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

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

greencharge2020.eu

GreenCharge Project Deliverable: D2.3

Description of Oslo Pilot and User Needs

Authors:
Runar Søråsen, Paal Mork (Oslo Kommune)
Åshild Lappegard Hauge, Karen Byskov Lindberg (SINTEF)
Frida Sund (eSmart Systems)
Gøran Vollan (Fortum)

www.civitas.eu

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About GreenCharge

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

The project promotes:

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

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

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

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

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

For more information

Project Coordinator: Joe Gorman, joe.gorman@sintef.no
Dissemination Manger: Arno Schoevaars, arno.schoevaars@pnoconsultants.com

Executive Summary

Within the GreenCharge project, Oslo is one out of three pilot sites. In the Oslo pilot, there is a particular focus on providing cost efficient home charging facilities for inhabitants living in blocks of flats. For piloting, the project has selected the Røverkollen housing cooperative, comprising 246 apartments distributed over five blocks. The housing cooperative has a stand-alone four-storey parking garage where most residents have their own parking spot.

In this report, an overview is given of the Oslo pilot site and its specific challenges are identified. The challenges include general mobility requirements, where many needs a car for their daily life and that potential buyers of electric vehicles (EVs) expect charging at their own dedicated parking place before committing to buying. This has been confirmed by a survey addressing all residents in the housing cooperative. In addition to charging for the residents, the housing cooperative sees an opportunity in providing charging to visitors and employees at a nearby work place.

As of 14.01.2019, there were 17 chargeable vehicles at Røverkollen (based on data from the Norwegian Public Roads Authority). The housing cooperative has established four outdoor semi-fast chargers. These are accessed through a rudimentary booking scheme. At the start of the project, 15 residents have signed a contract for using these outdoor chargers. Results from the conducted survey indicate that approximately 50 % of the residents at Røverkollen consider buying their own chargeable vehicle within two years.

GreenCharge has defined seven innovation scenarios. Four of these have been identified as relevant for the Oslo pilot:

2. Charging at booked Charging station
4. Home charging in older (groups of) residential or working buildings with common internal grid and parking facilities, or at work in (groups of) buildings with similar limitations
5. V2G (vehicle-to-grid)
6. Reacting to Demand Response (DR) request

Based on these selected innovation scenarios the different use cases to be implemented and tested at the Oslo pilot has been identified and detailed.

The expected growth in ownership of EVs, and the need for charging these EVs, is a challenge for the housing cooperative. This is both related to investment costs and the increased demand for electric power. To satisfy user needs a new charging infrastructure needs to be deployed in the parking garage. This needs to be implemented with demand management to ensure that the usage will not overload the electricity grid.

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List of Abbreviations

Table 1: List of abbreviations

Abbreviation	Explanation
AI	Artificial Intelligence
BEV	Battery Electric Vehicle
CMS	Charge Management System
DSO	Distribution System Operator (related to electric power distribution)
ESN	Energy Smart Neighbourhood
EV	Electric Vehicle
EV-SYS	EV in-vehicle system
FCEV	Fuel-Cell Electric Vehicle
ICT	Information and communications technology
LRG	Local Reference Group (stakeholders)
NEMS	Neighbourhood Energy Management System
OCP	Optimal Capacity Plan
PHEV	Plug-in Hybrid Electric Vehicle
PV	Photovoltaic
RES	Renewable Energy Source
RFID-Tags	Radio Frequency Identification Tags
SOC	State of Charge
V2G	Vehicle-to-Grid

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List of Definitions

Table 2: List of definitions

Definition	Explanation
Charge management system (CMS)	The Charge Management System balances the load between the connected chargers and keeps within the OCP generated by NEMS. Fortum Charge & Drive Management Cloud operates as the Charge Management System in GreenCharge
DSO	Distribution System Operator – responsible for operating and maintaining the electricity distribution grid.
Energy Smart Neighbourhood (ESN)	An energy smart neighbourhood (ESN) is a group of buildings embedding local RES and local energy storage and using smart control equipment to adapt the energy demand to the local production so as to reduce the burden on the public grid and the power bill. The smart control equipment does this by predicting local energy demand and energy production from local RES and leveraging demand flexibility and local storage resources to shift the loads in a coordinated way within the neighbourhood. The aim is to minimize the amount of energy taken from the grid, the demand peaks and the energy bill. As these may be partially conflicting goals, the inhabitants of the neighbourhood must define policies defining how to balance them.
Measure	A measure is a mobility or charging related action implemented by a city or other stakeholders, e.g. the implementation of a new infrastructure, the provision of a new service, a new organisation of the travel to work, or activities to change awareness, acceptance or attitude and behaviour of citizens or visitors.[1]
Neighbourhood energy management system (NEMS)	An ICT system implementing the smartness of an energy smart neighbourhood.
Optimal capacity plan	The Optimal Capacity Plan is generated by NEMS (eSmart) and sent to CMS (Fortum) to perform load balancing between the connected chargers in the garage
Photovoltaic	Photovoltaic panels (solar cell panels) converts light into electricity using semiconducting materials
Radio Frequency Identification Tags	An RFID tag is an electronic tag that exchanges data with an RFID reader through radio waves
Renewable Energy Source (RES)	Renewable Energy Source is a category of energy sources which does not involve the burning of fossil fuels as part of the energy production process. The most popular RES are photovoltaic panels, windmills and hydroelectric power plants. Typically, the carbon footprint of RES (caused by the building, operation and maintenance of the production facilities) lies in the area of 10 – 50 g CO2 equivalents per kWh, while for fossil energy sources like natural gas, oil and coal the carbon footprint lies in the area of 500 – 800 g CO2 equivalents per kWh. Nuclear power is not commonly counted as a RES, since the energy production process does consume a fuel and does produce a problematic waste (radioactive material). However, its carbon footprint is in the lower end of the RES range.

[1] See CIVITAS Satellite project deliverable D2.3 Refined CIVITAS process and impact evaluation framework, page 11.

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Definition	Explanation
Scenario	A scenario describes a specific use of a proposed system by illustrating some interaction with the proposed system as viewed from the outside, e.g., by a user, using specific examples. In GreenCharge, a scenario is a higher level of description of the system and can be modelled using one or several use cases.
State of charge (SOC)	The state of charge (SoC) is an indication of the amount of energy stored in a battery. It is given as a percentage, meaning the percentage of the full capacity currently available in the battery. The SoC is difficult to measure accurately, but several methods are available to give an approximate value, and most EVs has an instrument on the dashboard showing the SoC.
Use case	A use case describes how a system will be used and is a tool for modelling requirements of a system. In GreenCharge, a scenario is a higher level of description of the system and can be modelled using one or several use cases.
Vehicle to Grid (V2G)	Vehicle to Grid means to use the energy stored in the batteries of EVs connected for charging to provide energy to the grid in peak load situations.

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1 About this Deliverable

1.1 Why would I want to read this deliverable?

This document will describe the Oslo pilot in terms of challenges, user needs, use cases, scenarios, stakeholders and locations to be involved. It will also describe the starting point[2] of the pilot site, i.e. current situation before any measures has been introduced by the project. This deliverable is targeting readers that want a better understanding of relevant user needs and use cases when our society is transforming to large scale electric mobility. The focus of the Oslo pilot is on private electric vehicles (EVs) that need to be charged, typically overnight, in large parking garages in proximity to large apartment building. This deliverable will describe the starting point for the Oslo pilot site. Based on identified challenges and collected user needs different use cases are described. The goal is to provide the reader with a good overview of what user needs and use cases the demonstrations at the pilot site will fulfil.

1.2 Intended readership/users

This deliverable is mainly targeting two group of readers:

- Solutions developers within GreenCharge that will implement the different prototypes to fulfil user needs.
- As a public delivery the larger audience of innovators, including innovative companies and other organizations, seeking to provide valuable products and services to the domain of EV charging, based on an understanding of user needs and related scenarios.

In addition, this deliverable will, together with the "sister" deliverables for the other pilot sites (D2.9 and D2.16), provide input to D2.1 "Initial Strategic Plan for Pilots".

1.3 Other project deliverables that may be of interest

- **D2.1 Initial Strategic Plan for Pilots –** This description of the Oslo pilot and the user needs is input to the strategic plan (D2.1).
- **D3.1 Stakeholder Analysis Report** – Describes the result of the stakeholder analysis, identifying the concerns and needs from all stakeholders relevant for GreenCharge.
- **D2.4 Implementation Plan for Oslo Pilot** – Describe the planning of the tests to be carried out at the pilot site. It includes scenarios to be demonstrated, time schedules, stakeholders and locations selected, users selected for workshops and for testing, hardware and software to be installed, tests to be run and data to be collected, etc.
- **D2.8 Final Report for Oslo Pilot: Lessons Learned and Guidelines -** Describe the Oslo pilot, including the implementation, operation, the tests carried out, services and the data collected. Describe lessons learned and guidelines for apartment buildings.
- **D2.9 Description of Bremen Pilot and User Needs** – "Sister" delivery describing the specific situation in Bremen pilot.
- **D2.16 Description of Barcelona Pilot and User Needs** – "Sister" delivery describing the specific situation in Barcelona pilot.
- **D4.1 Initial Architecture** – This delivery describes the initial version of the GreenCharge architecture, including specification of interfaces and protocols for interoperability.

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[2] In the grant agreement this is denoted as the "baseline", but it has been decided that the term "baseline" shall only be used in relationship to the evaluation.

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1.4 Other projects and initiatives

- SEEV4-City: Municipality of Oslo is partner in this Interreg North Sea Region project where one of the objectives is intelligent load management for EV charging. In Oslo this project has deployed EV charging in Vulkan, making it one of the largest and most advanced EV charging garages in Norway and Europe. See https://www.seev4-city.eu for details.

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2 Introduction to the pilot site

Oslo is the capital and the most populous city of Norway. It is both a county and a municipality. The Oslo urban area extends well beyond the boundaries of the municipality.

Røverkollen housing cooperative is located in the eastern part of Oslo municipality. The first residents moved in during 1974.

Figure 1: One of the housing blocks of Røverkollen

The municipality of Oslo has an active policy to promote e-mobility. The city has identified that the main challenge for continued growth of e-mobility is provisioning of the required charging infrastructure.

2.1 Geographical location

Figure 2 shows a map of greater-Oslo, including surrounding municipalities, and the location of Røverkollen housing cooperative. Røverkollen is located in the eastern part of Oslo municipality and lies approximately 275 meters above sea level. The addresses are Sverre Iversens vei 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25.

