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Smart Energy Europe

V2X ENABLERS AND BARRIERS

Assessment of the regulatory framework of bidirectional EV charging in Europe

DNV

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1. EXECUTIVE SUMMARY

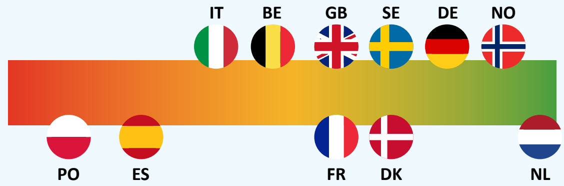
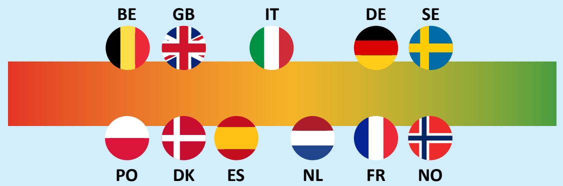
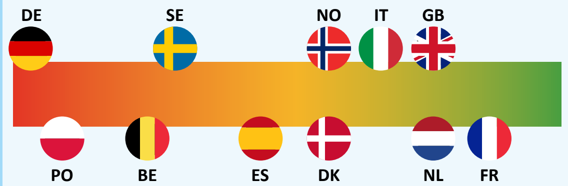
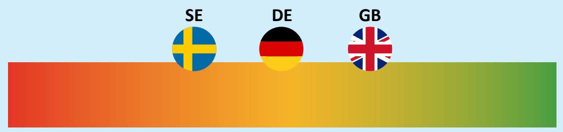
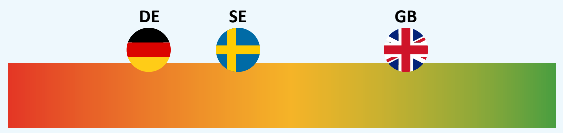
Europe's energy system is increasingly needing flexibility. While large-scale energy storage technologies have been the main focus, the importance of small-scale solutions, which are equally critical, is often overlooked. Demand-side flexibility (DSF) is one such solution that can help to integrate renewables, address the generation adequacy issue, balance demand and supply and to make efficient use of (often scarce) electricity infrastructure.

Bidirectional charging (also known as vehicle-to-everything or V2X and vehicle-to-grid or V2G) makes an important contribution to DSF by enabling electric vehicles (EVs) to become a Decentralised Energy Resource (DER), with energy storage functionalities on top of their primary transportation purpose. V2X is still in the early stages of development, however, all major EV Original Equipment Manufacturers (OEMs) either have V2X models or have committed to launch dates. Access to relevant markets and multiple energy suppliers/service providers are fundamental for the business case and future development of these models and a comprehensive regulatory framework must be in place to ensure that monetisation of the technology is possible via multiple routes.

Unlocking flexibility from EVs is not only a resource efficiency issue, it is also key to a fair and just energy transition. Indeed, without bidirectional charging, the terawatt-hours of batteries coming to Europe each year inside electric vehicles could be stranded assets 90% of the time when the vehicles are parked idle.

The role of policy and regulation is therefore to create the right framework for bidirectional charging and V2G to benefit all Europeans and to initiate the momentum required to scale these technologies. The objective of this study is to conduct an assessment of the current regulatory frameworks impacting bidirectional EV charging in different countries across Europe and explore what regulatory and political measures are needed for the technology to transition from pilot projects to widespread commercial adoption.

The framework for assessing the different countries is split into three areas: EV and charging development considerations, regulatory, policy and market considerations, and grid and system considerations. The performance of each individual country against this framework is explored throughout this report and summarised on the next page.

Section	Category	Country standings	Best practices
Grid and system considerations	EV and Charging Development Considerations		High Variable Renewable generation High EV market penetration V2X charging infraestructure targets
Regulatory, policy and market considerations	Regulatory Considerations		Double taxation has been eliminated V2X policies have been created V2G included in resource adequacy assessments
	Commercialisation Streams		Dynamic, capacity based tariffs exist for all consumers High level of adoption of smart meters V2G can participate in wholesale and flexibility markets
EV and Charging Development Considerations	Use of Standards		Accelerated roll-out of ISO 15118-20 for communications Battery warranties that do not exclude the possibility of V2X
	Requirements of System Operations		Connection agreement not linked to specific location Simplified guidance for new connections of V2X to network

Our analysis shows several barriers exist preventing the wide-scale adoption of V2X. These barriers are similar to the challenges faced by other demand-side flexibility, alongside other challenges experienced by other types of energy storage. For example, these include the double taxation of intermediately stored energy, inconsistent access to markets that offer diverse revenue opportunities for V2X (e.g., electricity and flexibility markets) and complicated uncoordinated technical requirements (e.g., for metering).

Following our review of the regulatory environment of selected countries, we propose a set of policy and market recommendations designed to encourage the rollout of V2X technologies across Europe through an enhanced legislative framework. The key recommendations are:

1.

Remove double taxation of stored energy

Bring forward measures to remove double taxation of stored electricity and ensure consistency in the tax treatment of losses in the storage cycle across European countries.

2.

Implement existing EU legislation

On the following measures that promote V2X:

- Electricity pricing and grid tariff methodologies that stimulate grid-friendly behaviour and are symmetric for intake and offtake;
- Open access to wholesale energy and balancing markets through an aggregation framework, allowing multiple service providers per connection point and making sure that market rules, such as metering requirements and minimum bid size, are fit for use;
- Distribution system operators (DSOs) procuring flexibility in competitive markets,
- Accelerated rollout of smart meters, whilst also allowing the use of dedicated metering devices and sub-meters, to unlock flexibility.

3.

Mandate bidirectional charging in certain public fleets and buildings with renewables

Introduce mandates for bidirectional charging for publicly owned fleets with long duration parking and in buildings with a renewable energy source on-site.

4.

Support development of V2X

V2X must be able to participate in the same mechanisms that are open to other technologies (e.g. stationary storage). These include capacity renumeration mechanisms (CRMs) and specific tendering and subsidies (e.g. flexibility support schemes and via the Net-Zero Industrial Act).

These recommendations are vital to ensure that Europe is able to capture the benefits that V2X offers. Our previous research has shown that unlocking smart charging and vehicle-to-grid (V2G) potential in just 30% of the charge points in the EU can provide 26 GW of upward and downward flexible power by 2030 and lead to financial benefits of €9.9 billion[1] across the 27 EU countries. Therefore, even a modest increase in V2X uptake as a result of these recommendations can have a significant impact across the EU.

1. Demand-side flexibility in the EU: Quantification of benefits in 2030, smartEn" and link to https://smarten.eu/wp-content/uploads/2022/09/SmartEN-DSF-benefits-2030-Report_DIGITAL.pdf

2. INTRODUCTION

Achieving a decarbonised energy sector while ensuring energy security is a top priority in Europe. Consequently, flexibility has emerged as a crucial element of the energy transition. According to the European Environment Agency and European Union Agency for the Cooperation of Energy Regulators Association (ACER)[2] by 2030 the EU will require double the amount of existing flexibility, as portrayed in Figure 1. It is needed to integrate renewables (by helping demand follow generation), address the generation adequacy issue, balance demand and supply and to make efficient use of existing electricity infrastructure. This shift can only be achieved through a mix of clean, flexible resources and supportive policies.

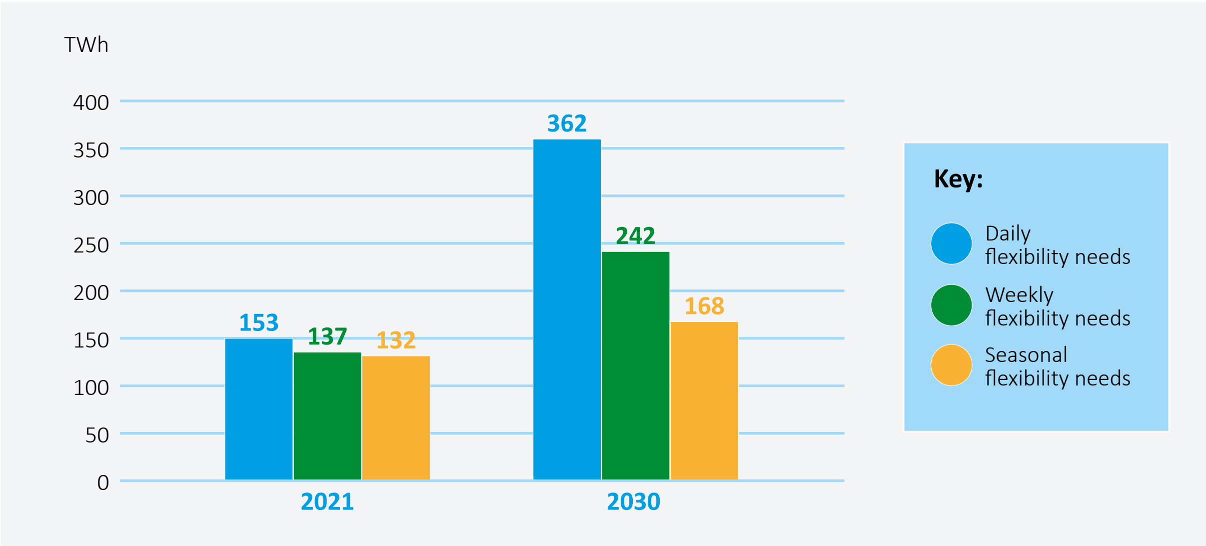


Figure 1 – Growth of flexibility needs in Europe between 2021 and 20302[2]

Given the increasing need for flexibility in energy systems, there is a large attention to storage technologies, mostly batteries. The current projections for installed storage capacity in the EU are 200 GW by 2030 and 600 GW by 2050, with specific incentives, tenders, and subsidies in place[3].

