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FLOW's D1.1 - Drivers: policies, framework conditions and key stakeholders in EV integration

Secchi, Mattia; Andersen, Peter Bach

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Flexible energy systems Leveraging the Optimal integration of EVs deployment Wave

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Deliverable 1.1

External drivers

Author: Peter Bach Andersen, Mattia Secchi
[Technical University of Denmark (DTU)]

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Table of Contents

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List of Acronyms

Acronym	Meaning
AC	Alternating Current
CPO	Charging Point Operator
DC	Direct Current
DSO	Distribution System Operator
TSO	Transmission System Operator
EV	Electric Vehicle
EMSE	Electric Mobility Service Providers
EVSE	Electric Vehicle Supply Equipment
EMSP	Electro Mobility Service Provider
G2V/CC	Grid-to-vehicle / Controlled Charging
POD	Point of Distribution
SOC	State-of-charge
TSO	Transmission System Operator
UX	User Experience
V2G/BC	Vehicle-to-grid / Bi-directional Charging
VGI	Vehicle-Grid Integration
WP	Work Package

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Executive Summary

This deliverable (D1.1 External drivers) documents the work carried out in work package 1, Task 1.1 “Drivers: policies, framework conditions and key stakeholders in EV integration”. The main external conditions, trends and motivations driving the electrification of transportation which are relevant to the FLOW project are going to be reviewed. In addition, the key stakeholders, with a special attention towards the EV users, are listed.

The European "Clean energy for all Europeans" and "Fit for 55" packages are identified as some of the most significant drivers for electrifying the transportation sector. The emphasis is put on achieving ambitious CO2 emission reductions – including an “ad-interim” 55% target reduction on the emissions of newly sold vehicles by 2030 compared to 2021, and a 100% reduction by 2035. Moreover, the "Fit for 55" package specifically refers to the charging infrastructure, as its proactive development is seen as key in order to achieve the EV diffusion targets: 30 million zero-emissions vehicles by 2030.

A number of key EU directives, regulations and initiatives have been proposed in order to achive the transportation sector electrification targets. D1.1 lists a number of these and states their relevance to the FLOW project. Among the most significant for smart charging, and ultimately V2G, are the Energy Performance of the Buildings Directive (EPBD) and Alternative Fuels Infrastructure Directive (AFID), which will help drive the deployment of a smart and sufficient charging infrastructure. Furthermore, the Common Rules for the Internal Market of Electricity Directive will help support the smart integration between transportation and the power system.

The countries represented in FLOW are taking steps and initiatives to support both EV diffusion, strengthening the charging infrastructure and facilitating market and grid integration. This is done in accordance with EU directives and regulations – but also by taking steps above and beyond the requirements which can serve both as inspiration for other contries and recommendations of the FLOW project. D1.1 briefly describes key activities in the three partner countries hosting the main demonstrations – Italy, Spain and Denmark. In Italy, some resolutions (such as 300/2017/R/EEL and 352/2021/R/EEL) facilitate pilot programs and testing of smart charging and V2G. In Spain, the Royal Decree 568/2022 establishes the general framework for the regulatory test bed to enable the development of pilot projects including local electricity markets. In Denmark, the energy industries are developing a “Industry guidance for grid companies procurement of flexibility services" which will help promoting the use of demand-side flexibility, including electric vehicles. More examples are listed in D1.1 both from the demonstration countries and from other countries represented by the WP partners.

A number of key stakeholders are identified and described in terms of motivations, demands and drivers. The FLOW project benefits from having many partners representing the different key roles in transport electrification and grid integration, including smart charging and V2G. The deliverable describes the EV users more in detail, including attitudes, demands and perceptions of smart charging concepts, and drivers for bidirectional charging systems acceptance. A stakeholder map is presented illustrating the flow of power and services between actors – as well as the key products which are part of the project domain.

As such, the WP1 partners hope to have provided insights on drivers and stakeholders which may help and inform the rest of the FLOW project.

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1. Background and Objectives

The overall purpose of WP1 is to establish a common knowledge baseline for FLOW and a synchronization of scenarios and terms across partners. As part of this effort, this deliverable seeks to strengthen the knowledge of the project partners on the main initiatives initiated to promote electric vehicles, their charging infrastructure, and grid integration, as well as the stakeholders covering a special role in this domain.

Both the initiatives taken by EU and member countries and the amount of stakeholders involved, are constantly subject to change, thus D1.1 "External drivers" hopes to provide an overview which is useful to the FLOW project.

More specifically D1.1 documents the tasks carried out in Task 1.1 "Drivers: policies, framework conditions and key stakeholders in EV integration" and therefore (from task description):

- Provides a common view of the main external drivers, in terms of stakeholder interests, policies and regulation which steer or slow down the direction of vehicle-grid integration.
- Reviews European and national policy goals and regulation within data interoperability and protection (cybersecurity), market regulation (tariff and incentive schemes) and achieving interoperability and grid stability.
- Provides a definition of the key actors and a description of the requirements and motivations for each.
- A special emphasis is placed on EV owners and what we know from previous projects on behavioral patterns and requirements for VGI.

The WP was not able to draw on inputs from the User and OEM panels as originally proposed, since they have not been established in time to provide inputs. As a compensation, inputs from multiple project partners, representing the insights and interests of such panels, have been included.

Further investigations of mobility trends were moved to D1.2.

2. Methodology

Deliverable 1.1 is non-technical, and largely based on a review of the scientific literature review, and on the experience/knowledge of the project parterns.

For the investigation of external drivers carried out in D1.1, we use a top-down approach by starting to describe goals and regulation on a European level (Chapter 4) – before considering actions and initiatives in the individual countries (Chapter 5).

Both for the investigation of external drivers and for the stakeholder investigation (Chapter 6), the deliverable has relied on the inputs from WP partners and on internal reviews, to ensure that descriptions are as neutral, complete and accurate as possible.

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For the EV user description in particular, the work is based on a large quantity of peer-reviewed papers and research.

3. European Targets for EV Diffusion and Integration

As of 2022, the transportation sector represents almost a quarter of Europe's greenhouse gas emissions. As part of Europe's strategy to become a climate-neutral continent by 2050, several targets have been established to promote the electrification of the sector and ensure an efficient integration with the electric grid and markets.

The first relevant package of directives from the EU, named "**Clean energy for all Europeans"** was adopted in 2019 and introduced 8 new laws, aimed at helping the EU to reach carbon net-neutrality (net-zero emissions) by 2050. The package not only envisions a 14% share for renewable fuels by 2030 (Renewable Energy Directive 2018/2001/EU), but also covers all the aspects related to renewable energy, including energy efficiency in buildings, energy governance, electricity regulation, and risk preparedness.

As an update to that first effort, in 2021, the EU issued another package, the "**Fit for 55**" one, elaborating new ambitious targets for the European energy transition. The package also reviews the emissions trading system, the laws on forestry and land use, and introduces new concepts such as the "social climate fund" and the "carbon border adjustment" mechanism.

One of the most ambitious targets set in the Fit for 55 package concerns the CO2 emissions from new vehicles and prescribes an "ad-interim" target reduction of 55% for cars and 50% for vans by 2030 compared to 2021. The reduction value then becomes 100% by 2035. This means that **from 2035, it will not be possible to sell new hybrid or internal combustion engine vehicles**. Therefore, the EU envisions 30 million zero-emissions vehicles and 3.5 million EV charging stations by 2030.

The introduction of that many charging stations will require an extension of the available EV charging network, so the EU issued a revision to the previous **AFID (Alternative Fuels Infrastructure Development) Directive**, aimed at accelerating the deployment of the necessary charging infrastructure for vehicles powered with alternative fuels.

The targets concern both the available charging power of the stations and their location.

In **urban areas**, 1 kW of publicly accessible power output should be available per BEV **light-duty vehicle,** whereas 0.66 kW are sufficient for PHEVs. Each parking area should have at least one 100 kW charging station for **heavy-duty vehicles** by the end of 2030, whereas every publicly accessible urban node needs to have at least 600 kW by 2025 and 1.2 MW by 2030, provided by stations with at least 150 kW of available power.

Along the motorways of the **Trans-European Network (TEN-T)**, the charging stations for **light-duty vehicles** should not be more than 60 km apart by 2025. Each recharging location in the "core" TEN-T network should provide at least 300 kW and have at least a single 150 kW station by 31/12/2025. In the rest of the TEN-T, the thresholds are the same but should be achieved by 2030 instead. All these values should be doubled instead, by 2030 for "core" TEN-T and by 2035 in the rest of TEN-T. The same approach is valid for **heavy-duty vehicles**, with power values that are much higher due to the larger

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battery sizes, i.e., 1.4 MW by end of 2030 and 3.5 MW by 2035, while a 350 kW station is required for each location.

At least one **hydrogen refilling station** with a capacity of 2 t/day and equipped with 700 bars dispensers should be available every 150 km by the end of 2030. In general, there should be no more than 450 km between any type of hydrogen charging point.

These targets highlight a clear vision where a network of charging stations should seamlessly connect Europe by 2030 and allow the EV owners to travel long distances without requiring an upgrade of the battery size.

4. EU Directives and National Implementation

4.1 EU Directives and Regulation

In the following sections, a collection of European directives and regulations concerning the development of the EVs charging infrastructure is available. Specific attention is placed on describing the relevance each one of those has to the FLOW project.

4.1.1 Emissions and Efficiency Requirements

Table 1. EV Emissions and Efficiency Regulation.