Figure 2: Map of greater Oslo and location of Røverkollen (source: Google Maps)

Figure 3 shows an aerial photo of the buildings belonging to Røverkollen housing cooperative. Here the five building blocks can be seen. The big building in the middle is the parking garage. (The building in the upper right do not belong to the housing cooperative).

In proximity to the housing cooperative is an Elementary school, Bjøråsen skole, with 380 pupils between 10 to 15 years of age, and with approximately 40 teachers. There are no other large work places in close proximity.

Figure 3: Aerial photo of Røverkollen (ref: norgeskart.no)

2.2 Demographic data

Oslo municipality has 673 469 inhabitants, however the greater urban area is home to more than one

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million inhabitants. The housing cooperative at Røverkollen comprises of 246 apartments distributed over five blocks.

2.3 Challenges at the pilot site

Some challenges related to both general mobility and e-mobility has been identified at the pilot site:

- General mobility preferences: The housing cooperative is situated at the end of the subway-line, and many of the inhabitants use public transport (see chapter 4 on user needs). Others feel that they live in the outskirts, and therefore need a car for their daily life.
- Requirements regarding EV charging facility: Several of the inhabitants that consider buying an EV consider charging at their own dedicated parking place a prerequisite.
- The nearby school does not provide charging to employees/visitors. It is therefore a possibility that the housing cooperative could provide and sell charging services to employees and visitors at the school. How to make this feasible?

The features and functions to be tested in the Oslo Pilot are as follows:

1. Charging location:
    i. Apartment buildings (with constraints in local electricity system)
    ii. Public spaces
2. Charging speed
    i. Normal and semi-fast
3. EV type
    i. Person cars
4. EV purpose
    i. Private (residents at Røverkollen) and public use (taxies and for employees at the school close by)
5. Ownership
    i. Individually owned and used
6. Smart charging
    i. Photovoltaic (PV) panels; Prediction based load balancing within neighbourhood; Booking; Priority charging; V2G; Stationary batteries
7. Business models
    i. Rewarding prosumers; Rewarding sharing of private charging points; Pay for priority booking; Rewarding V2G

Technical challenges:

- The pilot depends on the technological development of V2G, both within the car and in the charging box. Currently this technology is not commercially attractive for private owners as issues regarding the guarantee of the EV are not clarified when installing V2G feasibility.

Challenges regarding user acceptance:

- It is of high importance that the users of the new app of the EV-SYS (EV in-vehicle system, see Chapter 4) find it useful and that they are satisfied with the services the app provides.
- There is a great risk that users will find the app too complicated or cumbersome, so that necessary information is not entered from the driver into the system. Without the information on 1) state of charge upon arrival, 2) wanted state of charge upon leaving and 3) the time of departure, it is challenging for the NEMS (Neighbourhood energy management system, see Chapter 4) to operate at its optimum.

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3 E-mobility at start of project

3.1 Vehicle ownership and EV penetration

The table below summarises car ownership in Oslo municipality. Note that a lot of car leasing companies are located in Oslo. Typically, their vehicles are registered in Oslo, but used in other areas, so the numbers are probably a bit higher than the real ownership.

Car ownership in Oslo municipality (numbers from 2017)	
Total number of registered cars	368,445 (equal to 547 vehicles per 1,000 inhabitants)
Total number of registered EVs (including BEV, PHEV, FCEV)	48,733
Total number of registered non-plugin hybrid cars (HEV)	9,246

Based on a survey addressed to all households at Røverkollen housing cooperative, approximately 85% of the households have access to a car (see Figure 12 in section 4.3).

To get an overview of EVs at Røverkollen housing cooperative a request was sent to the Norwegian Public Roads Authority (Statens vegvesen) asking for number of chargeable vehicles (BEV and PHEV). The results are summarised in the table below:

EV ownership at Røverkollen housing cooperative (numbers from 14. January 2019)	
Total number of BEVs	16
Total number of PHEV	1
Total number of chargeable vehicles	17

Note that these numbers do not include vehicles owned by car leasing companies and are therefore probably a bit lower than the real use of EVs.

3.2 Existing charging infrastructure

Røverkollen contains four outdoor, semi-fast chargers today. These are one (two) phase chargers with 32 A, providing a maximum of 7.4 kW. The chargers are connected to apartment block number 33 with 80 A. Currently, there are 15 EV owners at Røverkollen registered and therefore allowed to use these four charging points.

Connected to the housing cooperative, there is a four-storey parking garage where the residents have their own parking spot. The garage contains 230 parking spots in total, without any EV charging points. The EV owners would much rather want to charge their car in the garage where its normally parked, instead of sharing only four charging points outside. In the current scenario, the residents would have to charge their car before moving it back to its regular spot when fully charged. They find this very inconvenient. The EV owners would also like to pay for the actual use (per kWh) instead of a flat rate.

3.3 Current usage of charging infrastructure

3.3.1 Booking system and payment method

As mentioned in *3.2 Existing charging infrastructure* there are 15 EV owners sharing the four charging points located at Røverkollen.

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After signing a contract for using the charging station, the users are given access with a card that activates the charging points. Then, via an online spreadsheet (using Google Docs), the EV owners can book the charging point for up to six hours at a time, which means four charging periods per day.

Figure 4 below illustrates how a typical week in the booking system looks like. The EV owners have to add their cars registration number, chosen from the drop-down menu, in the column matching the desired time for charging (cars with registration letters starting with E are EVs, others PHEVs).

Velg registreringsnummeret på bilen din for det tidspunktet du vil reservere.
Velg "Ledig" hvis du ikke trenger plassen allikevel. Det er ikke nødvendig å fjerne gamle reservasjoner.
Tidspunktet 23:00-08.00 på en dag gjelder natt TIL den dagen. Eks. 23-8 på mandag gjelder natt til mandag.

Mandag

Tid	P1	P2	P3	P4
23:00-08:00	Ledig	EKXXX16	ELXXX43	
08:00-14:00	EXXX83	EVXXX84		
14:00-18:30	EKXXX42			BTXXX44
18:30-23:00	EKXXX42	Ledig	EKXXX41	Ledig

Tirsdag

Tid	P1	P2	P3	P4
23:00-08:00	ELXXX43	Ledig	ELXXX14	EVXXX93
08:00-14:00	ELXXX43	ELXXX90	ELXXX39	EVXXX93
14:00-18:30			ELXXX09	ELXXX39
18:30-23:00	ELXXX83		Ledig	Ledig

Onsdag

Tid	P1	P2	P3	P4
23:00-08:00		EVXXX15		ELXXX14
08:00-14:00	ELXXX83	EVXXX15	Ledig	
14:00-18:30				ELXXX09
18:30-23:00	EVXXX51		EKXXX42	ELXXX09

Torsdag

Tid	P1	P2	P3	P4
23:00-08:00				ELXXX43
08:00-14:00		ELXXX83		ELXXX43
14:00-18:30	EVXXX84	ELXXX71	Ledig	EKXXX41
18:30-23:00	EVXXX84	ELXXX09		EKXXX41

Fredag

Tid	P1	P2	P3	P4
23:00-08:00	EKXXX16	EKXXX89	EKXXX42	ELXXX43
08:00-14:00		EKXXX89		ELXXX43
14:00-18:30	ELXXX90	BTXXX44	Ledig	
18:30-23:00		BTXXX44	ELXXX09	EKXXX42

Lørdag

Tid	P1	P2	P3	P4
23:00-08:00			ELXXX09	
08:00-12:00	Ledig			ELXXX83
12:00-17:00	ELXXX90	ELXXX71		ELXXX39
17:00-23:00	ELXXX90	EKXXX42	Ledig	ELXXX83

Søndag

Tid	P1	P2	P3	P4
23:00-08:00	EKXXX10		ELXXX09	Ledig
08:00-12:00			ELXXX09	
12:00-17:00	ELXXX71	Ledig		
17:00-23:00	EKXXX10	BTXXX44	EKXXX89	ELXXX83

Figure 4: Current booking system at Røverkollen

The residents pay a flat rate of 400 NOK per month (about 43 EUR) for access and use of the charging infrastructure. This is paid together with the monthly common costs to the housing cooperative. Of this amount, about ¾ covers the fixed costs for down payment of infrastructure and ¼ covers the electricity costs. Approximately 100.000 NOK of the investment costs are still to be paid off.

3.3.2 Electric consumption and usage

Meter number 7359992904711637 (block number 33) is the meter for the existing four semi-fast EV-chargers at Røverkollen. The total consumption on this meter is 3400 kWh per month, which makes an average per EV per month of 227 kWh.

The two different graphs below, Figure 5 and Figure 6, illustrates the hourly consumption for one of the highest and one of the lowest peak periods per October 2018.

Hourly consumption for Friday October 5th, 2018.
Total consumption: 153 kWh

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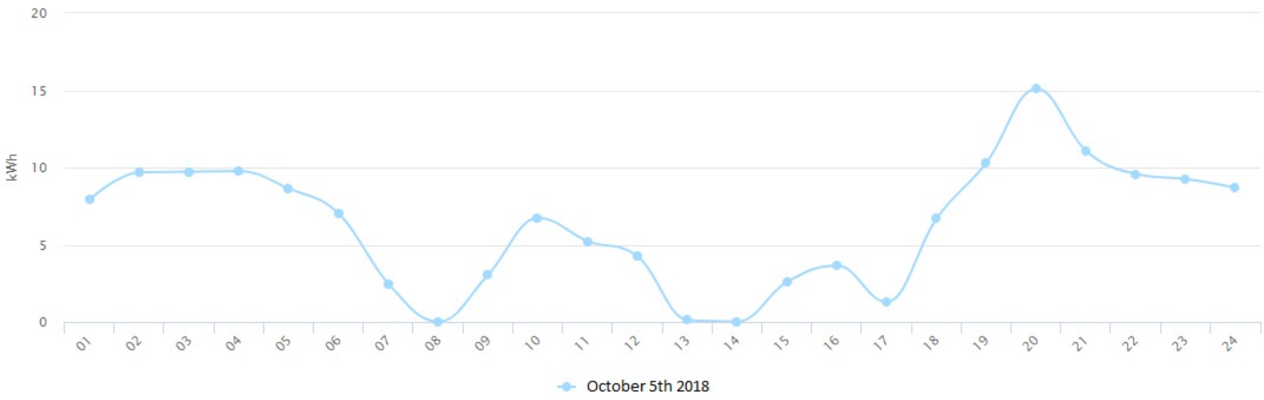

