SCALE

Stakeholder analysis

Project deliverable D1.2

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

Deliverable administrative information

Deliverable number	D1.2
Deliverable title	Stakeholder analysis report
Dissemination level	Public
Submission deadline	30/11/2022
Version number	V1.0
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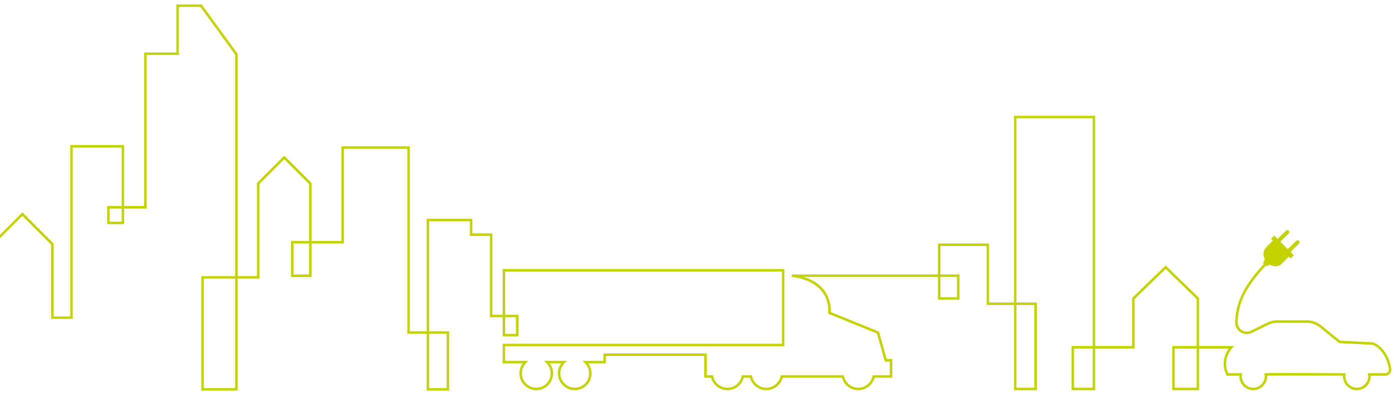
SCALE



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.

SCALE

List of abbreviations and acronyms

Acronym	Meaning
AC	Alternating Current
AFID	Alternative Fuels Infrastructure Directive
AFIR	Alternative Fuels Infrastructure Regulation
BESS	Battery Energy Storage System
BRP	Balance Responsible Party
BSP	Balancing Service Provider
CCS	Combined Charging System
CEP	Clean Energy for all Europeans Package
CPO	Charge Point Operator
DC	Direct Current
DER	Distributed Energy Resource
DSO	Distribution System Operator
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
MaaS	Mobility-as-a-Service
MCS	Megawatt Charging System
OCHP	Open Clearing House Protocol
OCPI	Open Charge Point Interface protocol
OCPP	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
VPP	Virtual Power Plant

Report executive summary

Key words

Electric vehicles, smart charging, Vehicle-to-Anything, flexibility markets, interoperability

Summary

The ambition of the European Union to achieve climate neutrality by 2050 have led to a notable increase in decentralised renewable energy resources and an accelerated electrification of industrial sectors such as infrastructure and mobility. New challenges related to grid reliability arose due to the intermittent nature of decentralised electricity production and a steady increase in electricity consumption. Electric vehicle (EV) charging can prove to be part of the solution to these challenges through the use of smart charging and bidirectional charging. End users, system operators, and participants in EV-related markets can all benefit from charging EVs in a flexible way.

This report pays specific attention to core principles of the European Union. By taking into account diverging levels of market maturity and differences in national policy frameworks, this report focuses explicitly on finding a balance between establishing free and fair market principles in emerging EV-related markets on the one hand, whilst simultaneously ensuring consumer protection on the other hand. Both existing and new market models are incorporated in four different industry value chains. The thorough examination of these industry value chains highlights both interactions between EV-related markets and challenges within specific markets. Fundamentally, the incorporation of flexibility models – such as non-firm contracts and congestion management – in energy markets and the planning process in the charging infrastructure market are identified as crucial challenges towards a large scale adoption of smart mobility solutions. As such, our research shows that there are still some major steps that need to be taken, especially related to bidirectional charging.

Lastly, this report identifies the most important stakeholders in the smart charging ecosystem. The analysis shows that stakeholders face a multitude of barriers ranging from economic, to societal, to political. For EV drivers, the most crucial objective is to grant end customers ownership of EV data, in order to allow them to freely participate in flexibility markets. On the manufacturer's end, we show that the lack of a common regulatory framework inhibits the cross-national penetration of EV-related markets. In general, uncertainties on technological advancements, the lack of clear regulatory frameworks to deal with flexibility propositions, and delays in market maturation due to a lack of inter-stakeholder dialogues are considered as additional crucial barriers towards the large-scale deployment of smart charging services. In order to tackle these barriers, specific attention should be given to interoperability, data accessibility, and fostering collaboration between stakeholder across the entire smart charging ecosystem.

Content

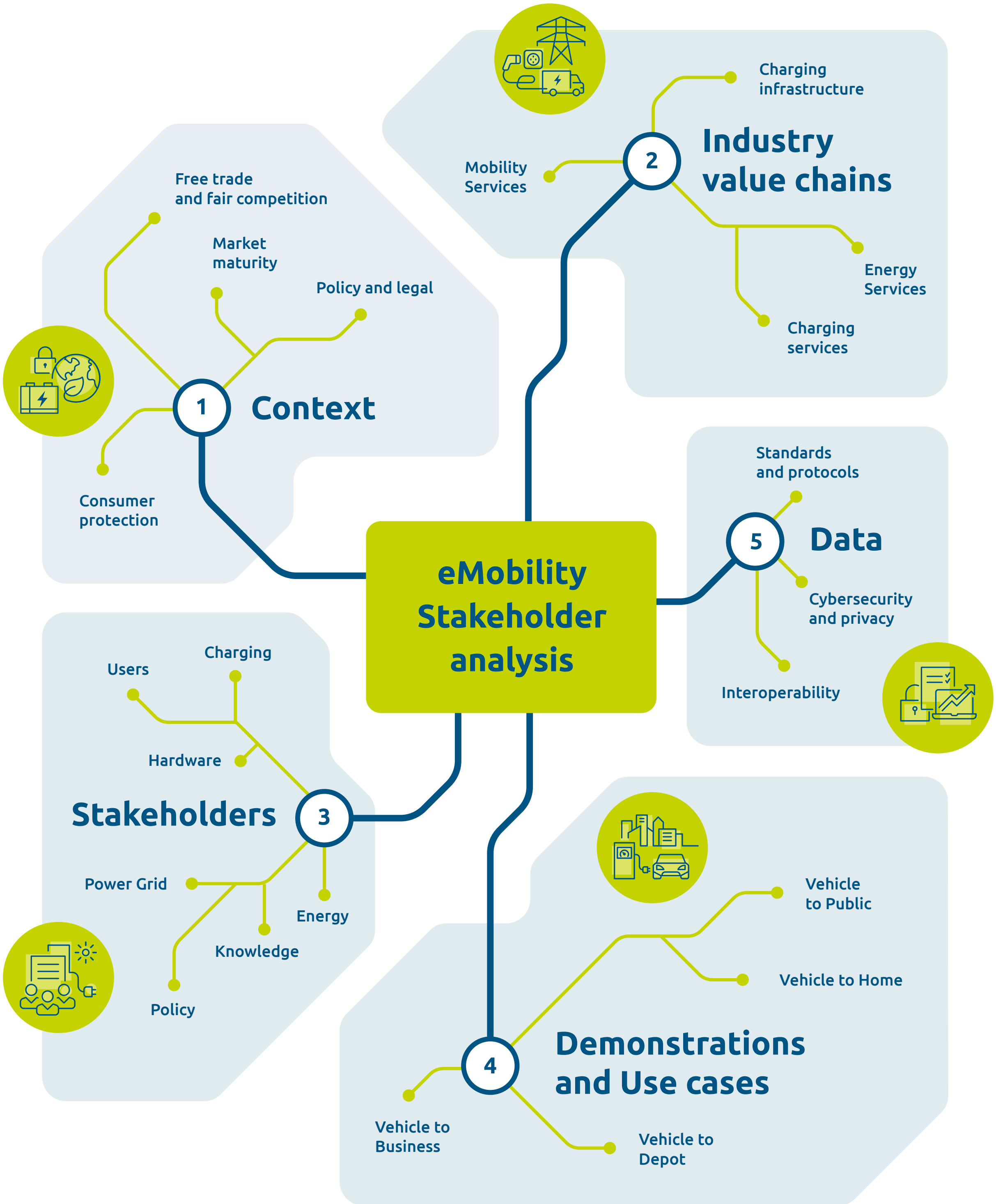


Figure: Overview structure of the document.

Purpose of the deliverable

Attainment of the objectives and explanation of deviations

The objectives related to this deliverable have been achieved in full and as scheduled.

Intended audience

This report analyses the needs, value cases, and barriers of a multitude of stakeholders and interested parties. Stakeholders are all dependent on other stakeholders within the smart charging ecosystem. The analysis will aid the development of the ecosystem by addressing the various trade-offs for the stakeholders. This report targets stakeholders, such as policymakers at local, national, and European levels, related European institutions and associations, academic and research structures, as well as the global (electric) vehicle and charging infrastructure market.

The stakeholder analysis conducted assessments and research through in-depth desk research, in-depth interview and expert sessions, benchmarked for the design of the system architecture. Research was not only aimed at end-users, but also reached a multitude of interest groups that will benefit from the project's results. The goal is to stimulate synergies across these interested parties. More precisely, this report targets original equipment manufacturers, automotive suppliers, electronic components and system manufacturers, RTOs and universities, transmission and distribution system operators, electricity and energy suppliers, charging point operators, battery manufacturers, local and regional authorities, transport operators and logistics-related industry, and NGOs and end-user associations.

Structure of the deliverable

The contents of this document are divided into six sections. The first section encompasses an overview of the current state of legislatorial and market developments in the contexts of the mobility industry, charging infrastructure, and the energy market as well as reviewing these developments in the context of EU principles of free trade, fair competition, and consumer protection. The second section aims to illustrate the overall system architecture within this context. The different roles and business perspectives within the smart charging and V2X ecosystem will be formulated. The third section is dedicated to the requirements for the scale-up of smart charging and V2X of each involved stakeholder by assessing their needs, value cases and barriers. The fourth section provides an overview of the different use cases of smart charging and V2X within the scope of the SCALE project, as well as an overview of the specific pilots the SCALE partners will conduct in each of these use cases. The fifth section goes beyond the business requirements of the involved stakeholders and aims to provide a preliminary outline of other integral requirements on interoperability, standards and communication protocols, and cybersecurity and privacy, which will serve as the foundation for data requirements in the system architecture. The final section summarizes the findings of this report in key observations and is dedicated to final conclusions and recommendations.

1 Context

1 Context

This chapter will examine legislatorial and market developments within the context of EU founding principles of free trade, fair competition, and consumer protection. First, recent developments in the EU's climate strategy and policies will be examined. These advancements will be reflected against the aforementioned founding principles of the EU. Furthermore, this section will review specific policies adopted by the EU and market maturation in the mobility, charging infrastructure, and energy sectors.

The European Union has set itself a binding target of achieving climate neutrality by 2050, with an intermediate ambition of reducing emissions by 55% by 2030 compared to 1990. As part of the so-called 'Fit for 55' package, the European Union has proposed a new set of measures affecting a wide range of industries, including automotive, agriculture, and construction. As our electricity system is changing due to the energy transition, the roles, needs, and expectations of both regulated and market parties are evolving as well. In order to deal with the challenges of the energy transition, EU wide legislation is necessary to ensure a free and fair electricity market.

The first challenge stems from the necessity to balance the generation and consumption of electricity. Disturbances in grid balance can lead to power outages and damage to equipment connected to the system. All market participants are responsible for balancing their electricity production and consumption, for which they will assign a Balance Responsible Party (BRP). The BRP is financially responsible for the imbalances they cause in the system. Therefore, they actively attempt to match supply and demand within their portfolio. When a real-time imbalance occurs despite these efforts, the operator of the high-voltage grids, known as the Transmission System Operator (TSO), is required to activate reserve capacity. The costs of the activation of reserve capacity will be delegated to the BRP responsible for the imbalance.

Balancing supply and demand has become increasingly challenging. Projected generation from renewable energy sources such as wind and solar energy is dependent on local weather forecasts and are therefore more difficult to predict. The rise of electricity consumption by small consumers, primarily caused by the electrification of buildings and the transport sector, has additionally led to a more volatile consumption pattern. Traditionally, TSOs have used power plants and large industrial consumers as flexible electricity sources. Following the European Union's goal of cutting emissions, flexibility from renewable energy sources has become a more enticing prospect.

Second, the surge in both electricity consumption and production puts constraint on the grid. Local electricity grids were constructed when consumption and generation were at much lower levels, so they cannot always transport all electricity at once. With a further rise in decentralised solar energy generation, electric vehicle (EV) usage and other industrial and household electronics, grid congestion will become more frequent.

EV charging can prove to be part of the solution to these problems through the use of smart charging, the essence of which is to change the time, speed and/or direction of the charging process. Shifting the charging process away from peak hours avoids grid congestion and mitigates the need for costly investments in grid expansion. Charging during periods of high renewable energy generation increases the share of energy consumed with renewable energy. Another application is bidirectional charging, in which energy from EV batteries can be used to feed electricity back into the grid or directly into a home, business, or depot (Vehicle-to-Anything, V2X) as a way to avert grid congestion and to help match supply and demand.

1.1 Free trade and fair competition

The internal market of the EU is built on basic principles such as free trade and fair competition between market participants. EU legislation aims to "ensure fair and equal conditions for businesses, while leaving space for innovation, unified standards, and the development of small businesses (European Union, 2022)." This coincides with the SCALE project criteria: a free market where a wide variety of market parties participate on equal footing minimises the costs for consumers and ensures that market participants can still make a profit in the system.

These basic principles are well established in both the automotive and the energy sector and continue to develop to improve market access and innovation. At the crossroads of these two well established markets lays a newly developing e-mobility market. Legislation is needed to ensure that new services emerging in this market are developed in a competitive market under fair market conditions. Open access to all parties will ensure that this evolving market remains a level playing field where the principles of innovation and profitability are not neglected and that market failures will be mitigated.

1.2 Consumer protection

Legislation and market maturation are also needed to guarantee that the newly developing smart charging and V2X market complies with the EU-wide principles of non-discrimination, efficiency and price transparency. Promoting fair competition will enable consumers to take full advantage of the opportunities of the liberalised internal e-mobility market, avoiding consumer lock-in. Additionally, establishing an open and free market will prevent unjust barriers with regard to market entry and activities, protecting the consumer against undesirable situations such as unnatural market monopolies.

The deployment of smart charging and V2X requires the collection, management, and sharing of personal and metadata. Data exchange is a prerequisite for smart charging services, as optimisation requires information on the EV driver's preferences, the electric vehicle, and the grid. With the expansion of data availability, further attention is needed for data privacy and cybersecurity, as the system will become increasingly vulnerable to cyber threats. SCALE will ensure a cautious balance between data availability and data security by ensuring that requirements for data availability comply with the General Data Protection Regulation.

1.3 Policy and legal

In recent years, the European Union has rebuilt its energy policy by adopting a set of eight directives and regulations known as the Clean Energy for all Europeans Package (CEP). The CEP lays out a framework on how Member States can achieve the EU's goals towards a low-carbon economy, by aligning the objectives of the European energy policy to the challenges of the energy transition, including a high share of renewable energy sources, more volatile supply and demand patterns and growing restraint on the grid. Furthermore, the package aims at complementing the dimensions of the energy union on energy security, efficiency, market integration, decarbonisation, and research and competitiveness.

The legislative acts of the CEP tackle a wide range of topics which (in)directly affect the e-mobility sector, including energy efficiency, renewable energy sources, and the internal electricity market. The Energy Performance of Buildings Directive (EPBD) establishes targets for the deployment of charging infrastructure for EVs at residential and non-residential buildings, complementing the Alternative Fuels Infrastructure Directive (AFID), which is concerned with publicly available charging points. The revised directives on renewable energy (RED) and energy efficiency (EED) provide support schemes for renewable energy sources and set out binding targets for efficient energy usage.

Yet, current regulation cannot adequately deal with new market participants emerging in the smart charging and V2X market

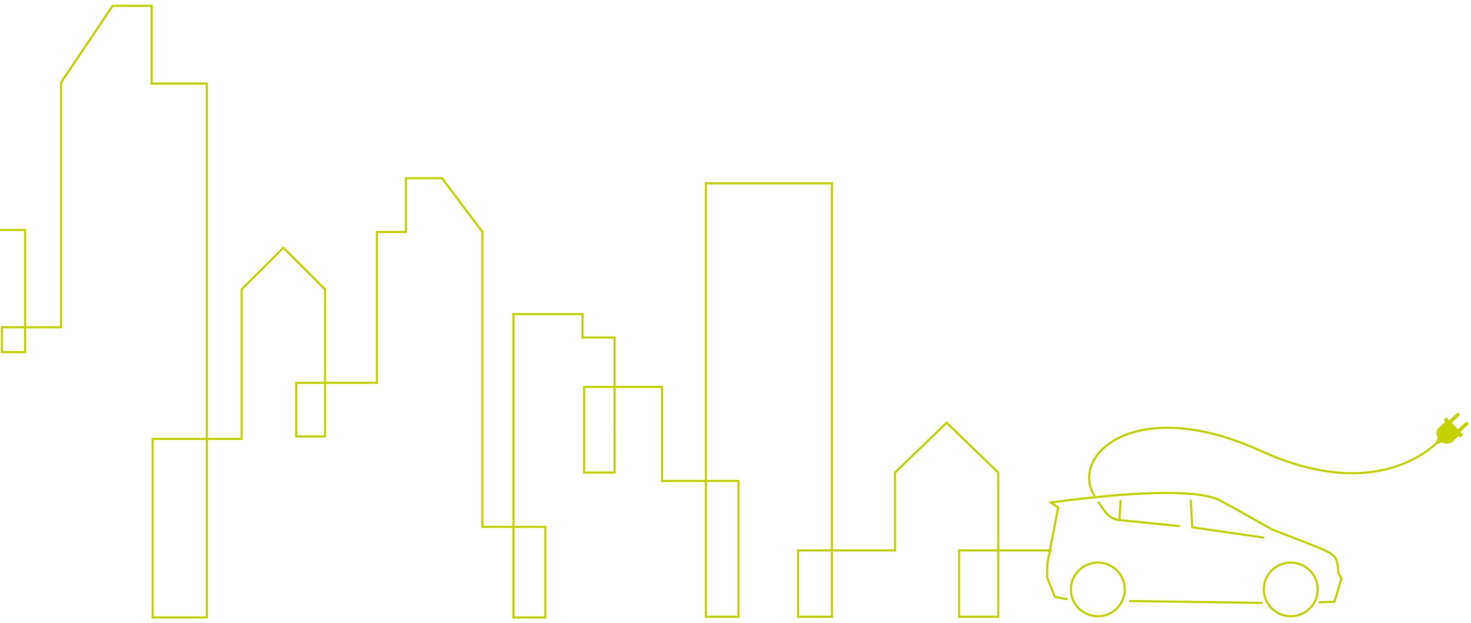
Another goal of the CEP is to redesign the European wide electricity market in order to make it more suitable for the high share of renewable energy sources and the growing demand for flexibility. The main building blocks in this design are the Regulation on the Internal Market for Electricity (2019/943, 'Electricity Market Regulation') and the Directive on Common Rules for the Internal market for Electricity (2019/944, 'Electricity Market Directive'). Key components of these legislative acts include the enablement of active consumer participation by means of providing flexibility and a further augmentation of the roles and responsibilities of existing market participants and network operators in the electricity market. The Electricity Market Regulation and Directive were decisive legal decisions for the advancement of the flexibility market.

On July 14th 2021, a new package was presented with the main goal of accelerating the energy transition by inflating the target of a 40 percent reduction in greenhouse gas emissions to a 55 percent reduction. In order to achieve this goal, the Fit-for-55 package includes revisions of existing electricity market directives and regulations, including AFID, RED, EED and the Energy Taxation Directive (ETD). Decarbonising the mobility sector is seen as a key objective in the package and, hence, these new laws will have a more significant emphasis on e-mobility. Other topics relevant to e-mobility, such as energy storage and data sharing, will also play a more noteworthy role in the Fit-for-55 package.

Considerable work has been done with regard to existing stakeholders in the energy market. Yet, current regulation cannot adequately deal with new market participants emerging in the smart charging and

V2X market. The transition to large-scale smart charging and V2X is conditional on EU wide rules on data sharing, billing processes, and interoperability. Further legislation is needed regarding the roles and responsibilities of these new parties and the interactions between new and existing stakeholders need to be addressed.

Differences in implementation of EU legislation between Member States can prove to be a barrier to large-scale smart charging and V2X deployment as well. The distinction between directives and regulations is important in this context. Regulations are binding legislative acts that overrule national laws. They are directly applicable to all Member States on a set date. Directives, on the other hand, lay down certain objectives and goals that must be achieved by all Member States. Individual countries can freely decide what national legislation they deem necessary to reach these goals. Consequently, national laws derived from EU directives can differ between EU countries. For example, the integration of small-size consumers in flexibility markets is triggered by legislation derived from the Electricity Market Directive. Such legislation include rules on aggregation contracts, dynamic price contracts and smart metering. Currently, this framework has only been enshrined in a handful of Member States, such as France, Finland, and Italy (smartEn, 2022).



CURRENT LEGISLATION	EU CODE	DESCRIPTION
MOBILITY AND CHARGING INFRASTRUCTURE		
Alternative Fuels Infrastructure Regulation (AFIR)	COM/2021/559	Revision of the Alternative Fuels Infrastructure Directive (AFID) of 2014. Expected to be published in early 2023. Sets targets for publicly available charging infrastructure and rules on interoperability of plugs, billing procedures, and communication procedures.
Energy Performance of Buildings (EPBD)	2018/844/EU	Is currently being revised (COM 2021 802). Sets targets for semi-public and private charging infrastructure at new and renovated buildings.
Clean Vehicle Directive (CVD)	2019/1161/EU	Sets targets for the public procurement of clean vehicles, including purchase, lease, and rent.
Emission Performance Regulation	2019/631/EU	Sets targets for the CO2 emission performance of new passenger cars and light commercial vehicles.
Renewable Energy Directive (RED)	2018/2001/EU	Is currently being revised (COM 2021 557). Sets a target for the amount of renewable energy in the energy mix, which includes rules on charging infrastructure and battery data sharing.
ENERGY SERVICES		
Electricity Market Regulation	2019/943/EU	Provides rules for the internal market for electricity, including trading on energy markets and balance responsibility.
Electricity Market Directive	2019/944/EU	Provides a framework for the participation of small-size consumers in the electricity markets, including rules on aggregation, demand response, and dynamic prices.
Energy Taxation Directive (ETD)	2003/96/EC	Is currently being revised (COM 2021 563). Includes rules on energy taxation for storage units, which will mitigate double taxation.
European Network Codes [ENTSO-E]	Multiple	A set of eight legislative acts aimed at harmonising national network codes. Includes rules on electricity balancing markets, congestion management, and grid connection requirements.
DATA		
Directive on batteries and waste batteries	2006/66/EC	Is currently being revised (COM 2020 798). Rules on sharing battery information.
General Data Protection Regulation (GDPR)	2016/679/EU	Sets binding rules on the availability of data streams and the security of data privacy.
Data Sharing Acts	Multiple	Legislative acts such as the Data Act, Data Governance Act, Digital Markets Act, and Open Data Directive are all aimed at creating a framework to facilitate data-sharing and innovation based on EU wide data availability, while ensuring privacy and interoperability. A sector-specific regulation on EV data sharing is expected in late 2022 (Ennis and Colangelo, 2022).

