



This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101056874.

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Deliverable administrative information

Deliverable number	D3.1
Deliverable title	Use case setup report
Dissemination level	Public
Submission deadline	30/6/2023
Version number	V1.0
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SCALE Introduction

SCALE (Smart Charging Alignment for Europe) is a three-year Horizon Europe project that explores and tests smart charging solutions for electric vehicles. It aims to advance smart charging and Vehicle-2-Grid (V2G) ecosystems to shape a new energy system wherein the flexibility of EV batteries' is harnessed. The project will test and validate a variety of smart charging and V2X solutions and services in 13 use cases in real-life demonstrations in 7 European contexts: Oslo (NO), Rotterdam/Utrecht (NL), Eindhoven (NL), Toulouse (FR), Greater Munich Area (GER), Budapest/Debrecen (HU) and Gothenburg (SE). Going further, project results, best practices, and lessons learned will be shared across EU cities, regions, and relevant e-mobility stakeholders. SCALE aims to create a system blueprint for user-centric smart charging and V2X for European cities and regions.

SCALE's consortium comprises 29 cutting-edge European e-mobility actors covering the entire smart charging and V2X value chain (equipment and charging manufacturers, flexibility service providers, research and knowledge partners, public authorities, consumer associations, etc.) It is led by ElaadNL, one of the world's leading knowledge and innovation centres in smart charging and charging infrastructure.

List of abbreviations and acronyms

Acronym	Meaning
AC	Alternating Current
AFID	Alternative Fuels Infrastructure Directive
BRP	Balance Responsible Party
BSP	Balancing Service Provider
ccs	Combined Charging System
CEP	Clean Energy for all Europeans Package
СРО	Charge Point Operator
DC	Direct Current
EED	Energy Efficiency Directive
eMIP	eMobility Interoperation Protocol
EMS	Energy Management System
eMSP	e-Mobility Service Provider
EPBD	Energy Performance of Buildings Directive
ETD	Energy Taxation Directive
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
FCR	Frequency Containment Reserves
FSP	Flexibility Service Provider
GDPR	General Data Protection Regulation
HEMS	Home Energy Management System
ISP	Imbalance Settlement Period
MWS	Megawatt Charging System
ОСНР	Open Clearing House Protocol
OCPI	Open Charge Point Interface protocol
ОСРР	Open Charge Point Protocol

OICP	Open InterCharge Protocol
OpenADR	Open Automated Demand Response
PKI	Public Key Infrastructure
PV	Photovoltaic
RED	Renewable Energy Directive
RTO	Research and Technology Organisation
SCALE	Smart Charging Alignment for Europe
ToU	Time-of-Use
TSO	Transmission System Operator
V2B	Vehicle-to-Business
V2D	Vehicle-to-Depot
V2G	Vehicle-to-Grid
V2H	Vehicle-to-Home
V2P	Vehicle-to-Public
V2X	Vehicle-to-Anything

Report executive summary

Key words

Electric vehicles, smart charging, Vehicle-to-Anything, flexibility markets, interoperability, Use cases, Control topology, System Architecture

Summary

SCALE (Smart Charging Alignment for Europe) is a three-year Horizon Europe project that explores and tests smart charging solutions for electric vehicles. It aims to advance smart charging and Vehicle-2-Grid (V2G) ecosystems to shape a new energy system wherein the flexibility of EV batteries' is harnessed. The project will test and validate a variety of smart charging and V2X solutions and services in 13 use cases in real-life demonstrations in 7 European contexts: Oslo (NO), Rotterdam/Utrecht (NL), Eindhoven (NL), Toulouse (FR), Greater Munich Area (GER), Budapest/Debrecen (HU) and Gothenburg (SE). Going further, project results, best practices, and lessons learned will be shared across EU cities, regions, and relevant e-mobility stakeholders. SCALE aims to create a system blueprint for user-centric smart charging and V2X for European cities and regions.



Figure: Use case locations

This deliverable 3.1 "Use case setup report" is the first report of Work Package 3, led by FIER Sustainable Mobility, and describes the setup of the use cases. The document describes the use case setup according to the framework set out in the previously released Stakeholder Analysis Report (D1.2, 2022), and combines parts of the unpublished work done on the Smart charging and V2X system architecture. Through this framework key elements of the industry value chains are described such as; Charging infrastructure, Mobility services, Charging services and Energy services. On system architecture the different control topologies and central communication protocols applied in the use case are explained. Also the overall learnings on the use case setup process are included.

Looking at the various mobility services it is apparent that within the different use cases there is good representation of relevant services such as car-sharing; private - and company cars and in the heavy duty vehicles, B2B. In SCALE we aim to better understand the impact of these different mobility services on the smart charging and V2X potential.

On the various charging services deployed in the use case a distinction is made between AC and DC charging. These two categories are further separated between unidirectional and bidirectional charging, and for DC charging also instant fast charging. There is good variation between the services that are deployed in the use cases, where many use case have more than one of these services included.

In SCALE the energy services are grouped into 4 categories;

- (1) Local behind-the-meter optimization
- (2) Balance responsibility
- (3) System balance
- (4) Congestion management

Each of these categories is again subdivided into the specific energy services. In the report an inventory of the planned energy services is provided for all use cases. All use cases are implementing "local behind the meter optimisation". Besides that, many use cases are planning to implement energy services in the other 3 categories.

With smart charging or V2X there is one actor in control of the charging session. In SCALE there are three control topologies that can be distinguished: the car manufacturer (OEM), the Charge Point Operator (CPO), or the Energy Manager (EM). In the use cases and within the SCALE goals of implementing open standards and protocols only the CPO and EM control topologies are applied.

SCALE aims to promote open standards and protocols that support smart charging and V2X in an interoperable manner. In the system architecture there has been much attention on communication protocols. In the report, for each use case it has been mapped which protocol and standards are planned to be implemented.

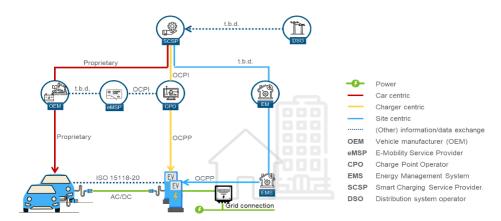


Figure: Example Use case architecture on communication protocols

In the setup of the use cases, we have seen strong dependencies between use case leaders and other consortium partners in terms of incorporating equipment, vehicles and software. In the end all subsystems that make up the complete system around a use case are needed to showcase the energy services that are planned to be implemented. We have seen that developments around standards and protocols that follow up each other in a rapid pace (e.g. ISO 15118-20 being recently released) it takes time for all the stakeholders involved to implement these new protocols into their products and software platforms. Product safety and related certifications, which cannot be compromised, are among the key factors to make this a time-consuming exercise. We also see that there are regulatory uncertainties and barriers around V2X that for certain use cases cause uncertainties on timing. From the EV OEMs it became apparent that grid code compliance is a key concern, in particular in relation

to AC charging and the upscaling to mass market deployment. These and other regulatory barriers will be addressed in more detail in WP5.

With an innovation project like SCALE, where we push the limits in terms of what is possible, these minor setbacks are to be expected and provide valuable insights. To continue to make progress, some of the use cases will start the execution phase with those energy services that can be done based on the products they can have available now. The more complex services will be added throughout the project. In many occasions this implies that the bidirectional services will be added in a later stage of the use case e.g. by updating product software.

For specifics and learnings on each use case and for overviews relating to the mobility services, charging services and energy services, control topology and communication protocols applied in the use cases we refer to the full report in which these are provided.

Table of contents

Del	livera	ible ac	dministrative information	2
SCA	ALE Ir	ntrodu	uction	4
List	of a	bbrevi	iations and acronyms	5
Rep	oort e	execut	tive summary	7
ł	Key w	ords		7
		-		
Pur	pose	of the	e deliverable	12
1.	Inti		tion	
1	l.1.	Setu	up process	14
1	1.2.	Cha	rging infrastructure	15
	1.2	.1.	Planning	15
	1.2	.2.	Installation	15
	1.2	.3.	Exploitation	15
1	1.3.	Mol	bility services	16
1	L.4.	Cha	rging services	16
	1.4	.1.	Unidirectional charging	16
	1.4	.2.	Bidirectional charging	16
	1.4	.3.	Instant fast charging	17
1	L.5.	Ene	rgy services	17
	1.5	.1.	Local behind-the-meter optimization	17
	1.5	.2.	Balance responsibility	18
	1.5	.3.	System balance	19
	1.5	.4.	Congestion management	19
1	L.6.	Syst	em architecture	20
	1.6	.1.	Reference architecture	20
	1.6	.2.	Control topology	20
	1.6	.3.	Communication protocols	21
2.	Ind	ividua	al use case setup	23
2	2.1.	Sma	art home charging	24
	2.1	.1.	A1 Self-consumption in single family housing (Munich)	24
	2.1	.2.	A2 Extension enabling participation in energy market (Munich)	27
2	2.2.	Sma	art charging at businesses & offices	30
	2.2 rea		B1 Grid-friendly, Vehicle 2 Building station-based car sharing service for commette tenant companies	

2.2.2. deale	B2 Future proof energy management and V2G pilot at Duna Auto, a multi brandship in Budapest	
2.2.3.	B3 Smart Charging in car dealer Depot	
2.2.4.	B4 V2G chargers at office and residential buildings (Gothenburg)	44
2.3. S	mart charging of light and heavy-duty fleets	50
2.3.1.	C1 Station-based Office B2B car-sharing with demand side management	50
2.3.2.	C2 Highway charging with local generation & storage (Eindhoven)	54
2.3.3.	C3 VPP with renewable energy generation and second life battery storage	59
2.4. S	mart public charging	64
2.4.1.	D1 Showcasing V2G at car dealership	64
2.4.2. city ce	D2: V2G and smart zero emission building energy management pilot in Erzsebetventer Budapest	
2.5.	ombination of innovation clusters	76
2.5.1.	Use case 00: Bi-directional ecosystem via combined V2G service	76
3. Concl	usions from use case set up	82
3.1. I	ntroduction	82
3.2. S	etup process	82
3.3.	harging infrastructure	83
3.3.1.	Planning	83
3.3.2.	Installation	84
3.3.3.	Exploitation	85
3.4. N	Nobility services	85
3.5.	harging services	86
3.5.1.	Unidirectional	87
3.5.2.	Bidirectional	87
3.5.3.	Instant fast charging	88
3.6. E	nergy services	88
3.6.1.	Local behind-the-meter optimization	88
3.6.2.	Balance responsibility	89
3.6.3.	System balance	90
3.6.4.	Congestion management	90
3.7. S	ystem architecture	91
3.7.1.	Control topology	91
3.7.2.	Communication protocols	92
3.8.	losing remarks	93
Referen	ces	94

Purpose of the deliverable

Deliverable 3.1 as part of Work Package 3 is led by FIER Sustainable Mobility and describes the setup of the use cases. For each use case the implemented charging concepts and energy services that will be tested are described. This document builds forth on the previously released Stakeholder Analysis Report(D1.2, 2022), the work done on the Smart charging and V2X system architecture (not yet published) and Deliverable 1.5 List of hard- and software requirements (D1.5, 2023).

1. Introduction

SCALE aims to advance EV charging technology and facilitate the mass market uptake of smart charging and Vehicle-to-Everything (V2X) technology. To do this, 13 use cases are executed over 4 innovation clusters: Vehicle-to-Home, Vehicle-to-Business, Vehicle-to-Depot, and Vehicle-to-Public. In all 4 innovation clusters, smart charging and V2X technologies will be tested. This *Use case setup report* (Deliverable 3.1) provides a comprehensive overview of the set-up of the use cases.

Per use case, a detailed description is included so that on use case level the set-up can be seen. In Chapter 1, the important aspects of the use case description are introduced and explained, followed by the individual use case descriptions in Chapter 2. Chapter 3 will have the conclusions/lessons learned from the setup period of the use cases of SCALE.

The use case descriptions in Chapter 2 start with the context and goals of the use case, as to understand the motivation behind the use case. After that, the control topologies are elaborated upon, describing how the charging sessions are being steered. Next, the assets used in the use case are listed such as the number of assets, charging power and type of installed vehicles, chargers, and other relevant assets. The stakeholders involved in the particular use case are also mentioned. These are SCALE partners as well as external organisations. Each use case description includes a Gantt chart displaying the timeline of the steps to be taken concludes with a list of the energy service that will be executed. By providing detailed information on these aspects, these individual descriptions contribute to a better in-depth understanding of the use cases.

Method of working in SCALE

In SCALE, the process of setting up the use cases is first of all done by the use case leaders. Of course, the use case leaders are cooperating with the SCALE Partners who provide their expertise, services and equipment. This is done in work package 3 in SCALE and is led by FIER Sustainable Mobility. The cooperation within SCALE is fairly intensive, this is necessary because most use cases are dependent on many different SCALE partners and on other SCALE work packages. There are monthly meetings, led by FIER, with all the use case leaders. In these meetings, the progress of set-up, encountered bottlenecks, and other relevant aspects are discussed. Work package wide challenges and activities are addressed by follow up meetings led by FIER. Besides that there are many bilateral exchanges among the use case leaders and other SCALE partners to further the development of individual use cases

Method of creating the use case set-up report

The Use Case Setup Report was prepared by FIER Sustainable Mobility and the use case leaders. The core information was provided by the use case leaders and consolidated by FIER into this report. based on the input of the use cases, FIER has drafted up the key learning and conclusions.

In this report, the same structure will be used as in the SCALE Stakeholder analysis, the set-up of the use cases is described on the 4 identified industry value chains. The 4 industry value chains are Charging infrastructure, Mobility Charging services, and Energy services visualised in Figure 1. A description is included per industry value chain followed by a description of how this is included in the SCALE use cases, the problems that were encountered on the topics and the mitigation measures that were taken. By using the industry values chains to describe the use cases that were set up, a comprehensive picture can be given of them.

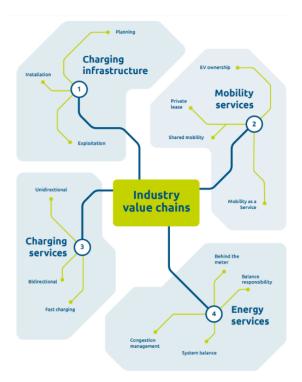


Figure 3: Industry value chains. Source: SCALE Stakeholder analysis

1.1. Setup process

The SCALE setup process is similar to most usual development processes, underneath the different steps are elaborated upon.

Specification of technical requirements

In this stage, the technical requirements for the setup are defined, based on the use case and its objectives. This involves identifying the hardware and software needed, as well as the performance and functional requirements. This is a task that in some use cases, for instance, in Utrecht (use case 00) and Eindhoven (use cases C2 and C3) had already been specified before the project because there already was a legacy from previous projects. In these use cases, only minor changes had to be made to the already existing situation. In other use cases that are set up from scratch, the specification of technical requirements took more time.

Software development

Once the technical requirements have been specified, the software development process begins. Enervalis is responsible for this stage as the leader of Work Package 2 (Development of Smart Charging and V2X Technologies and Solutions), which involves creating the software needed to run the use case. The needed development effort varies greatly between the use cases.

Delivery of hardware

Delivery of hardware is crucial for setting up the use case. With SCALE aiming high in terms of deploying hardware product innovations, this often involves development by individual partners in the project. With product developments executed in parallel to the use case setup, this often brings in uncertainties to the use cases setup planning.

Commissioning

This involves installing and configuring the hardware and software to ensure that safety can be guaranteed and that the systems are working correctly.

Validation

Once the system has been commissioned, the next stage is validation. This involves testing the system to ensure that it meets the technical requirements and that all components that make up the system are properly integrated.

Start use case execution

Once the system has been validated, and the system is working properly, the equipment can be taken into use, thus the use case execution stage can begin.

1.2. Charging infrastructure

The charging infrastructure industry value chain is separated into three phases: 1 planning, 2 installation, and ultimately 3 exploitation. As this is the setup report of the SCALE use cases, most use cases are in the planning and/or installation phase rather than the exploitation phase. The lessons learned report on the SCALE use cases, due September 2024, will have more insights on the exploitation phase as well. This being said, because SCALE is being built up from many already existing use cases and knowledge, there are use cases that are already in the exploitation phase. Also, because the use cases consist of several components, some parts of a use case can already be in the exploitation phase whereas other components are still in the planning phase.

