demonstrator's experiences. Yet, room for cross-pilot interoperability has been identified through eRoaming being Eurecat the CPO and ZET the EMP using Hubject platform.

Lessons learned from implementation of measures

The main lessons learned from the process evaluation are:

1. Implementing **the charging measure group**, the key lessons learned, important for future sustainable e-mobility strategies are:
    a) **Flexible charging.** Flexible charging is only possible is the user introduces in the system the current SoC manually, since automatic data collection is not possible, and the desired SoC at departure time. To ensure that SoC is provided, the charging point will be always switched off by default. With no smart charging activated (at initial state to collect baseline data) the charging point will only be activated when the user introduces the SoC. To facilitate the process, the most common used values will be presented as default value. However, acceptance of the value is needed.
    b) **Charge point equipment.** The decision of not using an off-the-shelf solution has turned to be a good idea after knowing the problems that other demos have had to interact with the charging point equipment and systems. However, for better exploitability and interoperability, it would have been better to support also OCCP. That can be added later, though.
2. Implementing **the smart energy management measure group**, in an office environment relies basically on management of charging points and HVAC. Beyond interoperability aspects, facility managers are reluctant to let HVAC to be managed automatically. A good convincing argument is to quantify the effects beforehand using meters readings from the building.

Recommendations

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.

Recommendation on stakeholder involvement:

- **Several types of actions and channels** must be considered to get input and to involve/provide information, depending on the stakeholder profile and the capability to meet face-to-face e.g.:
    - Face-to-face workshops and meetings.
    - Videoconference meetings
    - Information letters using digital channels (email)
    - Posting news and newsletters (use any new advance or event as an excuse to keep the community engage)
    - On-site posters
    - On-line questionnaires.
- **Affected stakeholders** must be involved in decision process to make sure we do not forget side effects.:
- **Redundancy of contact person:** To solve incidences as much as possible, more than one contact person should be provided (this covers situations where the main contact person is on a meeting, sick or on holidays)

Recommendations regarding the design of the price models:

- **Different electricity tariff schemes:** To provide interesting insights to facility managers about the potential of smart energy management, one cannot restrict the electricity price to the actual one. Different price schemes appear in an unforeseen manner (i.e., in Spain they changed the max power fees on June 1st 2021). Yet spot price is very volatile. The best information to be given is a sensitivity analysis.
- **The traditional approach to business models is not sufficient**. It must be recognised that:
    - The value proposition is not just about the economy. It is also about sustainability with respect to environmental and societal aspects, e.g., to reduce energy peaks.

Recommendation regarding the purchase of hardware and equipment:

- **Planned in advance.** To avoid bottle necks because the ordering has taken longer, or the delivery is delayed.
- **Standard/open protocols** make sure they allow interoperability using standard, or even better, open standards. However, be prepared to need several iterations to make it work. Try to make sure the provider has a good customer support to assist on technical issues.

Recommendations regarding policy, standardization, and harmonization issues:

- Regarding SoC:
    - Charging protocols must provide the current SoC to facilitate optimal charge planning in ESNs.
    - Navigation systems must facilitate the provision of desired SoCs, e.g., based on planned trips or artificial intelligence using input on the EV user's habits.
- Regarding software integration
    - The integration process is also cumbersome. It has to be taken into account to avoid delays. A good atmosphere helps in understanding each other and work for a common objective: the solution does not work if the components work separately; they have to work together. It is not helpful to blame others works but to find a solution together.

5.6.3 Impact evaluation

This section provides a summary of findings and results from the impact evaluation for each measure group of relevance to the demonstrator (see section 2.1), organised according to the impact categories defined by CIVITAS evaluation framework [10].

The findings are the indicators of relevance are defined in section 4.6.
The impact results are a comparison and a judgement of the baseline and the after findings.

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.

Note: Some findings (indicators) are established through simulations that extend the capability of the demonstrator.

5.6.3.1 Key impact – Measure group Charging

Impact category Society and People

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Society and People	**Awareness**	GC 6.1 Awareness level	Low		The number of e-car drivers at Eurecat is very low according to a poll issued in March 2020 to identify target users. Around 10 potential users were identified. However, changes in the staff may have changed this number. The rest of employees not having an e-car has little knowledge on charging details and how it can be optimized. The human resource department and the legal department, consulted for the implementation of the measure did not know much about the topic
	Acceptance	GC 6.2 Acceptance level	High*		Facility managers of the chosen premises were quite open to include charging capability although they had not perceived a need to do so..
	Accessibility	GC 6.3 Perception level of physical accessibility of service	Medium		
		GC.6.4 Operational barriers	Low		The users interested in charging at the premises are satisfied with the option of being able to charge. Some minor issues arose at the beginning, but they were solved. Direct contact was possible due to the fact that only 2 persons have used the charging points.

Impact category Transport System

The baseline is that 8 charge points existed before GreenCharge, but they were not monitored, no flexibility was provided, and they were reserved for use by specific employees.

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Transport system	**Number of EVs**	GC 5.1.1 Number of EVs	10*		
		GC 5.1.2 Share of EVs	< 1%*		
		GC 5.1.5 Number of planned EVs	Not available		
	Number of CPs	GC 5.2.1 Number of CPs	10*	11	The number of CPs with smart capabilities were 0 at the beginning and are 3 now.
		GC 5.2.4 Number of shared CPs	2	3	
	Utilization of CPs	GC 5.3.1 Share of connected time		25.80 %	
		GC 5.3.2 Share of charging time		37.39 %	
		GC 5.3.3 Energy per time unit		0.58 kW	

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.

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
		GC 5.3.4 Number of charging sessions		37	
	Charging flexibility	GC 5.13.2 Actual flexibility		0.845	

Impact category Environment

There are two baselines: 1) The energy from the public grid is used as it is. 2) The energy the public grid and energy from local RES are used with no local energy storage and management.

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Environment	CO2 emissions	GC 5.12.1. Average CO2 Emission per km driven	From grid: 27.6	27.5	Small saving.

5.6.3.2 Key impact – Measure group Smart energy management

Impact category Society and People

The baseline is the situation before GreenCharge

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Society and People	Awareness	GC 6.1 Awareness level	Low		Awareness on the potential to shape load demand is only know by researchers working in the energy domain.
	Acceptance	GC 6.2 Acceptance level	Medium		Facility managers and users accept the measure because they have to. In the case of facility managers, because it is a requirement of the project for which Eurecat receives funding, and in the case of e-car drivers, because the charging is offered for free. Offering flexibility is a kind of paying back for the energy used.
	Accessibility	GC 6.4 Operational barriers	Medium		No effective smart energy management has been experimented yet, thus it is unclear whether operational barriers will appear. However, initially, the option to adjust HVAC parameters has been perceived as difficult.

Impact category Energy

The baseline situation is no control and no predictability in the charging sessions, no control on the HVAC system and limited local production.

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.

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Energy	Share of green energy	GC 5.9.1 Share of green energy			
	Peak to average ratio	GC 5.10.1 Maximum peak power		1.72	
		GC 5.10.2 Average power demand		0.15	
	Self-consumption	GC 5.14.1 Energy self-consumption	0	13.98	
		GC 5.14.2 Energy self-sufficiency	0	73.17	

Impact category Environment

There are two baselines: 1) The energy from the public grid is used as it is. 2) The energy the public grid and energy from local RES are used with no local energy storage and management.

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Environment	CO2 emissions	GC 5.12.2 Average CO2 Emission per kWh used	From grid: 138 gCO2eq/kWh	With the PV panels and with/without no smart energy management 137.51 gCO2eq/kW[12]	Small reductionbecause the PV production is small

5.7 Barcelona Demo 3 (eBike sharing) evaluation

This section summarises the findings from the data analysis, the evaluation results, and the conclusions from the impact and process evaluations of Barcelona Demo 3.

5.7.1 Fulfilment of objectives and expected outputs

The tables below provide a compact overview of the fulfilment of the demonstrator objectives and expected output related to the expectations defined in section 3.7.1. Colour codes indicates the fulfilment (green = fulfilled, yellow = partly fulfilled, red = not fulfilled).

Measure group	Overall objectives	Detailed objectives	Fulfilment/Answer
EV fleet	Learn about the acceptance of e-bike service Learn about operation and maintenance and sustainability	How big is the target community that can become users of the e-bike sharing service?	
		How expensive is to operate the service? Can a sustainable business case be derived? As a stand-alone service or in combination with public transport operators?	
		How ICT enhance safety and security? (vandalism)	
		Will a booking system increase the number of users or number of trips?	
		Will it be possible to open the service to other group of users (i.e. during weekends)?	
Charging	Learn about charging management	How often do users not plug the bike when they finish the service? How can it be avoided?	
		How often need the bikes to be charged?	

[12] The number is the same for with or without smart energy management as all the PV production has been self-consumed.

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.

	complexity a sharing mobility service.	How predictable is the energy demand?	
		How feasible is to increase the use of charging points (open the infrastructure to other users with own bike that commute in the other direction)	
Smart energy management	Learn about charging flexibility potential Learn about how local RES and stationary battery can support e-bike charging with or without grid connection	How flexible is the charging process: ratio time to charge/ parking time	
		To which extend local PV panels support e-bike charging	
		How much energy locally produced will contribute to reduce carbon footprint and size of connection to the grid	
		How is the payback of a smart energy approach with local RES and stationary battery	
Business aspects	Learn if users are willing to pay for such a service	How much are users willing to pay	
		Are other stakeholders willing to subsidise the service (employers, public transport operators, townhall)	

Measure Group	Expected output	Fulfilment
EV fleet	• Increase of user acceptance for ICT enhanced functionalities (app, better maintenance) • Increase fleet control (detection of usage and trips within authorised area) • Minimize vandalism (users are registered and linked to a specific bike for each usage) • Persuade stakeholders to keep the service running (employers, public transport operator)	
Smart energy management	• Minimise or avoid energy usage of the grid (self-consumption) • Reduction of carbon footprint by using greener energy	

5.7.2 Process evaluation

This section provides the findings and results from the process evaluation for the implementation of the Barcelona D1 measures. The work is carried out as described in section 2.3.

Lessons learned from supporting activities

Here we summarize the supporting activities that contributed in a positive way.

Proposal of digitation of EV sharing service to St. Quirze townhall and FGC (railway operator): Taking as starting point the agreement between St. Quirze townhall, FGC and Eurecat for the set-up and operation of an e-bike sharing pilot in St. Quirze train station, Atlantis, Enchufing and Eurecat presented a proposal for digitation of the service that will allow to demonstrate GreenCharge goals, The proposals included the installation of PV panels, a stationary battery, geo-locations for the e-bikes, monitoring of e-bikes SoC, and monitoring and controllable charging points.

A first meeting was held with the townhall, operating the service. After their positive reaction, in a second meeting FGC was invited. They liked the idea as well.

To speed-up the process, instead of signing a new agreement with 7 parties involved, being 2 of them public organisation with long administrative processes, we decided to generate an appendix to the 3-lateral agreement in force until June 2022, including Atlantis, Enchufing and Millor Battery.

Technical meetings with the townhall

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.

After the first initial proposals, several meetings were held to go into the details of the proposals and define some adjustments.
Some meetings were organised to explain how it would be the interaction with users and employers and working on planning.
The communication with the townhall was fluent until April 2020. By then, the person responsible for the pilot leave the townhall. Her colleagues did not have the knowledge to take care of it and they were very busy due to the situation generated by Covid-19 pandemic. Recently, they have hired a new person and the situation is starting to unblock.

Technical visit to the e-bike station
FGC organised a technical visit to the e-bike station to discuss on site about the technical details of the implementation: where to install the PV panels, where will go the stationary battery, how the charging points will be organised. Safety aspects were discussed for the period the works would be carried out.

Technical report of electrical project
Enchufing was asked to provide a technical report of the electrical project specifying the electric circuit, the characteristics of the wiring and equipment.
This document has to be produced and signed by an electric engineer (collegiate member). The engineer is a member of Enchufing staff.

Communication with townhall and FGC (railway operator)
Further communication activities had taken place with FGC via email and phone calls to address aspects that have appeared along time. One of these situations was the replacement of the lock to access the station by an electronic lock.

Workshop with users
A focus group with a group of users of the sharing was organised. The goal was to know about the opinion of the service, why they use it, what was working fine and what not, and several aspects we had in mind to include. We, the consortium partners, were thinking on adding a route planner in the app, that turned to be it was not relevant for the users.
It was organised as a creativity session, where participants were asked about different topics, and they had post-its of several colours.
Unfortunately, the focus group had to be cancelled at the last minute because most of the attendants could not come for several reasons.
One of the complaints of the townhall, towards the employers, is that they did not grant their users to participate during working hours, although they provided the sharing service for free.

Questionnaire
The focus group above mentioned was replaced by a questionnaire, that was delivered online, by contacting the users via e-mail. The questionnaire was accompanied with an informative letter about GreenCharge project and the data management plan, as well as a consent section.
About 50% of contacted users responded to the questionnaire, which is a high rate for an online questionnaire. The fact that we did not have direct contact to the users (the townhall was the intermediary) was a drawback to control and have all the insights on the process.

Poster
A poster was prepared to explain in a visual manner the scope of the demonstrator, the upgrades included, a QR to download the app and a contact section. The poster was meant to be hand in the bike station as far as it was ready for the launch.

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Unfortunately, the Covid-19 forced to stop the service and the works.

Press release

Eurecat communication department worked together with the townhall press responsible to produce a press release to be issued when the pilot was re-launched. Unfortunately, the Covid-19 pandemic and mobility restrictions came first.

It was learned that publicity was one of the outcomes the townhall and FGC were expected from participating in the demonstrator. Communication and dissemination are also very relevant for GreenCharge project; thus, this is a win-win situation.

However, the process to get the press release accepted for all parties turn to be more tedious than expected. The lesson learned is that any communication activity has to be planned long before.

Internal meetings with GC partners involved:

Consortium partners Atlantis, Enchufing and Eurecat has hold numerous meetings to discuss about the design of the demonstrator, the implementation details and the exploitation plan (KER light business plan). Also, meetings and phone calls had taken place to sort integration issues, as they appeared.

Lessons learned from implementation of measures

The main lessons learned from the process evaluation are:

1. A lack of interest for some of stakeholders involved may become a bottle neck for the rest of stakeholders. If some stakeholders have a passive role in the preparation of the measure to be implemented (they just need to be there formally), they should leave or delegate control to the active stakeholders so that the plans are not delayed waiting for their approval.
2. The preparation for the implementation of the measure should be short (as short as possible). Otherwise, there is a loss of interest.
3. To keep stakeholders involved keep the communication alive by organising meetings, issues progress reports or generate information of interest.
4. External factors may affect the feasibility of the measure be flexible, prepare an alternative plan or decide to drop the measure.
5. A very group small of people may not care about the efforts put in a project and might be more interested in getting a charger for free (or even a bike) or have fun broken things. Add some protection.

Recommendations

Recommendation on stakeholder involvement:

- Sign a **binding agreement** with all involved parties:
    a) **Interests.** Make sure each party has an interest in the implementation of the measure.
    b) **Responsibilities.** State clear responsibilities of each party.
    c) **Planning.** Take the time to identify drivers, barriers and risks and plan accordingly. Write a contingency plan to address the risks.
    d) **Resources.** Make sure that all parties allocate the resources needed before the starting of the measure implementation.
- If a collaborative approach is chosen, **organise periodical meetings** on the progress of the implementation and derived action points to address issues assigning a responsible party and a deadline.
- If a turnkey approach is chosen (a party works on the implementation and the rest receive the results), the parties working on the implementation should have **total control of all aspects affecting the implementation** (technical, administrative, economic, access to users).
- Each stakeholder has to assign a **contact person** (at least) skilled to address any issue that may arise. The contact person may dispatch the issue to a member of their team to be actually addressed.

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Recommendations regarding the design of the business model and exploitation path:

- **The traditional approach to business models is not sufficient**. It must be recognised that:
  - The value proposition is not just about the economy. It is also about sustainability with respect to environmental and societal aspects, e.g., to reduce energy peaks.

Recommendation regarding the purchase of hardware and equipment:

- **Planned in advance.** To avoid bottle necks because the ordering has taken longer, or the delivery is delayed.
- **Standard/open protocols** make sure they allow interoperability using standard, or even better, open standards. However, be prepared to need several iterations to make it work. Try to make sure the provider has a good customer support to assist on technical issues.
- **Financial health of providers and obsolescence of products.** Although the electromobility and IoT market is not mature and evolve quickly, do an exploratory analysis of the products themselves and the providers roadmap and financial health. It might be the case that no further technical support is available because of the provider has gone out of business or the product is discontinued. Cost is a factor, but reputation of the provider is also relevant, especially if you are planning for long run measures.

Recommendations regarding policy, standardization, and harmonization issues:

- Regarding SoC:
  - Charging protocols must provide the current SoC to facilitate optimal charge planning in ESNs, even for LEV.
  - Navigation systems must take into account the type of vehicle to take into account energy needs (slopes) and safety (e-bikes).
- Regarding software integration
  - The integration process is also cumbersome. It has to be taken into account to avoid delays. A good atmosphere helps in understanding each other and work for a common objective: the solution does not work if the components work separately; they have to work together. It is not helpful to blame others works but to find a solution together.

5.7.3 Impact evaluation

This section provides a summary of findings and results from the impact evaluation for each measure group of relevance to the demonstrator (see section 2.1), organised according to the impact categories defined by CIVITAS evaluation framework [10].

The findings are the indicators of relevance are defined in section 4.7.
The impact results are a comparison and a judgement of the baseline and the after findings.

5.7.3.1 Key impact – Measure group EV fleet

Impact category Society and People

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Society and People	**Awareness**	GC 6.1 Awareness level	High*		According to the feedback from surveys issued in April 2019 and the knowledge of the person responsible in the townhall, the awareness of the service was high among respondents. However, the results are biased since the users were already users of the service. We take the opportunity to ask about energy flexibility and mobility patterns, and Shared EVs

					integrated with public transport was find as convenient. However, some of them found that the service might be better, especially in terms of maintenance. Regarding townhall and railway operator, they were not aware of GreenCharge before we arranged a meeting with them, but they were open and happy to collaborate and about the improvements GreenCharge would bring to the service.
	Acceptance	GC 6.2 Acceptance level	Medium*		In the past, some users complainted about not having always the same bike (apparently when a bike did not work users picked any other that worked, leaving the last one with no bike). This issue has been solved by users bringing their lock to block the assigned bike. That might cause some reluctance to the new service since we envisioned to have as much of it controlled digitally. We will have to make sure that the bikes are always operative or send a notification beforehand.
	Accessibility	GC 6.3 Perception level of physical accessibility of service	Medium		Answers did not lead to think that there are big issues regarding physical accessibility, apart that some users felt that the usage of the system was not efficient: some people had a bike assigned and they did not use it regularly. In the meantime, the bikes could be used by other users if they could access the station.
		GC.6.4 Operational barriers	Low		5.7.3

5.7.3.2 Key impact – Measure group Charging

Impact category Transport System

The baseline is that There were 5 pre-existing charging points, but these were not monitored or controlled, and they were assigned to a particular employee. The number of CPs with smart capabilities were 0 at the beginning and are 5 now. The non-smart charging points remain in the station.

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Transport system	**Number of EVs** in the fleet	GC 5.1.1 Number of EVs	5		
		GC 5.1.4 Number of planned EVs	5		
	Number of CPs in the station	GC 5.2.1 Number of CPs	5*	10	5 new CP.
	Utilization of CPs	GC 5.3.1 Share of connected time			
		GC 5.3.2 Share of charging time			
		GC 5.3.3 Energy per time unit			
		GC 5.3.4 Number of charging sessions			

Impact category Environment

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.

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Environment	**CO2 emissions**	GC 5.12.1 Average CO2 Emission per driven km	Calculations based on non-smart charging		

5.7.3.3 Key impact – Measure group Smart energy management

Impact category Society and People

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Society and People	**Awareness**	GC 6.1 Awareness level	Low		All elements correspond to the bike station, and apart from lighting, only the charging process is involved. The difference with smart charging is that ESN includes local RES and a stationary battery. The smart energy management runs behind the scenes, that is why awareness level is low, and acceptance level, as far as the bikes can reach their destination is not relevant for users.
	Acceptance	GC 6.2 Acceptance level	Not known		
	Accessibility	GC 6.4 Operational barriers	Medium		Operational barriers concern to the charging point operator and/or the EV fleet manager. Different systems have to be integrated and effort has to be put to validate everything works fine.

Impact category Energy

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Energy	**Share of green energy**	GC 5.9.1 Share of green energy			
	Peak to average ratio	GC 5.10.1 Maximum peak power			
		GC 5.10.2 Average power demand			
	Self-consumption	GC 5.14.1 Energy self-consumption			
		GC 5.14.2 Energy self-sufficiency			

Impact category Environment

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.

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Environment	**CO2 emissions**	GC 5.12.2 Average CO2 Emission per kWh used	Calculations based on non-smart charging		

5.7.3.4 Key impact – Measure group Business aspects

Impact category Society and People

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Society and People	**Accessibility**	GC 6.5 Relative cost of the service	Cost (per km) with no local RES or battery		

Impact category Economy

Impact category	Indicators and sub-indicators		Baseline findings	After findings	Impact results
Economy	**Capital investment cost**	GC 5.7.1 Charge investment costs	0	17 980 Euros	E-bikes 5 000 Euros IoT sensors 5 000 Euros Solar PV panels 350 Euros Charge points 3 250 Euros Battery storage 2 030 Euros Mgmt. & install. 2 350 Euros
		GC 5.7.2 Preparation and design costs			
	Average operating cost	GC 5.6.1 Total average operating costs			
		GC 5.6.4 Average energy cost			
		GC 5.6.5 Maintenance costs			
	Average operating revenue	GC 5.8.1 – Revenue from normal operation			
		GC 5.8.2 – Revenue from Penalties			

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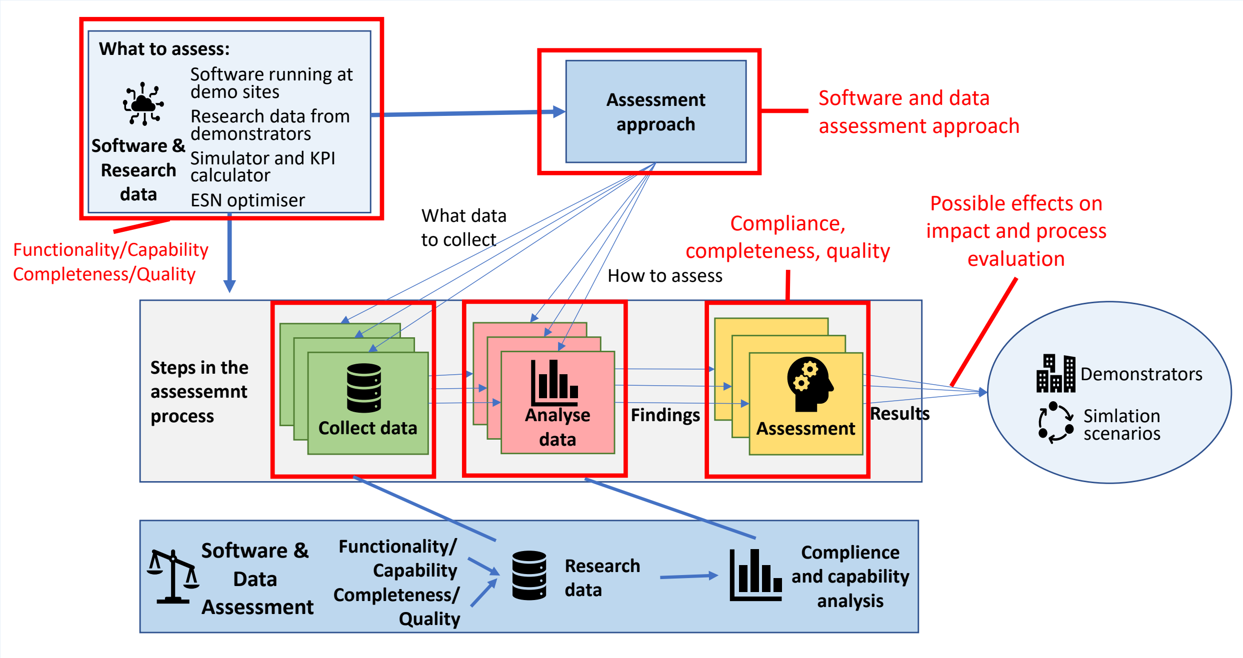
6 Software and research data assessments



The chapter has a focus on the assessment of software and research data.

The aim is to identify confounding factors that may affect evaluation results so that these factors can be taken into account in the evaluations in Chapter 5.

The focus of the assessments area as follows:

- For the software running at the demo sites, the compliance with the requirements in 0 is assessed.
- For the research data from the demonstrators, the quality and completeness of the data are assessed.
- KPI calculator, the ability to calculate the indicators in Annex B is assessed.
- For the simulator and optimizer, the compliance with the requirements in 0 is assessed..

6.1 Software and data assessment approach

The overall approach for the software and research assessments is illustrated above. Table 6-1 provides further details.

Table 6-1 Approach for evaluation of software and research data

	What to evaluate	Requirements defined by	Data collection approach
Software and research data evaluation approach	Functionality of software running at demo sites	GreenCharge deliverable D4.2 [3]. An overview of the requirements is provided in 0.	Observation of solution. Partners involved in demo are asked about the fulfilment of individual requirements.
	Completeness and quality of research data from demonstrators	GreenCharge deliverable D5.6 [6] - the requested syntax and semantics. Data collection plan (in intermediate evaluation reports D5.4/D6.3).	Compare with research data collection plan for each demonstrator. Use of syntax checker and data inspections building on D5.6..
	Simulator and optimizer functionality	Requirements and specifications in 0. Simulation plans in Chapter 4.	Partners involved in simulator development are asked about the fulfilment of the requirements. Ability to simulate the planned scenarios.

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	KPI calculation tool capabilities	Relevant indicators in Annex B.	Ability to calculate the relevant indicators in Annex B.

6.2 Assessment of software running at demo sites

This section summarises the assessment results regarding the compliance of the software with the requirements defined in the architecture deliverable D4.2 [3].

The aim is to identify possible confounding effects to be considered in the demonstrator evaluations.

Note: The validation of the functionality of the software systems (i.e., whether the functionality is that what is needed) is not addressed here. This is partly covered by the impact evaluation regarding acceptance, awareness and operational barriers covered in chapter 5.

Note: The goal in *not* to meet all requirements defined in D4.2, as D4.2 address ideal and complete operative solutions with a technology readiness level (TRL) of 9. The demonstrator are prototypes with TRL levels varying from 5 – 7, and for each demonstrator, just a subset of the requirements is of relevance.

Note: This section has a focus on what is or is not implemented. The Process evaluations in Chapter 5 will however also address that some features that are fully implemented may not be fully demonstrated. This aspect is not covered here.

A detailed overview of the requirements and compliances for the individual demonstrators are provided in Annex F. In general, we see:

- **Oslo D1 and Barcelona D2** have very many relevant requirements for charging and smart energy management, of which most are met. Both demos implement the most advanced local energy management.
- **Bremen D1** is also about charging and smart energy management with a focus on technology. The energy management is more limited than for those above. All relevant requirements are met.
- **Oslo Demo 2** has a focus on charging and implements functionality related to shared charge points, roaming and advanced booking. Almost all relevant requirements are met.
- **Bremen Demo 2**, **Barcelona Demo 1**, and **Barcelona Demo 3** are all about shared EV fleets, and those in Barcelona also address charging and to some extent smart energy management. Almost all relevant requirements are met.

Table 6-2 Requirements not fulfilled and possible effect on process and /or impact evaluation

Assessment of software running in demonstrators	Effect on impact/process evaluation						
	Oslo		Bremen		Barcelona		
Requirements not met	D1	D2	D1	D2	D1	D2	D3
SC1.1 Feedback to the user when EV cannot be charged to the target SoC.	G						
SC1.4 Notifications before the start of an advance booking and when it is finished		G					
SC3.1 The SoC of the battery should be provided from the EV to the system	R		R			R	
SC5.3 CP equipment display should show if a CP is booked and not available.		G					
SC6.1 Support sharing of information on shared CPs: Lack of standards.		R					
RM1.1 Roaming of booking and payment.		Y				Y	
EM1.3 Optimal use of different energy sources							
EM5.1 Full-fledged local energy management.	Y		Y				
EM5.4 CP equipment designed for remote control by third parties.	R						
EM7.5 EV Users should get information on cost effects with desired behaviour	G						
IR2 Interface for access to SoC from vehicle.	R		R			R	

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IR5 Use of OCPP2.0.					G	G	G
IR7 Interface for roaming of novel services.		Y				Y	

Table 6-2 provides an overview of the requirements that are of relevance but not met. The colour codes indicate whether this may affect the impact or process evaluations of the demonstrators.

- Green (G) indicate that the requirement is not met but that this is considered to have no effects on the impact/process evaluation.
- Yellow (Y) indicate that the requirement is not met, and this may affects the impact/process evaluation. Mitigating actions are however taken to fix the problem.
- Red (R) indicate that the requirement is not met and that this probably influences the impact/process evaluation.

SC1.1, SC1.4, SC5.3, and EM7.5 are about the provision of information and/or feedback to the EV User. The missing implementation of these requirements are marked as green. This functionality is not needed in the prototypes, and we consider this to have no effect on the demonstrator evaluations.

SC3.1 and IR2 are about direct access to the SoC of the EV battery in a standardised way via an open interface. This is not possible today due to the access restrictions of the in-vehicle systems. Software workarounds were implemented for all demonstrators. EV Users have manually provided SoC information in an App. ***This manual SoC input may to a large extend be inaccurate and even wrong and affect the impact evaluation*** since many of the indicators depends on the SoC value.

SC6.1 is about the sharing of charge point information, availability information included, according to standards. The aim is to facilitate the booking of charge points a long time in advance. Neither standards nor open channels for the sharing of such information exist, and the requirement is not met. ***The missing sharing of CP information might cause an effect on the impact evaluation for Oslo Demo 2 with respect to the number of users.***

RM1.1 **and** ***IR7*** are about the roaming of charging requests that provide novel functionality like charging flexibility and/or request advance bookings. The novel functionality and the roaming of charging and payment are implemented, but due complexity and lack of standards, the roaming of the novel functionality is not supported. Mitigating measures are taken during the implementation. Software workarounds are implemented to support the novel functionality locally and enable learning. Thus, the lack of the novel roaming abilities does not affect the impact evaluation.

EM5.1 address the limited size and complexity of the demonstrated ESN. Due to regulations, it was for Oslo Demo 1 not possible to connect different parts of neighbourhood into one, more full-fledged ESN covering the whole housing cooperative. This problem was however foreseen, and simulations of a more extended ESN were planned and prepared, among others through use of data collected from apartments. Bremen D1 was originally not planned to cover more than the charging facilities, so the evaluations should not be affected.

SC6.1, RM1.1, EM5.1, **and** ***IR7*** are all affected by the lack of standards, and the effects are addressed above. To address the lack of standards further, Deliverable D4.2 provides detailed specifications of solutions that may be input to standardisation.

EM5.4 is about a problem with the overriding of the charging equipment in Oslo Demo 1. The problem is outside the control of the project, and a software workaround is established (see details in the process evaluation in section 5.1.2). ***The workaround caused a reduction of the optimisation flexibility, and the impact evaluation might be affected.***

IR5 is about the use of OCPP2.0. We consider this not to be needed in the prototypes, and this has no effect on the demonstrator evaluations.

As a conclusion, the following has to be considered as a part of the demonstrator evaluations:

1. **Oslo D1, Bremen D1, and Barcelona D2:** The effect of manual input on SoC – it might be inaccurate or wrong.

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2. **Oslo D2:** The lack of charge point information sharing might affect the recruitment of charge point users.
3. **Oslo D1:** The reduced flexibility due to missing control of charging equipment must be taken into account.

6.3 Assessment of research data from demo sites

This section provides an **assessment of the research data delivered by the software running at the demonstration sites**.

The data has to be delivered according to technical specifications to facilitate automated calculations of indicator the indicators in section 2.2.1. The quality and the completeness of the data will to a large extend affect the quality of the evaluation of both the demonstrators and the simulated demonstrator extensions (see chapter 5).

The aim is to identify issues with the data that must be taken into account when the detailed evaluation approach for each demonstrator is planned (see Chapter 4).

An overview of the data collected is provided in Annex A.1. The data is partly static data defined manually and partly dynamic data established by the software.

Annex A.2 provides an overview of the research data collection form each demonstrator. The data collection is adapted to the data needed in the planned indicator calculations for each demonstrator.

The following is considered as a part of the data assessment:

1. **Data syntax:** A syntax checking tool is used. The syntax must comply with the specification of the data structures provided in GreenCharge deliverable D5.6 Open Research Data.
2. **Data content quality:** Manual checks have verified that the semantics are correct and that the data values are reasonable. GreenCharge deliverable D5.6 Open Research Data also plays a role here as it defines the semantics of the data.
3. **Data completeness in a continuous period.** Preferably, all relevant types of data should be available for this period as the different types of data depend on each other.
4. **How the data can be used.** The data can be used as baseline, after data, or context. Data can also be used in the construction of simulation scenarios. Such scenarios may extend the demonstrators, or they may be more fictional scenarios.

A summary of the assessment with respect to 1-3 is provided below, for each demonstrator. Decisions regarding 4 are provided as a part of the detailed evaluation approach for each demonstrator in Chapter 4.

Assessment of 1-3 for Oslo D1: Data are available on charging sessions, RES production, use of local energy storage, energy characteristics, and weather conditions. Before August 2021, the demonstrator was unstable and one or more of the data types are not continuously delivered. Parts of the data also had syntax and quality issues as the data was not delivered completely according to the requirements in D5.6. The stationary battery worked, and data was delivered for a period before June 2021, but then it stopped working due to a hardware error. Due to the delay of the App, booking data was not delivered until February 2022. Based on this, the following is input to the detailed evaluation plan in Chapter 4:

- The data to be used in the evaluations are from August 2021 till January 2022.
- Except for booking data and battery data, complete and high-quality data are delivered for this period.

Assessment of 1-3 for Oslo D2: The data collection plan was originally to collect data on bookings and charging sessions. Due to the delay of the App, the demonstrator has not been operational, and such data are not collected.

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Assessment of 1-3 for Oslo D3: Data was collected from nine apartments in the housing cooperative for use in simulations of more full-fledged energy smart neighbourhoods. This was not done, but more information on these fictive scenarios is provided in Annex H.