What is often overlooked is that today there are already 35GW of storage capacity[4] available[5], in the form of batteries in electric vehicles (EVs). Whereas their main application is transportation, they can be used in the electricity system when the EV is standing idle; for private vehicles, for instance, this is 95% of the time[6]. Their flexibility can be used either through smart charging (V1X), by optimising the charging process of unidirectional chargers, or through bidirectional charging (V2X).

V2X is a technology that allows the smooth integration of EVs into a renewables-based energy system. It enables EVs to become a Decentralised Energy Resource (DER), with energy storage functionalities, on top of their primary transportation purpose (Figure 2). Bidirectional charging offers an opportunity to provide even greater flexibility from the same assets by not only reducing demand at peak times but also feeding energy into the grid, reducing the peak further.

2. Flexibility solutions to support a decarbonised and secure EU electricity system — European Environment Agency (europa.eu).
3. Energy Storage Targets 2030 and 2050 | EASE: Why Energy Storage? | EASE (ease-storage.eu).
4. Over simplification, assuming all chargers have a 7kW power rating and there are more than 5 million EVs on the road in Europe according to the ACER.
5. Report- Vehicles in use, Europe 2023- ACEA- European Automobile Manufacturers' Association.
6. Unparking : MIT Senseable City Lab.

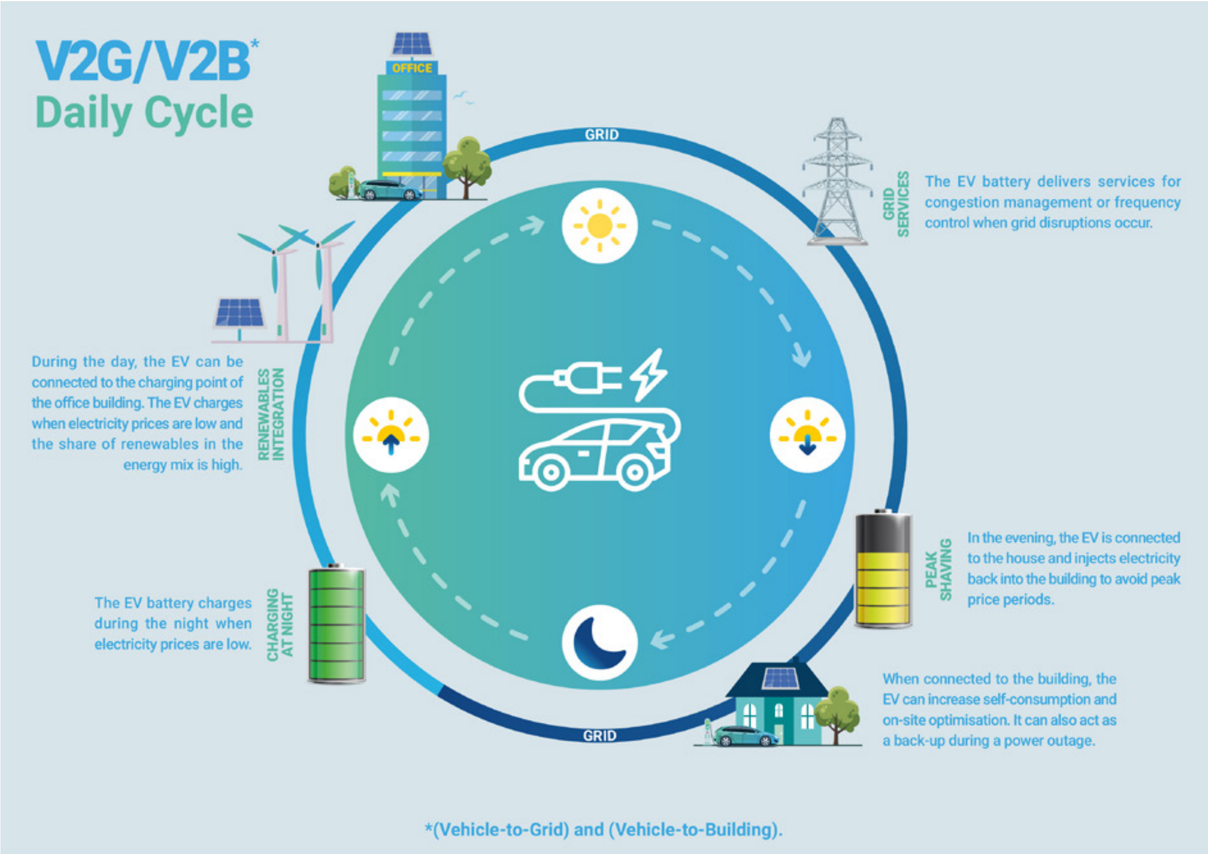


Figure 2 – V2X Market Opportunities for Different Types of Bidirectional Charging (V2G and V2B)[7]

Having noted the value of V2X, certain jurisdictions are already putting in place policies that promote bidirectional charging. For example, the State of California in the US has been discussing a mandate that would require all EVs sold in the state to have bidirectional capabilities by 2027. Similarly, in the UK, the EV fleet is already able to access the balancing mechanism through smart charging, with ongoing trials looking at how this can be extended to bidirectional charging.

The relevance of bidirectional charging in Europe will increase alongside the growth of the EV market, which has followed an S-curve with exponential growth in its early phases in leading countries. This means that while it may take six years for new EV sales to reach 10%, after another six years the share can reach 80%. Following this shift in EV sales, forecasts suggest that there will be between 48-56 million battery EVs across Europe by 2030[8 9].

To achieve these numbers and support the decarbonisation of transport, the European Commission's "Fit for 55"[10] package proposes several measures to promote the sale of EVs and the expansion and upgrade of the EU's network of chargers. The package includes revisions to the Alternative Fuels Infrastructure Regulation (AFIR), Renewable Energy Directive (RED) and Energy Performance of Buildings Directive (EPBD). These revisions contain references to the development of bidirectional charging alongside other measures setting binding targets for EV chargers, mandating smart charging for new and renovated charging points to facilitate the integration of renewables, and establishing requirements for installing chargers in buildings. This last one being particularly important since V2X is highly relevant for public buildings with long duration parking vehicle fleet and for the optimisation of self-consumption in residential buildings.

As of today, all major EV OEMs either have V2X models or have committed to launch dates[11], which will accelerate the rollout of V2X. This highlights the critical need for a regulatory framework that allows these vehicles to access a diverse range of markets and be compensated for the benefits they bring to the electricity system.

7. What is V2G/V2B?- V2MARKET (v2market-project.eu).
8. Download our Energy Transition Outlook 2023- DNV.
9. Global EV Data Explorer – Data Tools- IEA.
10. Fit for 55- The EU's plan for a green transition- Consilium (europa.eu).
11. Which electric cars can charge bidirectionally? (mobilityhouse.com).

2.1. Study Objective

Flexibility has a large role to play in future energy markets and V2X is one of a number of DERs that can provide some of the future flexibility requirements. However, there are still barriers that prevent its adoption. Recognizing its importance, this report provides a comprehensive assessment of the current regulatory frameworks impacting V2X in different countries across Europe and explores what is needed for the technology to move from pilot projects to widespread commercial adoption. It focuses on four main aspects:

1. Assessing **EV and charging development** as a proxy for V2X adoption, showcased in section 3.
2. Analysing **regulatory considerations and commercialisation streams** in each country regarding V2X, which may be found in section 4.1 and 4.2.
3. Studying **enablers and barriers in relevant national standards,** portrayed in section 5.1.
4. Analysing **DSO requirements,** shown in section 5.2.

The last two points focus on performing a comparative analysis of V2X feasibility across three countries: Great Britain, Sweden, and Germany. The countries were chosen to be a representative mix of best practices and areas of improvement within the studied categories.

The outcome consists of policy recommendations designed to encourage the rollout of V2X technologies across Europe. These policy recommendations may be found in section 6.2.

2.2. Background to Bidirectional EV Charging

2.2.1. TECHNOLOGY LANDSCAPE

Electric vehicles are becoming increasingly deployed throughout Europe due to cost reductions, technology advancements that enable better performance, and local, regional, and European legislation that promote the switch from internal combustion engine (ICE) vehicles. The Rocky Mountain Institute (RMI) forecasts suggest that Europe's market share for new EV sales will increase from 25% of all vehicle sales today to 80% by 2030 (Figure 3).

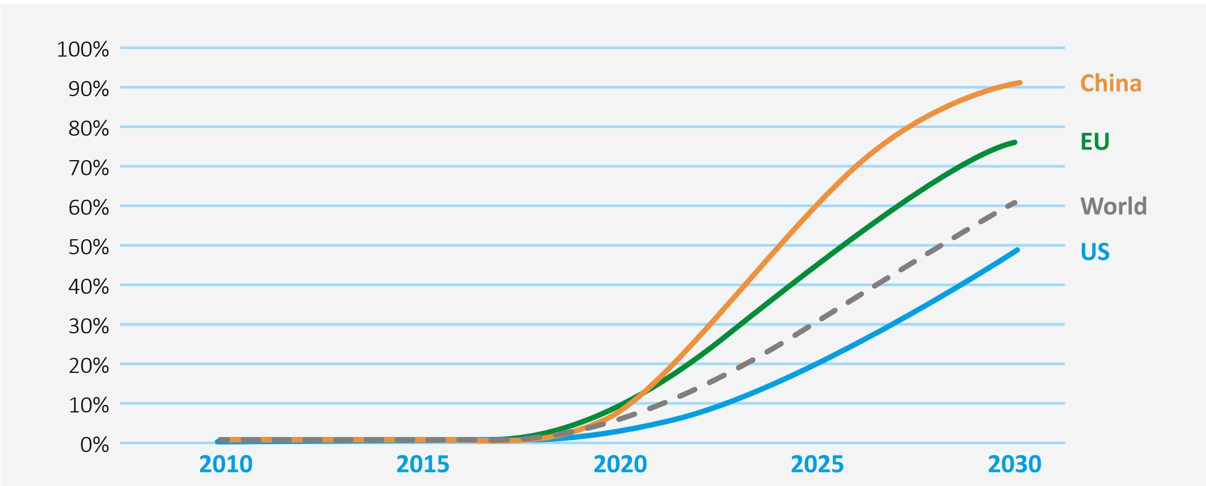


Figure 3 – RMI forecasts for market share of new EV Sales in leading market under 'fast change' scenario[12]

12. X-change: Cars (rmi.org).

Unidirectional charging, which is currently the norm, involves electric charge flowing from charging points to a vehicle's battery, modulated by the charger. Smart charging, also called V1G/V1X, is a form of unidirectional charging that enables the optimisation of the charging process; the energy used to charge the vehicle is adjusted in response to external signals, such as the state of the grid or, price of electricity. Smart charging allows one to smooth the load curve of EVs, helping the system, reducing consumers bills and decarbonising the energy system.