Most important smart charging related legislation.

1.4 Market maturity

In addition to the need for an expansive regulatory framework, large-scale smart charging and V2X will depend on the maturity of existing, modernising, and new markets. Market maturity can be measured by the share of the market potential that has already been exploited by market participants (Baudry and Dumont, 2016; Reeves, Rai and Margolis, 2017). In general, newer markets – such as the charging infrastructure market – are less mature as regulatory barriers and uncertainty regarding future market development can withhold actors to participate in the market.

The automotive market has experienced a high degree of maturity for decades, during which customer needs remained stable and the position of leading vehicle manufacturers has been consolidated. The introduction of EVs has changed the market dynamics drastically, leaving the e-mobility market much less mature than the general automotive market. Innovations and improvements in battery cost, battery range, and charging time provide market participants with growth opportunities. Further development of the e-mobility market is still necessary to guarantee a smooth integration in the smart charging and V2X ecosystem. Elements such as communication between EV and charging station and the sharing of battery data need to be developed further, while ensuring the increasing affordability of EVs.

The charging infrastructure market is a relatively novel and quickly developing market, shaped by technological developments – such as faster charging speeds and the emergence of bidirectional charging – and the integration of new market roles in the market. European wide legislation aimed at accelerating the growth of charging infrastructure has led to improved interoperability and an increase in the total number of both public and private charging stations. Such legislation includes harmonisation of plugs at publicly available charging stations and pre-cabling of charging stations at parking spots of new and renovated buildings.

Despite these endeavours, deployment of charging infrastructure differs largely between Member States. Over 60% of publicly available charging stations are located in three Member States: the Netherlands, Germany, and France (European Alternative Fuels Observatory, 2021). This uneven deployment hinders the growth of EV market share as a whole, as concerns regarding range anxiety are closely associated with the number of available charging stations. Again, the Netherlands, Germany, and France are market leaders regarding the total number of electric vehicles, accounting for two thirds of the European fleet.

The charging infrastructure market continues to develop as more people without an own driveway are buying EVs, shifting the demand more towards public, rather than private, charging stations (European Court of Auditors, 2021). Furthermore, EV manufacturers are moving up the value chain by investing in their own charging infrastructure and setting up mobility services (ElaadNL, 2022a). Supplementary legislation at the European level is needed to deal with these processes and to ensure a comparable increase of charging infrastructure within the EU. Due to the fact that in many Member States charging stations are still operated by DSOs and the total number of charging stations is lagging behind its market potential, the charging infrastructure market can be classified as relatively immature.

Market maturity of mobility and charging services markets is still relatively low. Due to the recency of European-wide legislation on energy market flexibility, there are currently only a limited number of parties that provide smart charging services for end consumers. These parties emerged bottom-up in mobility and charging services markets as they saw opportunities to make profit. Recently, the first top-down approaches aimed at further market development have been established. For instance, in The Netherlands, the roadmap 'Smart Charging for All' (slim laden voor iedereen) started in 2022 with the goal of ensuring that 70% of EV drivers will make use of smart charging by 2025 (Nationale Agenda Laadinfrastructuur, 2022).

The electricity market has experienced steady growth in market maturity ever since the liberalisation of electricity and gas markets in the 1990s. The liberalisation process has been accompanied by a large number of European directives with the objective of improving fair market access, free trade, and consumer protection. These laws include three energy packages adopted between 1996 and 2009, allowing for a polished transition from national energy markets dominated by monopolies to an open market.

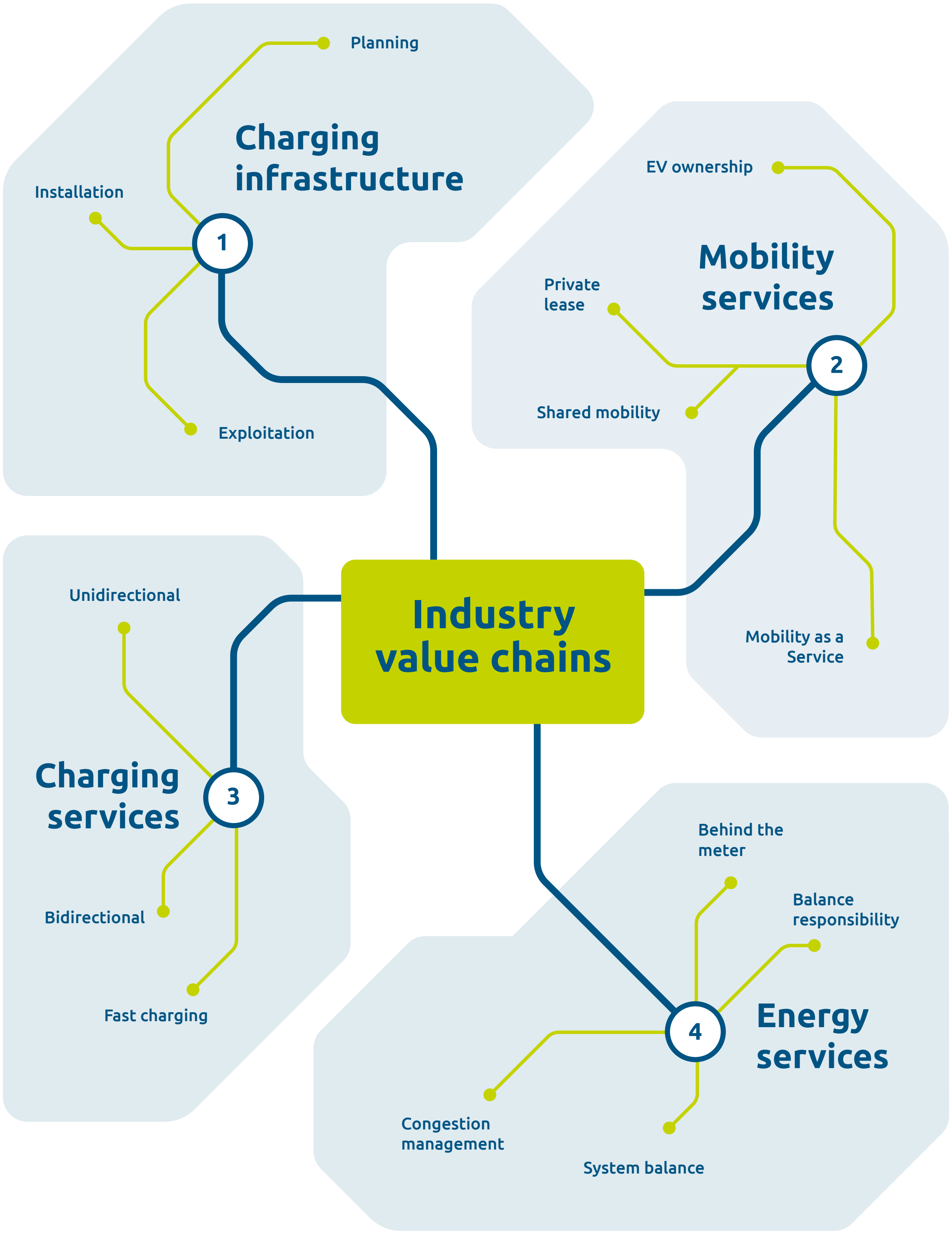
There are currently only a limited number of parties that provide smart charging services for end consumers

The development of distributed energy resources as flexibility sources is changing the dynamics of electricity market liberalisation. The CEP and Fit-for-55 package address this development by removing regulatory barriers to the trading of flexible energy. This includes incentives for system operators to procure flexibility. System operators are heavily regulated actors and are typically not active in the electricity market, creating new dynamics that require market development. Part of this recent development has been the establishment of flexibility market platforms that allow system operators to procure flexibility from distributed energy resources. Examples of such platforms are Equigy, GOPACS in the Netherlands, and ENERA in Germany (Valarezo, 2021; Dronne, 2021).

The recent energy packages enable customers to take a more active role in the electricity market, allowing them to monetise their flexible supply and demand for various energy services. The flexibility market in which these services can be offered is still relatively immature, so particular attention should be paid to potential market failures. Further research and market development are necessary to prevent such market failures and to clarify to customers what energy services are most profitable. The implementation of the Electricity Market Regulation and Directive have played a considerable role in the maturation of the flexibility market. In most Member States, it is possible to sign an energy contract with dynamic time-of-use prices (Enefirst, 2021) and customers are able to use even small loads as flexible sources (ENTSO-E, 2022). However, flexibility is still a growing market and in practice the supply of dynamic price and aggregation contracts is limited.

2

Industry Value Chains


Industry
value chains
1
Charging
infrastructure
Planning
Installation
Exploitation
2
Mobility
services
EV ownership
Private
lease
Shared mobility
Mobility as a
Service
3
Charging
services
Unidirectional
Bidirectional
Fast charging
4
Energy
services
Behind the
meter
Balance
responsibility
Congestion
management
System balance

2 Industry value chains

This chapter dissects the smart charging and V2X ecosystem into different industry value chains in order to analyse and understand different market models and processes within the ecosystem. The analysis is aimed at identifying different value streams and (market) roles present in each industry value chain, which will serve as fundamental input for the assessment of stakeholder's drivers, objectives, and barriers. Four industry value chains are evaluated: charging infrastructure, mobility services, charging services, and energy services.

2.1 Charging infrastructure

2.1.1 Planning

The planning of charging infrastructure is a crucial challenge both in the public and private domain. The adoption of EVs depends on the availability of charging infrastructure, while, simultaneously, the willingness for local governments and businesses to invest in charging infrastructure depends on the current and predicted EV uptake (Arias-Gaviria, 2021). This chicken-and-egg dilemma, combined with the total process length and installation costs, makes the planning process very complicated. As a result, the attitude towards the expansion of charging infrastructure differs largely between Member States. Two main approaches can be distinguished: a proactive approach – in which the installation process for new charging infrastructure is led by local governments or the business sector in advance – and a reactive or demand-driven approach – driven by driver requests for new infrastructure.

Recent European legislation has led to two significant advances in proactive planning, making it the dominant approach in most Member States. First and foremost, the ban on the sale of new fossil-fuels cars by 2035 has largely eliminated the uncertainty on future EV uptake, significantly mitigating the chicken-and-egg dilemma (European Parliament and Council, 2021a). The proposed Alternative Fuels Infrastructure Regulation (AFIR) sets specific targets for the installation of high power charging stations along the main European transport routes by 2025 and 2030. With regard to private charging infrastructure, the EPBD mandates the pre-cabling for smart charging ready charging stations in new and renovated buildings (European Parliament and Council, 2021b; European Parliament and Council, 2021c). Additionally, preventive grid reinforcement at home (single-phase to three-phase) or at larger buildings have become more common as a means to anticipate on future electrification.

With regard to public charging infrastructure, major cities within Western Europe are fading out reactive planning in favour of a data-driven approach. Data on the (expected) number of EVs, the availability of existing charging stations, and local grid capacity can be used to determine which locations require more publicly available charging stations. Local governments can decide whether to develop the necessary infrastructure themselves or give market participants the opportunity to deploy charging infrastructure via public tenders (Sustainable Transport Forum, 2020). Competitive tenders shift the financial risk from local governments to private market participants in exchange of control over the deployment process. In more mature markets, multiple market participants can compete in public tenders for the concession rights, which improves the chances of fulfilling additional requirements, such as smart charging capabilities, in the tender processes.

A potential obstacle in the planning phase is the total cost and duration of the installation process. Public charging close to home is the preferred charging method for EV drivers that do not have an own driveway. However, due to weatherproofing requirements, pedestal requirements, and permits, public charging stations are much more costly than private charging stations. On average, a normal power public charging station is three times more expensive than a residential normal power charging station, excluding grid connection costs (Jones, 2021). Furthermore, time-consuming tender processes and site preparation delays the installation of public charging stations compared to (semi-)private charging stations.

2.1.2 Installation

Charging infrastructure installation can be divided into three different components: civil work such as signage and pavement restoration, the cabling and installation of the charging station, and the connection between charger and the electricity grid. The process for private and semi-public installation is generally easier, as the existing grid connection and pre-cabling is usually sufficient and only occasionally requires local grid reinforcements. Furthermore, with regard to private charging, parts of the civil work process such as signage are not needed, further simplifying the installation process.

Public infrastructure installation requires coordination between site owners, grid operators, and charging station operators. Most public charging stations are installed in two phases. First, a preparatory phase in which the wiring and civil work is finished a few weeks in advance, and, second, the installation phase in which the charger is installed, connected to the grid, and formally registered (Bernard and Hall, 2021). Ideally, this process will be simplified and completed by as few parties involved as possible. This demands far-reaching coordination which is still missing in most major European cities and Member States in general. By authorising one party to carry out all three components of the charging station installation, the process can be streamlined and completed within one day. Such an approach is currently adopted in the Netherlands ("één arbeidsgang") (Stedin, 2019)

The installation of fast charging infrastructure is more complicated, costly, and time-consuming due to the grid connection needs and area requirements. Fast charging is done via DC charging, which means that the conversion from alternating current (AC) to direct current (DC) is done within the charging station. This allows DC charging stations to supply higher power, but it also means DC charging stations are larger, requiring more public space. The high power might demand a medium voltage connection. On top of this, possible congestion issues resulting from the high power demand of fast charging stations and more complicated licensing procedures add complexity and increase the total installation duration.

2.1.3 Exploitation

There are a handful of considerations that need to be addressed after the installation of the charging station, including data sharing, safety, functionality, and pricing. To improve usability, real-time information regarding charging stations needs to be readily available to EV drivers. This includes both static information, e.g. location, maximum capacity, and necessary socket, and dynamic information, e.g. availability and current price per kWh. Transparency of prices and free access to information increase user-friendliness and are therefore a prerequisite for further EV uptake. Ambiguity regarding the costs of the charging session, the charging speed, and the location of the charging station are some key bottlenecks still common for public charging nowadays (De Brey, Gardien and Hiep, 2021).

To ensure the availability of dynamic data, the communication between a charging station and a central system needs to be developed and standardised. Standardised communication protocols can also be used to communicate non-charging point related data, such as driver preferences (minimum state of charge required, etc.) in order to make use of smart charging. Similarly, charging station operators can forecast the total EV load, which can be used by system operators to predict peak demand in advance to timely mitigate grid congestion issues.

Billing is another important aspect applicable to public and semi-private charging. Billing consists of fee calculation, invoices and automatic collection of payments (Driivz, 2022). Site owners may want to charge fees for the use of charging infrastructure. These fees can be structured based on, for instance, energy consumed (price per kWh), session (fixed price per charging session), or subscription (fixed price per month/year). Payment can be done via credit card, RFID cards, or charging apps, but is likely to be simplified further with the introduction of Plug and Charge, which allows the automated billing process without the use of aforementioned payment methods (ElaadNL, 2021a). Extensive communication between charging station operators and mobility service providers has also made it possible to charge and pay at any given public charging station, regardless of car brand and subscriptions ("roaming").

Final considerations that need to be accounted for with regard to the optimal operation of charging stations are functional requirements. Preventive measures can be taken to prevent serious damage to equipment and to keep the charging system up to date. Intermittent maintenance consisting of visual inspections and charging tests will lead to the premature detection of faults and minor damage, preventing further damage – and thus higher costs – in the future. Software updates can also be realised in advance to account for modified standards and to prevent cybersecurity related issues. Charging station operators may still need to take reactive measures to fix physical damage and sudden malfunctions. Physical damage can be the result of poor installation like improperly mounted equipment, deliberate damage like graffiti, or miscellaneous causes such as vehicle collision or equipment degradation. Finally, sudden technical malfunctions – either with the supply power or within the charging station – can occur and may require a system reset or technical support.

2.2 Mobility services

The primary function of cars is mobility: getting from point A to point B. Access to your own car is commonly associated with owning a car, but this paradigm is changing. Private ownership entails a high initial investment as well as the expense and burden of maintenance, repairs, and insurance. Access to a parking spot is also required, which is becoming increasingly difficult especially in cities as public space is scarce and building standards for new developments are changing, allowing for fewer parking spots per household. For electric vehicles access to charging infrastructure is also necessary. This requires investment in a private charging station or availability of public charging infrastructure. The main benefit of private ownership is complete control of and access to the vehicle. The additional advantage of owning an electric vehicle is the ability to integrate it into Home Energy Management Systems and the potential to optimise electricity costs.

A company or private lease is an alternative to private ownership that still provides the benefit of accessibility. There are numerous variations depending on the contract, but the general idea is to make the driver's life easier. It alleviates the burden and insecurity associated with maintenance, repairs, and insurance, albeit at a higher monthly cost. Access to a parking space may still be an issue that the driver must resolve. For electric cars, a lease company could choose to offer smart charging services with the vehicle. This could benefit both the customer and the company, as there could be economies of scale from managing a larger lease fleet, whether it is cars or heavier vehicles like vans or trucks.

Mobility was traditionally associated with owning or leasing a car, but the prevalence of shared cars has grown in recent decades. The majority of cars are parked around 95% of the time. A car travels no more than 40 kilometres per day on average (ENTSO-E, 2021). In fact, few people drive more than 100 kilometres, whereas many more drive less than 15 kilometres daily. As a result, new value propositions for mobility services and car sharing can increase the utilisation of cars while also being financially beneficial and reducing parking congestion. Digitalisation and digital solutions have contributed greatly to this transition. Online platforms make it possible to share privately owned cars. However, car sharing companies are more common.

The majority of cars are parked around 95% of the time

Shared fleets are electrifying faster than privately owned cars because they drive more kilometres per year and thus have a stronger business case - EVs have a lower cost per kilometre than ICE cars. A larger EV fleet provides more charging flexibility as well as more opportunities for smart charging and vehicle to grid integrations. While meeting customers' need for mobility, the value of EV fleets can expand into offering flexibility on electricity markets, a role which is discussed further in the following section(s).

Shared EVs are also important in the larger picture of MaaS (Mobility-as-a-Service). It enables a person to plan, book and pay for multiple modes of transportation to meet their mobility needs. It can include for example trains, buses, cars, bicycles and Light Electric Vehicles such as scooters and mopeds. The prevalence of MaaS is growing, especially in urban areas and among younger generations. It is promoted by (metropolitan) regions as a way to reduce car ownership and emissions in order to improve air quality and utilisation of public space.

2.3 Charging services

2.3.1 Unidirectional (certainty, costs & carbon footprint)

Before a charging session can take place, alternating current (AC) from the grid must first be converted to direct current (DC). This is done with the help of an inverter, which is placed either in the EV (AC charging) or in the charging station (DC charging). As AC charging stations do not require the implementation of an inverter, production and operational costs are significantly lower than DC charging stations, with the charging station also being much smaller in comparison. Furthermore, whereas DC charging systems have a variety of different plugs, all EVs and AC charging stations within the EU are equipped with the same plug and socket outlet. The higher availability of AC charging stations as a result of cost efficiency have led to normal power unidirectional charging being the prevailing type of charging method. DC charging does have a significant advantage over AC charging: the charging speed. The inverter in a DC charging station can be much more spacious than the inverter in the EV, because weight and size limitations are less of a concern. Whereas AC charging stations generally deliver a maximum capacity of 11 kW with some exceptional stations providing 22 kW or 43 kW, DC charging stations are able to deliver charging capacity of at least 22 kW, going up to as much as 400 kW, charging an EV up to 80% within 30 minutes (Netherlands Enterprise Agency, 2019; Gilleran, 2021).

The rapid uptake of EV usage and the subsequent increase in EV charging – both AC and DC – causes severe issues with regard to electricity demand predictability and grid congestion. EVs can also prove to be part of the solution by modifying when and at what speed an EV is charged, also known as smart charging. Smart charging can be triggered to charge when there is a high share of sustainable electricity in the energy mix, to shave demand peaks and avoid grid congestion, or to charge when the electricity prices are at their lowest. Data availability is a prerequisite to get the most value out of smart charging, as the optimal charging profile is decided by smart technology and algorithms. The EV driver needs to communicate the expected parking time (or time of departure), the desired minimum state of charge, and the preferred application of smart charging (i.e. as cheaply as possible, using as much sustainable energy as possible, etc.). Furthermore, the current state of charge of the EV battery and the maximum supported charging speed by both the EV and the charging station need to be shared to ensure optimisation.

The prospect of smart charging is becoming more interesting every day. The necessity to charge smartly is growing as grid constraints and demand and supply fluctuations are becoming increasingly problematic. Different business models are currently evolving to use the flexibility of the EV charging process to charge cheaper, greener, and safer, which will be touched upon further in section 2.4. Technological advancements have likewise led to an easier and more efficient smart charging process. Automated communication between different actors in the smart charging chain eliminated rigid elements of the flexibility procurement process, allowing for a faster and safer exchange of information, energy flows, and financial compensation. EV charging is also becoming a more appealing source of flexibility, as the maximum charging speed is improving over time. As the maximum charging speed is increasing, the bandwidth of charging capacity in which smart charging can be deployed increases as well. It should be noted that from the e-driver's perspective charging smartly is less appealing at very high charging capacity, as the desired parking time at fast charging stations is much lower compared to normal charging stations. Therefore, the optimal charging capacity for smart charging is likely to be 11 or 22 kW.

Despite these developments normal ('dumb') charging is still the default. Awareness of smart charging possibilities is still scarce in most Member States. In Member States where different tariffs for day and night consumption are commonplace, such as France, smart charging is already growing in popularity by charging EVs during the night at off peak tariffs. Among EV drivers that have no experience with it, scepticism persists due to perceived uncertainties regarding revenue streams, delivered state of charge, and lack of control over the charging session. On the other hand, EV drivers that do make use of smart charging are generally positive (Kubli, 2022; Rijksdienst voor Ondernemend Nederland, 2022). This leads to the conclusion that it's valuable for the acceptance of large scale smart charging to start introducing the concept as soon as a new driver starts charging. In order to do this, the deployment is dependent on the maturity of flexibility markets. Such markets have only emerged recently after major barriers were addressed by the EU's Clean Energy package. Optimal business models and use cases for smart charging need to be fleshed out further to allow the growth of these markets.

2.3.2 Bidirectional (V2X)

EVs can also make good use of bidirectional charging due to the ability to store a lot of energy within the battery. The essence of bidirectional charging, also known as Vehicle-to-Anything (V2X), is to use the storage capacity of the EV for non-mobility related purposes. Discharging an EV battery can be used to better control energy in a home (V2H), a business (V2B), a depot (V2D), or even feed electricity back into the grid (V2G). Optimising the energy usage of a building or an EV fleet via the use of behind the meter charging or virtual power plants can drastically lower the costs of EV charging. A combination of locally generated renewable energy, battery storage, and peak demand reduction can reduce the dependency on the grid, thus lowering total costs. V2G on the other hand responds to grid conditions, rather than local circumstances. Because electricity is discharged directly into the grid, more stringent grid connection requirements are necessary. On the flipside, V2G can be used for grid-related flexibility services, making it an appealing alternative to local optimisation.