Name	Code	Relevance
Energy Efficiency Directive (EED)	2012/27/EU	Reduction of the energy demand from transportation by: - Making use of more efficient ICEVs. - Using alternative fuels which are more efficient and produce less CO2 per km (e.g., EVs).
Emissions Trading System (ETS) Directive	2003/87/EC	Allowing emission allowances trading between companies, to reduce emissions where it's possible and cheaper to do so. Possible trading of emissions between a company whose focus is on EVs, and a company who cannot have many EVs due to any possible reason (e.g., high emitted CO2 per kWh of consumed electricity).

4.1.2 Charging Infrastructure

Table 2. Charging Infrastructure Regulation.

Name	Code	Relevance
Energy Performance of the Buildings Directive (EPBD)	2018/844/EU	Includes electro-mobility in the calculation of the "smart readiness" indicator for a both the commercial and residential sectors. For public buildings, if the charging station is not already installed, parking space and cabling infrastructure should be predisposed to allow for a faster installation at a later time.

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Deployment of Alternative Fuels Infrastructure Directive (AFID)	2014/94/EU	Aims at developing a unified charging infrastructure in Europe, allowing for seamless travelling between the countries. Sets targets for the development of the charging infrastructure for light and heavy-duty EVs, both in terms of available charging power and spatial distribution.

4.1.3 Electricity Market, Grid and Energy System

Table 3. Electricity Market, Grid and Energy System Regulation.

Name	Code	Relevance
Common Rules for the Internal Market for Electricity Directive	2019/944/EU	Highlights the role of the smart metering infrastructure to empower and involve all the market actors, specifically prosumers and consumers, in achieving the target emissions reduction. Specifies that the distribution network development should be aimed at facilitating the connection of new types of loads, including EVs.
Renewable Energy Directive (RED)	2018/2001/EU	Aims for an increase in the use of renewable energy in the EU. This includes a 14% target for the use of renewable energy sources in the transportation sector.
Batteries and Waste Batteries	2006/66/EC	Sets sustainability, safety, performance, and durability requirements for all types of batteries. Proposes labelling and information requirements on hazardous materials used for manufacturing. Writes down suggestions on end-of-life management, by increased separate collection, recycling and materials recovery practices.
Risk Preparedness in the Electricity Sector	2019/941/EU	Establishes a common framework of rules on how to prevent, prepare for and manage electricity crises, to ensure that measures are taken in a coordinated and effective manner when required.

4.1.4 Other

Table 4. Other relevant regulation.

Name	Code	Relevance
General Data Protection Regulation	2016/679/EC	Protection of natural persons with regards to the processing of personal data and on the free movement of such data. Disaggregated EV consumption data from smart meters needs to be gathered and transmitted for interoperability purposes, so GDPR regulation is applied.
Digitalisation of Energy Action Plan	N.A. (work in progress)	In order to improve the efficiency of the energy system and help renewable integration, this plan will try to improve users' control over their energy use,

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		control the energy consumption of the ICT sector, and strengthen the cybersecurity of energy networks.
Cybersecurity Directive (NIS)	2016/1148/EU (NIS II work in progress)	Lays down measures for a high common level of security of network and information systems across the European Union.
Network Codes on Cybersecurity (ENTSOE)	N.A. (work in progress)	Aims to set a European standard for the cybersecurity of cross-border electricity flows. It lays down common minimum requirements for cyber risk assessment, cybersecurity certification of products and services, monitoring, reporting and crisis management.
ePrivacy Directive	2002/58/EC (work in progress)	Regulates the processing of personal data and the protection of privacy in the electronic communications sector.

4.2 Demo Countries: National Regulation and Initiatives

The purpose of this section is to describe any special initiatives or regulatory measures with may impact or support the planned demonstrations in the three primary demo countries of FLOW: Italy, Spain, and Denmark.

These initiatives are aimed at strengthening:

1. The EV diffusion and uptake speed in the EU
2. The Charging infrastructure, to support EV supply equipment (EVSE) rollout and requirements
3. The market and grid integration of EV-related products, grid codes, and smart devices

4.2.1 Italy

Table 5. Italian initiatives and regulatory measures to promote EV.

Name	Relevance
Budget Law for 2022	Establishes a Sustainable Mobility Strategy Fund (50M) for investments in sustainable mobility made by 2026, in continuity with the resources provided by the PNRR in the same area.
Decree Law 68/2022	Reserves 15 million euros for experimentation with new sustainable mobility solutions in urban areas.
Decree Law 17/2022	To promote the reconversion, research, and development of the automotive sector, it establishes a fund at the Ministry for Economic Development (MISE), with an allocation of 700 million euros for the year 2022, and 1,000 million euros for each of the years 2023 to 2030
Decree Law 50/2022	Provides one million euros for companies operating passenger transportation with Euro 5 and 6 buses, and for the conversion of heavy-duty vehicles to electric powered ones.
Decree of the president of the council of ministers (DPCM) April 6th 2022	New grants for the purchase of electric, hybrid and low-emission vehicles, cars and motorcycles, around 650 million euros for each of the years 2022-2023-2024. Incentives are provided for purchases for each year from entry into force.

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Decree Law 73/2022	The deadline for sellers to confirm the purchase of low-emission vehicles stipulated by DPCM April 6, 2022, was extended from 180 to 270 days.

Table 6. Italian initiatives to promote Charging Infrastructure rollout and define EVSE requirements.

Name	Relevance
Resolution 541/2020/R/EEL of the Italian Energy, Grids and Environment Regulator (ARERA)	On July 2021, ARERA started an experiment (which will last until 31st December 2023, unless extended) to facilitate the recharging at private charging stations at night, and during holidays. Specifically, private charging points will have an additional availability of up to 6 kW of capacity (from their current 2-4.5 kW) at night, on Sundays and other national holidays. This does not require an increase in the nominal power capacity, thus avoiding any additional payment.
Resolution ARG/elt 242/10 of the Italian National Regulatory Association (ARERA)	In order to support the installation of public charging points, ARERA introduced the possibility for charging point operators to apply for a volumetric network tariff (expressed only in €/kWh). This tariff was confirmed until 31 December 2023 only, unless extended.
PNRR (National Plan for Resilience and Recovery)	Mission 2: "Green Revolution and Green Transition" aims at decarbonizing end users in all sectors, with a particular focus on a more sustainable mobility. The project line included in the M2C2 component of this Plan allows for the installation of 21,355 fast and ultrafast public charging points.
Decree Law 83/2012	Provides useful definitions for the purpose of identifying low-emission vehicles and economic incentives for building infrastructures, as well as the purchase of low-emission vehicles (not just electric). The chosen approach applies a substantial "technological neutrality".
Legislative decree 257/2016	Implements Directive 2014/94/EU of the European Parliament and of the Council of October 22, 2014, regarding the establishment of an alternative fueling infrastructure (the so-called AFID). It contains useful elements for defining a business model, and states that the provision of electricity is not merely the provision of a "good", but it is rather a "service", including different components such as the location of infrastructure and different payment methods.
Budget Law for 2019	Provides a 50% tax deduction over 10 years for documented expenses incurred from March 1, 2019, to Dec. 31, 2021, for: purchase of the charging station; installation of the charging station; and increasing the power of the meter (up to a maximum of 7 kW).
Decree Law 76/2020	States that charging should be considered a "service" and not a "supply of electricity" in case the charging infrastructure is in public and private areas/buildings, or on private roads.
Decree Law 34/2020 (Superbonus)	Provides a refund, in the form of a "tax deduction" to the extent of 110% of the expenses occurred for the installation of infrastructure for charging electric vehicles in buildings from July 1, 2020, to June 30, 2022 (referred to in Article 16-ter of Decree Law No. 63 of June 4, 2013).
Decree Law 104/2020	Establishes a fund of 90 million euros for the year 2020 for the provision of grants to install electric vehicle charging infrastructure carried out by professionals and entrepreneurs who are subject to corporate income tax (IRES).

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Budget Law for 2021	States that highway concessionaires must equip their sections with high-powered charging points.
Decree Law 77/2021	Simplifies procedures for the installation of public access electric vehicle charging infrastructure, making it no longer subject to the request of a building permit (it is thus considered a "free construction activity").

Table 7. Italian initiatives and regulatory measures for market and grid

Name	Relevance
Decree of the Ministry of the Economic Development, issued the 30th of January 2020	The Decree establishes criteria and methods for promoting the diffusion of vehicle-grid integration technology (both G2V and V2G). It also mandates ARERA to define (in collaboration with CEI – Comitato Elettrotecnico Italiano, the body which issues technical legislation for the electric system) the minimum technical specifications that meters and devices installed at the recharging infrastructures must comply with, in order to provide flexibility services. According to the Decree, once such technical requirements are defined, ARERA will cover the additional costs associated with the installation of such devices. On September 2020 ARERA asked CEI to open a technical working table to define the requirements, whose works are still on-going.
Resolution 300/2017/R/EEL of the Italian NRA (ARERA)	ARERA launched pilot projects aimed at collecting useful elements to reform the dispatching system and provide new dispatching resources. These projects define the UVAM (Mixed Qualified Virtual Units) project, which are production (including storage systems) and/or consumption units that can participate to the Dispatching Services Market (managed by Terna, the Italian TSO), even at an aggregated level. Electric vehicles a charging stations powered by V2G may participate as well.
Resolution 352/2021/R/EEL of the Italian NRA (ARERA)	ARERA issued the regulatory framework allowing DSOs to present pilot projects aiming at testing procurement and remuneration schemes for local flexibility services provided by assets connected to distribution networks, according to the criteria set by Article 31 of the EU Directive 944/2019. The projects must ensure technological neutrality, so that service providers leveraging on charging infrastructures solutions are allowed to participate as well.

4.2.2 Spain

Initiatives or Regulatory Measures to Accelerate the Uptake of EVs

Within the framework of regulation and incentives for electric vehicles, it is worth highlighting the Strategic Project for Economic Recovery and Transformation (PERTE, Spanish acronym), which is a new public-private collaboration instrument in which the different public administrations, companies and research centers collaborate.