Assessment of 1-3 for Bremen D1: The demonstrator collected charging data from summer 2021, but the data were not complete until September 2021. From September, booking data, data on local energy production from RES, and energy characteristics were continuously delivered. Battery data were also delivered, but inspections of the data showed that the quality was low. The batteries have errors and have not worked as planned. Based on this, the following is input to the detailed evaluation plan in Chapter 4:

- The data to be used in the evaluations are from September till December 2021.
- Except for battery data, all relevant data are delivered for this period.

Assessment of 1-3 for Bremen D2: This demonstrator is not planned to be evaluated through automated KPI calculations. Data on charging sessions were however collected since the plan was to use the data to in simulations. The data quality is however not good enough for this purpose.

Assessment of 1-3 for Barcelona D1: The data was collected from the charging of eScooter batteries from the last part of July 2021 till the first part of October 2021. We do however want to have data from full months. Based on this, the following is input to the detailed evaluation plan in Chapter 4:

- The data to be used in the evaluations are from August 2021 till September 2021.
- Except for booking data and battery data, complete and high-quality data are delivered for this period.

Assessment of 1-3 for Barcelona D2:

Assessment of 1-3 for Barcelona D3:

6.4 Assessment of functionality and capabilities of the KPI calculator

The indicators used are specified in Annex B. The table below provides an overview the indicators to be calculated by the KPI calculator. The indicators and sub-indicators that are calculated manually are not included in the table.

The right column provides an assessment of the capability of the KPI calculator tool:

- Green "Yes" verifies that calculations are correct.
- Yellow "Uncertain" indicates that the correctness of the indicator calculation is uncertain
- Red "No" indicates that the calculation does not work as intended.
- Blue "Not tested" indicates that the calculation is not tested

Table 6-3 Ability to calculate indicators

Indicator	Sub-indicators	Correct calculation is verified
GC 5.3 Utilization of charge points	1. Share of connected time	
	2. Share of charging time	
	3. Energy per time unit	
	4. Number of charging sessions	
GC 5.5 Charging availability	1. Energy availability	
	2. Demand fulfilment	
	3. Share of no show	
	4. Average delay	
	5. Share of late plug out	
	6. Delay of plug out	
GC 5.13 Charging Flexibility	1. Offered flexibility	

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	2. Actual flexibility	
	3. V2G flexibility	
GC 5.4 Share of battery capacity for V2G	1. Average amount of energy	
	2. Share of battery capacity	
GC 5.9 Share of green energy	1. Share of green energy	
GC 5.10 Peak to average ratio	1. Maximum peak power	
	2. Average power demand	
GC 5.14 Self-consumption	1. Energy self-consumption	
	2. Share of self-consumption	
GC 5.12 CO2 Emissions	1. Average CO2 emission per vehicle km	
	2. Average CO2 emission per kWh used	
GC 5.6 Average operating cost	4. Average energy costs	
GC 5.8 Average operating revenue	1. Revenue from normal operation	
	2. Revenue from penalties	

6.5 Assessment of functionality and capabilities of the simulator and optimizer

This section summarises the assessment results regarding the capabilities of the simulator and the optimizer.

0 provides an overview of overall requirements to the simulator and optimizer and how these requirements are met.

The aim is to identify possible confounding effects to be considered in the evaluations of the simulation results.

0 provides an overview of how well the simulator software complies with overall requirements to the simulator. As illustrated, all assessments are met. It is not expected that the simulator will influence the simulation results.

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7 Evaluation conclusions

This Chapter provides conclusions from the evaluation work regarding:
- Conclusions regarding the impact and process evaluations across demonstrators and simulations.
- An assessment of the evaluation approach in general.
- An assessment of the confidence of the evaluation results.

7.1 Evaluation conclusion across all demonstrators and simulations

7.1.1 Impact evaluation conclusion across all demonstrators and simulations

The conclusions from the impact evaluation address the impact categories defined by the CIVITAS evaluation framework [10] based on the evaluation results from all demonstrators and simulations.

For each impact category, the indicators contributing to the results and a summary of the results found across demonstrators and simulations are provided. For the indicators, we indicate whether they were addressed by demonstrators (D), simulations (S) or both (D/S).

Impact evaluation conclusion - Society and people category
Measures: EV fleet, Charging, Smart energy management, and Business aspects

The category covers person and society related aspects with a link to the mobility system. The indicators of relevance are:
- GC 6.1 Awareness level (D)
- GC 6.2 Acceptance level (D)
- GC 6.3 Perception level of physical accessibility of service (D)
- GC 6.4 Operational barriers (D)

The charging, smart energy management, and business aspects for the Oslo Demo 1 has a high degree of acceptance and awareness. This is probably supported by a high degree of stakeholder involvement and engagement. The demonstrators addressing charging at work (Bremen D1, Barcelona D2) or travelling to work (Barcelona D3) are highly affected by the COVID situation. It has been difficult to impact the awareness and acceptance when people are working at home. A survey in Barcelona D2 do however confirm a relatively high degree of acceptance and awareness.

The results for EV sharing also varies. The EV sharing in Bremen D2 have struggled to get users. Two challenges that may be typical in Germany are observed: People are reluctant to use car sharing services (they prefer to use their own car), and they are reluctant to use electric cars. In addition, the COVID situation has also caused scepticism to the car sharing. The customers that have used the service are however very satisfied, and they have used it several times. The B2B eScooter sharing in Barcelona has however been operational with many customers. In this case, the COVID situation has had a positive effect on acceptance and awareness since the scooters were used in food deliveries. However, the B2C eScooter service was affected by the limitation of licences in Barcelona city and the damage caused to the batteries for the period that the service was on hold. Lack of experience in this situation prevent to take measures to minimize the impact on batteries.

In general, the evaluation results show that the services are easy to use. User engagement activities seem to have a positive effect on awareness and acceptance. This is also the case for the measures on smart energy management that are quite technically advanced. Regulations and subsidies also play an important role. The acceptance of the business and price models is also increased with stakeholder involvement.

The reliability of the results varies a between the demonstrators. For Oslo Demo 2, there is a lack of data since it did not become operations, but the results related to the business aspect are quite reliable. The data collection in Bremen Demo 1 was not sufficient. For Barcelona Demo 2 and Barcelona Demo 3, the number of users has been rather small and due to this, but the results may be biased or not be very confident. The fact that the service was free of charge may introduce also a biased to extrapolate conclusions for classical business model approaches. For Oslo Demo 1, there has been several rounds with surveys, interviews, and workshops that makes the results reliable.

Impact evaluation conclusion - Transport system category
Measures: EV fleet and Charging

The category covers the effect on the mobility system in terms of usage and its technical characteristics. The indicators of relevance are:

- GC 5.1 Number of EVs (D)
- GC 5.2 Number of CPs (D)
- GC 5.3 Utilization of CPs (D/S)
- GC 5.5 Charging availability (D/S)
- GC 5.13 Charging flexibility (D/S)

The evaluation results show that almost 80 charge points have been established during the project period and that more than 5500 charge sessions have been carried out, of which more than 2500 are included in the evaluations. For Oslo Demo 1 (charging in ESN), the number of EVs in the housing cooperative has increased significantly due to the establishment of new charge points. For Barcelona D2, employees have got accessed to shared CPs (before GreenCharge only some persons had accessed to a private CP).

The evaluation has provided insight into the charging behaviour. For Oslo Demo 1, Bremen Demo 1, and Barcelona Demo 2, the EVs can potentially be connected for long periods. This is however not always the case. The residents in Oslo Demo1 do, for example, not plug in their EV every day, and they charge a quite high share of the time when they are connected. Thus, they provide a lower flexibility than they could, and if V2G is going to be implemented, this charging behaviour must be changed. Despite of this, the actual flexibility provided is sufficiently high to have an effect on the smart energy management (see below).

The reliability of the indicator calculated based on data from the demonstrator are considered as reliable. Some demonstrators (Bremen Demo 1, Barcelona Demo 2, and Barcelona Demo 3) have to a little degree been used due to the Covid situation, and the results from the demonstrators are not representative for normal conditions. We do not have reliable data on the offered flexibility, but the offered flexibility provides to some extent insight into what can be expected. In any case, there would have been uncertainties about the flexibility provided by the EV user, since the EV battery's state of charge (SoC) cannot be collected automatically via open interfaces except for the cases that external sensors are installed, like in the e-scooters and e-bikes. The manual input needed may be inaccurate or even faulty. The simulations do however confirm the positive effect of flexibility, and we consider this to be a highly reliable result.

Impact evaluation conclusion - Energy category
Measure: Smart energy management

The category covers the use of energy and other aspect with the energy used. The indicators of relevance are:

- GC 5.9 Share of green energy (D/S)
- GC 5.10.1 Peak to average ratio (D/S)
- GC 5.14 Self-consumption (D/S)

This impact category is of relevance to Oslo Demo 1, Bremen Demo 1, Barcelona Demo1, Barcelona Demo 2, and Barcelona Demo 3.

The evaluation results confirm the positive effects of smart and green charging. Charging flexibility in combination with smart energy management contributed to a reduction of power peaks in the import from the grid, and PV production and stationary battery increased the self-consumption. The effect of the PV production on the greenness of the energy also varies between demonstrators. In Oslo, the greenness of the energy from

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the grid is already quite green due to the high degree of hydro power, and the effect of increased fraction of PV in the mix of the consumption was too small to be visible in the calculated KPIs.

It is also interesting to see that the effect of stationary batteries to some extent can be overtaken by smart energy management. This is important knowledge since stationary batteries are quite expensive.

We consider the reliability of the results is to be good. Admittedly, the simulations does not perfectly represent the real demonstrators, however, the improvements in KPI values are mostly sufficient to confirm an impact although the observed values themselves are inaccurate.

Impact evaluation conclusion - Environment category
Measures: Smart energy management and Charging

The category covers effects on the environment. The indicators of relevance are:

- GC 5.12 CO2 emissions (D/S)

The table below provides an overview of the results regarding the average CO2 Emission per km driven.

Demonstrator	With energy from grid	With the PV panels and no smart energy management	With PV panels and smart energy management
Oslo D1	31.38 gCO2eq/kWh	30.14 gCO2eq/kWh[13]	22.27 gCO2eq/kWh[14]
Bremen D2	Savings: > 3500 kg CO2		
Bremen D1	189 gCO2eq/kWh	58.7 gCO2eq/kWh[15]	45.9 gCO2eq/kWh[16]
Barcelona D2	138 gCO2eq/kWh	137.51 gCO2eq/kWh	137.51 gCO2eq/kWh[17]

The reliability of the results is high. For Oslo Demo 1, Bremen Demo 1, and Barcelona Demo 2 calculations are based on emission factors that also includes the construction of the EVs.

Impact evaluation conclusion - Economy category
Measure: Business aspect

The category covers the effectiveness or benefits of measure in relation to economic aspects. The indicators of relevance are:

- GC 5.6 Average operating cost (D)
- GC 5.7 Capital investment costs (D)
- GC 5.8 Average operating revenues (D)

In general, the evaluation of the business aspects is limited. For many demonstrators (Bremen Demo 1, Barcelona Demo 2, and Barcelona Demo 3), the business model is not complete, or the exploration of the model was difficult due to the Covid situation and the small size of the demonstrator. For Oslo D2, the business model was developed in detail but has not been tested and properly evaluated due to delays. The model is however designed to ensure a revenue also when the EV users does not show the desired charging behaviour.

The economic sustainability is highly dependent on the acceptance of the service. From Bremen Demo 2, this has been a challenge. Due to the COVID situation and a low acceptance of e-mobility and car sharing, there are few users and a low revenue. The leasing of the EVs has reduced the cost, but still there are challenges.

[13] This number is for period from August 2021 to January 2022.
[14] This number is for one week in August 2021.
[15] This number is for location 3 from September to December 2021.
[16] This number is for Location 3 from one week in September 2021.
[17] The number is the same for with or without smart energy management as all the PV production has been self-consumed.

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The Oslo Demo 1 business model is implemented and demonstrate. The evaluation shows that the integration of charging and smart energy management contributes to a sustainable business model. The PV panel has reduced the energy costs by 10%, but the potential is higher. A stationary battery can increase the self-consumption to about 100 % and reduce peak costs. The main reduction of the peak costs will however come from smart energy management.

The eScooter sharing in Barcelona has developed a business model that has been sustainable in the COVID period. It remains to see how this will develop.

The reliability of the above is quite high. We do however not know the exact effect of the smart energy management on the energy costs due to problems with the simulations and the automated calculations of the varying energy costs.

7.1.2 Process evaluation conclusion across all demonstrators

This section provides aggregated conclusions from the demonstrators that are intended to support new implementation of the GreenCharge concept

For all measures groups, stakeholder involvement and outreach activities are important. The following is recommended:

- **Several types of outreach actions** must be considered to get input on needs and opportunities, to create publicity, to provide information, and to communicate with and engage stakeholders. Such actions will be meetings and interviews with charge point owners and launch events. Information letters may also be sent to contact points for potential charge point users, e.g. e-mobility associations that can promote the charge points via their channels. The collaboration with city is particularly important regarding the provision of shared EVs and shared charge points.
- **Affected stakeholders** (building owner, employers, residents, EV users, city, and other actors in the value chain) must be involved whenever this is relevant, e.g. regarding purchase of hardware, technology design (e.g., App functionality), and business and price model design.
- **Experts** must be involved when this is needed, e.g. electrician and experts on energy management
- **Users** must know how they can find information and how they can get support.

Possible risks and recommendations on how to limit the risks for are provided below, organised according to the measure groups.

Process evaluation results **Measure groups: Charging and Business aspects**	
Risk descriptions	**Recommendations - Actions to limit risks**
e-Mobility - Low acceptance: The acceptance e-Mobility is low in some countries. The number of users of charging services may be low.	- Stakeholder involvement – see above - Local and national policy affects the acceptance and adoption. - The policy in general must make it easy the establish and offer charging services. Aspects such as taxation, subsidies and other incentives should be considered.
e-Mobility – Low accessibility: With more EVs, the access to charging may be a hurdle.	- Policies must recognise the potential of CP sharing (to utilise the capacity of private CP) - Advance booking must be tested to get more knowledge
e-Mobility – Lack of knowledge: The concept of smart and green charging may not be easy to understand	- Actors that can facilitate awareness, acceptance, access to potential users, and required space/ locations for charge points and stations for shared EV should be involved. This may for example be property owners, housing cooperatives (with access to residents), employers (with employees), and public transport providers (with travellers).
Technical - Lack of roaming standards: No standards for roaming of advance booking and booking enforcement.	- Protocols for roaming of in advance booking must be standardized. - Charging services should by default offer such roaming.

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Administration - Roaming challenges: The opening of APIs and onboarding into the roaming platform takes much time.	- The onboarding process must be planned and accounted for at an early stage as much calendar time will be required to get all the issues in order.
Behaviour/Economy - CP blocking: EVs may stay at the CP after received full charge and block CP and reduce incomes.	- Apps and other tools for charge planning must support flexible charging. - Business models must also address non-monetary values. - Price models must be designed to encourage desired charging behaviour – e.g., use of reward and penalties.
Behaviour/Economy – Low flexibility: Charging requests may not offer flexibility.	
Policy/Economy – Removal of incentives: A tax may be put on free charging at work. System may have to be refined to support payment. Few users may use the CPs, if a full-cost accounting is applied.	- The consequences of the taxation policy must be considered. - Use a low charging fee to avoid such taxation. - Use EMP/CPO that can support billing and payment.

Process evaluation results **Measure groups: Smart energy management and Business aspects**	
Risk descriptions	**Recommendations - Actions to limit risks**
Lack of knowledge: The concept of smart and green charging in ESN may not be easy to understand	- With the energy situation (need for smarter use of energy) ESN will be increasingly important. Dissemination, awareness and engagement activities are needed. - Involvement of property owners may (and others with energy use concerns) contribute to acceptance and awareness. - Experts must be involved
Behaviour - Low input accuracy: Manual charging requests are incorrect and prohibit optimal use of energy.	- Design price modes that encourage and reward desired charging behaviour, e.g. flexibility. - Notifications to EV users must be supported to prevent blockings - Current SoC must be delivered from in-vehicle systems (according to standards), and target SoC suggestions by artificial intelligence. - Use of min. SoC to ensure that EVs can be used earlier. - Ensure the possibility to easy update the charging constraints. - Navigation systems must in the future support charge planning and real-time SoC and desired SoCs in charging requests.
Behaviour - Low charging flexibility: EV Users may not provide the charging flexibility needed.	
Technical - No access to real-time SoC: Access to SoC is not supported by most protocols and **EVs**.	
Technical - Limited CP equipment control: Charging equipment may not allow local energy management systems to start/stop charging according to an optimal energy management plan for the ESN.	- Verify that the build-in energy management of the CP equipment is designed for remote control from a third party. - A local energy management system must be allowed to start and stop individual CPs, charge with different power at different CPs, etc. - The interfaces needed must be standardized.
Technical - Problems with 2nd life EV batteries. It is not straight forward to use such batteries as local storage for energy.	- There is a need for professional providers of such batteries that can test the batteries and verify that they can work as expected. - The quality of such batteries must be documented and guaranteed.
Technical - Challenging ESN integration: Smart charging in ESN is a challenge due to immature technology and lack of standards. Plug and play is not possible. The integration must be customised, and this takes time and resources. Unforeseen issues like integration and control problems will occur.	- Detailed specifications must be shared with providers. - The providers of the different systems must work together when interfaces are designed, and when the integrations of systems are implemented. - Experts must be involved - Do not underestimate the efforts required - A detailed plan on pending issues and interdependencies is needed and must regularly be updated to identify bottlenecks. - Frequent (weekly) meetings for follow up of blockers and problem solving are required.
Technical - Systems/hardware not designed for ESN. An integration of	

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systems and hardware from different providers requires careful investigations, planning, and customization. Legacy systems are not always prepared for the integration and control, and interfaces and solutions must be adopted.	- Buyers of solutions and equipment must be more demanding on interoperability aspects (pulling for interoperable solutions, for instance in tenders) - Providers of devices such as stationary batteries must recognize the needs in ESNs and support the control mechanisms required.

Process evaluation results **Measure groups: EV fleet measures and Business aspects**	
Risk descriptions	**Recommendations - Actions to limit the risk**
Low acceptance – e-Mobility: In some European countries the e-mobility maturity is low. It is challenging to find service users.	- Stakeholder involvement – see above - More marketing and easy access to information - Adapt price models to market - Involvement of cities, e.g., through pilot projects facilitating learning with respect to how the services are offered and business models.
Policy/Strategy - Lack of knowledge: Both cities and EV fleet operators have too little knowledge on opportunities, the policy needed and other aspects that can arrange for sustainable services	- Prioritise and put effort into the BMs to e ensure return of investment. - Request involvement from city that arrange for learning, e.g., pilot projects for testing of new services and business models. - Involve in pilots and other trials where the BMs can be tested. - Consult business model experts. The Booster service provided by the EU commission may be useful.
Policy - Business models challenges: The business models are critical. They may not be sustainable with respect to the economy. City policy may not arrange for sustainable business models. In some countries, EV fleet operating costs are high.	- City policy must arrange for viable business models for providers of shared EVs. - Taking the above into account, business model has to adopt a broader scope, either by establishing alliances, or by involving public administration as representatives of the interest of the general public. - The number of EVs offered must be carefully adapted to the demand to reduce the costs.
Economy - Market for shared EVs: Too few customers and low utilization of EVs make costs high and the revenue low.	- Seek market knowledge and information from experts - Collaborate with city to find good solutions - Run pilot projects to learn and to promote e-mobility acceptance - Adapt the number of shared EVs to the demand.
Behaviour - Vandalism: Equipment can be stolen or broken. Light EVs are especially vulnerable because they are light and have no identifiers.	- Adopt security measures (cameras) - Register users and link the usage of a bike with a user - Establish sanctions or penalties for users not fulfilling the terms of use.

7.2 Appraisal of evaluation approach

The impact and process evaluation of the GreenCharge demonstrators are based on the CIVITAS evaluation framework [10]. The framework provides guidelines for the approach that have been useful but had to be extended with simulations.

7.2.1 Impact evaluation

Many of the indicators used are based on indicators predefined in the CIVITAS framework. However, the framework had no support for indicators addressing e-mobility and smart energy management. Thus, new indicators have been defined to cover these aspects, and existing indicators have also been adapted to the needs in e-mobility. The indicators defined (D) or adapted (A) by GreenCharge are (see details in Annex B):

- **Society-people indicator:** GC 6.6 Shared EVs per capita (D)

- **Transport System indicators:** GC 5.1 Number of EVs (D), GC 5.2 Number of charge points (D), GC 5.3 Utilization of charge points (D), GC 5.5 Charging availability (D), and GC 5.13 Charging Flexibility (D)
- **Energy indicators:** GC 5.4 Share of battery capacity for V2G (D), GC 5.9 Share of green energy (D), GC 5.10 Peak to average ratio (D), and GC 5.14 Self-consumption (D)
- **Environment indicator:** GC 5.12 CO2 Emissions (A)
- **Economy indicators:** GC 5.6 Average operating cost (A) and GC 5.8 Average operating revenue (A)

The new indicators defined, and the adaption of existing indicators are to a large extend quantitative, and they are calculated based on research data collected by software systems. This approach is useful and gives interesting results but is also demanding, as described in section 7.2.3

The CIVITAS evaluation framework does not completely cover the needs in a project like GreenCharge, where the focus to a large extend is on new technology. The size and scope of the demonstrators are relatively small, and demonstrators could not produce sufficient results with respect to all the new measures addressed. Thus, a hybrid evaluation approach with simulations is used to extend the scale and to study measures and effects that cannot be addressed in the real-life demonstrators.

Based on the evaluation work in this project, the following observations and recommendations concerning the impact evaluation approach may be interest to other projects and for further refinements of the CIVITAS framework:

- **Common indicators for e-mobility and related smart energy use should be defined at a European level,** as done for other aspects by the CIVITAS framework. The indicators defined by GreenCharge may be input to such indicators.
- **A hybrid approach where traditional demonstrator evaluations are combined with simulations should be addressed and supported.** This may increase the evaluation quality in projects where new technologies are deployed

7.2.2 Process evaluation

The process evaluation addressed by CIVITAS is a very important supplement to the impact evaluation as it facilitates reflection and learning from implementation processes carried out. This may be useful in case of replications and arrange for improvements in new projects.

The process evaluation guidelines provided by the CIVITAS framework were to some extent not clear. In this report, we have tried to follow the approach, but **we have made some clarifications that we think may be useful:**

- The findings from the data analysis in each demonstrator is limited to address barriers, drivers, and supporting activities, as these issues can be derived directly from the data collected.
- The results from the evaluation of the findings are the lessons learned and recommendations for each demonstrator.
- The conclusion in section 7.1.2 provides an overview of risks and recommendations of general interest per measure group, across all demonstrators.

7.2.3 Research data collection and analysis

For the process evaluations, the data collection was done through document studies, focus groups and interviews. The focus group approach was in general harmonised across the demonstrators but adapted to the number of partners involved. When just a few partners, the focus group was more like an interview. For some demonstrators, key personnel left the project and could not be involved.

For the impact evaluations, research data were collected in traditional way through interviews and questionnaires, mainly targeted the indicators related to the society and people impact category. Different approaches were followed in the different demonstrators.

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The manual data collection for the process evaluation, the interview guide in Annex D.1 and the focus group meetings, worked well. A lot of input was collected.

The manual data collection for the impact evaluation could have benefited from a more coordinated approach, as the input is limited for some demonstrators, e.g. Bremen Demo 1.

Much of the research data was collected automatically by the software systems running at the demonstrator sites. Detailed specifications of how the data should be anonymised and delivered are provided (summarised in deliverable D5.6 "Open Research Data"). The communication of data requirements to those implementing the software was however a difficult task.

- All software developers did not value and understand the importance of the data to be delivered from their part of the system. Their focus was more on the functionality to be provided.
- In most cases, several rounds were required before the data met the syntax specifications and required quality.

The data syntax and quality verification were also demanding, even though a syntax checking was developed. A lot of manual work and effort has been to check the data, to detect issues regarding the semantics, and to negotiate about data improvements.

The work on the indicators was also demanding, and many iterations have been required. We had to

- Make detailed specifications of the research data needed. This is to a large extend quite technical data (the results are provided in deliverable D5.6).
- Make very detailed specifications of how the research data should be used in the calculations of the indicators, to support the implementation of the KPI calculator.
- Debug the KPI calculations. This was a challenge due to many dependencies, the use of dynamic data, and uncertainties around the data quality for long periods of the project. Many errors were detected at a very late stage.

The lessons learned are that the automated data collection was complex and require much effort. It might have been easier to receive data in different formats from the software developers and to transform the data to common formats afterwards. This might however have caused other problems like uncertainties around the anonymisation of the data, new semantic issues, difficulties regarding the identification of incomplete data, etc.

With respect to the indicator calculations, a better approach for the testing of the correctness of the calculations should have been established as an integrated part of the calculator development to facilitate verifications of calculations in a controlled setting.

Despite of the above, we consider the approach to be a necessity for the evaluation of charging in combination with smart energy management. We could not have achieved results of a comparable quality with a more traditional approach, and we consider the calculation rules together with the indicator framework to be very important results from the project. The timeliness and the quality of the data and the indicator calculations were however too low and caused a lot of extra work. More results would have been achieved if many of the problems had been avoided.

7.2.4 Simulations

In GreenCharge, the simulations became more relevant than anticipated due to very high ambitions regarding what to investigate and due to the challenges in the demonstrators.

In the demonstrators, the set of measures implemented influence each other, and it is impossible to study the effect of each measure individually. The simulations do however facilitate such studies as well as flexibility with respect to baseline and after situations. Thereby, the ability and control increase considerable with simulations.

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With simulations, it is crucial to use complete and reliable research data, and to have all the different types of research data needed – both the data that define the context for the simulations as well as data on the events to be studied. The automated data collection arranged for this, but as described in section 7.2.3, it was demanding to get the data in place.

The debugging of the indicator calculations made by the simulator has for in the same way as for the KPI calculator been challenging, and errors were detected at a very late stage.

We consider the hybrid approach with simulations to be an important extension of the evaluation approach suggested by CIVITAS even though we have experienced challenges in GreenCharge. The GreenCharge simulations have facilitated results that we could not have achieved through traditional evaluations of the physical demonstrators.

The delay of the optimiser and the debugging of the indicator calculations from the simulator have however caused a lot of extra work and delays, leading to fewer results We did among others not manage to simulate V2G and the fictive scenarios described in Annex H as planned.

A better approach for the testing the correctness of the simulator's indicator calculations should have been established. The choice to perform separate indicator calculations for the KPI calculator and the simulator was not a wise design. It has caused extra uncertainty about the correctness of indicator calculations and need for extra effort for debugging and verifying results. As for the KPI calculator, a better approach for the testing of the correctness of the calculations should have been established as an integrated part of the simulator development. The same software should have been used for both the KPI calculator and the indicator calculations from the simulator.

7.3 Evaluation confidence assessment

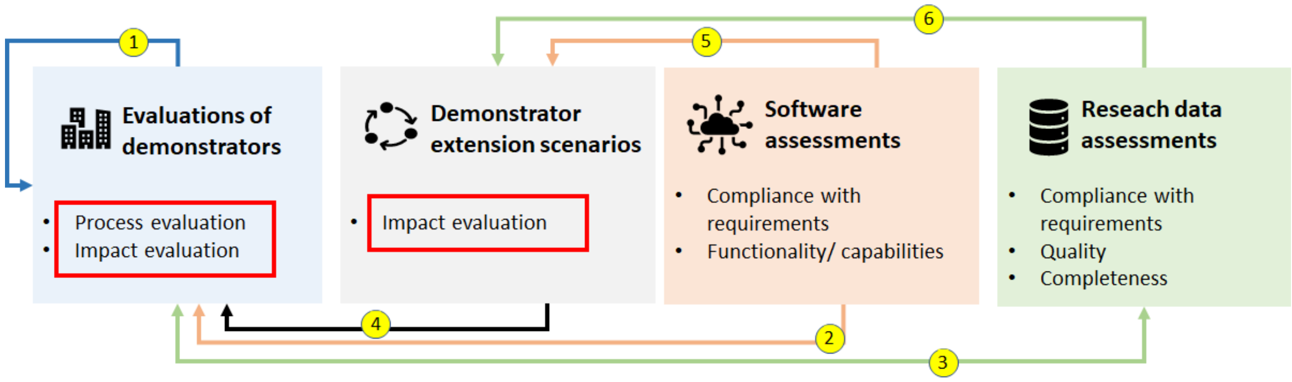

Figure 7-1 Dependencies affecting the evaluation quality

When the confidence of the evaluations is assessed, confounding factors caused by the approach must be considered as well as the dependencies illustrated in Figure 7-1 (the numbers refer to the labels in the figure):

1 Issues pointed out by the process evaluation results may affect the impact evaluations.

2 The quality and capability of the software running in the demonstrators and the KPI calculator may affect the impact evaluation confidence.

3+6 The quality and completeness of the research data from the demonstrators may affect the confidence of the impact evaluation of both the demonstrators and the demonstrator extension scenarios.

4 The simulations of the demonstrator extension scenarios will provide results that support more confident analyses of the impact evaluations of the demonstrators.

5 The quality and capability of the KPI calculator and simulator/optimizer will affect the correctness of indicators and the simulation ability to reproduce the real behaviour and thereby the confidence of the impact evaluations

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The following sections address possible effects of the common software and the research data, and the confidence of the process evaluation and impact evaluation results.

7.3.1 Possible effects induced by software and research data

Research data (Figure 7-1 label 3 and 6): For the process evaluations, we cannot see anything that has affected the evaluations in a negative way.

For impact evaluations, a better coordination of the manual data collection regarding the society and people impact category (see 7.2.3) could have improved the quality for some demonstrators.

The automated research data collection has generated more data than the data used in the evaluations. This is because we had to restrict evaluations to periods where we had complete sets of all the research data types needed. Our main concerns have been regarding:

- **The lack of data on full scale ESNs.** It has not been possible to demonstrate full scale ESNs due to regulatory, budget and project duration constraints. We planned to use simulations to address this gap. Demo 3 was among others added in Oslo to collect needed data from apartments. The simulations could however not be carried out due delays and simulator problems (see 7.2.4).
- **Incomplete/few research data:** Due to the Covid-situation and the limited number of users, some demonstrators have not been used to the planned extent. They have just been operative for short periods and had few users.

When looking at all demonstrators as a whole, **the quantity and quality of the research data are sufficient** to evaluate most measures, either directly in the demonstrators or through simulations. For some demonstrators, there is however a lack of data, either due to low quality of the delivered data or due to few users of the demonstrators (due to the Covid situation).

Demonstrator software (Figure 7-1 label 2) does, when we see all demonstrators as a whole, they fulfil almost all relevant requirements (see section 6.2). There are however some gaps caused by the lack standardized solutions, e.g., regarding the access to the SoC from in-vehicle systems which may cause inaccuracy in the flexibility data that can affect the evaluations.

The main problem with the demonstrator software is that part of the software has been very delayed. The delays made it impossible to evaluate Oslo Demo 2 and it also affected other demonstrators. The reasons are analysed in the process evaluation.

KPI calculator software (Figure 7-1 label 2 and 5) is used, and the correctness of the results are to a large extend verified. It is however not feasible to test everything as the testing was carried out very late in the project. It has not been possible to calculate some indicators the average energy costs. This may be due to the complex and heterogeneous tariff systems used with the energy sector. This weakness is partly compensated by manual calculations of the economic indicators when this has been possible. It is however not feasible to calculate the economic effects of the smart energy management due to many dynamic dependencies. This is a weakness as more accurate indicators with respect to this would have been appreciated.

We also experienced problems with the calculation of the CO2 emissions. Due to this, these were also calculated by hand.

In general, the KPI calculator has, when the correctness of the indicators has been verified, supported the evaluation in a good way and facilitated a decentralised approach where several partners have calculated the indicators in a coordinated and quality assured way across all demonstrators.

Simulator and optimizer software (Figure 7-1 label 2 and 5) has been delayed. As for the KPI calculator, we have not been able to simulate the effects on the economic indicators.

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Due to the delay, it has been necessary to limit the number of simulations. With more time, we could have explored the energy smart neighbourhood to a larger extend. The simulation results provided in this report are however relevant. We also recognize the simulator and the optimizer as core results from the project.

7.3.2 Confidence of process evaluation results

The focus and extend of the process evaluations vary between the demonstrators due to their different natures.

Oslo Demo 1 is established in a real environment with EV users and a housing cooperative, which also has economic issues. Legacy systems and new systems provided by 3 project partners as well as hardware and software from several third parties are integrated. Thus, the process evaluation addresses many different and relevant elements. It is likely that the results are relevant to others aiming for energy smart neighbourhoods and smart charging.

Oslo Demo 2 has many of the same characteristics as Oslo Demo1, but the number of systems to be integrated is smaller. The demonstrator failed (did not become operational), but still, or perhaps for that reason, the results regarding the implementation process provide insight and learning.

Bremen Demo 1 has a technology focus and has not emphasized stakeholder involvement and business models. Almost all software is developed by one partner. Thus, the process evaluation also has a focus on the technology. The most relevant experiences are regarding the use of 2nd life EV batteries.

Bremen Demo 2 has a focus on business challenges. The demonstrator has struggled due to the Covid situation and the low acceptance of e-mobility and car sharing in Germany. Thus, the process evaluation is a bit limited. Useful learning about the importance of business models and collaboration with the city is however provided.

Barcelona Demo 1 address a commercial eScooter sharing service, and the business-related issues are emphasized. Just one partner has been involved. The business model has changed during the execution of the process and some adaptations have been required. The process evaluation is a bit limited, also the energy management measure had not physically taken place, but considered as what-if scenarios.

Barcelona Demo 2 has offered charging capabilities to employees driving an EV. The number of users has been very limited (only 8 EV drivers, and just 2 of them had used the charging point regularly). The size of energy that could be managed did not require a sophisticated energy management system, but it has been used as a testbed to address interoperability issues.

Barcelona Demo 3 was seen as the most complete demo, including smart energy management and use of RES and storage to reach 100% self-sufficiency. Despite the efforts to unblock the progress of the demo for a variety of reasons, directly or indirectly linked to Covid, it has not been possible to launch the operational phase with real users**.** It has been useful, however, that special attention has to be put to vandalism and security.