Although the first models capable of delivering V2X were already introduced by Nissan and Mitsubishi in 2011 in Japan as a response to the Fukushima nuclear disaster of 2011 (Jones, 2013), the market has not yet developed to a good size population. There are currently only a limited amount of EV models available that are capable of bidirectional charging. This standstill in development has to do with the communication chosen. The first Nissan and Mitsubishi models that provided bidirectional DC charging did so via the CHAdeMO protocol, for which the cars have an extra socket which is also used for fast charging. CHAdeMO was rare in the European market however and is currently being phased out. Most EV manufacturers in the European market make use of the Combined Charging System (CCS) for DC charging, with key market players such as Nissan and Tesla now also moving towards CCS. However, bidirectional charging is not supported by currently deployed CCS equipment. Likewise, market evolution for bidirectional charging is still in its infancy, with no EVs being commercially available and the required communication protocol (ISO 15118-20) having been released only in 2022 (ISO, 2022).

2.3.3 Instant fast charging

Fast charging (≥ 50 kW) is likely to become less prevalent in the near future due to increases in EV driving range and the number of public and semi-private charging station. Higher prices for fast charging additionally make it a less enticing option compared to slower charging alternatives. Despite this, there are still some use cases in which fast charging will remain useful, such as long cross-country travels. In the context of smart charging, instant fast charging is mainly of interest for heavy-duty vehicles. Heavy-duty vehicles such as trucks and busses have a deviant driving and parking pattern. Electric cars only drive 40 kilometres and are parked over 22 hours a day on average (ENTSO-E, 2021). Therefore they do not need to charge every day and when they do, there is a large time span to do so. Most trucks and busses, on the other hand, require a full state of charge and can only be charged at night, usually at a depot. Due to the size of heavy-duty vehicle batteries (240 – 320 kWh for trucks), a fast charging speed of 50 to 70 kW is recommend (ElaadNL, 2022b; ING Economisch Bureau, 2019).

Furthermore, the inefficient consumption pattern of heavy-duty vehicles – 0.3 kWh per kilometre for busses; 0.9 to 1.8 kWh per kilometre for trucks (ElaadNL, 2022b) – can result in the need to charge fast during daytime. This is especially the case for trucks that travel long distances or drive both during day and night. These heavy-duty vehicles may require a charging capacity up to 1 MW. Currently, the Megawatt Charging System (MCS) is being developed, which will support a capacity up to 600 kW by 2024 (ElaadNL, 2022b). Fast charging might coincide with other electricity consumption peaks during daytime, which may prompt the need for smart charging to avoid grid congestion. This is undesirable for the share of heavy-duty vehicles that need the high power to charge quickly during daytime. Other heavy-duty vehicles and passenger cars that do not require maximum capacity at all times – e.g. during mandatory breaks – might want to adopt smart charging to save costs.

2.4 Energy services

2.4.1 Behind the meter

Changing the charging process from an uncontrolled to a 'smart' way can provide valuable behind the meter benefits for EV drivers at home and at company sites. Behind the meter optimisation is manifested in a handful of use cases based on price, self-consumption and emissions (Tveit, 2022; Bons, 2020).

Price-optimised charging can be triggered by financial stimuli such as time-of-use (ToU) tariffs. The commitment to accelerate the deployment of smart meter systems, following the Electricity Market Directive, and to grant each final customer the opportunity to enter a dynamic electricity price contract made price-optimised charging a possibility for all EV drivers in the EU. EV drivers can benefit from electricity prices based on ToU tariffs and spot market prices by charging at times when electricity prices are low and interrupting the charging process when prices are high. Similarly, bidirectional charging can be used to feed electricity into the home (V2H) or business (V2B) of the site owner during periods of high electricity prices.

Site owners with solar photovoltaic (PV) production have the additional financial benefit of optimising locally generated electricity. As the price of electricity from the grid is in most Member States much higher than the feed-in tariff from solar PV produced electricity into the grid, it is valuable to increase self-consumption. Similar to dynamic electricity prices, the charging speed can be adjusted based on the availability of solar energy and the electricity demand: when solar PV production is higher than the total electricity demand of a household or building, the charging speed can be increased to match supply and demand. Meanwhile, during periods of peak demand, EVs can decrease the charging speed or not charge at all and vehicles with bidirectional capabilities can even supply extra electricity to a building to avoid high electricity prices.

By shaving the demand peaks for households a third financial benefit to smart charging can be achieved. In the majority of Member States, grid fees are based on a combination of energy (kWh) and capacity (kW). In Member States in which capacity charges apply, EV users are incentivised to even out their electricity consumption to stay within the contract range, in order to avoid expensive spikes in capacity fees. This is especially the case in countries in which capacity has a higher weighting on grid fees than energy, such as Spain (E.DSO, 2021).

Smart charging can also be employed to charge using more renewable energy

Smart charging can also be employed to charge using more renewable energy. Charging faster when the mix of renewables in the grid is high can potentially lower the footprint of all EV drivers, even those not owning solar PV themselves. This can be done in a more static manner by arranging a charging schedule between sunrise and sunset or in a more dynamic way based on day-ahead prognoses of CO2 levels (Tveit, 2022). Site owners with solar PV have additional possibilities to optimise renewable energy usage by measuring the local production of solar energy at a given time and adjusting the charging speed of EVs. Finally, using a home energy management system (HEMS), the charging speed can not only be adjusted based on solar PV production, but also on the consumption of other household equipment such as heat pumps.

2.4.2 Balance responsibility

Supply and demand of electricity has to be – roughly – in balance at all times to keep the grid frequency at 50 Hz. Imbalances can lead to power outages and deterioration of and damage to electronic equipment. They can also lead to inconveniences, such as digital clocks running late. To ensure electricity generation and consumption is balanced at all times, the EU employs the concept of balance responsibility. Each market participant is responsible for the imbalances they cause in the electricity system (European Parliament and Council, 2019a). In practice, small-scale consumers will delegate this responsibility to a balance responsible party (BRP), which is usually their energy supplier.

BRPs should buy the exact same amount of electricity their consumers will consume to keep their portfolio in balance for every imbalance settlement period (ISP) of 15 minutes. Most BRPs are connected to large energy suppliers that also exploit electricity generators, such as power plants and solar parks, which they can buy electricity from to partly balance their portfolio. Based on weather forecasts and predicted consumption patterns, a BRP estimates the surplus electricity which they need to buy (if demand is higher than supply) or sell (if supply is higher than demand) on energy markets to balance their portfolio.

Parts of this process are completed months or even years ahead on the forward energy market, other parts one day ahead on the day-ahead market, or close to real-time on the intraday market. Deviations in actual supply or demand can occur as a result of changing weather or consumption patterns. BRPs actively try to avoid the imbalances caused by these deviations, as they will be held financially responsible if they contributed to imbalance in the entire grid. One way to achieve this is to make use of demand response. For example, if actual production turns out to be lower than estimated, BRPs may want to incentivise their consumers to also lower their consumption. Compensating consumers for lowering their consumption can be a cheaper alternative to buying deficit energy on the intraday market at much higher prices.

The ability to quickly change the intensity of the charging process makes smart charging a viable opportunity to provide demand response. However, most Member States require that demand response bids on the day-ahead and intraday market have a minimum size of 100 kW (smartEn, 2022). This demands the intervention of a new market role, known as the aggregator. The aggregator accumulates flexibility of customers and trades it on wholesale markets using bilateral contracts. The role of the aggregator is not only to allow small-scale customers to operate indirectly in energy markets, but also to act as an intermediary between BRPs and flexible customers.

2.4.3 System balance

Despite the efforts of BRPs to maintain balance in their portfolio, system imbalances can still occur in real-time due to forecast inaccuracies and outages of generators. The TSO, responsible for the real-time balancing of the grid, operates on the balancing market to procure and activate balancing reserves. The TSO has access to four different balancing reserves (FCR/aFRR/mFRR/RR), distinguished by the response time, ramp rates, and method of activation (automatic/manual) (European Commission, 2017).

Participation in balancing markets for small-size customers is similarly limited by the need for aggregation, as most Member States set the minimum bid size for balancing reserves at 1 MW (smartEn, 2022). Within the balancing market, the aggregator needs to be prequalified as a Balancing Service Provider (BSP). Customers can reach an agreement with a BSP to adjust their supply or demand at a given time, for which it will be compensated. The BSP combines the flexibility of a large number of customers and places a bid on the balancing market, specifying the bid size and the ISP in which the flexibility is to be activated. When the bid is activated, the TSO will compensate the BSP according to the imbalance price, which will eventually be transferred to the BRPs responsible for the system imbalance.

Providing flexibility on balancing markets might prove to be a lucrative use case for EV users. An EV user could reach an agreement with a BSP to temporarily diverge from its usual consumption pattern, by disclosing the desired time of departure and state of charge to the BSP in advance. The BSP can strategically decide when to adjust the charging process of an entire EV fleet, in order to meet its bid on the balancing market (AlSkaif, 2020). This process is applicable to both regular smart charging and V2G. Demand response via smart charging can be deployed to charge slower when demand exceeds supply. However, as EVs typically already charge at the maximum capacity, charging faster when needed is not possible in most situations. A solution would be to lower the default charging capacity slightly to broaden the bandwidth in which smart charging is possible (ElaadNL, 2020).

The holy grail of smart charging in balancing markets is V2G, in which the EV can not only assist in balancing the grid via demand response, but it is also able to feed electricity back into the grid. Smart charging adds three options to the charging process: speeding up, slowing down, and pausing the session. Bidirectional charging adds a fourth crucial option: energy supply. As a result, the power range of EVs supporting V2G is twice that of regular EVs, meaning that the potential provided flexible power is also up to twice as high. Additionally, whereas regular EVs can no longer provide flexibility when the battery is full, EVs supporting V2G can still aid in frequency balancing by supplying electricity to the grid.

2.4.4 Congestion management

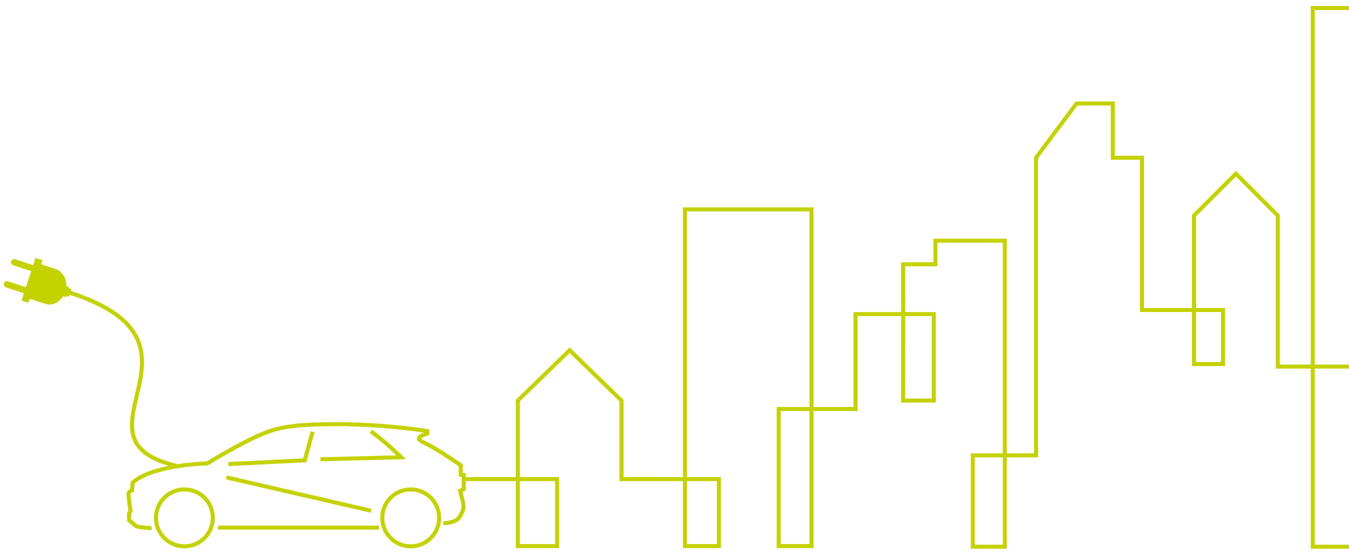
The rapid electrification of the building and mobility sectors, among others, is increasingly leading to grid congestion. The high simultaneous demand in power of electronic equipment can put serious constraints on the grid capacity, especially at peak hours. Even at low-voltage, EV chargers usually demand between 3.7 and 22 kW, compared to an average household peak grid load of 1.5 - 2 kW (ElaadNL, 2020). While the electricity grid can generally handle an occasional peak load well above 2 kW per household, a large number of EVs charging simultaneously will lead to grid congestion. Similarly, generation peaks of solar energy on sunny days can lead to supply-side grid congestion.

The concept of congestion management is not as well developed within European legislation as balance responsibility and system balancing

Historically, grid congestion was averted long-term by investing in grid reinforcements. However, such investments are expensive and system operators are currently not able to keep up with the pace of electrification. The alternative to costly investments is congestion management: interventions executed by system operators at the supply or demand side in order to prevent or mitigate grid congestion. The most interesting application of congestion management in the context of e-mobility is peak shaving: using smart charging to shrink the total peak demand by temporarily interrupting the charging process of an EV. Demand charge reduction can be done separately for a large number of EVs, but it is also possible to distribute a certain, strictly controlled, amount of power over a number of charging stations, which the stations as a group have to stay within. The more EVs are simultaneously charging, the lower the charging speed of each individual EV. On the plus side, a higher active charging power per session is feasible when only a limited number of EVs are charging, without a risk on grid overload. Additionally, bidirectional charging can be deployed at the local level to decrease energy needed from the grid by charging non-V2X cars with an urgent demand from the V2X-car or by supplying a building with energy from an EV fleet parked nearby, lowering the total demand at the distribution level (V2H/V2B).

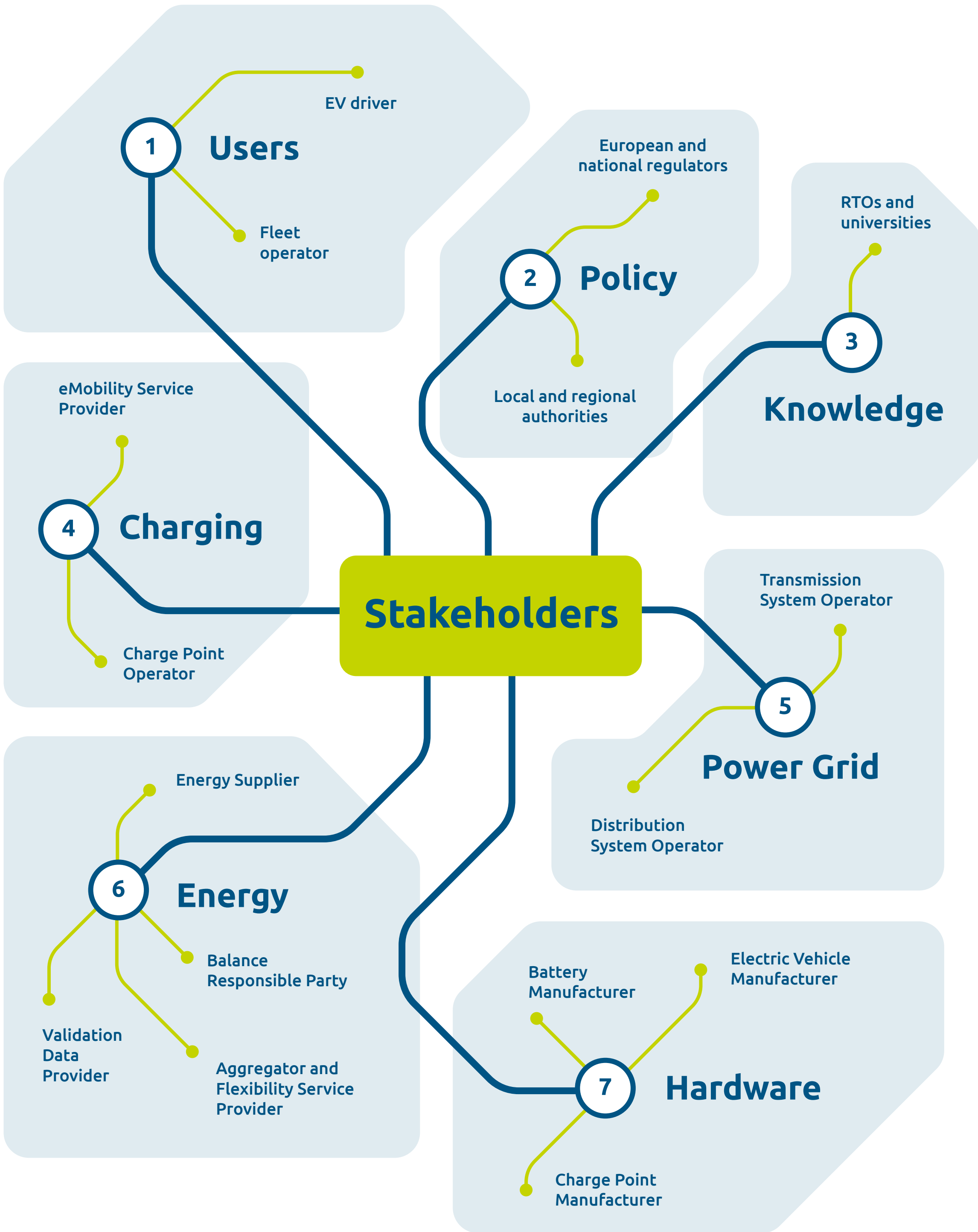
The concept of congestion management is not as well developed within European legislation as balance responsibility and system balancing. Prior to the Electricity Market Directive, most Member States did not allow system operators to procure flexibility due to unbundling requirements. Congestion management schemes have not been fleshed out in the majority of Member States due to a lack of a European wide framework and the recency of the Electricity Market Directive. Therefore, it is still unclear how congestion management markets will develop, how EV drivers will be compensated, and what market roles need to be developed further.

Furthermore, the activation of congestion management bids can lead to system imbalances and vice versa. For example, a system operator utilising smart charging in real-time to avert grid congestion will lead to an imbalance in the portfolio of the BRP, which needs to be compensated. Similarly, congestion management on the transmission system level can lead to congestion on the distribution level. A clear legal framework on the coordination between system operators, aggregators, and balancing market participants needs to be established. ENTSO-E, the European association for cooperation between TSOs, adopted the "One-System of Integrated Systems"-approach to improve cooperation between system operators, market participants, and customers with the aim to improve power flows and promote market platforms (ENTSO-E, 2018; ENTSO-E, 2021).



3

Stakeholders


Stakeholders
1
Users
EV driver
Fleet operator
2
Policy
European and national regulators
Local and regional authorities
3
Knowledge
RTOs and universities
4
Charging
eMobility Service Provider
Charge Point Operator
5
Power Grid
Transmission System Operator
Distribution System Operator
6
Energy
Energy Supplier
Balance Responsible Party
Validation Data Provider
Aggregator and Flexibility Service Provider
7
Hardware
Battery Manufacturer
Electric Vehicle Manufacturer
Charge Point Manufacturer

3 Stakeholders

This chapter identifies the main stakeholders in the smart charging and V2X ecosystem based on in-depth desk research, expert sessions, and input from SCALE partners. For each stakeholder, three key aspects are analysed: (1) the main driving forces for the stakeholder's interest in electric mobility, smart charging, and V2X services; (2) the most vital needs for the stakeholder towards the acceleration of large-scale smart charging and V2X services; and (3) the most crucial barriers identified by the stakeholder towards the acceleration of large-scale smart charging and V2X services.

3.1 Electric vehicle driver

3.1.1 Drivers

The primary concern of EV drivers is mobility. They have a car and want to know that they can get to their destination conveniently and affordably. This section focuses on the consumer – drivers of electric cars, and private ownership. Section 3.2 Fleet operators' covers cases where the driver is not the owner, such as a shared fleet.

EVs are more pleasant to drive than ICE cars, but the initial investment is still higher, and charging rather than refuelling requires both a behavioural and organisational shift. Early EV adopters frequently had their own driveway and charge point but as more people without a driveway purchase EVs, demand for charging infrastructure is shifting towards more public, rather than private, charging stations (European Court of Auditors, 2021).

Optimising charging requires giving users control and ownership over their own data

Early EV adopters have been accustomed to plugging in their car and charging starts immediately. However, charging patterns are beginning to shift, either as a result of external influence such as regulation or standards, or as a result of intrinsic motivation. Smart charging is becoming the norm. For private charging infrastructure the driver has more freedom of choice, but with public infrastructure decisions can be made centrally and rolled out on a larger scale, while still taking consumer (driver) preferences into account. Variations in consumer charging behaviour can be motivated by environmental ideology, economic incentives or be socially motivated

3.1.2 Objectives

A survey of 2241 Dutch EV riders in 2022 revealed that, above all, consumers want smart charging to be easy (87%), with access to transparent information (76%) and with the ability to control the charging session if necessary (73%) (Rijksdienst voor Ondernemend Nederland, 2022). Consumers prefer that charging their car requires as little effort as possible. And it's important that they know what to expect so that they can use their car for its main purpose – mobility. The reasons for adopting smart charging or V2X vary, and market propositions should reflect this. A consumer motivated by environmental ideology will likely want to charge as much renewable electricity as possible, whether generated by their own solar panels or from the market. Financially driven consumers charge as cheap as possible and respond to fluctuations in energy prices and grid tariffs. Socially motivated consumers respond to incentives around fair use and avoiding (local) grid congestion. Some consumers will be more active in managing their own choices, while others will rely on apps or smart home energy management systems to do so (ElaadNL, 2020).

3.1.3 Barriers

EV drivers want certainty that at the end of the charging session they have charged enough. Information about the charging session must thus be transparent and communicated clearly. Optimising charging also requires data from the EV and information from the driver, highlighting the importance of open data standards, and giving users control and ownership over their own data. Several Dutch pilot projects have also emphasised the benefits of an opt out setting to reassure drivers. It is almost never used (ElaadNL, 2021c), but it provides drivers with confidence and contributes to the acceptance of smart charging and V2X.

Range anxiety is frequently mentioned in the media as a source concern. In the Netherlands, with the most public charging stations in the EU (FIER, 2021) and a front runner in EV adoption, drivers have little range anxiety and it is decreasing (Rijksdienst voor Ondernemend Nederland, 2022). However, in the context of smart charging and V2X, charging 'enough' remains a concern. As a result, clarity, agency, and consumer awareness are important. Battery degradation is another concern. Research and subsequent communication on V2X and battery life is needed to alleviate this worry.

3.2 Fleet operators

3.2.1 Drivers

An EV Fleet Operator is responsible for managing and controlling EV fleet charging. Although this report focuses on logistics vehicles and shared cars, an EV Fleet operator could also manage taxis, buses, boats, construction vehicles or other EVs. The main challenge is to ensure that sufficiently charged vehicles are available when needed, taking into account charging times, expected operating time and charging cost optimisation (Ampeco, 2022). To adapt to this, current business processes may need to be modified.