1.2.1. Planning

The planning of charging infrastructure is a difficult process, the uptake of EVs is dependent on sufficiently dense charging infrastructure network. Also exploiting a profitable charging infrastructure is dependent on sufficient uptake of EVs. This is the well-known chicken-and-egg problem of electromobility (SCALE Stakeholder Analysis, 2022; page 19, subsection 2.1.1.). The SCALE use cases are, in many occasions, build forth on existing or already planned charging infrastructure initiatives. In such situations SCALE will add an additional layer with software and hardware updates to the existing situation and thereby implement the innovative smart charging and/or V2X solutions. Even though the charging infrastructure itself has already been placed, and in some use cases already operational, in SCALE these use cases will expand on the existing. This implies that for certain use cases there are dependencies to these existing or planned initiatives. The planning as provided by each the individual use case aims to incorporate all the relevant activities that are important to setup all the elements required for the execution of the use case.

1.2.2. Installation

The installation phase of the charging infrastructure deals with the actual placement of the charging equipment. Same as with the planning phase, many of the SCALE use cases are being carried out at existing sites. In these situations, the installation phase may refer to the phase where reworks on the existing hardware or software upgrades on the product lever are implemented. Aside from the fact that installation work is getting more expensive and delivery times for materials are relatively long, there are no unexpected results during the installation phase.

1.2.3. Exploitation

Naturally, because this is a report on the setup of the use cases, charging infrastructure is generally not in the exploitation phase. Although, as mentioned before, some use cases are already operating and, therefore, in the exploitation phase. SCALE will utilize the results and data that are being gathered from these already operational use cases, although none of the use cases is operational in their final form. Meaning that all these use cases will undergo modifications in some form or other.

1.3. Mobility services

Mobility can be offered to end users in different ways. As already written in the *Stakeholder analysis* of SCALE (*page 21*, *subsection 2.2*), the paradigm is shifting from only ownership of vehicles to other mobility services. In SCALE there is chosen to include different varieties of mobility services in the use cases. The mobility services used in SCALE are private cars, shared cars (business-to-business and business-to-consumer, and leasing cars (company cars). In SCALE we want to better understand the impact of different mobility services on the smart charging and V2X potential. E.g. the intentions of the explicit placement of shared cars in some use cases is that these are always connected to a charger when not in use, they are owned by a central professional organisation instead of by many individuals, and that their usage pattern is known from the reservation system. We foresee that these factors strongly enlarge the potential per car and cause car sharing systems to have an important position in scaling-up of V2X operation of e-cars. The same is true, to a lesser degree, for leased cars.

Most of the innovation in SCALE does not revolve around mobility services, the focus is on smart charging and V2X charging. That being said, V2X services can only take off, when all stakeholders from the entire ecosystem are participating. When, for example, looking at the flexibility that EVs can offer to the electricity grid, it is important that as many vehicles as possible are participating. One vehicle offers only a small flexibility potential. For this reason, it is important to understand all different potential stakeholders and test smart charging and V2X solutions in multiple mobility services.

1.4. Charging services

With the development of smart charging and V2X services within SCALE, the impact that charging of EVs has on the electricity grid is drastically reduced. This is done by implementing energy services; these are described in §1.6. Which energy services can be offered is determined by a number of factors, one of which is the charging service. As described in the SCALE *Stakeholder analysis* (page 23, subsection 2.3), 3 charging services can be determined: 1 unidirectional charging, 2 bidirectional charging, and 3 instant fast charging. All 3 charging services are being deployed in the SCALE use cases.

1.4.1. Unidirectional charging

Unidirectional charging means that the power is only going from the grid to the vehicle, this is the most well-known charging service today. Most of the currently available charging services are unidirectional. However, within this charging service, there is an important distinction to be made, between *smart charging* and *uncontrolled charging*. Uncontrolled charging stations can only deliver full power, at the request of the EV, and cannot be managed. With charging stations that have smart charging functionalities the power level can be controlled. This way, EV charging can become part of the solution instead of the problem. E.g. EV charging can be initiated or maximised when there is an abundance of renewable energy and can be stopped or reduced when there is high energy demand or there is congestion on the electricity grid. This way the charging sessions are contributing to a more stable electricity grid.

Within smart charging, there are different levels of control. The first, and often already available manner of smart charging, is charging stations controlled being reduced in power when the maximum power on the grid connection is reached. This is a very effective way of smart charging, but it doesn't take any other factors into account than the measurements at the grid connection. Within SCALE, the use cases go further than this. Additional data sources are used to manage and optimise the charge sessions. More on this will be described in the paragraph §1.6 on the Energy services.

1.4.2. Bidirectional charging

Bidirectional charging, as the term implies, means that power can go into the car, but also from the car back to other (non-mobility) related use. In this situation, the battery of the vehicle is being used to store energy that can be used at a later moment. The energy can flow back to several destinations, in Vehicle-to-Home (V2H), Vehicle-to-Depot (V2D), Vehicle-to-Business (V2B), or Vehicle-to-Grid (V2G). We see that many of the Energy Services that are described under §1.6 can be done both uniand bidirectionally, where the latter has the potential to create higher added value and minimise the need for grid reinforcements.

1.4.3. Instant fast charging

The third and last charging service is instant fast charging. The big difference compared to unidirectional charging and bidirectional charging is that with instant fast charging key priority is to charge an as high as possible amount of energy in as short as possible timeframe. Unlike the other charging services, instant fast charging can only deliver a satisfactory service when charging at high power. When someone is charging at his or her destination, it often doesn't matter if the vehicle is fully charged two hours before departure or two minutes before departure. This means that there is room to adjust the charging profile, with instant fast charging the charging profile can be adjusted to a lesser extent. Although there are limitations to the smart charging that can be applied to instant fast charging there is also a lot of potential. The planned roll out of a large network of instant fast charging locations alongside the highway in Europe's TEN-T network is expected to require huge investment in electricity grid. This can be reduced by implementing smart solutions, e.g. in combination with local energy storage, to reduce the impact of these charging locations on the grid. An example of this is use case C2 that aims to find the optimal set up and requirements for an on-line pre booking charging service along the public (future) instant fast charging facilities around the European highway network. Data of the booking system can be used to plan the charge sessions and make sure that maximum power is available during the planned charge time, while minimising the impact on the grid.

1.5. Energy services

In the combination of mobility and charging services, different energy services can be provided using the batteries in electric vehicles in a smart way. In SCALE, Energy services are divided into 4 categories: 1 local behind-the-meter optimization, 2 balance responsibility, 3 system balance, and 4 congestion management. Per category, different energy services can be identified. In this paragraph, the energy services are introduced.

Most energy services can make use of unidirectional or bidirectional charging services. The main difference is that with energy services via bidirectional charging the potential that can be offered to the grid is larger than with unidirectional charging. For instance, executing the energy service *Optimize PV self-consumption* aims to increase the use of generated power from a PV installation. With unidirectional charging, you can charge the EV when the PV installation is producing power and stop or reduce charging if there is no PV power generation. In this way, you are executing this energy service because you are optimizing the PV consumption. Unfortunately, when the battery is full, you can no longer execute the energy service. When using bidirectional charging for the same energy service, the EV can offer more value. In that situation you can charge the EV when the PV installation is generating power, provide power back to a home or other buildings when there is no PV power generation (for instance, at night), and charge it again the next day.

1.5.1. Local behind-the-meter optimization

Local behind-the-meter optimization is, as the name suggests, done without power going back to the grid. All the optimization, whether it is unidirectional (smart charging) or bidirectional (V2X), is taking

place behind the meter at a home, office building, or other location. The optimisation is typically controlled by the site owner.

Energy service	Description
Increase self-consumption of on-site renewable energy	When a consumer has rooftop solar with a feed-in tariff different from the supply tariff, value can be created by maximizing the consumption of locally generated solar
Reduce demand charges	When a consumer is exposed to capacity related charges (€/kW over a period), such demand charges can be reduced by applying peak shaving
Time-of-Use shifting	When a consumer is subject to time varying electricity prices in the form of static ToU, dynamic pricing, critical peak pricing, etc., value can be generated by avoiding exposure to high prices of behind-the meter consumption
Provide back-up power	When a grid outage is detected, the vehicle can provide back-up power to the household

Table 1: Local behind the meter optimization

1.5.2. Balance responsibility

On the electricity grid, the supply and demand needs to be balanced. The same amount of energy needs to be generated as energy that is used. The responsibility for matching supply and demand lies with the Balance Responsibility Party (BRP), which is the energy supplier on many occasions. Underneath are the energy services associated with balance responsibility. With a single car being typically too small of an asset to provide these services, aggregation of these assets is needed.

Energy service	Description
Wholesale market price arbitrage	Capacity can be managed as a subpool within the BRP's portfolio and gain additional revenues can be charged at low price moments and discharged at high price moments (BRP provides market access)
Intraday portfolio optimization	for BRP's with a large part of renewable energy in its portfolio, the flexibility of aggregated capacity within his portfolio of grid connections can be used to compensate for the forecast errors and the imbalances in his portfolio

1.5.3. System balance

For a stable electricity grid, the system balance is important. To achieve system balance, the electricity grid needs to maintain a stable frequency of 50 hertz. A Balance Service Provider (BSP) provides the service of this balancing to the TSO. EVs can be an example of assets that are used to provide the service. With smart charging electric vehicles can only be used as a demand asset, it can only take power from the grid. With V2G, the electric vehicles can also be used as suppling assets. With a single car being typically too small of an asset to provide these services, aggregation of these assets is needed. Underneath are the energy services associated with system balance.

Energy service	Description
FCR	Frequency Containment Reserve (FCR). Aggregated capacity offered by a BSP can be called upon by the TSO to restore imbalances in a Local Frequency Control Area.
aFRR	Automatic Frequency Restoration Reserve (aFRR). Aggregated capacity offered by a BSP can be called upon by the TSO to restore imbalances in a Local Frequency Control Area. Required activation is slower than FCR.
mFRR	Manual Frequency Restoration Reserve (mFRR). Aggregated capacity offered by a BSP can be called upon manually by the TSO to restore imbalances in a Local Frequency Control Area
Strategic reserve (adequacy)	es Aggregated discharging ability could be used as strategic reserves and provide an alternative for thermal power plants or industrial demand response capacity to improve the adequacy of the system

Table 3: System balance

1.5.4. Congestion management

The last of the 4 categories in which energy services are divided is congestion management. As described in the SCALE *Stakeholder analysis* (page 28, subsection 2.4.4.), congestion management is typically needed on occasions when certain parts of the distribution system risk to get overloaded or congested. Congestion management energy services can be aimed at preventing and resolving congestion. Below are the energy services related to congestion management.

Energy service	Description
Long-term Flexibility agreement	V1G/V2X can provide a non-wire alternative and expand the lifetime of the existing DSO infrastructure through long term congestion management contracts

Short term congestion management (D-1)	When congestion in the local grid is expected in D-1, V1G/V2X can provide congestion management services in short term congestion management markets through contracted bids
Operational congestion management (near real-time)	When congestion is detected in near real-time, congestion management services can be activated from V1G/V2X through non-contracted bids
Power Quality control	When the operational limits (voltage, phase imbalance,) of the local electricity grid are reached, rapidly discharging or charging electric vehicles could help restore the local grid within its normal operating boundaries

Table 4: Congestion management

1.6. System architecture

SCALE is testing several applications of smart charging and V2X charging solutions. The goal of the different solutions over different mobility services, charging services, and energy services is to ensure that electric vehicles are not a strain on the grid, but can support the grid and reduce the need for grid reinforcement. To use the charging sessions of electric vehicles to reduce the grid impact, the electric vehicles and charge points need to be able to work together and with many other systems that make up the smart charging and V2X ecosystem. Also, these subsystems of the ecosystem need to be interoperable in order to be ready for upscaling for mass deployment. There lies a great challenge, as the system architectures of these ecosystems are not yet fully developed and aligned among the different stakeholders in the ecosystem. One well known example is the ISO 15118-20 norm for communication between charger and EV. For most use cases this standard is an essential part of the system architecture because it enables high level communication between the vehicle and the charger that is crucial in many smart charging functionalities as well as bidirectional charging. For the complete overview of the SCALE protocols and standards we refer to the SCALE *Analysis of hard- and software requirements* (Deliverable 1.5, 2023)

1.6.1. Reference architecture

To have the ecosystem fully cooperating and communicating, a sound system architecture is necessary. This consists of all the actors involved, the roles of these actors, the communication protocols used, and the energy services provided. There is no one-size-fits all system architecture as every situation can have key differences leading to other choices in the system architecture. However, there are certain important aspects that are universal, or at least recommended. SCALE, task 1.4 and deliverable 1.4 aims to provide this input on the system architecture. The deadline for deliverable 1.4, Smart charging and V2X system architecture, is May 2024. Because the partners involved recognize the importance of a uniform understanding of the system architecture, the work on task 1.4 was already started. This was done to support the SCALE use cases in setting up their system architecture. Underneath here, two essential aspects of the system architecture are described, the control topology and the communication protocols.

1.6.2. Control topology

The control topology means the way of controlling a charging session, which actor is doing the actual controlling of the charging session. There are three control topologies that can be distinguished: the car manufacturer (OEM), the Charge Point Operator (CPO), or the Energy Manager (EM). Each of these control topologies has a control system which controls the asset. In Chapter 2 it will be indicated per use case which control topology is used. There is no good or bad choice, but the choice for a control topology does have implications for the rest of the

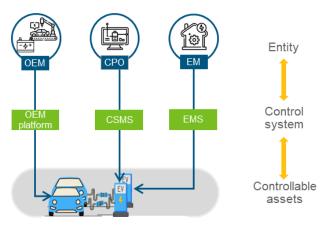


Figure 4: Control topologies

system architecture and data requirements. For example, the actors that need to be involved and the communication protocols that can be used.

1.6.3. Communication protocols

In the SCALE Analysis of hard- and software requirements (Chapter 3 & 4) a very detailed description of all the necessary hard- and software requirements for the electric vehicle, the charging station, and the Charge Point Operator (CPO) is given. This is very relevant and necessary input to the works done on the system architecture. Important protocols to be included in the system architecture are Open Charge Point Protocol (OCPP) and Open Charge Point Interface (OCPI). The latest or soon to be released protocol versions of OCPP & OCPI allow for most desired outcomes to be achieved by a V2X ecosystem. With regards to EV- Charging Station communication, the current dominant protocol for both AC charging is IEC 61851. This protocol is not considered future proof due to several reasons such as lack of support for bidirectional charging and an inability to exchange information between the EV and charging station for smart charging purposes such as present State-of-Charge (SoC) of the EV battery. The bidirectional communication capabilities that ISO 15118-20 offers in addition to IEC 61851 would close most of the gaps related to the desired system outcomes for the communication between the EV and the charging station.

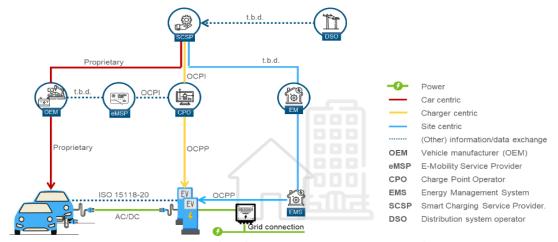


Figure 5: Example architecture on communication protocols

Figure 3 shows an example of a representation of the control protocols as part of the system architecture. In the use case description in Chapter 2 these will further be specified. For instance, which version of OCPP and OCPI are being used, or if the one of the recommended protocols cannot

be used. This can, for example, be the case with ISO 15118-20 for which the implementation in the EV or charger proves to be difficult. This system architecture is merely a representation of the potential actors in the system architecture of a use case with recommended communication protocols. Per use case, the system architecture will differ highly. This is not the final system architecture; this is just an example.

2. Individual use case setup

In this chapter we will provide specific details on the setup of each of the SCALE use cases, grouped per innovation cluster. SCALE has identified four Innovation Clusters (based on sites/ specific user groups) for which smart charging and V2X is either already playing a significant role or will become a necessity in the next years. SCALE will test and validate a variety of smart charging and V2X solutions and services in 13 use cases in real-life demonstrations structured by the four Innovation Clusters (A: Home, B: Business / office, C: Light- and heavy duty, D: Public). Use case 00 (WDS) is placed in a separate innovation cluster as it overarches the innovation clusters. Figure 6 provides on overview of the different locations where the use case are situated.