In general, the process evaluation results are reliable but for the topics and details covered as well as the comprehensiveness of the evaluations vary depending on the nature of the demonstrators.

7.3.3 Confidence of impact evaluation results

The impact evaluation is in general done in two ways: A traditional approach based on the CIVITAS framework and a hybrid approach including simulations. In both cases, the following must be in place:

- **A relevant indicator framework.** We think the indicator framework defined in section 2.2.1 includes the relevant indicators. Some of the indicators may be superfluous or they express a context more that an impact. This does however not affect the evaluation quality.
- **Well defined baseline and after situations** that facilitate impact analysis by means of relevant indicators. This has been a challenge for some demonstrators since a lot of new technology had to be developed and integrated. It was not feasible to collect data for both situations within the limits of the project. Thus, for

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many demonstrators a clear baseline did not exist. The hybrid approach has however contributed to solutions for some demonstrators, and the approach has been as followed:

- The operative demonstrator is used as a baseline.
- An artificial baseline is simulated to calibrate the simulation with the demonstrator.
- Additional measures are simulated, one by one, to generate the after situations where the cause of the impact is well defined.

In general, we think we have created well defined and reliable baselines and after situations for most demonstrators, as defined in Chapter 4 and for the impact categories in Chapter 5.

- **Sufficient amount of complete research data of good quality for a sufficient period.** For some demonstrators, there has been few users and some measures did not become operational. Thus, not all data are collected, and the amount of data is limited for dome demonstrators. We have to some extend coped with this through simulations using real and synthetic data.
- **Ability to establish the reliable baseline and after indicators from research data.** The evaluation periods are adapted to the availability of research data of good quality, as described in sections 6.3. The indicators are established through manual analyses, use of the KPI calculator, and simulations, as described in section 7.3.1.

The hybrid approach is used for Oslo Demo 1 and Bremen Demo 1, as it is a challenge to evaluate smart energy management without simulations. The evaluations of these demonstrators would have been less complete and less reliable with a manual and traditional approach.

Demonstrators are relatively small and limited, and none of them are full-fledged energy smart neighbourhoods. We had concrete plans for simulations of fictive scenarios of more compete energy smart neighbourhoods (see Annex H.1). This was however not possible due to the delay of the simulator and time-consuming debugging of the indicator calculations.

The reliability of the results for individual demonstrators is addressed in section 7.1.1.
For all evaluations, the GreenCharge indicator framework is used, and in general, a sufficient amount of research data is collected. For some demonstrators, the data amount is however limited.

The baseline and after situations strategies vary. The simulations extend the demonstrators and facilitate studies of more complex after situations. We experience that the simulations extend the value of the impact evaluation results.

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1 References

1. Hanssen, C.W., et al., *GreenCharge Project Deliverable: D1.1 Data Management Plan*. 2019.
2. Natvig, M.K. and C.W. Hanssen, *GreenCharge Project Deliverable: D9.1POPD - Requirement no. 1.* 2019.
3. Natvig, M.K., et al., *GreenCharge Project Deliverable: D4.2 Final Architecture Design and Interoperability Specification.* 2022.
4. Venticinque, S. and R.E. Sard, *GreenCharge Project Deliverable: D5.1 & D6.1Evaluation Design / Stakeholder Acceptance Evaluation Methodology and Plan.* 2019.
5. Esposito, A., et al., *GreenCharge Project Deliverable: D5.3 Simulation and Visualisation Tools (revised version)*. 2021.
6. Natvig, M.K., S. Jiang, and S. Hallsetinsen, *GreenCharge Project Deliverable: D5.6 Open Reseach Data.* 2022.
7. Bubilek, P., et al., *GreenCharge Project Deliverable: D2.8 Final Report for Oslo pilot: Lessons Learned and Guidelines.* 2022.
8. Günther , B., et al., *GreenCharge Project Deliverable: D2.15 Final Report for Bremen pilot: Lessons Learned and Guidelines* 2022.
9. Enrich, R., *GreenCharge Project Deliverable: D2.21 Final Report for Barcelona pilot: Lessons Learned and Guidelines* 2022.
10. Engels, D., *Refined CIVITAS process and impact evaluation framework.* 2015.
11. Engels, D. and G. Van Den Berg, *Measure reporting on evaluation approach and evaluation findings - RIA projects.* 2017.
12. EC-European Commission, *Sustainable and Smart Mobility Strategy–putting European transport on track for the future, SWD (2020) 331 final (COM (2020) 789 final)*. 2020, Brussels.

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Annex A Research data from demonstrators and simulations

This annex provides an overview of the research data collected from the demonstrators and produced by simulations. The data supports the establishment of the quantitative indicators defined in Annex B.

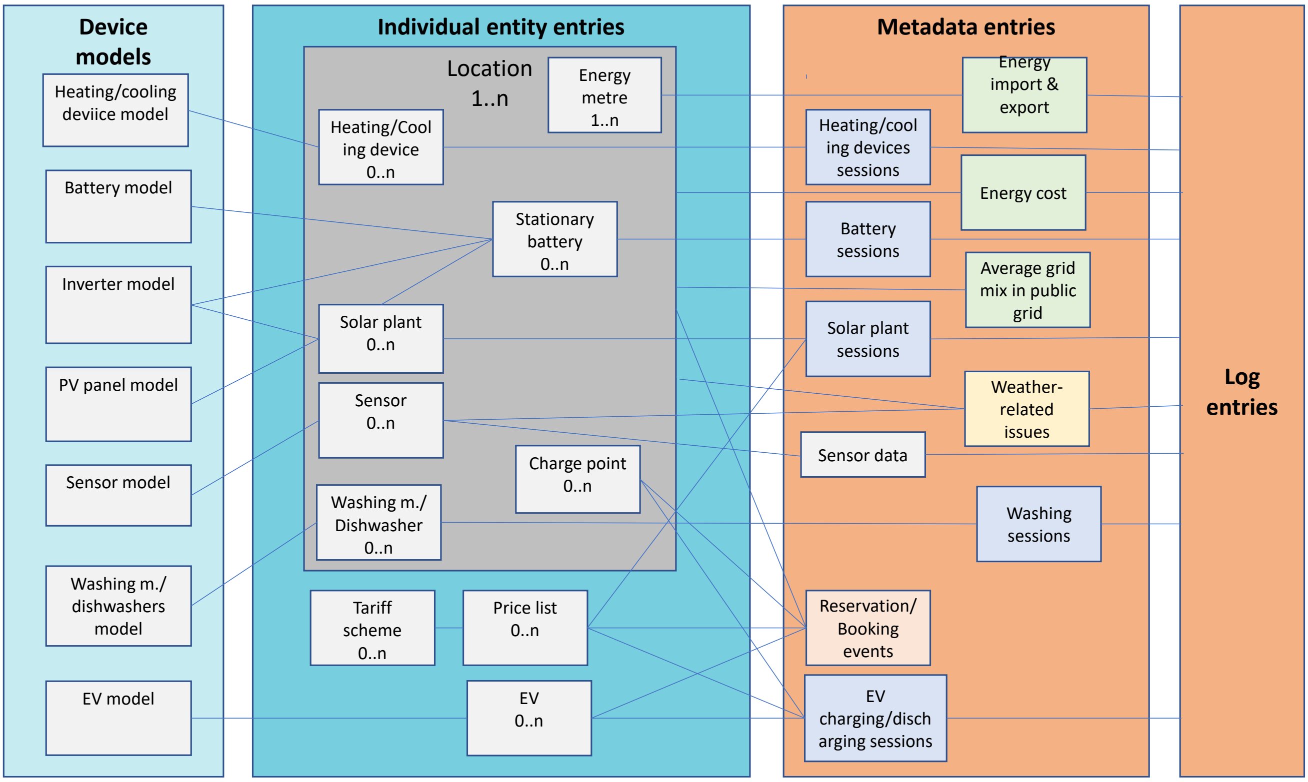
A.1 Overview of data used in automated KPI calculations

Parts of the research data are designed and established for use in automated KPI calculations. A full specification of these research data is published in deliverable D5.6 Open Research Data.

The data entry types of relevance are described in the figure below. The entry types of relevance are:

- **Device models entries** defining the characteristics of models or brands involved.
- **Individual entity entities** define elements involved in the demonstrator, among others the EVs, locations, charge points, solar plants, RES, and stationary batteries.
- **Metadata entries** are overall data on the activities in the demonstrators. This data is collected automatically.
- **Log entries** with time series describing use/production/import/export of energy (e.g., for charging sessions) or time series on energy characteristics (e.g. grid mix), costs and weather conditions. This data is collected automatically.

The figure provides an overview of the data elements in each entity type.



A.2 Data collected for automated KPI calculations

Annex A.1 provides an overview of the collected data: Device model entries, individual entity entries, and metadata and log entries. The tables below provide an overview of the data collected in each demonstrator. **Note:** D3 in Oslo is not a real demonstrator. It will not be evaluated but provides data on energy use in housing cooperative apartments for use in simulations.

The data collection methods for the different data types are indicated by the following codes:

- M: Data is manually collected
- A: Data is automatically collected by software systems
- M* or A*: The data define the context. Baseline and after data are the same..

The data availability is indicated by colours:

- Green: Data are collected (*provided)
- Red: Data fully or partly rejected due to quality issues, among others due to hardware errors
- Grey: Data not available or too limited.
- Orange: Data is collected for use in simulations (and not in demo evaluations)

Device types	Model and device datasets providing static data	Demonstrators							
		Oslo			Bremen		Barcelona		
		D1	D2	D3	D1	D2	D1	D2	D3
Charge points	Individual Charge points	M*	M*		M*	M*	M*	M*	M*
EVs	EV models	M*	M*		M*	M*	M*	M*	M*
	Individual EVs	A*	A*		A*	A*	M*	A*	
Stationary batteries	Battery models	M*			M*				M*
	Inverter models	M*			M*				M*
	Stationary battery	M*			M*				M*
RES	PV panel models	M*			M*			M*	M*
	Inverter models	M*			M*			M*	M*
	Individual Solar plants	M*			M*			M*	M*
Heating/ cooling devices	Heating/Cooling device models			A*				M*	
	Individual Heating/Cooling devices			A*				M*	
Energy metres	Individual Energy metres	M*		A*	M*		M*	M*	M*
Sensors	Sensor models			A*	M*				
	Individual Sensors			A*	M*				
Price lists	Individual price lists	M*	M*			M*			
Tariffs	Individual tariff scheme	M*	M*			M*			

Events/aspects	Metadata and log entries	Oslo			Bremen		Barcelona		
		D1	D2	D3	D1	D2	D1	D2	D3
Booking of charge point/energy	Metadata on reservation/booking events	A	A		A			A	
Charging sessions	Metadata on EV charging/discharging + log entries	A	A		A	A	A	A	
RES production	Metadata on solar plant sessions + log entries	A*			A			A	
Use of stationary energy storage	Metadata on battery sessions + log entries	A			A				A
Heating/cooling device sessions	Metadata on heating/cooling + log entries			A*				A*	
Energy characteristics	Metadata on energy import/export + log entries	A		A	A			A	
	Average grid mix in public grid	A*			A*			A*	
	Energy cost public grid + log entries	A*						A*	
Weather conditions	Metadata on predicted weather data + log entries	A*							

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	Metadata on measured weather data + log entries	A*							
Sensor data	Metadata on sensors + log entries			A*				A*	

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Annex B Indicators

The indicators described in this section are refined versions of the indicators described in the combined deliverable D5.1 and D6.1. The indicators are described and the approaches for the establishment of the indicators are also described.

Many of the indicators build upon the indicators described in the CIVITAS evaluation framework. In such cases we refer to CIVITAS (reference element in the indicator tables).

The table below provides an overview of the indicators, which sub-category they belong to (the categories are defined by CIVITAS), and the impact aspect they are targeting.

Indicator	Sub-category	Impact Aspect
Category: Transport System		
GC 5.1: Number of EVs	eMobility	Number of EVs
GC 5.2: Number of parking spaces with charging plug	eMobility	Charging availability
GC 5.3: Utilization of charge points	eMobility	Charging availability
GC 5.5 Charging availability	eMobility	Charging availability
GC 5.13 Charging flexibility	eMobility	Charging flexibility
Category: Energy		
GC 5.4 Share of battery capacity for V2G	eMobility	V2G
GC 5.9 Share of green energy	Fuel consumption	Energy consumption
GC 5.10 Peak to average ratio	Fuel consumption	Burden on grid
GC 5.14 Self Consumption	Fuel consumption	Energy consumption
Category: Environment		
GC 5.12 CO2 emissions	Pollution/Nuisance	Emissions
Category: Economy		
GC 5.6 Average operating cost	Cost	Operating costs
GC 5.7 Capital investment costs	Costs	Investment for acquiring and installing equipment
GC 5.8 Average operation revenue	Benefits	Operating revenues
Category: Society-people		
GC 6.1 Awareness level	Acceptance	Awareness
GC 6.2 Acceptance level	Acceptance	Acceptance level
GC 6.3 Perception of level of accessibility of service	Accessibility	(Physical) accessibility of service
GC 6.4: Operational barriers	Accessibility	Operational accessibility to (transport) services
GC 6.5: Relative cost of the service	Accessibility	Economic accessibility of (transport) services
GC 6.6: Shared EVs per capita	Accessibility	Vehicles availability

The measures defined in Chapter 2.1 are assessed by means of the indicators listed above. The mapping generic between measures and indicators is listed in the table below. Specific issues regarding the individual demonstrators (e.g., focus/objectives and the ability to collect data and establish baseline) may however affect the selection of indicators to be used in the assessment of each demonstrator. For the exact use of indicators in each demonstrator, see the description of the approach for each demonstrator in section 4.

Group	Measure	Relevant indicators
EV fleets	Shared EVs Shared EVs integrated with public transport Shared EVs in new housing cooperatives	GC 6.1 Awareness level GC 6.2 Acceptance level GC 6.3 Perception level of physical accessibility of service GC 6.4 Operational barriers GC 6.6 Shared EVs per capita
Charging	Private charge point Public charge point Shared CPs	GC 6.1 Awareness level GC 6.2 Acceptance level GC 6.3 Perception level of physical accessibility of service

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	Roaming Advance booking Battery swapping and charging Flexible charging Priority charging Priority access to CP	GC 6.4 Operational barriers GC 5.1 Number of EVs GC 5.2 Number of charge points GC 5.3 Utilization of charge points GC 5.5 Charging availability (with focus on energy availability) GC 5.13 Charging flexibility
Smart energy management	Local RES Local storage V2G Optimal and coordinated use of energy	GC 6.1 Awareness level GC 6.2 Acceptance level GC 6.4 Operational barriers GC 5.9 Share of green energy GC 5.10 Peak to average ratio GC 5.14 Self-consumption GC 5.12 CO2 emissions
Business aspects	Rewarding Eco driving Payment for sharing EVs	Linked to EV fleet: GC 6.1 Awareness level GC 6.2 Acceptance level GC 6.4 Operational barriers GC 6.5 Relative cost of the service GC 5.6 Average operating costs GC 5.7 Capital investment cost GC 5.8 Average operating revenues
	Payment for shared CPs Penalizing blocking of CP Penalizing priority in ESN Rewarding flexibility in ESN	Linked to Charging GC 6.1 Awareness level GC 6.2 Acceptance level GC 6.4 Operational barriers GC 6.5 Relative cost of the service GC 5.6 Average operating costs GC 5.7 Capital investment cost GC 5.8 Average operating revenues
	Rewarding prosumers in ESN Rewarding lower peaks in ESN	Linked to Smart energy management GC 6.1 Awareness level GC 6.2 Acceptance level GC 6.4 Operational barriers GC 6.5 Relative cost of the service GC 5.6 Average operating costs GC 5.7 Capital investment cost GC 5.8 Average operating revenues

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B.1 Society-people indicators

B.1.1 GC 6.1 Awareness level

Indicator GC 6.1	**Awareness level**
Category	Society-people
Sub-category	Acceptance
Impact aspect	Awareness
Context and relevance	People are more likely to take advantage of new measures or services if they are aware of them, i.e., if they are informed about the benefits of EVs or existence of EV sharing services. Service providers or authorities with an interest in an increased awareness of new measures may initiate information campaigns in order to raise awareness of the new integrated measures among potential users. Information regarding these measures may be disseminated by means of advertisements, leaflets, posters, etc. In this context, the core indicator will show what percentage of people has been reached and to what extent they have gained knowledge about the new measures, and thereby, whether or not (or to what degree) such an information campaign has been successful. The core indicator intends to assess whether the awareness of the policies and integrated measures (integrated measure group) has changed since they were implemented.
Definition	Awareness level is defined as the percentage of the target population with knowledge of a measure on account of provided information. This indicator is used to assess the awareness of the general public or a particular target group on measures. **Unit:** Percentage of people (within the group) aware of measure X (possible different levels of awareness 1 to 3 or 1 to 5).
Measurement	**Method**: • Surveys. • Visits to the webpage. • Number of new registrations after a campaign. **Frequency**: Measurements should be made at least twice during the project, i.e., before measure is introduced (baseline) and at the end of the project (ex-post). It seems also appropriate to measure the impact after each campaign or event. **Area of measurements:** GreenCharge Demonstrators.
References	Derived from CIVITAS indicator Awareness level
Comments	

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B.1.2 GC 6.2 Acceptance level

Indicator GC 6.2	**Acceptance level**
Category	Society-people
Sub-category	Acceptance
Impact aspect	Acceptance level
Context and relevance	Awareness (GC 6.1) and acceptance are closely related and should be analysed in conjunction. Those aware of a measure may or may not be satisfied with its existence and/or use. The core indicator intends to assess satisfaction with the existence and/or use of the measure.
Definition	Acceptance level is defined as the percentage of the target population who favourably receive or approve the measure. This indicator is used to assess the acceptance levels of general public or target groups on measures. **Unit:** Share of people with different levels of acceptance (from 1 to 10)
Measurement	**Method**: • Face-to-face interviews and/or online surveys • Understanding level (% of users with good understanding of the measures) • Usefulness level (% of users feeling measure is useful) • Willingness to change (% of users likely to change mobility behaviour) **Frequency**: Measurements should be made at least twice during the project, i.e., before measure is introduced (baseline) and at the end of the project (ex-post). Where appropriate, data could also be collected on an annual basis. • **Observed group**: Oslo: Inhabitants of flats, but perhaps also other parties involved (such as housing association, or charge point operator) Bremen: Citizens Barcelona: Citizens **Area of measurement**: Demonstration area
References	Derived from CIVITAS indicator Acceptance level
Comments	

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B.1.3 GC 6.3 Perception of level of (physical) accessibility of service

Indicator GC 6.3	**Perception of level of (physical) accessibility of service**
Category	Society-people
Sub-category	Accessibility
Impact aspect	(Physical) accessibility of service
Context and relevance	The main barriers to social inclusion in eMobility are accessibility and affordability. In terms of social inclusion and accessibility, this indicator concentrates on spatial accessibility and assesses the extent to which user perception of spatial accessibility changes compared to the situation prior to the implementation of the measure Accessibility in the context of this core indicator is limited to the spatial access to the service. User perception of accessibility should thus focus on such spatial dimension and disregard other accessibility factors such as economic (price of using the service in relation to personal income) or physical (e.g., problem-free access to charging services) accessibility. Spatial accessibility not only includes the distance to the closest charge point, but also the convenience of getting there.
Definition	Perception of service accessibility is defined as the user's perception of the physical accessibility of the service. This concern, for instance, the convenience of getting to the service, to use the service, etc. **Unit**: index of "accessibility perception" on a 5-point scale
Measurement	**Method**: • Surveys with a 5-point Likert scale. • Interviews • Usage **Frequency**: Measurements should be made at least twice during the project, i.e., before measure is introduced (baseline) and at the end of the project (ex-post). It seems also appropriate to measure the impact after each campaign or event. **Area of measurements:** GreenCharge Demonstrators.
Reference	Derived from CIVITAS indicator No. 3 Perception of level of (physical) accessibility of service. Instead of concentrating in transport we should focus on the services delivered by the project (sharing e-scooter service, charge points, …)
Comments	

B.1.4 GC 6.4 Operational barriers

Indicator GC 6.4	**Operational barriers**
Category	Society-people
Sub-category	Accessibility
Impact aspect	Operational accessibility to (transport) services
Context and relevance	Having a charge point and an EV is not a sufficient condition for eMobility. Other barriers have still to be overcome to make use of it or prefer it over other transportation modes. Certain knowledge is necessary to operate or make use of eMobility. Training and information should help to overcome this barrier and enable real equal accessibility for all citizens.
Definition	The operational accessibility to eMobility, as the average reported convenience **Result:** Qualitative study of barriers to eMobility and/or charging (split by type of barrier)
Measurement	**Method**: • Surveys. • Interviews • Usage. **Frequency**: Measurements should be made at least twice during the project, i.e., before CIVITAS measure is introduced (baseline) and at the end of the project (ex-post). It seems also appropriate to measure the impact after each campaign or event. **Area of measurements:** GreenCharge Demonstrators.
References	Derived from CIVITAS indicator No. 4 Perception of Operational Barriers. Instead of concentrating in transport we should focus on eMobility
Comments	

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B.1.5 GC 6.5 Relative cost of the service

Indicator GC 6.5	Relative cost of the service
Category	Society-people
Sub-category	Accessibility
Impact aspect	Economic accessibility of (transport) services
Context and relevance	This core indicator provides useful information in the context of eMobility and social inclusion. There are many categories of social inclusion, namely physical, geographical, exclusion from facilities, time-based exclusion, fear-based exclusion, economic exclusion and spatial exclusion. In terms of social inclusion and accessibility, this indicator concentrates on economic accessibility. Many measures may have impacts on the access to eMobility. These include access to EVs, the availability of charging infrastructure, the availability and access to shared EVs, costs, and promotion of eMobility. The core indicator can be used to addresses the charging cost in proportion to average personal income.
Definition	Relative cost of charging service is defined as the average service as a percentage of the average personal available income. **Unit:** % or percentage-based index
Measurement	**Method**: • Surveys • Interviews. • Usage • Incomes may be retrieved from statistics **Frequency**: Measurements should be made at least twice during the project, i.e., before measure is introduced (baseline) and at the end of the project (ex-post). It seems also appropriate to measure the impact after each campaign or event. **Area of measurements:** GreenCharge Demonstrators.
References	• Derived from CIVITAS indicator No. 5 Relative cost of the service
Comments	

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B.1.6 GC 6.6 Shared EVs per capita

Indicator GC 6.6	**Shared EVs per capita**
Category	Society-people
Sub-category	Accessibility
Impact aspect	Vehicle availability
Context and relevance	One shared EV may replace several individually owned vehicles. Vehicle sharing reduces the mileage driven and increases the use of other modes such as walking, cycling and public transport.
Definition	This indicator is derived by dividing total target group by the number of shared EVs. EVs may be shared electric bikes, scooters of cars available on street for users (who sometimes must go through a registration process and pay a registration fee) to hire. 1. The number of shared EVs per 1000 persons **Unit:** Number of shared EVs per 1000 persons per EV category 2. The share of shared EVs in general 3. The share of shared EVs among EVs.
Measurement	**Method**: This indicator is derived by dividing driving age population (18 and over) by the number of shared EVs available from service providers. **Frequency**: Measurements should be made at least twice during the project, i.e. before CIVITAS measure is introduced (baseline) and at the end of the project (ex-post). It seems also appropriate to measure the impact after each campaign or event. **Area of measurements:** GreenCharge Demonstrators.
References	Defined by GreenCharge. Derived from CIVITAS Bike sharing and stations per capita
Comments	

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B.2 Transport System indicators

B.2.1 GC 5.1 Number of EVs

Indicator GC 5.1	**Number of EVs**
Category	Transport system
Sub-category	eMobility
Impact aspect	Number of EVs
Context and relevance	It is relevant to measure the number or share of EVs in general or different types of EVs within a defined area.
Definition	The number of electric vehicles (EVs) in an area during a defined period. It can be relevant to measure within a defined area. Several sub-indicator alternatives are relevant: 1. **Number of EVs. Unit:** Number 2. **Share of EVs. Unit:** Percentage 3. **Number of specific EVs**, i.e., EVs of a specific type. **Unit:** Number 4. **Number of planned EVs**, i.e., the number citizens plan to buy. **Unit:** Number
Measurement	**Method**: (the numbers are referring to the sub-indicators) • Automatically established: Data on the number of EV registrations in the GreenCharge system (1) • Manually established: Counting the number of EVs/other vehicles (1,2,3) • Manually established: The number shared EVs is available from operators (4) • Survey: Ask about the number of EVs a community own or plan to buy (1,5,6) • Statistics: Can be used for scalability measures. **Frequency**: • Measurements at least twice during the project, i.e. before measure is introduced (baseline) and at the end of the project (ex-post). • Where appropriate, data could also be collected on an annual basis. **Area of measurements:** GreenCharge Demonstrators.
References	Defined by GreenCharge
Comments	

B.2.2 GC 5.2 Number of charge points

Indicator GC 5.2	**Number of charge points**
Category	Transport system
Sub-category	eMobility
Impact aspect	Charging availability
Context and relevance	It is relevant to measure the number of Charge points (CPs) in general or different types of CPs within a defined area.
Definition	The number of charge points (CPs) in a defined area. Several sub-indicator alternatives are relevant: 1. **Number of CPs**. Number of CPs available for charging. **Unit**: Number 2. **Share of CPs**. Share of parking spaces equipped with charging equipment. **Unit**: Percentage 3. **Number of private CPs**. **Unit**: Number 4. **Number of shared CPs. Unit**: Number
Measurement	**Method**: (the numbers are referring to the sub-indicators) • Automatically established: Data on the number of CP registrations in the GreenCharge system (1) • Manually established: Count the number of parking spaces, number equipped with/without charging equipment, and type (private/shared/max power) (2,3,4) • Survey: Ask about the number of CPs a community plan to install (5) • Statistics/Open data: Can be used for scalability measures **Frequency**: • Measurements should be made at least twice during the project, i.e. before measure is introduced (baseline) and at the end of the project (ex-post). • Where appropriate, data could also be collected on an annual basis. **Area of measurements:** GreenCharge Demonstrators.
References	Defined by GreenCharge
Comments	

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B.2.3 GC 5.3 Utilization of charge points

Indicator GC 5.3	**Utilization of charge points**
Category	Transport system
Sub-category	eMobility
Impact aspect	Charging availability
Context and relevance	The utilization of CPs indicates the how well the charging capacity is adapted to the charging needs. The Utilization of CPs also indicates the availability. High utilization may indicate low availability.
Definition	The utilization of the charge point as seen from the service perspective both with respect to the occupancy ratio (an EV is connected), the time used for charging (EVs may not charge the whole time they are connected), and the utilization of the charging capacity with respect to energy. Several sub-indicator alternatives are relevant: 1. **Share of connected time.** Time EVs are connected during a specific time span. **Unit:** Connected time/Time span 2. **Share of charging time.** Time the EVs are charging compared to the total connected time. **Unit:** Charing time/Time span 3. **Energy per time unit.** Energy EVs are charged with per connected time unit. **Unit:** Charged Energy/Connection time 4. **Number of charging sessions.** The number of charging sessions during a time span. **Unit**: Number
Measurement	**Method**: (the numbers are referring to the sub-indicators) • Automatically established: Calculated based on data collected from software systems (1,2,3) **Calculations based on data on charging sessions:** For each charging session for the selected charge point(s) and within the selected timespan: • Connected Time = Plug out time – Plug in time • Charging Time = Time the EV is actually charging • Charged Energy = Energy content at end – Energy content at start **The sub-indicators are:** 1. Share of connected time = (SUM of all Connected Time)/Timespan of interest 2. Share of charging time = (SUM of all Charging Time)/(SUM of all Connected Time) 3. Energy per time unit = (SUM of all Charged Energy)/(SUM of all Connected Time) 4. Number of sessions **Frequency**: Data should be collected continuously during the operation of the demonstrator. **Area of measurements:** GreenCharge Demonstrators.
References	Defined by GreenCharge
Comments	

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B.2.4 GC 5.5 Charging availability

Indicator GC 5.5	Charging availability
Category	Transport system
Sub-category	eMobility
Impact aspect	Charging availability
Context and relevance	The availability of CPs indicates how easy it is to get access to a charger. High availability may be good for users but bad for business. Thus, a balance is needed.
Definition	The availability of charging services as seen from the EV user's perspective measured by means of sub-indicators: 1. **Energy availability.** Energy transferred to the EV battery compared to energy demand. **Unit:** ChargedEnergy/ChargeDemand 2. **Demand fulfilment.** Share of charging sessions where EVs are charged according to the charging demand. **Unit:** Percent 3. **Share of no show.** Share of booked time slots that are not used. **Unit:** Percent 4. **Average delay.** Average delay in plug-in time for booked time slots. **Unit:** Minutes 5. **Share of late plug out.** Share of sessions with booked time slots that are not finished (plug out) in time. **Unit:** Percent 6. **Delay of plug out.** Average delay in plug-out time for booked time slots. **Unit:** Minutes
Measurement	**Method**: (the numbers are referring to the sub-indicators) • Automatically established: Calculated based on data collected from software systems (1-6) **Calculation based on research data:** For all Relevant bookings • ChargeDemand = Target energy content – Initial energy content • NoBookingRequests = #bookings in Relevant bookings • NoBookingAccepted = #accepted bookings in Relevant bookings • BookingsNotUsed = = with Charging session ID not matching Relevant charging session IDs • NoNotUsed = number of BookingsNotUsed For all CPs involved: Use metadata for all relevant EV charging session. For all logs: • NoCharging = # Relevant charging session • ChargedEnergy = Energy content at end – Energy content at start • ChargingTime = Charging time • NoFullyCharged = #sessions where ChargedEnery is equal to or larger than ChargeDemand • PlugInDelay = Earliest start time - Plug in time • PlugOutDelay = IF (Plug out time > Latest finish time) THEN (Latest finish time - Plug out time) ELSE 0 • NotFinishedInTime = # PlugOutDelay that are > 0 **The sub-indicators are:** 1. Energy availability = (SUM of all ChargedEnergy)/(SUM of all ChargeDemand) 2. Demand fulfilment = (SUM of all NoFullyCharged)/NoCharging 3. Share of no show = NoNotUsed/(NoNotUsed+NoCharging) 4. Average delay = (SUM of all PlugInDelay)/NoCharging 5. Share of late plug out = NotFinishedInTime/NoCharging 6. Delay of plug out = (SUM of all PlugOutDelay)/NoCharging **Frequency**: Data should be collected continuously during the operation of the demonstrator. **Area of measurements:** GreenCharge Demonstrators.
References	Defined by GreenCharge
Comments	

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.

B.2.5 GC 5.13 Charging Flexibility

Indicator GC 5.13	Charging Flexibility
Category	Transport system
Sub-category	eMobility
Impact aspect	Charging flexibility
Context and relevance	When the EV user allows flexible charging, this will facilitate Energy Smart Neighbourhood (ESN), i.e. that the charging system to adjust charging time to peak loads, energy tariffs, etc.
Definition	Different flexibility sub-indicators are relevant: 1. **Offered flexibility.** This is the flexibility offered by EV user. The user will provide charging constraints (when charging must be finalised and how much the EV must be charged) 2. **Actual flexibility.** This is the flexibility the system could have utilised, based on when the EVs actually are plugged in and out. 3. **V2G flexibility.** How much flexibility the EV user is willing to provide with respect to V2G. Some clarifications: • The flexibility gets higher if the charging can finish fast. E.g. that the amount of energy requested is low and/or the EV model can charge fast (high max charging power). • The flexibility gets higher if the time to the planned departure is long. • If the planned departure time is earlier than the actual plug out time, the actual flexibility is higher than the flexibility provided by the user. **Unit:** Index varying in [0,1]. The closer to 1 the better.
Measurement	**Method**: (the numbers are referring to the sub-indicators) • Survey: Users are asked about their willingness to provide flexibility (1) • Automatically: Calculated based on data collected automatically from software systems. This is data on EV models (collected through charging App), charging bookings/reservations, charging sessions (1,2,3) • Simulation: To explore the effects of "what if" scenarios regarding local RES capacity, number of EVs, storage capacity, V2G, provided flexibility, etc. (1,2,3) **Calculation based on research data:** Data on the EV and EV model constraints are needed • Offered Energy = Battery capacity - Min energy content the EV user can cope with • EV Charging Power = Max Charging Power AC IF charge point is of type AC, ELSE Max charging power DC (unit kW) • EV Discharging Power = Max discharging power IF charge point is of type AC, ELSE Max discharging power DC (unit kW) Data on the CP are needed and the power is the minimum of the capacity of the EV and the CP: • CP Charging Power = Charging capacity • Charging power = MIN(EV Charging Power, CP Charging Power) • Discharging Power = MIN(EV Discharging Power, CP Charging Power) Data on the booking constraints associated to all charging sessions are needed. • Relevant Bookings = all bookings for the selected charge point(s) within the selected timespan • For each booking in Relevant Bookings: ○ Requested Energy = (Target energy content - Initial energy content) (unit kW) ○ Min Energy Content = Minimum energy content the user can cope with ○ Offered FlexTime = Latest finish time – Earliest start time All charge sessions are linked to a booking. • For each charging session linked to a booking in Relevant bookings ○ Connected Time = Plug out time – Plug in time (unit t) ○ Actual FlexTime = Plug out time - Earliest start time The indexes for one charging sessions are • Offered Flexibility Index = 1 - (Requested Energy/Charging Power) / Offered FlexTime

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	• Actual Flexibility Index = 1 - (Requested Energy/Charging Power) / Actual FlexTime • V2G Flexibility Index = (Offered Energy/Discharging Power) / Offered FlexTime **The sub-indicators are:** 1. Offered flexibility = For all relevant charging sessions: The average of all Offered Flexibility Index 2. Actual flexibility = For all relevant charging sessions: The average of all Actual Flexibility Index 3. V2G flexibility = For all relevant charging sessions: The average of all V2G Flexibility Index **Frequency**: Data should be collected • Manually at beginning of the project and at the end. (1,3) • Continuously during the operation of the demonstrator (1,2 and manually at the end for 3 since V2G is only simulated) **Area of measurements:** GreenCharge Demonstrators and simulation scenarios
References	Defined by GreenCharge
Comments	**Example:** A Charging Station has 4 charge points (CPs) • 2 CPs can deliver 9 kW as maximum power • 2 CPs can deliver 6 kW as maximum power • The charge station has a maximum limit of 18 kW. In three hours, 54 kWh theoretically can be delivered. The charge station can control the distribution of the power among the individual CPs and start and stop the charging of EVs. The EVs • Request a certain amount of energy (=RequestedEnergy) • Can charge with a max power level per hour, decided by the EV model (= ChargingPower) • Will get an amount of energy depending on the charging capacity (= EnergyDelivered) The following cases illustrate the importance of flexibility. In the tables, yellow colour indicates that less energy is delivered compared to the request. Orange indicated that no energy is delivered.