EV fleets are a promising potential market for charging services because they can help fleet operators reduce costs by procuring and managing energy more efficiently. According to McKinsey, by 2030, the US market for energy-optimisation services to support the charging of electric-vehicle fleets could be worth $15 billion per year (Bland, 2020). Furthermore, the market size of EV fleets will grow dramatically: according to a study conducted by independent experts at TNO, by 2035, virtually all new electric freight trucks will be cheaper to run than diesel trucks while driving as far and carrying as much, and e-trucks will have a more advantageous total cost of ownership even sooner (TNO, 2022).

3.2.2 Objectives

The majority of logistics EVs are used during the day and parked at a depot at night, typically between 8 p.m. and 6 a.m. Smart charging is essential at the depot or charging hubs because plugging in all vehicles around the same time in the evening would result in a massive spike in electricity demand. To fully optimise cost and income, a fleet operator must react to electricity prices, grid costs and participate in flexibility markets. At the very least, the charging should be spread throughout the night. During operating hours, however, opportunity charging is used to minimise downtime, charging whenever possible, such as during a route stop or a mandatory break. By deploying smart charging and V2X when possible, electricity costs can be reduced and costly grid upgrades can be avoided, with the added benefit of increased resilience from the grid. An additional trend is to combine charging with energy storage and renewable energy generation and time-of-use arbitrage.

A shared electric car fleet has less predictable operating times and necessitates good algorithms and input data to make accurate predictions and optimal decisions. However, the same principles apply: smart charging can reduce costs by charging at off-peak times, V2X can optimise the savings, and a USP can be to run (primarily) on solar power

3.2.3 Barriers

The role of fleet operators will change as a result of electrifying fleets. Charging should not be an inhibiting factor to maximising EV fleet utilisation, but new business models can also be developed in which charging and discharging vehicles play a significant financial role. One challenge is that grid congestion is increasing as electrification grows. As a result, the market for charging services, platforms and other tools to help fleet operator manage their EV fleet is expanding. It is critical that open standards and protocols for both hardware and software are agreed upon or developed during this innovative stage.

3.3 Local and regional authorities

3.3.1 Drivers

Investment in charging infrastructure is one of the key driving forces for the transition towards electric mobility. Local and regional authorities play a crucial role in supporting the deployment of publicly available charging infrastructure. They can help shape the charging infrastructure market by controlling certain aspects of the planning, installation, and exploitation processes. Keeping in mind that in a competitive market multiple market participants are interested in operating public charging infrastructure, local and regional authorities can mandate certain requirements to make charging infrastructure future proof, i.e. requiring certain open hardware and software elements to support upgrades to smart charging and V2X. Both national and European-wide guidelines have been adopted in recent years to provide guidance for public tender procedures (Sustainable Transport Forum, 2020).

3.3.2 Objectives

The adaptation of multi-level regulatory frameworks can help overcome gaps in national policy frameworks. A certain level of standardisation of tender requirements can ease the public procurement process, especially for local and regional authorities in Member States that currently lack national guidelines. Standardisation of hardware and software requirements on a European level will remove inconveniences for CPOs, leading to an acceleration of public charging infrastructure deployment. Incorporating smart charging solutions into standardised regulatory frameworks can lead to additional benefits across the entire e-mobility value chain and ensure that newly installed charging infrastructure will be future proof.

3.3.3 Barriers

The installation process of public charging infrastructure is generally slow due to a combination of national legislation such as convoluted permit procedures and a lack of coordination between grid operators, site operators, and CPOs. The average time needed to install AC charging stations in major European cities is as high as 12 months in some cases (Bernard and Hall, 2021). Furthermore, while tender requirements on national and European level are generally well established, there is still vagueness regarding cybersecurity requirements and which communication protocols will become dominant in the future. Ensuring public charging infrastructure is future-proof in relation to data exchange is a significant barrier for local and regional authorities.

3.4 European and national regulators

3.4.1 Drivers

European regulators are driven by the need to accelerate measures to tackle climate change. In recent years, regulations aimed at decarbonising the transport sector have become increasingly ambitious, gradually sharpening targets from a 60% reduction of transport emissions by 2050 set in 2011 to a complete ban on new fossil-fuel cars by 2035 set in 2021 (Pollák, 2021). Specific European legislatorial acts to achieve this target are constructed in a manner to take into account key European principles. Legislation specifically aimed at e-mobility are assisted by strict rules on data sharing, free market principles, and fair competition to ensure the protection of consumer freedom of choice, technological neutrality, and consumer protection. Member States are bound to the targets set out and specific regulations and directive adopted by the European Union. Therefore, national regulators fulfil a key role in the accelerated transition towards e-mobility.

3.4.2 Objectives

In order to optimise the potential of e-mobility with regard to flexibility services, the acceleration of the e-mobility market should go hand in hand with measures taken related to smart charging and V2X. Necessary measures are ideally taken at the European level as much as possible, without violating the principle of subsidiarity, as to allow the harmonisation of national rules on e-mobility. From the perspective of cross-national stakeholders, such as EV and charge point manufacturers, MSPs, and energy suppliers, a European wide policy framework will greatly improve the possibilities to penetrate the European market as a whole, lowering consumer costs in the process.

The acceleration of the e-mobility market should go hand in hand with measures taken related to smart charging and V2X

Widespread awareness of smart charging and V2X needs to be developed to fully unlock their potential. The adaptation of multi-level regulatory frameworks in a smart charging and V2X perspective will be a major driving force towards far-reaching deployment of EV flexibility, but this will need to be accompanied with the right measures at all regulatory levels: from public tender procedures at the local level, to financial incentives at the national level, to the design of open standards at the European level. Likewise, the improvement of consumer awareness via public engagement, marketing strategies, and large-scale pilots is essential to allow EV flexibility to enter the public, and sequential, the political debate (Corchero, 2019).

3.4.3 Barriers

European and national regulators are dependent on a myriad of factors for the establishment and subsequent approval of new legislation. V2G related uncertainties, such as the effects of bidirectional charging on the power quality of the grid and battery lifetime, are still under discussion. The dependency on academic research and innovation and corresponding delays in necessary scientific data are a major barrier to the establishment of new legislation. Furthermore, a lack of political consensus, especially at the system operation level, complicates the harmonisation process. Fragmentation in national grid codes exist despite efforts from the European Union due to reluctances at the national level. This is mainly caused by the fact that system operators deal with specific characteristics of the transmission of distribution grids, such as the share of renewables in the energy mix and the current deployment of small-scale distributed energy resources, and harmonisation of grid codes are therefore not always deemed desirable.

3.5 RTOs and universities

3.5.1 Drivers

The primary purpose of research and technology organisations (RTOs) and universities is to act as an intermediary between research and development on the one hand and (local) industrial sectors, markets, and policymaking on the other hand. By disseminating scientific outcomes to the widest academic audience possible, RTOs and universities can contribute to knowledge sharing and synergy building between stakeholders of different sectors. In the context of smart charging and V2X, RTOs and universities have played a crucial role in studies on e-mobility related topics such as battery degradation, best practices related to smart charging, and grid impacts and potential value of V2X. Furthermore, academic knowledge has played a significant role in the development of inter-stakeholder tools, improving business-to-business interactions.

3.5.2 Objectives

In order to accelerate innovations related to e-mobility, strategic business partnerships should be developed between key stakeholders. RTOs and universities can play a critical role in the establishment of such partnerships by participating in European projects and supporting future research with quantitative and qualitative data. Long term agreements on issues of common interest, not only between universities and businesses, but also business-to-business, can foster mutual learning between the most critical value chain stakeholders. RTOs and universities can contribute to European projects by providing necessary data and knowledge and will benefit directly from project outcomes. A mutual framework in which knowledge and best practice can be shared is necessary to maintain long term collaboration, which goes beyond the SCALE project only.

3.5.3 Barriers

RTOs and universities are ultimately dependent on external factors for the acquirement of necessary information. A lack of funding, lack of dialogue between key stakeholders, and miscellaneous communication barriers have been named as potential barriers in long-term research programs. These barriers are likely to result in delays in results delivery. Considering the importance of research results for market development, necessary measures need to be taken to overcome these barriers

3.6 Charge point operator

3.6.1 Drivers

A charge point operator (CPO) installs and maintains charging stations from one or more manufacturers so that electric vehicles can charge. They are responsible for operating the hardware whereas the eMobility Service Provider (covered in section 3.7) is in charge of managing contacts and contracts with EV-drivers (Greenflux, 2021a). Many companies choose to serve as both CPO and EMSP, but these are distinct roles.

CPOs either buy charge stations from manufacturers to own and operate themselves, or operate them for an EV charge point owner. Furthermore, they provide diagnostics, maintenance, price tariff management, and other value-added services to ensure smooth network operation (Ampeco, 2022). They can influence the technology in EVSEs by specifying preferences for certain functionalities, such as smart charging or V2G, by exercising market power. Hardware choices are done based on the business case for each location. A DC charger, for example, is more expensive than an AC charger but can charger faster, making it more suitable for high-turnaround locations. AC chargers are less expensive and slower, making them ideal for destination charging at locations where the EV is parked for an extended time period, such as residential areas or office parking lots.

3.6.2 Objectives

The CPO benefits from high charge point utilisation and they want to minimise cost and maximise revenue. Smart charging proposals can account for this, optimising charging based on electricity prices, grid fees or grid capacity. Lower grid fees can for example be achieved through (virtual) clustering of EVSEs, or adjusting charging to available grid capacity. With the use of clustering, more charging stations can be added without requiring grid reinforcements. Flexible fees raise the grid fee when there is more grid congestion, whereas fixed fees with variable capacity reduce available capacity during peak hours. V2G is based on the same principles but also incorporates feeding into the grid. The current high and volatile electricity prices and volatility on the electricity grids (November 2022) are incentivising the development and implementation of smart charging and V2X. A greater price variance within a day creates more opportunities for optimisation.

3.6.3 Barriers

In order to scale up smart charging and V2X quickly, attention is needed for open standards and protocols for both hardware and software, as well as connectivity with grid data. Standardisation of tender procedures would provide clarity to CPOs for requirements regarding dynamic pricing schemes as well as smart charging and V2G operability and/or readiness. A basic set of requirements for public charging stations, which includes at least smart charging capabilities, would even out the total costs for installation and create a more level playing field for CPOs.

In many situations, a CPO prefers EVs to charge as quickly as possible and to stimulate EV drivers to make space when their EV is charged sufficiently, which would make smart charging uninteresting. Smart charging solutions should therefore include a balance between the number of charging sessions and the value of longer sessions due to smart charging and V2G. For instance, smart charging could be a lucrative proposition for CPOs at overnight charging, as the time that is needed to charge the EV is generally much lower than the time the EV is parked. Further elaboration of such business models is needed to ensure a CPO can generate the most value as possible. Open communication and exchange of needed data, e.g. EV driver preferences, is needed to facilitate the dynamic need for smart charging.

3.7 eMobility service provider

3.7.1 Drivers

The contracting party and point of contact for EV drivers is their energy mobility service provider (EMSP). EMSPs aim to make EV charging convenient for drivers by providing access to a large network of charging stations via a charging card or an app (Greenflux, 2021b). They standardise transactions and make billing and payments as simple as possible for drivers. Paying directly at an EVSE is a feature that is under development, but for the time being, payment for charging and billing are handled by an EMSP.

EMSPs also share real-time charging station data so that drivers can find an available station suitable for their needs. Furthermore, they can enter into roaming agreements with various CPOs to provide drivers with access to a large number of charge stations at predetermined rates. The EMSP role can be provided by a variety of companies, including energy suppliers, charge point manufacturers, consumer organisations, and others (ElaadNL, 2020).

3.7.2 Objectives

EMSPs play an important role in facilitating smart charging by offering propositions that respond to customer needs, combining charging needs with preferences such as low costs or charging on renewable energy. Different pricing models are possible, such as simply a mark-up on CPO prices, but complex tariff structures can also be simplified by the EMSP before being offered to drivers. Some customers prefer to make their own informed decisions about price, charging speed and energy source, whereas others prefer to be unburdened. EMSPs can help translating fluctuating market prices into a simple smart charging service, but they can also provide unique selling points such as smart charging on local renewable energy to their customers. Future energy markets with higher levels of renewable energy will have greater price volatility over the course of a day, necessitating greater flexibility. As previously stated, EV charging has the potential to provide a great deal of flexibility while also providing financial benefits. Furthermore, to offer even more flexibility on the market, EMSPs can take on the role of aggregator, as further explained in section 3.12.

3.7.3 Barriers

Further access to transparent information when providing smart charging services is needed. It must be clear to the customer what options are available and what the associated benefits are. EV drivers still face range anxiety and want to keep control over the charging session, which reduces the possibilities of other stakeholders in the ecosystem – including EMSPs – to fully utilise the potential flexibility. One possible solution an EMSP can make use of is to guarantee a minimum amount of energy served within a certain time period in the customer proposition. Likewise, for V2X propositions a possible inclusion is to never discharge the EV battery below a predefined level. Such flexible solutions to entice the EV driver to charge smarter must be developed further and must not be hampered by legal or financial barriers. A key barrier still existing in this context is the lack of access to proprietary EV data such as the state of charge. Giving customers control over this data allows them to enter flexible contracts with EMSPs and optimise the added value of EV flexibility across the smart charging ecosystem.

3.8 Distribution system operator

3.8.1 Drivers

According to the Electricity Market Directive, the roles of the DSO consist of "operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity (European Parliament and Council, 2019b)." Concretely, the DSO fulfils three roles within the electricity market: connecting distributed energy resources and the vast majority of energy consumers to the grid, physically transporting electricity flows across the distribution grid, and facilitating the market by managing registration of grid connections and market participants such as energy suppliers, BRPs, and flexibility providers. DSOs are held responsible for ensuring the availability of electricity for all consumers and will be held accountable for the frequency and average duration of system interruptions (also known as SAIDI and SAIFI, among others).

The roles and responsibilities of DSOs have not changed significantly over time, but meeting the objectives on system security have become more challenging as a result of the energy transition. With the rapid electrification of the energy system, issues regarding grid congestion and power quality on low-voltage grids are occurring at a higher rate than before. DSOs are currently not able to keep up with the pace of electrification simply by reinforcing the grid, as they face challenges regarding financing, lack of materials, and lack of personnel.

Recent pilot projects, such as FlexPower Amsterdam, have shown the advantages of non-firm capacity contracts specifically within the context of e-mobility

In contrast to the roles and responsibilities of DSOs, which have stayed more or less the same over the last few decades, the tools to deal with system security related issues have improved notably in recent years. DSOs were traditionally not allowed to actively participate in the electricity market as they were heavily regulated due to their status as a natural monopoly. Following the EU's regulations part of the CEP, DSOs are now allowed and incentivised to procure flexible assets in order to maintain system security (European Parliament and Council, 2019b). EVs capable of smart charging are a potential flexible asset to be used by DSOs in the near future.

3.8.2 Objectives

The most important need for DSOs is the incorporation of new tools in national, and in some cases European, legislation. DSOs should have the possibility to obtain flexibility via the connection and access contract. “Non-firm” access contracts would allow DSOs to remotely limit energy consumption or production at peak hours in exchange for a reduced network fee. Entering such contracts is currently not possible in most Member States due to incompatibility with national grid codes (EUniversal UMEI, 2021). A second tool DSOs could use is congestion management. If physical grid congestion can still not be averted, a DSO can request market participants to temporarily depart from their forecasted consumption and production patterns. This process, known as redispatching, was enshrined in European legislation in 2019, but is currently only fully implemented in a number of Member States, such as Finland, Ireland, and Portugal (smartEn, 2022). If even a market-based approach via redispatching is not sufficient to deal with grid congestion, mandatory controllability of assets at the grid connection should be possible as an emergency brake. An example of this is Gridshield, which is currently being developed in the Netherlands (ElaadNL, 2021b).

Ensuring coordination between system operators is another key objective for DSOs. DSOs need to cooperate with TSOs to make sure that congestion management measures do not lead to system balance related issues for TSOs and, vice versa, that operations by the TSO to ensure grid balance do not lead to grid congestion in DSO areas. Developing existing market platforms further and expanding them to other Member States is a prerequisite for a seamless system operation. Similar to this, the communication between DSOs and market participants is dependent on the availability and completeness of open communication protocols. To achieve this, protocols such as EEBUS, IEC 61850 and OpenADR must be updated and fine-tuned to the specific requirements of the e-mobility market.

3.8.3 Barriers

Non-firm access contracts are only sporadically available in the European Union. Only a few Member States currently allow for non-firm contracts or are in the process of implementing such variable capacity contracts in their national grid code. Recent pilot projects, such as FlexPower Amsterdam, have shown the advantages of variable capacity contracts specifically within the context of e-mobility (FlexPower, 2022).

Another major barrier associated with DSO flexibility services is the relative immaturity of congestion management markets, especially when compared to frequency balancing markets. Until recently, congestion management was only available to TSOs within the European legal framework. Many Member States are yet to clarify congestion management schemes for DSOs. Member States that have formulated rules and responsibilities for DSOs with regard to congestion management in recent years still face barriers related to market immaturity.

Certain barriers related to the procurement of EV flexibility by DSOs have been identified in these Member States. First, there are no unified European prequalification conditions for DSO markets, which leads to time-consuming and inefficient prequalification processes. Second, many Member States lack financial incentives to allow for voluntary congestion management by small-sized distributed energy resources, which restricts the DSO to mandatory measures by large electricity units only. Third, DSOs, which have historically been heavily regulated entities, now need to act based on market based principles when compensating consumers for voluntary congestion management. Many DSOs lack the necessary experience to do so. Last, the efficient management of distribution networks requires non-discriminatory access to metering data. This necessitates an extensive rollout of intelligent measurement systems. The mass rollout of smart meters is still a work in progress in the majority of Member States, with a penetration rate of 43% in 2020 expected to increase to 77% in 2024 (Tounquet and Alaton, 2019).

3.9 Transmission system operator

3.9.1 Drivers

TSOs are responsible for the reliable and safe operation of the electricity transmission grid. Safeguarding electricity supply is depended on the TSO's ability to maintain the grid frequency within predefined boundaries and to ensure that the transmission grid is able to transport the total electricity demand. Daily TSO tasks therefore consists of both resolving grid imbalances via the activation of balancing reserves (balancing) and preventing exceedances of the technical limits of the transmission grid by applying constraint management (e.g. congestion management at the high-voltage grid).

Increasing frequency instability resulting from the volatile production patterns of distributed energy resources, such as solar PV, forces TSOs to activate balancing reserves at higher total capacity and on a more regular basis. Historically, large power plants have been used to guarantee frequency stability, but their slower response time and high CO_2 emission output has dwindled their effectiveness. This leaves a lucrative market opportunity for smart charging and V2G in particular, as frequency balancing requires both up and down regulation of balancing energy. On the balancing market, TSOs can procure different reserves in order to restore grid frequency to tolerable levels. Frequency Containment Reserves (FCR) are the most optimal fit for smart charging and V2X, as it is needed most of the time, requires a fast response time (30 seconds), and requires high power (Roks, 2019).

3.9.2 Objectives

Balancing market prequalification processes need to be developed and standardised further, keeping in mind the specific characteristics of e-mobility. Most notably, defining the combination of charging station and EV as a single technical unit will simplify the prequalification process significantly, reducing redundancies and total costs. Due to the high total number of EVs and charging stations that can potentially provide grid services to the TSO, a future automated prequalification process should be defined to further advance prequalification efficiency.

It is possible that DSO and TSO activities on respectively the congestion management and balancing markets interfere with one another and can cause inadmissible effects on other system operator's activities. To prevent that measures taken by the TSO regarding frequency balancing cause grid congestion in distribution grids and, vice versa, that DSO activities on congestion management complicate the TSO's ability to maintain grid balance, there is a need for extensive cooperation between system operator. Such cooperation already exists in a number of Member States via market platforms such as Equigy and GOPACS, but legislation on system operation need to be revised to account for these new market platforms.

3.9.3 Barriers

Flexibility markets for TSOs are generally more mature than DSO markets. A European standardised framework has been put in place in 2017 following the guideline on electricity transmission system operation. Since the implementation of this regulation, multiple Member States have completed successful trials in which EVs have been used to provide FCR and other balancing reserves (TenneT, 2018;

Electric Vehicle Group, 2018). However, the balancing market is not yet fully equipped to deal with the specific characteristics of e-mobility. First and foremost, the minimum bid size on the balancing market in the vast majority of Member States is set at 1 MW, resulting in the need for the intervention of an aggregator. The addition of an aggregator in the flexibility frameworks leads to further complications, as the relations between aggregator and energy supplier, aggregator and BRP, and aggregator and system operator need to be recognised and established clearly in regulatory frameworks.

As the balancing market requires both up- and downregulation of balancing energy, EVs can most notably be of added value when they are capable of bidirectional power transfer. The vast majority of currently available EVs are not capable of providing these V2X services and a large scale adoption of V2X in the automotive market is not expected for at least a few years. EV flexibility on the balancing market is therefore limited to smart charging, which is considerably less flexible than V2X due to a smaller bandwidth and the inability to provide flexibility when the car battery is full.

3.10 Energy supplier

3.10.1 Drivers

Energy suppliers are the primary intermediary party between a consumer and the electricity market. Suppliers purchase electricity on wholesale markets via a BRP or directly from plant owners and sell it to consumers. In many Member States, energy suppliers fulfil a crucial role in the energy transition by compensating small-scale energy prosumers (e.g. households owning solar panels, or, in the future, households that make use of bidirectional charging) via feed-in tariffs or net metering. Suppliers are key enablers of the liberalised energy market and their roles and responsibilities have therefore been extensively described in European legislation. Consumers are free to purchase electricity from a supplier of choice and should be given transparent information on prices and tariffs. In return, suppliers are free to determine retail prices of electricity according to market based principles as to allow effective competition between suppliers (European Parliament and Council, 2019b).

3.10.2 Objectives

The gradual transition from internal combustion engine vehicles to electric vehicles enable suppliers to tap into a new market. In a sense, suppliers will act as the equivalent of filling stations for the e-mobility market. E-mobility is, first and foremost, a new business opportunity for suppliers as they will be able to sell more electricity and consequently generate higher profits. EV charging as a form of flexibility is another interesting prospect for suppliers with the use of dynamic pricing. The Electricity Market Directive allows suppliers in all Member States to offer dynamic electricity price contracts to consumers, the prices of which are directly linked to the prices of wholesale markets. Such dynamic pricing schemes will most likely lead to cost savings for both suppliers and consumers (European Parliament and Council, 2019b).

Communication across the smart charging value chain should be improved to maximise the value derived from EV related flexibility services. Communication protocols can aid in the automation of both business-to-business communication and communication between supplier and consumer's assets. Combining complementary back-end communication protocols is required for process optimisation. For instance, combining OCPP, used for communication between a CPO and a charging stations, with OpenADR, which a supplier can use for communication with a CPO, will allow for direct and delicate information exchange between the supplier and charging stations (Directorate General for Energy, 2021).