Bidirectional charging, on the other hand, allows the direction of electric charge to be reversed so that electric charge can flow either to or from the battery to the recharging point it is connected to. Bidirectional charging is still in the early stages of development, however, all major EV OEMs either have V2X models or have committed to launch dates (Table 1).

Table 1 – List of Vehicles Capable of V2X in Europe

OEM	Model	V2X Capability*	Year When First Capable in Europe	Charging Standard
Nissan	Leaf	V2G	2013	CHAdeMO
Nissan	e-NV200	V2G	2020	CHAdeMO
Hyundai	Ionic 5	V2L only	2021	CCS
MG	MG4 & MG5	V2L only	2022	CCS
Volkswagen	ID.5	V2G	2022	CCS
Genesis	GV60, GV70	V2L only	2022	CCS
Kia	EV6	V2L only	2022	CCS
Ford	F-150 Lighting	V2H	2023	CCS
Volkswagen	ID.Buzz, ID.3, ID.7	V2G	2023	CCS
BYD	Atto 3	V2L only	2023	CCS
Cupra	Born	V2G	2023	CCS
Volvo	EX90	V2G	2024 (tbc)	CCS
Kia	EV9	V2G	2024	CCS

*Refers to vehicle-to-grid, vehicle-to-home, and vehicle-to-load. Note that vehicles capable of V2G are capable of V2H and V2L

From the perspective of a consumer, V2X works very much the same as smart charging. The vehicle owner sets criteria such as the desired and minimum level of charge and when the vehicle should be charged by. An algorithm then optimises the charging schedule against these criteria and against an overall objective such as minimising cost or carbon emissions. The distinction with V2X is that the algorithm now has the possibility to discharge as well as charge the battery, so it has a greater degree of freedom to further optimise the charge schedule and the state of charge in the battery to the benefit of the consumer.

For example, in the context of high electricity prices, the algorithm may choose to supply electricity from the vehicle to the home instead of importing energy from the grid. Thereby reducing the cost of energy consumed at home and avoiding charging the EV with higher cost electricity.

There are two approaches to V2X that differ based on the location of the inverter in relation to the vehicle and the charging point (Figure 4). The inverter can either be located internally within the EV so that the vehicle discharges in alternating current (AC) to the charger. Or externally to the vehicle and located within the charger so the vehicle discharges via direct current (DC). This second configuration with off board bi-directional inverters can help with compliance of safety and network stability aspects such as voltage and frequency variation tolerance and the prevention of export on to a deenergised network during times of network outages.

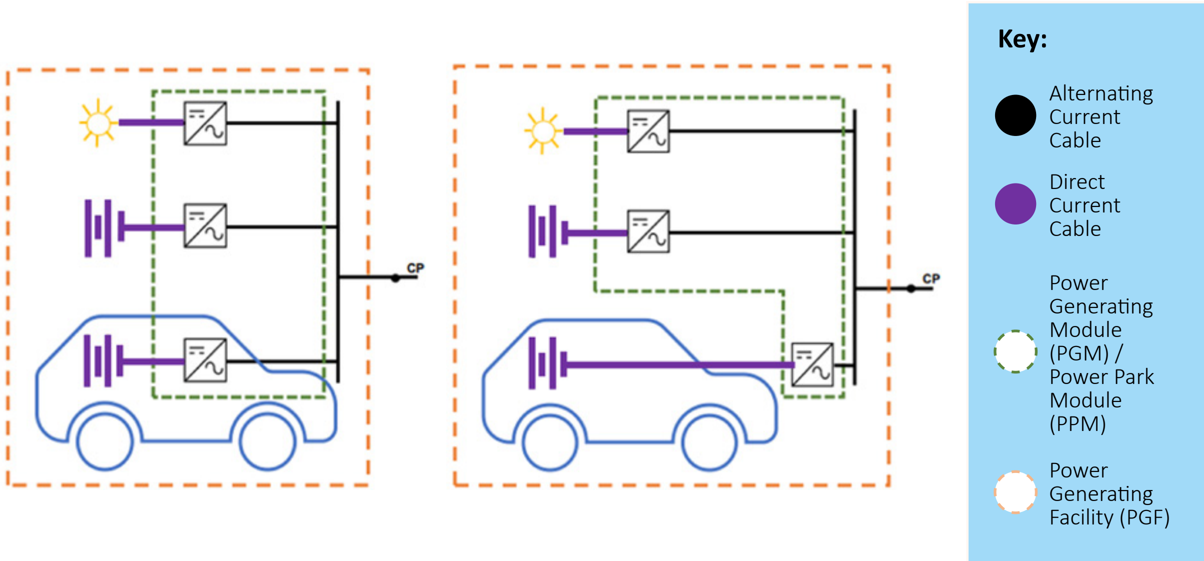


Figure 4 – Left: AC V2X vehicle is included in the generating unit; Right: DC V2X only the charger is included in the generating unit

Glossary

V2X is a collective term which describes all types of bidirectional charging (V2H, V2B, V2L and V2G) that in practice have the same functionality but with different technical requirements and associated costs. Vehicle-to-load (V2L), for instance, does not have to connect through a charger or synchronise with the grid, so from an engineering point of view is very different from vehicle-to-grid (V2G). It should not be confused with V2X in the telecom industry which relates to communications between vehicles and their environment.

V2B and **V2H** refer to the service where energy stored in an EV is used to power a home or a building. They may do this, for instance, to maximise the self-consumption of renewables, such as photovoltaic (PV) panels on a roof or to allow the building to shift its load away from peak electricity pricing.

V2L uses energy from an EV to directly power an appliance or another EV outside of a local electricity network.

V2G is a direct transfer of power from vehicles to electricity grids, where vehicles become able to earn revenue by offering symmetrical services (both upwards and downwards) for frequency and voltage regulation, capacity markets, wholesale markets and local flexibility markets. A key benefit of V2G over smart charging is that EVs can continue to benefit from offering flexibility even after their battery is fully charged. V2G also allows owners to earn revenue through price arbitrage by buying power when the price is low and selling when the price is high. On the other side, the energy system gains benefits by getting released from eventual tensions.

While these applications are all different, a smart algorithm can integrate them together and choose when to perform V2G, V2H, V2B to optimise energy consumption and savings.

Apart from differences based on the inverter location, there are also different EV charging systems in varying regions of the world. These systems regulate the types of plugs used, AC and DC charging, communications between charging station and vehicle, and load balancing among other factors. A well-known standard is the CHAdeMO, which was the only standard that allowed V2X until a few years ago when it started being phased out in Europe, due to most European EV manufacturers opting for the Combined Charging System (CCS) instead. Now it is used mainly in Japan. The CCS standard enables manufacturers to have one AC and DC charging port rather than two separate ones, which has led to a replacement of the CHAdeMO in most countries; now it is the agreed upon standard employed in Europe and North America.

A further classification of EVs is according to whether charge points are AC or DC. AC charge points, which offer lower power levels, are commonly used for home charging. In contrast, DC charge points, capable of high-kilowatt charging, are more frequently found in public locations for quicker charging on the go and for heavy-duty vehicles. Currently unidirectional chargers for all levels are commercially offered. However, chargers with bidirectional capabilities are not as widely available. At present only a few bidirectional chargers are available (and mostly only compatible with CHAdeMO chargers), but AC and DC bidirectional chargers are expected to become commercially available starting in 2024.

2.2.2. REGULATORY LANDSCAPE

The EU has provided overarching objectives relevant to V2X through different legislative instruments, enshrined in the Clean Energy for All Europeans and the "Fit for 55" packages. These sets of policies contain several directives and regulations which set out the goals and provide a governance framework for Member States, while allowing them flexibility to decide how they want to reach such goals. However, several relevant enabling legislations have yet to be fully transposed and implemented by Member States[13], such as the EU Electricity Market Design framework from 2019, which contains several important provisions for the development of demand side flexibility, for example non-discriminatory access to all electricity markets and the full recognition of independent aggregators as market participants.

Aside from providing objectives through directives and regulations, the EU also sets common network codes and guidelines for countries to follow in order to establish uniformity in certain areas. One such regulation is the Electricity Balancing Guideline. This document sets out EU-wide rules governing the functioning of the balancing mechanisms. Its focus is to create a market where countries can share the resources used by their Transmission System Operators (TSOs) to balance generation and demand while allowing renewables and demand response to participate in the market. This in turn diminishes consumer costs, increases security of supply, and promotes green energy. The goals set out by this regulation are fully aligned within the benefits that V2X can bring, which is why it is particularly relevant for V2X.