Case 1 – almost no flexibility provided

EV	Arrives	Leaves	RequestedEnergy (kWh)	EnergyDelivered (kWh)	ChargingPower (kW)
EV1	08:00	10:00	9	6	6
EV2	08:00	09:00	6	0	6
EV3	08:00	09:00	9	9	9
EV4	08:00	09:00	9	9	9

The charge station can charge EV3 and EV4 but must decline EV2. The charging of EV1 must be shifted to 09:00-10:00, but it cannot be fully charged due to limited EVChargingPower.

Case 2 – low flexibility provided

EV	Arrives	Leaves	RequestedEnergy (kWh)	EnergyDelivered (kWh)	ChargingPower (kW)
EV1	08:00	11:00	9	9	6
EV2	08:00	09:00	6	0	6
EV3	08:00	09:00	9	9	9
EV4	08:00	09:00	9	9	9

The charge station can charge EV3 and EV4 but must decline EV2. The charging of EV1 must be shifted to 09:00-11:00.

Case 3 – flexibility provided

EV	Arrives	Leaves	RequestedEnergy (kWh)	EnergyDelivered (kWh)	ChargingPower (kW)
EV1	08:00	11:00	9	9	6
EV2	08:00	09:00	6	6	6
EV3	08:00	11:00	9	9	9
EV4	08:00	09:00	9	9	9

The charge station can simultaneously charge EV2 and EV4 and partially EV1 (6+9+3 = 18 kWh). The charging of EV3 and the remaining 6 kWh charging of EV1 is shifted to 09:00 – 11:00. Thanks to the flexibility of EV1 and EV3, additional EVs can also be charged in this period with 18 kWh.

The table below summarized the cases with respect to energy charged compared to the requested energy.

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Cases	EnergyDelivered per EV (kWh)				Total Energy Delivered (kWh)	Requested Energy (kWh)
	EV1	EV2	EV3	EV4		
1	6	0	9	9	24	33
2	9	0	9	9	27	33
3	9	6	9	9	33	33

The tables below show the flexibility indexes. We see that high flexibility allows increased energy delivery.

Case	Flexibility index				Total Energy Delivered (kWh)	Requested Energy (kWh)
	EV1	EV2	EV3	EV4		
1	0,25	0	0	0	24	33
2	0,5	0	0	0	27	33
3	0,5	0	0,67	0	33	33

B.3 Energy indicators

B.3.1 GC 5.4 Share of battery capacity for V2G

Indicator GC 5.4	**Share of battery capacity for V2G**
Category	Energy
Sub-category	eMobility
Impact aspect:	V2G
Context and relevance	It is relevant to know how much energy storage capacity in EV batteries that can be used to provide energy flexibility, e.g. to increase consumption of green energy and to reduce power peaks.
Definition	The amount of energy EV batteries that can be used to accumulate energy-surplus, and to be returned before it is needed. Several sub-indicators are relevant: 1. **Average energy amount.** Amount of energy in EV batteries that can be used. **Unit**: kWh 2. **Share of battery capacity.** Share of capacity in EV batteries that can be used. **Unit**: Percentage of total EV battery capacity
Measurement	**Method**: (the numbers are referring to the sub-indicators) • Survey • Simulation: To explore the effects of "what if" scenarios regarding V2G (1,2) **Calculation by means of research data:** For all EVs involved: • BatteryCapacity is the battery capacity of the respective EV model For all Relevant bookings (with energy requests): • EnergyDemand = Requested amount of energy For all CPs involved: Use metadata for all relevant EV charging session. For all logs: • NoOfChargeSessions is the number of charge sessions carried out • MaximumChargePower is the maximum charge power possible • MaximumDisChargePower = MaximumChargePower • ConnectedPeriod = DisConnectionTime – ConnectionTime **The sub-indicators are:** 1. Average energy amount = (SUM of all MaximumChargePower*(ConnectedPeriod – (EnergyDemand/ MaximumChargePower)*0,5)/NoOfChargeSessions 2. Share of battery capacity = Sub-indicator 1/SUM of all BatteryCapacity **Frequency**: Simulation should be made with different parameters. **Area of measurements:** GreenCharge simulation scenarios

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Reference	Defined by GreenCharge
Comments	All

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B.3.2 GC 5.9 Share of green energy

Indicator GC 5.9:	**Share of green energy**
Category	Energy
Sub-category	Energy consumption
Impact aspect	Energy consumption
Context and relevance	To decide how green the energy used is. Preferably different periods of a year should be considered to see the differences between seasons, optionally 6 months (from/to mid-summer). There is some confusion between green, clean and renewable energy. The most critical point is whether we consider nuclear power to be green. For nuclear energy, mining, milling and enrichment of uranium into nuclear fuel result in the emission of carbon dioxide into the atmosphere from the burning of fossil fuels.
Definition	The share of green energy is the share of green energy versus total energy consumed. Sub-indicators are: 1. Share of green energy. **Unit:** percentage 2. Share of green energy in used energy. **Unit:** percentage
Measurement	**Method**: • Manually: Data defined as parameters to simulations (2) • Automatically: Data collected automatically from the energy management system/grid metres and public information on the energy mix in the provided energy (1-2) • Simulation: To explore the effects of "what if" scenarios regarding local RES capacity, number of EVs, storage capacity, V2G, provided flexibility, etc. (2) **Calculation based on research data:** We will first calculate the KPIs for a timeslot with constant energy mix and local PV production, and if we have input data represented as time series, we sum over the time series afterwards. Notation: • Upper case letters denote vectors with one element per energy source • Lower case letters denote scalars • S is the set of relevant energy sources. • G is the subset of S considered as green sources. We consider these to be: Biomass, Geothermal, Hydro Pumped Storage, Hydro Run-of-river and poundage, Hydro Water Reservoir, Marine, Solar, Wind Offshore, and Wind Onshore. Input data: • e_i : the amount of energy imported from the grid • e_{lp} : the amount of energy produced locally • M_i : the energy mix vector of the imported energy given as the fraction from each energy source • E_{lp} : the energy mix vector of the locally produced energy given as the amount of energy from each energy source (all zeros except the element representing solar = e_{lp}) To be calculated: • M_{lc} : the energy mix vector of the energy consumed locally given as fraction from each energy source • g_{ic} : the share of green energy of the imported energy • g_{lc} : the share of green energy of the locally consumed energy Formulae: • $M_{lc} = ((e_i * M_i) + E_{lp}) / (e_i + e_{lp})$ To calculate these values for longer periods where the input data are varying with time and given as time series, we need to align the time series such that they have the same slot length, sum over all timeslots in the period, and divide by the number of slots. Share of green energy in provided energy= g_{ic} = sum(M_i(s)) over all s in G (can be used as a baseline) **The sub-indicators are:** 1. Share of green energy = g_{lc} = sum(M_{lc}(s)) over all s in G **Frequency**: D Data should be collected continuously during the operation of the demonstrator.

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	Area of measurements: GreenCharge Demonstrators and simulation scenarios
References	Defined by GreenCharge,Derived from CIVITAS indicator Fuel mix.
Comments	RES to battery (V2G included) will increase RES consumption

B.3.3 GC 5.10 Peak to average ratio

Indicator GC 5.10	**Peak to average ratio**
Category	Energy
Sub-category	Energy Consumption
Impact aspect	Burden on grid
Context and relevance	It is important to reduce peak loads, to increase savings and to reduce grid losses.
Definition	The ratio of the highest energy peak to its average value, used as a measure to indicate the variability of the energy use. Sub-indicators are: 1. **Maximum peak power**. **Unit:** kW This is the peak within a time slot set to 15 minutes. 2. **Average power demand.** Relation between the maximum power in a sample divided by the average power: (Peak power (kW)/Average power). **Unit:** Absolute value (preferably as close to 1 as possible)
Measurement	**Method**: • Manual: Identify max power in historical energy bills (baseline data) (1,2) • Automatically: Calculated based on data collected automatically from the energy management system/grid metres (1,2) • Simulation: To explore the effects of "what if" scenarios regarding local RES capacity, number of EVs, storage capacity, V2G, provided flexibility, etc. (1,2) **Calculation based on research data:** The indicators can be calculated for the whole demonstrator, a location, a charging station or a charge point. We focus on energy demand. Use data on: • Energy meter data on import and export • EV charging sessions • Other energy demanding activities • Battery sessions • Import/export measured by metres. For a period, T is a vector with all consumptions in the demonstrator (EV charging sessions, heating/cooling sessions, stationary battery sessions, etc.). The vector will have as many components as time slots within the period T and will represent energy or power. • E(t) represents the energy. • P(t) represent the power. To calculate $\tilde{P}$ - **average power** we use energy or power $\tilde{P} = \frac{1}{T}\sum_{t=1}^{T} E(t)$ or $\tilde{P} = \frac{1}{T}\sum_{t=1}^{T} \Delta t * P(t)$ **The indicators alternatives:** 1. Pmax **max peak power** is: $Pmax = \max\left(\frac{E(t)}{\Delta t}\right)$ or $Pmax = \max(P(t)\ \forall t\ within\ period\ T)$ $where\ \Delta t\ is\ the\ time\ between\ 2\ consecutive\ measurements$ 2. Average power demand = $\frac{Pmax}{\tilde{P}}$

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.

	Frequency: Data should be collected continuously during the operation of the demonstrator. **Area of measurements:** GreenCharge Demonstrators and simulation scenarios
References	Defined by GreenCharge
Comments	

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B.3.4 GC 5.14 Self-consumption

Indicator GC 5.14:	Self-consumption
Category	Energy
Sub-category	Energy consumption
Impact aspect	Energy consumption
Context and relevance	It is relevant to reduce CO2 emission and grid fee through self-consumption of locally produced green energy.
Definition	The amount of energy produced locally that is consumed locally, or the share of the total energy consumption that is locally produced. The sub-indicators are: 1. **Energy self-consumption**, i.e. the energy consumed from local RES. **Unit:** kWh 2. **Energy self-sufficiency**, i.e., the share of the total energy consumption that is locally produced. **Unit:** Percentage
Measurement	**Method**: • Manual: Established based electricity bill (1,2) • Automatically: Calculated based on data collected from software systems. (1,2) • Simulation: To explore the effects of "what if" scenarios regarding local RES capacity, number of EVs, storage capacity, V2G, provided flexibility, etc. (1,2) **Calculation based on research data:** Use data on: • Total energy consumed from all local RES units • Total local energy production from all RES units Calculate: *Total local energy production* = sum of all production from RES in period *Total consumption of energy from RES = Total local energy production – sum of all energy exported* **The sub-indicators are:** 1. Energy self-consumption is: For all local RES $Energy\ self consuption\ = \frac{Total\ consumption\ of\ energy\ from\ local\ RES}{Total\ production\ of\ energy\ from\ local\ RES}$ 2. Energy self-sufficiency is: For all local RES $Energy\ self - sufficiency\ = \frac{Total\ consumption\ of\ energy\ from\ local\ RES}{Total\ local\ enery\ consumption}$ **Frequency**: Data should be collected continuously during the operation of the demonstrator. **Area of measurements:** GreenCharge Demonstrators and simulation scenarios
References	Defined by GreenCharge
Comments	

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B.4 Environment indicators

B.4.1 GC 5.12 CO2 Emissions

Indicator GC 5.12	CO2 Emissions
Category	Environments
Sub-category	Pollution/Nuisance
Impact aspect	Emissions
Context and relevance	Carbon dioxide is the most significant greenhouse gas, contributing about 80% of total EU greenhouse gas emissions, and transport is one of the main sources for CO2 emissions. Measures promoting eMobility will have impacts on CO2 emissions directly (through use of cleaner energy and vehicles) or indirectly (e.g., congestion reduction through use of shared EVs). This indicator can be used to assess the impacts of such measures on CO2 reduction. The CO2 emissions depend on the energy mix used. Smart and green charging with optimal use of locally produced energy from RES can reduce emissions. By means of this indicator we can assess the reduced emissions per kWh and per km driven with energy provided by the charging infrastructure compared with energy from the public grid.
Definition	CO2 emissions is defined by the following sub-indicators: 1. **Average CO2 emission per vehicle km**. **Unit**: gCO2eq/km 2. **Average CO2 emission per kWh used. Unit**: gCO2eq/kWh 3. **CO2 emission**. Unit: Kg Co"
Measurement	**Method**: • Manually: Calculated based on statistics on kWh per km and GC 5.12.2. (1, 3) • Automatically: Calculated based on data collected by software systems. (1, 2) • Simulation: To explore the effects of "what if" scenarios regarding local RES capacity, storage capacity, V2G, provided flexibility, etc. (2) **Calculation based on research data:** We will first calculate the KPIs for a timeslot with constant energy mix and local PV production, and if we have input data represented as time series, we sum over the time series afterwards. Notation: • Upper case letters denote vectors with one element per energy source • Lower case letters denote scalars • S is the set of relevant energy sources. • G is the subset of S considered as green sources. We consider these to be: Biomass, Geothermal, Hydro Pumped Storage, Hydro Run-of-river and poundage, Hydro Water Reservoir, Marine, Solar, Wind Offshore, and Wind Onshore. Input data: • e_i : the amount of energy imported from the grid • e_{lp} : the amount of energy produced locally • M_i : the energy mix vector of the imported energy given as the fraction from each energy source • E_{lp} : the energy mix vector of the locally produced energy given as the amount of energy from each energy source (all zeros except the element representing solar = elp) • F : the emission factors (gCO2eq/kWh) for the different energy sources. See table below:

Emission factors (gCO2eq/kWh) to be used for different energy sources:					
Biomass	740.00	Peat	350.00	Solar	30.00
Lignite	400.00	OtherFossil	400.00	Waste	295.00
Coal	820.00	Geothermal	375.00	WindOffShore	12.00
Gas	490.00	HydroPumped	240.00	WindOnShore	11.00
HardCoal	350.00	Hydro	24.00	Marine	24.00

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<table>
<tr><td></td><td>
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<tr><td>Oil</td><td>488.00</td><td>Nuclear</td><td>12.00</td><td></td></tr>
<tr><td>Shale</td><td>417.00</td><td>OtherRES</td><td>20.00</td><td></td></tr>
</table>
To be calculated:
• M_{lc} : the energy mix vector of the energy consumed locally given as fraction from each energy source
• c_{lc} : the CO2 emission (gCO2eq/kWh) of the locally consumed energy
• c_i : the CO2 emission (gCO2eq/kWh) of the imported energy

Formulae:
• $M_{lc} = ((e_i * M_i) + E_{lp}) / (e_i + e_{lp})$
• c_i = sum(M_i (s) * F(s)) over all s in S
• c_{lc} = sum(M_{lc} (s) * F(s)) over all s in S

To calculate these values for longer periods where the input data are varying with time and given as time series, we need to align the time series such that they have the same slot length, sum over all timeslots in the period, and divide by the number of slots.

The average energy use for electric vehicles is set to 0.2 kWh/km (https://www.elbilgrossisten.no/pages/ladeguiden-lade-elbi l)

Driving distance = Energy use from charging in kWh/(0.2 kWh/km)

The sub-indicators are:
1. Average CO2 emission per vehicle km = 0.2 kWh/km * c_{lc} for locally consumed energy
Average CO2 emission per vehicle km = 0.2 kWh/km * c_i for imported energy
2. Average CO2 Emission per kWh used = c_{lc} for locally consumed energy
Average CO2 Emission per kWh used = c_i for imported energy
3. The value found using the calculator provided by the Norwegian Environment Agency[18] with the Driving distance (compare with fossil vehicle Euro class 6)

Frequency: Data should be collected continuously during the operation of the demonstrator
Accuracy: as good as can be obtained within limits of models/resources available
</td></tr>
<tr><td>References</td><td>Derived from CIVITAS indicator no 24 CO2 Emissions. Adapted to eMobility by GreenCharge.</td></tr>
<tr><td>Comments</td><td></td></tr>
</table>

[18] https://www.miljodirektoratet.no/tjenester/klimagassutslipp-kommuner/beregne-effekt-av-ulike-klimatiltak/

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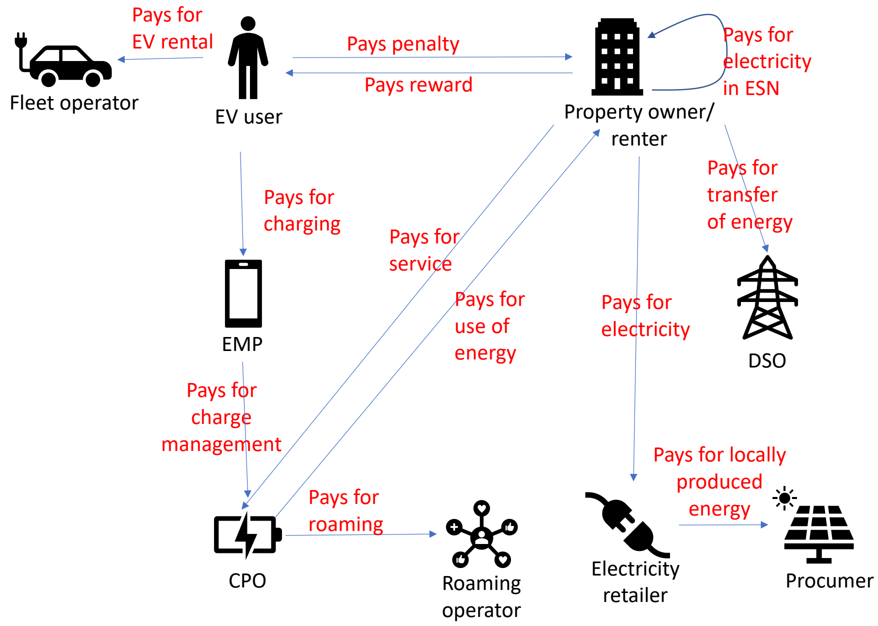
B.5 Economy indicators



The figure above shows the payment flows between stakeholders. The table below indicates how the payment flows are included in a selection of the economic indicators when charging is addressed from the property owner/renter's point of view. We also assume that the prosumer is the property owner. The letters in the table indicates the following:

- C: Economy aspects related to charging (from the perspective of property owner/renter)
- E: Economy aspects related to energy use in general in ESN

Selection of indicators	Payment flows to/from Property owner/Renter						
	Use of energy	Penalty	Reward	Electricity	Transfer of energy	Service (to CPO)	Locally produced energy
GC 5.6.4 Average energy cost				E/C	E/C		
GC 5.6.6 Service payment to CPO						C	
GC 5.8.1 Revenue from normal operations	C		(C)				E
GC 5.8.2 Revenue from penalties		C					

B.5.1 GC 5.6 Average operating cost

Indicator GC 5.6	Average operating cost
Category	Economy
Sub-category	Cost
Impact aspect	Operating costs
Context and relevance	Reduced operating costs are an important motivation for ESNs and charging infrastructure owners when it comes to the implementation of smart and green charging. Thus, it is relevant to investigate the changes in operating costs as an effect of smart energy management.
Definition	The operating costs have a direct relation to the operation of the ESN/charging infrastructure.

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	The sub-indicator are: 1. **Total average operating costs**.. **Unit:** Euro per month 2. **Personnel costs.** Average personnel costs per month for the operation of the ESN/charging infrastructure. **Unit:** Euro per month 3. **Energy costs from RES.** Average energy costs per kWh from use of energy from local RES shared within ESN. **Unit:** Euro per kWh for all 4. **Average energy cost for ESN.** This is the average energy cost per kWh for energy imported (payment to Retailer and DSO). **Unit:** Euro per kWh for all 5. **Maintenance costs.** Average maintenance costs per month the charging infrastructure. **Unit:** Euro per month 6. **Service payment to CPO.** May depend on 4. **Unit:** Euro per kWh for all Note: GC 5.6.4 + GC 5.6.6 are the actual average costs per kWh for charging via the charging infrastructure.

Measurement	**Method**:
	• Manual: Data collected from stakeholders (1,2,4,5,and 6)
	• Automatically: Calculated based on data collected from software systems. This is data on energy costs from Retailer and DSO, Data on production from local RES, prices that can be paid for the energy from local RES, and energy used for charging and other activities (3,4,6).
	• Simulator calculation: To explore the effects of "what if" scenarios regarding local RES capacity, number of EVs, storage capacity, V2G, provided flexibility, business models, etc. (3,4,6)
	
	Calculation based on research data (for 3, 4 and 6):
	Calculate energy use and production:
	• Use log entries for Energy import and export for the energy meter to get
	  o Energy import = Sum of all the positive values within timespan
	  o Energy export = Sum of all the negative values within timespan
	• Use log entries for Solar plant sessions (see 5.3.3) to get
	  o PV production = Sum of all the values within timespan
	• *Total energy used from grid*= Energy import + PV production - Energy export
	
	Calculate energy cost:
	• Cost for transfer of energy (payment to DSO)
	  o Use metadata from Individual price models of type "Transfer of energy" within timespan.
	  o *Cost paid to DSO* = sum of all relevant tariffs (adapted to unit Euro per kWh)
	• Calculate the cost for electricity (payment to retailer)
	  o Use metadate from Individual price models of type "Electricity" within timespan to find relevant tariffs where the retailer is the receiver of the payment:
	  Static energy cost paid to retailer = sum of all tariffs for timespan
	  o Use metadata from Energy cost in public grid and get variable market price matching timespan to find the spot prices:
	  Varying energy cost paid to retailer = Sum of all time interval within timespan (energy import * spot price)
	  o *Cost paid to retailer = Static energy cost paid to retailer + Varying energy cost paid to retailer*
	
	Calculate cost for service payment to CPO (payment to DSO)
	• Use metadata from Individual price models of type "Service" within timespan
	• *Cost paid to CPO* = sum of all tariffs (adapted to unit Euro per kWh)
	
	The sub-indicators are:
	1. Total average operating costs = 2 + 5 + ((6 + 3 + 4) * # kWh) (numbers refers to list below)
	2. Personnel costs. Manually collected. Unit: Euro per month
	3. Energy costs from RES is not used
	4. Average energy cost for ESN = (*Cost paid to DSO* + *Cost paid to retailer) / Total energy used from grid*
	5. Maintenance costs. Manually collected. Unit: Euro per month
	6. Service payment to CPO = *Cost paid to CPO*
	
	Frequency: Measurements should be at beginning of the project and at the end.
	
	Area of measurements: GreenCharge Demonstrators

References	Defined by GreenCharge

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.

Comments	

B.5.2 GC 5.7 Capital investment cost

Indicator GC 5.7	**Capital investment cost**
Category	Economy
Sub-category	Cost
Impact aspect	Investment for acquiring and installing equipment
Context and relevance	Capital investment cost is defined as the total capital costs for purchase of infrastructure and equipment per demonstrator. It can also include the total costs spent in setting up the measure and cover a period from the initiative of the measure preparation until the start of the measure implementation. This indicator focuses on the capital costs as a result of measure(s). The sub-indicators are: 1. **Capital investment costs** in infrastructure, equipment, vehicles 2. **Preparation and design costs**.
Definition	The indicators of relevance are 1. Total Capital Investment costs **Unit:** €
Measurement	**Method**: • Manual: Data on the costs are collected from stakeholders (market and business partners) (1) **Frequency**: Measurements should be at beginning of the project and at the end. **Area of measurements:** GreenCharge Demonstrators
References	Derived from CIVITAS indicator Capital investment cost. Modified by GreenCharge.
Comments	

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.

B.5.3 GC 5.8 Average operating revenue

Indicator GC 5.8	Average operating revenue
Category	Economy
Sub-category	Benefit
Impact aspect	Operating revenues
Context and relevance	Operating revenue is defined as total income per month. This indicator focuses on the operating revenues as a result of measure(s) and, therefore, on the economic perspective of the intended measure groups. It is for example relevant to estimate sustainability and impact of business models.
Definition	The sub-indicators are: • **Average operating revenues from normal operation** (Unit Euro per kWh) • **Average operating revenues from penalties** (Unit Euro per kWh)

Measurement	**Method**:
	• Manual: Data collected from stakeholder (1,2)
	• Automatically: Calculated based on research data collected by software systems (1,2)
	• Simulator calculation: To explore the effects of "what if" scenarios regarding measures (1,2)
	
	Calculation based on research data:
	Use data on:
	• Energy meter – for relevant location
	• Energy import and export – related to meter, to derive revenue from energy export
	• Reservation/booking events
	• EV charging sessions
	
	Revenue from surplus energy export:
	• Use log entries for Energy import and export for Meter within timespan
	    ○ Energy export = Sum of all the negative values within timespan
	• Use metadate from Individual price models of type "Electricity" within timespan to find relevant tariffs where the retailer is the payer.
	• Static payment from retailer = sum of all tariffs for timespan
	• Use metadata from Energy cost in public grid and get variable market price matching timespan to find the spot prices.
	• Varying payment from retailer = Sum of all time interval within timespan (energy import * spot price)
	• Revenue from retailer = Static payment from retailer + Varying payment from retailer
	
	Revenue from charging services:
	• For all relevant charging sessions within timespan
	    ○ Use metadata for Reservation/Bookings events and find price models where the receiver is the target for the revenue calculation and find relevant tariffs.
	    ○ For each tariff, use metadata from Individual tariffs
	    ○ Penalty tariffs = tariffs of type penalty
	    ○ Normal tariffs = tariffs of type other than penalty
	• Calculate revenues
	    ○ Calculate revenue for each tariff. If tariff/price is per kWh charged, use charging session data on energy charged to calculate revenues
	    ○ Normal revenue = sum of revenues calculated from Normal tariffs
	    ○ Penalty paid= sum of revenues calculated from Penalty tariffs
	
	The sub-indicators are:
	2. Normal operation revenue = Revenue from retailer + Normal revenue
	3. Penalty revenue = Penalty paid
	Area of measurements: GreenCharge Demonstrators

References	Derived from CIVITAS indicator Average operating revenue. Modified by GreenCharge.

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.

Comments	

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.

Annex C Questionnaires and interview guides for impact evaluation

This annex provides an overview of planned/accomplished interviews/surveys used to collect data for the impact evaluation.

C.1 Oslo demonstrators - Questionnaires and interview guides

C.1.1 Oslo Demo 1 (charging in ESN): Group interview - with housing cooperative board

General

1. What is the situation in your households with regard to car ownership and car use?
2. What are your thoughts about the future of electric cars and charging?
    a. Do you have, or are you planning to buy an electric car? Why?
    b. Has anything or anyone influenced your choices or thoughts? (neighbours / family, incentives / economy, conscience for the environment, idealism?)
3. What are your thoughts on car sharing? Are you interested in car sharing?

Process

4. What are your experiences and thoughts about the process of installing the Private CPs for EV in the housing cooperative?
5. How has the fact that the housing cooperative got CPs changed their thoughts about electric cars?
6. Did you understand the information provided? Are you missing any information? What?
7. How have you experienced the process of being part of a research project?
    a. Collaboration with researchers and the municipality?
8. How do you feel that the process of charging infrastructure installation has affected the residents? Have there been strong opinions among the residents?
9. Do you have the impression that more people have had plans to buy an EV?

EV users experience with the installation of CPs

10. What is your personal experience with the installed charging system?
    a. What are you most happy with?
    b. What are you least happy with?
    c. What do you think about the usability of the system?
    d. How satisfied are you with the capacity of the system? Do you always get charged when you need it? Have you ever experienced not having a fully charged car?
11. What feedback have you received from the other residents?
12. What do you experience that the other residents are most and least happy with?
13. How important is it for you that the garage plant's solar cell system is used to charge the electric cars?
14. How important is it for you to get information about how much of the electric car charging is based on solar power?

Flexible and priority charging (for those with an electric car, or those who have plans for it)

This system / app is not fully developed, so now we want to hear your thoughts on this, so that their opinions help to influence how it will be in the future.

Today, the charging system works like this: as long as you are plugged in, you get charging. If the system has capacity limitations, all cars will have reduced charging (i.e. it takes longer before the full battery).

Scenario 1: current solution, but with the possibility of flexible charging.

- We will now hear first if you are willing to be flexible for charging. Flexible charging means that the system itself decides when the car is charged so that you get the most renewable power at the same time as everyone gets enough power.

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

This means that the system optimizes the charging of all electric cars, by ensuring that the charging will use as much green energy as possible, charging when the electricity is cheap, avoiding the highest tariff and at the same time ensuring that users get what they need (enough power at certain times).

So even if you now pay a fixed price, you can with this technology, make the housing association save money (pay less for electricity) because you do not have to pay as much in infrastructure investment and less in operational costs. This will also have benefits for the individual households because the common costs decrease / do not increase.

15. Would you consider being flexible when charging your car, given that you can define when your car needs to be ready?
16. If you use flexible charging, and had plotted the expected departure time the next morning, but still had to use the car the same evening. Do you then expect some charging, or would you accept that the car had the same battery percentage as when you plugged it in?
17. Had cheaper charging costs been a factor that made you wait to charge the car? How much cheaper must the charging cost be for this to be a point for you (Percentage, or e.g. "half as cheap")

Scenario 2: flexible charging or priority charging
- We will now ask about the following: given that the default is flexible charging (i.e. that you are not guaranteed charging as soon as you plug in). In this case, we look at the possibility of choosing priority charging (i.e. that you are guaranteed power from the first second).

18. Would you be willing to pay more for priority charging? How much more would have been a reasonable price? (Percentage, or e.g. "half as cheap")
19. Which of these two scenarios do you think is the best option here?

Installation of OBD2 Dongle
This is something you install in the car, which transfers information about the battery contents (State-of-Charge) to the car's battery very often (Approximately every second or minute). The advantage is that the user does not have to enter the battery's energy content in the app when starting the charging, which makes it easier for the user, in addition to the fact that we get more correct values, as Dongle reads the battery's energy content itself.

20. Could you be willing to install an OBD2 Dongle in your car? (The answer does not determine whether it will be installed or not, but only questions to hear their thoughts).

Costs
21. What do you think about the price level for installing the CPs? Do you remember how much it cost? Do you remember what you thought when you heard the award?
22. What do you think about the price level of the charging box? Do you remember how much it cost? Do you remember what you thought when you heard the award? (For info: NOK 13,000 incl. Discount of NOK 5,400)
23. What do you think about the price level for charging the electric car? Do you remember how much it costs? Do you remember what you thought when you heard the award? (For info: DKK 1.9 / kWh and DKK 62 / month)
24. What do you think about the financial support the housing association has received from Oslo Municipality / GreenCharge / OBOS? How has this support possibly affected your and the others' opinion about electric cars / charging?
25. Are you satisfied with the investment in installing CPs for electric cars?

Suggestions for improvement from those who have experience with use:
26. What are the challenges with the charging system as it is today?
27. Do you have suggestions for improvements?

Suggestions from those without an electric car / experience:
28. Are there any changes in the system as it is today that had made you consider an electric car?

End
29. Do you know if the (public) charge points outside the garage are used, and for what? Are these charge points you recommend guests to use?

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.

30. Do you have anything to add? / Are there any other important questions you think have been forgotten in this interview?

C.1.2 Oslo Demo 1 (charging in ESN): Interview with residents

In general

1. What is the situation in your households with regard to car ownership and car use?
    a. Do you use a car a lot in everyday life?
2. What are your thoughts about the future of electric cars and charging?
    a. Do you have, or are you planning to buy an electric car? Why?
    b. Has anything or anyone influenced your choices or thoughts? (neighbours / family, incentives / economy, conscience for the environment, idealism?)
3. What are your thoughts on car sharing? Are you interested in car sharing?

Process and user experience

4. What are your experiences and thoughts about the process of installing the private charging stations for electric cars in the housing association?
    a. What are you most happy with?
    b. What are you least happy with?

If you have an electric car:

   c. What do you think about the usability of the system?
   d. How satisfied are you with the capacity of the system? Do you always get charged when you need it? Have you ever experienced not having a fully charged car?

5. How has it that the housing association got charging infrastructure for electric cars changed your thoughts about electric cars?
6. Did you understand the information provided in this process? Are you missing any information? What?
7. What are your thoughts on the board of the housing association in this process?
8. How important is it for you that the garage plant's solar cell system is used to charge the electric cars?
9. How important is it for you to get information about how much of the electric car charging is based on solar power?

Flexible and priority charging (for those with an electric car, or those who have plans for it)

This system / app is not fully developed, so now we want to hear your thoughts on this, so that their opinions help to influence how it will be in the future.

Today, the charging system works like this: as long as you are plugged in, you get charging. If the system has capacity limitations, all cars will have reduced charging (i.e. it takes longer before the full battery).

Scenario 1: current solution, but with the possibility of flexible charging.

- We will now hear first if you are willing to be flexible for charging. Flexible charging means that the system itself decides when the car is charged so that you get the most renewable power at the same time as everyone gets enough power.

This means that the system optimizes the charging of all electric cars, by ensuring that the charging will use as much green energy as possible, charging when the electricity is cheap, avoiding the highest tariff and at the same time ensuring that users get what they need (enough power at certain times).

So even if you now pay a fixed price, you can with this technology, make the housing association save money (pay less for electricity) because you do not have to pay as much in infrastructure investment and less in operational costs. This will also have benefits for the individual households because the common costs decrease / do not increase.

10. Would you consider being flexible when charging your car, given that you can define when your car needs to be ready?

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.

11. If you use flexible charging, and had plotted the expected departure time the next morning, but still had to use the car the same evening. Do you then expect some charging, or would you accept that the car had the same battery percentage as when you plugged it in?
12. Had cheaper charging costs been a factor that made you wait to charge the car? How much cheaper must the charging cost be for this to be a point for you (Percentage, or e.g. "half as cheap")

Scenario 2: flexible charging or priority charging
- We will now ask about the following: given that the default is flexible charging (i.e. that you are not guaranteed charging as soon as you plug in). In this case, we look at the possibility of choosing priority charging (i.e. that you are guaranteed power from the first second).

13. Would you be willing to pay more for priority charging? How much more would have been a reasonable price? (Percentage, or e.g. "half as cheap")
14. Which of these two scenarios do you think is the best option here?

Installation of OBD2 Dongle
This is something you install in the car, which transfers information about the battery contents (State-of-Charge) to the car's battery very often (Approximately every second or minute). The advantage is that the user does not have to enter the battery's energy content in the app when starting the charging, which makes it easier for the user, in addition to the fact that we get more correct values, as Dongle reads the battery's energy content itself.