Suppliers struggle with determining a fair and competitive price for electricity fed back into the grid via V2G services

3.10.3 Barriers

Suppliers struggle with determining a fair and competitive price for electricity fed back into the grid via V2G services. In a few Member States, such as the Netherlands and Italy, a net metering rule was introduced to accelerate investments in distributed energy resources such as rooftop solar PV. Under the net metering rule, the value of injected energy is deducted from the value of withdrawn energy, so consumers only pay to their supplier the net difference between withdrawn and injected energy (CE Delft, 2018). Net metering is a showstopper for using bidirectional charging for consumption optimisation behind the meter as there are no financial incentives to store locally produced electricity.

In most other Member States, incentives are given in the form of feed-in tariffs. Consumers are paid a certain price for renewable energy, which is much lower than the price paid to a supplier for withdrawn energy and therefore encourage self-consumption. Such prices can be fixed or a premium dependent on wholesale energy prices. In the case of the latter, suppliers may face difficulties with setting fair and competitive premiums for V2G services, especially when benchmarked against other forms of renewable energy such as wind. The lower revenue certainty compared to fixed tariffs can be an additional risk to small-scale producers and consequently impede market integration (Council of European Energy Regulators, 2016).

3.11 Balance responsible party

3.11.1 Drivers

In principle, each market participant is responsible for the imbalance they cause in the electricity system as a result of a mismatch between electricity production and consumption. Small-scale consumers, such as the vast majority of EV owners, generally transfer this responsibility to a Balance Responsible Party (BRP). A BRP needs to balance its portfolio consisting of a large number of consumers and producers. The business model of a BRP includes optimising its portfolio as accurately as possible in order to avoid imbalance charges and to receive compensation when mitigating system-wide imbalances.

Portfolio optimisation has become increasingly difficult as a result of the growing electrification of the energy system. Deviations in forecasted weather patterns and unreliable consumption patterns can lead to an imbalance in the BRP's portfolio, which are undesirable due to imbalance charges. To keep imbalance charges as low as possible, deviations from scheduled production and consumption should be averted. Smart charging and V2X are an enticing source of flexibility for to BRP due to the ability to respond to short-term signals and, in the case of V2X, the ability to adjust both consumption and production patterns.

3.11.2 Objectives

The integration of flexible assets in wholesale and balancing markets is a prerequisite for the successful portfolio optimisation of BRPs. Questions arise when and how balance responsibility in these flexibility markets need to be assigned. This is particularly the case when flexibility is provided by an independent or third-party aggregator, i.e. an aggregator not linked to the BRP of the prosumer. A clear framework needs to be defined to deal with a handful of atypical interactions between BRP and aggregator, e.g. specific rules if an aggregator fails to deliver its pre-arranged flexibility services.

3.11.3 Barriers

As the wholesale and balancing markets require both up- and downregulation of balancing energy, EVs can most notably be of added value when they are capable of bidirectional power transfer. The vast majority of currently available EVs are not capable of providing these V2X services and a large scale adoption of V2X in the automotive market is not expected for at least a few years. EV flexibility on the wholesale and balancing markets is therefore limited to smart charging, which is considerably less flexible than V2X due to a smaller bandwidth and the inability to provide flexibility when the car battery is full.

3.12 Aggregator and flexibility service provider

3.12.1 Drivers

The aggregator is a new market role that has been enshrined in European legislation to allow small size prosumers to participate in flexibility markets. An aggregator bundles a large number of small assets and offers the aggregated volume on one of the flexibility markets on behalf of their consumers with the end goal of making profit or reducing total energy costs. Two main business models for aggregators can be distinguished: the energy supplier or BRP acting as an aggregator and the independent aggregator not affiliated with either the energy supplier or BRP.

Offering flexibility via smart charging and V2X requires the use of an aggregator due to the minimum bid sizes enshrined in European and national laws (< 0.5 MW on wholesale markets, 1 MW on balancing markets). Therefore, the roles of the aggregator and Flexibility Service Provider (FSP) show a high degree of overlap in the context of e-mobility. For the purpose of this report the aggregator and FSP are combined as a single stakeholder. It should, however, be noted that an aggregator is not necessarily an FSP, as, for example, a BRP acting as an aggregator for portfolio optimisation purposes does not sell its flexibility to the market.

3.12.2 Objectives

The value of aggregation can be enhanced by allowing aggregators to have non-discriminatory access to all potential flexibility markets. Member States are hesitant to allow independent aggregators access to wholesale markets because clear rules regarding payment and compensation to BRPs are still missing (Bray and Woodman, 2019). The establishment of a regulatory framework is necessary to guarantee non-discriminatory access of both independent and BRP/supplier-hybrid aggregators to all flexibility markets. This framework should take into account specific characteristics of e-mobility. Most notably, aggregators must currently specify the composition of the pool of flexible assets to a TSO when placing a balancing reserve bid. Since EVs can be disconnected from the grid unplanned at any time, aggregators should be able to change the pool composition close to real time to replace EVs that have been disconnected.

3.12.3 Barriers

Aggregators are reliant on access to data to build advanced scheduling models. Currently, there is no legal framework in place to guarantee aggregators free access to important data. Real time EV data, such as state of charge, is proprietary to EV manufacturers and European wide legislation requiring free and non-discriminatory data sharing will likely not be implemented by Member States in the next few years (Ennis and Colangelo, 2022). There is an additional need for transparent and extensive communication between system operators and aggregators regarding the needs of the electricity grids (e.g. when and how much flexibility is needed) and the compensation by system operators for the delivered flexibility. The lack of long-term price signals, standardised access to TSO markets, and uniformity of European DSO markets minimises the business case for aggregators. A further development of open communication protocols and prequalification processes for DSO and TSO markets is required to minimise operational costs (Directorate-General for Energy, 2021).

3.13 Validation data provider

3.13.1 Drivers

In order to streamline the delivery of flexibility services to the grid, platforms that facilitate data exchange between system operators and aggregators need to be developed. Today, delivering such grid services is mostly done by a small number of market participants operating a limited amount of very large power generating or storage units. Validation of the delivery in that process is audit-based. In the future, flexibility services will be delivered more and more by smaller assets, such as V2G, where new market participants in the form of aggregators offer flexibility from a large amount of small assets. These larger numbers lead to additional challenges to validate delivery.

The proposed validation concept is aimed at validating energy transaction by using data and measurements from parties independent from the aggregator. The underlying rationale is that by allowing for independent validation, trust can be added to the flexibility transactions, because the third party providing these measurements has no commercial interest in strategic bids (gaming). The most notable example of a data validation platform in the European market is the Crowd Balancing Platform by Equigy, which facilitates the registration, bidding, and activation of flexibility transaction from aggregators.

The organisational role for providing this data is called the Validation Data Provider (VDP). Any organisation trusted by the buyer (e.g. a TSO) and the seller (e.g. an FSP) and able to provide independent measures indicating flexibility delivery from single devices can qualify as a VDP. Some typical examples are, for instance, Original Equipment Manufacturers operating their device IoT systems, CPOs, and DSOs that share smart meter data. The concept is generic, supporting validation based on device data (behind-the-meter), data from certified smart meters, or even a combination of the two.

3.13.2 Objectives

Within the framework of data validation, different objectives for system operators and market participants can be distinguished. For system operators, when procuring flexibility for ancillary services and/or congestion management, there needs to be certainty that the aggregator actually delivered what was agreed on. Furthermore, behind-the-meter data is considered necessary as it adds more accuracy to smart meter data and allows for models where multiple service providers provide flexibility services from different sources on one grid connection point. For some markets in Europe, e.g. Germany, the smart meter rollout hardly started, so such data is currently not an option.

The primary objective for market participants like Original Equipment Manufacturers is to allow energy market entry for their devices through a low-cost model. In order to achieve this, it is necessary to have an infrastructure that allows for the registration and validation of these Distributed Energy Resources (DER). This infrastructure should be based on a European standard and open data infrastructure for trusted data exchange on DER level in order to enable mass integration of DERs in electricity markets in a way that fully adheres to data privacy regulations in an easy manner. As system operators are hesitant to spend substantial amounts for flexibility services if they cannot be certain of delivery, the design of such standardisation should incorporate rules on how to embed unique identification and validation data into the V2X ecosystem.

3.13.3 Barriers

There is a lack of standardisation when it comes to the data from Original Equipment Manufacturers which adds to the data processing challenges. There is currently no widely accepted model on how to gain consent from the EV owner to share data with third parties such as aggregators and system operators. Aggregators are reliant on access to this proprietary data to build advanced scheduling models. Regulatory requirements on data sovereignty, such as the GDPR and the ‘right to be forgotten’, need to be taken into account, as data silos with vulnerable central storage and cost-intensive security are still common. Data processing itself suffers from a lack of standardisation, which leads to non-transparent data usage.

3.14 Electric vehicle manufacturer

3.14.1 Drivers

The business case for traditional car manufacturers to invest in e-mobility and for new EV-only manufacturers to emerge in the market has been improving as a result of EU policy. The EV market has gradually moved away from a business model based on the luxury of EVs towards one based on their economic and environmental characteristics (Bohnsack, Pinkse and Kolk, 2014), increasing market penetration in the process. This was motivated by a growth in public knowledge and demand in EVs and by EU policies specifically aimed at decarbonising the mobility sector. The first major push was the commitment of having at least 30 million EVs by 2030, which was accompanied by a set of measures to improve charging infrastructure availability and to ensure enough EV batteries will be available to manufacturers. This commitment was enhanced in 2021 by banning the sale of new fossil-fuel cars and vans as of 2035. This effectively mandates current automotive manufacturers to fully switch towards the production of EVs to stay competitive in the automotive market in the long term (European Parliament and Council, 2021a).

3.14.2 Objectives

From the perspective of the automotive market, the transition towards smart charging and V2X readiness necessitates the adoption of an EU-wide policy framework in favour of EV manufacturers. Manufacturers are hesitant to invest in smart charging and V2X because of the investment costs, while not profiting themselves from the unlocked flexibility. The current lack of demand from potential EV buyers for smart charging and V2X functionalities makes it difficult to justify additional costs. A regulatory framework in favour of the automotive sector would at least include measures to increase awareness of smart charging and V2X for end consumers and financial incentives to boost demand, such as tax breaks for “V2X-ready” EVs. This way, manufacturers are encouraged, but not mandated, to add more sophisticated functionalities to their EVs. This regulatory framework should also not inhibit manufacturers to move up the value chain by setting up their own EMSP services, investing in their own charging infrastructure (executing the role of a CPO), or signing aggregating contracts with consumers and acting as a FSP in the process.

3.14.3 Barriers

The business case for EV manufacturers is largely influenced by the ongoing discussion on the effects of bidirectional charging on battery degradation. A definite consensus on battery degradation is still absent, though several studies suggest that battery degradation is limited when discharging occurs at normal state of charge rates, i.e. between 20% and 80% (Roks, 2019; Jones, 2021; Thompson, 2018). Keeping the state of charge within these limits either requires a smart battery management system - which may induce additional costs for EV manufacturers - or clear rules for flexibility market participants to minimise the use of V2X at extreme state of charge rates. Alternatively, revising current agreements on battery warranties might be necessary to allow compensation to EV manufacturers for V2X-related battery degradation.

The manufacturer’s current business case for specifically AC V2G is severely limited due to differences in national grid codes. Power-generating modules, such as solar panels, need to comply with specific grid code requirements when feeding electricity into the grid. The same requirements apply to storage units when they feed electricity back into the grid. In the case of AC V2G, the necessary software is placed inside the EV, as this is the place where conversion of DC to AC occurs. EV manufacturers therefore have to ensure that the EV does not violate national grid codes when the EV battery is being discharged. Ideally, national grid codes on power generation are uniform between Member States to enable the mass production of V2X EVs across the European market. In 2016, the EU established a set of grid codes to bolster harmonisation of national grid codes, which includes a grid code on energy production known as the Requirements for Generators (European Commission, 2016). This grid code did however not lead to the desired harmonisation of national grid codes, as some requirements were open to interpretation and Member States were free to add additional, more stringent, requirements. The existing differences between national grid codes form a major barrier towards the mass production of V2G-ready EVs.

The lack of a clear regulatory framework that defines the hardware requirements for smart charging and V2X is another major barrier for EV manufacturers. The existence of such a framework would allow EV manufacturers to officially claim that their EV is either smart charging ready or V2X ready. In a number of Member States, the formulation of such a framework is currently in progress, such as the Smart Charging Requirements in The Netherlands (Nationale Agenda Laadinfrastructuur, 2020). However, no frameworks have officially been implemented in national legislation thus far.

3.15 Battery manufacturer

3.15.1 Drivers

The manufacturing processes for battery cells and EVs are generally separated from one another due to the high costs associated with the procurement of raw materials for batteries and the knowledge necessary for the battery manufacturing process. Battery (cell) manufacturers, which have historically mainly been concentrated in eastern Asia, were able to establish themselves as key players in the previously untapped market of EV batteries (Coffin and Horowitz, 2018; HEV TCP, 2022). Potential supply chain issues resulting from the rapid growth of the e-mobility market can prove to be a major issue for battery manufacturers in the future. Sustainable procurement of raw materials, such as cobalt and lithium, is a primary concern for battery manufacturers to prepare a future-proof business model. Battery manufacturers not only have to deal with an upsurge in prices of raw materials due to a growing demand (e.g. the tripling of lithium prices between 2015 and 2019), but also the uncertain availability of raw materials from politically unstable countries (Eddy, Pfeiffer and van de Staaij, 2019).

3.15.2 Objectives

A European wide strategy is needed to help foster synergies between battery manufacturers and EV manufacturers. Battery manufacturers are hesitant to move towards Europe and EU-based manufacturers are even moving to Asia as a result of underwhelming industrial infrastructure compared to eastern Asia and inconvenient permit procedures (Eddy, Pfeiffer and van de Staaij, 2019). A coherent strategy to attract large-scale battery manufacturers towards the European market will aid in capacity building between battery and EV manufacturers, reducing total manufacturing costs within the EV value chain and eliminating most supply-chain risks for EV manufacturers. Many Member States can attract battery manufacturers due to internal political stability, access to international markets, and proximity of research facilities, but this may need to be accompanied with a European wide strategy. Furthermore, synergies between battery and EV manufacturers should be strengthened via bilateral contracts to ensure a concurrent growth in battery cell supply and total EV demand.

3.15.3 Barriers

Battery manufacturing is ultimately limited by the fact that very few alternatives to the currently used raw materials exist. Critical raw materials such as lithium and cobalt cannot be replaced cost-efficiently with the current technology available. Furthermore, these raw materials are extracted from only a limited pool of countries, which severely increases the risk of supply chain issues due to dependencies on unstable political and geographical climates. Agreements between battery and EV manufacturers need to be sophisticated further to take into account supply chain issues and to deal with challenges related to V2X manufacturing. The contemporary European legal framework does not sufficiently deal with said supply chain issues and technological developments.

3.16 Charge point manufacturer

3.16.1 Drivers

Charge point manufacturers make charge stations and sell them to CPOs or directly to businesses or individuals. The stations must meet certain regulated requirements, most notably related safety and grid stability, but a manufacturer has plenty of leeway on developing their own products and typically has a range of products that meet various needs, whether simple or smart, fast or slow, AC or DC, which protocols to use and so on. In their design process they either respond to market demands or take a more innovative approach, but they must then convince the market to buy their product. Furthermore, they have the option of developing functionalities in-house or accelerating the process by purchasing hardware or software features from third parties, which is especially relevant for new advanced features associated with smart charging and V2X.

3.16.2 Objectives

Charge Point Manufacturers are a crucial link in the ecosystem because they must provide products capable of smart charging and V2X. DC discharging stations have been available for some time, but they are more expensive. The development of AC bidirectional chargers is on the rise. As of 2022, there are already multiple manufacturers that provide bidirectional charging stations, but there is a lot of room for growth. Charge point manufacturers might be reluctant to invest in innovative services such as bidirectional charging capabilities, as it is currently not completely clear when a charging station can be deemed “V2X ready”. A clear definition of what requirements should be complied with, which communication protocols should be implemented, et cetera, can help charge point manufacturers create a clear long-term business case.

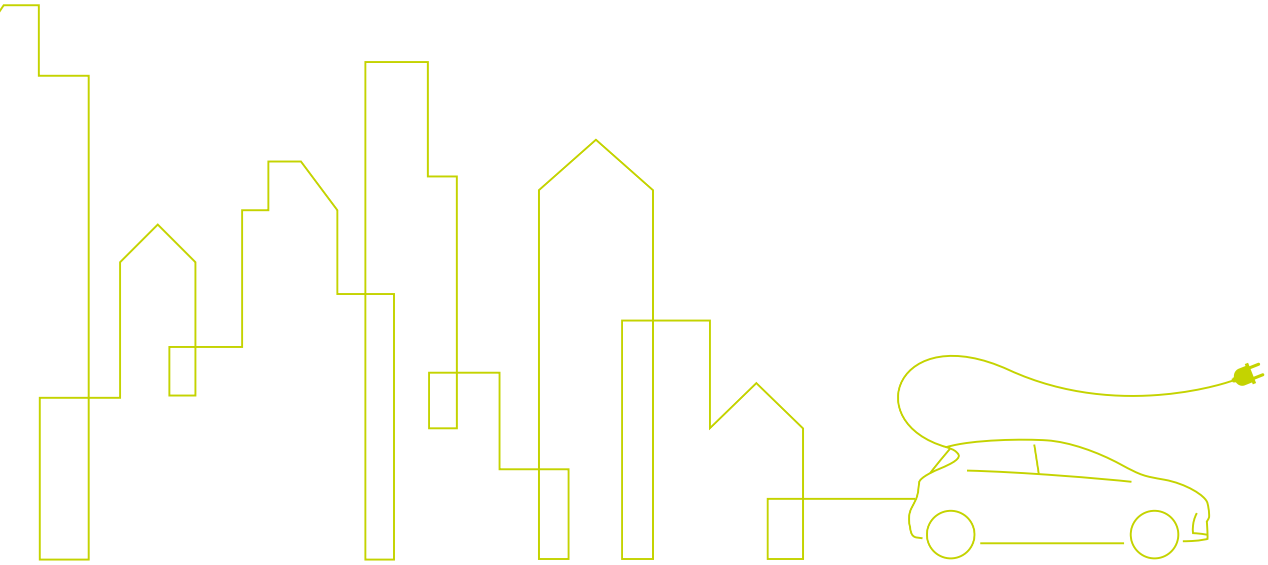
Similar to the EV manufacturer, a major barrier for charge point manufacturers is the absence of a regulatory framework that specifies when a charging station can be considered smart charging ready or V2X ready

3.16.3 Barriers

It is currently difficult to justify high investment costs for V2X charging stations as there are currently only a limited number of V2X ready EVs available on the market. Charge point manufacturers operating in multiple Member States are especially hindered by different tender procedures and grid code requirements. Building a European wide framework for charging infrastructure, which might include harmonisation of aforementioned tender and grid code requirements, would significantly improve the business case for charge point manufacturers to invest in V2X and mitigate the existing chicken-and-egg dilemma for V2G readiness. Similar to the EV manufacturer, a major barrier for charge point manufacturers is the absence of a regulatory framework that specifies when a charging station can be considered smart charging ready or V2X ready. The implementation of such a framework would enable charge point manufacturers to officially claim that they are able to provide smart solutions, thereby significantly improving their business case.

3.17 Concluding remarks

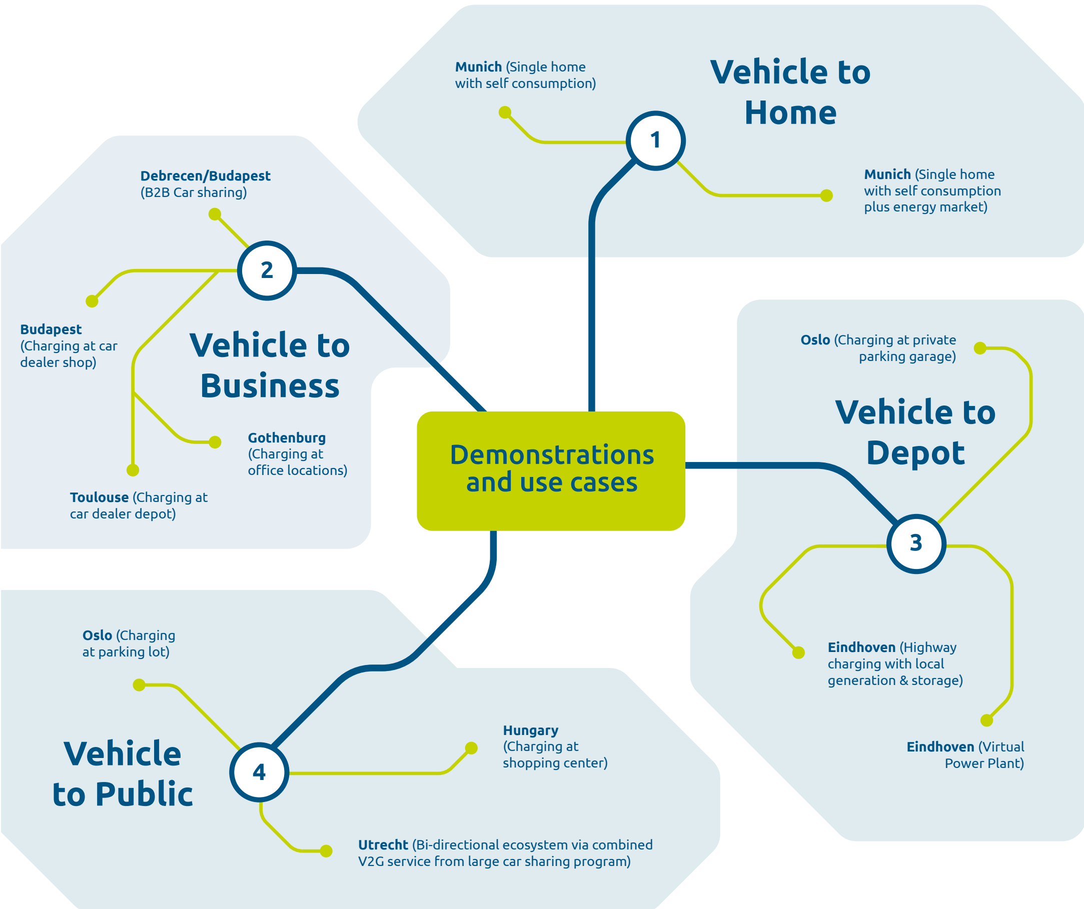
It should be noted that this report contains a preliminary overview of the stakeholders relevant for the SCALE project. Further assessment of the needs and barriers towards a large-scale adoption of smart charging and V2X will likely lead to the identification of new vital stakeholders in the smart charging ecosystem. For instance, by investigating the patent landscape of smart charging and V2X solutions, we will be able to identify new vital stakeholders and incorporate them in the project. Such stakeholders are not only newly emerging market participants with interesting in the SCALE project, but can also be market players with a vested interest of protecting their proprietary technological advancements. Identifying and incorporating these new stakeholders in the V2X system architecture is crucial for effective communication, cooperation, and synergy building at the European level.