Electric vehicles, and battery energy storage systems (BESS), were excluded in the EU regulations for establishing a network code on requirements for grid connection of generators (2016/631). The European Commission, the European Union Agency for the Cooperation of Energy Regulators Association (ACER), the European Network of Transmission System Operators (ENTSO-E) and the European DSO Entity have identified the need for updating the network codes with respect to new assets, including V2X. ACER and ENTSO-E have investigated the development of V2X, issuing recommendations[14], recognising that V2X is a resource which can support with flexibility services, and therefore greater penetration of variable renewable energy sources into the grid.

13. The implementation of the Electricity Market Design 2022, smartEn.
14. ENTSO-E Position Paper on Electric Vehicle Integration into Power Grids (entsoe.eu).

Relevant European Legislation Impacting V2X

EU's Directive on the common rules for the internal market for electricity (2019/944) and Regulation (EU 2019/943): aim to create a more competitive, consumer-oriented and sustainable internal electricity market. They contain several important provisions for the development of demand-side flexibility relevant to V2X, such as non-discriminatory access to all electricity markets and the full recognition of (independent) aggregators as market participants, as well as further integration of renewable energy into the electricity market.

In 2023, the European Commission is looking to reform electricity markets. The proposed reforms include a requirement for Member States to set national objectives for DSR and storage, which should benefit V2X providers. The Proposal sets out design principles for schemes to support flexibility from DSR and storage and requires TSOs to design standardized, short-term peak-shaving products that remunerate electricity reduction or use stored energy at peak hours. These amendments, along with accelerating progress in implementing the 2019 EU Electricity Market Design, will ensure that proper legal frameworks at national level are in place.

Alternative Fuels Infrastructure Directive (2014/94/EU) (AFID): aims to establish a common framework of measures for the deployment of alternative fuels infrastructure to ensure that alternative fuels are available throughout the EU. This Directive will be repealed by the AFIR.

Revised Alternative Fuels Infrastructure Regulations (2023/1804) (AFIR): provides relevant updates to the subject matter of the AFID, including a requirement for Member States to include bidirectional charging in their resource adequacy assessments and mandates infrastructure deployment targets for EVs, among other points beneficial for V2X. It will be applicable from 2024.

Energy Performance of Buildings Directive (2010/31/EU) (EPBD): aims to promote highly energy efficient and decarbonised buildings. While it does not directly relate to bidirectional charging, it pushes for the integration of renewable energy systems in buildings and V2X is a key player in the optimisation of self-consumption. A revision to this directive that could further drive V2X is in currently under consideration by the Council and the European Parliament.

Renewable Energy Directive (2009/28/EC) (RED): is the legal framework for the development of clean energy across all sectors of the EU economy. It was revised in 2018 (EU/2018/2001) to accelerate the clean energy transition and a new revision was proposed in 2021 due to the same cause. This last revision (the RED III) contemplates implementation of credit mechanisms for EV charging from renewable energy source electricity (RES-E), which could boost V2X adoption.

Energy Taxation Directive (2003/96/EC) (ETD): outlines taxation related to energy in the EU. A revision has been proposed to bring it in line with the "Fit for 55" package, including measures to prevent the double taxation of stored electricity by differentiating energy transferred for storage from end-use. The discussion process, however, is stalled in Council.

2.2.3. V2X VALUE STREAMS

Opportunities for V2X are more likely to exist where vehicles are parked for longer durations: in buildings, residential off-street parking, workplaces, and overnight vehicle parks such as at airports. These opportunities may also extend beyond light duty vehicles to heavy duty vehicles such as buses and trucks in depots. Whether in the form of V2B, V2H or V2G, bidirectional charging brings benefits to companies, consumers, and network operators alike in each of these settings.

For vehicle manufacturers, charge point operators and software service providers, V2X brings value streams in the form of product differentiation and revenue from playing a part in energy management systems.

For consumers, V2G may bring strong direct financial benefits. A study led by smartEn and DNV in 2022 quantified these benefits from demand side flexibility in 2030 across the EU's 27 countries. This scenario assumed 30% of charge points in the EU to have bidirectional capabilities.

The study estimates that demand side flexibility in V2G and smart charging and V2G can lead to a cost reduction of 48% per year in consumer's energy bills (equivalent to €0.07 per kWh saving or €9.9 billion) compared to EVs with no V2G and smart charging capabilities.

V2H and V2B also bring important advantages to consumers. One such advantage is the integration of renewable energy sources. With more and more buildings getting solar PV systems and the recast EPBD aiming to promote the uptake of renewable energy in buildings, V2H and V2B can play a crucial role. Not only do they maximise self-consumption by storing surplus energy instead of this energy being fed to the grid at low prices, but they also serve as backup power for the home or building if needed.

Network operators benefit from V2X by its provision of different services such as peak-load management, congestion mitigation, voltage control and ancillary services. The above-mentioned study estimates that V2G will provide 26 GW of upward and downward flexible power within the examined case in 2030.

15. Demand-side flexibility in the EU: Quantification of benefits in 2030, smartEn".

V2X Pilot Projects in Europe

Led by Octopus Energy and Octopus Electric Vehicles, **Powerloop** was a key UK V2G pilot project. It aimed to validate the feasibility of domestic V2G technology through a trial involving 135 customers and concluded in 2022. All 135 participants leased a Nissan Leaf—95% received the 40kWh model and 5% got the 62kWh version. Participants also received a free Wallbox Quasar bi-directional V2G charger, controllable via the Wallbox Charger App. The primary interface for scheduling charging and discharging was the online Powerloop dashboard or app with scheduling done in the cloud and sent to the charge point. Phase 2 of the trial demonstrated participation of the vehicle fleet in the Balancing Mechanism, the preeminent TSO balancing market in GB. On receipt of dispatch signals from the system operator, the Kraken platform updated the schedules of all the cars; delivering the response on aggregate while ensuring that each customer's ready-by time and target state-of-charge were reached at the end of the overnight session. Benefits realised by scheduling the car (dis)charging for system benefit were returned to the customer. Initially this was done via a £30 monthly reward for making their vehicle available for V2G service between 4-7pm at least 12 times a month. This was then updated to a time-of-use tariff to encourage charging and discharging at specific times: static dual-band tariffs for charging and discharging, with the preferential rate period extended to periods when (dis)charging actions were scheduled by the Kraken platform. Analysis demonstrated that customers in the Powerloop V2G trial saved up to £180 per annum (scaled up to the full year/10,000 miles driving) compared to smart charging, by offsetting home demand and exporting power to the grid.

In Denmark, **Nuvve** has been operating the world's first commercial V2G services for over seven years across several operational vehicle fleets. Thes fleets provide Frequency Containment Reserves with some 50 V2G-enabled electric vehicles charging and discharging in a dozen sites across the country. The data gathered since 2016 is a unique real life validation of the benefits of V2G for the system and its users across several series-produced V2G-enabled EV models.

At the **EUREF Campus** in Berlin, AUDI and The Mobility House have been implementing the intelligent and grid-serving integration of electric vehicles into the power grid. In the first half of 2022, the potential of aggregated vehicle batteries in the energy market was demonstrated for the first time in a field test via real energy market applications on the electricity exchange. In the test, the 18 vehicle batteries of the stationary EUREF storage were treated like the mobile batteries of a fleet of 18 AUDI e-tron vehicles. For this purpose, a driving profile based on German average values from AUDI AG was assigned to the batteries in the storage system. Values in a four-digit euro range per vehicle and year were realized (around 1500 Euro per vehicle).

Another relevant example is the German **Bidirektionales Lademanagement (BDL)** with participation of BMW AG. This project combined industrial and academic partners from the automotive and energy sectors to test bidirectional charging applications and demonstrate the customer benefits and value of the technology. The project tested operation of 50 BMW i3's in residential and commercial settings for a year and concluded in December 2022. The project concluded that customers with a large PV system, high household power consumption and connection time during the night reached the best results. It was also suggested that the rollout of smart meters is a fundamental prerequisite for the implementation of V2X.

The EVVE Project has the objective to deploy and operate 800 distributed bidirectional charging stations (BCS) across Europe, with a strong focus on France. The BCS are deployed for private B2B charging needs and associated to cars with a compatible technology and usage-pattern (electric vehicles often connected to their charging station at depot during night and weekend for example). EDF, with the largest V2G-compatible EV fleet in France (more than 450 Nissan Leaf and e-NV200), plays a major role in the project as it is planned to install roughly 400 BCS (half in CHAdeMO, half in CCS) for its own sites during the project. EVVE project deployment officially began in April 2021. Finally, in the French region Occitanie, the **Flexitanie Project** initiated by Dreev and EDF, deployed around 40 V2G charging points.

Progress is being made on several of the challenges identified in these European trials. Firstly, the incremental cost of a bidirectional charger compared to a unidirectional charger has reduced significantly in the last five years and is expected to continue to do so. Recent studies into battery degradation have shown that how you manage an EV battery has a much larger impact on battery degradation that whether the vehicle is using V2X. Finally, regulatory barriers that have historically affected V2X are slowly being addressed as discussed further in this report.

2.3. Framework for Assessing V2X Enablers and Barriers

The framework for assessing the different countries is split into three areas related to the development of V2X:

- **EV and charging development considerations**
- **Regulatory, policy and market considerations**
- **Grid and system considerations**

In section 3 , we start by exploring the development of charging infrastructure, government goals for EVs and how energy is generated in each of the assessed countries to understand whether these create a landscape that promotes V2X. Section 4.1 focuses on relevant regulatory aspects such as the double taxation of stored energy and the presence of specific V2X policies. Then, recognising that market access is fundamental for its development, we assess whether V2X is able to access revenue streams and if so whether there is sufficient incentive to encourage its rollout in section 4.2. This study examines 11 European countries, selected to create a sample of Europe with a range of EV uptake rates and relevant policies and is based on the availability of information. These countries are Belgium, Denmark, France, Germany, Great Britain (GB), Italy, Norway, The Netherlands, Poland, Sweden, Spain (see blue and green countries in Figure 5).