Figure 6: Use case locations

2.1. Smart home charging

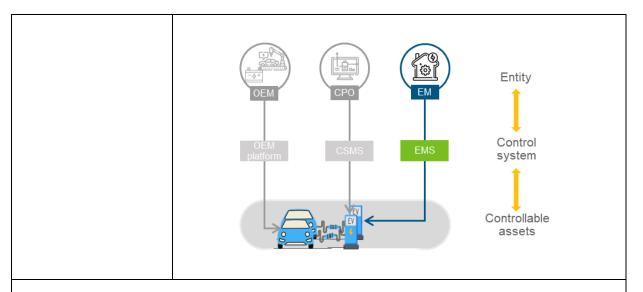


In this innovation cluster, charging of EVs will take place predominantly at home. Therefore, it offers important potential for smart charging and V2X functionalities. Utilizing smart charging and V2X can in this Innovation Cluster increase the uptake of EVs (through cost benefits and ease of use), increase the utilization of locally produced renewable energy (through self-

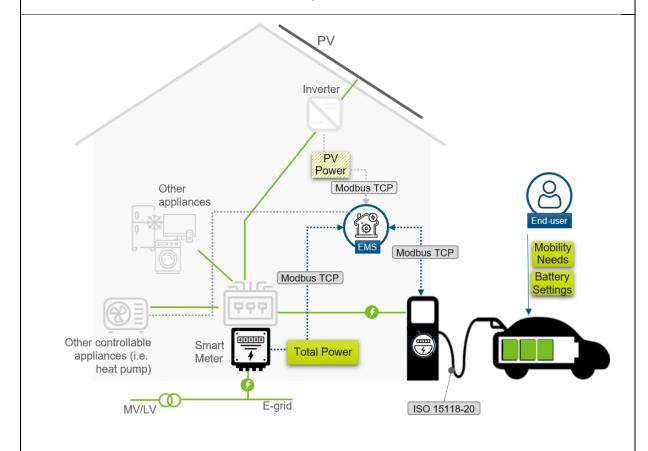
consumption of the generated local renewable energy), and lower the dependency on the grid. The highest focus is reducing costs and create a high usability for users to ensure high participation throughout society.

2.1.1. A1 Self-consumption in single family housing (Munich)

Introduction		
Use case lead	Sono Motors GmbH	
Context of the use case	The use case is about vehicle-to-home in the residential sector for self-consumption.	
	The use case was planned to be executed in the greater Munich area in Germany, with two residential single-family homes that already have pv power installed. The houses would have been equipped with a home-energy-management system, a grid-compliant wallbox, and a bidirectional vehicle from Sono Motors.	
	The use-case is cancelled as Sono Motors is withdrawing from the SCALE project due to recent development in its business focus. The use case will be replaced by a similar one in 2023.	
Description of the use case	The user has access to control his local energy system including the vehicle-charger combination via the Sono app or the vehicle's infotainment system. The home-energy-management system controls the charging and discharging of the energy flow based on the user's settings. In particular, the battery is charged during the time of PV production and discharged during the night/evening hours. The EMS is designed to avoid feeding back into the public grid from the EV due to	
	regulatory and economic reasons.	
The goal of the use case	This use case aims to tackle the challenge of integrating an AC bidirectional vehicle into residential home energy systems in a cost-efficient and user-friendly way. By this, the vehicle's battery can be used as a "mobile home storage" for locally generated pv energy and increase the household's self-consumption	
Use case setup		
Control topology		



Visualization system architecture



Facts and figures

Charge point

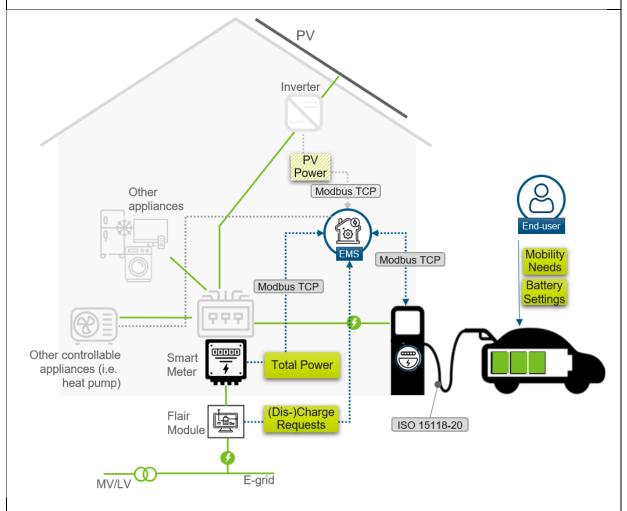
AC (bidirectional) - fully compliant to grid codes
11 kW
Sono Motors

EV	Sono Motors Sion	
PV system	5-7 kW per home	
Local EMS device	Enervalis EMS	
	Stakeholders	
Site owner	Private individuals	
End-user	Private individuals	
Local energy optimization	Enervalis	
DSO	LEW Verteilnetz GmbH	
	Timeline	
Specification of technical requirements	01/06/2023 – 31/01/2024	
Software development	TBD	
Delivery of hardware	TBD	
Commissioning	TBD	
Validation	TBD	
Start use case execution	TBD	
Energy Management Services		
Behind the meter optimization		
Increase self- consumption of on- site renewable energy	Yes	
Goal of the energy management services		

- Primary objective: Increase self-consumption & reduced fee-back to the public grid.
- 2. Secondary objective: Reduce charging cost and thereby TCO.

2.1.2. A2 Extension enabling participation in energy market (Munich)		
Introduction		
Use case lead	Sono Motors GmbH	
Context of the use case	The use case is about vehicle-to-grid in the residential sector with a focus on the DSO of beneficiary.	
	The use case was planned to be executed in the greater Munich area in Germany, with two residential single-family homes that already have PV power installed. The houses would have been equipped with a home-energy-management system, a grid-compliant wall box, a bidirectional vehicle from Sono Motors and grid monitoring box from the DSO which is called "Flair Module".	
	The use-case is cancelled as Sono Motors is withdrawing from the SCALE project due to recent development in its business focus. The use case will be replaced by a similar one in 2023.	
Description of the use case	The increase in distributed energy systems with their volatile production imposes challenges on the distribution grid. The "Flair Module" from the DSO Lechwerke Verteilnetz GmbH (LVN) will be installed in the residential home. It measures grid parameters independently and, if necessary, provides set points to the charger requesting it to charge or discharge the vehicle to reduce the stress for the grid.	
The goal of the use case	The overarching goal was to utilise the vehicle battery to actively reduce the stress for the distribution grid by not only stopping to charge but actively discharging when needed.	
	Use case setup	
Control topology	DEM CSMS EMS Control system Controllable assets	

Visualization system architecture



Facts and figures

Charge point	AC (bidirectional) - fully compliant to grid codes 11 kW Sono Motors
EV	Sono Motors Sion
PV system	5-7 kW per home
Local EMS device	Enervalis EMS
Other	Flair Module from Lechwerke Verteilnetze GmbH. The device is capable of: - Measuring grid parameters - Recording and processing of measurement data by algorithm - Sending of setpoints to controllable loads and generators

Stakeholders		
Site owner	Private individuals	
End-user	Private individuals	
Local energy optimization	Enervalis	
DSO	LEW Verteilnetz GmbH	
	Timeline	
Specification of technical requirements Software	01/06/2023 – Delayed because of discontinuation of Sono Motors participation. tbd	
development		
Delivery of hardware	tbd	
Commissioning	tbd	
Validation	tbd	
Start use case execution	tbd	
	Energy Management Services	
	Behind the meter optimization	
Increase self- consumption of on- site renewable energy	Yes	
Congestion Management		
Short term congestion management (D-1)	Yes	
Power Quality control	Yes	
Goal of the energy management services		
	 Primary objective: Stabilisation of the distribution grid Secondary objective: Local optimisation 	

2.2. Smart charging at businesses & offices



This innovation cluster focusses around smart charging and V2X in the context of business and offices. For employees parked at their office, the charging time is typically not of key importance. What is important is that there is sufficient range when going home. This presents potential for smart charging and V2X services because of the central control of charging,

long stationary time, and an already high uptake of EVs in company fleets. This potential includes reducing the costs through self-consumption and demand charge reduction, this increases the use of locally generated renewable energy and lowers the peak loads on the grid.

2.2.1. B1 Grid-friendly, Vehicle 2 Building station-based car sharing service for commercial real estate tenant companies

Introduction	
Use case lead	Serviced Office Belbuda, DBH Group: Zsolt Puja
Context of the use case	The use case takes place in Hungary, in two locations, one in Budapest, one in Debrecen. Full electric car-sharing service, with a station-based car sharing business model, which would be unique to the serviced office market. The service is planned to be provided to tenants as part of the serviced office service package. The project would enable the roll-out to the Hungarian market, as a first, a 100% electric, station-based corporate car sharing service, which would focus on office and industrial park rental companies. The service will be offered to office rental companies, so that they will be able to offer to their own tenants an office location-based car sharing service, which they might use for business purposes for their employees there, or offer as employee benefit, and enhance employee satisfaction.
Description of the use case	2 office locations of DBH will be supplied with office-carsharing cars. Upgrading existing recharging points, the pilot will connect electric vehicles (EVs), car-sharing model and building energy management to combat climate change in a unique way. The first objective of the pilot is to determine the optimal business model for the proposed new commercial office car-sharing service in Europe, including clearly identify customer segments on the market, and therefore we could adjust the business model for their needs. The second objective of the study is to identify a scalable, yet efficient solution, how the GoodMoovs platform can be integrated with DBH SO's customer management software and business processes. The third objective is to set up and experiment with the demand side load management smart charging feature, covering the integration between the vehicle, the recharging point, the building energy management system, and the grid operator, and prepare the blueprints for a suitable technical solution, which enables the use of the new service in a commercial office building environment and beyond. The fourth objective is that how the service can be exploited as a white-label, licensable product, and how can it be rolled out to the European market, considering differing technical (building, DSO) and business, regulatory environments.

Planned model: Office Meeting room Contract Car selection EV to rent for Q business travel Smart charging tatus to "parking / Start session via Booking an waiting" app appointment Available as part (S) of the Serviced Office package Travel back start Invoice automatically issued with other smart charging and

The goal of the use case

The project aims to introduce a fully electric car-sharing service, unique in the Hungarian market, linked to the office building rental business service, with a station-based car-sharing business model and a smart charging system, which would be offered to tenants as part of the serviced office offer. The project would focus primarily on office-based businesses, with the service being used by customers mainly for business purposes - protecting the environment and saving significant costs for the employer. We estimate that for a rental company, compared to alternative solutions, the solution offered could save up to 40% in costs and 60% in CO2 emissions, and could be offered as a benefit in kind to employees, increasing employee satisfaction.

stop session

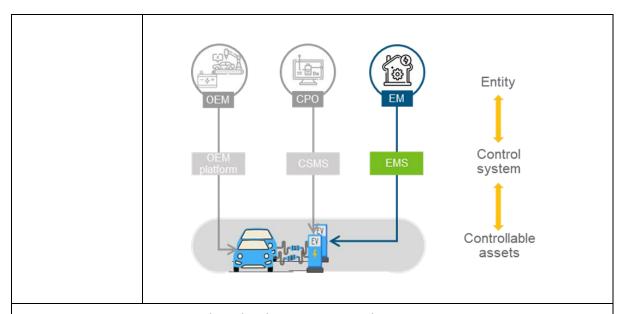
services

Thanks to the 'smart charging' system installed as part of the project, electric vehicles on the charger will consume power when the grid is 'low demand', avoiding overloading the grid, including at night or during 'cost-effective' early morning hours.

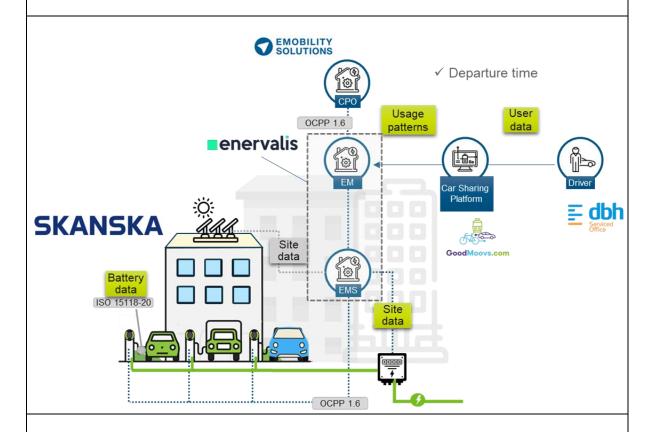
The use case aims to set up and experiment with the demand side load management smart charging feature, covering the integration between the vehicle, the recharging point, the building energy management system, and the grid operator, and prepare the blueprints for a suitable technical solution, which enables the use of the new service in a commercial office building environment and beyond.

Use case setup

Control topology



Visualization system architecture



Facts and figures

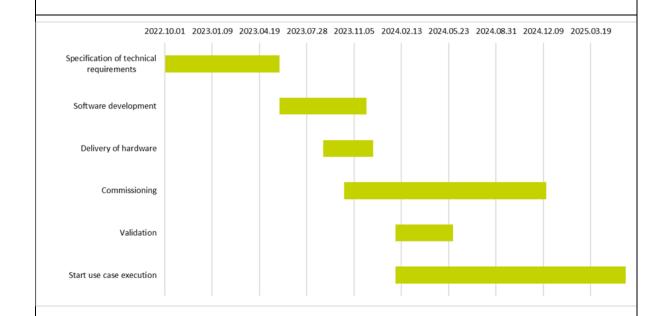
Charge point

ETREL INCH AC 22 kW wall box

EV	1 # Opel Mokka Elegance – already purchased
_,	2 # Nissan Leaf or Renault Zoe - planned
	Include:
Local EMS device	
	- Brand
Other	SMART CAR SHARING SYSTEM Provided by GoodMoovs
	Stakeholders
Site owner	Skanska
Site Owner	DP Group
	2. Gloup
End-user	Customers of Serviced Office Belbuda (DBH)
Ellu-usel	customers of Serviced Office Belbudd (BBH)
Fleet operator	DBH
СРО	Emobility Solutions (EMS)
MSP	Emobility Solutions (EMS)
Local energy	SKANSKA
optimization	
DSO	Eon AG
	Timeline
Specification of	
technical ·	if applicable: delayed because of + mitigation measure
requirements	(Please adapt to actual situation, if necessary)
Software	15/05/2023 – 31/05/2023 if applicable: delayed because of + mitigation measure
development	(Please adapt to actual situation, if necessary)
Delivery of	
hardware	if applicable: delayed because of + mitigation measure
	(Please adapt to actual situation, if necessary)
Commissioning	25/05/2023 - 30/06/2023
	if applicable: delayed because of + mitigation measure
1	

	(Please adapt to actual situation, if necessary)
Validation	25/05/2023 – 01/12/2023 if applicable: delayed because of + mitigation measure (Please adapt to actual situation, if necessary)
Start use case execution	01/06/2023 – 01/06/2025 if applicable: delayed because of + mitigation measure (Please adapt to actual situation, if necessary)

Gantt chart



Behind the meter optimization Reduce demand charges Goal of the energy management services What is the goal of using these services, reduce cost of charging, increase used RE influx, increase peak power charging, etc. 1. Primary objective Optimization of smart charging features in connection with car sharing operation 2. Secondary objective Reducing building's electrical power capacity and saving operational costs this way.