The PERTE VEC (Electric and Connected Vehicle in its Spanish acronym) includes different initiatives and specific funding schemes such as those described below:

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1. **PERTE-VEC:** Call for applications for the PERTE Electric and Connected Vehicle integrated line of support (Support for EV manufacturing industry).
2. ***MOVES III***: Contains two incentive programs aimed at promoting electric mobility: the first one to promote the purchase of electric vehicles, and the second to support the deployment of charging infrastructure.
3. ***MOVES Singulares II***: contributes to both the creation of new mobility and to the development of electric vehicles without acting directly on the value chain. This scheme allows for the promotion of innovation and new business models in electric mobility.
4. ***MOVES FLEETS***: it allows to acquire electric vehicles for headquarters and services and to undertake a comprehensive transformation of the fleet operations, as well as to develop in-house charging solutions, and to provide the necessary management and training systems to transform its fleet, if necessary.
5. Programs to integrate Artificial Intelligence (AI) into value chains to transform the sector.

Initiatives or Regulatory Measures to Accelerate the Charging Infrastructure Rollout

In addition to the plans mentioned in the previous points, there are other regulations that aim at incentivizing or regulating the implementation of recharging points. They include Royal Decree-Law 29/2021, which includes some of the following measures to encourage the deployment of charging points:

1. Mandatory installation of electric charging points in petrol stations whose annual sales exceed a certain threshold.
2. Simplification of licensing and administrative processes for the installation of recharging points.
3. Minimum number of electric charging points in existing car parks attached to buildings for non-residential use.
4. Local tax reductions to contribute to the deployment of electric vehicle charging points.

Another regulation which is relevant to the EVSEs is the Royal Decree 1125/2021, which regulates the granting of direct subsidies to distribution system operators (DSO) for investments in the digitalization of networks, and in the infrastructure for electric vehicle charging at public access points with a capacity of more than 250 kW. Despite of all this, the minimum time required for commissioning new HPC (High Power Chargers) connected at HV (High Voltage) is 8 months at best, due to the complex permitting processes. This scenario has room for improvement.

Initiatives or Regulatory Measures to Facilitate the Grid Integration and the Participation to the Different Markets

The regulatory framework currently guiding regulatory development in this area at European level is the Clean Energy Package and, in particular, EU Directive 2019/944 concerning the common rules for the internal market in electricity.

At the national level, the regulatory framework for demand flexibility (including EVs) is underdeveloped. It is gradually being modified with the aim of transposing the European Directives. Currently, flexible demand only is allowed in the electricity markets, and the regulatory framework does not allow to inject energy into the grid. These barriers and limitations disincentivize the participation of different actors, and their removal could attract new participants to the flexibility market.

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At the regulatory level, Royal Decree 568/2022 establishes the general framework for the regulatory test bed, namely regulatory sandbox, conceived as a controlled environment for carrying out tests to enable the development of pilot projects to facilitate research, innovation, and regulatory improvement in the electricity sector. This new legal framework will allow testing the implementation of, for example, local electricity markets not contemplated in the current regulation that allow for demand-side participation.

4.2.3 Denmark

Initiatives or Regulatory Measures to Accelerate the Uptake of EVs

As reported by the association of Danish car porters, by November 2022 Denmark has reached 100k BEVs, corresponding to 10% of the 1 million EVs which is the national target for 2030. **Error! Reference source not found.** shows the forecast (black) and status (yellow) for the total fleet of BEVs in Denmark – as well as the monthly forecast (green) and actual sales (blue). Both monthly sales and total fleet size, so far, follow the forecast.

Denmark introduced several national incentives to promote electric vehicles. Some of the most significant of these are:

1. A discount in the registration fee of low-emission vehicles (based on emission-levels and battery size).
2. Free parking in some Danish cities.
3. Discounts in ownership- and electricity fees.

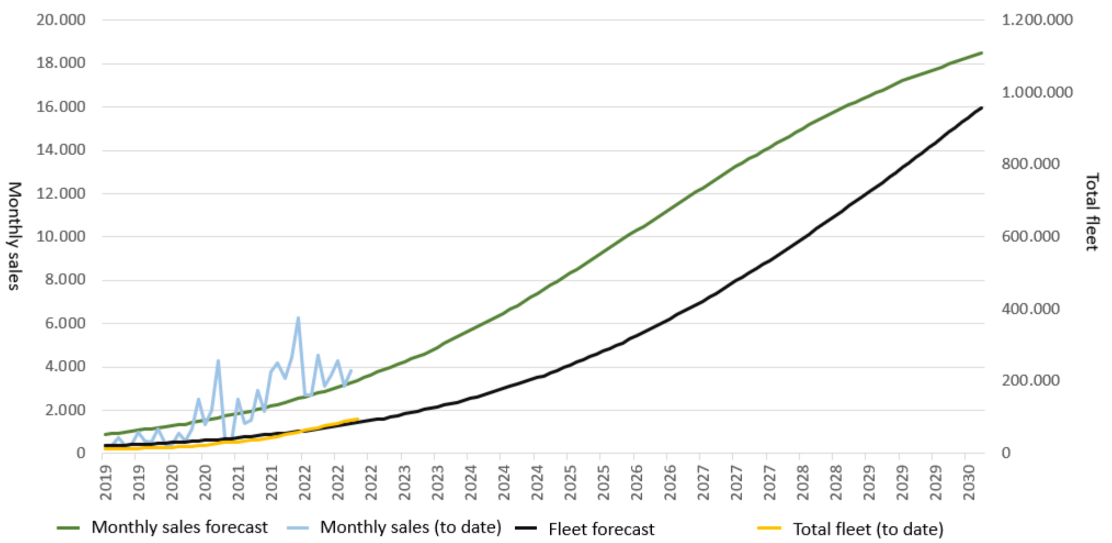

Figure 1. Monthly circulating EV fleet and EV sales forecasts for Denmark. Source: Dansk e-Mobilitet.

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Initiatives or Regulatory Measures to Accelerate the Charging Infrastructure Rollout

As per a recent analysis of an updated EV stations database, in November 2022 Denmark has a total of ~7500 publicly available normal chargers and 1322 chargers with a nominal power over 50 kW. According to a recent Danish charging infrastructure study, published in 2022, there is an estimated need of 67000 public and semi-public chargers by 2030.

Besides implementing Energy Performance of the Buildings Directive (EPBD) and the Alternative Fuels Infrastructure Directive (AFID) in national legislation, the Danish government have made several public green funds available for accelerating the investments in both normal and fast chargers.

Several additional national initiatives have been carried out:

- Integration of EV charging infrastructure data (both static and dynamic) in a national data repository for market data (DataHub), led by Danish TSO EnergiNetDK
- The establishment of a new national knowledge centre on charging infrastructure (2022)

Other (smaller) initiatives, are:

- Smart-from-start: recommendations from Danish e-Mobility and DTU on charger requirements.
- A common national charge-map and guidelines on charging infrastructure collected in common information webpage
- ChargePoint Calculator: A tool for forecasting the need of charging infrastructure in cities and municipalities

Initiatives or Regulatory Measures to Facilitate the Grid Integration and the Participation to the Different Markets

Electric vehicles play a major role in the grid development plans by Danish DSOs. Forecasting tools used by the DSO provide the expected amount of EVs and coincidence factors of charging. Another focus point is on quantifying and utilizing available demand-side flexibility.

As such the Danish trade organization "Intelligent Energy" has proposed a national industry standard "Industry guidance for grid companies' procurement of flexibility services" for the DSOs to make use of load flexibility. As part of this initiative, a roadmap has been developed (se figure below).

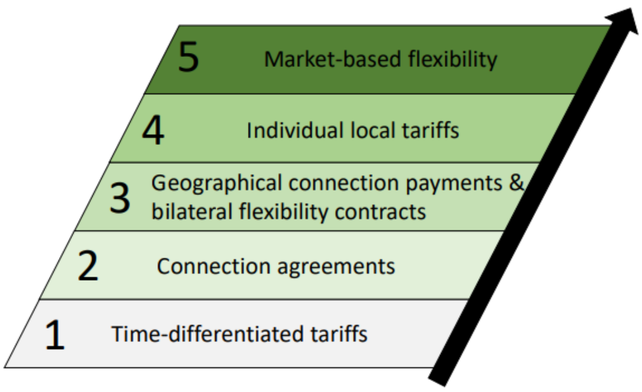

Figure 2. Roadmap for the use of EV flexibility for DSOs in Denmark. Source: Tim Unterluggauer, DTU, 2022.

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The largest Danish DSO, Radius, are currently developing the first two steps of the roadmap (Time-differentiated tariffs and connection agreements) - but are also engaged in several projects exploring bilateral contracts with Electro-Mobility Service Providers (EMSPs) to provide flexibility from EV fleets.

Furthermore, the Danish TSO, Energinet has conducted pilot programs for allowing EVs to participate in the ancillary services market under temporarily relaxed terms. These programs have allowed for a national trial in which V2G vehicles have provided frequency regulation under commercial terms.

Finally, a technical regulation by the Danish TSO Energinet describes the technical requirements for battery plants and electric vehicles for connecting to the grid and participating in the provision of ancillary services.

4.2.4 Best Practice Examples from Partner Countries

While all EU countries are expected to implement the EU directives and regulation described in section 4.1, we are also looking for country initiatives going "above and beyond", which could serve as an inspiration to others. Therefore section 5.2.4 will present such regulation/initiatives.

Table 8. Examples of EV related initiatives in the partner countries.