Next, in the grid and system considerations section (section 5), we explore the practical challenges of implementing V2X from a safety, communications and system operator perspective for three countries. GB, Germany, and Sweden were selected as case studies to explore these topics in greater detail (see green countries in Figure 5).

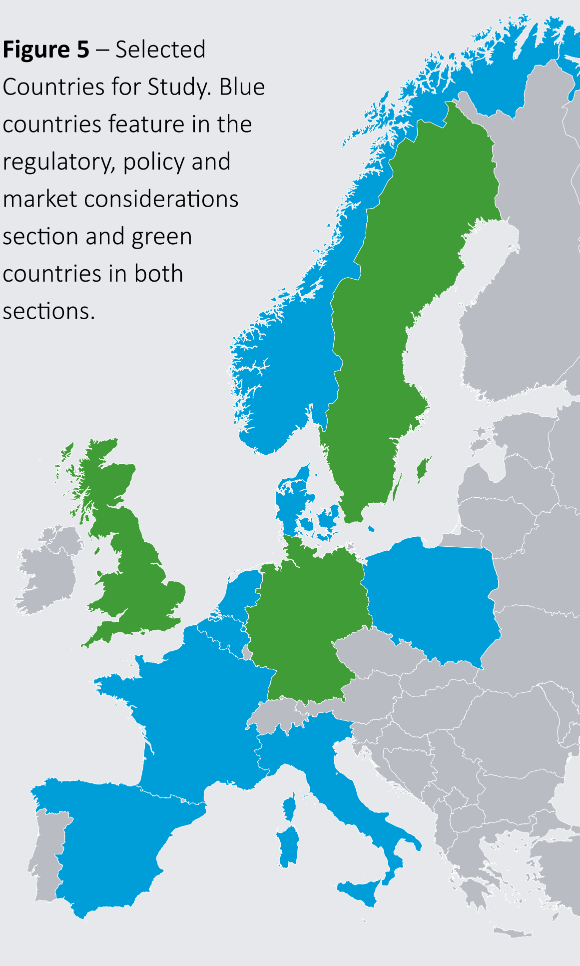


Figure 5 – Selected Countries for Study. Blue countries feature in the regulatory, policy and market considerations section and green countries in both sections.

2.3.1 METHODOLOGY

We devised a list of relevant questions to explore these topics and grouped them as shown in Table 2. The answers were rated as red, amber, or green based on the level of maturity of the V2X aspect they represent, within the report text a brief overview of some representative countries is given. Detailed answers for each of the studied countries may be found in Appendix A.

The scoring for each individual question has been combined for every category to give an overall category score which is visualised on the maps of Europe featured throughout. Our approach broadly weighted each question equally, however, expert judgement was also used based on the content of each answer and, where ratings appeared on the borderline between scores, we gave one key question from each category (as shown in Table 2) greater weighting and influence on the overall score. The exact methodology of scoring varies based on the questions, therefore a full breakdown on the scoring approach is shown in Appendix B.

Table 2 – Framework for Assessing Enablers and Barriers

Section	Category	Detailed Question
EV and Charging Development Considerations		What is the total fleet share for EVs and charging infrastructure in 2022? *
		What are the government goals for charging station buildout by 2030?
		What is the percentage of net electricity generation based on VRES and are there any mechanisms to credit EV charging from renewables?
Regulatory, Policy and Market Considerations	Regulatory considerations	Are there specific national V2X policies in place?
		Are there double taxes or levies charged for V2G? *
		Do system operators consider V2G as a part of their resource adequacy assessment?
	Commercialisation Streams	Do electricity prices encourage V2G, V2H and V2B? *
		Can V2G participate in wholesale energy and balancing markets?
		What capabilities do smart meters have and are they widely adopted?
		Can wholesale settlement and customer billing be based on metering devices behind the connection point?
		Can V2G participate in local flexibility markets? *
		Are network tariffs an opportunity or barrier to DER?
Grid and System Considerations	Use of standards	Are there barriers in national standards where V2X is specifically mentioned?*
		Are there standards related to off grid power storage and usage for buildings or dwellings creating barriers to V2X deployment?
		Are there barriers to V2X deployment in national electrical safety standard requirements for charging infrastructure?
		Is bidirectional charging included in regulations for charging communication protocols?
	Requirements of system operators	Do the DSOs have specific requirements defined in their connection agreements regarding bidirectional charging? *
		Is the registration of export capability and generation linked to a specific grid connection?

* Due to their impact on the development of V2X, some key questions were given a higher weighting during scoring.

3. EV & CHARGING DEVELOPMENT CONSIDERATIONS

In this section we have looked at the current penetration of EVs and chargers to understand consumer confidence in adopting low carbon technologies as a proxy for V2X, and to provide valuable insights into the effectiveness of current policies for the decarbonisation of transport. The availability of charging infrastructure, the share of new EV sales, and the existing EV fleet share provide an indication of the likelihood that V2X capable EV models and chargers will be adopted. We have also looked at the current electricity generation mix to highlight countries with greater shares of variable renewable energy sources (VRES) that is complemented by flexibility, such as V2X.

The results show that Europe has a landscape of infrastructure that is somewhat ready to facilitate the rise of EVs and V2X technologies. Most countries have either set high goals for charging stations, integrated a high share of VRES into their energy infrastructure or provide measures to credit EV's charged with renewable energy. Nonetheless, a big disparity exists among the efforts of different countries.

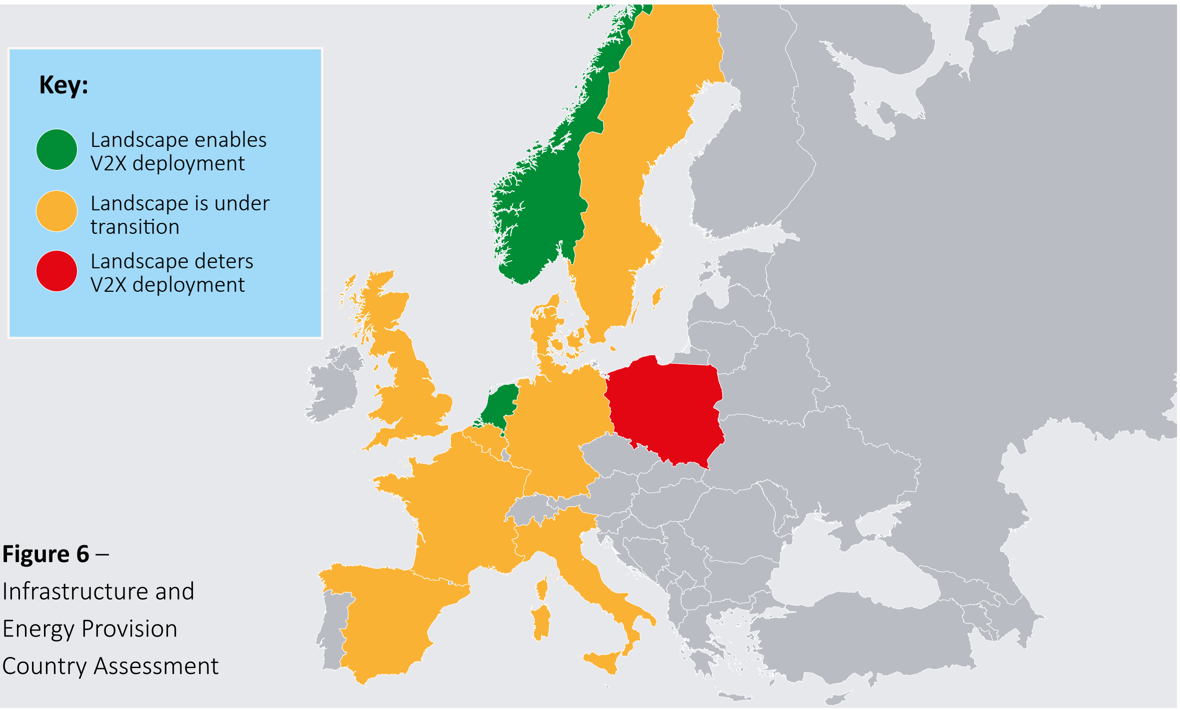


Figure 6 – Infrastructure and Energy Provision Country Assessment

Table 3 – General Market Environment Detailed Question Scoring

Detailed Question	BE	DK	FR	DE	GB	IT	NL	NO	PO	ES	SE
What is the total fleet share for EVs and charging infrastructure in 2022? *	🟠	🟢	🟠	🟠	🟠	🔴	🟢	🟢	🔴	🔴	🟢
What are the government goals for charging station buildout by 2030?	🟠	🟠	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟠	🟠
What is the percentage of net electricity generation based on VRES and are there any mechanisms to credit EV charging from renewables?	🟠	🟠	🟠	🟢	🟠	🟠	🟢	🟠	🔴	🟠	🟠

* Due to their impact on the development of V2X, some key questions were given a higher weighting during scoring.

3.1.1. WHAT IS THE TOTAL FLEET SHARE FOR EVS AND CHARGING INFRASTRUCTURE IN 2022?

Relevance: Understanding the availability of charging infrastructure, the share of new EV sales, and the existing EV fleet share is essential for estimating the potential of the electric vehicle market in Europe. These metrics provide insights in understanding the resource allocation, consumer confidence in adopting EVs, and provide valuable insights into the effectiveness of current policies for the decarbonisation of transport.

Country standings: Overall, the data suggests that while some countries are well-aligned in their growth of EVs and supporting infrastructure, others are experiencing imbalances that could either hinder or accelerate future adoption, depending on various socio-economic factors (Table 4).