2.2.2. B2 Future proof energy management and V2G pilot at Duna Auto, a multi brand car dealership in Budapest

dealership in Budapest		
Introduction		
Use case lead	EMS - Janos Ungar, Zoltan Meszaros	
Context of the use case	Where does the use case take place (country, city, etc.), and what is the problem encountered?	
	The use case will take place at Duna Auto, one of the largest multi brand car dealerships in Budapest, Hungary. The V1G charge points can be used by customers or staff with any EV. However, the V2G charger to be installed should be used by the project V2G compliant car (TBD) via a for selected users.	
	With the help of a newly designed internal electricity and communication network at the dealership and repair center we will demonstrate how such a system including a complex PV system, a cluster of smart charging stations and an industrial scale storage system enables to maximize the level of renewable energy usage and decreases dependence from public electricity network while also making use of the battery capacities of the vehicles parked at the site as buffer and as balancing capacity as well.	
Description of the use case	At Emobility Solutions use case, there are several buildings at the site, also positioned as one of Hungary's smart energy and electromobility demonstrational and living lab, where a bidirectional charger will be installed to demonstrate V2G functionality. The buildings are going to be equipped with a 400kWp rooftop solar PV in 2023. There are already over 30 charging points in operation (including AC and DC technologies) and an additional charging station will be installed during the autumn 2023. A V2G compliant EV would be used in the demonstrations in 2024. However, the vehicle is not yet contracted.	
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The goal of the use case

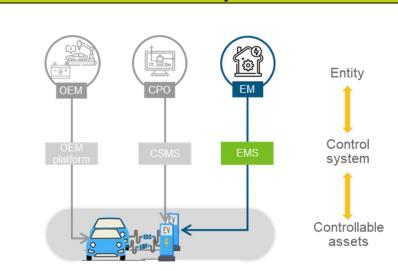
The main goals with this use case are the followings:

 One of the main goals is to increase the self-consumption of the onsite solar PV through V1G and V2G technology. Through V1G CP, this is achieved by charging the EV when there is excessive PV production. Using the V2G CP, this is achieved by saving the extra power of solar PV at sunny time by charging the EV and

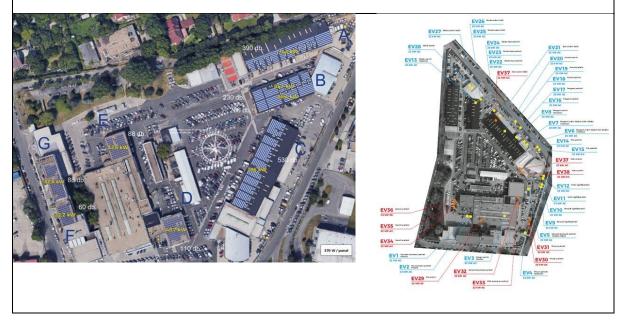
- realising the energy (discharging the EV) when required in the building at peak time
- Reduction of the electricity bills for the building is another important goal to be achieved in this use case. In this scenario, the EV will be charged at off-peak time when the electricity price is low and will be discharged at peak times when the demand for electricity is high.
- Due to high power tariffs, reducing the peak load is another goal to be achieved by this use case. In this scenario, the EV scheduling will be done to not charge the EV at peak time, and if possible to discharge it during that period.
- The demonstrations will be conducted following a modification of the ISO standard 15118-2 and later utilizing a full integration of the 15118-20 standard for the V2G communication.

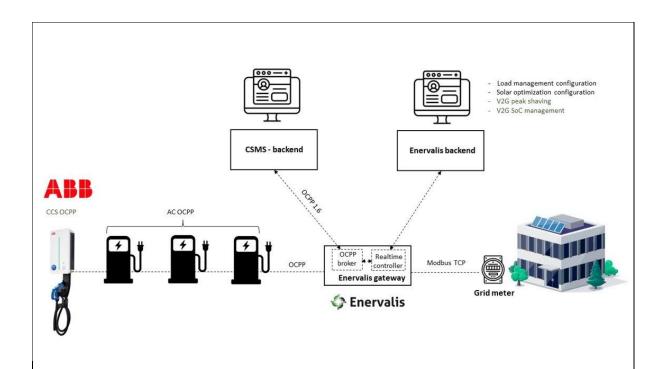
Use case setup

Control topology



Visualization system architecture





Charge point	Include: V1G Charge Point 1-26 (CP1): - AC - 22 kW AC - ETREL V1G Charge Point 27-31 (CP2): - DC - 24 kW DC - IES Synergy V2G Charge Point 32-35 (CP3): - DC - 11 kW DC - ABB
EV	Include: - TBD retrofit for V2G / bidirectional charging
Stationary battery	Include: - Storage capacity: TBD - Power: TBD - Lithium-ion battery
PV system	Include: - Power: 430 kWp
Local EMS device	Include: - Enervalis gateway

Stakeholders

Site owner	Duna Auto
End-user	EMS-Duna Auto Living Lab and Duna Auto customers
Fleet operator	Duna Auto and EMS
Local energy optimization	Enervalis
DSO	EON
TS0	MVM
	Timeline
Phase 1: V1G	
Specification of technical requirements	01/10/2022 - 31/05/2023
Software development (EMS /)	31/05/2023 - 01/12/2023
Delivery of hardware (CP1)	01/09/2023 - 15/12/2023
Commissionin g	15/10/2023 - 15/12/2024
Validation	01/02/2024- 01/06/2024
Start use case execution – phase 1	01/02/2024 - 01/06/2025
Phase 2 V2G	
Specification of technical requirements	01/03/2023-31/08/2023
Software development	01/09/2023-28/04/2024
Delivery of hardware (CP 2, EV,)	01/11/2023-20/11/2023
Commissionin g	21/11/2023-15/12/2023

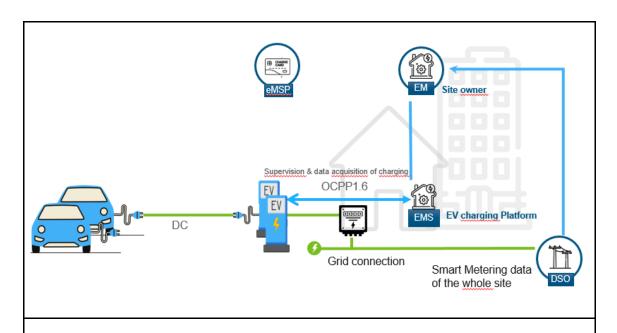
Validation	10/01/2024-31/03/2024	
Start use case	01/04/2024	
execution -		
phase 2		
	Gantt chart	
Phase 1 (V1G):		
2022.1	0.01 2023.01.09 2023.04.19 2023.07.28 2023.11.05 2024.02.13 2024.05.23 2024.08.31 2024.12.09 2025.03.19	
Specification of technical requirements		
Software development		
Delivery of hardware		
Commissioning		
Validation		
Start use case execution		
Phase 2 (V2G):		
	2023.03.01 2023.06.09 2023.09.17 2023.12.26 2024.04.04 2024.07.13 2024.10.21 2025.01.29 2025.05.09	
Specification of technical re	quirements	
	evelopment	
•	of hardware nmissioning	
Con	Validation	
Start use cas	e execution	
Energy Management Services		
Behind the meter optimization		
Increase self-	Voc	
consumption of on-site renewable	Yes	

energy

Reduce demand charges	Yes
Provide back- up power	TBD
	Goal of the energy management services
	 The energy management system (EMS) will be developed by EMS and Enervalis in which different goals will be followed. Primary objective is to develop an optimal EMS to reduce the electricity cost of the use case by V2G. This also includes peak load reduction of the use case. Secondary objective is to develop an optimal EMS to increase the self-consumption of solar PV and hence reduce the carbon emission to get as close as possible to a net zero emission in this use case.

2.2.3. B3 Smart Charging in car dealer Depot

	Introduction	
Use case lead		
Use case lead	Enedis Ramma Bookin	
Context of the use case	The use case will take place at a car park depot in Toulouse, France, where cars are stored (+ some services such as charging for EVs) before being delivered somewhere else. The V1G charge point is used by the staff to charge EVs that must be charged at about 50% SOC before being delivered (current average is about 10 EVs per day). The main problems encountered is that no smart charging strategies have been applied, even night shifting is not applied. Up to now, the number of EVs are manageable but as electrification of the car fleet is growing, we need to understand how much power capacity will be requested in mid-term (including smart charging option) for this use case.	
Description of the use case	The site is already equipped with rooftop solar PV and some V1G chargers are already installed.	
	The need is to analyse the data and define smart charging scenarios to be applied against: • local peak reduction • tariffs optimization • local PV synchronization.	
The goal of the use case	The main goal, from DSO perspective, is to reduce the interaction with the grid, and thus the grid reinforcement. But as a whole, it is to forecast how much power increase will be needed for this kind of sites which are numerous and get ready for a fair power increase.	
	Use case setup	
Control topology	Before getting any automation or external control (which is not available), we will start by some alerts to push charging session to be scheduled at the right time (for instance by night). Entity Control system Controllable assets	
Visualization system architecture		



Charge point	Include: - DC - Charging power: 22 kW - TbD
EV	Include: - Several brands and models (fleet from B2B customers of site owner): this is dynamic and not handled by site owner. - Average of 10 EVs per day are charged. However only last session of the working day might be shifted to night.
PV system	Include: - PV system is owned by another Business Peak generation is of 12 MW - Power It is too high against the charging power. Some scaling reduction will be needed for data analysis.
Stakeholders	

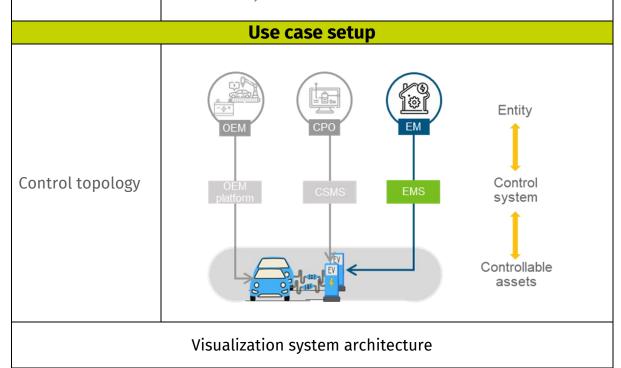
Site owner	Car depot owner	
DSO	Enedis	
Other	PV site owner	
Timeline		
Get parties agreements signed	15/06/2023	

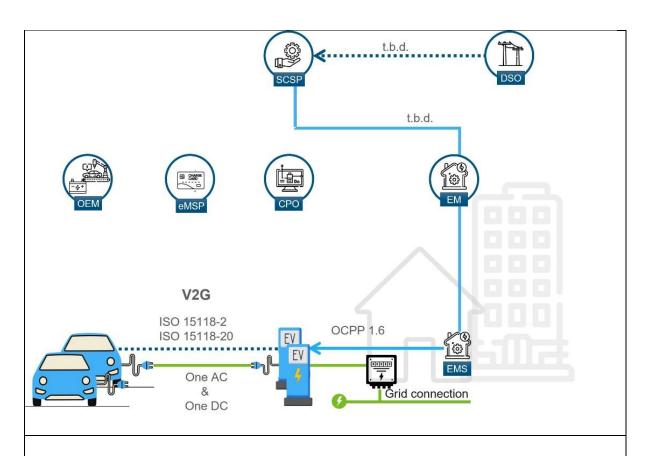
Specification of technical requirements	30/06/2023 (Real description of the site and chargers available and chosen when agreement signed)	
Software development	Done. The structure has been already developed. Needs to get data to be fed.	
Delivery of hardware	Done. The chargers are already installed. We will use the one on site.	
Commissionin g	NA	
Simple scenarios testing Start use case	15/10/2023 same than agreement 01/11/2023	
execution		
	Gantt chart	
Software development Agreements be Specification of technical	requirements narios testing ase execution	
	Energy Management Services	
	Behind the meter optimization	
Increase self- consumption of on-site renewable energy Reduce demand	Yes (simulated) Yes	
charges		
Goal of the energy management services		
	The goal of using these services is to: Optimize the use of available power capacity for charging, Increase used RE influx (simulated as self-consumption site), Shift to lower prices as Time-of-Use tariffs	

2.2.4. B4 V2G chargers at office and residential buildings (Gothenburg)

	1.1	
Introduction		
Use case lead	Chalmers - David Steen, Rahmat Khezri	
Context of the use case	The use case will take place at Chalmers University of Technology, Gothenburg, Sweden. One of the chargers will be installed in a living lab where novel energy solutions can be demonstrated and tested. The use case will include the EV into the existing building EMS to assess the potential gain from V2G	
Description of the use case	The test site is located at Chalmers University Campus in Gothenburg. The AC bidirectional charger will be installed at a smart building called HSB Living Lab, while a DC charger will be installed in one of Chalmers Campus buildings, to demonstrate V2G functionality in different settings and environment. The HSB LL is a smart residential building equipped with rooftop solar PV, stationary battery energy storage, and some controllable loads. The charge station will be installed during the autumn 2023 and a V2G compliant EV from Polestar will be used in the demonstrations. It is notable that a V1G charge point is already installed in this building.	
	The V2G-ready DC charge station will be installed at Chalmers campus testbed. The testbed is operated by Akademiska hus, the owner of the buildings and energy infrastructure at Chalmers Campus. The testbed enables researchers to perform real life demonstration in a controlled environment.	
	Due to the lack of public V2G compatible EVs, the use case will foremost focus on demonstrating the V2G functionality using the Polestar 2 EV, and private V2G charging.	
The goal of the use case	The main goals with this use case are the followings: One of the main goals is to increase the self-consumption of the onsite solar PV through V1G and V2G technology. Through V1G CP, this is achieved by charging the EV when there is excessive PV production. Using the V2G CP, this is achieved by saving the extra power of solar PV at sunny time by	

- charging the EV and realising the energy (discharging the EV) when required in the building at peak time.
- Reduction of the electricity bills for the building is another important goal
 to be achieved in this use case. In this scenario, the EV will be charged at
 off-peak time when the electricity price is low and will be discharged at
 peak times when the electricity price is high.
- Due to high power tariffs, reducing the peak load is another goal to be achieved by this use case. In this scenario, the EV scheduling will be done to not charge the EV at peak time, and if possible to discharge it during that period.
- Estimating the battery degradation of EV's battery for discharging through V2G technology. This helps us to figure out if it is economic to discharge the EV if the battery degradation cost is considered.
- The demonstrations will be conducted following a modification of the ISO standard 15118-2 and later utilizing a full integration of the 15118-20 standard for the V2G communication.



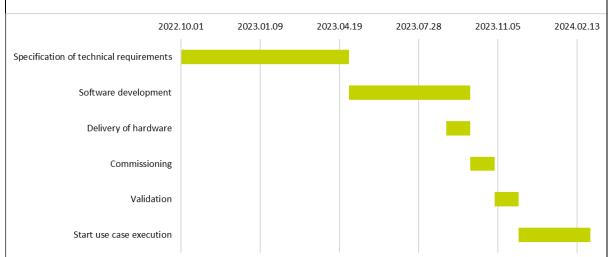


Charge point	Include: Charge Point 1 (CP1): - AC - 11 kW AC - CTEK Charge Point 2 (CP2): - DC - 22 kW DC - Ferroamp
EV	Include: - One Polestar 2 retrofit for V2G / bidirectional charging
Stationary battery	Include: - Storage capacity: 7.2 kWh - Power: 6 kW - Lithium-ion battery (Polyntech/FerroAmp) -
PV system	Include: - Power: 18 kWp
Local EMS device	Include: - EMS is developed by Chalmers university.

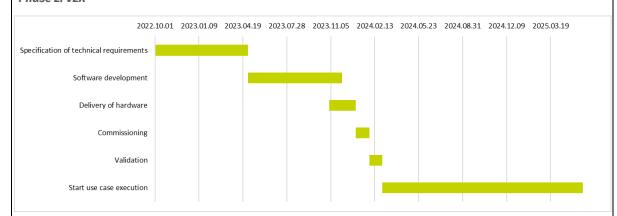
Stakeholders		
Starcholders		
Site owner	HSB Living Lab and Akademiska Hus	
End-user	HSB Living Lab and Akademiska Hus	
Fleet operator	Chalmers University of Technology	
Local energy optimization	Chalmers University of Technology	
DSO	Goteborg Energi	
TSO	Svenska Kraftnat	
	Timeline	
Phase 1: V1G and V2G with AC charger based on ISO 115118-2 with extension		
Specification of technical requirements	01/10/2022 - 01/05/2023	
Software development (EMS /)	01/05/2023 - 01/10/2023	
Delivery of hardware (CP1, EV)	01/09/2023 - 01/10/2023	
Commissioning	01/10/2023 - 01/11/2023	
Validation	01/11/2023- 01/12/2023	
Start use case execution – phase 1	01/12/2023 - 01/03/2024	
Phase 2 V2G		
Specification of technical requirements		
Software development	01/05/2023 - 01/12/2023	

Delivery of hardware (CP 2)	01/11/2023 - 01/01/2024
Commissioning	01/01/2024 - 01/02/2024
Validation	01/02/2024- 01/03/2024
Start use case execution – phase 2	01/03/2024
Gantt chart	

Phase 1: V1G



Phase 2: V2X



Energy Management Services

Behind the meter optimization

Increase	self-	
consumption	of	Yes

on-site renewable		
energy		
Reduce demand		
charges	Yes	
Time-of-Use		
shifting	Yes	
Congestion Management		
Operational	Yes	
congestion		
management		
(near real-time)		
Goal of the energy management services		
	 The energy management system (EMS) will be developed by Chalmers in which different goals will be followed. Primary objective is to develop an optimal EMS to reduce the electricity cost of the use case by V2G. This also includes peak load reduction of the use case. Secondary objective is to develop an optimal EMS to increase the self-consumption of solar PV and hence reduce the carbon emission to get as close as possible to a net zero emission in this use case. 	