4 Demonstrations and use cases

4 Demonstrations and use cases

In this chapter the needs, barriers, and recommendations from specific use case contexts, rather than for the smart charging and V2X ecosystem as a whole, are illustrated. Data, software, and hardware requirements, existing barriers, and possible recommendations are mapped on the aforementioned industry value chains and will serve as primary input for further SCALE work packages. The preliminary analysis of the use cases show a high degree of comparability between different use cases. For instance, multiple use case leaders named economic and societal factors, such as clear financial benefits for the end user and ensuring the ease of use of smart charging services, as the most important measures for the success of their pilot projects. To achieve this, specific attention should be given to the availability of 'V2X-ready' EVs and charging stations, including the implementation of communication protocols such as ISO 15118-20 and OCPP.



Munich

A1 Self-consumption in single family housing

A2 Extension enabling participation in energy market

4.1 Vehicle to Home

4.1 Vehicle to Home

4.1.1 A1 Self-consumption in single family housing (Munich)

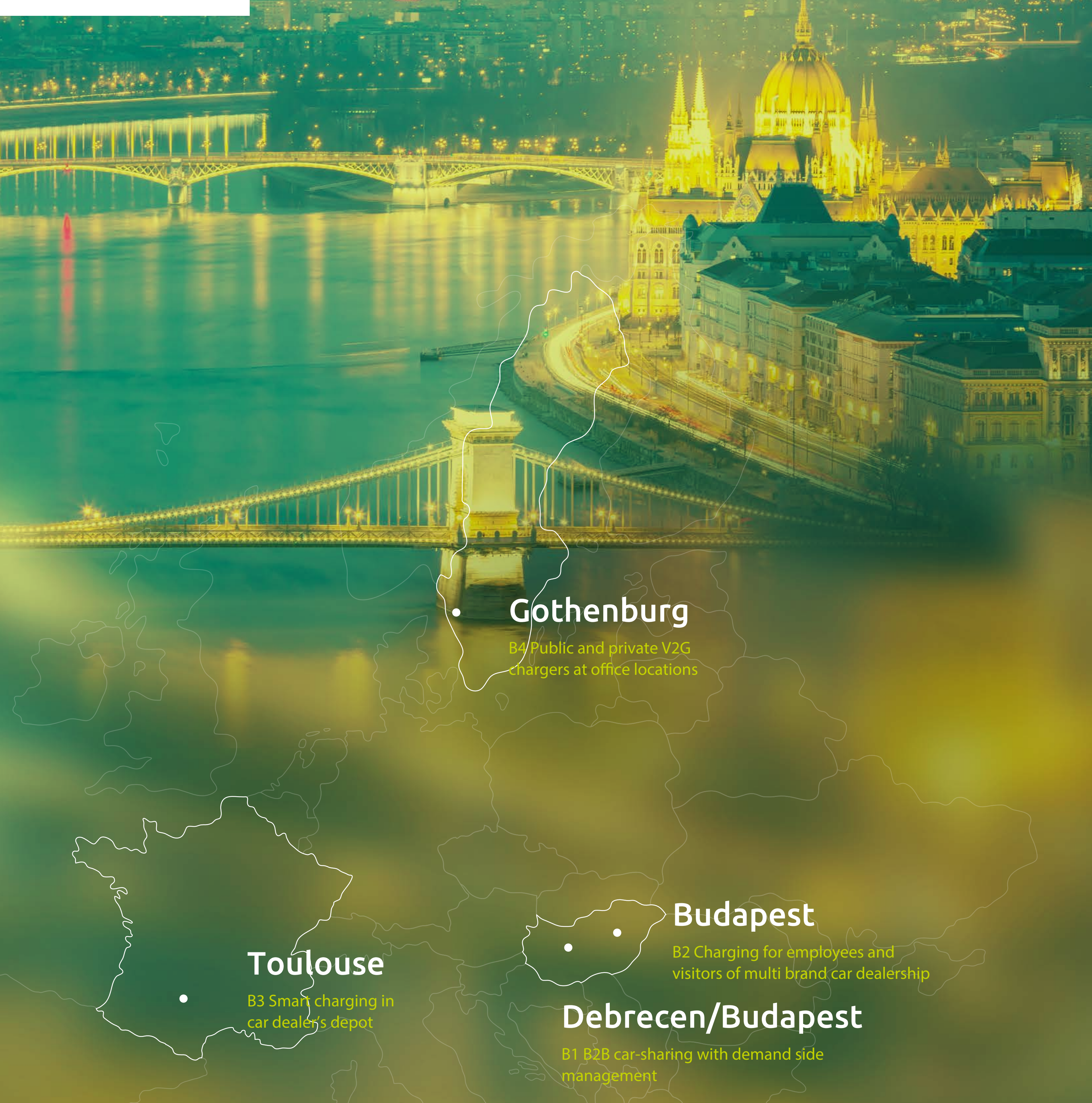
CATEGORY	FEATURES	REMARKS
VISION		
Context	Two households in the Greater Munich area with a Sono Motors vehicle and PV systems installed. The vehicle is used as mobile home storage (vehicle-to-Home).	
Stakeholders involved	EV OEM DSO EMS supplier TSO	SONO Motors LWN ENERVALIS Amprion
Motivation	Optimisation of local self-consumption by utilising the vehicle battery as home storage. Temporarily, storing surplus electricity from the building's rooftop PV system in the vehicle battery enables the owner to use more locally generated PV power. The motivation is to design a system that allows local electricity optimisation while respecting the user's mobility needs and reducing the complexity for the end customer for ensure usability.	
VALUE CHAIN & REQUIREMENTS		
Charging infrastructure	AC Bidirectional (V2H)	Integration of communication protocol ISO 15118-20. Ensure compliance with low-voltage grid-codes.
Mobility services	N/A	N/A
Charging services	AC Bidirectional (V2H)	Customer satisfaction on the control over the charging process.
Energy services	Behind the meter	Increased self-consumption and consequently lowered interaction with the grid.
USE CASE SPECIFIC SYSTEM ARCHITECTURE ELEMENTS (input for WP2)		
Functional requirements	• Control over the charging process and its parameters by the end user (Target SOC, Departure Time, Immediate Charge Target).	

Hardware	• V2H capable wallbox • Local HEMS-Controller • Smart Meter • V2H capable vehicle
Software solutions	• Implementation of the ISO 15118-20 standard in the car and wallbox • Implementation of control algorithms in the HEMS • Mobile app and vehicle infotainment for the user
Data	• Integration of PV installation, smart meter and wallbox into the HEMS • Integration of the HEMS backend and the SONO backend
Contribution to ASSESSMENT AND MONITORING FRAMEWORK (KPI) (input for WP 4)	
Demand flexibility & Storage resilience	• Optimisation of local energy system and usage of its flexibility.
Energy consumption & Grid integration	• The buildings are grid connected and will fulfil low-voltage grid codes. The electricity exchange with the grid will be reduced.
Economic viability	• AC bidirectional charging is cost efficient. Savings potential is dependent on national regulation and feed-in schemes.
Social acceptance	• Considered high as it is an individual support of the energy transition.
BARRIERS/RECOMMENDATIONS POLICY FRAMEWORK TO ENABLE MASS-DEPLOYMENT (Input for WP5)	
Legal (EU and national)	• Definition of "Mobile Electricity Storages" analogous to "Stationary Electricity Storages" in laws, decrees and regulatory instructions. • Affordable, simple and EU-wide and uniform requirements regarding metering concepts.
Grid code	• EU-wide, uniform requirements
Technical	• Definition of how grid-codes should be implemented in wallbox and vehicle to ensure interoperability. • Missing messages and signals in the ISO 15118-20 with regards to grid-code compliant implementation. • HEMS development and seamless integration to ensure high efficiency.
Data	
Market	• Open market without proprietary systems, for instance, in choice of HEMS.
Commercial	• The cost of the system must be compensated by the reduction in costs by increased utilization of solar energy. If the cost reduction is lower than the cost of the system, the commercial value will be low, as will the uptake.

4.1.2 A2 Extension enabling participation in energy market (Munich)

CATEGORY	FEATURES	REMARKS
VISION		
Context	Two households in the Greater Munich area with a Sono Motors vehicle and PV systems installed. Households are able to deliver power back to the grid (Vehicle-to-Grid).	
Stakeholders involved	Car OEM, DSO EMS supplier TSO BSP BRP	SONO Motors LWN ENERVALIS Amprion Equigy Local energy supplier
Motivation	Assess the potential of delivering power back to the grid via V2G technology from a single household. The goal is to increase the renewable energy utilisation and increase the flexibility and stability of the grid. The focus is on the technical solutions needed as well as on the usability for the end user, to find the optimal interface for the end user to control the (dis)charging.	
VALUE CHAIN & REQUIREMENTS		
Charging infrastructure	Exploitation	Integration of communication protocol ISO 15118-20.
Mobility services	N/A	N/A
Charging services	Bidirectional	AC bidirectional charging. Customer satisfaction on the control over the charging process.
Energy services	System balance & Congestion management	BSP Equigy includes the two households in its portfolio, customer control combined with BSP need for power is the challenge.
USE CASE SPECIFIC SYSTEM ARCHITECTURE ELEMENTS (input for WP2)		
Functional requirements	• Control over the (dis)charging process and its parameters by the end user.	
Hardware	• V2X capable wallbox	
Software solutions	• Implementation of the ISO 15118-20 standard (in the car and wallbox). • Interface for the user	

Data	• Integration of PV installation, smart meter & autonomous anti-congestion device, and wallbox into the HEMS. • Integration of the HEMS backend and the SONO backend. • Connection of Equigy's crowd balancing platform to Sono backend via API.	
Contribution to ASSESSMENT AND MONITORING FRAMEWORK (KPI) (input for WP 4)		
Demand flexibility & Storage resilience	• High	
Energy consumption & Grid integration	• The buildings are grid connected and will fulfil low-voltage grid codes. The grid integration is improved if electricity can be supplied upon demand.	
Economic viability	• AC bidirectional charging is cost efficient. Viability dependent on equipment and implementation cost as well as potential revenues.	
Social acceptance	• Considered high as it is a support of the energy transition.	
BARRIERS/RECOMMENDATIONS POLICY FRAMEWORK TO ENABLE MASS-DEPLOYMENT (input for WP5)		
Legal (EU and national)	• Definition of "Mobile Electricity Storages" analogous to "Stationary Electricity Storages" in laws, decrees and regulatory instructions. • Affordable, simple and uniform requirements regarding metering concepts. • No additional fees, duties and charges for mobile storages compared to stationary storages.	
Grid code	• Recommendation: EU-wide, uniform requirements.	
Technical	• Implementation of the Equigy Crowd Balancing Platform.	
Data		
Market	• Open market without proprietary systems, for instance, in choice of HEMS.	
Commercial	• The cost of the system must be compensated by the compensation from the grid operator or aggregator. The legal framework and the technical requirements for implementation define the necessary compensation.	



4.2 Vehicle to Business

4.2 Vehicle to Business

4.2.1 B1 B2B car-sharing with demand side management (Debrecen/Budapest)

CATEGORY	FEATURES	REMARKS
VISION		
Context	Carsharing fleet at "serviced office" locations by DBH. The carsharing program is available to users of the serviced offices.	
Stakeholders involved	Site owner Site user (operator) E-Mobility solutions DSO Fleet operator	S IMMO A.G. (parent company: CPI Property Group) ESTON (building operation) DBH Serviced Office E. ON AG DBH Serviced Office & GoodMoovs
Motivation	Showcase for a positive business case of EV-carsharing for the fleet operator and the user. For this, more information is needed on the end user and its preferences with regards to mobility modes. Reduce demand charging (peak shaving) and Time-of-Use shifting will be used to improve the business case. Establish a sustainable business model in the serviced office business market with the usage of smart charging, as monitoring and managing the energy consumption of the cars.	
VALUE CHAIN & REQUIREMENTS		
Charging infrastructure	Exploitation	Smart charging capabilities and V2B experimentation with building energy management system (provided the V2X cars are available).
Mobility services	Carsharing fleet	
Charging services	Unidirectional charging	Controlled charging (V1G) from central control Cluster of charging points must be and can be monitored and managed
Energy services	Behind the meter	
USE CASE SPECIFIC SYSTEM ARCHITECTURE ELEMENTS (input for WP2)		
Functional requirements	• Control over the charging process and SoC of the shared cars.	

Hardware	• Smart charging capable cars and charging stations • Dedicated hardware in cars for car sharing management platform functionalities.
Software solutions	• Implementation of the ISO 15118-20 standard (in the car and charging station). • Interface for controlling the booking, including integration with the building EMS. • Car Sharing software framework
Data	• Data integration with building EMS, pricing, and booking system. • Client's car sharing usage data and recharging preferences.
CONTRIBUTION TO ASSESSMENT AND MONITORING FRAMEWORK (KPI) (input for WP 4)	
Demand flexibility & Storage resilience	
Energy consumption & Grid integration	• Aims to shift electricity consumption away from a utility provider's peak hours. Using input from sensors and users, smart charging attempts to balance efficient electric grid usage with the user's charging needs.
Economic viability	• Due to the high price of fuel & taxes on company owned cars, it will pay better for business partners to make use of electric shared cars as part of serviced office services. • Generates revenue from car sharing service and smart charging capabilities to building operator.
Social acceptance	• User friendly system and interface for end users.
BARRIERS/RECOMMENDATIONS POLICY FRAMEWORK TO ENABLE MASS-DEPLOYMENT (input for WP5)	
Legal (EU and national)	• National policy recommendations on V2X requirements in office buildings. • Car sharing incentive policy recommendations. • Hungarian government policy will prevent businesses and households to feed-back renewable energy to the grid, due to overload concerns. • Permitting process is long and difficult.
Grid code	
Technical	• Barrier: implementation of ISO 15118-20 in the carsharing cars and charging stations. • Barrier: installing smart charging stations that are V2X ready and can cope with the future higher demands for CPU in the charger.
Data	
Market	• Lack of available V2X ready chargers. • V2X chargers and vehicles are not available or very difficult and costly. • Feeding back into the grid is barely profitable.
Commercial	• The commercial viability of the carsharing program must increase by using the cars in the VPP (virtual power plant), otherwise mass-market uptake will not be achieved.

4.2.2 B2 Charging for employees and visitors of multi brand car dealership (Budapest)

CATEGORY	FEATURES	REMARKS
	VISION	
Context	At Duna Auto based on the recently renewed internal electricity grid over 30 charge point (including AC, DC and HPC chargers) were already installed. A 400 kWp PV roof-system and a similar sized battery energy storage system will be installed in 2023. The green energy produced by the PV system will be optimally used by the buildings and the chargers since we will use demand side management. Optimised energy usage of EV chargers ready for ISO 15118 will also be supported through a dynamic load management system that is connected and synchronised with building energy management system. With the help of 1 or 2 additional bidirectional charges installed within the frame of the project as well as a few capable vehicles V2X, V2G, V2P scenarios could be experimented and utilised. Static and dynamic data of chargers would be provided for optimisation and research activities also demonstrating the practical usage of IDACS, how it can contribute to the ultimate charging experience.	
Stakeholders involved	Site owner, EMS as CPO and system integrator as well as EMP, Current, Enervalis, DSO, ABB	
Motivation	Duna Auto is a multi-brand car dealership. The site was built more than 30 years and it is going through a complete renovation. This includes besides the buildings and the basic infrastructures but also the entire business model as well. e-mobility solutions (EMS) will demonstrate a future proof complex energy system with minimal dependence on the public electricity network and maximising renewable energy usage both at the buildings as well as for related mobility needs. This concept could be adopted to all kind of business or industrial sites. The results and findings of the demonstration could be well used by the regulators in Hungary as well as in other CEE countries.	
	VALUE CHAIN & REQUIREMENTS	
Charging infrastructure	Exploitation	Additional V2G chargers could be installed

Mobility services	Individual / private fleet	
Charging services	Unidirectional / Bidirectional / Instant fast charging	AC and DC charging also supplied from the PV systems as well as boosted by the BESS at peak consumption periods
Energy services	Behind the meter / balance responsibility / system balance / congestion management	BESS to increase total power. In later phase flexibility service could be offered to the grid since the BESS is scalable
USE CASE SPECIFIC SYSTEM ARCHITECTURE ELEMENTS (input for WP2)		
Functional requirements	• Upcoming pillars such as PV System and BESS should be installed according to current plan and all kind of system planning should happen accordingly.	
Hardware	• V2X, V2G capable chargers and V2X, V2G capable vehicles.	
Software solutions	• Back-end and front-end extensions (e.g. DSM, dynamic load management, dynamic pricing, ISO 15118-20 standard.	
Data	• PV System, Battery, Building Energy System and Charging data to be feed in and used for optimisation, data exchange, roaming..	
Contribution to ASSESSMENT AND MONITORING FRAMEWORK (KPI) (input for WP 4)		
Demand flexibility & Storage resilience	• Optimisation of local energy system including PV system, BESS, and usage of its flexibility.	
Energy consumption & Grid integration	• The buildings are grid connected but the incoming grid power is limited. Increase of grid power capacity needs to be avoided. The electricity exchange with the grid (dependence) will be reduced.	
Economic viability	• V2X and therefore economic potential is dependent on national regulation and feed-in schemes.	
Social acceptance	• EV user acceptance risk is considered high. Right balance of rewards need to be explored.	

BARRIERS/RECOMMENDATIONS POLICY FRAMEWORK TO ENABLE MASS-DEPLOYMENT (input for WP5)		
Legal (EU and national)	• Affordable, simple requirements regarding procurement of flexibility services by grid operators • Netting rule • Affordable grid connection costs	
Grid code	• EU wide, uniform requirements.	
Technical	• Proper implementation of ISO 15118-20 in EVs needs to become widespread. • Proper implementation of smart charging and ISO 15118-20 in public charging points needs to become widespread. • BEMS development and seamless integration to ensure high efficiency. • Proper implementation of low-level communication for EVs to allow delayed charging.	
Data	• Open data and open-source development.	
Market	• Access to V2X ready EVs and charging stations	
Commercial	• The cost of the system must be compensated by the reduction in costs by increased utilisation of solar energy and BESS. If the cost reduction is lower than the cost of the system, the commercial value will be low, as will be the uptake.	

4.2.3 B3 Smart charging in car dealer's depot (Toulouse)

CATEGORY	FEATURES	REMARKS
VISION		
Context	At this depot where cars are stored before transported to the dealers shops, 8 chargers are placed. These chargers need to get the electric cars charged to around 50% SoC (or more depending on clients requested service) in a specific time frame.	
Stakeholders involved	Site owner MSP DSO	To be confirmed Current Enedis
Motivation	The deadlines and the needed SoC are relatively clear for the cars that need to be charged. The future of EVs flows are unknown, which makes the decision to equip the charging infrastructure difficult to optimise. It is therefore needed to have in mind smart charging strategies to better use the installed chargers and limit the power capacity. Therefore, this is the perfect opportunity to test smart charging peak shaving and time-of-use shifting. Specifically will be looked to reduce the costs. Trial will include signals from PV surplus in the area.	
VALUE CHAIN & REQUIREMENTS		
Charging infrastructure	Exploitation	V1G controllable charger
Mobility services	n/a	
Charging services	Unidirectional charging	Central controllable charging, able to differ charging power & shift time of sessions.
Energy services		
USE CASE SPECIFIC SYSTEM ARCHITECTURE ELEMENTS (input for WP2)		
Functional requirements	• Have insight in the data as to enable optimisation of charging strategies.	
Hardware	• V1G capable charging stations.	
Software solutions		
Data	• Access to the data of the site, depot, PV installation, and cars. This can be difficult since they have different owners. • Access to meteorological office local data for weather forecast.	

Contribution to ASSESSMENT AND MONITORING FRAMEWORK (KPI) (input for WP 4)		
Demand flexibility & Storage resilience		
Energy consumption & Grid integration	• Decrease of power capacity (in kW) after optimisation via smart charging strategies (10% to 30%). • Increase of Renewable share in energy consumption for EV charging (in kWh) (10% to 30%).	
Economic viability		
Social acceptance		
BARRIERS/RECOMMENDATIONS POLICY FRAMEWORK TO ENABLE MASS-DEPLOYMENT (input for WP5)		
Legal (EU and national)		
Grid code		
Technical	• Sub Metering each charging session. • Calculating the Renewable part of EV charging session. • Telecoms infrastructure quality in the area/site/chargers.	
Data	• Access to the data of the site, depot, PV installation, and cars. • Access to meteorological office local data for weather forecast.	
Market		
Commercial	Confidentiality of data and outputs	

4.2.4 B4 Public and private V2G chargers at office locations (Gothenburg)

CATEGORY	FEATURES	REMARKS
	VISION	
Context	At Chalmers university in Goteborg in a smart building parking garage there will be EV bidirectional charging with AC and DC chargers. The setup also includes a rooftop solar PV and a stationary battery.	
Stakeholders involved	Site owner & Local energy optimisation DSO TSO	Chalmers Göteborg Energy Svenska Kraftnat
Motivation	Research the potential of V2X technology. Areas of interests are self-consumption, peak shaving, price arbitrage, congestion management, and back-up power. By comparing the different services that V2X can fulfil in the Vehicle-2-Buidling Innovation Cluster, better choices can be made what services yield the most benefits.	
	VALUE CHAIN & REQUIREMENTS	
Charging infrastructure	Exploitation	AC & DC V2X capable chargers including rooftop PV and stationary battery
Mobility services	n/a	
Charging services	Bidirectional charging	Billing process, communication between EV and EVSE and DSO, and FCR contribution
Energy services	Behind the meter	SoC control for the user and energy management control of the building
	USE CASE SPECIFIC SYSTEM ARCHITECTURE ELEMENTS (input for WP2)	
Functional requirements	• Control over the charging process and SoC of cars and stationary battery, to be controlled for any car (also visitors).	
Hardware	• V2X capable charging stations and cars. • Stationary battery. • AC and DC bidirectional chargers.	
Software solutions	• Implementation of the ISO 15118-20 standard (in the car and charging station). • Interface for end user to control parameters for SoC. • Optimisation algorithm for the EV scheduling.	