Name of initiative	Country	Description
Political incentives: National Electric Mobility Platform	Germany	Purchase grant (environmental bonus) for BEVs and PHEVs, Support for the roll-out of charging stations, increasing the number of electric vehicles in the public-sector vehicle fleet, vehicle tax exemption for BEVs
Best practice: Smart solar system for bidirectional charging	The Netherlands	The municipality of Utrecht has developed a system for electricity exchange between solar panels on buildings, bi-directional batteries (of nearby parking cars), and the electricity grid, all connected via charging points, that not only allow to equalise electricity supply and demand through time, but also provide nearby storage capacity for solar electricity, hence keep the electricity grid balanced. The city's task is to drive a wide roll-out of AC bi-directional charging points.
FlexiNet	The Netherlands	Intelligent flexibility by integrated hybrid storage techniques in the building environment. Energy interactions in and around house combining V2G electric EV- with heat-storage to provide home comfort in all seasons.
ElaadNL	The Netherlands	Founded in 2009, the ElaadNL partnership brings together all the Dutch grid operators to combine knowledge and funds for research and innovation in the field of smart EV charging infrastructure in the Netherlands. The innovation center participates in several projects that research and test a range of smart charging solutions ranging

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		from market-based procurement of flexibility, solar energy storage applications and V2X.
ESB Networks National Networks Local Connection Programme	Ireland	The distribution system operator, ESB Networks has defined a detailed plan and roadmap for the introduction of distribution system-based flexibility services. The roadmap includes definition of services, proposed market frameworks, roadmap for pilots and details of technical implementation requirements. Although not specific to EVs, flexibility from EV charging would be procured though this framework.

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5. Stakeholders

Error! Reference source not found. gives an overview of the different stakeholders involved in the development of the EV charging infrastructure. In the following sub-chapters, each one of them will be described in detail, based on their motivations, demands and drivers.

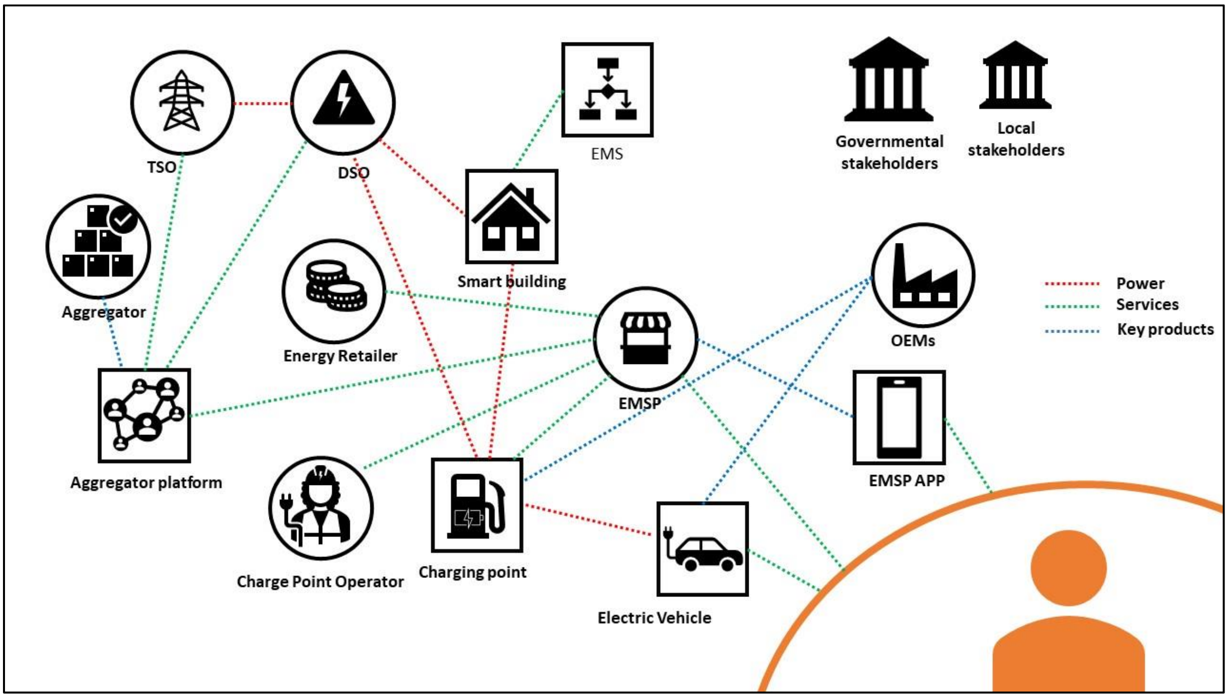

Figure 3. Most relevant interactions between stakeholders (in circles) and key products (in squares). If a stakeholder is responsible for a key product, this is marked by a blue line.

The electricity system consists of a rather complex relationship between several stakeholders and key products, the most relevant of which are presented in **Error! Reference source not found.**. The electricity is transported by Transmission System Operators (TSO) and Distribution System Operators (DSO) directly to the charging points or through a smart building that features an Energy Management System. The exchange of electricity along this path is facilitated by several stakeholders, out of which the Electro-Mobility Service Provider (EMSP) takes a central role. Besides being the direct link between the user and the charging points, the EMSP also facilitates the purchase (and potentially the sale) of electricity from/to the energy retailer through the aggregator platform. Original Equipment Manufacturers are responsible for products that can conveniently facilitate V2G charging. The end user administers charging settings (including V2G options) and payment through the EMSP app. Outside of the electricity system, Governmental and local stakeholders try to direct the system towards their overall interests in different ways, e.g., regulations.

In this chapter we seek to provide an overview of each of these stakeholder's interests in an electricity system with a focus on Vehicle-Grid Interaction/integration (VGI). We seek to provide a detailed description for each of the stakeholder when it comes to their motivations, demands, and drivers. Further technology improvements, needed for participating and contributing to such a system, are listed as well, if relevant.

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5.1 Energy Retailer

Any entity which is authorized by the market regulator to buy or sell electricity on the market, is a retailer. Consumers generally stipulate a purchase agreement with a retailer, so they represent a contact point between the production and the consumption sides.

Motivations

The increased electrification of consumption and the introduction of new technologies for smart charging and V2G will imply the creation of new market dynamics, which will be integrated into the current services provided by energy retailers. Thus, they are particularly interested in participating to the V2G market since their involvement will eventually lead to an increase in the amount of energy sold. The introduction of retailers into the market of electric mobility has enabled them to extend the sale of electricity, not only to the end user but also to the EMSP. Furthermore, the development of new services like V2X and smart charging raises new challenges that can be caught as opportunities by retailers, such as market repositioning and the possibility to expand the range of services integrated into the offers.

Demands

The major obstacle retailers may face in entering the V2G market is the lack of a defined market regulation. The existing technical and structural problems, related to the exchange of data, require the introduction of platforms to integrate the management of multiple services, including grid flexibility ones.

Drivers for Further Development

In the upcoming years, the penetration of multiple EVs will lead to a larger number of users that will request access to services, resulting in an increment of economic benefits. Furthermore, the complexity of the system implies the development and integration of flexibility within other services of the energy market.

5.2 Transmission System Operator

As a grid operator, system, and market facilitator, TSOs have a triple perspective and task, when speaking of e-mobility. They should ensure coherent grid and charging infrastructure planning (especially with high power requirements) as well as facilitate and enable the flexibility opportunities provided by EV smart charging and guarantee a safe management of the electricity system while deploying new distributed resources.

Motivations

Optimal management of the charging process will be fundamental to tackle the potential system challenges and take advantage of all the available opportunities. According to the Global EV Outlook 2022 by IEA for Europe, the share of electricity consumption attributable to EV will increase to 4-6 % of the total electricity consumption, driven by decarbonization goals in the transport sector (source: IEA Global EV Outlook (2020)). For example, Italy foresees 10 million electric vehicles (both battery electric and hybrid) in circulation in its 2030 policy scenario (Documento Descrizione Scenari Terna-Snam 2022, the energy system development scenario issued by the Italian electricity and gas TSOs).

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Those EVs, will replace a large part of today's gasoline and diesel cars. As a reference, in September 2021, e-mobility in Italy consisted in about 321.000 electric cars circulating in the whole country. Despite this, expected percentage values in total electricity consumption are still low, and will not imply significant challenges in terms of energy consumption. However, if smart charging is not properly deployed, power issues could arise due to massive EV diffusion. For example, uncoordinated charging in the evening hours would generate a fast ramp up in the EV load, potentially worsening the already critical evening ramp. Nowadays, evening load ramps are managed by the TSO by making use of resources offering their flexibility on the ancillary services market – at present, mainly thermo-electric power plants. In the future, the use of smart charging and V2G could potentially contribute to the EV load curve shifting power demand to more suitable times. Aggregated smart EVs could also support ancillary services markets, reducing the need to switch on thermo-electric plants for flexibility provision, while also contributing to increasing renewable energies integration.

Demands

For EVs to participate in markets and unlock flexibility for grid management and new opportunities for the stakeholders, various barriers need to be considered and overcome. Planning of charging infrastructure should be conducted taking grid operators into account, especially TSOs for whom high power charging is a particular concern. On top of that, expressing mandatory national deployment targets for smart charging at the EU level could favor the roll out of smart charging infrastructure both in private and public areas, and constitute a push for standardization. In this sense, the development of industry-supported open standards and protocols should be supported at the international level and consider the grid-readiness of e-mobility devices to guarantee the interoperability of charging networks and the capability to perform V2G. Cooperation between market actors and system operators should be enhanced too, in order to maximize the benefits for the different players across the value chain.

Drivers for Further Development

TSOs should be involved in as many aspects of e-mobility development as possible, to properly address the foreseen challenges and maximize all the opportunities related to the adoption of EVs. This would also facilitate the delivery of consumer-oriented services aimed at grid/system management. In this view, it is fundamental for TSOs to characterize the EV related technology as a flexible resource through dedicated projects – this can enable the identification of technical, standardization and regulatory issues and suggest viable solutions. TSOs should also cooperate with other grid operators, market operators, regulation authorities to jointly define and implement the best solutions to unlock the potential of EVs to provide flexibility services.