2.3. Smart charging of light and heavy-duty fleets

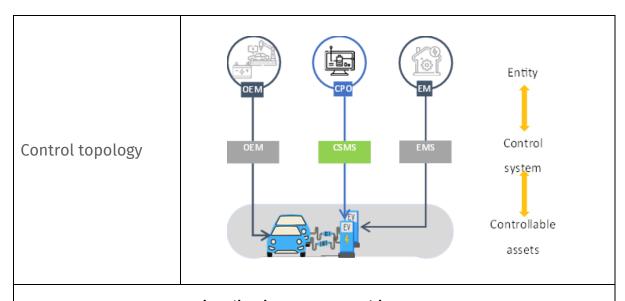


In this innovation cluster smart charging and V2X is taking place in the context of light and heavy duty fleets typically located at depots. Heavy duty vehicles require larger batteries and thus larger charging times. Because these are often commercially exploited vehicles, their utilization rate (the time that they are on the road) is essential. Because charging power is

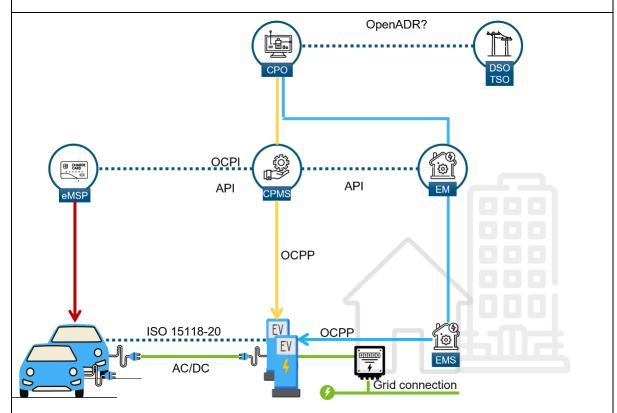
crucial, SCALE will implement a charging solution with local battery storage to increase charging speeds without costly grid reinforcements. Also, cost reductions can be achieved through SCALE's solutions utilizing smart charging and V2X services to enable load balancing services and reduce peak loads on the power system.

2.3.1. C1 Station-based Office B2B car-sharing with demand side management

Introduction		
	incroduction	
Use case lead	CURRENT - Åsmund Frengstad	
Context of the use case	Oslo, Norway. The challenge is operational cost for landlord to supply EV charging to all the tenants, especially grid tariff because of Peaks. In addition, looking into how local produced power could be an asset to reduce the cost.	
Description of the use case	Mustad Eiendom is a property owner in Oslo that owns 350 000 m ² and plans to re-develop the whole portfolio located on the pilot premisses. At the location there is a shopping mall, a waterfall with power production and loads of office spaces. They are operating approximately 150 AC charging stations today. And are looking for ways to reduce cost and increase user charging experience. By applying Smart Charging and V2G, the charging plaza should lower the peak max, and the load curve should align (inverted) with local production and energy prices.	
The goal of the use case	 Reducing grid fee Generate revenue from flexibility. Find a business model for V2G that includes EV driver 	
	Use case setup	



Visualization system architecture



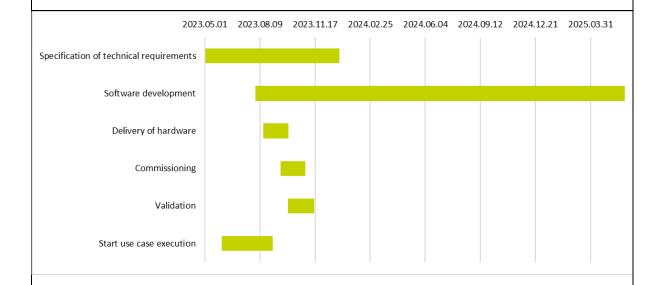
Facts and figures

	Include: - 151 Schneider Evlink SWB - 22 KW - AC
Charge point	 1 We Drive Solar AC charging station 22 KW AC (bidirectional) 1+X DC V2G capable 20 kW bi-directional (Nor gruppen)

	11 kW ABB DC bidirectional
	T. N. A. A. B. B. C. Grant Collonal
	Include:
EV	 Various but will include VW and KIA Ev6 and ID series (V2G capable- ISO 15118-20)
	Evo and to series (v20 capable- 130 13110-20)
	Include: TBD
Stationary battery	- Capacity - Power
	- Brand
1546 1	Schneider LMS ecostructure)
Local EMS device	
	Stakeholders
Site owner	Mustad Eiendom
СРО	CURRENT
MSP	CURRENT
Local energy	CURRENT
optimization	
DSO	Elvia
Flexibility provider	ENFO
BSP	TBD
BRP	Statkraft
TSO	Statkraft
	Timeline
Specification of	01/05/2022 – 31/12/2023 already operating with 151 CP for V1G
technical	direday operating with 151 CP JOI VIG
requirements	01/08/2023 – project end
Software development	MVP will continuously be developed according to project
	15/09/2022 20/0/2022
Delivery of hardware	15/08/2023 – 30/9/2023 integration and testing of v2g AC hardware is assumed done by end of July
	For DC station it depends on brand and delivery time

Commissioning	15/09/2023 -30/10/2023	
Validation	29/09/2023 -15/11/23	
Start use case execution	01/06/2023 - 01/09/2023	
Gantt chart		

Ganti Chart



Energy Management Services

Behind the meter optimization Increase self-Yes consumption of onsite renewable energy Yes Peak shaving Yes Dynamic grid tariffs **Congestion Management** Long-term Flexibility Yes agreement Grid-serving Yes power range Yes Market-based redispatch Yes Power Quality control

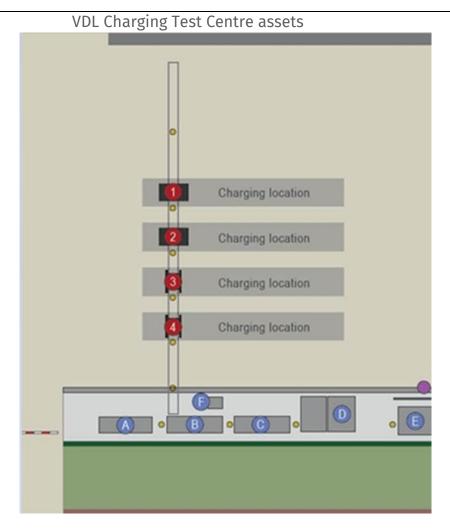
Balancing responsibility		
Spot market trading	Yes	
Market oriented price signal	Yes	
System balance		
FCR	Yes	
aFRR	Yes	
mFRR	Yes	
strategic reserves (adequacy)	Yes	
Goal of the energy management services	What is the goal of using these services, reduce cost of charging, increase used RE influx, increase peak power charging, etc. 1. Primary objective a. Reduce cost b. Increase range of operative service, with in the physical boundaries 2. Secondary objective a. Create secondary revenue stream	

2.3.2. C2 Highway charging with local generation & storage (Eindhoven)

Introduction		
Use case lead	VDL – Peter Cremers	
Context of the use case	VDL DC Charging Test Centre Valkenswaard, greater Eindhoven region, The Netherlands Reaching carbon neutrality in road freight- and passenger transport zero emission vehicles are the backbone to meet these goals. Next to Electric public transport buses these kind of EV vehicles starting to hit the market. Today the charging infrastructure that is indispensable to operate heavy duty EV's on the European highways is almost complete missing and not adapted to the specific needs, power demands and sizes of parking spaces of these types of sustainable transport.	
Description of the use case	Simulation of the optimal set up for highway DC High Power charging for long haul E coaches and other heavy duty EV's. As OEM we need to simulate and validate these high-power smart charging models, cloud services and communication protocols on our Charging Test Centre to be compliant to the latest standards and market demands.	
The goal of the use case	Heavy Duty EV's are business tools run by professional transport operators so reducing charging time and (on-line) pre booking services as part of their Fleet management systems are essential for a correct trip planning and to avoid high operational costs.	

Therefore, we need to continue the developments for high power smart charging infrastructure for long haul EV transport across Europe otherwise social acceptance of electrified coaches will be hard to realize. Use case setup Entity Control topology Control system Controllable assets t.b.d. OCPI-EV centric Charger centric Site centric (Other) information/dat Proprietary OCPP Vehicle manufacturer OEM FMS Fleet Management Sys eMSP E-Mobility Service Pro CPO Charge Point Operator **Energy Management S** SCSP Smart Charging Service Grid connection DSO Distribution system ope

Visualization system architecture



In 2018 VDL ETS has opened HVDC Charging Test Centre for HD vehicles:

- 1.4MW connection to the grid (E)
- 6 different chargers 40 450kW (C-F)
- Contact hoods for roof mounted pantographs & 2 inverted pantographs
- 3 different CCS plugs (40kW, 150kW /200A, 300kW/400A cooled) chargers (C-F)
- 3 * 150kW parallel smart charging system (D)
- Bidirectional energy storage system for battery lifetime testing & BESS-2X (D)
- Camera monitored

Facts and figures

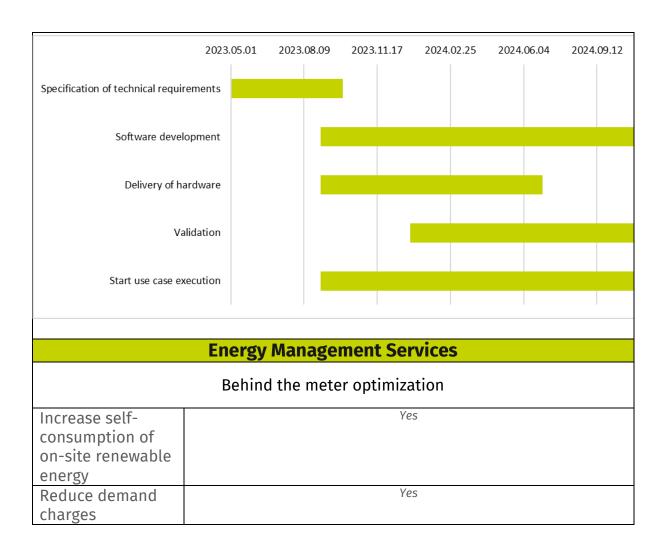
DC	Charge	points

Asset name	Asset type	Asset brand	OEM type number
Charge point	DC charger 150kW (for IMP)	ABB	HVC150
Charge point	DC charger 450kW (for RMP)	Heliox	450kW opp. Charger
Charge point	3x DC 150kW (CCS/RMP)	Siemens	SINEDC

Available DC HP chargers on VDL Charging Test Centre

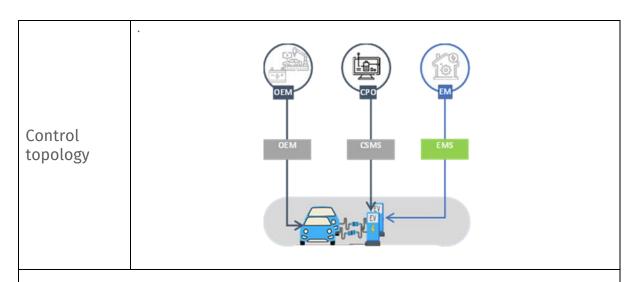
EV's	Include: - VDL E-buses test vehicles - VDL E-truck test vehicle Depending on the content of project test plan which has to be developed with the partners based on the latest standards and functionalities related to high power DC charging of heavy-duty EV's several vehicles of the VDL test fleet will be upgraded and tested during the project.
Stationary battery	ENERGY STEMENS Include:
	 420kWh second life BESS Reused second life VDL Bus battery packs Bidirectional charging especially V2D and hybrid charging with limited grid capacity will be tested with this set-up
PV system	Include: - Roof mounted on VDL office Valkenswaard - Solar edge - 190 panels of 320Wh peak - 2x SE 25k Inverter
Local EMS device	Include: - EMS system from Enervalis to be implemented.

Other	Bi-directional ISO15118-20 charging communication standard has been delayed consequentially the update of the available DC chargers and the EV's also have been e delayed. These updates to be further adapted/validated during the next phase of the project.
	Stakeholders
Site owner	VDL
End-user	VDL as optimized Charging Test Centre
Fleet operator	n.a.; VDL test vehicles are available
СРО	VDL (in case of testing at the VDL Charging Test Centre); by implementing these technologies in the EV's and by using public chargers the charging controls and services will move to a commercial CPO .
MSP	n.a.
Local energy optimization	VDL in cooperation with UC partners Enervalis and Goodmoovs during the project but will be on depot level.
	Timeline
Specification of technical requirements	1-5-2023 up to 1-10-2023
Software development	1-9-2023 up to M32 Several loops and validations.
Delivery of hardware	1-9-2023 up to 30-6-2024
Commissioning	n.a
Validation	1-1-2024 up to M32 permanent process of the development loops
Start use case execution	1-9-2023 up to M32 be aware this is a Test Centre so no formal commissioning and final execution.
	Gantt chart

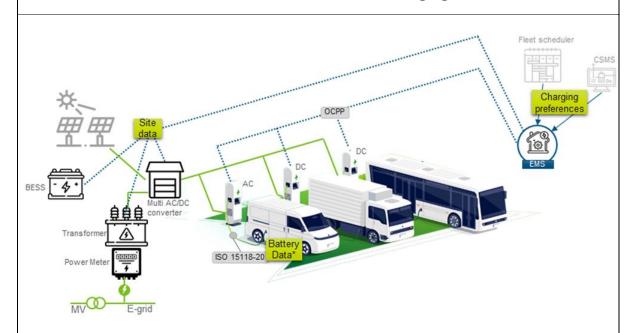


2.3.3. C3 VPP with renewable energy generation and second life battery storage (Eindhoven)

	Introduction	
Use case lead	VDL – Ruud Bouwman	
Context of the use case	VPP: Virtual Power Plant at VDL Charging Test Centre Valkenswaard	
the use case		
Description of the use	Optimized Energy management and costs optimalisation of a large Charging Centre or logistic depots.	
case		
The goal of the use case	Being independent as possible of the grid capacity during high power DC charging of large EV's by a Virtual Power Plant with renewable sources (solar energy buffered in a large BESS) and simulate smart charging of multiple EV's and V2x. Reuse of batteries of EV's into BESS applications.	
Use case setup		



Overview architecture & assets on VDL Charging Test centre



Energy Service	Required data	Other aspects
Optimized PV self- consumption	Site Data, Charging preferences and additional PV-forecast data.	
Peak-shaving	Charging preferences	
Time-of-use shifting	Charging preferences	
Increase behind-the- meter charging power	Charging preferences	

^{*} Battery data could also be retrieved using other means (i.e. hardware device). Common in commercial and shared fleets.