15. Could you be willing to install an OBD2 Dongle in your car? (The answer does not determine whether it will be installed or not, but only questions to hear their thoughts).

Costs
16. What do you think about the price level of the charging box? Do you remember how much it cost? Do you remember what you thought when you heard the award? (For info: NOK 13,000 incl. Discount of NOK 5,400)
17. What do you think about the price level for charging the electric car? Do you remember how much it costs? Do you remember what you thought when you heard the award? (For info: DKK 1.9 / kWh and DKK 62 / month)
18. What do you think about the financial support the housing association has received from Oslo Municipality / GreenCharge / OBOS? How has this support possibly affected your and the others' opinion about electric cars / charging?
19. Are you satisfied with the investment in installing CPs for electric cars?

Suggestions for improvement from those who have experience EVs:
20. Do you have suggestions for improvements?

Suggestions from those without an electric car / experience:
21. Are there any changes in the system as it is today that had made you consider an electric car?

End
22. Do you know if the (public) charge points outside the garage are used, and for what? Are these charge points you recommend guests to use?
23. Do you have anything to add? / Are there any other important questions you think have been forgotten in this interview?

C.1.3 Oslo Demo 1 (charging in ESN): Survey November 2018 – Pre installation of charge points

Use of e-car and access to charge points

Purpose with the survey

More and more people choose to buy electric cars. The Board of Røverkollen therefore wishes to conduct a survey of needs and wishes for the charging of electric vehicles also in the garage.
…

Background for the survey

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.

Statistics from Statistics Norway show that more new electric cars are already registered than petrol, diesel and hybrid cars. In addition, the Government has set a goal that all new cars should be emissions-free by 2025. This goal is set as part of the National Transport Plan for 2018-29. Today, it is only possible to charge electric cars with the four joint charge points outside the buildings at Røverkollen. It is desirable to eventually establish the possibility of charging in the garage as well.

Questions

1. What is your age group?
   ☐ 18–25 ☐ 25–35 ☐ 35–55 ☐ 55–65 ☐ 65–75 ☐ Over 75

2. How many people in your household have a driving license for car (class B)?
   ☐ 0 ☐ 1 ☐ 2 ☐ 3 or more

3. Do the household have a car, or have a car at one's disposal?
   ☐ owns, number of cars: _______ ☐ borrows /rents ☐ Do not have a car

4. ***If you have a car***: Do you have a parking spot in the housing cooperatives' garage?
   ☐ Yes, number: ————— ☐ No, I do not need a place

5. ***If you have a car***: Do you have a commercial vehicle? (e.g. taxi or van)
   ☐ yes, profession (voluntary): ____________ ☐ No, I do not have a commercial vehicle

6. ***If you have a car:*** How often do you use the car you use the most?
   ☐ several times a day ☐ Daily ☐ 3–4 times a week ☐ 1–2 times a week ☐ More seldom week

7. ***If you have a car***, How many electric vehicles or chargeable hybrid cars?
   Number of el-cars: ___________ Number of chargeable hybrid cars: ______________

8. ***If you have el-car or chargeable hybrid car***: How often do you have to charge the chargeable car you use
   ☐ Daily ☐ 3–4 times a week ☐ 1–2 times a week ☐ more seldom than once a week

9. Do you have plans to buy el-car or chargeable hybrid car?
   ☐ Yes, clear plans ☐ Yes, within 2 years ☐ No, however I need car in my everyday life ☐ No, I do not need a car in my everyday life ☐ I already poss

10. How important is it for you today that charging possibilities are available in parking spots in the garage f cooperative?
    ☐ very important ☐ a bit important ☐ not very important ☐ not important ☐ not relevant

11. How important do you think it will be for you in 3 years that there is charging opportunities on the parki garage for the housing cooperative?
    ☐ very important ☐ a bit important ☐ not very important ☐ not important ☐ not relevant

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.

12. How likely is it that you would like to use car sharing? (if the cars are available in close proximity to the housing cooperative)

☐ very likely ☐ a bit likely ☐ not very likely ☐ completely unlikely ☐ not relevant

13. If you have / want to get an electric car, do you want to share the charging point with others through a booking sy this can reduce your expenses?

☐ Yes, that will be important ☐ No, I would rather have my own charging point

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.

C.1.4 Oslo Demo 1 (charging in ESN): Survey March 2020 for– After installation of charge point

How?

November 2019 a round of interviews were conducted. The interviews were conducted both individually and in groups. One group interview with the board of the housing cooperative, and six individual interviews with residents.
The interviews were conducted among the residents in the housing cooperative. The group interview lasted about 1,5 hours, while the individual interviews lasted between 20-40 minutes.
Recordings were made from the interviews, which later were written down and analysed.

Who?

The interview participants were selected from lists received from the board of the housing cooperative. One list of residents who had ordered and installed private charge point, and from a list of residents who signed up as interested to participate in interviews at an information meeting. Both residents with and without electric vehicles (EV) were contacted. All the interview objects were contacted by email. The residents who first responded were chosen to participate.

What?

The interview guide consisted of general questions about the occupant's car situations, thoughts on cars in the future, experience with the installed charging system, finances and costs, and suggestions for improvement.
As the app was not yet in use and therefore the possibility to use prioritised and flexible charging was not the case, hypothetical questions were asked about these themes.

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. What is your age group?

☐ 18–25 ☐ 25–35 ☐ 35–55 ☐ 55–65 ☐ 65–75 ☐ Over 75

2. How many people in your household have a driving license for car (class B)?

☐ 0 ☐ 1 ☐ 2 ☐ 3 or more

3. Do the household have a car, or have a car at one's disposal?

☐ Owns, number of cars: ☐ Borrows/rents ☐ Do not have a car

4. **If you have a car:** Do you have a parking spot in the housing cooperatives' garage?

☐ Yes, number: ______________ ☐ No, I do not need a spot

5. **If you have a car:** Do you have a commercial vehicle? (e.g. taxi or van)

☐ Yes, profession (Voluntary): ______________ ☐ No, I do not have a commercial vehicle

6. **If you have a car:** How often do you use the car you use the most?

☐ Several times a day ☐ Daily ☐ 3–4 times a week ☐ 1–2 times a week ☐ More seldom once a week

7. **If you have a car:** How many electric vehicles or chargeable hybrid cars?

Number of el-cars: ____________ Number of chargeable hybrid cars: _______________

8. **If you have el-car or chargeable hybrid car:** How often do you have to charge the chargeable car you use the n

☐ Daily ☐ 3–4 times a week ☐ 1–2 times a week ☐ More seldom than once a week

9. **If you have el-car or chargeable hybrid car:** How satisfied are you with the new charging system?

☐ Very satisfied ☐ A little satisfied ☐ A little unhappy ☐ Very unhappy ☐ Not relevant

10. Do you have plans to buy el-car or chargeable hybrid car?

☐ Yes, clear plans ☐ Yes, within 2 years ☐ No, however I need a car in my everyday life ☐ No, I do not need a car in my everyday life ☐ I already have an el-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.

11. Has the new charging system affected your thoughts on buying an el-car or chargeable hybrid car?

☐ Yes ☐ No

12. What is your motivation for buying, or planning on buying, a private charging point? (Sort by what's most important by giving numbers between 1 and 5, where 1 is most important and 5 least important)

Reduce charging cost	Charging with green energy	Guaranteed spot for charging	Guaranteed a fully charged car	Borrow/rent out the charging spot
_________	_____________	______________	______________	___________

13. How likely is it that you would like to use car sharing? (if the cars are available in close proximity to the hou cooperative)

☐ Very likely ☐ A bit likely ☐ Not very likely ☐ completely unlikely ☐ Not relevant

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.

14. Do you know about the four semi-fast charging spots available outside of the garage?

☐ Yes ☐ No

15. **If yes:** do you recommend these charging spots to guests or visitors?

☐ Yes ☐ No – Why not?: __________________________________

PART 2 – CLAIMS ABOUT CHARGING

Please answer those who already have an El-car or chargeable hybrid, or who plans on buying one in near future

Additional information:

- **Flexible charging** means that the system decides when the cars are charging, that way it use much renewable energy as possible, at the same time as everyone gets power.
- **Priority charging** means guaranteed power right away.

16. I always need a fully charged car

☐ Yes, this is very important ☐ I can some days have a partly charged car ☐ No, this is not that important

17. I am willing to be flexible on when my car is being charged, as long as I can define the time it needs to be charge

☐ Yes, willing to be flexible ☐ Yes, willing to be flexible some days ☐ No, not willing to be flexible

18. I would use flexible charging if it gave me a:

☐ Yes, if it gave me a __________% cheaper price ☐ Yes, I would consider it for environmental reasons, regardless of price ☐ No, not willing to use charging

19. I am worried about the costs of charging my el-car or chargeable hybrid car

☐ Very worried ☐ A little worried ☐ Not very worried ☐ Not worried at all ☐ Not relevant

20. It is important for me to deduce my carbon (Co2) footprint

☐ Very important ☐ A little important ☐ Not very important ☐ Not important at all ☐ Not relevant

21. If the system postponed charging to a time with cheaper electricity/green energy, I would be willing to pay e prioritised charging (to get charging right away) the times I need this.

☐ Yes, willing to pay twice as much ☐ Yes, 40% more ☐ Yes, 20% more ☐ No, not willing

22. Per week I typically need prioritised charging (the alternative is charging at night)

☐ More than 5 times a week ☐ 4-5 times ☐ 2-3 times ☐ About 1 time per week ☐ Less than 1 time week

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.

23. I am willing to use an app to specify when my car needs to be fully charged with flexible charging

☐ Yes willing, and positive to use an app ☐ Yes, willing, but a little negative to use an app ☐ No, not willin

24. I am willing to use an app to specify how much my car needs to be charged with priority charging (to avoid char when the electricity is expensive)

☐ Yes willing, and positive to use an app ☐ Yes, willing, but a little negative to use an app ☐ No, not willin

25. Battery capacity of my car is

☐0-15 kWh ☐15-30 kWh ☐ 30-45 kWh ☐>45 kWh

26. Charging speed of my car when plugged into my private charging point is:

☐3,7 kWh ☐7,4 kWh ☐ 11 kWh ☐22 kWh

27. When I plug my car in, I usually need:

☐0-15 kWh ☐15-30 kWh ☐ 30-45 kWh ☐>45 kWh

28. When I plug my car in, I usually need it back within

☐ Less than 1 hour ☐1-3 hours ☐ 3-5 hours ☐ more than 5 hours

Thank you for participating!

C.1.5 Oslo Demo 1 (charging in ESN): Survey when demo is fully implemented - evaluation of the GC app and flexible charging

February 4th 2022, an interview with the chairman of the board of Røverkollen housing cooperative was conducted. The interview lasted for about two hours. Recording was made from the interview, which later were written down and analysed. The interview was about the following topics and questions:

How has it been using the app during development.?

How was the support during development?

Further development, suggestions for the App?

How do you suspect new user will react to the App and the smart charging?

What can you tell us about Business model and pricing?

Have there been questions about the PV panels?

What are your recommendation to other housing cooperative if they should invest in EV chargers?

What are the important lessons learned?

C.2 Bremen demonstrators - Questionnaires and interview guides

C.2.1 Bremen Demo 2 (car sharing): Questionnaire to actual and future users

How?

Flyers were distributed in the vicinity of the sharing station. The flyer include a QR code to answer a survey and offered a reward (free minutes of the service).

Who?

It targets residents that are current or potential users of the carsharing service.

What?

An online survey through Jotforms tool

Sample questions

1. What is your age group?
   - 18-25
   - 26-35
   - 36-45
   - 65 or older
2. Please select your gender
   - Male
   - Female
   - N/A
3. How far do you live from the nearest city center (km)?
   - 5
   - 12
   - 18
   - 20
4. Which type of Mobility do you use regularly?
   - My own car
   - Public transport
   - (e-)bike
5. Does the COVID-19 pandemic affect your mobility?
   - 1
   - 2
   - 3
   - 4
   - 5
6. If yes, how?
7. Do you think Car-Sharing is a save service?
   - 1
   - 2
   - 3
   - 4
   - 5
8. Do you own a car?
   - Yes
   - No
9. Are you planning to buy a car in the next 12 months?
   - Yes
   - No

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.

10. Will this car most probably be an e-car?
    - Yes
    - No
11. Would an e-car-sharing possibility available in a range of 50 meters around your residence affect this decision?
    - Yes
    - No
12. Because of which reason you would not use e-car-sharing?
    - Distance
    - Safety
    - Too expensive
    - Not enough offer
13. How much money would you spend on such a service (€ per month)?
14. How much is that of your monthly income (%)?
15. If the Car-Sharing Station is more than a 10 min. foot walk away, would you use an eScooter to get to the Car-Sharing Car?
    - Yes
    - Maybe
    - No
16. Would you use public transport to get to the Car-Sharing Car?
    - Yes
    - Maybe
    - No
17. Would you use Bike-Sharing to get to the Car-Sharing Car?
    - Yes
    - Maybe
    - No
18. How much money would you spend on such a service (€ per month)?
19. Which car/ride sharing apps do you use?
20. In which cases you'd prefer e-car-sharing?
    - To go shopping
    - To visit friends
    - To get to work/school/university
    - To travel
    - To visit another city
    - Work
21. If you use an e-car, what role does the range play?
22. Would you like to use a smartphone app for booking and accessing the e-car sharing?
    - Yes
    - No
    - I don't know
23. Which indicators are important for you?
24. Do you want to participate in our raffle and win 3 hours of free e-car-sharing? Please, submit your email address here

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.

C.3 Barcelona demonstrators - Questionnaires and interview guides

C.4 Barcelona demonstrators - Questionnaires and interview guides

C.4.1 Barcelona Demo 1 (e-scooter sharing service): Interview to fleet operators

How? On-line interview

Who? Fleet operators of MOTIT sharing service .

What? Hold an interview to MOTIT partners that take care of the daily operation on-site

Sample

Questions

WARMING

- What is your activity? What relationship do you have with GreenCharge?
- Write at least 1 thing you like
- Write at least 1 thing you don't like
- Write at least 1 improvement

SMART CHARGING

- Do you know of the impact that electromobility can cause to the grid? Do you have an opinion on that?
- Does the charging of batteries have an impact on your installation? How easy/difficult would be to scale up? How often do you reach the maximum power? Do you know if you operate close to the limit? How often?
- Did you know/understand what smart energy management mean?
- Is it useful/interesting for you?
- Which operational barriers do you perceive in implementing smart management? Physical barriers? Economic barriers?

GREEN ENERGY

- Do you use green energy?
- Are you willing to use green energy? Why? Why not? Under what conditions?
- Is the usage of green energy relevant for your business? Your customers?
- Are you considering/open to generate locally your energy? Why? Why not?
- "Which operational barriers do you perceive in implementing smart management? Physical barriers? Economic barriers?

FLEXIBILITY

- On average, how much time are the batteries in the battery hub compared to the time they are actually charging?
- Can this time change? If not, under what conditions could it change?
- Would you consider to change your charging profile depending on electricity tariffs? And participating in a demand response program or responding to a signal from the grid operator to decrease or increase energy consumption at certain periods?
- Would you consider to offer energy to the grid when you do not need it? Why or why not?
- Which operational barriers do you perceive in implementing smart management? Physical barriers? Economic barriers?
- How much in advance do you know about your energy needs? Do you know it based on bookings? Historical records? Average per trip?

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BATTERY HUBS

- What do users prefer: free-floating or station-based?
- What implications of having station-based or free-floating for the operator?
- How does multilocation hubs improve (or not) the fleet operation?
- How are perceived by the users? In terms of acceptance? In terms of awareness?

USERS PROFILE

- Can you identify different user profiles?
- How loyal they are?
- Why do they choose MOTIT? What are the drivers to choose your service?
- What are the barriers for not using MOTIT or not using it more often?
- Do you receive many complaints? What are the most common ones?
- Do you receive many praises? What are they happy about?

OTHERS

- Can you summarise you point of view of electromobility?
- Any comment/suggestion/concerns

C.4.2 Barcelona Demo 1 (e-scooter sharing service): Interviews to users

How? On-line interview

Who? Users of MOTIT e-sharing service.

What? Hold an interview to MOTIT users to get insights about user acceptance.

Sample

Questions

USERS PROFILE

- Optional: age/gender
- Since when are you a user of MOTIT?
- Do you own any vehicle?
- Why do you use MOTIT?
- How often do you use MOTIT?
- How did you discover MOTIT?
- Are you a user of other sharing services?
- What is your opinion on sharing services?
- Which operational barriers (if any) have you identified in the service? Physical barriers? Economic barriers?
- Bearing in mind your incomes, how accessible do you find the service? (how cheap/expensive is it compare to other mobility options?)

ENERGY AWARENESS/INTERST

- Do you know/check/care about the energy usage per trip?
- Do you know/care about your carbon footprint?
- Is the fact that the scooter is electric the main/a reason for choosing the service?
- Are you aware/concern about the origin of the energy used for charging?
- Would the energy source (green energy/locally produced) affect your choice? (Yes/No depending on what factors?
- Do you have insights on how the charging process is done? Do you care?

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ECO-DRIVING MEASURE

- How would you define your driving profile? Smooth? Aggressive?
- Did you know that your driving profile can affect the energy consumed? And the duration of the battery?
- Would you change your driving profile to save energy?
- Would you change your driving profile if a reward program was in place?
- What kind of reward would be interesting for you?

OTHERS

- Can you summarise you point of view of electromobility?
- Any comment/suggestion/concerns

C.4.3 Barcelona Demo 2 (charge @ work): Poll to obtain the number of EV drivers

Poll March 2020 – Eurecat employees

How? Publish an article in the weekly Eurecat newsletters describing GreenCharge project and asking for users. A link to Doodle to complete a poll was included.

Who? Eurecat employees that may become users of the charging points.

What? The goal is to raise awareness of the measures to be implemented in GreenCharge by Eurecat employees and to know who drives an EV and may become a potential user of the service.

Sample

Do you own an electric vehicle, do you plan to buy one in the coming months or do you want to give us your opinion on electric vehicles and mobility? Participate in the GreenCharge project!

Now that we are preparing for the regular return to the offices, from the Applied Artificial Intelligence Unit we are looking for colleagues, especially those who have an electric vehicle, who want to give us their opinion on mobility and the electric vehicle, and whether their habits have changed as a result of COVID and / or sustainability measures.
We would also like to announce that within the European GreenCharge project we have deployed 3 points to charge slow-charging electric vehicles with a reservation system for use by Eurecat workers who work or visit the Cerdanyola and Manresa headquarters.

How can you help us?
Everyone
1. Answering the questionnaire
If you are an electric vehicle user:
2. Use the charging points at Eurecat using the reservation system
3. Give feedback on the experience and respond (survey, interview).

For more information and questions contact Regina Enrich a regina.enrich@eurecat.org

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.

C.4.4 Barcelona Demo 2 (charge @ work): Survey to Eurecat employees

Survey November 2021 – Eurecat employees

How? On-line survey using Office365 forms published in the weekly Eurecat newsletters. Several reminders to foster participation.

Who? Eurecat employees that may become users of the charging points.

What? The goal is to update the list of employees that drives an EV or are considering to buy an EV soon. Also we were interested in the mobility preferences and awareness of electromobility and energy impact.

Sample

Questionnaire on electricmobility

This questionnaire is aimed at Eurecat employees to know how the electric vehicle fits in their mobility preferences, what value a shared charging infrastructure has and the potential of the management of energy. It is part of the European project H2020 GreenCharge.

A bit about you

In this section we will ask you some socio-demographic questions. You are free not to answer all of them if you consider that they violate your privacy, but remember that the results will only be used for research purposes and the individual responses or the names of the people who responded to the survey.

1 How old are you?

- Between 18-25 years old
- Between 26-35 years old
- Ente 36-45 years old
- Between 46-55 years old
- Between 56-65 years old
- Over 65 years old

2 I'm ...

- Female
- Male
- Non- binary

3 What city/town do you live in?

4 Which Eurecat headquarters do you usually work at?

5 Roughly how far do you live from work?

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About mobility

In this section we want to know how you move, what type of vehicles you have and if you are a user (current or potential) of electric vehicle

6 How many motorized vehicles do you have at home at your disposal?

7 Before March 2020 (when teleworking became mandatory), could you go to work by car or motorcycle (or similar motorized vehicle)?

- All the time
- Most days
- Seldom
- Never

8 In this new stage of hybrid work model (office/teleworking), do you plan to go to work by car or motorcycle?

- All the time
- Most days
- Seldom
- Never

9 Have the pandemic or the new hybrid work mode changed your mobility habits? If so, how?

10 Approximately, how many kilometers do a week on the different journeys to go to work, shopping, leisure activities, etc... ? (In this question think about the situation until November)

- Less than 20 km
- Between 20 and 50 km
- Between 51 and 100 km
- Entre 101 i 200 km
- More than 200 km

11 If the distance will increase significantly from December, indicate how many kilometers you estimate you will travel per week from December.

12 How many of the journeys you make are by public transport?

- Less than 25%
- Between 26% and 50%
- Between 51% and 75%
- More than 75%

13 How many of the routes are on foot or with another non-motor vehicle (bicycle, skateboard,...)

- Less than 25%
- Between 26% and 50%
- Between 51% and 75%

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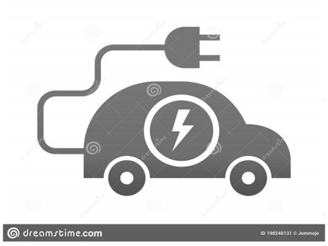
- More than 75%

14 When choosing your mode of transport, you consider....

- Cost
- Speed
- Comfort
- Environmental impact
- Others

15 Do you have a car or electric motorcycle at home or are you a user of it?

- Yes
- No
- Not yet, but I'm considering it



If you do not have an electric vehicle....

16 The next car/motorcycle you will buy will be

- Plug-in Electric
- Hybrid
- diesel/petrol
- Other types of combustible
- I'm not going to buy one

17 If you do not opt for a plug-in electric car it is because....

18 How do you value the initiative of putting electric vehicle charging infrastructure at Eurecat's facilities?

☆ ☆ ☆ ☆ ☆

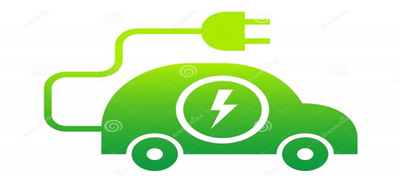
19 How do you value using renewable energy at Eurecat's facilities?

☆ ☆ ☆ ☆ ☆

20 Do you want to share any other comments, suggestions or reflections with us related to this topic?

If you are an EV user... or you plan to be soon

21 Why did you decide to buy an electric vehicle?



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22 Do you have charging infrastructure at home for private use?
- Yes
- No

23 How do you think vehicles should be charged
- Always with renewable energy
- With renewable energy whenever possible
- It is indifferent

24 You would agree to be flexible when charging the vehicle if
- You could save money
- You could use green energy
- Other reason
- No, I always want to load it as fast as possible

25 Do you need to charge your car while you're at work?
- Yes
- No
- Sometimes

26 What a fraction of the time your vehicle is parked with respect to the time it takes to charge
- 50% more time than necessary for recharging
- More than 75% would be parked and already loaded
- I don't know

27 Hypothetically, would you be willing to use the car's battery to store energy and use it later ? (A GreenCharge will not implement it, but we want to know the potential)
- Yes, as long as it did not affect my commute
- Yes, if I found it financially profitable
- Yes, if I allowed myself to cover all my energy needs with renewable energy
- No

28 How do you value the initiation of putting electric vehicle charging infrastructure at Eurecat's facilities?

☆ ☆ ☆ ☆ ☆

29 How do you value using renewable energy at Eurecat's facilities?

☆ ☆ ☆ ☆ ☆

30 If the service is paid (during the Greencharge project we guarantee that it will be free), you would use the charging point
- Yes, if I only had to pay the cost of energy
- Yes, if it was loaded with renewable energy
- Only if I got cheaper than at home
- Only in emergencies

31 Do you think you will be able to use the charging points in Cerdanyola or Manresa before February 2021? It would help us a lot in the project having users to collect data and extract indicators
- Yes
- No

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Thank you very much for collaborating with us responding to the survey

...

Please leave your email so that I can contact you and explain how the booking system works and see the compatibility of the plugin

Do you want to share any other comments, suggestions or reflections on this topic?

For more information about the project, please contact Regina Enrich

C.4.5 Barcelona Demo 3 (e-bike sharing service): Survey to users of the service before GreenCharge

<u>Survey May 2019 – Sant Quirze e-bike sharing service users</u>

How? On-line survey using Office365 forms distributed through email with a link to access. Several reminders to foster participation.

Who? Users of the current e-bike sharing service in Sant Quirze (BCN.D3)

What? The goal is to gather the user satisfaction for the current e-bike service and gather user needs and interest in some of the improvements we were planning, as well as willingness to pay.

Sample

Purpose with the survey

The main purpose of the survey is to retrieve information about the user needs to help to better define new functionalities to be included in the service. Furthermore, it is intended to serve as base line data collection for the usage of the service and mobility preferences.

The survey is answered anonymously. The personal information about age and gender is kept to a minimum and it is not mandatory to answer all questions. None of the questions can be traced back to the respondent as a person. The survey is delivered by the townhall, there is no direct contact between the respondents and Eurecat. A letter explaining the project, the purpose of the survey and the data treatment is attached.

The respondents were given nearly a month to reply and several reminders were issued.

Introduction to the survey. Consent request

Initial survey of users of electric bicycle service for industrial zone.

We would appreciate very much if you answered this question about your experience with electric bicycle service in the industrial zone of Sant Quirze del Vallès. It will help us capture real needs and implement improvements within the GreenCharge project.

- Answer with the utmost sincerity, but if you are not comfortable with any questions, leave it blank

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- If you have any remark about a question, add it to the answer box of some questions or at the end of the questionnaire

- If you have general comments, add them to the bottom of the questionnaire

1.Do you accept these conditions:

- Your answers will be treated anonymously

- The results of the survey may be published anonymously and in reports and publications of the project

- Answers can be saved up to 6 months after the project is completed. Then they will be eliminated permanently.

You need to answer to continue

- *Yes*
- *No*

Questions

Section 1: Tell us about you

We would need some socio-demographic information

2.How old are you?

- 18-25
- 26-35
- 36-55
- 56-65
- 66-75
- Over 75

3.You are...

- Male
- Female
- I don’t want to answer

4.Do you live in Sant Quirze del Vallès?

- 25 km away (or more)
- 10-25 km away
- Less than 10 km away

5.Your choice for a mobility option is based on...

- Time/speed
- Cost
- Convenience (comfort)
- Environmental impact

Section 2: The e-bike sharing service

The following questions are related to the e-bike sharing service for Sant Quirze industrial zone, as it is today

6.How did you get to know about the e-bike sharing service?

7.Do you use it regularly?

- Yes
- No

8.How many times have you use it?

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- More than 50
- 50 to 25
- 25 to 10
- Less than 10
- None

9.Why do you use the e-bike sharing service? Or why not?
10.If possible, would you use it for other time slots? Or other purposes?

- Yes
- No
- It depends

11.When? Why? On which is depends?
12.Do you know other people that may like to use the sharing service as well?

- Many
- Some
- None

13.Why don't they use it?
14. Are you a user of any other sharing service?
15. Which ones?
16. According to your user experience with the e-bike sharing service, would you buy your own an e-bike?

Section 3: How can we improve the service

Within the framework of the GreenCharge project we propose to add new technologies to the service that facilitate their use. These measures include the development of a smartphone app. Your opinion will help us design this app to include the features that are useful to you.

17. Tell us at least one thing that you like about the e-bike sharing service
18. Tell us at least one thing that you don't like about the e-bike sharing service
19. Make a proposal for improvement
20. We may improve the registration process if ….
(some ideas: it is an on-line process through an app, we can link the user and the bike in user at any moment, …)
21. We may improve the incidences and notification process if ….
22. What is your opinion on booking? What is your proposal to manage booking offenses (anyone not returning the bike on time, anyone not using the bike s/he has booked,…)
23. Are you satisfied with current security measures? How can security be improved?
24. If security measures were satisfactory, would you bring your own e-bike?
25. What would you like the app to have? Usage history? Carbon footprint? Service usage?
26. Do you think it should include a bike trip planner? Or it is not necessary since you already know the route?
27. Would you be willing to pay for the sharing service? Who do you think should manage/operate it?
28. Any further question, suggestion, comment you would like to share with us?

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C.5 Other questionnaires and interview guides

Interview guide for group- and individual interviews (adjust to number and group of residents participating)

General

- What is the situation in your household with respect to car ownership and use?
- What are your thoughts on electric vehicles and charging (future scenario)?
    - Do you have or do you plan to buy an EV? Why?
- What are your thoughts on car sharing? Are you interested in car sharing?

The process

- What is your experience on the process of installing private charging in the housing cooperative?
- Did you understand the information, did you miss any information? What?
- What is your opinion of the housing cooperative board in this process?

User experience with the installed charging system

- If you have an EV; what is your experience with the installed charging system?
    - What are you most and least satisfied with?
    - What do you think of the user interface/ app?
    - What do think about priority charging, and have you used it?
    - How satisfied are you with the capacity of the system? Do you always get charging when you need it?

Costs

- What do you think about the price level of the system? What would be a reasonable price?
- Do you have an understanding of the financial support to the housing cooperative from Oslo municipality/ Green Charge/ OBOS? Has this support affected your opinions on EV/ charging?

Suggestions for improvements

- What is the most hassle with the charging system today?
- Do you have suggestions for improvements?
- Do you have anything to add?

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Annex D Data collection for process evaluation

This annex provides an overview of the measures used to collect data for the impact evaluation.

D.1 Focus Group interview guide

The same focus group interview guide is used for all demos.

"Warm up" questions

Opening question – to get everyone involved in the talk:

1. You have been involved in the implementation of the demo. **Can you briefly tell which tasks you carried out?**

Introductory questions – to trigger the memory

2. **What is your general impression of the results achieved and what have you learned?**

Transition questions –to set the context:

3. Demonstrators may be developed from scratch or existing systems may be adapted. There may be several focuses such as technology, society, or business aspects. **What were the focus and extend of the work you did?**

Key questions

Planning

4. Think back to when you decided what to implement and how to do it. **How did you plan the work**?

Implementation of technical solution

5. Think back on when you developed the solution. **Which main barriers did you experienced?**
6. When you succeeded- **What was the main drivers or reasons for success?**
7. You probably experienced challenges and concerns, and you probably also needed coordination with others. **Which activities were taken and/or should have been taken to address challenges, concerns, and coordination?**

Implementation of business models

8. What about the work on the business models – **Which barriers and success factors did you experience?**

Future implementations

9. If solutions like those in the demonstrator are taken further and implemented elsewhere - **What will you say are the main risks to be aware of and your advice?**

End questions

Facilitate reflection about the above – all participants should answer.

10. **What are most important factors concerning barriers, drivers, supporting activities and risks?**
11. **How well did this summary fit with what you said?**
12. **Have we discussed all relevant issues? Is there anything that you want to say that you didn't get the chance to say?**

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Annex E Process evaluation input

This annex provides an overview of the data collected about the implementation of the demonstrators. This includes for each demonstrator:

- Results from the pre-analysis done before the formal process evaluation.
- An overview of supporting activities carried out.
- An overview of the barriers experienced.
- An overview of the drivers that were utilised.

E.1 Oslo D1 Process evaluation input

Oslo D1 Pre-analysis

Responsible stakeholders. Several stakeholders with different roles are involved in the demonstrator:

- Housing cooperative residents have purchased charge points and used the charge points to charge their EVs. Some residents have also provided input and feedback through participation in surveys and interviews that have been input to design decisions.
- The housing cooperative (represented by their administration) has offered the premises of the housing cooperative for use in the demonstrator, and they have also co-financed the installation of among others PV panels, stationary batteries and sensors: They have provided crucial input and insight on needs, possible barriers and opportunities and contributed to efficient communication with the residents as well as communication with suppliers.
- SINTEF has assisted the municipality of Oslo in the coordination and roll-out of the demonstrator. SINTEF has been responsible for the communication with housing cooperative administration and has assisted the housing cooperative with procurement of hardware. SINTEF has also been responsible for the definition of the concepts to be demonstrated.
- Oslo municipality has been responsible for the coordination and roll-out of the demonstrator. They have also carried out outreach activities and provided subsidies for the procurement of hardware.
- eSmart has been responsible for the implementation of the smart energy management.
- Fortum has been the charge point manager (CPO).
- ZET has been the electric mobility provider (EMP). They have implemented the app used by the residents to request the charging and the app backend which among others coordinates the information exchange between the EMP (ZET), the CPO (Fortum) and the local energy management (eSmart).
- PNO/EGEN has been responsible for the work on the business and price models.

Target groups affected by the measures. The following stakeholders are affected by the solutions:

- Housing cooperative residents can charge their EVs at their own charge points. They can reduce their charging costs by allowing flexible charging (instead of priority charging). The charging costs may indirectly also be reduced thanks to the smart energy management and reduced operating costs for the charging infrastructure provider (due to self-consumption and peak shaving), and the energy mix will be greener (due to use of RES). They must provide more input (via the App) compared with traditional charging.
- The housing cooperative can probably offer charging to more residents without additional grid investments due to the smart energy management. The energy costs will be reduced due smart energy management due to use of RES and stationary batteries, self-consumption and peak shaving.
- Oslo municipality can use the experiences from the demonstrator when new charging infrastructures are established.

Possible drivers. Several aspects will affect the demonstrator in a positive way

- As pointed out in D51/D6.1 [4], Norway has incentives and policy for eMobility (see https://www.regjeringen.no/no/tema/transport-og-kommunikasjon/nasjonal-transportplan/id2475111/ -), and it is also stated that charging infrastructures should be provided by housing cooperatives. In addition, there is a financial support for EV (tax reductions, etc.)

- There is in general a positive attitude towards e-mobility in Norway.
- The new communication from the European Commission on "Sustainable and Smart Mobility Strategy – putting European transport on track for the future" [12] states that the uptake of zero emission vehicles must be boosted. In addition, it is announced that the upcoming revisions of the alternative fuel directive and the building directive will address a smooth integration of charging infrastructures into the electricity grid as well as charge points in buildings,
- The business aspect measures include incentives and penalties (penalizing priority, rewarding, rewarding desired consumption pattern, etc.). Other measures such as use of RES and optimal and coordinated use of energy may reduce the energy costs.