5.3 Distribution System Operator

DSOs are responsible for the correct operation of the distribution network, typically the LV and MV side of the electric system. They need to ensure security of supply, comply with technical regulations, and are responsible to evaluate and enact all the connection requests to the grid.

Motivations

Electrification of the transportation, heating, and industrial sectors will lead to a significant increase of the energy demand while, at the same time, a vast amount of new renewable and distributed energy resources should be connected to the grids. This will have a deep impact on electricity distribution networks that will have to face different consumption patterns, temporary congestion and voltage problems. To face the large amount of connection requests and new power flows values, always guaranteeing the right timing and high levels of safety, DSOs will have to undertake a shift in the traditional connection requests management towards an innovative planning methodology which, in addition to the reinforcement of grids capacity, leverages the use of ancillary services. For instance, when the DSO forecasts congestion, it can request the customers located in the affected grid area to temporarily reduce the power consumption by adequate values.

This new role of the DSOs will require huge investment in modernization and digitalization of networks to effectively forecast and integrate electric vehicle loads and other flexible resources in order to ensure an efficient, reliable and flexible management of the distribution grids.

Demands

As the charging infrastructure for EVs is, and will be, mainly connected to distribution grids, DSOs will be key in the achievement of the EU 2050 decarbonization targets set by the EU for the mobility system and the objectives of the AFID regulation. In this respect, DSOs play a double role as both responsible for distribution grid planning and promoters of the roll-out of charging infrastructure.

The increasing electrification of the transport system will require the adoption of innovative solutions for network planning that, in turn, rely on an increasing digitalization. The collection, management and sharing of distribution grid data will be paramount to achieve the digital and energy transition. EU and national regulation should promote the accelerated roll-out of smart meters and advanced metering and define access rules for EV and charging point data. This will allow for both better understanding of user behavior and improved grid observability. Another crucial requirement for network planning is making the location and capacity information of both publicly and non-publicly accessible charging infrastructure available to DSOs. To this end, a coordinated approach with local and regional municipalities with responsibility for electrification strategies should be pursued. The active engagement of DSOs in the planning of charging infrastructure roll-out should be promoted to identify the best suited connection points for overall system efficiency. At the same time, Member States should promote further investment in distribution networks based on efficient cost-benefit analysis that promotes both improved grid connectivity and grid capacity.

Article 33 (2) of the Directive (EU) 2019/944 establishes that DSOs "shall not own, develop, manage or operate recharging points for electric vehicles, except where distribution system operators own private recharging points solely for their own use". Nevertheless, a derogation is foreseen if it is established that there is no interest from other operators to perform such activities and the non-discriminatory principle is fulfilled. When these conditions are met, the possibility of DSOs performing installation and operation can present a cost-efficient solution and could be evaluated at national level to promote the deployment of charging points. In any case, the role of DSOs in the installation and connection strategy must be acknowledged to achieve an efficient and coordinated long-term network planning.

Charging infrastructure should be equipped with the necessary technical and communication devices to manage the charging process particularly at the low-voltage level, where most of the charging takes place. It is necessary to define specific requirements that the charging point must observe to be connected to the distribution grid. Such requirements are concerned not only with technical aspects,

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but also with how the charging point shall communicate with the DSO and other stakeholders. Additional aspects to be considered for the provision of ancillary services include data exchange policies, commands acquisition, and the interaction with other charging points connected to the same point of distribution (POD).

DSOs will also need new grid tools to increase the visibility of network constraints, monitor the grid in near real-time, and manage the flexibility resources provided. The existence of several stakeholders related to EVs charging points implies the need for a strong coordination among them. In this regard, primarily, DSOs must provide access to the distribution grid to supply the charging points. For residential users, there is no way to suggest an alternative location to provide supply; on the other hand, public charging points should be identified according to the grid capability. Regardless of the user category, it could be also useful to define a *non-firm contract* where the available power that a charging point can absorb from the distribution grid can be limited by DSO whenever the continuity of the electric supply service must be guaranteed.

Considering the importance of charging points data and other data (like the ones related to the PoD) in the grid management, it is necessary to adopt a register to share them with all stakeholders. From the DSO point of view, the register should include the significant data of charging points such as the nameplate power, the typical consumption profile and the capability to provide ancillary services to the grid. The register should also be connected to, or be part of, the Flexibility Register - a database collecting data from all the available flexible distributed resources. Moreover, the Flexibility Register should provide coordination between DSO and TSO to share ancillary services provided by charging points. In this regard, it could be necessary to define an identification methodology for the flexible resources available, without causing issues on the distribution grid.

Drivers for Further Development

DSOs can deploy an effective cooperation with Charging Point Operators and design consistent flexibility products to speed up EVs charging infrastructures deployment and minimize network costs, where EVs can help balance peaks and plunges in generation. Exploitation of real-time energy flow data combined with the new computing technologies will empower advanced monitoring and efficient network management.

In order to maximize the value derived from the massive increase of parked EVs connected to the grid, the local and global ancillary services will have to ease the involvement of Distribution Energy Resources (DER) as the e-vehicles, stating clear rules and fair compensation. Customer benefits may include an opportunity to reduce their mobility costs by trading time flexibility with service cost savings. Financial incentives can be offered through smart network tariffs/variable contracts when shifting charging outside peak/congestion hours.

5.4 Aggregator

The aggregator represents the contact point between the grid operator (TSO and/or DSO) and the EV charger owner or operator, providing flexibility services. As such, its main interest depends on the portfolio of managed assets.

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Motivations

The role of the aggregator is essential for providing portfolio and risk management services to increase the reliability of grid services and to simplify operations, avoiding direct interactions between the grid operators and each EV charger owner/operator.

For V2G services, the aggregator takes responsibility for the coordination of registered EV chargers, trading optimization, provision of the data interface between the EV chargers and DSO/TSO, and bi-directional communications with each EV charger.

The aggregator is responsible for monitoring the system and coordinates transactions on behalf of the EV operator following grid operator requests, local system frequency, or varying market prices. The site operator is responsible for directly monitoring EVs parked within its local area and reports the collected data (e.g., initial SoC, arriving time, departure time, final SoC) to the aggregator, typically in a batch mode of data communication used to monitor large volumes of EVs (Z. Yang et al., 2011).

The aggregator is responsible for collecting grid signals from the system operators and price signals from the market exchanges and then requesting the EVs to provide the demanded services, e.g., discharging the EV to route the previously stored energy from the EVs to the grid. Alternatively, the EV chargers might follow the local frequency of the power grid for providing frequency response services. The aggregator oversees distributing the revenue delivered to the aggregator from the grid operator to the owners or operators of the EV chargers within the aggregated virtual unit utilized during V2G operation.

Although individual EV plug availability is highly stochastic, the availability of hundreds of EVs can be estimated, and optimal aggregation strategies can be proposed to reduce the energy costs for a pre-defined set of grid utilities. At the same time, the reliability of the response provided for grid services and energy trading increases.

The primary services that can be provided to the grid are price arbitrage, frequency regulation, voltage support, and DSO congestion management (Amamra & Marco, 2019). With price arbitrage, the additional discharging capability of V2G allows the trading of positive and negative energy into the wholesale markets. It could create additional profits by selling energy from the EV during high-price periods (Kiaee et al., 2015). Existing research provides that EV batteries can provide, in addition to ordinary flexibility services (e.g., tertiary reserve), faster services (e.g., primary reserve or fast primary reserve). V2G scheduling optimization is typically based on up and down price regulation. Voltage regulation studies show that the DC link capacitor of the EV charger is sized to supply reactive power to the grid without engaging the EV battery, causing no degradation in it (Wang et al., 2019).

The main concerns affecting V2G participation are market access conditions, technical regulatory framework, and on-site technical capabilities such as charging and vehicle technology. While regulations and market rules directly prevent the involvement of V2G resources in the markets, the technical variables can significantly influence the benefits. Literature shows that an effective business model minimizes the battery degradation cost (Amamra & Marco, 2019).

Demands

In order to overcome the main challenges, regulators and system operators in each market must clearly define the overall regulatory framework to ensure a level playing field is provided for V2G

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resources. The regulation must be defined in such a way that it guarantees access to a broader market, so that is up to the aggregator to select the most suitable market to participate in.

From the technical point of view, regulators need to identify the minimum technical requirements that charging infrastructure must meet to provide services (such as telemetry or maximum end-to-end latency). Additionally, a precise technical alignment between the aggregator and charging owner or operator must be in place, with implicit and explicit financial incentives clearly defined. The aggregator needs to have access to data or results of technical limitations of the site, chargers, and EVs connected to the chargers, near real-time status, availability, and behavioral analysis of charging stations (such as site forecasts) to have better insight. This data would be used for portfolio management and market bid/offer management.

Commercially, the aggregator and the owners or operators of the chargers should agree on a financial framework, as the aggregator will be responsible for distributing the revenue generated in energy markets to the EV chargers.

Drivers for Further Development

Actively participating in grid services that offer flexibility is essential to foster the green energy transition. On the other hand, valuable market remuneration is necessary to create a business case promoting participation in scale. Thanks to a solid regulation framework, EV sites can participate in V2G programs without impacting daily operations for EV car owners.

Market revenues are also essential to offset the higher cost of the V2G infrastructure to the site owner. From a customer standpoint, the revenues are essential to balance their battery degradation costs and improve the overall economics of owning an EV. Providing grid services empowers them to actively help society and the energy system while generating additional financial value.