		Asset name	Asset type	Asset brand	OEM type number
		Charge point	DC charger 150kW (for IMP)	ABB	HVC150
		Charge point	DC charger 450kW (for RMP)	Heliox	450kW opp. Charger
		Charge point	3x DC 150kW (CCS/RMP)	Siemens	SINEDC
DC	Chargo				

DC Charge points

Available DC HP chargers on VDL Charging Test Centre

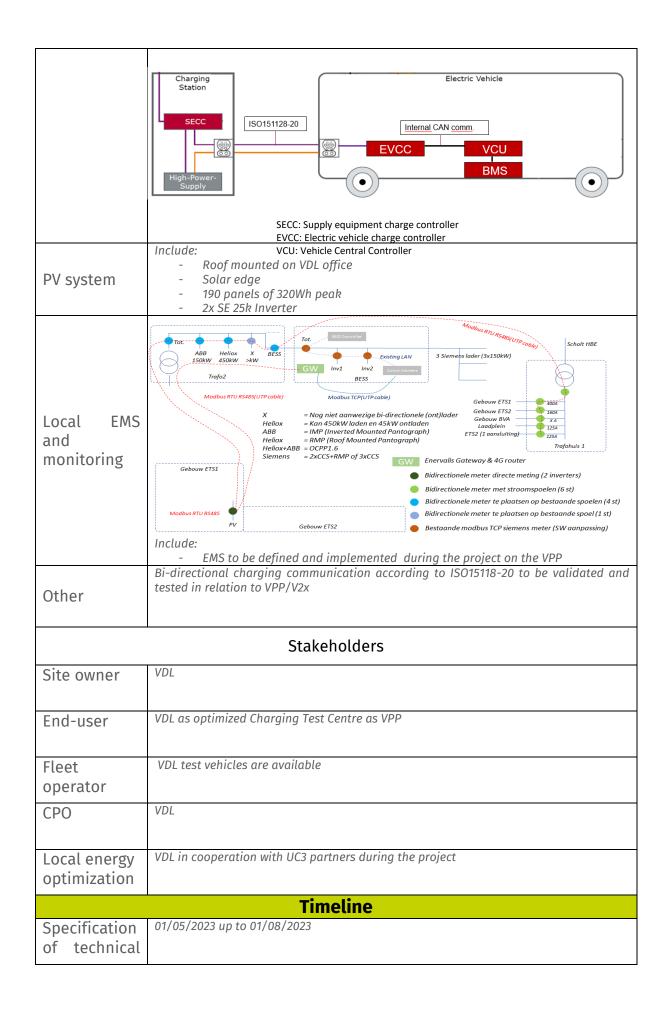
During the project one or more chargers will be updated for V2X functionalities whereby V2D (BESS) is the minimum and depending on legislations in NL we will investigate if also V2G is possible in Valkenswaard. Set of 3 chargers are already combined for smart charging functionalities.

Include:

- VDL E-buses several test vehicles
- VDL E-truck test vehicle

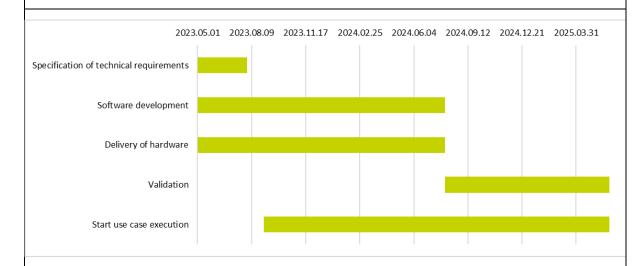






requirement s		
Software development	01/05/2023 up to 01/08/2024	
development		
Delivery of	01/05/2023 up to 01/08/2024	
hardware		
Validation	Start 01/08/2024 including V2D / implementation 15118-20	
Start use	01/09/2023 connecting and completing the different VVP functionalities	
case		
execution		
County also ut		

Gantt chart



Energy Management Services Behind the meter optimization Yes, by direct use and storage in BESS Increase selfconsumption of on-site renewable energy Yes, only during High power charging Reduce demand charges Goal of the energy management services Only local energy management on the VDL Charging Test Centre. Optimise self-use of available local onsite solar energy on depots/ minimize use of grid during test charging sessions and store- and recover energy (V2BESS and BESS2V) during charging- or battery high voltage test on EV vehicles. Reduce CO2 footprint of the test facility

2.4. Smart public charging



In this innovation cluster the charging is taking place at public locations. Over 50% of EU population lives in apartments which leaves the EVs to be parked at on or off-street parking. Smart charging and V2X services can make big impacts through the large amount of available parked EVs. SCALE will implement and test ecosystems of smart charging and V2X that will

help municipalities and parking operators to manage energy demand, relieve local congestion, and support reducing peak loads. Also, the call for a 'right to plug' in apartments and non-residential buildings increase the importance of charging infrastructure capable of reducing the need for grid reinforcements.

2.4.1. D1 Showcasing V2G at car dealership

Introduction IT: Åsmund Frengstad
IT: Åsmund Frengstad
IT: Asmund Frengstad
case takes place in Lørenskog, Norway. The challenge is operational cost
nt (HQ of Norway's biggest car dealership)
cing peak power, optimize charging according to Spot market price and
y.
ould like to showcase the vehicles capabilities of V2G (KIA) and see how
r sharing fleet can benefit from Smart Charging and V2G. As well as gaining in how to align their business with the change to electric drive trains.
et site is the HQ of one of Norway's largest Car dealerships and importers
They are looking into new business models with the emerging E-mobility
ite there are 3 different dealerships, a car sharing service as well as service 5.
ying Smart Charging and V2G, the charging plaza should lower the peak
d the load curve should align (inverted) with local production and energy And also look at the opportunities coming from V2G over AC connected to even to the complete on plot.

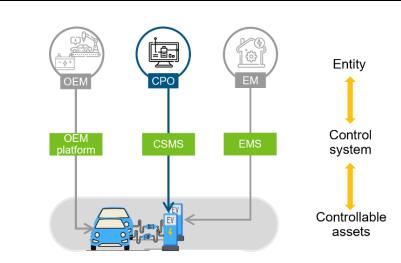


The goal of the use case

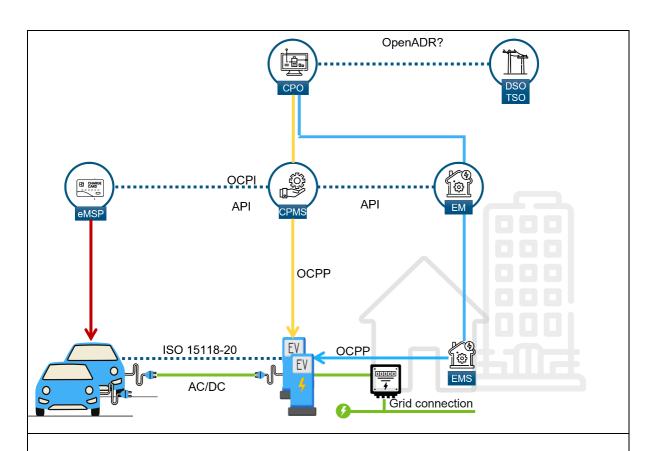
Reducing grid fee Generate revenue from flexibility. Find a business model for v2g that includes EV driver

Use case setup

Control topology

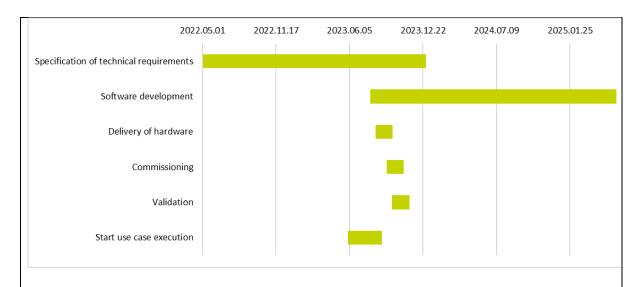


Visualization system architecture



Charge point	Include: - 1 We Drive Solar AC charging station 22 KW - AC (bidirectional) - 1+X DC V2G capable 20 kW bi-directional (Nor gruppen) - ABB DC bidirectional	
EV	Include: - Varius but will included Daimler and KIA - Ev6 and EQ series	
Stationary battery	Include: TBD - Capacity - Power - Brand	
Stakeholders		
Site owner	Bertil O. Steen AS	
СРО	CURRENT	

MSP	CURRENT	
Local energy optimization	CURRENT	
DSO	Elvia	
Flexibility provider	ENFO	
BSP	TBD	
BRP	Statkraft	
TSO	Statkraft	
	Timeline	
Specification of technical requirements	01/05/2022 – 31/12/2023 already operating with 151 CP for V1G	
Software development	01/08/2023 – project end MVP will continuously be developed according to project	
Delivery of hardware	15/08/2023 – 30/9/2023 integration and testing of v2g AC hardware is assumed done by end of July	
Commissioning	For DC station it depends on brand and delivery time 15/09/2023 –30/10/2023	
Validation	29/09/2023 -15/11/23	
Start use case execution	01/06/2023 - 01/09/2023	
Gantt chart		



Energy Management Services

Behind the meter optimization Yes Increase selfconsumption of on-site renewable energy Yes Reduce demand charges Yes Time-of-Use shifting **Congestion Management** Long-term Flexibility agreement Short term Yes congestion management (D-1) Operational Yes congestion management (near real-time) Power Quality Yes control Balancing responsibility Wholesale market Yes price arbitrage Intraday portfolio Yes optimization

System balance		
FCR	Yes	
aFRR	Yes	
mFRR	Yes	
Strategic reserves (adequacy)	Yes	
Goal of the energy management services	Primary objective a. Reduce cost b. Increase range of operative service, with in the physical boundaries Secondary objective a. Create secondary revenue stream	

2.4.2. D2: V2G and smart zero emission building energy management pilot in Erzsebetvaros, city center Budapest

	Introduction
Use case lead	EMS : Janos Ungar, Zoltan Meszaros
Context of the use case	The use case will take place in Erzsebetvaros, one inner city district of Budapest, at a traditional market Hall, that was built in 1897 and renovated in 2015. The V2G capable chargers to be installed could be used by the public in V1G in the project period and by a V2G compliant car (TBD) leased via the project for selected users for testing and demonstration.
	As part of a newly designed energy community, we will demonstrate how such a system including a PV system, 2 smart V2G AC charging stations and a storage system enables to maximize the level of renewable energy usage and decreases dependence from public electricity network while also making use of the battery capacities of the vehicles parked at the site as buffer and as balancing capacity as well.

Description of the use case





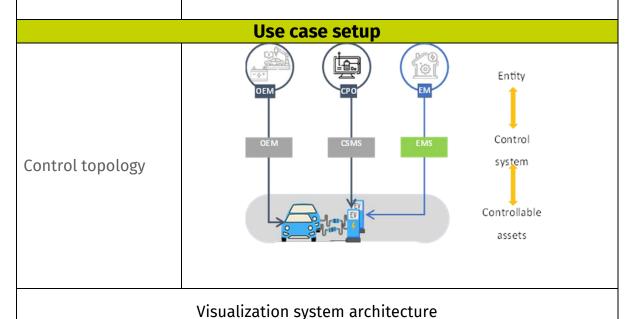


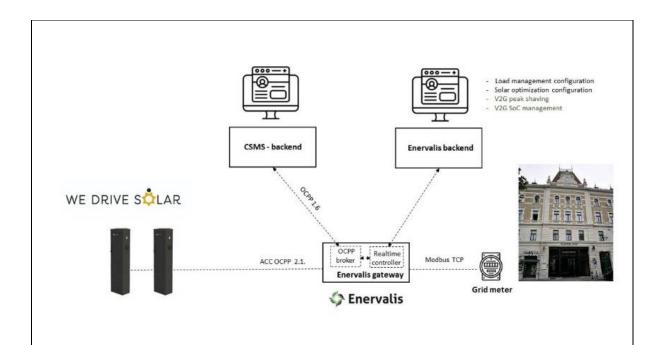
At Emobility Solutions use case, at the market hall also positioned as one of Hungary's first energy community system developed and operated by a local government, 2 bidirectional chargers will be installed to demonstrate V2G functionality. The building is going to be equipped with a 100kWp rooftop solar PV in 2023. A V2G compliant EV would be used in the demonstrations in 2024. However, the vehicle is not yet contracted.

The goal of the use case

The main goals with this use case are the followings:

- One of the main goals is to increase the self-consumption of the onsite solar PV through V1G and V2G technology. Through V1G, this is achieved by charging the EV when there is excessive PV production. Using the V2G, this is achieved by saving the extra power of solar PV at sunny time by charging the EV and realising the energy (discharging the EV) when required in the building at peak time.
- Reduction of the electricity bills for the building is another important goal to be achieved in this use case. In this scenario, the EV will be charged at off-peak time when the electricity price is low and will be discharged at peak times when the demand for electricity is high.
- Due to high power tariffs, reducing the peak load is another goal to be achieved by this use case. In this scenario, the EV scheduling will be done to not charge the EV at peak time, and if possible to discharge it during that period.
- The demonstrations will be conducted following a modification of the ISO standard 15118-2 and later utilizing a full integration of the 15118-20 standard for the V2G communication.





Charge point	Include: V2G Charge Point 1-4 (CP1): - AC - 22 kW AC - We Drive Solar
EV	Include: - TBD retrofit for V2G / bidirectional charging
Stationary battery	Include: - Storage capacity: TBD - Power: TBD - Lithium-ion battery
PV system	Include: - PV system including BESS - Power: 100 kWp
Local EMS device	Include: - ENERVALIS

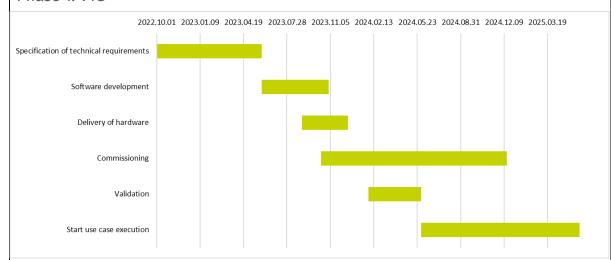
Stakeholders

Site owner	Erzsebetvaros, district of Budapest
End-user	EMS-Erzsebetvaros Energy Community and public customers

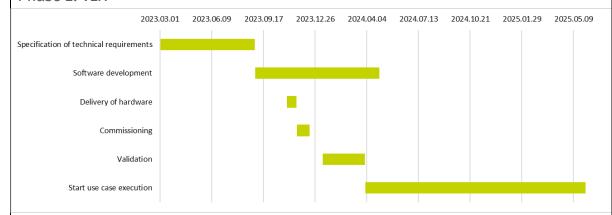
Fleet operator	Erzsebetvaros and EMS
Local energy	Enervalis
optimization	FOU
DSO	EON
TSO	MVM
	Timeline
Phase 1: V1G	
Specification of technical requirements	01/10/2022 - 31/05/2023
Software development (EMS /)	31/05/2023 - 01/11/2023
Delivery of hardware (CP1)	01/09/2023 - 15/12/2023
Commissioning	15/10/2023 - 15/12/2024
Validation	01/02/2024- 01/06/2024
Start use case execution – phase 1	01/06/2024 - 01/06/2025
Phase 2 V2G	
Specification of technical requirements	01/03/2023-31/08/2023
Software development	01/09/2023-28/04/2024
Delivery of hardware (CP 2, EV,)	01/11/2023-20/11/2023
Commissioning	21/11/2023-15/12/2023
Validation	10/01/2024-31/03/2024
Start use case execution – phase 2	01/04/2024

Gantt chart

Phase 1: V1G



Phase 2: V2X



Energy Management Services

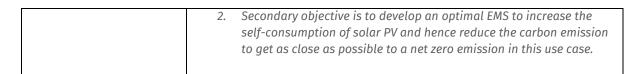
Behind the meter optimization

Increase self- consumption of on- site renewable	Yes
energy	
Reduce demand	
charges	Yes
Provide back-up	700
power	TBD
1	

Goal of the energy management services

The energy management system (EMS) will be developed by EMS and Enervalis in which different goals will be followed.

1. Primary objective is to develop an optimal EMS to reduce the electricity cost of the use case by V2G. This also includes peak load reduction of the use case.



2.5. Combination of innovation clusters

Because the Utrecht use case overarches and does not specifically fit to one of the innovation clusters, it is described separately.