Possible barriers and risks. Preliminary barriers and risks were identified in D5.1/D6.1 [4]. Since then, some barriers and risks are not relevant anymore, and new risks have emerged. The total list of foreseen barriers and risks are listed below as well as the status at the start of the demonstrator:

- Policy barriers and risks:
  - Possible changes in the EV policy (removal of financial support) and a transition towards more use of public transport (from D51/D6.1).
- Behavioural barriers and risks:
  - Too few residents will use EVs (from D51/D6.1).
    Status: Not relevant anymore. Many residents have bought an EV.
  - The residents will not use the charge points – they find the user interface too advanced (from D51/D6.1).
    Status: Possible barrier/risk with respect to the interface of the App.
  - Unclear information and/or residents misunderstanding information regarding costs and incentives. In such cases, they may not adapt to the desired behaviour (use of flexible charging), and too many users may use priority charging.
    Status: Possible barrier/risk.
  - Users may provide incorrect data on charging constraints (energy demands and latest finish time) and may thereby limit the effects of the energy optimisation.
    Status: Possible barrier/risk.
  - The price model used does not encourage the desired behaviour.
    Status: Possible barrier/risk.
  - Due to the Covid-19 situation, residents will work at home and the mobility will decrease. The residents will not use and charge their EVs to the extend needed to do a proper evaluation.
    Status: Possible barrier/risk.
- Technical barriers and risks:
  - Cannot get State of Charge (SOC) from the EV, and correct SOC is not received via the App. (from D51/D6.1. SOC cannot be collected from the EV so it has to be provided via the App.)
  - Technical problems with the software systems in the ESN.
    Status: Possible barrier/risk.
  - Technical problems with the integration of devices (batteries, PV panels, etc.) into the ESN.
    Status: Possible barrier/risk.
- Economic barriers and risks:
  - The costs are higher than expected, and the measures have to be reduced (from D51/D6.1).
    Status: Not relevant anymore. We have found founding to all investments.
  - The housing co-operative board decides to reduce/take away their investments (from D51/D6.1).
    Status: Not relevant anymore. All investments are done or alternative funding is used.
  - The municipality decides to take away all/ some of the economic support (from D51/D6.1).
    Status: Not relevant anymore. The municipality has supported the project.

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- The costs are higher than expected, and the charging costs have to increase, and the residents will use other types of transport (from D51/D6.1).
  Status: Possible barrier/risk.

Oslo D1 Supporting activities

Supporting activities are activities that are intended to support a successful implementation of the measures. The activities are linked to the different stages of the implementation process:

- **Design** – when measures are planned, prepared, and designed.
- **Implementation –** when measures were realised and deployed.
- **Operation** – when measures are in operation

The table below provides an overview of activities. The measure groups are closely related. Thus, we do not distinguish between the different groups unless this is especially mentioned.

Supporting activity (stage)	Target group(s)	Main objectives
Questionnaires (design) – see C.1	Residents	• Get baseline data on the need and willingness among the residents to get charge points in the garage.
Workshops on demo content (design)	Local demo group (partners, technology providers, housing cooperative).	• Provide information. • Exchange of expectations. • Identify initial situation. • Defining scope of demonstrator.
Workshop on business model design; Business Model Innovation game (design)	Project partners involved in demo, Local Reference Group.	• Identifying the current business model and cost/revenue streams. • Explore innovative business model elements.
Meeting on business models (design)	Housing cooperative leader, project partners involved in the demo.	• Agree on business models that will be implemented. • Agree on price models, reward and penalty mechanisms included.
Regular technical meetings (design/implementation)	Demo coordinator, technology providers, and (when needed) housing cooperative board. Partners responsible for design/implementation.	• Clarify and agree on needed functionality. • Define need for technical installations (CP, infrastructure, PV, battery, etc.), what and who (responsibilities). • Solve problems and clarifications on dataflow, content, and responsibilities.
Meetings and telcos with housing cooperative (design/implementation))	Leader of housing cooperative. Steering committee of housing cooperative.	• Information exchange. • Good relationship and mutual understanding. • Access to information on concerns. • Willingness to contribute to the research.
Subsidies of charge points from Oslo municipality (implementation)	Charge point owners	• Stimulating e-mobility. • Reducing investment costs for residents. • Encourage use of EVs and participation on project.
Subsidies of PV panels and stationary battery from Oslo municipality (Impl.)	Housing cooperative	• Stimulating e-mobility. • Reducing investment costs for the housing cooperative.
Email account as a communication channel towards residents (all stages)	Residents	• Provide contact info to the residents for questions and feedback on implementation and use of chargers (not about App – this is handled vis App support function)
Workshop on business models (implementation)	Local demo group (partners, housing cooperative).	• Defining business model and price models for charging solution in housing cooperative.
Workshop (telco) to agree on the business model and price model to be used (Implementation)	Housing cooperative EMP	• Prepare operation, billing and payment.
Information meetings (implementation)	Residents	• Willingness to buy private charge point and thereby increase the number of EVs. • Willingness to use App to authenticate, provide data and start charging session.

Supporting activity (stage)	Target group(s)	Main objectives
Questionnaire – repeating the first with some extra questions (impl.) – see C.1	Residents	• Get more baseline data • Check if the residents' wishes and needs has changed. • Collect feedback on the installed charge points and willingness to offer flexibility / pay for priority.
Interviews (implementation) – see C.1	Residents	
Launch event with media (impl.)	Public	• Promote the project and demonstrator for the public. • Meeting with reference group.
Information letters (implementation)	Residents	• Summarize results from questionnaire. • Provide a written thanks for participation. • Increased acceptance and awareness. • Prepare launch of App and demo.
Information meeting for App launch (implementation/operation)	Residents	• Support for use and setup of App for charging.
User guidance supporting use of App (operation)	Residents	• Increase acceptance and awareness and to support use. • Support use and avoid problems.
Focus group (design/impl.) – see Annex D	All involved in demo	• Input to process evaluation.
Questionnaire (operation) – see C.1	Residents	• Feedback on first test of EMS and use of App (planned).
Weekly meetings addressing roll out barriers (implementation)	All partners involved in the demo impl.	• Identify (potential) problems. • Agree on actions, responsibilities, and follow up actions

Oslo D1 Barriers

The table below provides an overview of the barriers observed, and actions taken to overcome the barrier.

Category	Barriers observed	Actions to overcome barriers
Impl. capacity/ Technical	1. **Changing of partners' roles:** Partner could not implement new CPO-functionality and App as planned.	- Another partner took the EMP role and implemented CPO extensions, integration with other systems, and an App with a backend. - Reallocation of tasks and budget - Contract amended addressing changes. - New plans for the technical realisation.
Impl. capacity	2. **Covid-19:** Ordinary meetings were not possible due to Covid-19. Key personnel in project and for suppliers were not available for long periods due to sickness.	- Telcos and use of digital communication were extensively used and worked well. - We had to wait till personnel was back from sickness.
Impl. capacity/ Technical	3. **Coordination and communication problems:** The meetings common to all demonstrators did not follow up the demo at a sufficient detailed level.	- Weekly telcos with focus on the Oslo demonstrators. - More detailed follow up of blockers and coordination between activities. - Work as a team - Experts had to explain problems in a way that was understandable.
Impl. capacity/ Technical	4. **Very challenging to lead the demo activity:** Expertise is needed within many areas (energy, hardware, software, integration/development process, etc.)	
Technical	5. **Complex solution and functionality:** An integration of systems from several partners was required, and the requirements changed due to more insight.	
Technical	6. **Local grid infrastructure:** The housing cooperative had several sub-grids. Due to the physical grid configuration, they could not be integrated into one ESN.	- Used the garage as an ESN in the demo. - Simulation workaround: Data are collected from some apartments, and data from the

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Category	Barriers observed	Actions to overcome barriers
		garage and apartments are input to a simulation of a more complex ESN.
Technical	7. **Integration of stationary battery:** The interface provided did not work as expected. The provider of the battery did not respond for a long time. Then they claimed that it would work, but they did not understand what was needed. At the end, a hardware error was discovered, and the battery could not be used.	- A lot of time and resource demanding testing and investigation - The provider was pushed to do problem fixing. - Technical support from Germany after months with requests - New battery by the end of the project, but too late …
Technical	8. **Integration of heating cables:** This was more challenging than expected. It was difficult to predict consumption pattern due to unknown dependencies on temperature, delay, humidity, etc.	- We did not integrate the cables. The icing problem made it too risky. We do not know when icing will occur since this depends on several conditions. - Software workaround: Integration of heating cable load as a background load.
Technical	9. **Integration with CP equipment:** The interface provided did not work as expected. The built-in energy management (for simple load balancing) blocked the scheduling done by the ESN energy optimizer.	- A lot of time and resource demanding testing and investigation - The local energy system of the CP equipment provider was disabled. - See below (Risk related to integration of CP equipment)
Technical	10. **Risk related to integration of CP equipment.** The disabling of the CP build-in energy management (see above) was a safety risk in case of technical problems (loss of internet, software errors, etc.). Charging may be blocked, fuses may blow, equipment may be damaged, etc.	- Software workaround: A low speed default charging ensured some charging in any case. - Capacity was reserved for low-speed charging, to prohibit overloading. - Disadvantage: The reservation leaves less capacity for use in optimisations, and the value of the solution is reduced. - The housing cooperative was involved to approve the solution.
Technical	11. **Access to SoC:** Current protocols do not support access to current SoC from the EV's on-board systems.	- Software/manual workaround: The EV user is asked to provide the initial SoC via the App. - The EV user must also provide input on the desired SoC after the charging. - Disadvantage: Inaccurate values
Technical	12. **Integration between management systems:** There are no standardized interfaces for integration of charge management and local energy management.	- The interfaces had to be customized to the individual systems and their capabilities. - The design and implementation of interfaces were however expected and accounted for.
Technical	13. **Software and integration errors:** It was very demanding to get the software to work and to integrate the systems. Especially between CPO and EMP (EMP developed solutions from scratch) and between LEM and EMP.	- Time and resource demanding testing, debugging, and bug fixing. - Involvement of business leaders to get resources and priority - Took time to involve the right personnel, but situation improved late 2021. Good collaboration between system developers in different companies. - See also 3
Impl. capacity	14. **Changes and sickness in personnel.** Time consuming to build knowledge, insight and capacity. Not always easy to get priority. Key personnel were for long periods not available, among others due to Covid-situation.	

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Category	Barriers observed	Actions to overcome barriers
	15. **Loss of support from operative and expert CPO personnel** due to restructuring of company (linked to the commercial agreement with the CPO)	
Impl. capacity	16. **Delays.** Parts of the functionality (among others the App) could not be put into operation due to technical challenges and priorities	- Charging without use of App in Oslo D1 till February 2022 (important to collect research data)
Economic	17. **Traditional business models:** They addressed the commercial actors and their income and represented no innovation.	- Re-design of business model with a focus on the housing cooperative and the economic effects of the ESN.

Oslo D1 Drivers

The table below provides an overview of the drivers observed and the actions taken to make use of the drivers.

Category	Drivers observed	Actions to make use of drivers
Impl. capacity	1. **Multidisciplinary team:** Consortium with technical, business oriented, and scientific personnel	- Multidisciplinary meetings and workshops - Internal reviews of deliverables across disciplines
Impl. capacity	2. **Flexibility of partner.** The partner took a new role and responsibility for large parts of the software development.	- Contract amendment - New plans where extended CPO functionality and App was developed by new partner after a contract amendment.
Impl. capacity	3. **Follow up meetings:** Dedicated meeting every week for follow up of the demonstrator	- All partners involved participated - Detailed minutes where blockers were identified, and tasks assigned - Follow up of tasks assigned.
Behavioural	4. **Positive attitude:** Housing cooperation administration had a very positive to the new solutions suggested by the project.	- Members of the administration were interviewed on needs and possibilities. - The leader was involved in decisions on app functionality and business models. - The leader was involved in decisions regarding risks.
Behavioural	5. **Subsidises:** The CP subsidies contributed to the recruitment of participants.	- The investments in CPs became more attractive to the residents.
Behavioural	6. **Activities**: The demo was promoted through launch event showing hardware, videos on smart energy management, information letter to residents, and information meetings.	- Dissemination: Media on launch event and use of video at events, meetings, etc. - Demo preparations: Awareness and knowledge among residents
Behavioural	7. **eMobility acceptance:** There is a high acceptance of e-mobility in Norway	- Many residents planned to purchase an EV. The recruitment became easy. - Residents were very interested in purchasing CPs.
Economic	8. **eMobility incentives:** Norway has economic incentives for eMobility (tax reductions, toll road fee reductions, etc.)	

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Category	Drivers observed	Actions to make use of drivers
Economic	9. **Business model workshop:** The workshop involved all relevant partners as well as a representative from the housing cooperative	- Use of canvas showing money flows. - Clarification of roles and focus. - Focus on needs (income, panelising priority, etc.)
Economic	10. **Subsidises:** > 250 000 Euros from the Municipality of Oslo for CP equipment (a share), stationary battery (100%) and PV panels (100%). About 10 000 Euros from OBOS (housing cooperative association. Smaller amount from the Climate initiative in Oslo	Made investments in hardware possible - 64 charge point equipments - Stationary battery for energy storage - PV panels for solar plant on the roof - The demonstrator of this size would have been impossible without these subsidises.
Economic/ Technical	11. **Technical solutions:** The solutions facilitate the implementation of business models that rewards desired behaviour.	- Business model workshop where the business models were discussed with those implementing the technology and designed. - Extra fee was put on priority charging.

E.2 Oslo D2 Process evaluation input

Oslo D2 Pre-analysis

Responsible stakeholders. Several stakeholders with different roles are involved in the demonstrator:

- The housing cooperative (represented by their administration) has offered the premises of the housing cooperative for use in the demonstrator: They have provided crucial input and insight on needs, possible barriers and opportunities.
- Oslo municipality has been responsible for the coordination and roll-out of the demonstrator. They have provided subsidies for the procurement of the PC hardware, and they have also carried out outreach activities to recruit customers.
- SINTEF has assisted the municipality of Oslo in the coordination and roll-out of the demonstrator. SINTEF has been responsible for the communication with housing cooperative administration and has assisted the housing cooperative with procurement of hardware. SINTEF has also been responsible for the definition of the concepts to be demonstrated.
- Fortum has been the charge point manager (CPO).
- ZET is the electric mobility provider (EMP). They have implemented the app used by the EV users to request the charging and the app backend which among others coordinates the information exchange between the EMP (ZET), the CPO (Fortum) and the roaming provider (Hubject). They have also implemented novel CPO-functionality supporting the advance booking of charge points.
- Hubject has been the roaming provider.
- PNO/EGEN has been responsible for the work on the business and price models.

Target groups affected by the measures. The following stakeholders are affected by the solutions:

- EV users (visitors to the housing cooperation, residents in the area, visitors to/employees at the nearby school, etc.) will get access to more charge points.
- Housing cooperative will get a revenue from the use of the charge points, and they can offer their visitors access to charge points.

Possible drivers. Several aspects will affect the demonstrator in a positive way

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- As pointed out in D51/D6.1 [4], Norway has incentives and policy for eMobility (see https://www.regjeringen.no/no/tema/transport-og-kommunikasjon/nasjonal-transportplan/id2475111/ -),. In addition, there is a financial support for EV (tax reductions, etc.)
- There is in general a positive attitude towards e-mobility in Norway, and there are probably several potential users of the charge points.
- EV users will hopefully appreciate the ability to book access to a charge point in advance. This will ensure more predictable charging.

Possible barriers and risks. Some barriers and risks of relevance to Oslo Demo 2 were identified in D5.1/D6.1 [4]. Since then, some barriers and risks are not relevant anymore, and new risks have emerged. The total list of foreseen barriers and risks are listed below as well as the status at the start of the demonstrator:

- Policy barriers and risks:
  - Possible changes in the EV policy (removal of financial support) and a transition towards more use of public transport (from D51/D6.1).
- Behavioural barriers and risks:
  - Too few EV users will use the charge points.
    Status: Possible barrier/risk.
  - The EV users will not use the charge points – they find the user interface too advanced (from D51/D6.1).
    Status: Possible barrier/risk with respect to the interface of the App.
  - EV users will block the charge point. The price models are designed to prevent this, but it may not work.
    Status: Possible barrier/risk.
  - Due to the Covid-19 situation, the mobility, and thus also the use of EVs, will decrease, and EV users will not charge their EVs at the charge points.
    Status: Possible barrier/risk.
- Technical barriers and risks:
  - Technical problems with the software systems or the integration between EMP, CPO and roaming provider.
    Status: Possible barrier/risk.
- Economic barriers and risks:
  - The costs are higher than expected, and the measures have to be reduced (from D51/D6.1). Status: Not relevant anymore. We have found funding to all investments.
  - The municipality decides to take away all/ some of the economic support (from D51/D6.1). Status: Not relevant anymore. The municipality has supported the project.
  - The revenue to the housing cooperative will be too low to cover the investments.
    Status: Possible barrier/risk.

Oslo D2 Supporting activities

Supporting activities are activities that are intended to support a successful implementation of the measures. The activities are linked to the different stages of the implementation process:

- **Design** – when measures are planned, prepared, and designed.
- **Implementation –** when measures were realised and deployed.
- **Operation** – when measures are in operation.

The table below provides an overview of activities. The measure groups are closely related. Thus, we do not distinguish between the different groups unless this is especially mentioned.

Supporting activity (stage)	Target group(s)	Main objectives

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.

Information meetings (design)	Leader of housing cooperative Steering committee of housing cooperative	- Willingness to share charge points. - Agreement on the solution. - Access to information on concerns. - Willingness to contribute to the research.
Workshop on business model design and Innovation game (design)	Project partners involved in the demonstrator, Local Reference Group	- Identify the current business model and cost/revenue streams. - Explore innovative business model elements.
Meeting on business models (design)	Housing cooperative leader, project partners involved in the demonstrator	- Agree on business models. - Agree on price models, reward and penalty mechanisms included.
Workshop (telco) to agree on the business model and price model to be used (Implementation)	Housing cooperative EMP	- Prepare operation, billing and payment.
Charge point subsidies (implementation)	Housing cooperative	- Willingness to offer shared CPs to test the pre-booking of charging sessions.
Communication strategy (implementation)	Citizens in general. Visitors to housing cooperative. Employees of and visitors to a school in the neighbourhood. E-mobility association	- Awareness - Acceptance - Recruitment of users of the shared CPs. - Information about where the CPs are, booking, etc.
Weekly meetings addressing implementation and roll out barriers.	All partners involved in the demo implementation.	- Identify (potential) problems. - Agree on actions and responsibilities. - Follow up actions.
Focus group (design and implementation) – see Annex D	All partners involved in demo	- Input to process evaluation.
User guide and support for use of App (Implementation/operation)	Residents/ visitors	- Support the users of the public chargers.
Questionnaire (operation)	Visitors	- Collect feedback from users on pre-booking of charge points (planned).

Oslo D2 Barriers

The table below provides an overview of the barriers observed, and actions taken to overcome the barrier.

Category	Barriers observed	Actions to overcome barriers
Impl. capacity/ Technical	**1. Changing of partners' roles:** partner could not implement new CPO-functionality and App as planned.	- Another partner took the EMP role and implemented App, CPO extensions and integrations with other systems. - New plans for the technical realisation. Reallocation of tasks and budget - Contract amended addressing changes.
Impl. capacity	**2. Covid-19:** Physical meetings were not possible due to Covid-19	- Telcos and use of digital communication were extensively used and worked well.

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Category	Barriers observed	Actions to overcome barriers
Technical	**3. Booking principles:** These were scarcely discussed before the project. No existing systems had such functionality.	- New functionality and new coordination mechanisms were designed and implemented.
Impl. capacity	**4. Lack of continuity.** Several partners replaced their personnel and got new roles. Due to the complexity, this caused problems. The transfer of knowledge took time and delayed the work.	- The changes in personnel were required. - Weekly telcos with all partners involved focusing on the Oslo demonstrators to follow up the status.
	5. Limited testing ability: The outdoor charges have been the back-up for the garage in Demo 1 during construction work in the garage (for several months late 2021) and when chargers did not work in the garage. This limited the testing capability.	- Postpone activity till after construction work - Did not start demo operation.
Impl. capacity	**6. Administrative and formal issues:** The onboarding into the roaming platform, the opening of APIs, and contractual issues (between partners on prices and payment conditions) were not accounted for and took much more time than expected and became blockers. "Small" errors in agreements and contracts caused may iterations and delayed the process.	- Weekly telcos (same as above) focusing on the Oslo demonstrators to follow up the status and blockings. - Bug fixing in agreements/contracts. - We could not speed up the process as much as desired. - Involvement of leaders. - Late roll-out of App
Technical	**7. Software delays.** The implementation and roll out of the App to be used was delayed.	
Economic	**8. Business models**: Initially, these were too generic, not properly linked to the demonstrator, did not use the opportunities created by the technology, and did not properly address how they could be used to affect the behaviour in a positive way.	- Multidisciplinary meeting, including the leader of the housing cooperative, with co-creation of business models that are aligned with the technology. - Use of diagram showing the money flows. - Identified and adapted to needs: Easy to understand, penalise blocking, ensure income also in case of blocking, and adaption to general price level.
Technical	**9. Roaming:** Combining booking and roaming is more complex and challenging than expected.	- Focus was on the implementation of the booking functionality to facilitate learning. - Used the learning to specify novel roaming solutions in the architecture (D4.2).
Impl. capacity/ Technical	**10. Coordination and communication problems**: The meetings common to all demonstrators did not follow up the demo at a sufficient detailed level.	- Weekly telcos (same as mentioned above) with focus on the Oslo demonstrators. - More detailed follow up of blockers and coordination between activities.
Behavioural	**11. User are needed:** Plans for provision of information to other housing cooperatives and to a school in the neighbourhood, and for dissemination through the network of the e-mobility association were established. Due to the delay, this was not accomplished.	- The housing cooperative will do this after the end of the project.

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Oslo D2 Drivers

The table below provides an overview of the drivers observed and the actions taken to make use of the drivers.

Category	Drivers observed	Actions to make use of drivers
Impl. capacity	1. **Multidisciplinary expertise:** Consortium with technical, business oriented, and scientific personnel	- Multidisciplinary meetings and workshops - Internal reviews of deliverables across disciplines
Impl. capacity	2. **Flexibility of partner.** The partner took a new role and responsibility for large parts of the software development.	- Contract amendment - New plans where extended CPO functionality and App was developed by new partner after a contract amendment.
Impl. capacity	3. **Positive attitude:** Housing cooperation administration had a very positive to the new solutions suggested by the project.	- Members of the administration were interviewed on needs and possibilities. - The leader was involved in decisions on app functionality and business models.
Economic/ Technical	4. **Technical solutions:** Solutions facilitate the implementation of business models supporting booking enforcement.	- Business model workshop where the business models were discussed with those implementing the technology.
Economy	5. **Business model workshop**: All relevant partners were participated as well as a representative from the housing cooperative.	- Use of canvas showing money flows - Clarification of roles - Focus on needs – income, booking enforcement through penalties, alignment with price level in general
Impl. capacity	6. **Follow up meetings:** Dedicated meeting every week for follow up of the demonstrator	- Meetings with all partners involved - Detailed minutes where blockers were identified, and tasks assigned - Follow up of tasks assigned.
Economic	7. **Subsidises**: From municipality	- Installation new CPs to be shared with the public.

E.3 Bremen D1 Process evaluation input

Bremen D1 Pre-analysis

Responsible stakeholders. Several stakeholders with different roles are involved in the demonstrator:

- PMC have established the charging infrastructure and the smart energy management solution with solar panels and stationary energy storages. They offer charging services to the EV users involved.
- Employers have company EVs, visitors, and employees commuting with their own EV – all may use the charge points.
- EV users that may charge at the charge points. These are the users of company EV, visitors to the companies and employees.

Target groups affected by the measures. The following stakeholders are affected by the solutions:

- Employers get the possibility to offer use of the charge points to their visitors, and they can charge their company EVs. They can also offer employees access to charging.
- EV users will get access to more charge points.

Possible drivers. Several aspects will affect the demonstrator in a positive way, as pointed out in D5.1/D6.1 [4]:

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

- The only incentive for EV users in the city of Bremen is free parking, but only if charging is at publicly accessible charge point's. This applies during the day for max. 3h, as well as overnight (18-6). There are no further incentives for EV's, like in some other cities throughout Germany. The reason behind this is that Bremen is aiming overall at less cars in the city.
- The charge points installed may give more incentives for EV's.

Possible barriers and risks. Some barriers and risks of relevance to Oslo Demo 2 were identified in D5.1/D6.1 [4]. Since then, some barriers and risks are not relevant anymore, and new risks have emerged. The total list of foreseen barriers and risks are listed below as well as the status at the start of the demonstrator:

- Behavioural barriers and risks:
  - Too few EV users will use the charge points (from D5.1/D6.1).
    Status: Possible barrier/risk. The focus of the demonstrator is however now targeting the testing and evaluation of the technology.
  - Due to the Covid-19 situation, the mobility, and thus also the use of EVs, will decrease, and EV users will not charge their EVs at the charge points.
    Status: Possible barrier/risk.
- Technical barriers and risks:
  - Some planned demonstrator activities turn out to be more difficult than planned to implement in a practical demonstrator (from D5.1/D6.1).
    Status: Possible barrier/risk.
  - Technical problems with the software systems or the integration with the devices in the ESN.
    Status: Possible barrier/risk.
  - Technical problems with the devices in the ESN (PV panels, stationary batteries, etc.)
    Status: Possible barrier/risk. Such problems have already occurred during the implementation stage. One second life EV battery that is used as a stationary energy storage has stopped working.
- Economic barriers and risks:
  - The cost of an EV. Typically, a surplus of 10-15 T€ compared to equivalent cars with combustion engine (from D5.1/D6.1).
    Status: Possible barrier/risk. However, this is to a large extend counterbalanced by a massive financial support (federal/seller) to EV customers (typically 9000 €).
  - The cost of energy. Currently the price for charging at publicly accessible charge point's varies from about 0,40 to 0.89€ per kWh, the latter number being about 3 times the price of residential electricity (updated from D5.1/D6.1).
    Status: Possible barrier/risk.
  - The costs of the infrastructure are higher than expected or parts of the infrastructure must be replaced, and the measures have to be reduced.
    Status: Possible barrier/risk. We have so far found a funding for all investments except for the replacement of the non-working second life EV battery system (used as a stationary energy storage).

Bremen D1 Supporting activities

Supporting activities are activities that are intended to support a successful implementation of the measures. The activities are linked to the different stages of the implementation process:

- **Design** – when measures are planned, prepared, and designed.
- **Implementation –** when measures were realised and deployed.
- **Operation** – when measures are in operation.

The table below provides an overview of activities. The measure groups are closely related. Thus, we do not distinguish between the different groups unless this is especially mentioned.

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.

Supporting activity (stage)	Target group(s)	Main objectives
Workshop on business model (design)	Local reference group (external stakeholders)	• Defining business model options • Explore innovative business model elements.
Questionnaire (design)	Potential EV drivers (users) within staff	• Create awareness • Derive expected demand of charging energy
Technical meetings (design/implementation)	Persons responsible for design/implementation	• Clarify and agree on needed functionality. • Agree on technical modifications to existing charging infrastructure (CP, infrastructure, PV, battery, etc.)
Focus group (design and implementation) see Annex D	All partners involved in demo	• Input to process evaluation.
User guidance supporting the use of the web-APP (operation)	CP-users	• Increase acceptance and awareness. • Support use and avoid mistakes.

Bremen D1 Barriers

The table below provides an overview of the barriers observed, and actions taken to overcome the barrier.

Category	Barriers observed	Actions to overcome barriers
Contractual	1. **Changes in CPs:** After the first year, charging stations available and planned for the implementation phase were no longer accessible – the renting contract was cancelled.	- 2 (larger) stations on private parking ground were rented for the remaining project duration. Proprietary backend could be interfaced to these 2 stations for charge control and data collection.
Impl. capacity	2. **COVID-19:** Most of the period 04/2020-06/2020 employers were urged to give their employees a home-office option, whenever possible. Only 20% of staff was on-site during that time – no EV drivers among them.	- Functionality and technical tests of data collection and delivery to repository were performed by having 2 employees from PMC charging once a week. At least the technical work on getting the demo up and running could be continued during that time
Stakeholders	3. **Few users:** The number of users increased slower than expected. Since the beginning of 2021 the number of commuting EV drivers increases still slowly but steadily.	- In the initial phase 2 drivers from outside were allowed to use the CPs.
Technical	4. **2nd-life EV battery:** Integration of stationary battery taken from own decommissioned EVs; no documentation available of car battery (ZEBRA), supplier no longer existent, access to communication interface failed.	- A lot of testing - Another charging station with a stationary battery installed was tried instead (but w/o EV battery) and modified to provide remote data from CP, battery, and PV. But the battery could not be used.
Technical	5. **Access to SoC:** The charger cannot get access to the SoC from in-car communication system, which is needed to optimize the charging profile.	- Software/manual workaround, whereby the EV-user is asked to provide the initial SoC via the web-based APP. Another potential solution to this issue would need access to the EV's OBD-ports including mobile communication.

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Category	Barriers observed	Actions to overcome barriers
Economic	6. **Business model:** There is no commercial business model for the provider of the charge@work options, since no charging fee is involved up to date.	- Develop Light Business Plan for the supplier of comprehensive solutions.
Legal	7. **No direct access to users** (employees working in the area) is possible due to GDPR. This is a handicap to raise awareness and getting feedback from potential users	- Informal talks have helped to reach users

Bremen D1 Drivers

The table below provides an overview of the drivers observed and the actions taken to make use of the drivers.

Category	Drivers observed	Actions to make use of drivers
Expertise	1. **Technical knowledge** in backend programming enabled smooth data collection process.	- Acting both as CPO and developer of CP prototype promoted the technical implementation process and the data flow process.
eMobility acceptance	2. **EV acceptance:** Increasing fraction of commuting staff considers investment in private EV. An increasing number of EV models is available and charge@work option is made possible	- Recruitment of EV users is expected to become much easier in the coming months.
Policy	3. **Federal allowance on buying an EV** instead of a conventional car encourages companies and staff members to buy more EVs for their business fleet and as own private EV, respectively.	- Additional users of CPs could be acquired until summer 2021 (in total 11 by 10/2021).
Policy	4. **On-site PV:** Additional photovoltaic installation lower the cost for electricity. Self-consumption is in particular high for companies with technical equipment running all day long. On-site EV chargers makes PV extension even more attractive.	- Additional on-roof PV extends the options for the company to give electricity to the chargers at a reduced fee. Such an extension of the existing on-roof PV will be realised in the time beyond the project.
Behavioural	5. **Positive attitude from staff members:** Researchers and technicians (those with private EV) liked charging at the demo chargers being part of a “green” project.	- Continue optional free charging for staff members, if willing to “pay” with their charging data/behaviour (SoC, remove EV after booked charging time, etc.). These data can be used within internal projects on smart energy management.
Economy	6. **Business model workshop** with all involved partners and external stakeholders.	- Further work on business model planned to develop concepts for CPOs to invest and operate chargers on private ground.

E.4 Bremen D2 Process evaluation input

Bremen D2 Pre-analysis

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

Responsible stakeholders. Several stakeholders with different roles are involved in the demonstrator:

- Housing cooperative offers space for the station where the EVs are parked and charged. The housing cooperative also is the market channel for the shared EV fleet.
- Residents in housing cooperative are potential users of the shared EV fleet.
- ZET offers the shared EV fleet service and the digital services needed by the users of the fleet – the residents of the housing cooperative.

Target groups affected by the measures. The following stakeholders are affected by the solutions:

- Housing cooperative
- Residents in housing cooperative

Possible drivers. Several aspects will affect the demonstrator in a positive way**, a**s pointed out in D51/D6.1 [4].

- A fleet of shared EVs that is available to residents in *a new* housing development reduces the need for car ownership and parking spaces. Find more about supporting city policy in deliverable D2.14.
- Bremen is aiming at less cars in the city. This objective can be met easier by fostering Car Sharing and not just by switching from conventional to electric cars (from D51/D6.1).

Possible barriers and risks. Some barriers and risks of relevance were identified in D5.1/D6.1 [4]. Since then, some barriers and risks are not relevant anymore, and new barriers and risks have been detected. The total list of foreseen barriers and risks are listed below as well as the status at the start of the demonstrator:

- Behavioural barriers and risks:
  - Too few users of the EV fleet for the station in the vicinity of the housing cooperative.
    Status: Possible barrier/risk.
  - Too few users of the EV fleet for the station close to public transport.
    Status: Possible barrier/risk.
  - Due to the Covid-19 situation, the mobility, and thus also the use of the EV fleet, will decrease.
    Status: Possible barrier/risk.
- Technical barriers and risks:
  - Technical problems with the fleet management system and/or the App.
    Status: Possible barrier/risk.
- Economic barriers and risks:
  - Cost may be too high. The cost of a new EV is typically, a surplus of 10-15 T€ compared to equivalent cars with combustion engine (from D51/D6.1).
    Status: Possible barrier/risk. The business models and price models are important.
  - Market access.
    Status: Possible barrier/risk. The liaison with the roaming operator may open for market opportunities.

Bremen D2 Supporting activities

Supporting activities are activities that are intended to support a successful implementation of the measures. The activities are linked to the different stages of the implementation process:

- **Design** – when measures are planned, prepared, and designed.
- **Implementation –** when measures were realised and deployed.
- **Operation** – when measures are in operation.

The table below provides an overview of activities. The measure groups are closely related. Thus, we do not distinguish between the different groups unless this is especially mentioned.

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Supporting activity (stage)	Target group(s)	Main objectives
Workshop on business model design; Business Model Innovation game (design)	Project partners involved in the demonstrator, Local Reference Group	- Identify the current business model and cost/revenue streams.
Information letter to new residents (implementation/operation)	Residents	- Increase awareness and recruitment of customers.
Web site for the service (implementation/operation)	Housing cooperative, Residents	- Increase awareness and recruitment of customers. - https://share.zet.technology/
Shared information with cooperatives: How to … (implementation/operation)	Housing cooperative	- Increase awareness and recruitment of customers.
Survey (implementation/operation)	Residents	- Get feedback on awareness and acceptance level.
Communication towards residents to make the shared EV attractive (implementation/operation)	Residents	- Increase awareness and recruitment of customers.
Participation in the EU Booster service (implementation/operation)	EV fleet operator	- Viable exploitation plan.
Dialogue on the experiences from the design and implementations stages (design and implementation) – based on see Annex D	Partners involved in demo	- Input to process evaluation.
Activities regarding possible exploitation after project (implementation/operation): - Work on MaaS platform with multimodal route planning, shared EVs included. - Work on new market channels: Agreements with PT operator	PT operator and other transport service providers	- Facilitate a new market channel for shared EVs.