To conclude, the market regulations must set the standards to guarantee the proper implementation of such services without overcomplicating the enablement requirements (e.g., no real-time sub-sec telemetry from each EVSE) which will increase the costs for enabling the services. More straightforward market standards are essential to boost participation and create market competition.

5.5 Electric Mobility Service Providers and Aggregator Platforms

Electric Mobility Service Providers (EMSPs) are the actors directly interfacing with the EV users for their private and public charging needs by offering services via app, managing payment, and customer care.

Motivations

V2G/G2V technologies represent an opportunity for EMSPs, as they enable them to differentiate their product portfolios by anticipating new user needs driven by widespread EV adoption. The spread of the EV integration technology will also make possible to identify efficient solutions able to minimize the cost of energy while guaranteeing the charging needs and a satisfactory customer experience.

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Aggregator platforms (or Energy Management Systems) are the tools able to manage the EVs grid integration by smoothly enabling the interactions toward the EMSP, the CPOs, and other downstream users. The spread of VGI adoption constitutes, by its nature, the chance for offering new services toward these actors.

Demands

As any private actor involved in the VGI value chain, the EMSPs and smart charging platforms benefit from clear and reliable market and regulatory rules, product definitions and technical requirements. An important demand of EMSPs is the high level of adaptability of the already available charging infrastructures and management platforms to the new requirements, market rules and products. Otherwise, the actors considering only the future or "retrofitted" infrastructures would be limited in the offering of such services.

Being in direct contact with the EV user, the EMSPs and smart charging platforms require that the deployment and exploitation of VGI technology by all the stakeholders involved is designed around "simplicity of application" and "low barriers for user-entry" Ignoring the user experience (UX) aspect, would simply make the efforts of all the other involved stakeholders ineffective, as number of flexible EVs available would not be high enough due to users lack of interest/high cost of entrance.

Drivers for Further Development

Drivers for EMSPs and smart charging platforms are linked to both regulatory and business environment developments. On the regulatory side, the development of market rules, products and technical requirements are crucial to design new offers around G2V and V2G technologies. On the business development side, two important drivers are the readiness of the other actors involved in the flexibility value chain, and the availability of flexible assets (i.e., clients interested to participate in such markets and massive diffusion of suitably equipped vehicles).

5.6 Charging Point Operators

Charging point operators (CPOs) own the charging equipment hardware, maintain the network connection, and sets the prices for the use of the EVSE, which is then taken as a reference by the service providers.

MotivationsBy making use of smart energy management technologies, the grid can be stabilized and EVs can be charged without an accelerated investment in grid reinforcement. By choosing proper chargers for home charging and office/public charging, as well as fast/ultra-fast charging, an energy management system could ease the burden induced by an exponential increase in EV penetration, while also introducing a new revenue source for supporting the grid stability. This revenue source varies depending on the country and can potentially be attractive for the involved stakeholders in some countries and less attractive in others. Within the energy markets, smart energy management technologies will typically involve the frequency containment resources (FCR) and potentially also the frequency following response (FFR) domain.

Flexibility services and balancing services are closely related, and the implementation of bidirectional models often have an increased value for all the involved stakeholders. By making use of bidirectional

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battery technologies, it is also possible to store energy when it is cheap and the indirect CO2 emissions are low, and then release it when the electricity is expensive, and its CO2 content is higher.

Demands

Combined efforts can ensure and allow the consumers to charge their EVs when electricity is either cheap and/or 'greenest'. Greenest could be defined as when the CO2 content in the electricity production is low, compared to other timeslots during the day, or days if forecasted over a period. Within the greenest charging period, it is then important communicating with the user to ensure that insight to a breakdown of the CO2 content can be visualized in sufficient details.

Both dynamic pricing and CO2 based evaluation of the greenest charging period should be integrated on a platform with the possibility to have such features and other solutions implemented. However, when it comes to roaming, the present APIs and many platforms are not yet able to handle dynamic pricing or CO2 content variations on an hourly basis. Hence, this task will have an impact on consumer and society value to develop in a standardized way and to roll-out to the end-users' benefits.

Further methods could be developed to interact with TSOs and DSOs on load shaving and peak shaving so that local requirements can be executed avoiding potential difficulties such as blackouts or local constraints.

Drivers and Further Development

There are many focus areas for the CPOs, which support market requests and needs. Within the dynamic pricing domain, there is a need to ensure local models are driven by the requirements of TSO demands or the national energy association demands. Hence, beyond a general model which can be based on spot-pricing plus additional components, there is a need to develop further models that support the energy market required components. For this to work throughout Europe, and across the e-mobility branch, the market needs to be able to share such information over hubs or via OCPI-like bilateral API connections.

The development of a communication protocol and integration between different stakeholders' platforms can lead to the increase of participation and the scalability of the system.

Demand-side response (DSR) requirements are also of high importance and must be implemented in standardized ways to facilitate stakeholder requirements across energy market boundaries.

Currently, V2G technologies have been mainly used for research purposesor small scale for commercial demonstration - but these projects will need to evolve fast. Soon we will see large scale potential in V2G as well for flexibility and grid balancing possibilities. The larger potential is enabled by new EV platforms which support either AC or DC interfaces to carry out V2G in order to support the grid needs. However, the level of customer-oriented involvement is still scarce, due to very few EVs and chargers being involved in V2G applications. We expect this application area to grow fast with the mass introduction of the many new EVs supporting V2G. Having the V2G potential 'just around the corner', allows for a VGI technology to be implemented.

In this context, the role of the CPO is fundamental to enable the active participation of the end user to the flexibility service. This proactive approach facilitates the integration of flexibility energy market, user needs and mobility market, in order to reach greener and more sustainable mobility.

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5.7 Electric Vehicle Users

In order to successfully design and implement VGI, it is necessary to match users' mobility needs and requirements with the goals of the energy sector. Therefore, practice and research need a better understanding of potential customers' acceptance of the new technology. Hence, understanding users' attitudes and needs is crucial for the development of a smart charging technology and should serve as a basis of the development of products and services related to bidirectional charging (Sovacool, Noel, et al., 2018).

Motivations

The literature shows a heterogeneous view of users on concepts such as V2G, controlled charging (i.e., CC), bidirectional charging (i.e., BC) or smart home services, even among experienced EV drivers (Kubli, 2022).

Perceived benefits Overall, consumers consider CC and V2G to be environmental-friendly and beneficial for health, as renewable energy sources are promoted and emissions are reduced (Hadi Amini et al., 2019). Another positive aspect concerns the integration of a local energy source into the household power supply, not least because of the additional emergency power supply by the car (Noel et al., 2018). The opportunity to contribute to the stabilization of the power grid seems to be appealing (Kämpfe et al., 2022), however, consumers do not want to take too much responsibility for grid stability (Will & Schuller, 2016). In addition, customers associate CC and V2G with a financial benefit (Kämpfe et al., 2022).

Concerns On the other hand, users express numerous concerns, which may be an obstacle to participate in CC or BC. These concerns or barriers mainly relate to the perceived risk of data misuse and hacking and thus an assault on privacy. Potential customers are concerned that private data could be transmitted, traced back and thus, energy companies could gain access to private household data (Gonzalez Venegas et al., 2021). In addition, costumers fear that non-entitled persons could bring energy usage and the charging process under control and gain unauthorized access to the vehicle and its location (Sovacool, Noel, et al., 2018). Furthermore, users fear personal restrictions due to the timely limited availability of their vehicles and contractual obligations. For costumers, this means a loss of freedom, flexibility or spontaneity and thus a loss of autonomy (Kämpfe et al., 2022). Especially the high effort involved, e.g., through additional planning, is perceived as a factor disturbing their lifestyle (Delmonte et al., 2020). On the technical side, consumers worry about faster battery degradation, resulting in frequent battery replacements and thus higher costs (Göhlich & Karohs, 2018). This, in turn, increases the existing range anxiety (Huang et al., 2021). Some users also care about hazards through technical disturbances, such as danger of fire and explosion of the battery, and anticipated health risks due to electromagnetic radiation from smart meters (Noel et al., 2019). Another barrier of participation in V2G is the fear of financial losses and hidden costs, such as omitted disbursements or double burden of taxes. In addition, a lack of comprehensible laws and rules for the integration of V2G leads to uncertainty and thus inhibits participation in V2G (Karohs & Göhlich, 2018).

Factors influencing user perceptions Demographic factors, such as age, gender, employment and education influence user perceptions of electric mobility and V2G (Sovacool, Kester, et al., 2018) Men, for instance, show a slightly higher interest in V2G and are more willing to participate than women are. However, this does not apply to younger men, although people in vocational training are more willing

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to use V2G (Geske & Schumann, 2018). In addition, users' knowledge and understanding of the system as well as possible energy-saving options also play an important role in participation in V2G or similar projects (Kubli, 2022). Often, potential customers have incomplete knowledge regarding the benefits of electric mobility and V2G (Kester et al., 2018a). Many of the psychological barriers originate from this lack of knowledge. The experiences of users regarding the benefits of BEVs and of smart technologies also affect the understanding of the systems (Kim & Shcherbakova, 2011). A high customer involvement and transparency may increase the willingness to participate in research projects in this field. Acceptance for BEVs can especially be increased by including the interests of the BEV users in a transparent way (Meisenbacher et al., 2021). Furthermore, perceptions and preferences towards electric mobility vary across countries or samples globally and even within Europe (Kuhn & de Jong, 2017).