2.5.1. Use case 00: Bi-directional ecosystem via combined V2G service

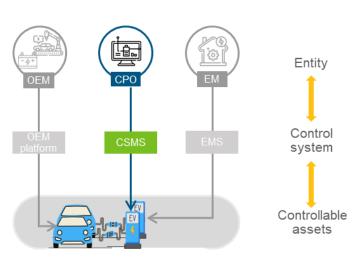
This use case is set up to prove the potential when V2X services are scaled. In Utrecht, a bi-directional ecosystem is created that supports power system stability, supplies flexibility to the electricity grid with the goal to reduce / postpone grid reinforcements costs and lowers the peak load of the power system. Unique is that the entire fleet of shared V2G cars is owned by a professional entity, this enables easy bundling and intelligent charging management. Shared EVs are always connected to the charger when not being used and through the reservation schedule, V2G operation can be predicted better than with private EVs. The V2G chargers are also available to 'normal' on street parking and are able to charge non-V2X ready EVs as well.

	Introduction
Use case lead	We Drive Solar: Bart van der Ree, Robin Berg
Context of the use case	In Utrecht, the Netherlands, a world-wide unique bi-directional ecosystem is created which currently is the largest V2G living lab in the world. It consists of (at the time of writing) about 650 AC-bidirectional charging stations and about 250 smart-charging shared EV's. The 'Utrecht bidirectional Ecosystem' supports power system stability, supplies flexibility to the electricity grid with the goal to reduce / postpone grid reinforcement costs and lowers the peak load of the power system, and is a major driver for innovation and upscaling of AC-V2G technology. This use case is set up to prove the potential when AC-V2G services are scaled up.
Description of the use case	Unique is that the pilot has been based on a fleet of V2G cars which is owned by a single professional entity, this enables easy bundling and intelligent charging management. The V2G chargers are also available for 'normal' on street parking and can charge non-V2X ready cars as well.
	THE PARTY SPAR
The goal of the use case	 The main goals of the Use Case are: Congestion management – reducing and/or delaying the need for future grid reinforcements with associated high societal costs, thus also reducing the future costs of EV driving for all users. Grid balancing (via Day Ahead / FCR / AFRR) and Time-of-use price arbitrage - reducing charging costs for shared EV exploitation and private EV charging

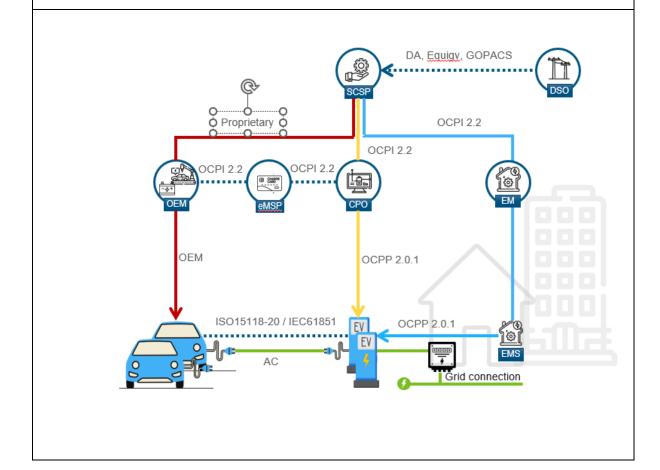
- Maximized utilization of renewables by EV's
- Creating a virtual power plant. that can deliver above services in order to reduce grid reinforcement costs as well as EV charging / driving costs in the future.

Use case setup

Control topology

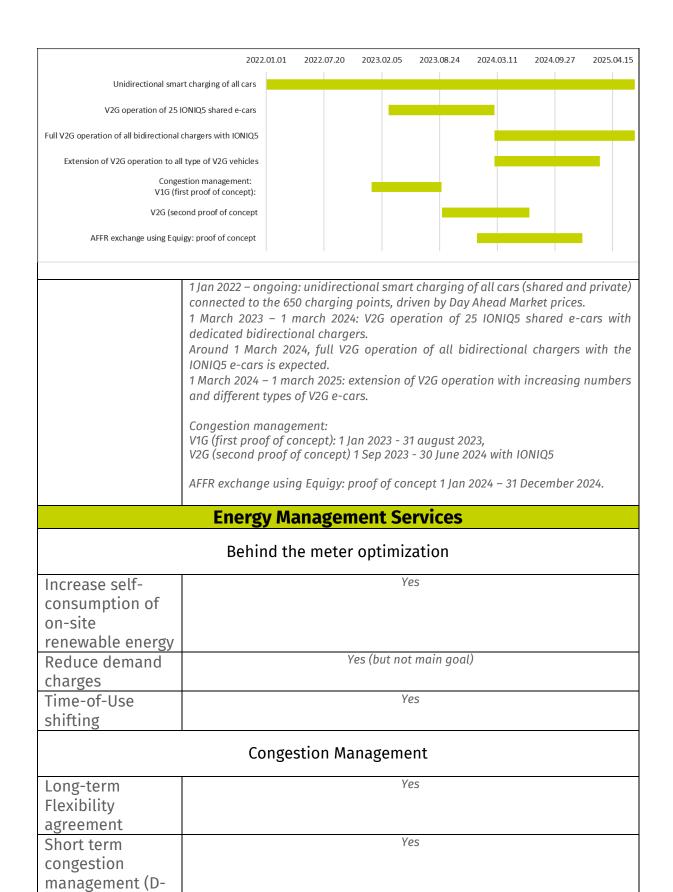


Visualization system architecture



	Facts and figures							
Charge point	AC: Presently about 650 We Drive Solar Chargers (about 1300 charge points), capable of ISO15118-20 AC bidirectional charging as well as IEC61851 charging. Charging power: 17 or 22 kW 25 Korean V2G chargers that are compatible with the present IONIQ5 software version and operate V2G with these cars.							
EV	Include: - Presently about 250 shared EV's - Models: Renault ZOE, Tesla Model 3, Hyundai IONIQ5 (25x), Hyundai Kona (40x)							
Stationary battery	Two Tesla Power Pack stationary batteries operated by We Drive Solar are part of the Utrecht Bidirectional Ecosystem: - Capacity: 760 and 845 kWh respectively - Power 400 kW and 590 kW respectively - Brand: Tesla Power Pack							
PV system	We Drive Solar operates a number of PV systems in / around the city of Utrecht, including 400kWp on Stationsgebied, 595 kWp on Triodos Bank (Odijk), and 4000 panels on a.s.r., totalling over 2 MWp of solar power							
Last Mile Solutions back office from Enervalis energy management back of chargers.								
	Stakeholders							
Site owner	Various: City of Utrecht, a.s.r., Triodos Bank, Utrecht Science Park, Jaarbeurs and several other owners							
End-user	We Drive Solar shared e-car users Private (or leased) e-car owners charging on WDS chargers							
Fleet operator	We Drive Solar							
СРО	We Drive Solar							
MSP	We Drive Solar							
Local energy optimization	All WDS chargers are smart charged based on Day Ahead electricity prices, when connected to shared EV's or to regularly charging private EV's. For non-regular private EV-chargers (guests), smart charging is bypassed. Several pilots are ongoing or finished: smart charging on district level, dynamic grid tariff experiment, proof-of-concept GOPACS congestion management services.							
DSO	Stedin (and some WDS chargers are in the service area of Liander)							
Flexibility provider	Enervalis							
BSP	TBD							

BRP	ED.Mij
TSO	TenneT
	Timeline
Specification of technical requirements Software development	 The technical requirements have already been specified, with the exception of coupling to Equigy and Gopacs. 1 jan 2022 – ongoing: unidirectional smart charging of all cars (shared and private) connected to the 650 charging points, driven by Day Ahead Market prices. 1 March 2023 – 1 March 2024: V2G operation of 25 IONIQ5 shared e-cars with dedicated bidirectional chargers. Around 1 March 2024, full V2G operation of all bidirectional chargers with the IONIQ5 e-cars is expected. 1 march 2024 – 1 march 2025: extension of V2G operation with increasing numbers and different types of V2G e-cars. Congestion management: V1G (first proof of concept): 1 jan 2023 - 31 august 2023, V2G (second proof of concept) 1 sep 2023 - 30 june 2024 with IONIQ5 AFFR exchange using Equigy: proof of concept 1 jan 2024 - 31 december 2024. Software necessary for full V2G compatibility of Hyundai IONIQ5: expected 31 dec 2023 (but uncertain) Software necessary for Equigy and Gopacs coupling: expected 30
Delivery of hardware Commissioning	Growth of WDS chargers and shared EV fleet: continuous towards goals. Some of the charging infrastructure has been build prior to the exact hard- and software requirements in SCALE where clear. In some selected cases, therefore, the charging infrastructure may have to be retrofitted to be able to deal with the most recent requirements, such as new cyber safety requirements that demand much computing power. In that particular case, use case 00 in Utrecht, it is yet to be determined if such a retrofit is actually needed. Commissioning of full V2G operation of IONIQ5 with WDS-chargers (after software update): expected January 1, 2024
Start use case execution	Use Case is already operational, with V1G smart charging (see above) and with V2G charging with Korean chargers to IONIQ5. After IONIQ5 software update (expected end 2023): full V2G operation.
	Gantt chart



Yes

1)

Operational

congestion

management (near real-time)						
	Balancing responsibility					
Wholesale market price arbitrage	Yes					
Intraday portfolio optimization	Yes					
	System balance					
FCR	Yes					
aFRR	Yes					
	Goal of the energy management services					
The primary objective of the above services is to enable fast further expansion electric mobility and sustainable energy production without the associa excessive grid loads and high costs for grid reinforcement. Secondary, but more immediate objective is to improve the business cases for						
	charging and EV car sharing and thus to promote EV upscaling.					

3. Conclusions from use case set up

3.1. Introduction

In Chapter 1, the introduction and framework including the relevant elements of the use cases are described. In Chapter 2, the details and timeline of the individual use cases is described. In this chapter

3, conclusions will be drawn according to the framework and individual inputs of the use cases.

The four industry value chains are Charging infrastructure, Mobility services, Charging services, and Energy services, visualised in Figure 4. The conclusions on the set up of the use cases are written per industry value chain. A description is written on how this is included in the SCALE use cases. For instance, it will be described which use cases executed unidirectional charging, bidirectional charging, and instant fast charging.

By using the industry values chains to describe the use cases that were set up, a comprehensive picture can be given of the SCALE use cases.

3.2. Setup process

Some of the use cases are being built upon various ongoing pilots which have preceded SCALE. This can be in the form of vehicles, chargers, other infrastructure, or soft- and hardware

Charging infrastructure

Private lease services

Shared mobility as a Service

Charging 3

Services

Balance responsibility

Fast charging

Congestion management System balance

System balance

Figure 71 Industry value chains Source: SCALE Stakeholder analysis

development. In SCALE the use cases built forth on these existing pilots with new innovations. This enables SCALE use cases to make the next steps in smart charging and V2X.

In the setup of the use cases, we have seen strong dependencies between use case leaders and other consortium partners in terms of incorporating equipment, vehicles and software. In the end all subsystems that make up the complete system around a use case are needed to showcase the energy services that are planned to be implemented. We have seen that with development around standards and protocols that follow up each other in a rapid pace (e.g. ISO 15118-20 being recently released) it takes time for all the stakeholders involved to implement these new protocols into their products and software platforms. Product safety and related certifications, which cannot be compromised, are among the key factors to make this a time-consuming exercise. We also see that there are regulatory uncertainties and barriers around the V2X aspects that for certain use cases cause uncertainties on timing. From the EV OEMs it became apparent that grid code compliance is a key concern for them, in particular in relation to AC charging and the upscaling to mass market deployment. These and other regulatory barriers will be addressed in more detail in WP5.

With an innovation project like SCALE, where we push the limits in terms of what is possible, these minor setbacks are to be expected and provide valuable insights. To continue to make progress some of the use cases will start the execution phase with those energy services that can be done based on the products they can have available now. The more complex services will be added throughout the projects. In many occasions this implies that the bidirectional services will be added in a later stage of the use case e.g. by updating product software.

In the Table 5, we have provided an overview of the timeline per use cases, distinguishing between the execution of the unidirectional and bidirectional energy services.

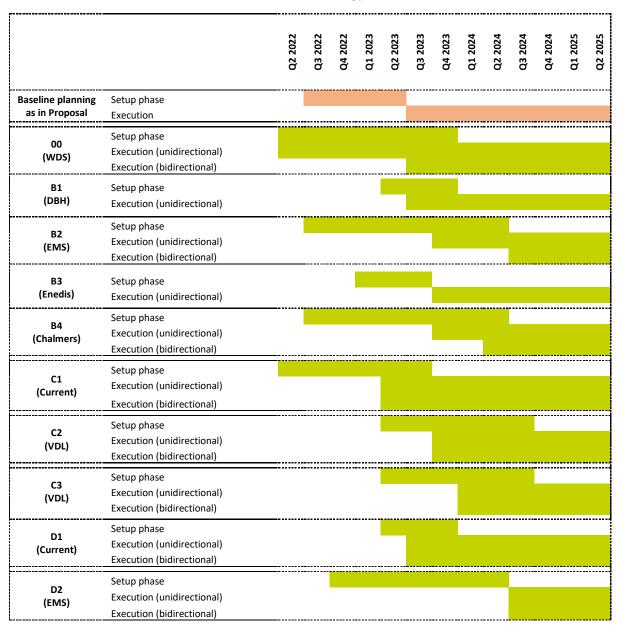


Table 5: Use case timelines

3.3. Charging infrastructure

The conclusions are described per section: 1 planning, 2 installation, and 3 execution. As this is the setup report for the uses cases, the planning section is more elaborate than the installation and execution section.

3.3.1. Planning

The SCALE use cases are, as much as possible, constructed of existing initiatives and charging infrastructure. That is why the planning within the use cases differs widely among use cases. In some use cases the charging infrastructure needs to be build up completely, and in others the site is already operational and new layers of SCALE innovation will be added for the use case. Also many use cases

find themselves in a situation where new innovative hardware will be added to existing sites, for the use case execution.

The use cases of SCALE deal with the earlier described challenges in the planning phase. They are included in the project because of the innovative power and knowledge that can be gained for further developing smart charging and V2X. However, the companies implementing the charging infrastructure are doing so to operate them profitably. The SCALE partners had already planned the charging infrastructure during the proposal phase, as expected, there were no changes in the planning phase coming from the SCALE partners. However, in the use cases, there are also several local stakeholders involved that are not part of the SCALE consortium. In the planning phase, there have been a couple of issues in setting up the use cases caused by local stakeholders. Local partners have withdrawn from their use case because participating in the use case was no longer attractive (e.g. D2 - Hungary, shopping malls). In Oslo (C1) a pilot needed to change location since the initial site owner was not prepared to take the risk of new technology in their operations. In these situations new locations where found to run the planned use cases. In use case B3, the site owner of this car depot had postponed the decision on making the necessary arrangements with use case leader Enedis. The dependency on the local partner outside of the SCALE consortium, in this case, caused some delay in the set-up process.

The planning phase has been finished and moved on to the installation phase in almost all use cases. The exception being use cases A1 and A2, Sono Motors will soon leave the SCALE consortium due to project external circumstances. Therefore, these use cases will be executed with different partners. How this will take place exactly is to be confirmed. Whether or not these partners are already part of the SCALE consortium, it's likely that the planning phase will have to be done by these new partners. For use case D2, the planning phase is also still ongoing. In that use case, the local partner, Stop Shop, withdrawn their interest in using its charging infrastructure at their premises for the SCALE demonstration pilot. The new partner is brought on board (Erzsebetvaros, a district in the centre of Budapest, Hungary which is dedicated to introduce its sustainable energy development program including energy communities) and the planning phase is nearing its end here.

The main takeaway from all use cases is that the planning phase used more time than expected at the time of proposal development. The main reasons for that:

- First, as addressed in the previous paragraph, in the initial phase of SCALE there was uncertainty from some OEMs on the availability of V2X-capable equipment like chargers and vehicles. This disrupts the planning phase because it is difficult to plan for alternatives if there is no certainty about their availability. During the planning phase, most use case leaders had to adapt their planning several times.
- Second, worldwide logistical issues and shortage on microchips are hampering the planning and installation phase. This is another reason why many use cases are encountering delays in their activities.
- Third and last, the earlier described issues with local stakeholders, in particular the site owners, caused delays in a small number of use cases.

3.3.2. Installation

With a large portion of the charging infrastructure in use cases already existing from previous initiatives, the installation phase means; (1) reworking and upgrading existing chargers at charging locations, (2) adding new innovative charge points to existing charging locations, and (3) installation of completely new charging locations. During the first year it became apparent that in situations where

new innovations are implemented in existing charging infrastructure, this sometimes led to technical issues. In these situations that is a risk that unplanned retrofits are required. In additional we have seen some unplanned efforts related to the integration between charger and EVs. An example here is use case 00 in Utrecht, where it is yet to be determined if a retrofit is actually needed for some of the chargers.