Data	• Data integration with building EMS • Data integration with Spot electricity market • Data integration with solar insolation forecasts • Data integration with EV availability • Data integration with DSO and TSO requirements
Contribution to ASSESSMENT AND MONITORING FRAMEWORK (KPI) (input for WP 4)	
Demand flexibility & Storage resilience	• Providing time shifting of energy • Increasing the energy supply resilience by V2X • Increasing the lifetime of EV through smart charging
Energy consumption & Grid integration	• Increasing self-consumption • Providing flexibility to the grid
Economic viability	• Minimising charging cost of EVs • Minimising the energy cost of smart buildings with EV
Social acceptance	• Decreasing CO2 emissions
BARRIERS/RECOMMENDATIONS POLICY FRAMEWORK TO ENABLE MASS-DEPLOYMENT (input for WP5)	
Legal (EU and national)	
Grid code	• Requirement for market service by single EV and EV aggregators.
Technical	• Implementation of ISO 15118-20 in the carsharing cars and charging stations. • Installing smart charging stations that are V2X ready and can cope with the future higher demands for CPU in the charger.
Data	• Data availability from DSO and TSO for EV
Market	• Lack of available V2X ready chargers. • Lack of available V2X compatible EV.
Commercial	

Oslo

C1 B2B car-sharing with demand side management

Eindhoven

C2 Highway charging with local generation & storage

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

4.3

Vehicle to Depot

4.3 Vehicle to Depot

4.3.1 C1 B2B car-sharing with demand side management (Oslo)

CATEGORY	FEATURES	REMARKS
VISION		
Context	Mustad Eiendom, parking facilities in this community. Parking and charging of private and company cars in office dedicated private garage and for a shopping mall. Currently, there are around 120 chargers installed.	
Stakeholders involved	Vehicle users Fleet operator CPO & MSP Local energy optimisation DSO Flexibility provider TSO & BRP & BSP	Tenants (external) Hyre (external) Current ENFO/Current Elvia To be confirmed Statkraft
Motivation	Public charging is an important factor, especially in cities. In this use case will be showcased what the impact is of the different smart charging services can be. Implemented will be peak shaving, time-of-use shifting, and price arbitrage, but also providing back-up power and optimising behind the meter charging with V2X capable cars and chargers.	
VALUE CHAIN & REQUIREMENTS		
Charging infrastructure	Exploitation	V1G capable before retrofitting after retrofitting capabilities for V2X
Mobility services	Individual EV drivers & EV fleet operators	External users
Charging services	Unidirectional	Individual steering of retrofitted chargers
Energy services	Behind the meter	Integration with the building EMS *(Energy Management System).*
USE CASE SPECIFIC SYSTEM ARCHITECTURE ELEMENTS (input for WP2)		
Functional requirements	• Control over the chargers functionality, OCPP smart charging • SoC (State of Charge) and target time by the end user.	
Hardware	• Fully implemented OCPP 1.6 J chargers for V1G. • Deployment of a draft version of OCPP 2.1 to support V2G data exchange. • Bidirectional cars. • Bidirectional chargers (AC & DC).	

Software solutions	• Interface for the end user controlling the charging.
Data	• Implementation with the DSO, building EMS, and vehicles.
Contribution to ASSESSMENT AND MONITORING FRAMEWORK (KPI) (input for WP 4)	
Demand flexibility & Storage resilience	• Uncertain of what power market FCR, aFRR, MRR etc. it can be implemented to (depends on physical installation and national regulations).
Energy consumption & Grid integration	• MID certified energy meters is a must on the chargers for some markets there would be other additional measurement requirements. • Uncertain of what the actual requirements for grid integrations are, will warry per country.
Economic viability	• The delta between cost of goods sold and goods bought provides an economical viable opportunity for v1g, for V2G cost of HW and access to cars need to improve but that is within the market forecasts.
Social acceptance	• Uncertainty of acceptance from EV drivers willingness to share battery in V2G, we need to find the acceptance point in terms of kick back and amount of flexibility that is offered.
BARRIERS/RECOMMENDATIONS POLICY FRAMEWORK TO ENABLE MASS-DEPLOYMENT (input for WP5)	
Legal (EU and national)	• Uncertain what level of power fed back to the grid will be allowed.
Grid code	
Technical	• Implementation of ISO 15118-20 similar over different car- and charger brands.
Data	
Market	• Bidirectional cars are currently unavailable in the market, chargers are only available mid next year.
Commercial	• Profitability for retrofitting older model chargers is unclear (topic of research).

4.3.2 C2 Highway charging with local generation & storage (Eindhoven)

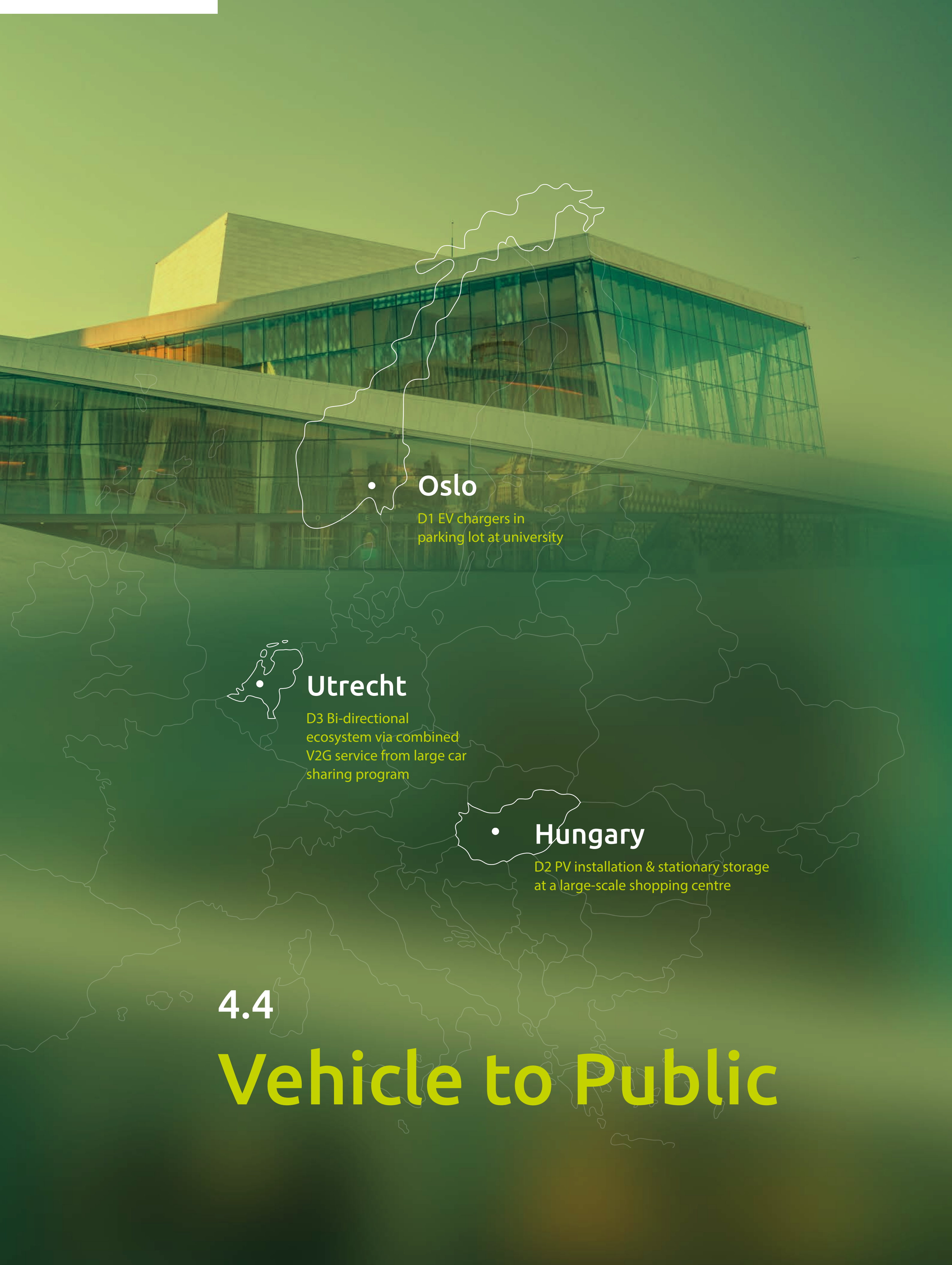
CATEGORY	FEATURES	REMARKS
VISION		
Context	At the testing facility of VDL ETS for heavy duty, mostly busses. Testing for high power charging with a reduced grid connection. Site consists of 5 high power chargers (up to 450 kW), a 420 kWh stationary battery, and demo vehicles.	Specifically aimed at future highway charging for long haul heavy duty vehicles.
Stakeholders involved	Site owner & CPO Local energy optimisation DSO TSO	VDL ETS ENERVALIS ENEXIS TenneT
Motivation	In the future, at many locations charging facilities will be needed. This system will be used to reduce the needed grid reinforcement and at the same time deliver the needed high power for fast charging. The same system, consisting of an energy management system, chargers, and BESS (Battery Energy Storage System), can be used for increased self-consumption and other services.	
VALUE CHAIN & REQUIREMENTS		
Charging infrastructure	Exploitation	DC V2X fast chargers that comply with the new ISO 15118-20 standard.
Mobility services	n/a	
Charging services	Instant fast charging	Fast charging with combined power from the grid and from stationary BESS.
Energy services	Behind the meter	Increased charging power
USE CASE SPECIFIC SYSTEM ARCHITECTURE ELEMENTS (input for WP2)		
Functional requirements	• Combination with planning system, charging power ready when needed.	
Hardware	• V2X capable high power charging stations. • V2X capable demo vehicles (heavy duty). • Solar panels	
Software solutions	• Implementation of the ISO 15118-20 standard (in the vehicles and charging stations). • Planning/ scheduling system.	
Data	• Data integration with vehicle (SoC), BESS, and planning system.	

Contribution to ASSESSMENT AND MONITORING FRAMEWORK (KPI) (input for WP 4)	
Demand flexibility & Storage resilience	• Bidirectional BESS & Vehicles will increase flexibility as the demand on the grid will reduce
Energy consumption & Grid integration	• Total consumption not (noticeable) influence as efficiency is already very high but power peaks on the grid are reduced.
Economic viability	• If fast charging isn't possible due to the grid connection being too small then smart charging solution & a BESS is quickly viable.
Social acceptance	• The public will not notice or mind if a BESS is placed next to a charging station. • A lot of batteries are needed for electrification in general, raw materials are scarce. Using them to produce a BESS for fast charging instead of producing e-vehicle might raise some questions. Using second life batteries for a BESS might increase social acceptance.
BARRIERS/RECOMMENDATIONS POLICY FRAMEWORK TO ENABLE MASS-DEPLOYMENT (input for WP5)	
Legal (EU and national)	• To implement the same system throughout Europe (needed for long haul heavy duty), the same system must be implemented over multiple countries. Different regulations and procedures regarding BESS and grid connections make this difficult.
Grid code	
Technical	• Implementation of ISO15118-20 in heavy duty vehicles and charging stations. • Insufficient understanding on increased battery degradation when using vehicle batteries bi-directional.
Data	
Market	
Commercial	• Making 'extra battery degradation' from bi-directional vehicles economical interesting for vehicle owners.

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

CATEGORY	FEATURES	REMARKS
	VISION	
Context	At the testing facility of VDL ETS for heavy duty, busses. Testing for high power charging of heavy duty vehicles without connection to the grid. Site consists of 5 high power chargers (up to 450 kW), a 420 kWh stationary second life battery, and demo vehicles.	
Stakeholders involved	Site owner & CPO Local energy optimisation DSO TSO	VDL ETS ENERVALIS ENEXIS TenneT
Motivation	Test the business case of being independent of the grid. By enabling a VPP (Virtual Power Plant), foreseeing in the energy need through PV installation and a BESS (Battery Energy Storage System). The increased utilization of renewable energy (solar) combined with the second life batteries used as storage make this a particular environmentally friendly use case.	
	VALUE CHAIN & REQUIREMENTS	
Charging infrastructure	Exploitation	DC V2X fast chargers that comply with the new ISO15118-20 standard.
Mobility services	n/a	
Charging services	Instant fast charging	Sufficient charging power and storage from the PV installation and BESS, also in the future when accounting for battery degradation.
Energy services	Behind the meter	Sufficient energy generation across seasons, enough solar power in the winter.
	USE CASE SPECIFIC SYSTEM ARCHITECTURE ELEMENTS (input for WP2)	
Functional requirements	• Have the grid connection on stand-by in case the PV and BESS system cannot supply sufficient power.	
Hardware	• V2X capable high power charging stations. • V2X capable demo vehicles (heavy duty). • Solar panels	

Software solutions	• Implementation of the ISO15118-20 standard (in the vehicles and charging stations). • System predicting amount of energy needed, amount of energy available and then managing those available sources. (i.e. if power is needed, use solar or use batteries or reduce charger power?).
Data	• Data integration with vehicle (SoC), BESS, and planning system.
Contribution to ASSESSMENT AND MONITORING FRAMEWORK (KPI) (input for WP 4)	
Demand flexibility & Storage resilience	
Energy consumption & Grid integration	• Try to reduce grid consumption to 0.
Economic viability	• If grid connections are not available are the grid is already over loaded then economic viability is no longer a discussion.
Social acceptance	• With the exploded energy prices the social acceptance should be high.
BARRIERS/RECOMMENDATIONS POLICY FRAMEWORK TO ENABLE MASS-DEPLOYMENT (input for WP5)	
Legal (EU and national)	
Grid code	
Technical	• Implementation of ISO15118-20 in heavy duty vehicles and charging stations.
Data	
Market	
Commercial	• Commercially difficult because of the uncertainty regarding the PV-generation over an entire year.



4.4 Vehicle to Public

4.4 Vehicle to Public

4.4.1 D1 EV chargers in parking lot at university (Oslo)

CATEGORY	FEATURES	REMARKS
VISION		
Context	Oslo science park, parking garage of the university. Parking and charging of private and company cars. Currently, there are around 40 chargers installed.	
Stakeholders involved	Vehicle users Fleet operator CPO & MSP Local energy optimisation DSO Flexibility provider TSO & BRP & BSP	Tenants (external) Hyre (external) Current ENFO/Current Elvia To be confirmed Statkraft
Motivation	Public charging is an important factor, especially in cities. In this use case will be showcased what the impact is of the different smart charging services can be. Implemented will be peak shaving, time-of-use shifting, and price arbitrage, but also providing back-up power and optimising behind the meter charging with V2X capable cars and chargers.	
VALUE CHAIN & REQUIREMENTS		
Charging infrastructure	Exploitation	V1G capable before retrofitting after retrofitting capabilities for V2X
Mobility services	Individual EV drivers & EV fleet operators	External users
Charging services	Unidirectional	Individual steering of retrofitted chargers
Energy services	Behind the meter	Integration with the building EMS (Energy Management System).
USE CASE SPECIFIC SYSTEM ARCHITECTURE ELEMENTS (input for WP2)		
Functional requirements	• Control over the chargers functionality, OCPP smart charging. • SoC (State of Charge) and target time by the end user.	
Hardware	• Fully implemented OCPP 1.6 J chargers for V1G • Deployment of a draft version of OCPP 2.1 to support V2G data exchange. • Bidirectional cars. • Bidirectional chargers (AC & DC).	

Software solutions	• Interface for the end user controlling the charging.
Data	• Implementation with the DSO, building EMS, and vehicles.
Contribution to ASSESSMENT AND MONITORING FRAMEWORK (KPI) (input for WP 4)	
Demand flexibility & Storage resilience	• Uncertain of what power market FCR, aFRR, MRR etc. it can be implemented to (depends on physical installation and national regulations).
Energy consumption & Grid integration	• MID certified energy meters is a must on the chargers for some markets there would be other additional measurement requirements. • Uncertain of what the actual requirements for grid integrations are, will warry per country.
Economic viability	• The delta between cost of goods sold and goods bought provides an economical viable opportunity for V1G, for V2G cost of HW and access to cars need to improve but that is within the market forecasts.
Social acceptance	• Uncertainty of acceptance from EV drivers willingness to share battery in V2G, we need to find the acceptance point in terms of kick back and amount of flexibility that is offered
BARRIERS/RECOMMENDATIONS POLICY FRAMEWORK TO ENABLE MASS-DEPLOYMENT (input for WP5)	
Legal (EU and national)	• Uncertain what level of power fed back to the grid will be allowed.
Grid code	
Technical	• Implementation of ISO15118-20 similar over different car- and charger brands.
Data	
Market	• Bidirectional cars are currently unavailable in the market, chargers are only available mid next year.
Commercial	• Profitability for retrofitting older model chargers is unclear (topic of research).

4.4.2 D2 Smart charging, aggregated self-balancing, and electromobility driven loyalty program at shopping center chain including PV systems and battery energy storage systems (Hungary)

CATEGORY	FEATURES	REMARKS
	VISION	
Context	120 smart charging points were recently installed at 14 different locations of Stop Shop's nation-wide shopping center chain. According to current planning at several locations roof-top PV systems and battery energy storage systems will be installed in 2023. We could here initiate a pilot for energy aggregation: renewable energy production as well as using this energy at different locations with an internal balancing system. Both the energy aggregation including smart and eventually V2G charging as well as the green loyalty program for EV users are innovative elements of the demonstration.	.
Stakeholders involved	Site owner, EMS as CPO and system integrator as well as EMP, Current?, Enervalis, DSO, ABB?	
Motivation	According to our assumption this form of aggregation would hugely support the increase of green energy usage in buildings and at the smart charging networks. The business model as well as the technical solutions developed and tested within the project will be essential for any follower initiative and would also be excellent for regulators to explore.	
	VALUE CHAIN & REQUIREMENTS	
Charging infrastructure	Exploitation	Additional V2G chargers could be installed
Mobility services	Individual / private fleet / shared fleet	All variants could be explored
Charging services	Unidirectional / Bidirectional / Instant fast charging	Charging points also supplied from the PV systems as well as boosted by the BESS at peak consumption periods
Energy services	Behind the meter / balance responsibility / system balance / congestion management	BESS to increase total power. In later phase flexibility service could be offered to the grid since the BESS is scalable
	USE CASE SPECIFIC SYSTEM ARCHITECTURE ELEMENTS (input for WP2)	
Functional requirements	• Upcoming pillars such as PV System and BESS should be installed according to current plan and all kind of system planning should happen accordingly	

Hardware	• V2X, V2G capable chargers and V2X, V2G capable vehicles
Software solutions	• Back-end and front-end extensions (e.g. DSM, dynamic load management, dynamic pricing, loyalty program, ISO 15118-20 standard
Data	• PV System, Battery, Building Energy System and Charging data to be feed in and used for optimisation, data exchange, roaming
Contribution to ASSESSMENT AND MONITORING FRAMEWORK (KPI) (input for WP 4)	
Demand flexibility & Storage resilience	• Optimisation of local energy system including PV system, BESS, and usage of its flexibility.
Energy consumption & Grid integration	• The buildings are grid connected but the incoming power capacity is limited. Increase of grid power capacity needs to be avoided. The electricity exchange with the grid (dependency) will be reduced. • Decrease of overall charging power capacity by using smart charging system and V2X as well as an increase of green energy usage at the site.
Economic viability	• V2X and therefore economic potential is dependent on national regulation and feed-in schemes. Execution of VPP and aggregation is dependent on regulation.
Social acceptance	• EV user acceptance risk is considered high. Right balance of rewards needs to be explored. Electromobility oriented loyalty program should be tested.
BARRIERS/RECOMMENDATIONS POLICY FRAMEWORK TO ENABLE MASS-DEPLOYMENT (input for WP5)	
Legal (EU and national)	• Affordable, simple requirements regarding procurement of flexibility services by grid operators • Netting rule • Affordable grid connection costs
Grid code	• EU wide, uniform requirements
Technical	• Proper implementation of ISO 15118-20 in EVs needs to become widespread. • Proper implementation of smart charging and ISO 15118-20 in public charging points needs to become widespread. • BEMS development and seamless integration to ensure high efficiency. • Proper implementation of low-level communication for EVs to allow delayed charging.
Data	• Open data and open-source development.
Market	• Access to V2X ready EVs and charging stations.
Commercial	• The cost of the system must be compensated by the reduction in costs by increased utilisation of solar energy and BESS. If the cost reduction if lower than the cost of the system, the commercial value will be low, as will be the uptake.

4.4.3 D3 Bi-directional ecosystem via combined V2G service from large car sharing program (Utrecht)

CATEGORY	FEATURES	REMARKS
VISION		
Context	We Drive Solar is an innovative, quickly growing e-car sharing fleet operator and charging point operator in the city and region of Utrecht. The vehicles (all BEVs) and the chargers are in ownership and control of the carsharing operator – the chargers in Utrecht for the duration of the concession given out by the City of Utrecht. The charging points are ISO-15118 AC-V2G capable; full V2G operability with the Hyundai IONIQ5 V2G Production car is expected by spring 2023.	
Stakeholders involved	Site owner / local authority Fleet operator / CPO / MSP DSO BSP / BRP TSO Regional authority	City of Utrecht We Drive Solar Stedin ENERVALIS TenneT Province of Utrecht
Motivation	Create a virtual power plant / grid flexibility provider by controlling smart / V2G charging of all BEVs in the shared fleet. The goal is to increase the use of renewable energy and support the electricity grid while at the same time enabling a viable business case for the carsharing fleet owner, CPO and quality-of-service for the end user. Other goals include improving healthy and clean mobility, alleviating urban planning problems and improving air quality. There will be price optimisation via wholesale market price arbitrage and time-of-use shifting. The grid support will be through congestion management, power quality control, FCR, aFRR. The amount of flexibility and grid support that can be offered by a carsharing fleet operator will be tested in this use case.	
VALUE CHAIN & REQUIREMENTS		
Charging infrastructure	Exploitation	Proper data integration with charging and energy services to optimise charging services.
Mobility services	Exploitation	
Charging services	Smart and bidirectional (V2G)	Controlling the (dis) charging process of all vehicles.
Energy services	System balance & Congestion management	Price optimisation

USE CASE SPECIFIC SYSTEM ARCHITECTURE ELEMENTS (input for WP2)		
Functional requirements	• Control over the (dis)charging process. Sufficient State-of-Charge (SoC) also when car battery is being used for FCR/aFRR and other grid services.	
Hardware	• V2G capable charging stations and cars.	
Software solutions	• Implementation of the ISO15118-20 standard (in the cars and charging stations). • Additional protocols including OCPP, OCPI, TOMP • Integration with Equigy's Crowd Balancing Platform.	
Data	• Data integration with DSO & TSO (Equigy CBP, GOPACS).	
Contribution to ASSESSMENT AND MONITORING FRAMEWORK (KPI) (input for WP 4)		
Demand flexibility & Storage resilience	• KPIs might be in the line of % smart charging / load shifting, % V2G charging.	
Energy consumption & Grid integration	• % load shifting, % reduction in kWh costs	
Economic viability	• Multiple / complex business case (CPO, MSP / car sharing operator, value of grid services).	
Social acceptance	• In shared car customers, in charging point users, among citizens	
BARRIERS/RECOMMENDATIONS POLICY FRAMEWORK TO ENABLE MASS-DEPLOYMENT (input for WP5)		
Legal (EU and national)	• Double energy taxation, barriers for procurement of flex services by grid operators, netting rule, grid connection costs.	
Grid code		
Technical	• Proper implementation of ISO15118-20 in cars needs to become widespread. • Proper implementation of smart charging and ISO15118-20 in public charge points needs to become widespread (Elaad, 2022a). • Implementation of the Equigy Crowd Balancing Platform and/ or other flexibility platforms in such a way that they are well accessible for BEV fleet owners / distributed flexibility sources. • Proper implementation of low-level communications for cars to allow delayed charging.	
Data	• Strive for open data / open source development	
Market	• Development of flexibility market mechanisms accessible to distributed flexibility sources	
Commercial	• The commercial viability of the carsharing program must increase by using the cars in the VPP (virtual power plant), in order to achieve mass market uptake.	