Figure 5: Hourly consumption on meter for EV chargers. Oct 5th

Hourly consumption for Sunday October 21th, 2018.
Total consumption: 32 kWh

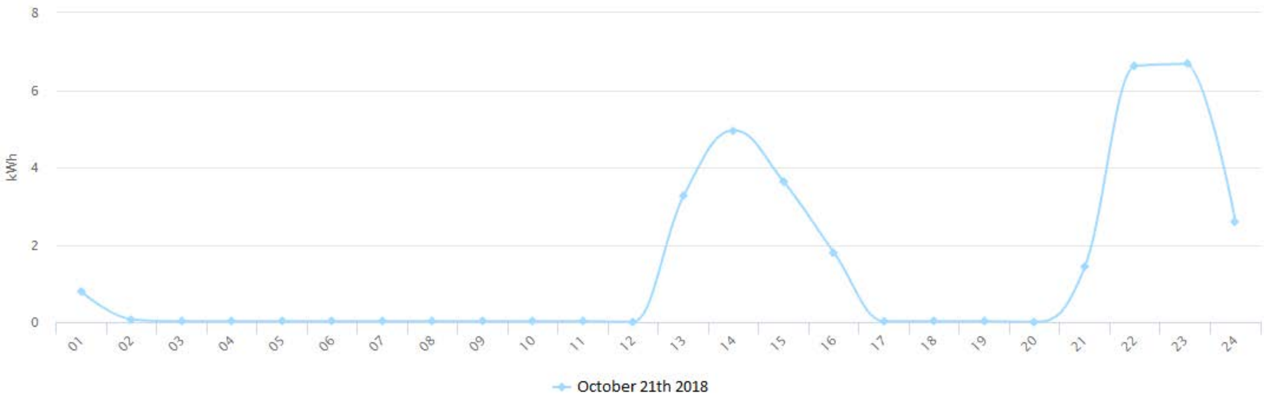

Figure 6: Hourly consumption on meter for EV chargers. Oct 21th

Based on the previously mentioned survey addressed to all households, approximately 80% of the EV users report that their EV needed to be charged every day, whilst 33 % answered that three or four times a week is sufficient. See section 4.3 for details.

Figure 7 below shows the monthly view of the consumption on meter number 7359992904711637 (belonging to the charging points at Røverkollen). This gives us insights to the daily usage of the chargers and allows us to see that the four EV chargers where used every day in October 2018. The information collected from Hafslund Nett also shows that the same goes for both November and December - with the highest consumption in December.

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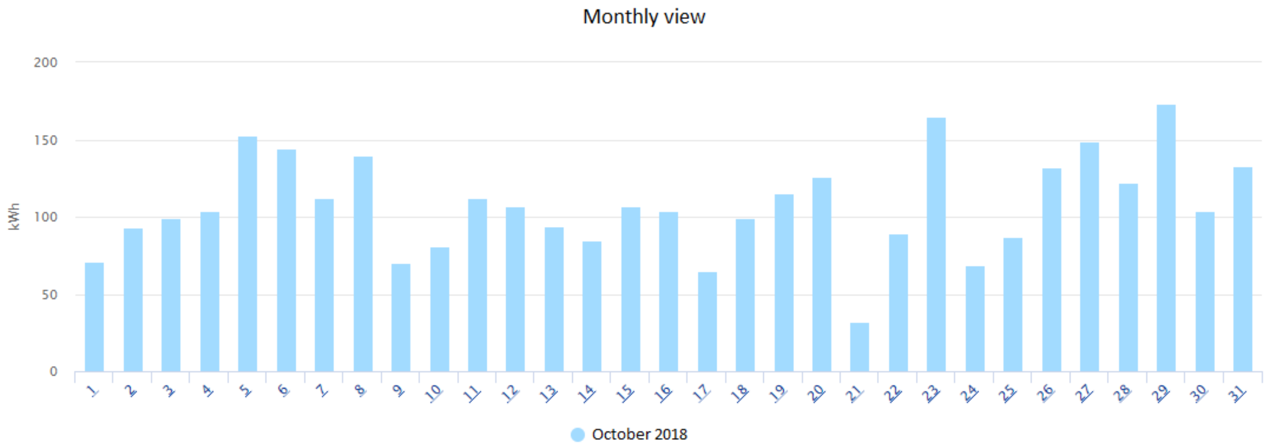

Figure 7: Consumption on EV chargers per October 2018.

3.4 Energy and power situation

At Røverkollen there is a total of nine main meters, distributed over the parking garage, the community house "Røverbo" and five building blocks. According to Røverkollen's outlined electricity consumption per meter at Hafslund Nett's web page, we find that only two of the meters (respectively 7359992903023373 and 7359992900553651) show meter data throughout 2018. This makes it challenging to sum up the total consumption for Røverkollen per year. The total consumption per meter and the max effect kWh per hour, based on the available data, is illustrated in Figure 8.

2018						
Meter number	Meter point ID	Description	Position at Hafslund Nett	Tot. consump pr meter	Periode metered	Max effect kWh/h
7359992894284128	707057500057009844	Sverre Iversens vei 1, 3 and 5	Sverre Iversens vei 3	55282,10	Sept-Dec	54,20
7359992903019208	707057500057084245	Sverre Iversens vei 7 and 9	Sverre Iversens vei 7	8393,15	Dec	20,85
7359992894251151	707057500056968058	Sverre Iversens vei 11, 13 and 15	Sverre Iversens vei 13	99437,00	Sept-Dec	85,90
7359992902087123	707057500056968638	Sverre Iversens vei 17 and 19	Sverre Iversens vei 17	15043,80	Dec	33,90
7359992902084238	707057500057008999	Sverre Iversens vei 21, 23 and 25	Sverre Iversens vei 23	61203,80	Sept-Dec	46,50
7359992903048000	707057500057008982	Sverre Iversens vei 31 and 33	Sverre Iversens vei 33	34886,10	Sept-Dec	58,90
7359992903023373	707057500055091948	Community house and janitors office	Sverre Iversens vei 25	57724,73	Jan-Dec	27,96
7359992900553651	707057500052792657	Parking garage	Sverre Iversens vei 31	219610,00	Jan-Dec	98,00
7359992904711637	707057500056969598	Semi-fast EV chargers	Sverre Iversens vei 33	10217,45	Okt-Dec	19,03

Figure 8: Meters at Røverkollen

The meter for the garage (7359992900553651) is, based on the available consumption data illustrated in the table above, the one that contributes the most in the peak period. However, this may have had a different outcome if all the meters where showing data at Hafslund Nett's website for all months in 2018. Figure 9 illustrates the total consumption on the meter in the parking garage.

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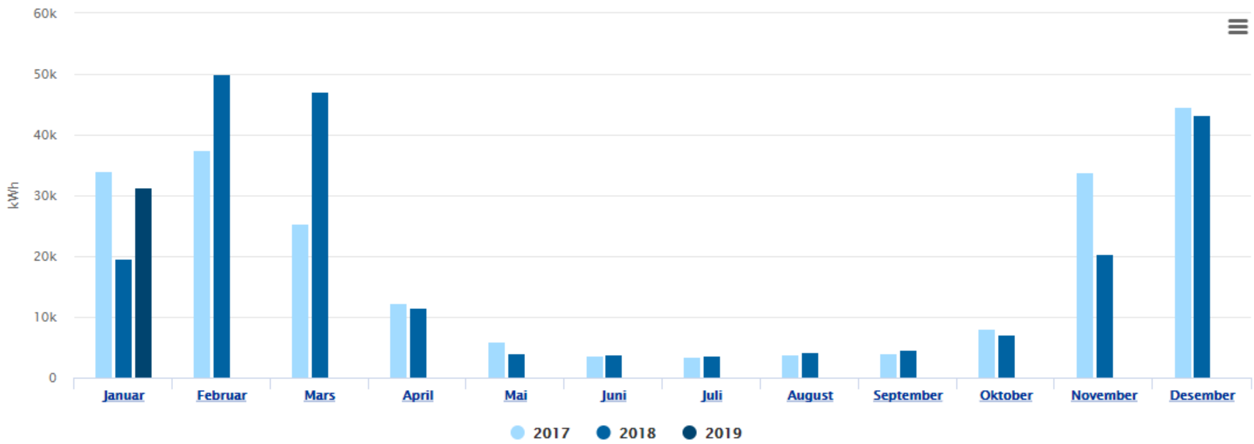

Figure 9: Consumption data for the parking garage in 2018. Meter nr 7359992900553651

The invoice for the meter in the garage shows that the max-effect in the parking garage today at summer time is 9-11 kW with a consumption of 100 000 – 150 000 kWh for the whole period. At winter time the max-effect is 90-98 kW with a consumption of 11 000 – 26 000 kWh. The possible total-effect in the garage is 125 kW (a planned upgrade of the cable into the garage will increase the possible total effect). These calculations are based on the current situation in the garage at Røverkollen, without any charging facilities.

We have, based on the current invoices for the meter in the garage, made some assumptions regarding the future power situation in the parking garage at Røverkollen. Our assumptions are based on scenarios where a full charging infrastructure has been implemented in the garage and a total of 30 cars charging at once. The two scenarios below illustrate the significant difference between cars charging in the garage with and without optimization of the charging system:

With optimization and 30 cars charging at the same time, the new effect-top in the garage will be 120 kW. The additional costs during winter time are assumed to be 3 300 NOK/mth. and during the in-between season, 1 650 NOK/mth.

Without optimization the new effect-top in the garage are assumed to be 250 kW. During winter time, the additional costs in the garage will be 16 000 NOK/mth. and 8 000 NOK/mth. for the in-between season.

3.5 ICT systems and interoperability

The current charging stations at Røverkollen are managed through iCloud – backend system provided by DEFA (previously Salto). This system handles the authentication of the user who wants to charge, and the start and stop of charging. To be able to charge, the user has to have a registered RFID-card (Radio frequency identification) that appear in the "white-list" for the group of chargers on this site. The white list is managed by Røverkollen through a web-based interface, where the site owner is allowed to manage the RFID cards and their owners. Only cards that are activated in this white list will be able to start and stop charging. Currently, there are no roaming options as the chargers are reserved for private use by the residents of Røverkollen only. "Guest charging" have to be cleared through an owner of an approved card, and only if the charging session is booked through the "in-house" booking system as described in section 3.3.1.

There is no payment transaction connected to each charging session, as the access and use of the chargers is managed as a fixed fee per month, covering both the right to use the infrastructure and the variable cost of charging, including the electricity used.