To prevent this from happening also in other use cases there is good exchange among use case leaders on these situations.

Asides from the fact that installation work is getting more expensive and delivery times for materials and labour are relatively long, there are no foreseen roadblocks with any of the use cases in the installation phase.

3.3.3. Exploitation

Naturally, because this is a report on the setup of the use cases, most charging infrastructure is not in the exploitation phase. Although, as mentioned before, some use cases are already operating and, therefore, in the exploitation phase. SCALE will utilize the results and data, which are being gathered from these already operational use cases, although none of the use cases is operational in their final form. Meaning that all these use cases will undergo modifications in some form or other during the project. Therefore, there are no conclusion on the exploitation of the use cases in SCALE at this point.

3.4. Mobility services

In SCALE we want to better understand the impact of different mobility services on the smart charging and V2X potential. We foresee that the type of mobility services will influence the smart charging and V2X potential per vehicle. What we can already see in this phase is that in the case of car sharing, charge sessions can be planned around car bookings. We expect similar results from the (C2) highway charging use case that will investigate reservations systems.

As it's too early to draw any conclusions at this point, we can already conclude on which mobility services are deployed in the use cases. The overview of that is presented in table 6.

Use case	Type of service
00 – We Drive Solar	Car-sharing; private cars
A1 – Sono Motors	Private cars
A2 – Sono Motors	Private cars
B1 – DBH	Car-sharing
B2 – Emobility Solutions	Private cars and company cars
B3 – Enedis	Company cars
B4 – Chalmers	Company cars
C1 – Current	Private cars and company cars
C2 – VDL	B2B
C3 – VDL	B2B
D1 – Current	Private cars and company cars
D2 – Emobility Solutions	Private cars and company cars

Table 6: Mobility services

3.5. Charging services

The charging services, unidirectional charging, bidirectional charging, and instant fast charging are all deployed in the SCALE use cases. SCALE aims to draw conclusions on the smart charging and V2X potential of the different services that we've identified. There are also differences between charging services and the legal framework around V2X. An example of this is the difference in grid code compliance between AC and DC charging as addressed in 3.2. We envisage to see more of these commercial and regulatory barriers in the remaining SCALE period.

In table 7 below, the overview is presented of the charging services in the different use cases.

	AC				
Use case	Unidirectional	Bidirectional	Unidirectional	Bidirectional	Fast charging
00 – We Drive Solar	√	✓			
A1 – Sono Motors		✓			
A2 – Sono Motors		✓			
B1 – DBH	✓				
B2 – Emobility Solutions	✓		✓	✓	
B3 – Enedis			✓		
B4 – Chalmers	✓	✓		✓	
C1 – Current	✓	✓	✓	✓	
C2 – VDL					✓
C3 – VDL			✓	✓	
D1 – Current	✓	✓	✓	✓	
D2 – Emobility Solutions		✓			

Table 7: Charging services

3.5.1. Unidirectional

Unidirectional smart charging is being executed in several use cases in SCALE. Most of the energy services can be done unidirectionally, meaning that their broad range of smart charging innovations are included in SCALE. An example of this is use case C3. There, instant fast charging is done smartly to reduce the impact on the grid of the charge session and at the same time deliver full power to the vehicle (more on this in §3.5.3). In other use cases with unidirectional smart charging, such as use case B1, the vehicle charging will be steered based on the building energy consumption.

First lessons learned for use case execution – unidirectional charging

As discussed in §1.5, there are different levels of control when talking about smart charging. A more advanced option gave issues for several use cases. The issue is that the charging power can't go below a certain current threshold (typically 6 Ampere) when applying charge profiles with the IEC61851 standard. Below that threshold, some cars stop the charging session and, in most cases, don't resume charging. This is an issue since it reduces the amount of power reduction can be realized in smart charging and therefore limits the smart charging potential. Also, if the car stops charging and can't start again in the same session, the car will not be fully charged when needed. In the Utrecht use case (use case 00), this is solved by testing charging EV's (both shared EV's and private EV's) with interrupted charging. If the EV exhibits this problem, it will be charged with minimum 6A. If it doesn't exhibit the problem, in the future the full range of smart charging is used on that car. Other workarounds are also possible, but all such workarounds reduce the potential for smart charging and/or have other side effects.

3.5.2. Bidirectional

Bidirectional charging adds an additional layer of complexity compared to unidirectional charging. This complexity covers the technological, economic, and regulatory aspects of the use cases.

Technological barriers

Within SCALE, most of the use cases will make use of bidirectional charging. Because bidirectional charging has a higher level of technological complexity compared to unidirectional charging, the bidirectional elements will in many cases be added in a later stage in the project. Equipment used for bidirectional charging can also be used for unidirectional charging. For instance, in the use cases in Oslo, there is already planned for a bidirectional capable vehicle. However, the chargers are not ready for bidirectional charging yet.

Regulatory barriers

Besides the implementation of the right communication protocols, e.g. ISO 15118-20, there are already some regulatory challenges identified in setting up the use cases and, eventually, in the uptake of mass deployment of bidirectional charging services. In use cases where power is delivered back to the grid, an noteworthy issue was found. In the case of V2G with DC chargers, only the charge point needs to adhere to the local grid codes. In the case of V2G with AC chargers, however, both the car and charger need to be certified as a combination. Here we find that because the car is mobile and can cross national borders, there are many different codes to comply with. There are also many charger and car combinations possible, which creates an additional layer of complexity in the certification process. In later reports of SCALE, this will be addressed more in depth, as this is an issue

that will need European wide collaboration to solve. The use cases are, however, dealing with this issue presently.

There are also regulatory barriers that have an impact on taxation of the energy supplied back into the grid. This causes a situation where double taxation can occur which has a negative impact on the business case for V2G related energy services. The impact of this varies among EU countries.

Commercial barriers

The rapidly changing energy landscape, the steep inflow of renewable energy into the electricity systems and with increasing electricity demand due to electrification of heating and mobility is already resulting in a big impact on the electricity system and associated markets. This creates uncertainty on the revenue potential of the energy services that will be deployed in the use cases. With the focus on the use cases in SCALE slowly shifting to the exploitation phase, the commercial potential to enable and upscale smart charging and V2X gets more attention and will be the central theme in upcoming SCALE deliverables.

3.5.3. Instant fast charging

The only use case with instant fast charging is C2 (VDL). This is about highway charging for heavy-duty use such as long-haul trucks and buses. They need instant fast charging along highways to reach their destination as fast as possible. One of the biggest challenges of future long-haul heavy duty is expected to be the planning of the charging sessions. VDL is working with partners to try and develop solutions that can plan and reserve the charging session for a vehicle, ensuring a charging spot and sufficient power to charge the arriving vehicle(s).

3.6. Energy services

Via the charging services, different energy services can be provided using the batteries in electric vehicles. Energy services are divided into four categories, local behind-the-meter optimization, balance responsibility, system balance, and congestion management. Per category, different energy services can be executed. In this paragraph, the energy services executed in SCALE are described per energy service.

In Chapter 1, the difference between unidirectional and bidirectional charging on the potential of the energy services has been explained. In SCALE, many energy services are being carried out via unidirectional as well as bidirectional charging services. In the following tables, unidirectional charging is abbreviated with V1G, bidirectional charging is abbreviated with V2X for simplicity.

As it is too early to draw any concrete conclusions on the energy services in use cases, overviews are provided on what energy services are planned to be implemented in each of the use cases.

3.6.1. Local behind-the-meter optimization

Local behind-the-meter optimization is, as the name suggests, done without power going back to the grid. All the optimization, whether it is unidirectional (smart charging) or bidirectional (V2X), is taking place behind the meter at a home, office building, or other location. In table 8 we provide an overview of the energy services done in each of the use cases. We see that all the use cases are implementing local behind the meter optimisation.

Use case	Increase self- consumption of on-site renewable energy		Use case consumption Reduce demand renewable charges		Time-of-Use shifting		Provide back- up power	
	V1G	V2X	V1G	V2X	V1G	V2X	V1G	V2X
00 – We Drive Solar	✓	✓	✓	✓	✓	✓		
A1 – Sono Motors		✓						
A2 – Sono Motors		✓						
B1 – DBH	✓		✓					
B2 – Emobility Solutions	✓	✓	✓	✓				
B3 – Enedis	✓		✓					
B4 – Chalmers	✓	✓		✓		✓		
C1 – Current	✓	✓	✓	✓	✓	✓		
C2 – VDL		✓		✓				
C3 – VDL		✓		✓				
D1 – Current	✓	✓	✓	✓	✓	✓		
D2 – Emobility Solutions		✓		✓				✓

Table 8: Type of local behind the meter optimization

3.6.2. Balance responsibility

On the electricity grid, the supply and demand need to be balanced. The same amount of energy needs to be generated as the energy that is used. The responsibility for matching supply and demand lies with the Balance Responsibility Partner (BRP), which is the energy supplier on many occasions. Underneath are the energy services associated with balance responsibility. In table 9 we provide an overview of the energy services done in each of the use cases.

Use case	Wholesale mark	et price arbitrage	Intraday portfo	lio optimization
	V1G	V2X	V1G	V2X
00 (WDS)			✓	✓
C1 (Current)	✓	✓		✓
D1 (Current)		✓		✓

Table 9: Use cases with Balance responsibility

3.6.3. System balance

For a stable electricity grid, the system balance is important. To have system balance, the electricity grid needs to maintain a stable frequency of 50 Hertz. A Balance Service Provider (BSP) provides the service of this balancing. EVs can be an example of assets that are used to provide the service. With smart charging electric vehicles can only be used as a demand asset, it can only take power from the grid. With V2G, the electric vehicles can also be use as supply assets, supplying power to the grid. Underneath are the energy services associated with system balance. In table 10 we provide an overview of the energy services done in each of the use cases.

Use case	FCR		FCR aFRR		mFRR		Strategic reserves (adequacy)	
	V1G	V2X	V1G V2X		V1G	V2X	V1G	V2X
00 (WDS)		✓		✓				
C1 (Current)		✓		✓		✓		✓
D1 (Current)		✓		✓		✓		✓

Table 10: Use cases with System balance

3.6.4. Congestion management

The last of the four categories in which energy services are divided is congestion management. As described in the SCALE Stakeholder analysis (Deliverable 1.2, 2022; page 28, subsection 2.4.4.), congestion management is needed in the occasion when demand or supply is too high, and the grid capacity becomes insufficient. Congestion management energy services can be aimed at preventing and resolving congestion management. Below are the energy services related to congestion management. In table 11 we provide an overview of the energy services done in each of the use cases.

Use case	Long-term Flexibility agreement		Short term congestion management (D- 1)		Operational congestion management (near real-time)		Power Quality control	
	V1G	V2X	V1G	V2X	V1G	V2X	V1G	V2X
00 (WDS)	✓	✓	✓	✓	✓	✓	✓	✓
A2 (SONO)				✓				✓
B4 (Chalmers)						✓		
C1 (Current)	✓	✓	✓	✓	✓	✓	√	√
C3 (VDL)								✓
D1 (Current)		✓		✓		✓		✓

Table 11: Use cases with Congestion management

3.7. System architecture

Determining the exact system architecture has been challenging for the use cases due to a couple of reasons. The key reason was the aforementioned rapidly changing ecosystem of protocol, standards and related products and services. This meant that the configuration of the use case knew some uncertainties on the individual system architecture. As also concluded in the SCALE *Analysis of hard-and software requirements* (page 5), the adoption of newly introduced protocols, such as ISO 15118-20, OCPP, or OCPI standards, usually takes a lot of time. Through various exchanges between SCALE partners, the use cases succeeded in visualising the control topology and architecture on communication protocols.

3.7.1. Control topology

The use cases in SCALE make use of different control topologies, these are listed in table 12. There are three main control topologies, via the OEM, the CPO and the EM (Energy Manager) as visualised in figure 8. SCALE doesn't prescribe a control topology, they do, however, have implications for the rest of the system architecture. In the table below, the conclusions can be drawn that the control topology via the OEM isn't utilized in SCALE. A likely reason for this is that there are currently no open standards for the OEM control topology.

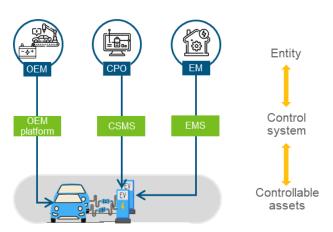


Figure 8:2 Control topologies

Use case	OEM	СРО	EM
00 – We Drive Solar		✓	
A1 – Sono Motors			✓
A2 – Sono Motors			✓
B1 – DBH			✓
B2 – Emobility Solutions			✓
B3 – Enedis			✓
B4 – Chalmers			✓
C1 – Current		✓	
C2 – VDL			✓
C3 – VDL		✓	
D1 – Current		✓	
D2 – Emobility Solutions			✓

Table 12: Use cases and their control topologies

3.7.2. Communication protocols

The protocols applied for communication between the different subsystems of the use cases are

visualized in table 13. First conclusion is that the use cases are relatively well aligned on the protocols they are planning to implement. To be capable of bidirectional charging, OCPP 2.0.1 or higher is necessary in combination with ISO 15118-20. As concluded in the SCALE Hard- and software requirements, the new releases of protocols and standards implemented with quite some delay. ambition is, however, implement all these standards within SCALE.

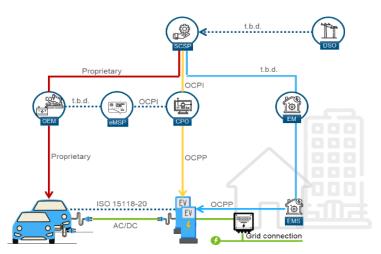


Figure 9: Protocols in SCALE system architecture

Use case	EV - charger	Charger - EMS	Charger - CPO	CPO - SCSP	CPO - eMSP
00 – We Drive Solar	IEC 61851 / ISO 15118-20	OCCP 2.0.1	OCPP 2.0.1	OCPI 2.2	OCPI 2.2
A1 – Sono Motors	ISO 15118-20	Modbus TCP	n.a.	n.a.	n.a.
A2 – Sono Motors	ISO 15118-20	Modbus TCP	n.a.	n.a.	n.a.
B1 – DBH	ISO15118-20	OCCP 1.6	OCCP 1.6	n.a.	n.a.
B2 – Emobility Solutions	ISO 15118-2 / ISO 15118-20	OCPP 1.6, OCPP 2.0.1	n.a.	t.b.d.	n.a.
B3 – Enedis	IEC 61851	OCPP 1.6			
B4 – Chalmers	ISO 15118-2 /ISO 15118-20	OCPP 1.6	n.a.	t.b.d.	n.a.
C1 – Current	ISO 15118-2 /ISO 15118-20	OCPP 1.6-2.1	OCPP 1.6-2.1	OCPI 2.2	OCPI 2.2
C2 – VDL	?				
C3 – VDL	?				
D1 – Current	ISO 15118-2 /ISO 15118-20	OCPP 1.6-2.1	OCPP 1.6-2.1	OCPI 2.2	OCPI 2.2
D2 Emobility Solutions	ISO 15118-2 / ISO 15118-20	OCPP 2.0.1.	n.a.	t.b.d.	n.a.

Table 13: Protocols applied for communication between the different subsystems of the use cases

3.8. Closing remarks

This deliverable in Work Package 3 describes the setup of the use cases and should be seen as the first step the works to be done. In the 2 remaining years of SCALE the focus will shift towards the execution of the use cases. This involves to start up the monitoring of the use cases (WP4), explore and work out the regulatory barriers (WP5) and business cases (WP3 & WP5) in relation to upscaling smart charging and V2X for mass market deployment. Besides that, lessons learned in the use cases will be fed back into the work done in WP1 (e.g. SCALE system architecture). The activities will be closely aligned with the work done in WP2 where many of the SCALE innovations are developed.

References

- Meersmans, Jelle: Analysis of hard- and software requirements SCALE Project deliverable 1.5 (2023)
- Langenhuizen et. al: Stakeholder analysis SCALE Project deliverable D1.2 (2022)