5

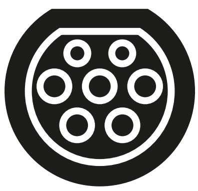
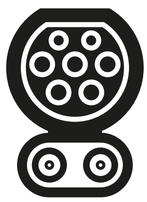
Data

5 Data

5.1 Interoperability

E-mobility market growth is fundamentally conditional to the degree of user centricity of the provided services. Ideally, charging an EV should be as convenient as refuelling a fossil-fuel vehicle. This requires an open charging infrastructure in which all market participants can participate on a non-discriminatory basis and the various systems within the e-mobility market can work together. Ensuring that assets and systems from different manufacturers can work together, also known as interoperability, will accelerate the adoption of EVs, reduce costs, and encourage innovation. It is therefore necessary that all different system aspects within the e-mobility market – from EV to charging station and from energy supplier to mobility service provider – speak the same language. Interoperability does not only facilitate consumer convenience by allowing EV drivers to charge at any charging station regardless of the EMSP they are contracted to or the CPO that operates the charging station, but it also enables participation in flexibility markets via automated communication between the charging station and actors such as the CPO and DSO. Freedom of choice is also improved significantly due to interoperability because consumers can freely switch products (e.g. vehicle brand, EMSP contract) without facing serious disadvantages.

European legislation has so far mostly focused on hardware interoperability. As early as 2014, the European Union proposed standard socket outlets for both AC and DC charging stations with the publication of the alternative fuels infrastructure directive (European Parliament and Council, 2014). AC charging stations should at least be equipped with a Type 2 socket outlet or connector. EVs currently sold on the European market are equipped with a Type 2 socket and are therefore able to charge at any AC charging station. For DC charging, charging stations should at least be equipped with Combo 2 connectors, which uses the Combined Charging System (CCS) standard based on Type 2 connectors. There are still some major EV manufacturers that do not yet support DC charging with CCS, and, as a result, many DC charging stations are still equipped with CHAdeMO or Tesla connectors in addition to the required CCS connector. Recently, key market players such as Nissan announced they will move towards the CCS format for new models, making hardware interoperability for both AC and DC charging only a matter of time (Sustainable Transport Forum, 2020).

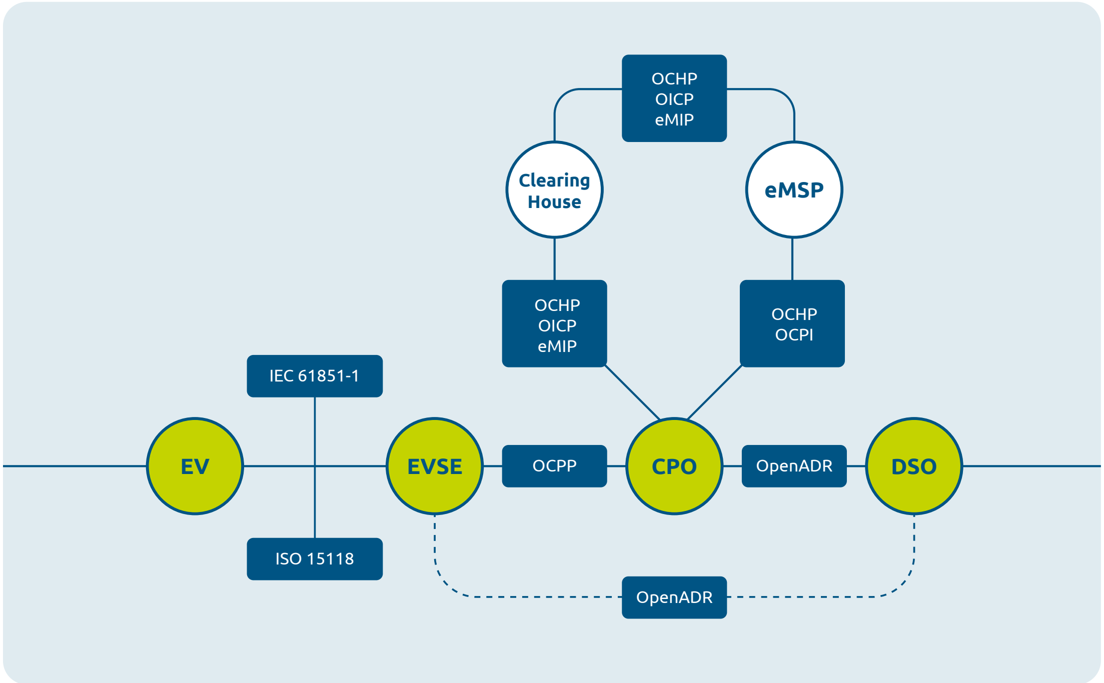
Plug			
Plug name	Type 2 ('Mennekes')	Combined Charging System (CCS) – Type 2	CHAdeMO
Purpose	AC (dis-)charging	DC (dis-)charging	DC (dis-)charging

Overview of commonly used plugs for EV charging in the European market.

Additionally, the first major steps towards software interoperability were also taken with the publication of the alternative fuels infrastructure directive. The directive mandated that, from 2020 onwards, EV drivers should be able to charge at any publicly available charging station in the European Union on an ad hoc basis without the need to enter a contract with the relevant CPO. User centricity was further improved by allowing EV drivers free, transparent and non-discriminatory access to databases which include the geographical location of charging stations and the prices charged by operators of charging stations (European Parliament and Council, 2014). Software interoperability can especially be tricky if the EMSP an e-driver is contracted with does not simultaneously act as a CPO (i.e. it does not operate its own infrastructure) or when the e-driver charges at a charging station owned by a different CPO. An important aspect of interoperability, known as roaming, resolves this issue: by ensuring that the software systems of the CPO and EMSP speak the same language via communication protocols, the necessary data (e.g. user identification, amount of energy charged) can be communicated (Sustainable Transport Forum, 2020).

5.2 Standards and protocols

Software interoperability does not only cover the communication between CPO and EMSP (roaming), but is generally divided into four different domains: (1) communication between EV and charging point, (2) communication between charging point and a central management system, (3) roaming, and (4) communication between DSO and CPO or between DSO and charging station (ElaadNL, 2017). The figure below shows an overview of the most common standards and communication protocols:



Overview of dominant standards and protocols related to EV charging.

Most communication protocols are open, which means they have been developed by a standardisation organisation, are not subject to intellectual property, and are publicly accessible at no or minimal cost (ElaadNL, 2017). This is in contrast to closed or proprietary protocols, which have been developed by private organisations, do not support communication with other products without a translation and cannot be freely used. Open protocols allow existing stakeholders to move up the value chain and set up additional services without needing to pay hefty license prices or develop new protocols on their own, which significantly increases market adoption and interoperability.

5.2.1 EV – charging point

IEC 61851 is the standard protocol for EV charging in Europe. The standard includes base level front-end communication for both AC and DC charging. Smart charging is supported on a base level by adjusting the charging speed during charging, but bidirectional power transfer is currently not supported. The ISO 15118 protocol is a communication protocol between an EV and a charging station in a more advanced form known as 'High Level Communication'. Compared to IEC 61851, ISO 15118 allows for a higher level of user friendliness thanks to automated authentication and authorisation known as 'Plug and Charge', secure data exchange, and more sophisticated smart charging capabilities.

The ISO 15118-20 version, published in early 2022, provides the basis for bidirectional charging, energy management, and wireless charging. A dynamic mode was added in addition to the existing scheduled mode from ISO 15118-2, which allows secondary actor systems to control the power flow fulfilling the user's mobility needs and its own constraints. Securing communication to the EV with digital certificates is mandatory with ISO 15118-20. Plug and Charge makes use of a specific set of digital certificates (different from those used to secure the communication) embedded in the vehicle to authenticate the contracting party. They replace the external identification means such as RFID cars. This way, information exchange will be automatic and secure (ElaadNL, 2022a).

Market adoption for ISO 15118-20 is still relatively low as the protocol has only been released recently

To further enable Plug and Charge, a set of roles, policies, and procedures, known as a Public Key Infrastructure (PKI) is needed to manage digital certificates and public-key encryption. A PKI is therefore a necessity for identifying each unique EV. As of 2022 there is already one PKI in operation, but it is expected that more PKIs will enter the e-mobility market. When there are multiple PKIs, by their nature they will not be interoperable unless all PKIs are mutually interested to 'trust' each other and agree on technical, operational and governance aspects of interoperation. As owners and participants of PKIs are each other's competitors, they are reluctant to cooperate, which may result in a plethora of independent, non-interoperable PKIs. One single neutral PKI system for e-mobility, which guarantees fairness, openness, and a level playing field will require additional effort and commitment from the side of legislators and the industry (ElaadNL, 2022a).

Market adoption for ISO 15118-20 is still relatively low as the protocol has only been released recently. There are currently no mass produced EV models that support ISO 15118-20 and charging stations supporting earlier versions of the standard have mainly been used in pilot projects. V2X testing has therefore mainly been conducted with the CHAdeMO standard, which supports bidirectional power transfer for DC charging. As many Asian EV manufacturers are gradually replacing CHAdeMO in favour of CCS and due to a general lack of cybersecurity features in the standard, DC V2G via CHAdeMO is not expected to be used to a significant degree in the European market. On the other hand, ISO 15118 is currently included in the Sustainable Transport Forum recommendations for public tenders for charging infrastructure and is expected to be mandated as a European standard as part of the Alternative Fuels Infrastructure Directive (AFIR). Mass market adoption of the standard can thus be expected in the next few years.

5.2.2 Charging point- central management system

The Open Charge Point Protocol (OCPP) has been designed and developed to standardise the communications between a charging station and a central management system, which is used for operating and managing charging stations. The communication protocol is open and freely available to ensure the possibility of switching from charging network without necessarily replacing all the charging stations or significant programming, including their interoperability and access for electric grid services. The protocol is intended to exchange information related to transactions and for operating a charge point including maintenance (ElaadNL, 2017). OCPP is currently the de facto standard in Europe for back-end communication between a charging station and a central management system.

Market adoption of OCPP is high due to it being publicly available at no cost without licensing obligations or usage restriction and because it is included in tender requirements in municipalities all over Europe. Many parties have extensively used OCPP over recent years despite it not being a formal de jure standard. OCPP supports high-level use cases such as authorising charging sessions, billing, and smart charging, but does currently not describe the communication between charging station and central management system to allow bidirectional power transfer. The necessary update to add V2X information exchange to OCPP is currently under development and expected to be released in 2023 and will support bidirectional charging via both CHAdeMO and ISO 15118-20.

The open protocol IEC 63110 is a standard currently under development with similar functionalities to and based on input from OCPP. The core functionality of IEC 63110 is to standardise the functionalities of OCPP into a de jure standard and to include additional functionalities such as bidirectional power flow. The first version of IEC 63110 is expected to be released in 2024, but it is unclear when IEC 63110 will be finalised and ready for market adoption. Furthermore, whether the standard will offer significant advantages over OCPP, especially considering the high current market adoption of OCPP within the European Union and given the fact that the standard will cover roughly the same functionalities, remains to be seen.

5.2.3 Roaming

Roaming enables EV drivers to use charging stations that are not part of the charging network of their EMSP. Four main roaming protocols were developed in the European market in the previous decade: Open Charge Point Interface protocol (OCPI), Open Clearing House Protocol (OCHP), eMobility Interoperation Protocol (eMIP), and Open InterCharge Protocol (OICP). These protocols consist of the same core functionalities: identification of the EV driver, authorisation of the charging session, information recording and exchange, billing, and data security (Van Der Kam and Bekkers, 2020; Maheshwari and Nair, 2021). The most essential distinctive feature is the governance of the protocols. OCPI is managed by an independent knowledge platform and is considered to be the most open to stakeholder involvement. The other protocols are attached to roaming hubs and are in principle proprietary to roaming hub operators. Current differences between these protocols were primarily caused by different stakeholder involvement in the development process. For instance, OICP has more sophisticated communication to handle the automatic identification of the EV, because many stakeholders involved in the development process were EV manufacturers (Van Der Kam, Ferweda and Bekkers, 2020).

IEC 63119 is a standard currently under development aimed at harmonising roaming communication. The standard will describe the technical specifications and make it possible for CPOs and EMSPs to exchange data across Member States through roaming hubs or on a peer-to-peer basis (European Commission, 2021). As it is unlikely that existing roaming protocols will be harmonisation by the market itself given the fact that harmonisation will lead to financial disadvantages for protocol developers, a top-down approach via the IEC – and possibly European legislation - can push market participants towards standardisation to some extent. It is, however, currently unclear whether IEC 63119 will appeal to market participants across the entire European Union. The dominant roaming protocols were developed taking into account specific national contexts and it is unclear whether a European standardised protocol will still deal with these differences to a significant degree (Van Der Kam and Bekkers, 2022).

5.2.4 DSO communication

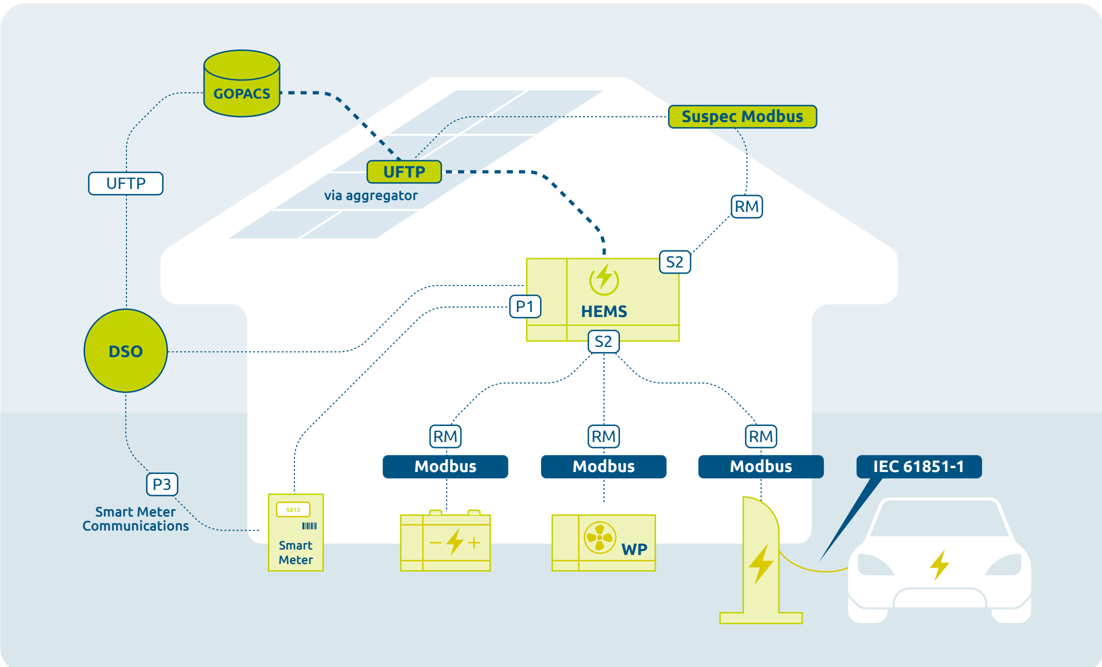
DSOs will likewise profit from standardised communication, as it allows them to send signals to smart energy devices for demand response purposes. This can either be done through direct controllability of the charging station by the DSO, or indirectly via the CPO for public charging or an energy management system (EMS) for private charging.

DSOs will likewise profit from standardised communication, as it allows them to send signals to smart energy devices for demand response purposes

Open Automated Demand Response (OpenADR) was the first standard developed for demand response purposes. The protocol is aimed at automating demand response communication and it supports a system and/or device to change power consumption or production of demand-side resources. This can, for example, be done based on grid needs, either by means of tariff and/or incentives or emergency signals that are intended to balance demand to sustainable supply (ElaadNL, 2017). Contracts between stakeholders need to be established to allow EVs to be used as demand response assets. This can be achieved for example by combining the smart charging signals from OCPP with demand response signals from OpenADR. A CPO could then send signals to a DSO via OpenADR regarding the available EVs to be used for demand response, which can help a DSO in creating more sophisticated congestion management models (Hoekstra, 2016).

In-home flexibility protocols are designed to standardise the communication for residential charging. These protocols describe the communication between smart energy devices – such as EVs, but also heat pumps, stationary batteries, solar panels et cetera – and EMSs. Unlocking flexibility requires that different devices are interoperable, i.e. they are able to communicate with each other, and are controlled in a smart way. Achieving interoperability between smart devices from different manufacturers necessitates the use of communication protocols (TKI Urban Energy, 2020).

After receiving signals from parties requesting flexibility, an EMS can control smart devices either directly or indirectly. In the direct approach, the EMS has a direct connection with each smart device and uses a single protocol. Protocols such as EEBus Spine and Modbus have been developed in recent years to allow different types of energy devices to communicate with each other (BDL, 2020). In the indirect approach, the EMS does not communicate directly with devices, but through software equivalents known as 'Resource Managers'. To make different communication protocols interoperable, it is necessary that a standardised interface at the grid connection point is available to define common data models and message structures. The standardisation body CEN-CENELEC defines such an interface, known as S2, in the standard EN 50491-12-2. An EMS can communicate with Resource Managers using S2 regardless of the communication protocol implemented in the smart device. It should be noted, however, that the S2 interface has not been tested in practice so far (TKI Urban Energy, 2020).



Example of standards and protocols used for in-home flexibility.

5.3 Cybersecurity and privacy

All charging stations together form a smart network to optimally deploy the use of renewable energy and grid capacity. To make this possible, all the different elements have to communicate with each other and are connected to various ICT systems and back offices, as described in 5.2. The charging infrastructure faces the challenge of being open and accessible to everyone: for all kinds of vehicles, software systems, charging protocols, and apps, whilst at the same time being protected against cyberattacks. Necessary measures need to be taken to ensure that the charging process is as straightforward as possible for EV drivers, while making sure that the network is properly secured.

One way to improve cybersecurity in the smart charging chain is to include technical security measures in tender requirements for public charging infrastructure. A set of cybersecurity requirements for charging stations was published in 2017 and updated in 2019 by ElaadNL and ENCS. The document provides guidance to CPOs as to what technical measures they can take to improve cybersecurity, but it also allows local governments to mandate these requirements via public tenders (ElaadNL and ENCS, 2019). The requirements are aligned with worldwide standards on cybersecurity such as ISO 27001 and IEC 62443. More and more local governments all over Europe include cybersecurity requirements in public tenders, but these requirements are still informal in nature: there is currently no legal obligation to comply.

Cybersecurity can furthermore be improved by including it as an integral part of communication protocols. For example, using digitally secured certificates is a mandatory component of ISO 15118-20 for all functionalities, compared to the ISO 15118-2 version which makes secure communication mandatory only for specific features (Plug and Charge, metering). Other communication protocols and standards, such as OCPP, will likewise include sturdier cybersecurity measures in the near future.
A higher degree of interoperability will increase two-way communication as more stakeholders will be digitally connected. Access to data across the entire value chain is instrumental for bringing stakeholders together and optimising e-mobility related services such as invoicing and smart charging. Digitalisation and data availability make it possible to develop business cases and provide flexibility to the energy market. Digital tools such as smart meters allow consumers to participate in flexibility markets, but, more generally, can also allow consumers to receive real time signals to charge cheaper or charge solely on renewable energy.
Clear rules need to be established to protect consumer and business privacy. The steady increase in data flows in the e-mobility sector will only increase vulnerability if not accompanied by a data exchange framework between grid operators, aggregators, and relevant charging infrastructure stakeholders. The right for consumers to share general data with third party has been established with the implementation of the General Data Protection Regulation (GDPR). The proposed Data Act will establish high-level principles on data sharing, most notably requiring prior consent from consumers for data sharing and introducing interoperability obligations, which will be key to ensuring consumer privacy (Ennis and Colangelo, 2022; European Commission, 2022).

Interoperability between different e-mobility services is a crucial factor towards EV market adoption. Communication protocols have been developed in the last decade to enable products and systems to work with each other and many are still under development to be used in future EV flexibility markets. It is essential that the decisions that are made now are futureproof: smart charging and V2X should be supported, security should be an integral part of legislation and communication protocols, and the openness and neutrality of standards and protocols should be supported to avoid consumer lock-in.

6 Conclusions

6 Conclusions

The overarching aim of the SCALE project is to facilitate the mass deployment of EVs and smart charging infrastructure. It aims to advance smart charging and V2X ecosystems to shape a new energy system wherein the flexibility of EV batteries' is harnessed. SCALE will accelerate the deployment of smart charging and V2X services by developing an open system architecture and reducing uncertainties for all stakeholders involved in the ecosystem.

The main contribution of this stakeholder analysis report is the identification and evaluation of vital stakeholders in the ecosystem, which will be used as primary input for the design of the system architecture. The report indicates that a large number of stakeholder play a relevant role in unlocking the flexibility of EV charging and a growing number of stakeholders across the ecosystem have a clear interest in accelerating the adoption of large-scale smart charging and V2X. Each of these stakeholders face significant barriers that need to be addressed to fully unlock the potential of flexible mobility services. For consumers, it is crucial that barriers to entry flexibility markets are removed, for example by allowing access to data that is currently proprietary to EV manufacturers. System operators primarily face obstacles related to flexibility market immaturity. European legislation can help remove these obstacles by harmonising prequalification processes for flexibility services and by defining a framework for flexible solutions such as non-firm contracts and congestion management. Lastly, market participants will greatly benefit from a further development of widely accepted standards, open communication protocols, and national frameworks on smart charging and V2X requirements.

The assessment of stakeholder's drivers, objectives, and barriers demonstrates the need for cross-sectoral collaboration and knowledge exchange. The next step for the SCALE project is to build an alliance with interested stakeholders from different value chains to foster synergies and improve collaboration across the entire ecosystem, thereby mitigating uncertainties related to technological advancements and potential value streams. The findings of this report will furthermore serve as fundamental input for future SCALE topics such as data requirements, business case development, and standardisation of smart charging and V2X. More advanced in-depth research will be conducted in future deliverables with close collaboration between SCALE partners by using the system architecture defined in this report.

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Appendices

SCALE Partners

List of participating cities:

- Oslo (NO)
- Rotterdam & Utrecht (NL)
- Eindhoven (NL)
- Toulouse (FR)
- Greater Munich Area (GER)
- Budapest & Debrecen (HU)
- Gothenburg (SE)

List of partners:

- (Coordinator) STICHTING ELAAD NL
- POLIS - PROMOTION OF OPERATIONAL LINKS WITH INTEGRATED SERVICES, ASSOCIATION INTERNATIONALE POLIS BE
- GoodMoovs NL
- Rupprecht Consult – Forschung & Beratung GmbH RC DE
- Trialog FR
- WE DRIVE SOLAR NL BV NL
- UNIVERSITEIT UTRECHT NL
- LEW Verteilnetz GmbH DE
- BAYERN INNOVATIV - BAYERISCHE GESELLSCHAFT FUR INNOVATION UND WISSENSTRANSFER MBH DE
- ABB BV NL
- Enervalis BE
- GEMEENTE UTRECHT NL
- Equigy B.V. NL
- SONO MOTORS GMBH DE
- Meshcrafts As (Current) NO
- Research Institutes of Sweden AB SE
- ETHNIKO KENTRO EREVNAS KAI TECHNOLOGIKIS ANAPTYXIS (CERTH) GR
- FIER Automotive FIER NL
- Emobility Solutions Kft. HU
- Serviced Office Belbuda Kft HU
- Enedis FR
- L'ASSOCIATION EUROPEENNE DE LA MOBILITE ELECTRIQUE (AVERE) BE
- Norsk elbilforening NO
- VDL ENABLING TRANSPORT SOLUTIONS BV NL
- Urban Electric Mobility Initiative UEMI DE
- Renault FR
- Chalmers University SE
- Polestar SE
- Hyundai NL


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