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3.6 Policy and incentives for e-mobility

The municipality of Oslo has an active policy to promote e-mobility. In 2008 the municipality developed a 10-point plan to reduce greenhouse gas emissions. One point was to support deployment and use of EVs through curb side charging for EVs. The goal of Oslo is to reduce greenhouse gas emissions with 36% within 2020 and 95% within 2030 (compared to 1990). There is also a goal to reduce local pollution. To achieve its goals the city has introduced several incentives (packages of measures) to make EVs more attractive than tailpipe vehicles. Working in tandem with national legislations and regulations the EV users in the city benefit from exemption from VAT and other purchase taxes on EV, reduced annual vehicle taxes, reduced road tolls, access to taxi/bus lanes (partly) and free parking. These incentives have proved to be effective and has resulted in the fact that more than 50% of all new vehicles purchased in Oslo are either BEV or PHEV. It has also resulted in the world's largest charging infrastructure per capital.

Reducing greenhouse gas emissions has not only been about EVs. In addition, measures have been implemented to increase walking and biking and to make use of shared transport solutions more attractive. This includes bus, tram, metro and train. The city has also implemented "green mobility houses", where the travelers can find charging opportunities, bicycle parking, car sharing services, electric scooters etc., all at one place. Moving forward, the city administration is further pursuing solutions and technologies enabling zero emission transport. This includes electrification of all vehicles, including buses and taxis, and ensuring zero emission from the maritime sector (including harbor operations). Specifically, the goal is to have a zero-emission taxi fleet by 2023.

To accelerate the electrification of the transport sector the city is managing several grants, including:

- Grants for deployment of charging infrastructure in homes and for housing associations.
- Grants for charging infrastructure for priority segments such as taxis and commercial vehicles.
- Grants for electric trucks and heavy machinery (both purchase of vehicles and charging infrastructure).

Most of these grants are in collaboration with ENOVA, which is a Norwegian governmental funding agency supporting investments in environmentally friendly solutions.

The city has identified that the main challenge for continued growth of e-mobility is provisioning of the required charging infrastructure. One of the main barriers in this regard is limited urban area available for this charging infrastructure, especially along streets, where it competes with other desirable urban developments such as bicycle roads etc.

The municipality has not developed a Sustainable Urban Mobility Plan (SUMP) but have developed a *"Climate and Energy Strategy for Oslo"* [1]. This was adopted by the City Council in Oslo 22.06.2016. The strategy defines 16 initiatives for reaching their goals related to climate and energy. Of these initiatives, seven are directly related to transport and mobility.

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.

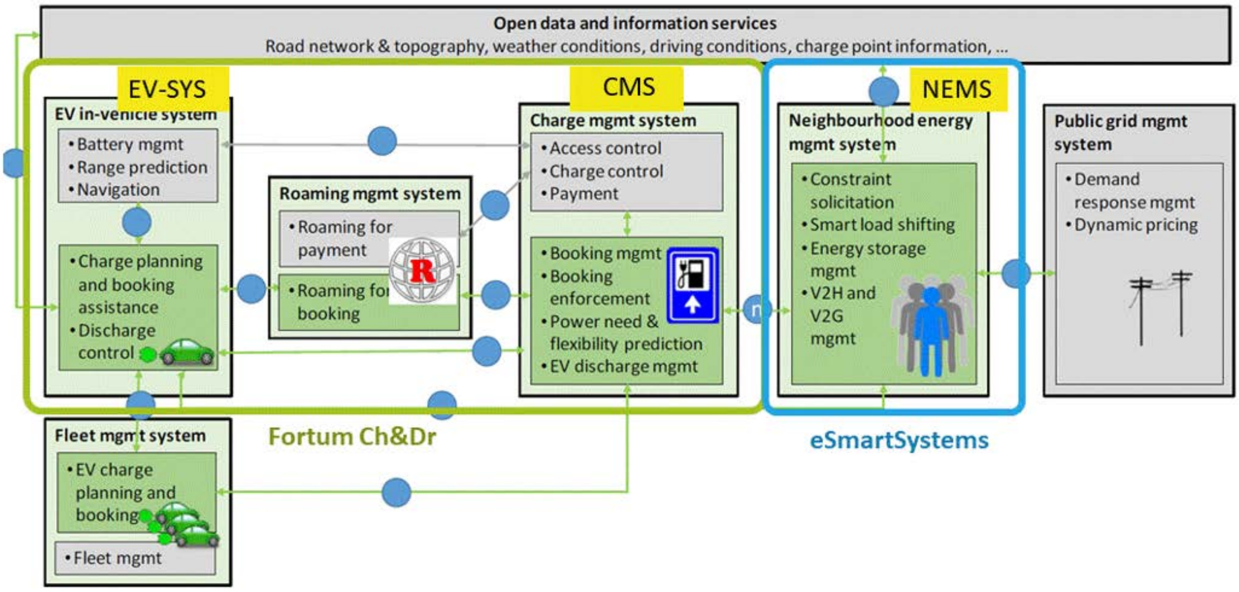
4 User needs

The cases to be investigated in the Oslo pilot involves development and deployment of software and hardware, by Fortum Charge & Drive (C&D) and eSmart Systems. The figure below as a copy of Figure 2 in 'Part B – Project Description' of the GreenCharge proposal. Here, the following abbreviations are defined:

EV-SYS: EV in-vehicle system (either through an app in the smart phone, or a display in the charging box)

CMS: The charge management system which enables optimal scheduling of an EV fleet (several EVs connected in the garage)

NEMS: The neighbourhood energy management system which enables optimal utilisation of the local renewable generation (PV), the stationary battery and the flexibility options of the CMS.



4.1 Scenarios

In the project description (section 1.3.1) seven innovation scenarios are presented. The scenarios give examples of how GreenCharge technology and business models may work in typical situations. A scenario describes a specific use of a proposed system by illustrating some interaction with the proposed system as viewed from the outside, e.g., by a user, using specific examples. The seven innovation scenarios are:

1. Charge planning and booking
2. Charging at booked charging station
3. Booking enforcement
4. Home charging in older (groups of) residential or working buildings with common internal grid and parking facilities, or at work in (groups of) buildings with similar limitations
5. V2G (vehicle-to-grid)
6. Reacting to Demand Response (DR) request
7. E-Mobility in innovative 'mobility as a service' (MaaS)

In GreenCharge, a scenario is a higher level of description of the system and can be modelled using one or several use cases.

For the Oslo pilot, the relevant scenarios are 2, 4, 5 and 6. Scenario 1 is also partly relevant for Røverkollen, but as described in the project description, this scenario is mainly relevant for fast charging for range extension, while charging at Røverkollen is considered destination charging. Scenario 1 is therefore excluded

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from the following descriptions. In the following sections scenarios 2, 4, 5 and 6 are presented and evaluated according to applicability to the situation at Røverkollen housing cooperative.

4.1.1 Scenario 2 'Charging at booked charging station'

Scenario 2: Charging at booked Charging station

1. EV approaches booked charging station and sends an approaching message to the Charge management system.
2. Charge management system sends guiding info to the EV in-vehicle system (c) who displays it to driver to assist the navigation to the booked charging point. This could include a detailed map of the charging facility, with indication of route to the booked charging post, the location of the EV and audio directions, like the navigation system normally works. Ideally this functionality would be seamlessly integrated with the navigation system.
3. The EV parks at the booked charging post and the EV in-vehicle system authenticates the EV (g) to the Charge management system.
4. The Charge management system controls the charging, making sure to obey the constraints provided in the booking, and in collaboration with the Neighbourhood energy management system leveraging any flexibility.

Outside the common garage facility at Røverkollen there are 4 semi-fast chargers. These chargers are owned by the housing cooperative and are today only available for the residents at Røverkollen. With a new booking-facility they can be made available for the public, like visitors and guests, but also for taxis and/or staff of the school that is located next to Røverkollen. Further, if a resident need to have a faster charging speed than what is available within the garage, this can be enabled by booking and using the semi-fast chargers outside the garage.

The use cases for this scenario include (detailed descriptions are provided in Section 4.4 and Appendix A):

Use case #4: The EV that arrives at the parking place has booked charging via the app in advance and plugs in the vehicle to start charging.

Use case #3: The EV that arrives at the parking place has not booked charging via the app in advance. This driver must open the app and place a booking before the charging is enabled.

4.1.2 Scenario 4 'Home charging'

Scenario 4: Home charging in older (groups of) residential or working buildings with common internal grid and parking facilities, or at work in (groups of) buildings with similar limitations

1. In the afternoon, many people return home and connects their EV to their home charging point.
2. Those who need the car soon again indicate that to the charge planning assistant.
3. Rather than starting the charging of all the cars immediately after connection, the *energy smart neighbourhood management system*, possibly in collaboration with a local *charge management system*, schedules the charging of the different vehicles according to their expected future use and SOC, so as to exploit as far as possible locally produced electric energy while also considering other tasks that need electric power in the neighbourhood.

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

Scenario 4 is the most relevant scenario as Røverkollen is a housing cooperative, and hence will provide home charging for a large group of residential users. Røverkollen consists of about 245 apartments divided on 5 apartment blocks, and with a separate parking house with 230 parking places. As the parking places are all situated in the same building, the EV chargers will be connected to the common electricity infrastructure in the parking house. Load profiles of EV charging from previous studies show that charging often starts when people return home, which most probably will reinforce the already existing peak load of the area. Hence, a smart charging strategy of the EVs connected to the power grid in the parking house may alleviate the maximum power demand of Røverkollen in total.

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The challenges with this scenario are identified as follows. To enable smart charging of several EVs, it is necessary to have information on the current status of the car and driver. That is, its current state of charge (SOC), the wanted SOC at the next departure, and at what time the next departure is scheduled. With this information at hand, the NEMS will know how much battery capacity that is available and how much energy is needed to be charged within a certain time frame.

The main challenge is however how to get this information, as the protocols within the EV cars do not allow for exporting the current SOC (in %), nor the total battery capacity (in kWh). An app on the driver's smartphone is proposed as one solution, where the users may enter this information themselves. However, there is a risk that the users will need teaching and training on how to use the application. A recent study on a new grid tariff from NVE[3] shows that people find it difficult to understand the difference of energy (kWh) and power (kW). Hence, it is most important that the user interface on the application is intuitive and easy to interpret. Old persons may be more reluctant to new technologies and would need more training/teaching. The advantage is that in a housing cooperative, people may be used to sharing collective goods.

Additionally, the CMS would need to offer the following features for the end-user:

- Prioritised charging
- Default charging strategy if no information is entered in the app (e.g. fully charged in 5 hours)

The potential for this scenario is extensive as it allows for management of loads not only for the EV fleet, but also the load of the apartment blocks.