Table 4 – EV and Charging Infrastructure in Countries with Highest EV Fleet Share[16]

OEM	Norway	Sweden	Netherlands	Denmark	Others
Penetration of EVs in existing vehicle stock*	27%	8.9%	5.3%	6.3%	<3%
Share of sales of new EVs*	88%	53%	36%	38%	<20%
EV charge points (per 1,000 vehicles)	12.8	5.6	13.9	5.8	<3.0

*Both BEV and PHEV are included.

Norway stands out with a high market penetration of EVs, boasting a new vehicle sales share of 88% for EVs and an existing fleet share of 27% for EVs additionally, it boasts 12.8 CPs per 1,000 vehicles. The Netherlands shows a new vehicle sales share of 36% for EVs, and an impressive number of 13.9 CPs per 1,000 vehicles.

Countries like Germany and Belgium appear to be preparing for a surge in EV usage, with infrastructure that currently seems to outstrip actual vehicle ownership. For Germany, there are 2.4 CPs per 1,000 vehicles. However, its current EV fleet share is below 5%. In Belgium, there are 4.8 CPs per 1,000 vehicles, but an existing EV fleet share of 4.08%.

On the other end of the spectrum, Italy, Spain, and Poland lag in both infrastructure and fleet share, pointing to potential barriers to EV adoption. On average, Italy, Spain, and Poland have less than 1 CP per 1,000 vehicles, a new vehicle sales share of less than 10% for EVs, and an existing fleet share below 1%.
It's important to note that only certain electric vehicles are currently capable of participating in V2X operations, and equally only a small number of charge points are capable of bidirectional charging. While the concept of V2X is gaining traction, it's essential to recognise that the widespread adoption of this technology is still in its early stages, and most electric vehicles on the road today are not equipped to feed electricity back into the grid. However, the penetration of EV's in the market and charging point infrastructure serve as an indirect indicator or proxy for V2X adoption.

There are currently no requirements or mandates for bidirectional vehicles or chargers in any of the assessed countries. Due to the higher costs of V2X-enabled chargers, policies that boost their uptake and the uptake of V2X-capable vehicles would help to increase the economies of scale that can help to reduce costs and increase the viability of V2X business cases.

Summary: The EV fleet share among the surveyed countries presents a diverse landscape, characterised by varying levels of infrastructure development and consumer adoption. On average, across the studied countries, the total EV fleet share for EVs in 2022 was approximately 5%. The range varied significantly, from as low as 0.2% in Poland to as high as 27% in Norway. This broad range highlights the varying levels of EV adoption and infrastructure development across different countries. In terms of charging infrastructure, there is no national rollout of V2X capable charge points in any of the assessed countries.

16. Norway – the EV capital of the world (visitnorway.com).
Country comparison | European Alternative Fuels Observatory (europa.eu).
EV charging statistics 2023- Zapmap (zap-map.com).

3.1.2. WHAT ARE THE GOVERNMENT GOALS FOR CHARGING STATION BUILDOUT BY 2030?

Relevance: Charging infrastructure is a big driver behind EV adoption which in turn is fundamental for the uptake of V2X capable vehicles. It is crucial to examine the potential for policy incentives to inadvertently lock countries into a unidirectional charging infrastructure where V2X could bring higher value. The existing policy landscape poses this risk as infrastructure providers are financially incentivised to scale the output of current unidirectional technologies. This could limit the adoption of innovative solutions, such as bidirectional charging systems, which may offer more sustainable and efficient alternatives in certain scenarios.

Country standings: Most countries have set some form of goal for the installation of charging stations. These goals typically focus on public charging stations or a combination of public and private charging points, however no specific examples of targets or mandates for bidirectional chargers in buildings were found.

An important difference between public and private is that the installation of public charging points is likely to focus mainly on unidirectional charging, since V2X is not a priority for public charging. However, more charging infrastructure is a driver for EV adoption which is the basis for V2X and is why public charging targets are important as well. Germany stands out, in this regard, for having set a target of 1 million public charging points by 2030 and granting a right for charging infrastructure to tenants and apartment-owners in the Building Electric Mobility Infrastructure Act.

Other countries have taken alternative approaches to increase the rollout of charging infrastructure which could incentivise both public and private charging stations. Sweden, for instance, prefers market mechanisms over specific targets, with various incentive programmes for chargers such as the Klimatklivet that work for public as well as private stations. Meanwhile, France has a mixed target of 7 million public and private charging points by 2030 and offers varying subsidies on purchase and installation of chargers for private and public entities. Regarding private charging, Norway has taken a more fundamental approach by granting apartment residents the right to access charging infrastructure. This is key for V2X since apartment car parks will contain longer duration parking where bidirectional charging can yield the most value. In practice this means that local apartment boards have to say yes to requests for chargers. The cost of the extra cabling and electricity capacity can be split among everyone in the apartment block, but the EV charger cost is paid for by the resident making the request.

Summary: Overall, the policy push to build charging stations reflects the increasing popularity of electric vehicles and the need for sustainable transportation. Charging infrastructure is changing and being upgraded rapidly, it is expected that a significant turn-over of charge points will occur as V2X becomes more standardised and while several countries have ambitious charging goals, there is still little mention of targets for bidirectional charging, which leaves the risk that a large number of them will need to be replaced in the future.

The goals outlined above will be supplemented by the AFIR requirements that EU Member States set for both distance and fleet-based charging. EU Member States will be required to provide at least 1.3 kW of publicly accessible charging power for each battery electric vehicle (BEV) and a charging pool every 60 km along the EU's main highways from 2025 and its secondary highways from 2030 onwards. These efforts are a step in the right direction for EV adoption, however they may not incentivise the uptake of V2X. Charging stations in highways have a higher priority to charge vehicles as fast as possible and they are not meant for long stays which allow V2X functionalities to be used. Instead, more regulatory efforts should be focused on increasing V2X capable chargers in public places where the vehicles spend long periods of time and may contribute to V2X (such as airports, stations, overnight public parking spaces, kerbside, etc.).

3.1.3. WHAT IS THE PERCENTAGE OF NET ELECTRICITY GENERATION BASED ON VRES AND ARE THERE ANY MECHANISMS TO CREDIT EV CHARGING FROM RENEWABLES?

Relevance: The proportion of electricity generated from Variable Renewable Energy Sources (VRES) is critical, given its direct influence on V2X technologies. V2X serves as an auxiliary energy storage solution, reducing the need for curtailment therefore complement higher penetrations of VRES. An important distinction here is made between VRES and renewable energy sources (RES) since, although high renewable generation in a country is desired, a high percentage of renewable energy may not necessarily be an incentive for V2X if the amount of variable production (wind and solar) is low.

As renewable penetration based on VRES is set to rise due to the evolving European legislative framework, the role of V2X technologies in managing this change becomes increasingly important. To help drive its adoption, the implementation of credit mechanisms for renewable energy source electricity (RES-E) used to charge EV's as outlined in the RED III is also vital as it offers financial incentives to consumers for charging.

Country standings: Countries including Germany (33%), and The Netherlands (25%) are leading the way in integrating VRES and credit mechanisms. The integration of high percentage of VRES with effective schemes such as Germany's use of the Treibhausgas (THG) Quote to credit the emissions savings from electricity charged by BEVs and The Netherlands's credit mechanism based on Renewable Fuel Units, underscores their commitment to providing consumers with routes to access green energy.

Spain, Denmark, and France lay at the middle of the list. While Spain and Denmark have a high percentage of electricity generated by VRES (33% and 52% respectively), they do not have a credit mechanism for EV charging based on renewables as contemplated in the RED III yet. However, Spain has commissioned a study to analyse the importance and viability of implementing such a mechanism. On the other hand, France has a low amount of VRES electricity generation (10%); nonetheless, in 2022 it established its Taxe Incitative Relative à l'Utilisation de l'Energie Renouvelable dans les Transports (TIRUERT) which is a fiscal instrument that, among other things, credits renewable electricity charged at public stations. At the other end of the spectrum, Poland, with only 11% of its net electricity based on VRES, lags behind. While it has a Guarantees of Origin system in place, it does not have a credit mechanism for RES-E for EV's and the lower percentage of variable sources in its electricity matrix suggests that there is less need for V2X to provide its grid stabilisation services.

Norway and Sweden are particular cases in themselves, having high percentage of renewable energy (99% and 69% respectively), but most of it coming from steady sources such as hydropower. Both countries have energy tracing schemes in place, showing their commitment towards an energy sector based on green energy. However, due to the high penetration of RES in their system, particularly in Norway, neither country has established credit mechanisms for EV charging from renewables.

Table 5 – Percentage of electricity from Renewable Energy and from Variable Sources by country in 2022[17]

	BE	DK	FR	DE	GB	IT	NL	NO	PO	ES	SE
Electricity from RES (%)	26%	78%	25%	44%	41%	40%	37%	99%	20%	45%	69%
Electricity from VRES (%)	18%	52%	10%	33%	25%	16%	25%	10%	11%	33%	17%

Summary: The percentage of variable renewable generation ranges from 10-52% across the studied countries. However only Germany, The Netherlands and France have integrated crucial mechanisms for fair compensation of V2G contributions, as they provide a transparent and verifiable mechanism for tracking the flow of electricity between the EVs and the grid, where the EV entity can be compensated fairly if the supplied energy comes from low/no carbon sources. While there are certain countries with a high percentage of renewable energy generation, it does not necessarily complement V2X if it does not come from variable sources.

17. IEA and IRENA country reports for 2022.

4. REGULATORY, POLICY AND MARKET CONSIDERATIONS

This section outlines the main findings from our review into the regulatory, policy and market aspects that impact V2X deployment across Europe.

Specific government policy and regulations for each country are studied since they provide the context within which the market for V2X will develop, set targets that send a signal to the market and establish whether there are any incentives that might help the V2X business case. In this regard, the EU provides legislation that sets out goals and guidelines within a certain subject. Member countries have the flexibility to develop their strategy regarding the topic and the freedom to implement them in a way that is best for their own regulatory frameworks.