Demands

Users expect a smart charging system to be simple. It must be comprehensible, easy to handle, and suitable in everyday life without much effort (Kämpfe et al., 2022). In particular, this refers to the following components: *charging and charging hardware*, *user interface, business model*, and *range*. In terms of the overall system, simple communication structures and technical solutions are required to control and automatically optimize the charging process relating to price, merit or benefit (Balta-Ozkan et al., 2014),. Besides, the system should be reliable and trustworthy including a trusting and secure handling of user data (Kämpfe et al., 2022). As users perceive smart charging as environmentally friendly, they also expect appropriate feedback on environmental factors, such as energy consumption (Milchram et al., 2018). This aspect addresses the user interface as well as the business model.

Charging and charging hardware Little literature exists concerning the handling of the charging process itself. Consumers prefer to charge their BEV at home (Gonzalez Venegas et al., 2021), have established charging habits (Delmonte et al., 2020) and are willing to pay a premium for flexible solutions that e.g., facilitates (cheap) access to public chargers (Visaria et al., 2022). Home charging stations are required to be theft-proof, aesthetic, compact, weatherproof, and cost efficient (Kämpfe et al., 2022). Moreover, public charging should guarantee short charging durations, for example by fast charging options (Döring & Aigner-Walder, 2017) and could compensate for range limitations due to small driving autonomy or limitations in the min-max attainable SOC. Participants asked for visible, simple to use and comprehensible charging stations (Kämpfe et al., 2022). Missing standards in the authorization process and the handling of heavy recharger cables were criticized. Thus, chargers should fit the needs of the grid on the one hand and the user on the other hand (Marinelli et al., 2020).

User interface Potential users require several alternative interaction options with a consistent design (Kämpfe et al., 2022). In addition, simplicity, customizability (Will & Schuller, 2016), reliability and transparency (Meisenbacher et al., 2021) are important characteristics to customers. The interface should provide clear and sufficient feedback on the charging process and status via live monitoring (Meisenbacher et al., 2021) and decrease effort for the user by leading him through the process (Huber et al., 2019). Furthermore, the interface should be compatible with other (existing) applications (H. Yang et al., 2017). To interact with the charging management system, domestic users prefer a charging app that is compatible with different operating systems such as iOS or Android and accessible via various devices such as smartphone, tablet, the internet and the vehicle's user interface (Kämpfe et al., 2022). Nevertheless, the charging process itself should also be able without having to use any additional devices such as smartphones e.g., due to lack of internet service in some areas (Delmonte

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et al., 2020). The charging assistant should enable the user to make all settings that are essential for controlled charging (Kämpfe et al., 2022). Consumers want the charging assistant to provide them with information and feedback about the charging concept, including their participation, as well as mode and status of the charging process (Kämpfe et al., 2022). Moreover, users claim for value-added services, e.g., for the use of public charging infrastructure, calendar functions, incentives, etc (Kämpfe et al., 2022).

Business model Trust is crucial in the relationship between the customer and the service provider. The contractual partner is thus important to customers (Kubli, 2022). For instance, in studies in German intelligent charging projects, it was found that as an aggregator or juridical partner, users either prefer their current power provider, or the car manufacturer (Kämpfe et al., 2022). The contract should regularize security of power supply, remuneration, contractual duration, compensation of battery aging, as well as details of participation on V2G (Park Lee, 2019). Users particularly consider the contract elements remuneration, guaranteed energy and discharging cycles to be important (Zonneveld, 2019). Regarding billing modalities, (Will & Schuller, 2016) suggest charging tariffs according to the customers' contribution to grid stability or integration of renewable energies. In contrast, (Parsons et al., 2014) recommend eliminating contract requirements and allowing consumers to provide the V2G-service at their convenience on a pay-as-you-go basis instead. Finally, the acceptance rate of a business model depends on the respective user group (Döbelt & Kreußlein, 2019). Regarding the communication of providers with potential costumers' aspects of innovativeness, the support to the grid and the environmental benefits of bidirectional charging systems should be highlighted (Kubli, 2022).

Car and range (Franke et al., 2017) and (Haustein et al., 2021) both found that range satisfaction increases with experience with BEVs. However, there are substantial inter-individual differences in the perception of comfortable range and range buffers (Franke et al., 2012). Referring to V2G, mobility requirements must at least be guaranteed (e.g., by providing minimal security range; (Kämpfe et al., 2022), and at best be enhanced (e.g., by remote access to the system) by the system (H. Yang et al., 2017). Regarding vehicle instrumentation, users demand clearly and simply displayed information providing detailed feedback (Neumann & Krems, 2015). Particularly, users ask for a breakdown of all energy loads while driving (Rauh et al., 2015) (Franke et al., 2015), for displays of 'per-tank of fuel' (Stillwater et al., 2012), 'points-of-no-return' and the 'true' remaining range (Franke et al., 2015). The smart charging system should not restrict the use or functionality of a BEV, also in terms of safety (Kämpfe et al., 2022).

Drivers for Further Development

Financial incentives The findings on financial incentives are ambiguous. On the one hand, financial incentives increase the acceptance of smart charging concepts (Gonzalez Venegas et al., 2021). On average, consumers expect a monthly discount of around 20% of their charging costs (Will & Schuller, 2016). On the other hand, users are very pessimistic about the income generated by their participation in V2G (Noel et al., 2019). In addition, the annual net income of V2G is relatively low. Therefore, the expected income is not a sufficient incentive to use the technology (Delmonte et al., 2020). Similarly, users would not pay more for an electric vehicle for the fact that it is V2G-enabled (Schmalfuß et al., 2017). However, they are willing to participate in smart charging projects for a rather low reward (for instance in the form of money transitions to bank account (Schmalfuß et al., 2017), if this does not restrict the range too much (Noel et al., 2019). In contrast, savings seem to be a promising motivation

(Delmonte et al., 2020). Users perceive energy savings and their resulting positive impact on the environment as even more important than cost efficiency (Ballo, 2015), even if the current electricity costs could alter this tendency. Additionally, especially early adopters are more likely to be persuaded by non-financial incentives than by financial ones (Huber et al., 2019).

Non-financial incentives In addition to financial incentives, non-monetary incentives have a high potential to increase participation in controlled charging, or even have a larger impact on acceptance than financial benefits (Huber et al., 2019). Since users perceive smart charging as environmentally friendly, the use of renewable energies or the purchase of environmental certificates represent major incentives (Huber et al., 2019). Therefore, the ability of a vehicle to perform bidirectional charging is perceived as beneficial and can influence the purchase decision of a BEV (Kubli, 2022). However, users often prioritize their personal mobility needs over the environmental benefits of BEVs (Rezvani et al., 2015). Additionally, the acceptance of users can be increased if smart charging systems are able to secure grid stability (Huber et al., 2019). Nevertheless, the acceptance of bidirectional charging among EV drivers can be increased by compensations such as fast charging or lower costs of charging (Kubli, 2022)(Huang et al., 2021).

Other incentives derive from instrumental motives focusing on functional attributes (Bohnsack et al., 2015) and the hedonistic motivation to use new technology (Rezvani et al., 2015). Even though EV drivers show little interest in technical aspects in detail and are therefore not particularly motivated by them (Huber et al., 2019), the experience of special features of the system can positively affect the perception of symbolic and hedonistic attributes (Milchram et al., 2018). These functionalities include, for example, gamification elements or feedback, such as the insight into data (Schmalfuß et al., 2017). As emotions (positive and negative) influence, to some extent, the purchase of new technologies, these functionalities are essential (Rezvani et al., 2015). Other aspects, such as mobility-related incentives (extra kilometres for rental vehicles or reduced train tickets) or battery-related incentives (extension of the battery warranty, bonus points for new battery, etc.) can increase the acceptance of CC (Huber et al., 2019).

Social factors Policy and society have a significant influence on the acceptance and use of concepts such as V2G. The way politics spread information (Noel et al., 2018) and the strength of the electric vehicle legislation, influence user perceptions, preferences and purchasing patterns (Kester et al., 2018b) Policy also plays an important role in standardization, as standards must be part of a continuous political process (Huang et al., 2021). Further, the social environment of potential users decisively influences the acceptance of e-mobility and smart charging (Milchram et al., 2018). Knowledge gaps and social norms in particular lead to users' orientation towards others (Hansen & Borup, 2014).

5.8 Car Manufacturers

Car manufacturers are responsible for the entire process of developing, marketing, and selling electric vehicles, thus they could greatly benefit from faster EV uptake speeds.

Motivations

Car manufacturers are in general interested in making the charging process efficient, effective, and satisfactory for the users. With its focus on acceptance of electromobility and ease of interaction,

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incorporating the users of these interface constitutes a crucial aspect of this technological progress. In order to achieve these goals, as an example, BMW plans to develop generic requirements for human-machine interfaces (HMI) of charging solutions. Through collaboration with OEM, suppliers, research institutes, as well as grid operators they seek a better understanding of how to advance users' interaction with e-mobility. This process includes, on the one hand, HMI development from a technical charging and grid perspective and, on the other hand, a human-centric perspective.

Demands

Car manufacturers' needs and standards should be addressed in conformity with the expected V2X/smart charging transition scenario. Manufacturers are currently working on electric vehicles with a range of more than 600 kilometres, and the efficiency is, in general, improving, so that cars don't have to charge as often, or can charge with a regular plug at home (from IEA's Trends in EV Light-Duty Vehicles). To meet these targets, an effort at the EU policy-making level is complementary to foster the V2X/smart charging transition: to steer car manufacturers to that shift, state aid and subsidies should go hand in hand with the implementation of European Union's cluster files such as the Trans-European Transport Network (TEN-T) policy, and the ones presented in 5.1. A successful, wide-scale and fair integration of the system depends on how the regulatory framework will support OEM's adjustments by counterbalancing market flick of tails. In addition, the lack of comparative advantages with trading partners, the costs associated with industrial adaptation to smart charging/V2X, and the dispersion of investment due to different product assortments and their functionalities may be more burdensome than expected; therefore, adequate political commitment is expected to address all the variables and anticipate the challenges that may affect the industry, while ensuring the highest standards of flexibility and range of complementarity for smart charging solutions. The recently approved 2035 ban on the sale of new internal combustion engine cars creates the momentum and the pre-conditions to meet these expectations: policy recommendations will be made to avoid blockages in the value chain to support the transition from a multilevel stakeholder perspective. As "standardization" and "replication of actions" are indeed achievements for FLOW, a more comprehensive legal framework (including incentives), increased awareness for end consumers, and infrastructure deployment will enable domestic industries to adapt and invest toward more sophisticated capabilities such as V2X, preparing for a mass-market uptake.