The interface between the neighbourhood energy management system (NEMS) and the charge management system (CMS) is not fully clarified and will be further elaborated in Q3-Q4 of 2019.

Use Case #1: Normal Charging in the garage

Use Case #2: Long-term parking (enabling V2G) in the garage

4.1.3 Scenario 5 'Vehicle-to-Grid'

Scenario 5: V2G

On a cloudy afternoon, the ESN does not have enough local energy production to cover the need. However, during the sunny morning, several connected EVs with still some time left before their agreed deadline were already charged above the required charge level. In this situation, the excess energy stored in the car batteries can be fed back into the neighbourhood.

1. During the morning when the sun is shining (as forecasted) and excess local production is foreseen, the *Neighbourhood energy management system (NEMS)* instructs the *Charge management system (CMS)* to “overcharge” vehicles, preferably ones with planned connection times stretching into the afternoon when the forecast predicts little local production.
2. In the afternoon, a household in ESN schedules a load, e.g. the running of a washing machine or a water heater on-cycle.
3. The Neighbourhood energy management system finds that local RES has been exhausted in the allowable period for the load. Also, the possibilities to delay other loads, e.g. charging EVs has been exhausted. But there are “over”-charged EVs with planned connection time overlapping the allowable period for the load.
4. The Neighbourhood energy management system schedules the load in the overlapping period and instructs the Charge management system to discharge the battery of the selected EVs in accordance with this schedule.
5. The Charge management system controls the discharging of excess power from the selected EV batteries accordingly, and if necessary, the recharging to comply with the constraints.
6. The Charge management system in collaboration with the Neighbourhood energy management system ensures that the owners of the involved EVs and local PV systems are compensated for the additional discharge/charge cycle and for the provided excess energy.

Scenario 5 with vehicle-to-grid (V2G) charging/discharging would be relevant if there existed a real challenge with the capacity of the power grid in the area surrounding Røverkollen. According to Hafslund

[3] NVE - The Norwegian Water Resources and Energy Directorate

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Nett (the DSO), the available grid capacity is good, and hence this scenario is not relevant to reduce grid burden.

There are several challenges with the implementation of this scenario. First of all, most EV cars do not feature V2G technology today. There are, however, some exceptions, like e.g. Renault Zoe. Secondly, installing power electronics within a car that does not facilitate power being redrawn from the car to the grid, will cause the guarantee of the battery to expire.

Therefore, the project evaluate that this scenario only will be possible to investigate by buying a test car that features V2G or by simulations.

Use case #2: Long-term parking (V2G possibilities) in the garage

4.1.4 Scenario 6 'Demand Response request from Grid operator'

Scenario 6: Reacting to Demand Response (DR) request 1. Public grid requests demand reduction or feed-in 2. For acute requests, the *Neighbourhood energy management system (NEMS)* reschedules already scheduled flexible loads and/or exploits charging EV batteries to satisfy the request.

As for Scenario 5, Scenario 6 would also be relevant if there existed a challenge in the grid capacity towards Røverkollen. However, we regard this scenario as interesting for simulations as it will prepare the software to handle Demand Response requests from the DSO. This may be used in other housing associations when the software solutions from GreenCharge is implemented in other housing cooperatives with limitations on their grid connection.

To ease the burden on the public power grid, the request for demand response would target the total consumption at Røverkollen, including the individual apartments, the common housing cooperatives consumption (for lighting, hot tap water, elevators etc.) and the charging of EVs. However, as these customers/consumers have individual meters (for each separate household, and the 9 meters at the housing cooperative), the monetary benefit for each individual of coordinating their consumption might be negative. This is because they are billed per meter point. In order to harvest the benefits of coordinating individual loads in a neighbourhood, the meter point would need to be moved upward to a higher level in the electricity grid. Physically this is feasible, however there are large regulatory obstacles to enable this.

Therefore, as there are currently no grid congestions in the area, and due to regulatory barriers, this scenario will be accomplished through simulations.

Because it concerns the total electricity consumption of Røverkollen, all use cases are involved in this scenario:

Use case #1 and 2: Charging in the garage, both normal and V2G

Use case #3 and 4: Charging outside the garage at the semi-fast chargers, with or without prior booking

4.2 Stakeholders

Hafslund Nett is the local distribution system operator (DSO). Hafslund Nett owns and operates the local electricity grid at Røverkollen and in the municipality of Oslo as such. See more at: https://www.hafslundnett.no/

Bravida is the electrical contractor that will install the electric infrastructure within the parking house. See more at: https://www.bravida.se/en/.

Oslo Municipality is both the largest city and the capital of Norway. The municipality has, since 2008, had an active plan to reduce greenhouse gas emissions, both through regulations and through funding mechanisms. See https://www.oslo.kommune.no/startpage/ for more information. Project partner in GreenCharge.

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Fortum OY is one of the largest energy companies in the Nordic countries and is registered in Finland. Their main focus is zero emission power generation and smart energy solutions. Fortum Charge&Drive (C&D) is Fortum's brand within e-mobility solutions and have been investing in public fast-charging networks in the Nordic countries. As of today, Fortum C&D has a dominant market share in the Nordic countries, with Norway as the lead country for e-mobility solutions. The backbone of the e-mobility business is CDMC – a cloud solution for managing chargers and charging networks. This includes operations, customer service, access management and payment system. Fortum C&D is a project partner in GreenCharge where they will provide the software for the Charge management system (CMS), as well as a smartphone application.

eSmart Systems is a software company that provides Artificial Intelligence (AI) driven software solutions to the energy industry and service providers. Their cloud born platform is designed to handle and exploit IoT, Big Data and Analytics in real time. It has broad application possibilities that brings huge opportunities for cost savings in forms of improved knowledge about the state of power grid components as well as greatly improved optimization of distributed energy resources. Common to the applications is vast data quantities gathered from sensors, which are analysed using deep learning, advanced predictions and optimization models. This results in completely new ways of visualizing data, making decisions and saving resources and costs. See more at https://www.esmartsystems.com/about-us/. eSmart is a project partner in GreenCharge, where they will provide the cloud and software for the Neighbourhood energy management system (NEMS).

Futurehome is a software and hardware developer that enables smart management of energy use in private homes. Their platform provides security management (door-locks, intruder alarm and fire alarms), energy billing and energy management. Futurehome is already a provider of security management at Røverkollen. In GreenCharge it is proposed that Futurehome will provide sensors and actuators within the apartment blocks that may enable smart management of the building's loads. Futurehome's sensors will provide data to the data cloud of the NEMS provided by eSmart Systems.

OBOS is Norway's largest housing administrator, and one of the largest Nordic housing constructors. OBOS is a cooperative building association and is owned by its members. Røverkollen is a member of OBOS. In GreenCharge, OBOS is interested in lessons learned from the implementation and operation of Røverkollen as it is relevant to most of their housing cooperatives situated throughout the country.

Residents of Røverkollen housing cooperative. Røverkollen housing cooperative consists of 246 apartments/households. The total number of residents is not fully known, however according to a user survey carried out in Nov 2018, the age of the residents lies between 35 to 65 years old. The results from the survey shows that of the respondents who do not already possess an electric car, 15 % have clear plans about it and 21 % of the respondents will buy a chargeable car within 2 years. This means than within 2 years, it is likely that 50 % of the households will have chargeable vehicles. This indicates future needs for charging facilities. (The residents are described in more detail in the section *4.3 User needs*.)

4.3 User needs

In November 2018, the housing board at Røverkollen administrated the survey on the residents plans to buy an electric (EV) or chargeable car (plugin-in hybrid electric vehicle – PHEV), and their associated charging needs. The number of respondents was 81, a participation rate of 33 %. Most of the respondents were between 35 and 65 years old. Most of the households have one or two persons with a driving license. The respondents were also asked if they had a commercial vehicle (taxi or van), but very few had (question 5).

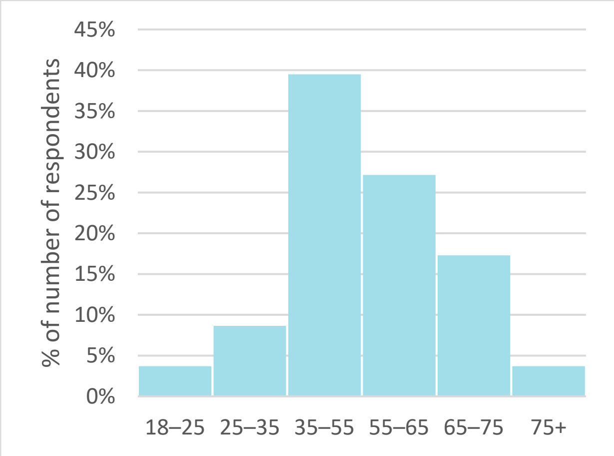


Figure 10 Age of the respondents

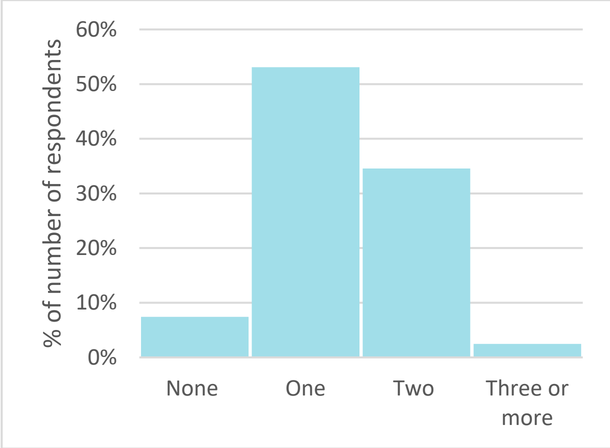


Figure 11 Driving license for car per household. (Q2: How many people in your household have a driving license for car (class B)?)

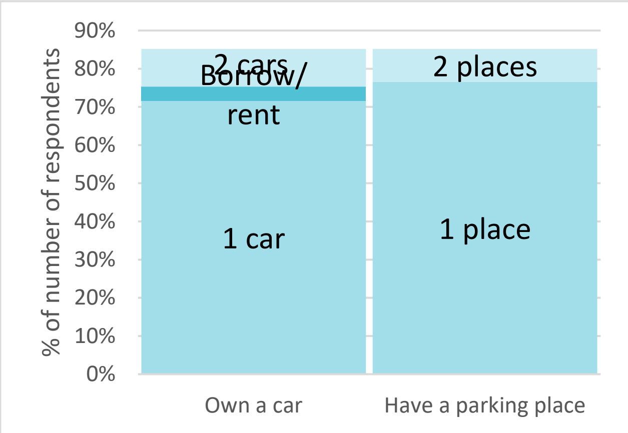


Figure 12 Car ownership and parking ownership. (Q3 and 4: Do you have or dispose car and parking place in the garage?)