The general market environment is then presented since market conditions directly dictate the business case that will drive the development of V2X on a commercial scale. In this aspect it is important to consider how V2X assets are exposed to price signals through electricity pricing and network tariff structures, how accessible wholesale energy and balancing markets are to V2X and whether metering supports the monetisation of flexibility.

4.1. Regulatory Considerations

The deployment of V2X is encouraged to varying degrees in government policies and regulations among the countries assessed. The study examines this through several related questions. Our overall findings suggest there are only a limited number of examples of specific targets, incentives or subsidies for V2X across the assessed countries. While pilot projects are ongoing in most countries, only Germany has a specific plan in place, which is only an inspection order so far. Additionally, countries are found to have varying success with the implementation of EU legislation designed to treat electricity that passes through intermediate storage such as an EV battery on a level playing.

Resource adequacy assessments that include new technologies such as V2X will ensure that these technologies are appropriately valued and are taken into consideration in the future planning of networks. There are only a limited number of countries that currently include V2X in their resource adequacy assessments.

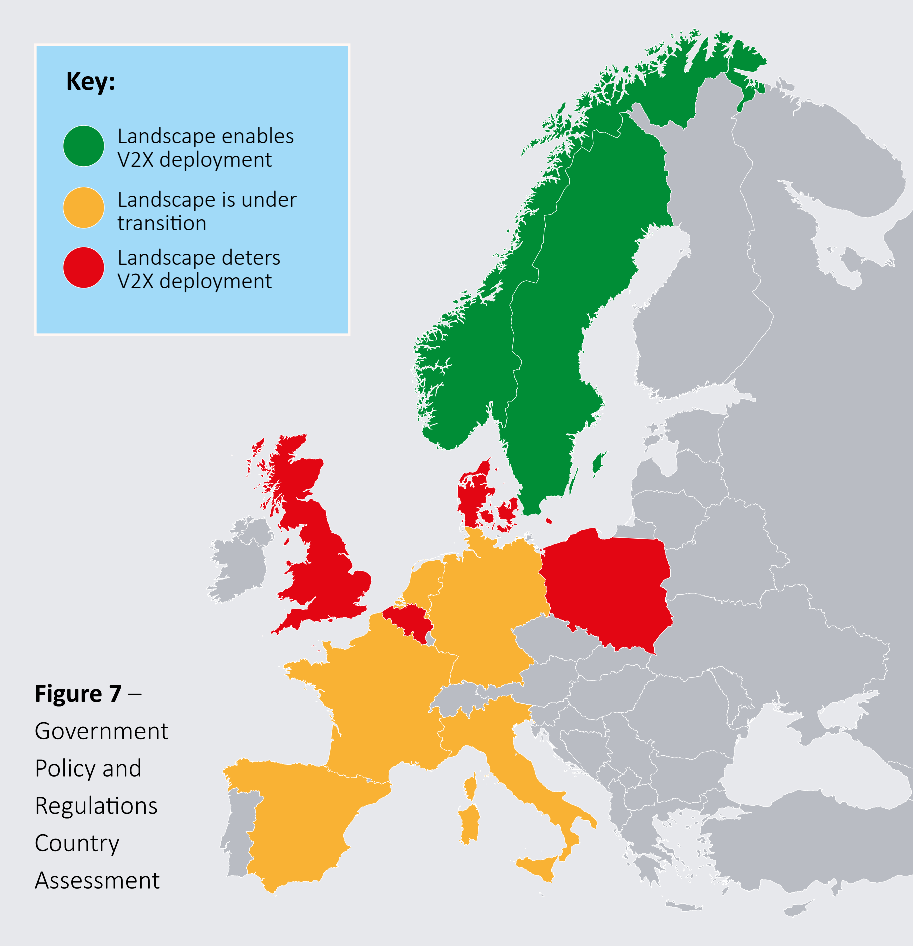


Figure 7 – Government Policy and Regulations Country Assessment

18. European resource adequacy assessment (europa.eu).

Table 6 – Government Policy and Regulations Detailed Question Scoring

Detailed Question	BE	DK	FR	DE	GB	IT	NL	NO	PO	ES	SE
Are there specific national V2X policies in place?	Orange	Orange	Orange	Green	Orange	Orange	Orange	Orange	Orange	Red	Orange
Are there double taxes or levies charged for V2G? *	Red	Red	Orange	Orange	Red	Green	Orange	Green	Red	Green	Green
Do system operators consider V2G as a part of their resource adequacy assessment?	Orange	Orange	Green	Orange	Orange	Red	Orange	Orange	Orange	Red	Orange

* Due to their impact on the development of V2X, some key questions were given a higher weighting during scoring.

4.1.1. ARE THERE SPECIFIC NATIONAL V2X POLICIES IN PLACE?

Relevance: Policies provide the context within which the market for V2X will develop, set targets that send a signal to the market and establish any incentives that might help the V2X business case. Clear V2X policies do not guarantee that the market conditions are ideal for V2X yet, as they need to be accompanied by other regulations and measures addressed further in the report. As EU legislation does not mandate V2X, this report investigates how Member States have shaped specific policies and plans in this regard.

Country standings: Germany and GB have the clearest V2X planned strategies in place. The new German charging infrastructure masterplan makes specific reference to bidirectional charging, setting out the ambition for the electricity system to take advantage of the flexibility that EVs offer[19]. Furthermore, the German government is providing targeted support for research and development in V2X topics, as highlighted in the financial priority called Bidirectional Fleet Power Plant 2025. The goal of this is to take bidirectional charging out of the pilot phase and applied more widely. Additionally, with a new strategy paper (Q3 2023) of the federal government, further bonus payments were released for combined PV – storage – EV systems in order to promote the overall expansion. This measure is highly relevant since it could encourage bidirectional charging in residential systems in order to optimise self-consumption.

Within GB, V2X was featured in the EV Smart Charging Action Plan (2023)[20], which committed to delivering the Vehicle-to-X Innovation Programme, an innovation funding round, to address barriers to wide-scale deployment specific to this technology, by 2025. However, it was noticeably absent from the scope of the UK's 2021 smart charging legislation, which applies to GB and was designed to ensure that charge points have smart functionality that reduces their impact on the grid[21].

While no specific policies are in place yet, on-going trials and pilots for V2X were observed in all other countries except for Poland. The on-going trials focus on a range of technical and commercial issues.

Summary: While V2X policies are still not in place in most of the assessed countries, the vast majority have some form of V2X pilot project. Although pilot projects are not necessarily considered official government policy, their execution is often supported by government innovation funding streams and the studies may provide a pathway towards official policy roll-out.

4.1.2. ARE THERE DOUBLE TAXES OR LEVIES CHARGED FOR V2G?

Relevance: A historical barrier to the deployment of energy storage is where taxes accrue when a battery is charged and then again when it is discharged, leading to double taxing. Plus, the energy fed back into the grid will be taxed another time when finally consumed. Grid connected energy storage devices may be considered as both a producer and consumer of energy. If storage is considered an energy consumer for taxation purposes, energy offtake by storage will constitute a taxable event. Subsequently, if also considered a producer, the discharge energy will be taxed again when finally consumed by the end-user. This double taxation would also theoretically apply to electric vehicles and adds to the complexity and costs of V2G business models.

19. Charging Infrastructure Masterplan II (nationale-leitstelle.de).
20. Electric vehicle smart charging action plan- GOV.UK (www.gov.uk).
21. Regulations: electric vehicle smart charge points- GOV.UK (www.gov.uk).

Country standings: Double taxation of energy storage varies across the countries studied. Spain, and Sweden, for instance, have eliminated this as part of their tax regimes whereas it still occurs in other countries such as Denmark and GB.

In Germany, the Energy Financing Act (EnFG) mentions that levies for electricity storage and energy loss shall be reduced to zero for intermediate storage that is withdrawn from and injected into the grid within the same year, explicitly including charging points for EVs. However, intermediate storage in mobile storage is still charged with grid fees and energy tax, making business cases very difficult.

Summary: While some countries have already taken the initiative to eliminate double taxation, there are on-going discussions to address this issue through a revision of the 2003 Energy Taxation Directive (ETD)[22] to bring it in line with the "Fit for 55" package. The proposed changes include, amongst many other energy-related aspects, measures to prevent the double taxation of stored electricity by differentiating energy transferred for storage from end-use. The tax treatment of losses in the storage cycle is another area that could be addressed as part of this assessment as there is currently uncertainty over whether it should be considered as end-use. The discussion process, however, is stalled in Council and very unlikely to be agreed upon at EU level in the near future.

If or when this revision is approved, the removal of double taxation for V2G may be complex and varies from country to country, especially when storage is mobile, and the EV can be charged in one place and discharged in another. The added issue of distinguishing which energy comes from on-site generation (such as a PV system) and which from the EV needs to be addressed. Furthermore, the need to split the round-trip cycle of V2G from the regular charging of the vehicle and regular consumption of the house would have to be addressed. The removal of double taxation for V2G will probably not be possible without significant adjustments to the metering devices at consumer points and additional administrative burden for consumers, energy suppliers and tax authorities. However, the industry is already testing and providing suitable measuring and netting concepts, which would help decrease the administrative burden or avoid the addition of new boundary meters. In general, removing double taxation should be defined based on a simple but precise procedure.

4.1.3. DO SYSTEM OPERATORS CONSIDER V2G AS A PART OF THEIR RESOURCE ADEQUACY ASSESSMENT?

Relevance: Understanding the role of innovative mechanisms in resource adequacy assessments is crucial for gauging the strategic focus of energy policy. If system operators account for technologies like V2G in these evaluations, it often indicates a priority to incentivise and develop these solutions. Such an approach can provide valuable insights into the future direction of a more flexible and reliable energy infrastructure.