Drivers for Further Development

There are plenty of applications available that offer public and private vehicle charging – often with very different HMI solutions. By following a benchmarking approach of user testing, specific advantages and disadvantages for HMI development can be further developed. This can give impetus to the development of prototypical HMI solutions which shall further be evaluated in subsequent user studies regarding their positive impact on user acceptance and usability.

5.9 Charger Manufacturers

Charger manufacturers produce a range of EV-related products that must fulfil certain regulated requirements with regards to security and network stability.

Motivations

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Their economic margins allow them to not only to keep market demands in consideration, but also take a more innovative approach (ECA, 2021). Such an "open space for designing solutions" is the key enabler for innovation but may also produce knowledge dispersion and a lack of the minimum standards and interoperability (i.e., charging stations availability, payment system, data management, information for users) which are required to create an EU-wide charging infrastructure system.

Demands

According to the 2016 EU Low Emission Mobility Strategy, the ultimate goal is to make recharging EVs as easy as refuelling an ICE vehicle, so that they can seamlessly travel throughout the EU. Additionally, charging station deployment is a crucial precondition for the integration of V2X/Smart charging solutions. Charger manufacturers, as OEMs, might be reluctant to invest in new technologies due to high costs, market unpreparedness and lack of legal framework. The link between the EV and its charging station lies in the standard technical and legal requirements needed for an interoperability of the system. The charger manufactures should be supported to run towards the V2X/smart charging framework at the same pace of EVs deployment, in order to ensure a complementarity and a further stimulus for investments. With the introduction of tax breaks and subsidies for the construction of the infrastructure, relevant stakeholders could have the conditions to invest and deploy, in accordance with stakeholders from the entire ecosystem. The creation of an EU-wide framework for charging infrastructures, which could include the standardization of the requirements for tenders and network codes, would significantly improve the business case for charging point manufacturers to invest in V2X. Policy regulations are the enablers, as much as round table for relevant stakeholders: a clear definition of requirements to comply with, communication protocols to adopt and range of flexibility is therefore significant for the increase of investments of charger manufacturers in V2X. Communication and dissemination of relevant strategies is a further tool for replication and standardization of actions for market actors and relevant stakeholders across the smart charging/V2X value chain.

Drivers for Further Development

Most of scepticism towards EVs uptake at EU level stems from the lack of charging infrastructure, which is an obstacle to mass market deployment: the low diffusion of electric vehicles often dampens investors' enthusiasm for charging infrastructure, and vice versa. To this regard, CPMs and CPOs have adopted a cautious approach when it comes to implementing a wide European charging network: this framework results in a chicken-egg dilemma. To overcome the lock-in effect, EU legislation has recently led to a significant upgrade in the planning scheme for the diffusion of a European smart charging ecosystem, making it the dominant approach in most member states: the ban on the sale of new fossil fuel cars by 2035 has largely removed uncertainty about the future adoption of electric vehicles, significantly mitigating the chicken-and-egg dilemma. Moreover, the proposed infrastructure regulation for the Alternative Fuels Infrastructure Regulation (AFID) sets specific targets for the installation of high-power charging stations along major European transport routes by 2035. Regarding private charging infrastructure, the Directive on the energy performance of buildings (EPBD) requires pre-cabling for smart charging stations in new and renovated buildings.

The interoperability of these policies is a key factor in ensuring the deployment of charging points in tandem with the uptake of electric vehicles in the coming decades: this set-up would succeed in ensuring investors' confidence and market reliability.

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In terms of implementation by member states, national subsidies and tax deductions are also key to supporting the charging manufacture industry, along with EU policy framework.

5.10 Governmental Stakeholders

As explained in a recent ETIP SNET report on e-mobility, one key stakeholder category in the electromobility ecosystem is the governmental authorities at all different levels, from EU decision makers and national regulators to local authorities in charge of urban mobility and planning.

In the 2021 report on smart mobility, the International Council on Clean Transportation explains how the overarching driver for governmental stakeholders to incentivize the uptake of EVs, smart charging and V2X applications is the decarbonization of the transport sector. That objective must be achieved by meeting the power demand resulting from its electrification with renewable energy generation. This goal is reflected in the increasingly stringent targets on emissions reduction and phase-out of internal combustion engine vehicles put in place by the EU and reinforced by national strategies in many Member States.

Local Governments

On top of the benefits related to system decarbonization, in 2020 the European Commission published a report on smart mobility highlighting additional drivers for local authorities, such as the direct reduction of air and noise pollution in cities, an increased efficiency and potential multi-modal integration of the local transport system, the creation of new business models, new employment opportunities, and a better use of public space.

A 2019 study in Germany found that local governments, such as municipalities and provinces, play an important role in the market diffusion of EVs, as they can promote electrification of public transport while at the same time increase the attractiveness of e-mobility for residents and private companies. Additionally, local authorities share with national governments part of the responsibility for implementing policies regulating the local transport system, as well as land use and management of public areas. As the presence of clear rules on public charging is positively correlated to a higher adoption of EVs (Rajon Bernard et al., 2021), local administrators play an important role in influencing the uptake of e-mobility by designing and implementing policy that meets the needs of their citizens. Several aspects should be considered when addressing such a task. Firstly, municipalities are responsible for assessing and determining the location of public charging infrastructures in agreement with the CPOs and local DSOs involved in the connection to the grid. The local authority is also responsible for selecting the most appropriate model for the operation, maintenance, and exploitation of the installed infrastructure, for example by means of granting licenses or concessions. Secondly, municipalities are responsible for issuing traffic orders to regulate the use of parking spaces for the purpose of EV charging. Thirdly, according to their policy strategy, decision makers can set the conditions that determine what charging infrastructure will be suitable for installation, including requirements concerning (cyber)security, interoperability and readiness for smart charging and V2X applications. Lastly, local and regional authorities, together with national governments can put in place incentives, financial or otherwise, to support the growth of the EV market and promote the offering of smart and bi-directional charging to market and network operators (Rajon Bernard et al., 2021).

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National Governments and Regulators

When discussing national governments and their interests, all the drivers mentioned above for the local governments remain relevant. Additionally, national governments within the EU, are responsible for reaching the EU 2050 Climate Target plan presented in the "fit for 55" package by the European Commission, thus covering a prominent role in the promotion of the energy transition. Consequently, National Governments should recognize the importance of an accelerated adoption of EVs and roll-out of charging infrastructure and should work towards the implementation of an enabling regulatory framework. At the same time, national decision makers should ensure that consumers are well-informed and well- encouraged to adopt EVs, as well as to promote the efficient expansion of the EV market (Li et al., 2022).

The main roles attributed to national governments are policymaking, regulatory functions, executive or implementing functions as well as promoting consumer awareness, through various initiatives, including information campaigns. National governments must remember that for consumers to choose EVs as their preferred vehicle option, this must make financial and practical sense. As a matter of fact, consumers need a straightforward way to charge their vehicles at home, at work, or other practical locations. Apart from the latter, National Governments should explore optimal solutions to ease common drivers concerns such as range anxiety, which hinders consumers from using their EVs for long distances. When encouraging consumers to adopt EVs, policies adopted by national governments represent a key enabler. Examples range from tax incentives, which may reduce effective purchase costs, to regulations on emissions, which can alter the vehicle supply mix, thus appealing to the end consumer concerned with sustainability issues. Finally, policies that increase the visible benefits of driving an EV, not necessarily financial, must be introduced as well, such as the use of convenient parking spaces or high-occupancy-vehicle lanes. However, governments need to consider whether such initiatives unintendedly favor car use over other preferred transport modes, and what happens when the EV market reaches a certain penetration threshold.

While local governments have the responsibility of ensuring charging point availability within their district, from an overarching national level, national governments are the ones that must ensure harmonization between different local governments, whilst also exploring the possibilities to aid them in the promotion of infrastructure development. At the same time, an increase in EVs diffusion and load electrification in general, implies an increased burden on electricity grids, hence national governments and regulators should address challenges related to grid planning, management and operation, in collaboration with their national grid operators.

EU Institutions

As part of the EU's ambitious goal to become a climate-neutral continent by 2050, a multitude of new legislations are in the pipeline in the coming years, with many of them targeting mobility. This makes the EU Institutions a prominent stakeholder in the promotion of the electrification of the sector and the uptake of G2V/V2X solutions. Besides the ambition to carbon neutrality for environmental purposes, the RePower EU program also strives to decrease dependency on fossil fuels from countries outside the EU by 2030.

The role of EU institutions in accelerating the adoption of EVs is varied, ranging from promotion and encouragement to the implementation of tangible directives, regulations and policies. Currently, the

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EU promotes the use of EVs in multiple ways, from encouraging manufacturers to create low-emission vehicles to pushing for the roll out of charging infrastructure. Recently, the European Parliament adopted a minimum requirement for charging infrastructure for electric cars as part of the Fit-for-55 package. The EU is also imperative in promoting open standards that prevent large companies from controlling the market and preventing vendor lock-in effects, thereby ensuring consumer protection. Lastly, the EU's vision and its mandates on interoperability of charging infrastructure constitute another imperative point to allow EV charging and communication with the electricity grid anywhere in the EU.

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