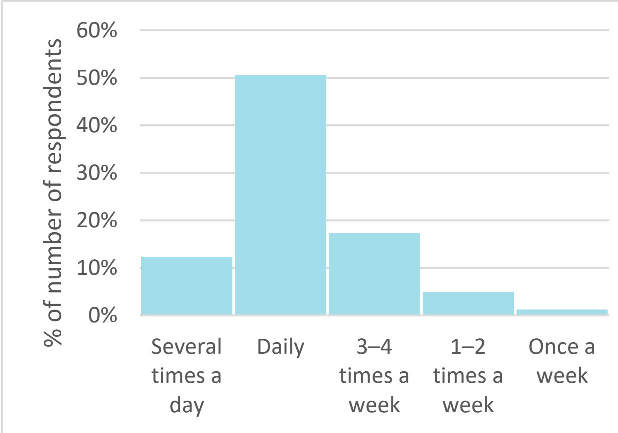
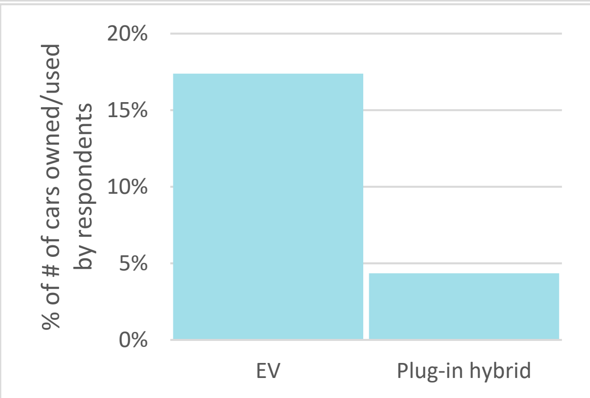


Figure 13 Frequency of car use. (Q6: If you have a car: How often do you use the car that you use the most?)

Figure 12 shows that over 80 % of the households that have a car also have, or dispose, a parking place in the common garage. Figure 13 shows that among the households that have a car, 50 % use the car daily, and 17 % use the car 3-4 times a week.



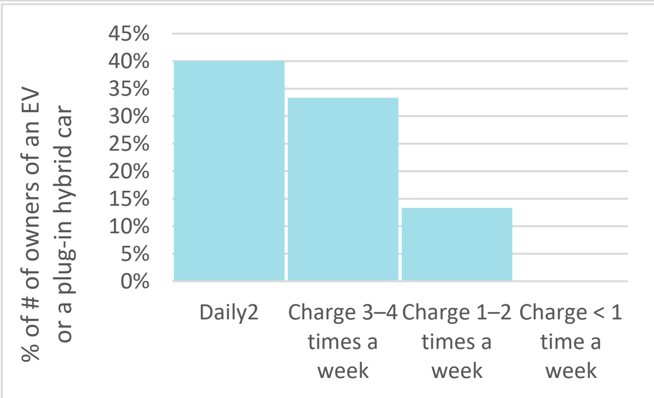


Figure 14 Current ownership of chargeable vehicles. (Q7: If you have a car, how many electric vehicles or chargeable hybrid cars do you have?)

Figure 15 Current frequency of charging needs. (Q8: If you have a chargeable car: How often do you have to charge the car you use the most?)

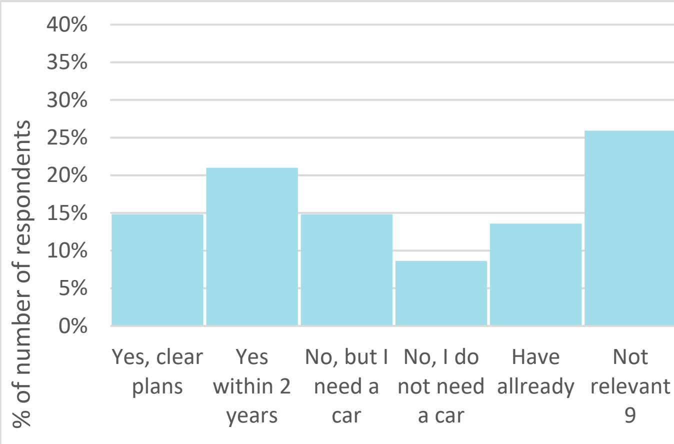


Figure 16 Future plans for ownership of chargeable vehicles. (Q9: Do you have plans to buy an EV or a plug-in hybrid car?)

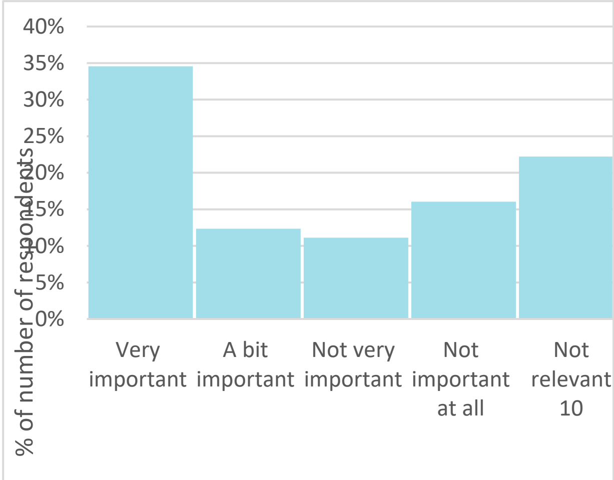
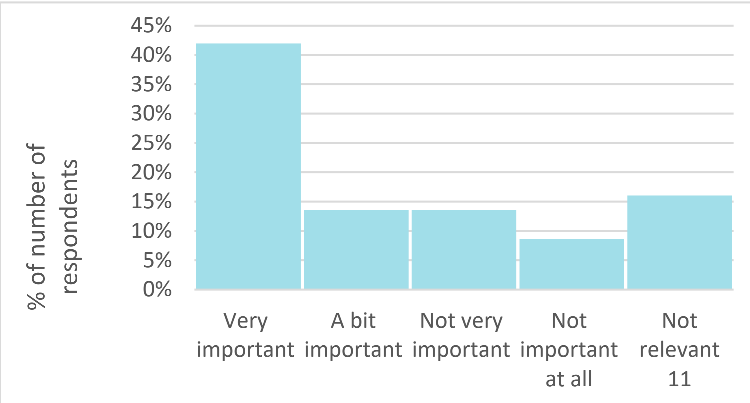


Figure 17 Importance of charging facility at own parking place. (Q10: How important is it for you to day that charging possibilities are available in parking spots in the garage for the housing cooperative?)

The current status of car ownership at Røverkollen is shown in Figure 14 and Figure 15. Of the respondents, 17 % of the car owners have electric vehicles, and 4 % have chargeable hybrid cars. Of the respondents, among the owners of the chargeable cars, 80 % of them must charge their car daily, and 33 % charge their car 3-4 times a week. Figure 16 shows that the respondents who do not already possesses an electric car, 15 % have clear plans about it, and 21 % of the respondents will buy a chargeable car within 2 years. This means than within 2 years, it is likely that (17 +15+21=) 50 % of the households will have chargeable vehicles.

The residents were also asked about the importance of charging possibilities in the parking spots in the housing cooperative garage, and 50 % say that it is very important or a bit important (cf. Figure 17). When the residents are asked how important the charging possibilities in the parking spots in the garage are in three years, the number of respondents stating that is important or a bit important, has increased to 56 % (cf. Figure 18). However, it is important to notice that many residents also find it not important, or not relevant, indicating that many of them use a fossil fuelled car, or use other alternative transportation such as walking and/or public transport.



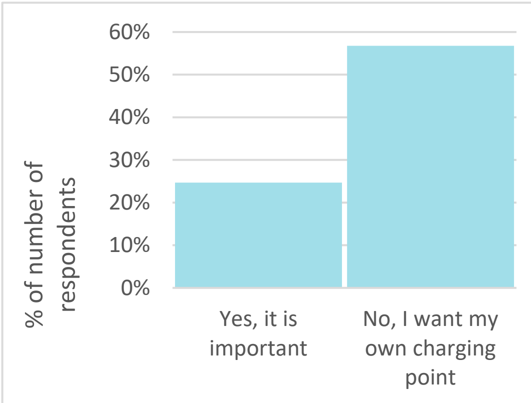


Figure 18 Importance of charging facility within 3 years. (Q11:

Figure 19 Willingness to share charging

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How important do you think it will be for you in 3 years that there is charging opportunities on the parking spots in the garage for the housing cooperative?)	**point with others?** (Q13: If you have / want to get an electric car, do you want to share the charging point with others through a booking system if this can reduce your expenses?)

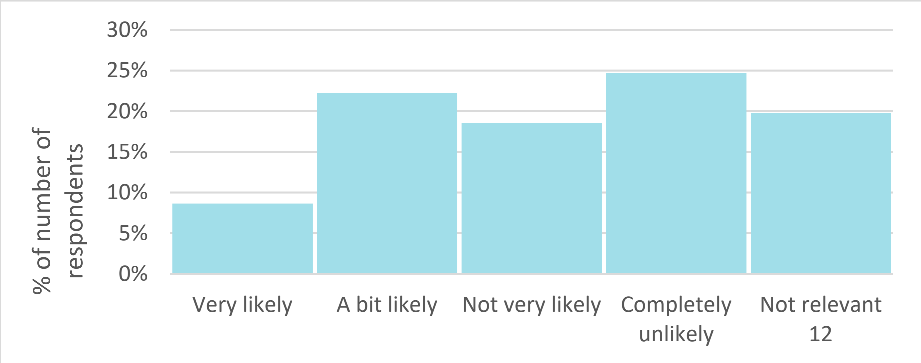

Figure 20 Likelihood for car sharing. (Q12: How likely is it that you would like to use car sharing, if the cars are available in close proximity to the housing cooperative?)

30 % of the respondents say that it is very, or a bit likely that they will use car sharing if the cars are available near the housing cooperative.

Among the residents that have or want to get an electric/chargeable car, 57 % state that they do not want to share the charging point with others through a booking system, even if it can reduce their expenses. Only 25 % are interested in this type of sharing.

4.4 Use cases

Based on the scenarios described in Chapter 4.1, the following use cases are derived to be tested in the Oslo pilot.

4.4.1 Use Case #1: Normal charging in the garage (in scenario 4 and 6)

The most common use case is that a resident of Røverkollen arrives the garage in his/her EV. The car is parked at its individually owned parking place and charged through its individually owned charging box, that is connected to the housing cooperative's charging infrastructure.