Bremen D2 Barriers

The table below provides an overview of the barriers observed, and actions taken to overcome the barrier.

Category	Barriers observed	Actions to overcome barriers
Behaviour	**Different views:** The fleet operator and the housing cooperative may have different views upon the service. The housing cooperative may expect EVs to be available and visible before they are booked (no booking in advance).	- Dialogue - Change in behaviour – planning the use of the EVs in advance
Economic	**Costs:** The operating costs of the EV sharing service is high.	- The number of EVs was reduced. - Restructuring of the EV sharing company and business models. - Sell the product in another way: Software as a Service (SaaS) and in-vehicle system.
Economic	**EV utilisation:** The utilization of the EVs was low when 5 cars were offered.	- The number of EVs were reduced.

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.

Category	Barriers observed	Actions to overcome barriers
Economic	**Business model:** The business model for EV sharing was not viable. It was difficult to plan the business models while the implementation was taking place.	- The business model was changed to fleet management as a service. The EVs are owned by another company. - The Booster services of the Commission was used to improve the exploitation plan and business strategies. - Interactions with public transport planned
Impl. capacity	**Knowledge:** Fleet owners need knowledge on e-mobility, challenges, different approaches and modalities. They need education/guidance from a neutral stakeholder.	- Experience and understanding were gained during the project.
Impl. Capacity	**COVID-19:** Communication difficulties due to Covid-19	- Telcos were used, but did not solve all the challenges. Physical meetings in a relaxed environment would have made communication easier

Bremen D2 Drivers

The table below provides an overview of the drivers observed and the actions taken to make use of the drivers.

Category	Drivers observed	Actions to make use of drivers
Knowledge	**For the city:** New knowledge on what mobility is about and the actual challenges.	- See different carsharing approaches and find market for different players, e.g. for the combination of station based + free-floating. - Address different players in town and make viable business for several companies: understand how policies have to be adjusted. - Calculate the fee/car utilization rate needed to make the business viable. This can also be used for the tuning of subsidies for transition from ICE to EV, and for companies to see where to go (in the business model)
Economy	**Subsidies from city**	- Made the EV fleet operator less dependent on the use of the EVs.
Exploitation	**Booster service** provided by the European Commission	- Supported the work on the exploitation planning.

E.5 Barcelona D1 Process evaluation input

Barcelona D1 Pre-analysis

Responsible stakeholders. Several stakeholders with different roles are involved in the demonstrator:

- MOTIT as mobility service provider and link to actual fleet operators. It offers support in the designing phase of the service and provides the hardware (vehicle, sensors, battery hub,…) and software (backend, app) assets.
- EUT as provider of smart charging and ESN software for simulation purposes and coordination of all demos in Barcelona, links the demonstration activities with the project requests.
- Fleet operators are entities that operates the sharing service on a daily basis, interact with the customers and take care of the charging processes and the maintenance, on site.

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.

- PNO/EGEN as offers business perspective to re-think the business model

Target groups affected by the measures. The following stakeholders are affected by the solutions:

- EV fleet operator defines the strategy to replace the batteries according to the state of charge and the availability of a charging slot. Typically, they do it when the SOC of the e-scooters reaches a certain threshold. This strategy may change after GreenCharge, considering the future usage of the service and the energy costs. Either the fleet operator or the mobility provider (back-end operator) will need to define the flexibility.
- EV users of the sharing service has a main concern to get access to a vehicle whenever they need. However, in GreenCharge we propose them to be aware that they driving pattern have an impact on the energy used, thus, they are incentivized to shift to a smoother driving pattern.

Possible drivers. Several aspects will affect the demonstrator in a positive way**,** as pointed out in D51/D6.1 [4].

- One of the most important drivers are subsidies to promote the purchase of EVs
- Measures to ban combustion vehicles in certain areas of the cities.
- Incentives to promote use of renewable energy sources and self-consumption It will be important to monitor the progress to find the opportunity to install additional PV panels in some premises in the demonstrator.
- Variable tariffs (from June 2021) also applicable to grid connection capacity may foster the penetration of smart charging to take advantage of off-peak energy use.
- Some users may perceive public transportation as an infection focus after COVID-19 and users may preferred individual mobility.
- During COVID-19 there was a huge increase of delivery services, either by restaurants that were forced to close and offered take-away or by on-line shopping. Delivery companies found the sharing service as a way to cover the peak demand without purchasing new vehicles.

Possible barriers and risks. Some barriers and risks of relevance were identified in D5.1/D6.1 [4]. The barriers and risks have been updated according to current situation:

- Behavioural barriers and risks:
  - Change in the perception of sharing services after the pandemic may affect number of users
  - Change on mobility patterns: after the pandemic, home working will be a more extended option and number of trips maybe reduced
  - Acceptance of changing driving behaviour
- Technical barriers and risks:
  - Technical problems with the fleet management system and/or the App.
  - Low flexibility due to high EV usage
- Economic barriers and risks:
  - Cost for devices needed to monitor and control charging may be too high compared to savings.
  - Cost of local RES.
- Regulatory barriers and risks:
  - Barcelona city council limited the number of licenses of EV sharing services, in particular for LEV, to operate in the city.

Barcelona D1 Supporting activities

Supporting activities are activities that are intended to support a successful implementation of the measures. The activities are linked to the different stages of the implementation process:

- **Design** – when measures are planned, prepared, and designed.

- **Implementation –** when measures were realised and deployed.
- **Operation** – when measures are in operation.

The table below provides an overview of activities. The measure groups are closely related. Thus, we do not distinguish between the different groups unless this is especially mentioned.

Supporting activity (stage)	**Target group(s)**	**Main objectives**
Workshop on business model design; Business Model Innovation game (design)	Project partners involved in the demonstrator, Local Reference Group	- Identify the current business model and cost/revenue streams.
Conduct surveys to understand mobility profiles	EV users	- Increase awareness of user needs and preferences
Conduct market analysis to explore B2B business feasibility	Delivery companies	- Increase awareness of user needs
Analyse driving patterns	EV users (indirectly)	- Determine if driving profiles are different enough to implement an eco-driving rewarding scheme.
Interviews	Kiosks tenants	- Enrol in the B2B approach with battery hubs.
Marketing campaigns	Citizens	- Recruit customers.
Questionnaires	EV fleet operators and users	- Final interviews to stakeholders to learn about their experience

Barcelona D1 Barriers

The table below provides an overview of the barriers observed, and actions taken to overcome the barrier.

Category	**Barriers observed**	**Actions to overcome barriers**
Behaviour	- The fleet operator might have other business priorities, to assure his business' sustainability, before embarking on changes in the operation of his fleet. - For non-consolidated businesses, experimenting some measures may put at risk clients' satisfaction	- Meetings to find a trade-off between project goals and business operation - Extract potential impact of the measures using the simulator with real data gathered as baseline.
Behaviour	- The COVID-19 has arisen awareness of how expose we are to viruses by sharing the same space or objects with others. That may have decreased (at least temporary) the interest in sharing services.	- Include hygienic measures and transmit trust as soon as mobility restrictions were eased.
Technical	- The new e-scooter need to go through a homologation process before being able to put them into operation. The process took much longer than previous homologations.	- Follow-up the homologation process - Progress on other activities to be sure everything will be ready for operation

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.

Category	Barriers observed	Actions to overcome barriers
Impl. capacity	- The initial service used to define the measures went out of operation. A new business has been designed. However, the main efforts have gone on the implementation of the business and GreenCharge activities cannot start until the service is operational	- Work in parallel in other issues and try to avoid bottle necks. - Flexibility of partners to adapt to new schedules. - Re-defined uses cases to adapt to the new situation keeping the goals to be demonstrated in the demo.
Impl. capacity	- Extracting measurements or including extra sensors involved participation of stakeholders not involved in the project more interested in keeping the system as-it-is than risking to	- Try to find workarounds to add non-intrusive sensors or push providers to get the needed support.
Economic	- Business model was a challenge. It was difficult to fit economic sustainability and project goals. External factors influence highly roadmaps and they are out of our control.	- The first business model workshop helped in open different perspectives - Meet to iterate on some ideas until finding an option that suited involved stakeholders
Legal framework	- Barcelona city council set-up a regulation to limit the number of e-scooter operators in Barcelona. Due to high competition, many operators were off - Constraints on mobility stopped business operation for months. As a result batteries were totally depleted and it was impossible to restore them.	- Try to find new business opportunities. - The rest of partners involved, to apply understanding - Use data from other locations

Barcelona D1 Drivers

The table below provides an overview of the drivers observed and the actions taken to make use of the drivers.

Drivers observed	Actions to make use of drivers
EV fleet operator: find new alliances to keep the business running.	Broaden the concept of use cases: - Take into account not only the charging but the trip itself. - Analise the behaviour in other city sizes (medium instead of big)
New business development	- Understand from the very beginning how a business is designed and implemented
Delivery of parcels coming from e-commerce and take-away meals have increased vastly during the pandemic	- A room to offer e-scooters for delivery to increase temporary the size of the fleet of established delivery companies or offer freelancers the opportunity that get into business with minor investments.

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E.6 Barcelona D2 Process evaluation input

Barcelona D2 Pre-analysis

Barcelona D2 Pre-analysis

Responsible stakeholders. Several stakeholders with different roles are involved in the demonstrator:

- Eurecat facility managers are responsible for the maintenance of the installation, the authorization for works in building, the first contact point to end-users. They are also in charge of applying changes in the HVAC operation according to results of smart energy management systems.
- Eurecat human resources department are responsible for taking care of equity and fostering actions to enhance employee loyalty (talent keeping)
- Eurecat AAI Technology Unit has been involved in the development of the software systems, the commissioning of technical works from third parties, recruitment of users, data collection and the management of the demonstration activities, in general.
- Hubject is responsible for providing support in the enrolment process of Eurecat in the e-Roaming platform, and make sure the end-to-end communication works.
- ZET is responsible for providing the ZET app to interact with Eurecat charging infrastructure to demonstrate interoperability.

Target groups affected by the measures. The following stakeholders are affected by the solutions:

- Eurecat employees are potential users of the charging facilities is they drive an electric car. They are also relevant for the acceptance of ESN in case they notice a loss of comfort
- EV drivers (mainly Eurecat employees) but eventually also visitors driving an electric car can user the charging points
- Eurecat facility managers have to interact with the charging infrastructure and charging systems for maintenance and to provide temporary constraints (works on the electric network, parking space allocated for other purposes,…)

Possible drivers. Several aspects will affect the demonstrator in a positive way**,** as pointed out in D51/D6.1 [4]. New regulations and market trends have introduced new drivers that updates the list presented previously.

- One of the most important drivers are subsidies to promote the purchase of EVs. EVs are much more expensive than ICE cars, but recently, additional tasks have been added to the purchase and ownership of ICE cars linked to carbon emissions. The gap between both is reducing.
- Unavailability of new cars: due to COVID-19 the scarcity of electronic equipment has caused delays on the car chain manufacture and buyers have to wait months to get their new vehicle. In some cases, the availability of plug-in electric vehicles is higher, so it is renting or leasing options. Some users may end shifting to electric mobility.
- Measures to ban high pollutant vehicles (diesel cars manufactured before 2006, among others) in Barcelona and its metropolitan area.
- Incentives to promote use of renewable energy sources and self-consumption It will be important to monitor the progress to find the opportunity to install additional PV panels in some premises in the demonstrator.
- Variable tariffs (from June 2021) also applicable to grid connection capacity may foster the penetration of smart charging to take advantage of off-peak energy use.
- Introduction of the figure of the energy aggregator (different to retailer) to trade in the energy market (spot price market) and, in the near future, in the balancing market (selling of energy flexibility)
- New regulation under construction to open energy flexibility market to a broader group of stakeholders. An increase of demand for energy optimization systems, to be prepared for the future market, has been observed.

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.

- Commitment from Eurecat to participate in a program for reduction of carbon emissions and becoming a nearly net zero energy building organisation

Possible barriers and risks. Some barriers and risks of relevance were identified in D5.1/D6.1 [4]. The barriers and risks have been updated according to current situation:

- Behavioural barriers and risks:
  - From March 2020 until March 2022, most part of employees have been working from home. That has affected the opportunities to record charging sessions, but it has also affected the energy usage of the buildings. Thus, the data collected are not as significant as it was expected
  - Change on mobility patterns: after the pandemic, home working will be a more extended option. A big share of Eurecat employees can adopt a hybrid plan to work 2 days at the office and 3 at home. This policy is in place since March 14th, 2022.
  - Acceptance of charging behaviour: provision of SoC may be seen as a hassle, booking in advance may be seen as too much effort for planning
  - Complaints for discomfort (real or subjective) when changing HVAC set-points when the operation goes back to normal. For the moment, ventilation is the main driver in terms of HVAC operation
  - Criticisms on EV for not being sustainable (lithium from batteries is scarce, cobalt miners have very poor working conditions, batteries are difficult to recycle…)

- Technical barriers and risks:
  - Technical problems with data gathering, data storage, failures of the electric or communication wiring.
  - Low flexibility due to short visits
  - Webapp/app not compatible with all devices (certain smartphones models or operating systems or browser versions)
- Economic barriers and risks:
  - Cost for devices needed to monitor and control charging may be too high compared to savings.
  - Cost of local RES, especially installation.
  - One of the incentives for purchasing an EV is that municipalities offered charging for free in public charging point. The policy changed during the project; in fact, now charging at public charging points owned by Barcelona city council is more expensive that charging at charging points in underground parking lots operated by utilities.
  - Another incentive for purchasing an EV was that energy cost per km was lower compared to ICE cars. This is still the case, but cost of electricity is ramping up with no clear reasons, even before Ukraine war. That might dissuade potential buyers forecasting that the price of energy for EVs will be comparable to the cost of fuel.

Barcelona D2 Supporting activities

Supporting activities are activities that are intended to support a successful implementation of the measures. The activities are linked to the different stages of the implementation process:

- **Design** – when measures are planned, prepared, and designed.
- **Implementation –** when measures were realised and deployed.
- **Operation** – when measures are in operation.

The table below provides an overview of activities. The measure groups are closely related. Thus, we do not distinguish between the different groups unless this is especially mentioned.

Supporting activity (stage)	Target group(s)	Main objectives

Compile current capabilities of Eurecat buildings – Interview with head of Eurecat infrastructure	Eurecat managers	- Identify the current situation of the charging infrastructure. - Identify local RES - Identify organisation roadmap and sensitivity for e-mobility
Interviews with e-car drivers	EV users	- Identify potential users of the charging infrastructure - Explore their mobility needs (always in the same working place or across sites) - Analyse reasons for buying an EV
Interview with Human Resources department	Employer	- Establish policy for charging (see if free charging is acceptable from the point of view of equity)
Interview legal department	Employer	- Determine if Eurecat can "sell" energy as a charge point operator
Interviews with other companies	Employers	- See feasibility to replicate the same use case.
Communication of plans to implement a charging service (internal newsletter and poll)	EV users (Eurecat employees owning or planning to buy an e-car)	- Recruit users - Obtain a register of potential users of the charging service
Interviews with other Eurecat departments involved in e-mobility projects	Researchers	- Identify synergies, capabilities, existing infrastructure and user needs
Survey on willingness to pay and mobility patterns	Employees	- Identify if and at which price level employees are willing to pay for charging their EV. - Identify how long the EV will stay in the premises
Workshop to define the use case to show interoperability through eRoaming	Eurecat AAI department, Eurecat Legal department, Hubject, ZET	- Identify requirements and opportunities and plan the tasks to be done

Barcelona D2 Barriers

The table below provides an overview of the barriers observed, and actions taken to overcome the barrier.

Category	Barriers observed	Actions to overcome barriers
Impl. capacity	1. **Volume of tasks:** In order to cover as many objectives as possible, many components have been added to the system. We have decided to deploy a self-made solution for charging points to assure interoperability and controllability of all elements, as well as for economic costs. However, the workload involved has become huge.	- Implementation iterative, starting from the most critical elements and building on that. For instance, energy monitoring was seen as the most urgent, while e-roaming has been the last development addressed
Impl. capacity	2. **Covid-19:** Access to the premises where not allowed during the lock-down. The installation of equipment was interrupted	- Other tasks such as e-roaming development were done in the meantime.
Impl. capacity	3. **Team interaction:** Home-office policy affected team interaction and coordination	- The Team gets used to make an intensive used of MS Teams (corporate tool) and after a while coordination was fluent again.

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Category	Barriers observed	Actions to overcome barriers
Impl. capacity	4. **Job rotation**: Some members of the team left Eurecat. Recruitment of new staff was difficult at the worst months of the pandemic. Of special impact was the leave of all members of the staff that had been involved in the implementation of the pre-existing monitoring system for the building in Manresa.	- Extra-effort was put but the rest of the members of the team, reallocation of tasks among different projects took place - As Covid-19 situation improved, human resources started to recruit.
Technical	5. **IT infrastructure:** Changes in the corporate network had affected communication between sensors and the data base	- Implement alerts (connected to MS Teams channel) to have early warnings when a failure of communication appears - Spread the word among IT support members and colleagues from other departments with some involvement in any aspect affecting the demonstration activities to let them know the work done and to ask to communicate any change prior to take action
Technical	6. **Communication Protocols:** Standard protocols turn not to be so standard. Implementation of data connectors based on MODBUS protocol to extract data from the inverter was more complex than expected	- Invest more effort. Never give up - Ask colleagues that had previous experience
Technical	7. **Third parties APIs:** Uncontrolled changes in third APIs used to get electricity prices and share of green energy. They are not tied to freeze a version or to send messages announcing the changes. Thus, changes are noticed afterwards when gaps are detected in the data base. Unplanned extra effort to adapt to the new changes is required.	- Implement alerts (connected to MS Teams channel) to have early warnings when a failure of communication appears.
Technical	8. **Robustness:** It is difficult to keep the systems 24/7 operational, especially if low (or none) usage is observed	- Implement alerts (connected to MS Teams channel) to have early warnings when a failure of communication appears. - Learn from experience: it took longer to identified and fix the first issues, but the last ones have been addressed quicker since they were easy to “guess” the cause.
Technical	9. **Access to SoC:** Current protocols do not support access to current SoC from the EV's on-board systems.	- Software/manual workaround: The EV user is asked to provide the initial SoC via the App. - The EV user must also provide input on the desired SoC after the charging.
Technical	10. **Booking through e-roaming:** Current version of Hubject e-roaming platform does not support booking as defined in GreenCharge. Advance booking of a charging point is a different concept within Hubject.	- CPO (Eurecat) and EMP (ZET) agrees on implementing a webservice to exchange booking calendar and demonstrate interoperability

Category	Barriers observed	Actions to overcome barriers
Technical	11. **E-roaming integration:** The time needed to integrate (and test) the charging management system with Hubject platform took much longer than expected	- Hubject representative in the project has interface Eurecat development team and Hubject onboarding team to ease communication and understandability of the scope of the use case.
Administrative	12. **Commissioning of equipment and services:** The process to request the purchase of equipment (sensors) or technicians tasks (electrical wiring extension, certification of installation and ethernet network extension) is complex at Eurecat and takes time	- Plan purchases in advance. - Request “usual” service providers to speed-up the process - Friendly communication with responsible people always eases the way and grant from some flexibility
Administrative	13. **Approval of actions:** Any intervention in the facility has to follow a multiple step procedure to reach the general manager approval	- Learn from experience - Use hierarchical organisation to reach decision levels - Search for complicities
Economic	14. **Cost of equipment and professional services:** The purchase of some sensors needed, and specially, the works to be performed by technicians are expensive.	- Keep to a minimum the investment, according to number of targeted users. If demand increases, the installation will be extended
Economic	15. **Business-as-usual:** So far, a cost-benefit analysis just based on savings due to energy shift does not justify the investment, and operation and maintenance costs of an energy smart system	- Include additional benefits such as air pollution reduction, well-being - Inform about actual and coming regulation for NZEB and carbon emissions. The message is “we have to work now to be prepared for the future”
Behaviour	16. **No business aspects:** No incentives are put in place to motivate users to change their behaviour	- Emphasize the positive effects on the organisation - Communicate in a friendly manner that “Energy if given free of charge: some effort is expected in exchange” - Ask for complicity: from researcher-to-researcher
Behaviour	17. **Booking downsides:** In interviews with charging point operators, they express they opposition to charging point bookings	- Test with “friendly” users in a controlled environment to showcase the potentials and learn from practice in order to be able to provide guidelines by the end of the project.
Behaviour	18. **Homeworking:** Decrease in the charging sessions and the need to visit different premises for meetings	- Take the most of the data that can be gathered and complemented it with surveys and simulations

Barcelona D2 Drivers

The table below provides an overview of the drivers observed and the actions taken to make use of the drivers.

Category	Drivers observed	Actions to make use of drivers
Economic/Technical	1. **Equipment partially in place:** Building with relevant equipment needed in	- Choose sites with equipment in place to reduce cost

Category	Drivers observed	Actions to make use of drivers
	place (PV panels, energy monitoring system)	- Define the use cases according to the possibilities of the sites and the goals of the project
Economic/Policy	**2. Subsidies:** Incentives in the purchase of e-cars together with the opportunity to offer charging for free	- Use free charging as a motivation for e-car drivers to participate in the demonstration activities and take the effort to provide charging needs and SoC in every charge session
Policy	**3. Low Emission zones:** Prohibition to access Barcelona metropolitan area with high pollutant cars may increase e-car sales	- Be alert of employees buying a new car - Resume communication activities to raise awareness
Policy	**4. Local RES:** A change in regulation has removed taxes that apply to PV installations connected to the grid and has made the installation of PV panels more attractive from a payback perspective. Some townhalls subsidies the installation through building tax reduction	- Explore by means of simulations scenarios with future PV installations to showcase positive cost-benefit results - The addition of local RES broadens the scope for energy management systems exploitation
Policy	**5. Charging manager role:** For some time, in Spain, any company (or individual) providing energy through a charging point, needed to be registered as a charging manager. This is one of the reasons that few charging point operators were in place and that businesses based on CP sharing were not an attractive option	- Eurecat can “sell” energy in the charging point with no need of any administrative process. This was a convincing point to put in operation the charging points. Although now the energy for charging is offered for free, it will not be the case in the long-term.
Impl. capacity	6. **Follow up meetings:** Dedicated meeting for follow up status of implementation and organising next steps	- Follow up of tasks assigned. - Understand all aspects of the demonstrator
Behavioural	7. **Positive attitude from external stakeholders:** During the definition phase, local GreenCharge partners (especially Atlantis and Eurecat) visited other companies that might be interested in being involved in demonstration activities or that had experience in electromobility. They were open to collaboration and share their point of view and experience	- Learn from past experiences (not reinventing the wheel). - Learn about their requirements and needs to define the functionalities of the systems (smart charging and energy management) - Think about operational barriers and usability
Behavioural	8. **Positive attitude in the demonstrator:** Eurecat departments involved in the demo has shown a high degree of collaboration	- Find the opportunity to do the demonstrator in Eurecat. - Doors open for extension of the demo, if new demand arises

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Category	Drivers observed	Actions to make use of drivers
Behavioural	9. **Skilled and committed team:** The amount of work to be done (more and more complex than expected), the changes in the staff and the pandemic have challenged the team	- Make use of their flexibility and motivation to sort out complex issues and situations

E.7 Barcelona D3 Process evaluation input

Barcelona D3 Pre-analysis

Responsible stakeholders. Several stakeholders with different roles are involved in the demonstrator activities and facilitating the realization of the demo:

- Atlantis has deployed IoT devices for geo-tracking, monitoring of the e-bike battery, monitoring and control and monitoring of stationary battery, charging points, access to the station. They have developed the app for the service and adapted their fleet back-end system to the requirements of the demo. They are in charge of collection and storing data related to the EVs and IoT devices. They are the first contact point for claims and issues posted through the app.
- Enchufing has installed the charging infrastructure, the PV panels and the stationary battery, as well as the new batteries to the bikes with communication capabilities through CAN bus protocol.
- Eurecat has been involved in the development of the energy management system, the deployment of sensors for energy production and energy grid consumption, communication activities and elaborating and gathering data through surveys, research data formatting and uploading to the repository. Eurecat has coordinated the demo activities.
- Sant Quirze Townhall provides the sharing service (as it was before GreenCharge), and access to the users and support communication activities. They own the e-bikes and are responsible for their maintenance. They sign the agreement with the users and employers to grant access to the service.
- FGC (railway operator) owns the bike station and pay for the electricity for the charging. They are responsible for the maintenance of the installation.
- Employers of nearby companies are enrolled in the program that provides access to the EV sharing service. They are in charge of recruiting users among their employees.
- Bike workshop is in charge of the maintenance of the e-bikes and assist users whenever they find an electric or mechanical problem in the e-bikes. They were hired to fix the e-bikes before the launching and were expected to do weekly maintenance tasks.

Target groups affected by the measures. The following stakeholders are affected by the solutions:

- EV users (employees of the above-mentioned companies) are expected to use the service during the period they are granted and fulfil the terms and conditions of the agreement. For GreenCharge pilot they are expected to use the app to make use of the e-bikes, use the assigned e-bike and plug-in the bike when they arrive to the station. It will be also of much help when they complete the surveys, provide feedback and notify issues in the service
- FGC (railway operator) might be slightly affected for an increase of commuters shifting from private cars to public transportation. However, the size of the demonstrator produces no real impact
- Sant Quirze Townhall gains visibility by promoting such a service and may attract more companies to establish in the town, thus generating more incomes in the form of taxes

Possible drivers. Several aspects will affect the demonstrator in a positive way**,** as pointed out in D51/D6.1 [4]. New regulations and market trends have introduced new drivers that updates the list presented previously.

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- Measures to ban high pollutant vehicles (diesel cars manufactured before 2006, among others) in Barcelona and its metropolitan area.
- Incentives to promote use of renewable energy sources and self-consumption It will be important to monitor the progress to find the opportunity to install additional PV panels in some premises in the demonstrator.
- The service was already in operation and the townhall was very committed to promote it and to show potential for extending to other spots until March 2020.

Possible barriers and risks. Some barriers and risks of relevance were identified in D5.1/D6.1 [4]. The barriers and risks have been updated according to current situation:

- Behavioural barriers and risks:
    - The service was based on the good will of users. Security measures were shown to be weak to avoid vandalism, misused of e-bikes and unauthorized access to the station. A new access mechanism has been put in place to minimize the risk, but still cooperation of the users is needed to make a proper use of the e-bike and fulfil the indications (bike to be taken, charging point to be plugged in to)
    - Change on mobility patterns: after the pandemic, home working has been used extensively (many companies have shifted to home-working or hybrid models even when mobility constraints were released) and number of trips will be lower. Yet some users may prefer to use private car to public transportation to minimise COVID-19 infection risk.
    - Lack of users or regular use of the service is a risk with major consequences on the representativity of the results obtained
- Technical barriers and risks:
    - The service was interrupted early in 2020 and has been not operating since then. The bikes need servicing even if they are not used, and big investment needed to be made to make them operational again.
    - Devices can fail: IoT devices, electronic access, charging points or e-bikes. They affect deeply the service since there are no replacement vehicles and the number of available bikes is very limited.
    - Technical problems with data gathering, data storage, failures of the electric or communication wiring.
    - Low predictability of charging sessions due to short historical records of usage and random patterns
    - App not compatible with all devices (certain smartphones models)
    - No spare parts or technical support because of discontinued products or providers going out of business and low supply from China manufacturers
- Economic barriers and risks:
    - Cost of operation and maintenance is too high for a private operator to derive a sustainable business case. It can only work with public funding.
- Other barriers and risks:
    - Neither the railway operator nor the townhall are members of the consortium, thus they do not have legal obligation (or it is too difficult to claim) to support the demonstrator. They can change their roadmap or reject to assume any cost for e-bikes servicing or station and maintenance. In fact, the point of view of the townhall has changed and its continuity is under discussion.

Barcelona D3 Supporting activities

Supporting activities are activities that are intended to support a successful implementation of the measures. The activities are linked to the different stages of the implementation process:

- **Design** – when measures are planned, prepared, and designed.

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- **Implementation** – when measures were realised and deployed.
- **Operation** – when measures are in operation.

The table below provides an overview of activities. The measure groups are closely related. Thus, we do not distinguish between the different groups unless this is especially mentioned.

Supporting activity (stage)	Target group(s)	Main objectives
Interview with Sant Quirze townhall to propose an upgrade of the service	Municipality	- Identify the current situation - Learn about the roadmap - Learn about the interest in participating - Learn about the administrative procedure to include GreenCharge partners in the agreement
Survey to the EV sharing users	EV sharing users	- Identify user satisfaction/user experience - Identify user patterns - Identify needs not covered - Identify interest on some new functionalities to be included - Identify willingness to pay for the service
Interview with FGC (railway operator)	PT operator (owner of the bike station)	- Present new functionalities - Identify interest and roadmap (potential replicability) - Get authorisation to perform the measures - Sign an extension of the agreement with new partners (GC partners)
Meetings with townhall	Municipality	- Follow progress - Notify of issues (vandalism) - Learn about roadmap (after suspension for COVID-19) - Unblock issues
Communication with FGC (email and phone calls)	PT operator (owner of the bike station)	- Inform on vandalism issues - Inform about proposal to change access to the station - Ask for permission to do the changes
Meetings with GC partners	Technology providers	- Find solutions to blocking issues.
Poster for the new service	EV sharing users	- To let users know about the functionalities of the new service and the app to register
Terms and conditions	Townhall, employers, employees	- Definition of the new terms and conditions of the service including the ICT tools. It has been done by GreenCharge local partners and handed over to the townhall to be approved by local government.
Beta testing	Greencharge local partners (Atlantis, Eurecat)	- Involve friends & family to test the service and be sure everything works fine - Use sample trips to extract data for research data and simulation

Barcelona D3 Barriers

The table below provides an overview of the barriers observed, and actions taken to overcome the barrier.

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Category	Barriers observed	Actions to overcome barriers
Impl. capacity	1. **Limited scope of action:** any action on the EV sharing service and the station has to be agreed with townhall and railway operator. Their roadmap is not aligned to GreenCharge project	- Apart from authorization, the workload that the townhall and railway operator is kept to a minimum. - All investments, commissioning, development and deployment is performed by GreenCharge partners (Atlantis, Enchufing, Eurecat)
Impl. capacity	2. **Covid-19:** Access to the premises where not allowed during the lock-down. The installation of equipment was interrupted	- No action was possible.
Impl. capacity	3. **Team interaction:** Due to interruption of activities due to Covid-19 and holidays period communication between partners was interrupted	- Meetings on demand to address specific points were performed - Bilateral technical meetings, phone calls or emails were exchange directly between technical staff.
Impl. capacity	4. **Contact in townhall was absent:** In April 2020 the contact person in the townhall left her position. She had been in the pilot (before GreenCharge project) since the beginning and was very motivated and enthusiastic. No replacement came until a year later. In the meantime, no one in the townhall had the knowledge or the time to address our requests, decide on restoring the service again or take any other decision. Yet, when the new contact person has arrived, she has not the historical background and cannot take decision by herself. Besides she is does not find any sense in such a limited pilot.	- Provide her with all the information and background we have collected so far - Support her on any action she may need - Assume extra effort to avoid that the pilot is dropped
Impl. capacity/ Economic/ Technical	5. **E-bikes need servicing:** the e-bikes are in a very poor state. They have not been serviced for 1 or 2 years. The townhall is responsible for the maintenance, but they have not allocated budget this year	- GreenCharge: Atlantis, Enchufing and Eurecat took the responsibility to assume the cost and efforts to have the e-bikes and the charging infrastructure operational again.
Impl. capacity	6. **Size of the pilot:** The size of the fleet is rather small (5 e-bikes).	- Scalability to be achieved through simulations using patterns extracted from real data
Technical	7. **Communication Protocols:** Standard protocols turn not to be so standard. Implementation of data connectors based on CAN protocol to extract data from the battery was more complex than expected (reverse engineering needed to be applied)	- Invest more effort. - Try several makes and models - Never give up
Technical	8. **Third parties APIs:** Uncontrolled changes in third APIs used to get electricity prices and share of green energy. They are not tied to freeze a version or to send messages announcing the changes. Thus, changes are noticed afterwards when gaps are detected in	- Implement alerts (connected to MS Teams channel) to have early warnings when a failure of communication appears.