There are several versions of this use case dependent on the state of charge (SOC) of the battery upon arrival, and the wanted SOC at the expected departure.

The use case requires an app (or display at charging box) to be developed where the user (drivers) enters information that is demanded by the NEMS and CMS. Based on the information from the newly arrived EV together with the information on the current status of the system (number of EVs already charging, the electricity consumption of the garage as such, the PV production and the SOC of the stationary battery), the NEMS and CMS schedules the most optimal charging for the arrived EV.

An extension of this use case is when the driver requests priority charging upon arrival, communicated through the app/display.

Use case #1 occurs in scenario 4 'Home charging'. Scenario 6 'DR requests from Grid operator' involves optimal utilisation of all connected EVs to respond to DR requests from the grid operator (DSO), and hence use case #1 also occurs in this scenario.

4.4.2 Use Case #2: Long-term parking (V2G possibilities) in the garage (in scenario 5)

If V2G-technology is available in the car and in the charging box, the connected EV may be used as an additional flexible resource in the CMS and NEMS (presupposing V2G features are implemented in the

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software), as it may be used in the same way as a stationary battery, providing both discharging and charging flows.

Use case #2 occurs in scenario 5 'V2G', as well as scenario 6 'DR requests from Grid operator'.

4.4.3 Use Case #3: Drop-in charging (in scenario 6)

Visitors and other stakeholders identified in Scenario 2, arrive at Røverkollen and would like to charge their car. As they do not have access to the private garage, they can charge at one of the four publicly available semi-fast chargers located outside the private garage. To be able to charge, the driver needs to download the charging app, do a registration and book the charging point.

Use case #3 occurs in scenario 6 'Demand Response request from Grid operator'.

4.4.4 Use Case #4: Charging with booking (in scenario 2 and 6)

This use case is an extension of use case #3. Visitors at Røverkollen would like to be sure that there is a charging point available as he/she arrives at Røverkollen. As the visitor has been there before and installed the app, he/she makes a booking of the charging point prior to arrival.

Use case #4 occurs in scenario 2 'Charging at booked charging station', and in scenario 6 'Demand Response request from Grid operator'.

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5 Technological Requirements

The results of the survey presented in section *4.3 Use cases and user needs* states that it is likely that 50 % of the residents at Røverkollen will have their own chargeable vehicle within two years. 50 % of the respondents also says that charging possibilities in the parking spots in the garage is *very* or *a bit important.* Most of the respondents, as much as 57 %, states that they do not want to share a charging spot with someone else through a booking system – they want to be able to charge their own vehicle at their own parking spot in the garage.

Today's charging infrastructure and booking system at Røverkollen is not suited to handle an increase in EV's this size. The parking garage requires a new charging infrastructure, providing the residents at Røverkollen the possibility of buying their own charging points. The parking spots are legally registered and cannot be moved between residents. Therefore, the new charging infrastructure must include all four storeys of the parking garage.

Read more about the technological architecture, specification of interfaces and protocols for interoperability in GreenCharge deliverable *D4.1 Initial Architecture.*

<u>Technology used to satisfy the user needs</u>

Use Case	**Use Case #**	**Technology**	**Stakeholder(s) involved**	**Demo Site**
Normal charging in the garage	1	Car connected to charge point Charging app – user to enter required information to start charging Charging Management System - Charging started from app, relevant information transferred to NEMS Neighbourhood Energy Management System - Receives data from CMS, update predictions and creates a capacity plan that is sent to CMS Charging Management System - Performs charging to connected cars	Fortum and eSmart Systems	Røverkollen housing cooperative parking garage
Long-term parking (V2G possibilities) in the garage	2	To be decided (simulations)	-	Røverkollen housing cooperative parking garage
Drop-in charging (4 semi-fast chargers outdoors)	3	The chargers will be connected to Fortum's backend system for management and operation of the charging stations at the site. Typically, the available methods of starting and stopping a charging session are Fortum's C&D App, RFID-tag and SMS.	Fortum	Røverkollen housing cooperative semi-fast outdoor charge points

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		For bookable charging stations the user needs to use the App. If the user is on site and has no app the user needs to download the App. Roaming is available through the Hubject's Intercharge network[4]. The App will guide the user to the location and list the available chargers, showing the current state of the chargers. The procedure for charging is: • Connect car to the available charging outlet • Choose the outlet in the app and press "start" to initiate the charging session, or The charging session will start immediately after authentication and can only be terminated through the same tool as the starting of the session. The cost of the charging session will be calculated according to the price plan of the specific charging point after end-of-charge, and the amount will be drawn from credit/debit card.		
Charging with booking (4 semi-fast chargers outdoors)	4	Booking of charging can only be done through the App interface. Depending on the regulations of the site in question, a user may be allowed to reserve a specific outlet for charging for a specific period (from DDMMYY/hhmm to DDMMYY/hhmm) When arriving at the charging point, only the user with the approved reservation can start the charging process. The process of start and stop of a	Fortum	Røverkollen housing cooperative Semi-fast outdoor charge points

[4] It is uncertain if booking is possible through the Intercharge network and associated App. See deliverable D2.4 for further details regarding the Intercharge network

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		charging session is identical to the above procedure, but only the App will be allowed to start charging.		

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6 Future work

This report has provided an overview of the Oslo pilot as part of the GreenCharge project. Major challenges, both related to mobility in general and e-mobility has been identified. The status of e-mobility at the start of the project has been described, including grid limitations and existing charging infrastructure. Based on seven innovation scenarios (as described in the project description) and user needs, the following four use cases have been defined:

- Use Case #1: Normal charging in the garage
- Use Case #2: Long-term parking (V2G possibilities) in the garage
- Use Case #3: Drop-in charging
- Use Case #4: Charging with booking

Based on these use cases and user needs, overall technical requirement has been derived.

The next step is to implement the needed changes at the pilot site to enable testing of these use cases. The needed changes are documented in deliverable D2.4 *"Implementation Plan for Oslo Pilot"*. Deliverable 2.4 describes the planning of the tests to be carried out at the pilot site, including time schedules, identification of relevant users and other stakeholders. D2.4 also include hardware and software requirements, both for enabling the use cases, and to collect required data for evaluation purposes.

The final findings from the demonstration activities at the Oslo pilot site will be documented in D2.8 *"Final Report for Oslo Pilot: Lessons Learned and Guidelines"*.

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.

7 References

[1] *"Climate and Energy Strategy for Oslo"*, accessed 15.02.2019 from https://www.oslo.kommune.no/getfile.php/13174213/Innhold/Politikk%20og%20administrasjon/Etater%2C%20foretak%20og%20ombud/Klimaetaten/Dokumenter%20og%20rapporter/Climate%20and%20Energy%20Strategy%20for%20Oslo%20ENG.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.

A Appendix

A.1 Use Case 1: Normal charging in the garage

1. Description

The EV driver arrives at his/her dedicated parking space in the garage. The SOC of the EV battery is at x %, and the wanted SOC at next departure is minimum y %. The assumed departure time is within z hours. These three parameters (SOC at arrival, SOC at departure and time of next departure) varies between users and vehicles.

2. Actors

The primary actor is the EV driver and the secondary actors are other possible users of the EV. This includes the partner, children with a driving license or other friends or family members of the driver.
Stakeholders:

- Housing cooperative
- Operator of the Neighbourhood energy management system (NEMS)
- Charging operator that operates the charge management system (CMS), Fortum Charge & Drive
- Distribution System Operator (DSO) Hafslund
- Other EV users of the housing cooperative connected to the charging infrastructure in the garage at the time of charging

3. Preconditions

Preconditions to start charging:

- The driver has a charging demand
- The three parameters (SOC at arrival, SOC at departure and time of next departure) are provided either by the in-vehicle-system or by the EV driver upon arrival
- The driver has a user account with the charging operator (Fortum Charge & Drive)

This information can either be provided via an application on the driver's smart phone, at a display within the car or at the physical charging point. If the information is not provided; the system will set these parameters automatically according to system defaults, based on previous experience or through machine learning.
The following information is added once by the EV user and stored in the user profile in the charging app:

- Maximum battery capacity
- Minimum charging level demand (normally)
- EV registration number
- Contact information (for notifications, e.g. in case charging cannot be provided)

In cases where there is an extraordinary charging need, this will have to be registered manually in the application.

4. Basic Flow

The basic flow or success flow illustrates the straightest or simplest path to accomplishing the goal.

1. The EV driver parks the car in the parking garage and connects the car to the charge point
2. The driver will choose to use default values for charging or enter new values if default values does not match user needs for next charging session.
3. The energy needed for charging is calculated and communicated to the CMS. The CMS transfers the relevant information to the NEMS
4. The NEMS system assigns energy profile for charging according to the total energy demand, the availability of energy and energy price
5. The NEMS system updates predictions and creates an Optimal Capacity Plan (OCP). The CMS receive data for power availability from NEMS according to OCP.

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6. The CMS optimizes the charge schedule according to the available power and charging demands recommended by NEMS, and priorities defined by the EV users
7. The App provides feedback on charging progress
8. The CMS calculates the charging cost and registers under user's account

5. Exception Flow

The exception flow illustrates the things that can happen that prevent the user from achieving their goal. This chapter refers to the points in *1.4 Basic Flow.*
The required data is not provided with the app:

2.1 System displays a warning message
2.2 Actor enters additional data

The NEMS system does not assign as much energy as required for charging:

4.1 The NEMS is not able to schedule all the charging requests according to the total energy demand and the availability of energy in the grid.
4.2 The NEMS prioritizes the energy use and updates the OCP for charging according to the priority among the EV users

Charge rejection:

6.1 The CMS notifies the user on deviation to the charge request according to the provided contact information

A.2 Use Case 2: Long-term parking (V2G possibilities) in the garage

1. Description

The EV driver arrives at his/her dedicated parking space in the garage. The SOC of the EV battery is at x %, and the wanted SOC at next departure is minimum y %. The assumed departure time is within z hours. These three parameters (SOC at arrival, SOC at departure and time of next departure) varies between users and vehicles.

Use Case #2 looks at long-term parking in the garage at Røverkollen and the support of Vehicle-to-Grid (V2G) possibilities. V2G is a kind of two-way charging where an EV communicates with the power grid to sell demand response services by e.g. returning electricity to the grid. Not all EVs support V2G at this stage, so an essential condition in this use case is that the EV driver owns one that does. Nissan Leaf and Renault Zoe are examples.

2. Actors

The primary actor is the EV driver and the secondary actors are other possible users of the EV. This includes the partner, children with a driving license or other friends or family members of the driver.
Stakeholders:

- Housing cooperative
- Operator of the Neighbourhood energy management system (NEMS)
- Charging operator that operates the charge management system (CMS), Fortum Charge & Drive
- Distribution System Operator (DSO) Hafslund
- Other EV users of the housing cooperative connected to the charging infrastructure in the garage at the time of charging

3. Preconditions

Preconditions to start long-term parking with V2G possibilities:

- The driver has a long-term parking demand
- The three parameters (SOC at arrival, SOC at departure and time of next departure) are provided either by the in-vehicle-system or by the EV driver upon arrival

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- The driver has a user account with the charging operator (Fortum Charge & Drive)
- The EV driver has a car that supports V2G
- The driver must indicate that V2G is allowed, while being parked on a long-term basis

This information can either be provided via an application on the driver's smart phone, at a display within the car or at the physical charging point. If the information is not provided; the system will set these parameters automatically according to system defaults, based on previous experience or through machine learning.

The following information is added once by the EV user and stored in the user profile in the charging app:

- Maximum battery capacity
- Minimum charging level demand (normally)
- EV registration number
- Contact information (for notifications, e.g. in case charging cannot be provided)
- Allow for V2G

4. Basic Flow

The basic flow or success flow illustrates the straightest or simplest path to accomplishing the goal. With the precondition that the EV user drives a car that supports V2G:

1. The EV driver parks the car in the parking garage for long-term parking and connects the car to the charge point
2. The driver enters the required information in the application, indicates that V2G is allowed and confirms the charge request
3. The energy needed for charging is calculated and communicated to the CMS. The CMS transfers the relevant information to the NEMS
4. The NEMS system assigns energy profile for charging according to the total energy demand, the availability of energy and energy price
5. The CMS determines the periods when the car is being charged/discharged; the energy stored in the batteries of the EVs provides energy to the grid in peak load periods

5. Exception Flows

The exception flow illustrates the things that can happen that prevent the user from achieving their goal. This chapter refers to the points in *1.4 Basic Flow.*

The EV is not set up with V2G possibilities:

2.1 The car will not be available for V2G

V2G has not been approved in the app:

2.1 The car will not be available for V2G

The EV owner returns earlier than expected:

5.1 The EV is not fully charged as the available battery capacity has been used in peak load periods to help with capacity constraints

A.3 Use Case 3: Drop in charging at private charging stations

Any person who visit the site can use the charging station if it is available.

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The SOC of the EV battery is at x %, and the wanted SOC at next departure is minimum y %. The assumed departure time is within z hours. These three parameters (SOC at arrival, SOC at departure and time of next departure) varies between users and vehicles.

1. Actors

The Primary Actor is the EV driver.
Secondary actors are other possible users of the EV. This includes the partner, children with a driving license or other family or friends of the driver.

Stakeholders:

- Housing cooperative
- Operator of the neighbourhood energy management system (FutureHome?)
- Charging operator that operates the charge management system (Fortum Charge & Drive?)
- DSO
- Other EV users of the housing cooperative connected to the charging infrastructure in the garage at the time of charging

2. Preconditions

The driver has a charging demand.
The driver has not prebooked the charging point.
The driver must have a user account with the charging operator (here: Fortum Charge & Drive) or any other operator that is supported by Hubject.
The three parameters (SOC at arrival, SOC at departure and time of next departure) would need to be provided either by the in-vehicle-system or by the EV driver when plugging into the system.
The information is to be provided via the app on the driver's smart phone.
If not provided, the system will set these parameters automatically according to system defaults or from experience or through machine learning.
The charging management system must know the following information: the account information which is provided through the app, the SOC, maximum battery capacity, minimum charging level demand, or, if this information is not available, the energy demand for the charging session.

3. Basic Flow (success flow)

1. The EV driver parks the car and finds available charging point
2. The EV driver connects the car for charging.
3. If not app: The driver downloads the Charge&Drive-App and sign up for an account at Fortum C&D, enters the constraints/requirements to the app and confirms the charge request. The energy needed for charging is calculated and communicated to the "Charge management system".
    a. The available methods of starting and stopping a charging session are C&D App, RFID-tag and SMS. If booking is required, the charging cannot be started through RFID or SMS.
    b. The App and RFID requires a registered account, allowing the operator (Fortum), to charge a credit/debit card hold by the user, while SMS can be used without prior registration.
4. Booking and start/stop charging is done through the App.
5. The car is charged.
6. Terminating charging:
    a. The charging session is terminated through the app
7. After charging: the app provides feedback on charging progress, and costs.

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4. Alternative Flow

3.1 If the user already has the app: The driver enters the constraints/requirements to the app and confirms the charge request.

5. Exeption Flow

(The numbers refer to the numbers in chapter 5 'Basic Flows')
If the charging fails to start, the app provides a number where to call for assistance.

A.4 Use Case 4: Booking at private charging stations

Any person who visit the site can use the charging station if it is available.
The SOC of the EV battery is at x %, and the wanted SOC at next departure is minimum y %. The assumed departure time is within z hours. These three parameters (SOC at arrival, SOC at departure and time of next departure) varies between users and vehicles.

1. Actors

The Primary Actor is the EV driver.
Secondary actors are other possible users of the EV. This includes the partner, children with a driving license or other family or friends of the driver.
Stakeholders:

- Housing cooperative
- Operator of the neighbourhood energy management system (FutureHome?)
- Charging operator that operates the charge management system (Fortum Charge & Drive?)
- DSO
- Other EV users of the housing cooperative connected to the charging infrastructure in the garage at the time of charging

2. Preconditions

- The driver has a charging demand.
- The driver has prebooked the charging point.
- The driver must have a user account with the charging operator (here: Fortum Charge & Drive) or any other operator that is supported by Hubject.
- The three parameters (SOC at arrival, SOC at departure and time of next departure) would need to be provided either by the in-vehicle-system or by the EV driver when plugging into the system.
- The information is to be provided via the app on the driver's smart phone.
- If not provided, the system will set these parameters automatically according to system defaults or from experience or through machine learning.
- The charging management system must know the following information: maximum battery capacity, minimum charging level demand, EV registration number, contact information (for notifications, e.g., in case charging cannot be provided).

3. Basic Flow (success flow)

1. The EV driver parks the car and finds available charging point
2. The EV driver connects the car for charging.

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3. If not app: The driver downloads the Charge&Drive-App and sign up for an account at Fortum C&D, enters the constraints/requirements to the app and confirms the charge request. The energy needed for charging is calculated and communicated to the "Charge management system".
    a. The available methods of starting and stopping a charging session are C&D App, RFID-tag and SMS. If booking is required, charging session cannot be started througn the RFID and SMS
    b. The App and RFID requires a registered account, allowing the operator (Fortum), to charge a credit/debit card hold by the user, while SMS can be used without prior registration.
4. Booking is placed in the booking system of Fortum Charge and Drive.
    a. Hold the RFID-tag in front of the RFID reader of the charging staion, or
    b. Send sms to start charging according to instructions at the charging station
5. The car is charged.
6. Terminating charging:
    a. The charging session is terminated through the app.
7. After charging: the app provides feedback on charging progress, and costs.

4. Alternative Flow

3.1 If the user already has the app: The driver enters the constraints/requirements to the app and confirms the charge request.

5. Exception Flows

(The numbers refer to the numbers in chapter 5 'Basic Flows')
If the charging fails to start, the app provides a number where to call for assistance.

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Members of the GreenCharge consortium

SINTEF	SINTEF AS (SINTEF) NO-7465 Trondheim Norway www.sintef.com	**Project Coordinator:** Joe Gorman Joe.Gorman@sintef.no **Technical Manager:** Shanshan Jiang Shanshan.Jiang@sintef.no
eSmart systems	eSmart Systems AS (ESMART) NO-1783 Halden Norway www.esmartsystems.com	**Contact:** Frida Josefin Sund frida.sund@esmartsystems.com
HUBJECT	Hubject GmbH (HUBJ) DE-10829 Berlin Germany www.hubject.com	**Innovation Manager:** Sonja Pajkovska sonja.pajkovska@hubject.com
eurecat Centre Tecnològic de Catalunya	Fundacio Eurecat (EUT) ES-08290 Barcelona Spain www.eurecat.org	**Contact:** Regina Enrich regina.enrich@eurecat.org
ATLANTIS TRACKING YOUR WORLD	Atlantis IT S.L.U. (ATLAN) ES-08013 Barcelona Spain www.atlantisit.eu	**Contact:** Ricard Soler rsoler@atlantis-technology.com
enchufing	Millot Energy Solutions SL (ENCH) ES-08223 Terassa Spain www.millorbattery.com	**Contact:** Gerard Barris gbarris@enchufing.com
motit www.motitworld.com	Motit World SL (MOTIT) ES-28037 Madrid Spain www.motitworld.com	**Contact:** Valentin Porta valentin.porta@goinggreen.es
Freie Hansestadt Bremen	Freie Hansestadt Bremen (BREMEN) DE-28195 Bremen Germany	**Contact:** Michael Glotz-Richter michael.glotz-richter@umwelt.bremen.de

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ZET GmbH (MOVA)
DE-28209 Bremen
Germany
www.zet.technology

Contact: Nils Jakubowski
nils@zet.technology

Personal Mobility Center Nordwest eG (PMC)
DE-28359 Bremen
Germany
www.pmc-nordwest.de

Contact: Bernd Günther
b.guenther@pmc-nordwest.de

Oslo kommune (OSLO)
NO-0037 Oslo
Norway
www.oslo.kommune.no

Contact: Sture Portvik
sture.portvik@bym.oslo.kommune.no

Fortum OYJ (FORTUM)
FI-02150 Espoo
Finland
www.fortum.com

Contact: Jan Ihle
jan.haugen@fortum.com

PNO Consultants BV (PNO)
NL.2289 DC Rijswijk
Netherlands
www.pnoconsultants.com

Contact: Arno Schoevaars
arno.schoevaars@pnoconsultants.com

Universita Deglo Studi Della Campania Luigi Vanvitelli (SUN)
IT-81100 Caserta
Italy
www.unicampania.it

Contact: Salvatore Venticinque
salvatore.venticinque@unina2.it

University of Oslo (UiO)
NO-0313 Oslo
Norway
www.uio.no

Contact: Geir Horn
geir.horn@mn.uio.no

ICLEI European Secretariat GmbH (ICLEI)
DE-79098 Freiburg
Germany
www.iclei-europe.org

Contact: Stefan Kuhn
stefan.kuhn@iclei.org

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