Category	Barriers observed	Actions to overcome barriers
	the data base. Unplanned extra effort to adapt to the new changes is required.	
Technical	9. **Robustness:** It is difficult to keep the systems 24/7 operational, especially if low (or none) usage is observed	- Implement alerts (connected to MS Teams channel) to have early warnings when a failure of communication appears. - Learn from experience: it took longer to identified and fix the first issues, but the last ones have been addressed quicker since they were easy to “guess” the cause.
Technical	10. **Access to SoC:** Current SoC could only be roughly estimated through voltage level	- Replacement of bike batteries with more advanced battery management system that provide information about SoC and many other parameters such as overcurrent, overtemperature, or additional errors (only partially, since there was a discontinuity of electronic circuitry)
Technical	11. **Use app for access:** It was not originally envisioned to digitise the access to the station. At least in the first iteration it was defined to maintain the access through a physical key. However, vandalism increased during the pandemic and a solution needed to be found to avoid unauthorised access by someone that might have copied the key.	- Install an electronic lock - Install an IoT device to remotely control a relay to release the lock - Develop the functionality to read a tag using NFC in the app - To adapt the back-end system to restrict access temporary to any user
Administrative	12. **Approval of actions:** Any intervention or decision in the facility has to be approved by the townhall and the railway operator. They are public organisations and a high level of bureaucracy that slow down the approval	- Major approval and signing of an agreement was done at the beginning. - Workaround to get the agreement through signing the minutes of the minutes instead of having a formal agreement signed by the major and the general manager of the railway operator. - Limit the number of requests for approval (concentrate in blocks) or use silent approval approach - Do as much as the writing as possible, to let the third party only the approval
Administrative	13. **Responsibilities:** The townhall and the railway operators are not involved in GreenCharge in any manner, not even as third parties. That limit their commitment or fulfilment of planning. The responsibilities of each member were established at the beginning and reflected in the minutes of the meeting that all partners approved. However, when unforeseen issues pop up it is difficult to claim them to be solved. They are big organisations with other priorities	- Do our best to keep the demo alive. - Be flexible, even assuming more responsibilities or efforts - Take note for further initiatives to careful though in any circumstance that might arise

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Category	Barriers observed	Actions to overcome barriers
Administrative	14. **No direct access to users:** GreenCharge cannot access directly the users or their employers. It is difficult to control information flow and get to know their interests and thoughts	- An information letter explaining the project was prepared - A consent form was prepared - A workshop (focus group) was organised to customise the service (unfortunately it was cancelled) - A questionnaire was prepared and delivered, that contained questions to know get insights on the usage of the service but also on their perception and interests. - A new poster in the e-bike station was installed that explains the new concept, links to the market to download the app and redirects to the townhall for information
Economic	15. **Cost of equipment and professional services:** The purchase of some sensors and the electronic lock (not planned), and specially, the works to be performed by the locksmith were more expensive than planned.	- Costs were distributed among partners according to their budgets and skills - There was no other option to do the investment to avoid dropping the demo
Economic	16. **Business-as-usual:** So far, a cost-benefit analysis just based on savings due to energy shift does not justify the investment, and operation and maintenance costs of such a service. It is not viable without public funding	- Include additional benefits such as air pollution reduction, well-being - Inform about actual and coming regulation for NZEB and carbon emissions. The message is "we have to work now to be prepared for the future"
Behaviour	17. **No business aspects:** No incentives are put in place to motivate users to change their behaviour	- Communicate in a friendly manner that individual efforts are relevant to mitigate climate change
Behaviour	18. **Homeworking:** After the covid-19, it is said that employers will keep home-working policies (at least partially). These will reduce the number of potential users or the trips a user does.	- Taking advantage of the digitisation of the service more flexible approaches could be implemented to grant access to several users to the same e-bike, different days of the week. Decisions will be taken according to behaviour observed
Behaviour	19. **Vandalism:** During the Covid-19 lock-down several intruders accessed the bike station and spoiled or stole some of the equipment (charger, wiring)	- A new lock with brand new keys an electronic access has been installed - For the moment, only the townhall, railway operator and police have access to the bike station. - No key should be given to particular users

<u>Barcelona D3 Drivers</u>

The table below provides an overview of the drivers observed and the actions taken to make use of the drivers.

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Category	Drivers observed	Actions to make use of drivers
Impl. capacity	**1. Previous background**: A member of the team working in the project (now in Enchufing, previously in Eurecat) has being involved in the original initiative that created the EV sharing service (in 2016) and was in charge of the maintenance of the bikes until mid-2018. He has all the conceptual and technical background	- Selection of the initiative as a GreenCharge demonstrator - Easy to contact through the previous established relationship - Definition of the improvements based on his knowledge of the service and experience as responsible for the maintenance for a certain period
Impl. capacity	**2. Adaptability to GreenCharge goals:** The owners of the service accepted the proposal of changes that the GreenCharge partners involved in the demo has presented.	- Shape the actuations in the service according to GreenCharge needs (include local RES, smart charging and smart energy management)
Technical/Economic	**3. Skills of participant partners:** The partners participation in the demo (Atlantis, Enchufing, Eurecat) have the skills and capacity to deploy the hardware needed without support of external parties (except for unforeseen events reported as barrier Vandalism previously)	- Atlantis provided all IoT devices, developed app and adapt fleet management backend - Enchufing provided PV panels, stationary battery, e-bike batteries and hardware for the charging points. They did the electrical installation and certified it. They integrate IoT devices. - Eurecat provided the smart management and energy management software
Technical	**4. No digital legacy systems:** The service operated in a manual way. No previous ICT system existed, thus there were no constraints of choosing a specific protocol or brand to interoperate with.	- Selection of equipment and software according to partners expertise and economic constraints
Policy	**5. Corporate mobility plans:** Big companies have to elaborate a mobility plans to facilitate commuting of their workers	- It is the driver to approach employers whose employees may be interested in using the service (it has done when the initiative was created) - It is a driver to find exploitation paths (it is part of the KER analysis)
Policy	**6. Low Emission zones:** Prohibition to access Barcelona metropolitan area with high pollutant cars may foster commuters to use public transport rather than private cars	- Potential reduction of users for home-office policies may be compensated by new PT users due to low emission zones restrictions
Impl. capacity	**7. Roadmaps for expansion:** From the meetings with the townhall and the railway operator we learned that there were plans for build more bike stations in the town and in other train stations.	- The new service has been defined bearing in mind scalability (some of the decision taken has no sense for a single bike station with 5 e-bikes) - Use the demo and a living lab for later replication - Use it to analyse exploitable assets

Category	Drivers observed	Actions to make use of drivers
Behavioural	**8. Good will of users:** Most of the users behave properly (plug in the e-bikes when the finish, not stole the e-bikes, ride careful) based on previous operation of the service.	- Avoid using sophisticated physical systems to be sure that each bike is placed in its charging point - Avoid using additional systems to make use the user takes the assigned bike - Avoid adding locking system to the bike to avoid it is taken when it is not in the parked in the station - Launch the demo and observe what happens before investing in more equipment or developments
Behavioural	9. **Positive attitude and motivation of the townhall:** During the first year of involvement, the person in charge of the service in the townhall was very enthusiastic about the upgrade of the service and was very responsive.	- Get a lot of insights about the service - Organised workshops to shape the service - Issue questionnaires to end users - Prepare a press release
Behavioural	10. **Positive attitude of GreenCharge involved partners:** Atlantis, Enchufing and Eurecat have been enthusiastic about the possibilities offered by the site to demonstrate GreenCharge concept and to collaborate together. They have shown flexibility to adapt to a changing situation	- To overcome difficulties generated by the suspension of the service due to Covid-19 restriction. - To invest more resources to keep it alive

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Annex F Verification of functionality provided by demonstrator software

In the following tables, the compliance with requirements and specifications in D4.2 [1] is verified for each demonstrator as follows:

- **NA – Not Applicable.** The fulfilment of the requirement is not assessed. The reason may be one of two
  - The topic addressed by the requirement is not targeted by GreenCharge.
  - The requirement is not planned to be fulfilled by the demonstrator.
- **Y – Yes.** Requirement is fulfilled. The cell has a green colour.
- **N - No.** Requirement is not fulfilled.
  - If the requirement is relevant, the cell has a red colour.
  - If the requirement is not relevant, the cell has no colour.
- **P – Partly.** Requirement is partly fulfilled.
  - If all relevant parts are fulfilled, the cell has a green colour.
  - If relevant parts are not fulfilled, the call has a red colour
- **?** – The functionality is not yet decided upon (may be supported in the next iteration).

When relevant, details are provided in the comment column.

F.1 Smart Charging (SC) and roaming (RM) requirements

SC1 Relevant information and feedback to user		Oslo		Bremen		Barcelona			Comments
ID	Description	D1	D2	D1	D2	D1	D2	D3	
SC1.1	For a booking request, feedback to the user is needed when the electric vehicle cannot be charged to the target State of Charge (SoC) at the planned end time.	N[1]	NA[2]	NA	NA	NA	P	NA	[1]Not prioritised [2]Will always have enough energy.
SC1.2	EV Users should get information on prices for charge services as a part of the information about charge points (in case of pay per use business model).	Y[1]	Y[1]	NA	NA	NA	NA	NA	[1]App shows the prices
SC1.3	If the EV is assigned a specific charge point or, or if some charge points cannot be used since they are pre-booked by others, the EV User must get information on this.	NA	Y[1]	NA	NA	NA	Y	NA	[1]The App shows the status
SC1.4	The EV User must on request get notifications before the start of a booked charging period and when the charging is finished.	NA	N[1]	NA[2]	NA	NA	P[3]	NA	[1]Not prioritised [2]Focus on technology and not user interaction [3]The end of the car not implemented yet
SC1.5	EV Users should be able to request status information regarding the charging/discharging.	Y[1]	NA	NA[2]	NA	NA	y	NA	[1]The App shows the status [2]Focus on technology and not user interaction
SC1.6	It must be possible to request information about the charging with respect to energy use, grid mix and savings.	P[1]	P[1]	NA[2]	NA	NA	Y	Y	[1]Energy use is provided. Grid mix/savings is NA. [2]Focus on technology and not user interaction
SC1.7	The system must record data that supports statistics and feedback to the EV User.	Y	Y	NA[1]	NA	Y	Y	Y	[1]Focus on technology and not user interaction
SC1.8	The energy management system must provide data that supports the calculation of savings and improvements (e.g. in the grid mix)	Y	NA	Y	NA	NA	P	P	
SC1.9	The EV User must get information on malfunctions and deviations.	Y	Y	NA[1]	NA	?	?	?	[1]Focus on technology and not user interaction

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SC1.10	EV Users must get detailed billing information.	Y	Y	NA	NA	NA	P[1]	P[1]	[1]No payment associated, but cost of energy price
SC1.11	A detailed service record with all information needed to document the billing must be established and recorded by the system.	Y	Y	NA	NA	NA	NA	NA	
SC2 Standardised terminology and content in user interfaces		**Oslo**		**Bremen**		**Barcelona**			**Comments**
ID	**D1**	**D1**	**D2**	**D1**	**D2**	**D1**	**D2**	**D3**	
SC2.2	The terminology established in this document must be used as a common terminology.	NA	NA	NA	NA	NA	NA	NA	Not relevant since the demonstrators are prototypes. The terminology aspects have not been addressed.
SC2.2	The common terminology must be used when the charging request is specified and when of default values are defined. This includes charge point booking, energy booking, charging flexibility and V2G.	NA	NA	NA	NA	NA	NA	NA	
SC2.3	The common terminology must be used when the EV User is supported in the identification of the charge point to use	NA	NA	NA	NA	NA	NA	NA	
SC2.4	The common terminology must be used in feedback on the charging/discharging and when information about the charging (with respect to energy use, grid mix and savings) and billing information is provided.	NA	NA	NA	NA	NA	NA	NA	
SC3 Digital support for charge planning		**Oslo**		**Bremen**		**Barcelona**			**Comments**
ID	**Description**	**D1**	**D2**	**D1**	**D2**	**D1**	**D2**	**D3**	
SC3.1	The SoC of the batteries should be provided from the EV to the GreenCharge system.	N[1]	NA	N[1]	NA	Y[2]	N[1]	Y[2]	[1]Manually via App [2]From LEVs in-vehicle sys
SC3.2	The priority charging should adapt to available energy in real time.	Y	NA	NA	NA	NA	NA	NA	
SC3.3	The EV User must be authorised before the charging can be booked/used.	Y	Y	Y	NA	NA	Y	NA	
SC3.4	Roaming should facilitate charge planning across EMPs/CPOs.	NA	Y	NA	NA	NA	Y[1]	NA	[1]Only for demonstration purposes
SC3.5	EV User should get the charge point access confirmed before the detailed charge planning starts (to avoid the definition of charging requests that cannot be accepted).	Y	Y[1]	NA	NA	NA	Y	NA	[1]Can see the availability in a calendar view
SC3.6	The system must support the EV User in the localisation of relevant charge stations.	NA	Y[1]	NA	NA	NA	NA	NA	[1]Can see the availability in a calendar view
SC3.7	The system must facilitate use of default values when the charging request is defined.	Y	Y	NA[1]	NA	NA	Y	NA	[1]Focus on technology and not user interaction
SC3.8	It must be possible to constrain the flexibility of charging in accordance with user needs.	Y	NA	NA[1]	NA	Y	Y	NA	[1]Diffenet approach
SC4 Business model motivating non-blocking		**Oslo**		**Bremen**		**Barcelona**			**Comments**
ID	**Description**	**D1**	**D2**	**D1**	**D2**	**D1**	**D2**	**D3**	
SC4.1	Business and price model must define fees for charge point blockings to avoid waiting time.	NA	Y[1]	NA	NA	NA	NA	NA	[1]Quantification depends on behaviour
SC4.2	The technology must facilitate the use of price models that prohibit blocking	NA	Y	NA	NA	NA	NA	NA	
SC4.3	Bookings must be enforced. EV Users that block the charge point after the end of the booked period must be adequately penalized.	NA	Y	NA	NA	NA	Y	NA	
SC4.4	Blocking of charge points by non-charging vehicles must be detected to facilitate enforcement.	NA	Y[1]	NA	NA	NA	NA	NA	[1]As long as they are connected

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SC4.5	Technology must support business and price models aiming for high utilization of charge points.	NA	Y	NA	NA	NA	NA	NA	
SC5 Digital support for booking of charging		**Oslo**		**Bremen**					
ID	**Description**	**D1**	**D2**	**D1**	**D2**	**D1**	**D2**	**D3**	
SC5.1	The EV User must get support in finding the charge point to book and in the booking of charging.	NA	Y	NA	NA	NA	Y	NA	
SC5.2	EV Users that have booked a charge point should on request be notified some time before the booking period starts.	NA	N[1]	NA	NA	NA	Y	NA	[1]Not prioritised
SC5.3	When a charge point is booked, this should be communicated by the user interface of the charging equipment, and it must be impossible for EV Users that have not booked the charge point to charge at charge point.	NA	P[1]	NA	NA	NA	P[2]	NA	[1]No info via equipment, but in a calendar view that must be used for booking [2]No energy will be if it has not been booked
SC6 Shared private CPs		**Oslo**		**Bremen**		**Barcelona**			**Comments**
ID	**Description**	**D1**	**D2**	**D1**	**D2**	**D1**	**D2**	**D3**	
SC6.1	Solutions for CP sharing must support the sharing of CP information through channels used by potential customers. Information on CP availability must be included.	NA	N[1]	NA	NA	NA	NA	NA	[1]No public channels for such info and no standards.
SC6.2	Solutions for CP sharing must support roaming to be attractive to more users.	NA	Y	NA	NA	NA	P[1]	NA	[1]Not open to the general public
SC6.3	Solutions for CP sharing must support authorisation of EV Users and charge management that starts and stops charging provided that the EV User is authorised.	NA	Y	NA	NA	NA	Y	NA	
SC6.4	Solutions for CP sharing must provide standardised interfaces that allow applications from third parties to support EV User in the use of shared charge points.	NA	NA	NA	NA	NA	NA	NA	Lack of standards

RM1 Roaming of booking and payment		**Oslo**		**Bremen**		**Barcelona**			**Comments**
ID	**Description**	**D1**	**D2**	**D1**	**D2**	**D1**	**D2**	**D3**	
RM1.1	Roaming must facilitate booking of charging and energy (long time in advance) across eMobility Providers (EMPs)/Charge Point Operators (CPOs).	NA	P[1]	NA	NA	NA	P[1]	NA	[1]Roaming of payment is supported. Booking is supported through App, not roaming of booking
RM2 Standardised interfaces for roaming		**Oslo**		**Bremen**		**Barcelona**			**Comments**
ID	**Description**	**D1**	**D2**	**D1**	**D2**	**D1**	**D2**	**D3**	
RM2.1	The interfaces needed for roaming must be standardised and support all relevant services related to smart and green charging.	NA	NA	NA	NA	NA	NA	NA	Standards are not ready
RM3 Roaming for light EV (LEV) charging		**Oslo**		**Bremen**		**Barcelona**			**Comments**
ID	**Description**	**D1**	**D2**	**D1**	**D2**	**D1**	**D2**	**D3**	
RM3.1	The same roaming principles should be followed for all types of electric vehicle charging.	NA	NA	NA	NA	NA	NA	NA	Standards are not ready
RM3.2	EV Users with a subscription should be able to use that subscription for charging of all their electric vehicles, light electric vehicles included.	NA	y	NA	NA	NA	Y	NA	

F.2 Local Energy Management (EM) requirements

EM1 Optimal use of local RES and energy storage		**Oslo**		**Bremen**		**Barcelona**			**Comments**
ID	**Description**	**D1**	**D2**	**D1**	**D2**	**D1**	**D2**	**D3**	

EM1.1	The system must receive information of future energy demands (booked or predicted) to be able to have an overview of the future energy flexibility.	Y	NA	NA	NA	Y[1]	Y	Y[1]	[1]Estimated by system based on historical recorded weather forecasts
EM1.2	The system must obtain information of future energy availability from the distribution grid, local RES, local storage and V2G flexibility.	P[1]	NA	NA	NA	P[1]	P[1]	P[1]	[1]V2G is not implemented
EM1.3	Based on predicted energy availability, the optimal use of the different energy sources (RES and storage included) must be planned, and energy consuming devices and batteries must be controlled accordingly.	Y	NA	NA	NA	N[1]	Y	Y	[1]Simulated based on collected data
EM1.4	The system must predict the energy needs and the local production of energy from RES and use the outcome of these predictions to plan the use of energy from local RES.	Y[1]	NA	NA	NA	NA	Y[1]	Y[1]	[1] To be reflected by the self-consumption indicator
EM2 Energy management according to grid tariffs, local constraints and preferences		**Oslo**		**Bremen**		**Barcelona**			**Comments**
ID	**Description**	**D1**	**D2**	**D1**	**D2**	**D1**	**D2**	**D3**	
EM2.1	The system must plan energy use according to predefined rules.	Y[1]	NA	Y	NA	Y	Y	Y	[1]Even more advanced – according to predictions
EM2.2	It must be possible to define rules regarding the use of energy from local RES.	Y	NA	NA	NA	P[1]	P[1]	P[1]	[1]Not configurated by the user
EM3 Reduced peak loads		**Oslo**		**Bremen**		**Barcelona**			**Comments**
ID	**Description**	**D1**	**D2**	**D1**	**D2**	**D1**	**D2**	**D3**	
EM3.1	The system must plan and manage optimal energy use. The energy use must be distributed over time to avoid peak loads and to maximise utilisation of locally produced energy and minimise cost. It must be possible to configure the balancing between possibly conflicting goals.	Y	NA	Y	NA	Y	Y	Y	
EM3.2	The system must predict future loads and energy flexibility through input on energy demands.	Y	NA	NA	NA	Y	Y	Y	
EM3.3	The system must reduce the power peaks compared to a solution where no peak reduction measures are taken	Y[1]	NA	Y[1]	NA	NA	NA	NA	[1]To be reflected by the peak load ratio indicator
EM5 Charging integrated in energy smart neighbourhood		**Oslo**		**Bremen**		**Barcelona**			**Comments**
ID	**Description**	**D1**	**D2**	**D1**	**D2**	**D1**	**D2**	**D3**	
EM5.1	A full-fledged ESN with a hierarchical organisation of the energy management system must be possible. The energy management may for example be carried out at an ESN level, a building level, and a charging hub level. These energy management sub-systems must collaborate to become a full-fledged GreenCharge system.	N[1]	NA	N	NA	NA	?	NA	[1]Supported by software but impossible due to regulations.
EM5.2	The energy management must take all loads in the neighbourhood into account when the energy use is planned.	Y	NA	NA	NA	NA	Y	NA	
EM5.3	The integration of charging into ESNs as well as other energy use, energy storage, and energy production must be standardised. With standardised integration, the need for careful investigations, planning, and customization will be reduces, and the ESN realisation will become more feasible.	NA	NA	PNA	NA	NA	NA	NA	Standards do not exist.

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EM5.4	The charge point equipment used in the ESN must be designed for remote control from a third party like the local energy management systems. It must be possible to override less advanced built-in control mechanisms to start and stop individual charging and to charge with different speeds, adapted to both the energy availability and the needs of the EV user.	P[1]	NA	NA	NA	NA	Y	NA	[1]It should be possible to override the management system, but in practice this was just possible to some extent. See details in process evaluation.
EM5.5	It must be possible to use second life EV batteries as stationary energy storage in the ESN. To make such re-use safe, the batteries should be provided by an existing OEM or a contracted supplier. This market must evolve to make use of such batteries viable.	NA	NA	P[1]	NA	NA	NA	NA	[1]Second hand batteries are used they are not provided with guaranties from a supplier. Thus, several problems are experienced.
EM5.6	Simple/normal energy management (e.g., even distribution of energy among EVs) must be possible if advanced energy management (see EM5.7) cannot be provided.	NA	NA	NA	NA	NA	NA	NA	More advanced energy management is provided. See EM3.
EM5.7	Advanced energy management taking predictions and user demands must be taken into account.	Y	NA	NA	NA	NA	Y	NA	
EM6 Business models rewarding flexibility and adaption to energy availability		**Oslo**		**Bremen**		**Barcelona**			**Comments**
ID	**Description**	**D1**	**D2**	**D1**	**D2**	**D1**	**D2**	**D3**	
EM6.1	A price model must define the prices for priority and how flexibility should be rewarded (e.g. depending on the degree of flexibility provided).	Y	NA	NA	NA	NA	NA	NA	
EM6.2	Business and price models should provide incentives for desired behaviour. Priority requests should be penalised (e.g. extra fee per Kw or for a full charging cycle) and V2G should be rewarded.	P[1]	NA	NA	NA	NA	NA	NA	[1]V2G not addressed
EM6.3	The technology should facilitate the use of business and price models encouraging desired behaviour	Y	Y	NA	NA	NA	NA	NA	
EM7 Motivating feedback on cost and emission reduction		**Oslo**		**Bremen**		**Barcelona**			**Comments**
ID	**Description**	**D1**	**D2**	**D1**	**D2**	**D1**	**D2**	**D3**	
EM7.1	The system must collect and manage data that facilitate the provision of information to the EV Users.	Y	NA	NA	NA	Y	Y	Y	
EM7.2	The EV User should get information on the energy amount transferred to the battery of the electric vehicle.	Y	NA	NA	NA	Y	Y	Y	
EM7.3	The EV User and the Charge Point Operators (CPO) should get feedback/statistics on the local energy mix during charging compared with the energy mix in the distribution network.	NA	NA	NA	NA	Y	Y	Y	
EM7.4	The Charge Point Operators (CPO) should get feedback/statistics on savings in energy costs due to the smart energy management.	NA	NA	NA	NA	P	NA	NA	
EM7.5	EV Users should get information on prices showing the cost reductions they will get with desired behaviour (booking, flexibility, V2G, etc.)	N[1]	NA	NA	NA	NA	NA	NA	[1]Not prioritised.
EM8 Easy to be rewarded		**Oslo**		**Bremen**		**Barcelona**			**Comments**
ID	**Description**	**D1**	**D2**	**D1**	**D2**	**D1**	**D2**	**D3**	

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EM8.1	The prices (rewarding desired behaviour) and the business models must be easy to understand and easy to adapt to.	Y[1]	Y[1]	NA		Y	NA	NA	[1]Designed to fulfil the criteria.
EM8.2	The EV User should be supported when default values and charging requests are defined to make smart and green charging easy.	Y[1]	Y[1]	NA	NA	NA	NA	NA	[1]Designed to fulfil the criteria.
EM9 Business models rewarding prosumers		**Oslo**		**Bremen**		**Barcelona**			**Comments**
ID	**Description**	**D1**	**D2**	**D1**	**D2**	**D1**	**D2**	**D3**	
EM9.1	The amount of energy provided by RES must be recorded	Y	NA	NA	NA	NA	Y	Y	
EM9.2	There must be a price model for prosumers	Y	NA	NA	NA	NA	NA	NA	

F.3 EV Fleet Management (FM) requirements

FM1 Optimise charging according to planned fleet operations		**Oslo**		**Bremen**		**Barcelona**			**Comments**
ID	**Description**	**D1**	**D2**	**D1**	**D2**	**D1**	**D2**	**D3**	
FM1.1	The SoC of the batteries should be provided to the fleet management system during EV operation.	NA	NA	NA	Y	Y	NA	Y	
FM1.2	The geo-location of the vehicles should be provided to the fleet management system.	NA	NA	NA	Y	Y	NA	Y	
FM4 Viable EV sharing business models		**Oslo**		**Bremen**		**Barcelona**			**Comments**
ID	**Description**	**D1**	**D2**	**D1**	**D2**	**D1**	**D2**	**D3**	
FM4.1	Data on the use of the eco-driving mode should be provided to the fleet management system during EV operation.	NA	NA	NA	Y	?	NA	NA	
FM4.2	Business models should define a discount for eco-driving.	NA	NA	NA	Y	?	NA	NA	

F.4 Generic (GR) and infrastructure (IR) requirements

GR: Generic requirements from pilots (that are either applicable to several/ all aspects above, or are not directly related to a specific aspect from above):		**Oslo**		**Bremen**		**Barcelona**			**Comments**
ID	**Description**	**D1**	**D2**	**D1**	**D2**	**D1**	**D2**	**D3**	
GR1	Safety: Safety will be paramount to prevent injuries.	NA	NA	NA	NA	NA	NA	NA	Not verified since this was not a focus area in the project
GR2	Openness: Non-proprietary solutions for HW and SW will be preferred to avoid dependencies with third parties not participating in the project and to assure access to all the features provided by any device.	NA	NA	NA	NA	NA	NA	NA	
GR3	Multi-language support: The user interfaces of the App for EV Users and the backend systems for system administrators will support multi-languages.	NA	NA	NA	NA	NA	NA	NA	
GR4	Availability: The solution must have a high and well-defined availability goal. This means that the systems components and the communication between them must function as required and prevent disruptions due to failures and system upgrades.	NA	NA	NA	NA	NA	NA	NA	
GR5	Availability: Procedures and responsibilities that ensure availability must be defined.	NA	Y[1]	NA	NA	NA	NA	NA	[1]Booking enforcement
GR6	Security: Information security in general should be according to ISO/IEC 27002 Information	NA	NA	NA	NA	NA	NA	NA	

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	technology — Security techniques — Code of practice for information security controls								Not verified since this was not a focus area in the project
GR7	Security: Information security related to roaming and payment should be according to IEC 27001 Information security management systems	NA	NA	NA	NA	NA	NA	NA	
GR8	Privacy: the system must ensure the privacy of the EV Users. The solution must be compliant with GDPR.	Y	Y	Y	Y	Y	Y	Y	
GR9	Security – access control: The access to the systems involved must be secured through identification, authentication, and authorisation of users.	Y	Y	Y	Y	Y	Y	Y	
GR10	Security – authentication of systems: The systems involved in communication must be authorised.	NA	NA	NA	NA	NA	NA	NA	Not verified since this was not a focus area in the project
GR11	Security – data integrity: The integrity of the data exchanged between systems must be ensured,	NA	NA	NA	NA	NA	NA	NA	
GR12	Security – non-repudiation: It must be ensured that the one part on a transaction cannot deny having received the transaction.	NA	NA	NA	NA	NA	NA	NA	
GR13	Security – information content protection: The information content in transactions should be protected through cryptography whenever this is relevant.	NA	NA	NA	NA	NA	NA	NA	
GR14	Scalability: The solutions should work when full emobility of the transport sector is achieved, i.e. when all vehicles are electric, and the charging infrastructure covers all charging needs.	NA	NA	NA	NA	NA	NA	NA	

IR Interface requirements		Oslo		Bremen		Barcelona			Comments
ID	**Description**	**D1**	**D2**	**D1**	**D2**	**D1**	**D2**	**D3**	
IR1	Standard: Compliance with widely adopted standard solution, protocols and interfaces will be considered in the choice to facilitate future interoperability of the solutions developed.	P[1]	P[1]	P[1]	NA	P[1]	P[1]	P[1]	[1]When standards exist and are appropriate-
IR2	Vehicle information should be obtained from the electric vehicle by means of the OBD2 standard. This also include data on the State of Charge (SoC) when such information is openly available via this interface.	N[1]	NA	N[1]	P[2]	P[3]	N[1]	P[3]	[1]SoC access not supported by current standards [2]Spexial agreement for fleet [3]Via other interface
IR3	For Charge Service Provisioning: Charging requests must provide necessary information for smart charging.	Y	Y	Y	NA	Y	Y	Y	
IR4	For interactions with Local Energy Management: Information needed for optimal energy use by individual energy demanding activities must be exchanged.	Y	Y	Y	NA	NA	Y	NA	
IR5	For interaction between electric vehicle charging and Charge point operation: The interface between the charging equipment (EVSE) and the charge managements must be according to the Open Charge Point Protocol (OCPP 2.0).	P[1]	P[1]	P[1]	P[1]	N	N	N	[1]OCPP is used, but not 2.0
IR6	For interactions with the in-vehicle system when charging/discharging (V2G); The interface must be according to the ISO 15118 Road vehicles – Vehicle to grid communication interface.	NA	NA	NA	NA	NA	NA	NA	V2G will be simulated

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IR7	For interaction with Roaming: The interface used towards roaming should be according to IEC 63119 and IEC 63119-1 ED1 – Information exchange for Electric Vehicle charging roaming service (when the standard is ready).	NA	N[1]	NA	NA	NA	N[1]	NA	[1]Standard not yet approved and implemented
IR8	For publication of CP information: An standardised interface for the sharing of CP information should be used. Information showing when the CP is reserved and available must be shared.	NA	NA	NA	NA	NA	NA	NA	Standard and public infrastructure for the sharing of CP information are not available
IR9	For charge planning: A standardised interface for charge planning is needed. The interface must define a charging request in such a way that the smart energy management can be informed about the energy demand.	NA	NA	NA	NA	NA	NA	NA	Standard does not exist.

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Annex G Verification of simulator and optimizer functionality

In the following tables, the compliance with simulator requirements is verified:

- **Y – Yes.** Requirement is fulfilled. The cell has a green colour.
- **N - No.** Requirement is not fulfilled.
- **NA – Not Applicable.** The fulfilment of the requirement is not yet assessed.

When relevant, details are provided in the comment column.

ID	Requirement	Implemented	Comments
RS1	Support for booking of charging	Y	
RS2	EV Users with a subscription should be able to use that subscription for charging of all their electric vehicles, light electric vehicles included.	Y	
RS3	inclusion of heater/cooler and background loads	Y	
RS4	V2G: ability to exploit discharging of EVs connected for charging when possible within constraints set by user	Y	
RS5	automatic feeding of the input data of the simulation sessions starting from the data collected in the Pilots	Y	
RS6	Graphical User Interface to facilitate the definition and configuration of different simulation scenarios	Y	
RS7	running an interactive simulation that can be paused and resumed configuring breaks in advance	N	Specification are changed during the project.
RS8	integration in the simulator of different schedulers with different optimization algorithms	Y	
RS9	Visualization of simulation results	Y	
RS10	Computation of simulation related KPIs	Y	
RS11	Computation of other parameters and violation of constraints	Y	This allows, for example, to check that the power peak does not exceed the maximum power at each charge station.
RS12	PV scale up	Y	
RS13	EV scale up	Y	
	Scenario generation according Degree of flexibility	Y	To mitigate low use of App
RS14	Scenario generation according Degree of Booking	Y	To mitigate low use of App
RS15	Scenario generation according Booking Time Ahead	Y	To mitigate low use of App
RS16	Web GUI reachable remotely	Y	
RS17	Settings of HC Deviation	Y	
RS18	Setting of HC max power	Y	
RS19	Dummy Optimizer	Y	The development of a dummy optimizer for the testing of the simulation tool.
RS20	Support for import devices and logs from other scenario generating mixed Scenarios	Y	
RS21	REST APIs to allow to set any configuration scenarios, and to start and stop the simulator.	Y	This allows for batch execution of simulations.
RS22	Charging session scale ups	Y	It is implemented importing EVs from the same or from other scenarios as new EVs. This functionality cannot be used interactively by the GUI.
	Optimise based on energy greenness	Y	
	Optimise based on energy cost	Y	
	Optimise based on load peak reductions	Y	Covered i by respecting constraints
	Simulation with no optimisation (baseline)	Y	

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Annex H Fictive scenarios

Due to the delays in pilot implementations and consequently in the availability of data, the time available for evaluation was dramatically reduced, and we had to drop the simulation of fictive scenarios meant to investigate the impact of the GreenCharge measures in more diverse and larger ESNs than was implemented in the demonstrators. This appendix describes such fictive scenarios and how the simulations were planned to be carried out.

H.1 Small residential neighbourhood

The scenario combines smart charging with other energy use and local energy production in an ESN. It is meant to represents a small block of flats (9 flats) located in the Oslo area, heated by electric room heaters and floor heating cables, with a central DHW tank serving the whole block, a parking garage in the basement with a private charge point for each flat, and set in a future where most households have a car, and all cars are electric.

To create the scenario, the following data collected from the Oslo pilot (P1D1 and P1D3) is needed:

- Charging data from Oslo D1 (the garage) including charging sessions logs from 9 CPs and static data about the CPs and EVs using them are used to simulate the charging demand.
- Logged PV production prediction from the PV plant on the garage roof are used to simulate the PV plant.
- Specifications for the stationary battery of Oslo D1 are used to simulate the stationary battery.
- Data from apartments (Oslo D3[19]), including static data about the energy consuming devices in the flats, the size of the rooms they are heating, constraints on the energy supply to the flats, logged energy consumption of heating devices in the flats, and total energy consumption of each flat are used to simulate the energy demand of the flats
- Data from one hot water tank of the DHW plant of one block of flats in Oslo D3, including max power, water volume, and logged energy consumption are used to simulate the central DHW supply facility.

To capture the impact of the seasonal variation of insolation, temperature, wind, precipitation and driving conditions, we simulate one summer week, one autumn week and one winter week.

Flexible charging means that flexibility is provided by the EV driver through an app when the EV is connected for charging. Unfortunately, the app in Oslo D1 was seriously delayed and was taken gradually in use only in February 2022, the last month of the project. Therefore, we do not have sufficient data for offered flexibility. For the simulations we use instead the a posteriori potential flexibility computed from the charge logs.
This most likely will result in a bit more flexibility and more precise prediction than what we would get from the app.

The flexibility of the HC devices is modelled as a corridor for the cumulative energy consumption of the heating device (see D5). The width of the corridor is set to allow a variation of the temperature in the room of +- 2°C.

The simulations aim to investigate in more detail the impact of the following measures:

- Local RES (PV plant on the roof)
- Local storage (Stationary battery).
- Optimal and coordinated use of energy

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[19] Oslo D3 is not a real demonstrator – it is not evaluated as such. Oslo D3 has however collected data on energy use in 9 apartments of the housing cooperative and common hot-water tanks.

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- Flexible charging

To achieve that simulation of several variants of the scenario with different combination and dimensioning of these measures was planned.

7.4 Office building with charging facilities for employees

This scenario is meant to represent an office building with parking for employees equipped with charge points and a local PV plant. It was meant to be realised by combining the office building of Barcelona D2 and the charging traffic recorded in Bremen D1. However, this scenario was not elaborated to the same extent as the small residential neighbourhood one before it was realised that we would not have time to simulate the fictive scenarios.

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