Country standings: Some countries are proactively integrating V2G considerations into their resource adequacy assessment. For instance, in the UK the ESO does consider the impact of V2G in their resource adequacy assessments for the 2030s, specifically looking at the effects of demand-side response. The French TSO, RTE, also considers V2G in its resource adequacy scenarios, albeit with very conservative assumptions.

While not taking such an explicit approach, several other countries are making headway to include V2G in their resource adequacy assessment, such as the Netherlands and Sweden. The TSO in the Netherlands already factors smart charging into the resource adequacy assessment and V2G is expected to follow. In Sweden, proposals for future capacity mechanisms to ensure resource adequacy post-2025 will be open to demand-side management and energy storage, potentially paving the way for V2G. Lagging behind in this regard are Norway and Italy. In Norway, demand-side response is not included in Statnett's resource adequacy assessment, meaning V2G is not yet considered. Furthermore, the country does not currently employ a resource adequacy mechanism. In Italy, resource adequacy assessments currently focus solely on the growing demand from electric vehicles and not V2G.

Summary: In general, across the studied countries, there is still a lack of full integration of the benefits that V2G can provide into resource adequacy assessment. Recognizing V2G in this process will allow for a more nuanced understanding of how V2G can contribute to ensuring that energy generation adequately meets demand, thereby enhancing grid reliability and informing better policy and investment decisions.

22. Revision of the Energy Taxation Directive: Fit for 55 package (europa.eu).

4.2. Commercialisation Streams

Examining the wider market landscape, both electricity prices and network tariffs impact the feasibility of V2G, V2H, and V2B technologies. Exposing consumers to time-varying electricity prices with sufficient spread throughout the day encourages implicit flexibility and can benefit the grid by encouraging load shifting away from peak periods. Time of use (TOU) and dynamic elements to electricity and network tariffs ensure access to price signal for end users. The EU's 2019 Electricity Market Directive (EMD) included an entitlement to a dynamic electricity price contract which has been implemented across Europe to varying degrees.

An additional source of revenue is the explicit participation of V2X in energy markets, balancing markets, and local flexibility markets through an aggregator. The degrees to which V2X and other DSR can access these markets varies across Europe as often these markets were originally designed for large thermal generation. Aggregation can be performed by suppliers or by independent aggregators. The latter requires the implementation of the independent aggregator framework as foreseen in 2019 EMD.

Appropriate metering underpins both implicit and explicit flexibility delivery and fair reward for the value they bring. For V2X, this means that access to a smart meter or an asset level sub-meter or dedicated measurement device that meets the technical requirements of the market is a necessary basic condition.

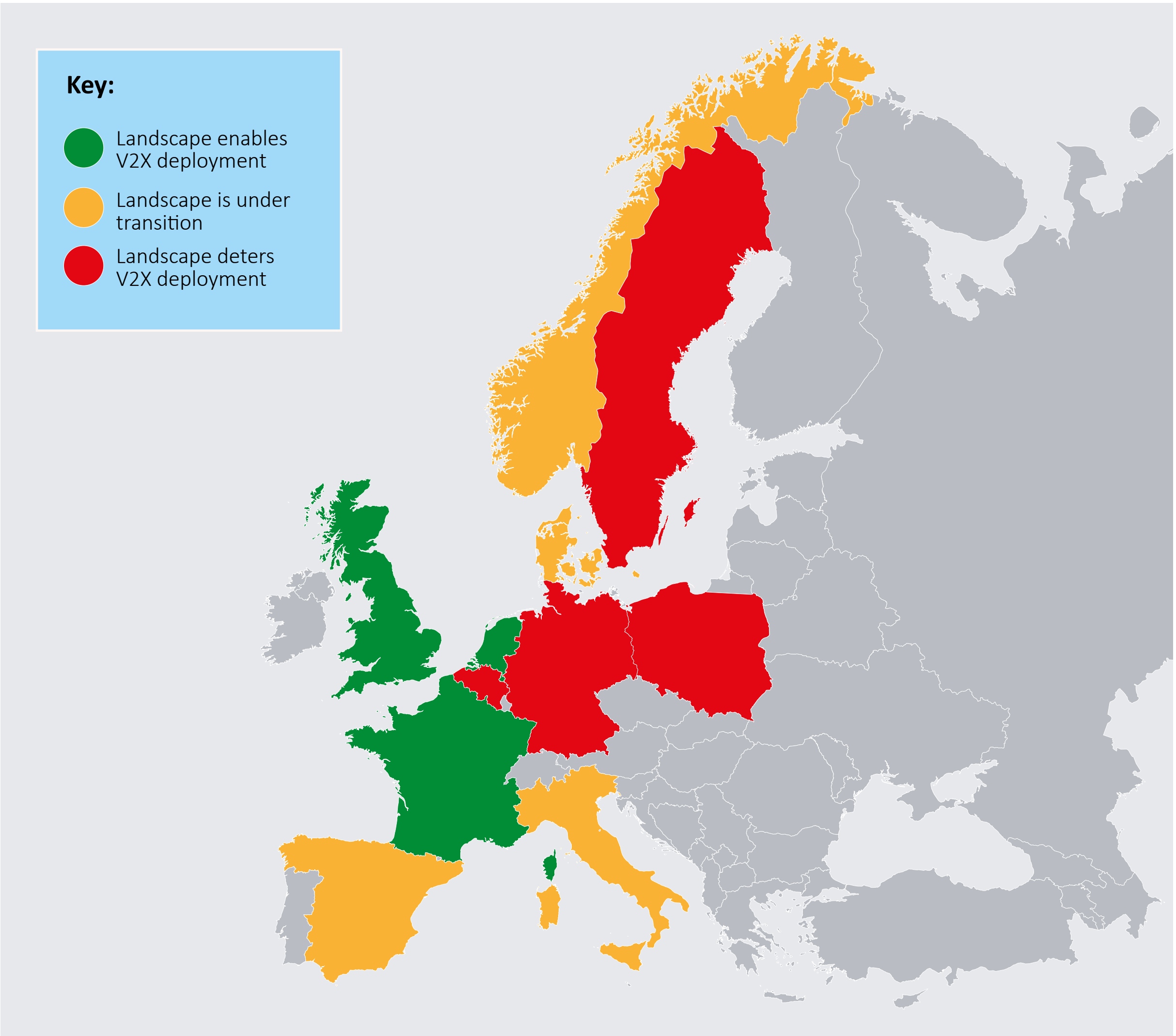


Figure 8 – Government Policy and Regulations Country Assessment

Table 7 – Government Policy and Regulations Detailed Question Scoring

Detailed Question	BE	DK	FR	DE	GB	IT	NL	NO	PO	ES	SE
Do electricity prices encourage V2G, V2H and V2B? *	Red	Amber	Red	Red	Amber	Amber	Amber	Amber	Amber	Amber	Amber
Can V2G participate in wholesale energy and balancing markets?	Green	Amber	Green	Red	Green	Amber	Amber	Amber	Red	Red	Red
What capabilities do smart meters have and are they widely adopted?	Red	Green	Green	Red	Amber	Green	Green	Green	Red	Green	Green
Can wholesale settlement and customer billing be based on metering devices behind the connection point?	Amber	Amber	Amber	Red	Amber	Amber	Amber	Amber	Red	Amber	Red
Can V2G participate in local flexibility markets? *	Red	Amber	Green	Red	Green	Amber	Green	Amber	Red	Red	Amber
Are network tariffs an opportunity or barrier to DER?	Amber	Amber	Amber	Red	Amber	Green	Amber	Amber	Amber	Green	Red

* Due to their impact on the development of V2X, some key questions were given a higher weighting during scoring.

4.2.1. DO ELECTRICITY PRICES ENCOURAGE V2G, V2H AND V2B?

Relevance: V2X requires a sufficient spread of electricity prices to incentivise charging and discharging. Static time of use (TOU) tariffs and dynamic tariffs can encourage consumers to be more flexible in the timing of their electricity usage. They can also contribute to the business case for hybrid PV – EV systems, as consumers can use EV storage as a buffer to optimise the timing of charge and discharge cycles, avoid higher electricity prices.

Additionally, consumer protection mechanisms (such as the UK's price cap on domestic energy tariffs) might serve a dual purpose of affordability and market stability. Yet, in the context of V2X and demand-side flexibility overall, they obscure true price signals that are essential for the optimal operation of dynamic pricing. Price volatility is a great incentive for the case of V2X, but policies that insulate consumers from extreme price volatility dilute the economic incentives intended to shift consumption to off-peak hours. Badly designed subsidies and financial incentives for renewables, while advantageous for renewable adoption, might distort market signals.

Country standings: Italian energy retailers are proposing variable price offers based on historical (last month) energy market prices, for example indexed to the National Single Price (PUN, the reference price). These tariffs are based on historical averages in three time slots, which represent a combination of static, ToU and close-to-dynamic pricing that is challenging to optimise flexible assets against. There are also offerings where the price of energy is lower in a specific timeframe (night-time) than in daytime; in some cases, it is set at zero for a few hours of each day. Furthermore, the low cost of export remuneration in Italy for those who have rooftop solar is an incentive for V2H; by implementing the technology they can consume most of the in-house produced energy to save against purchase energy prices.

In France, there are flat and time of use tariffs that give consumers some choice. There is a choice between regulated or non-regulated tariffs, with regulated tariffs being the most common. The 'Tempo' tariff is a critical peak pricing tariff that is a combination of static and mobile peak periods. The tariff has a fixed price most of the year, with a maximum of 22 days with very high prices. This incentivises flexibility, such as V2X, on the days where the loads on the network and the value of flexibility is at its highest.

The Netherlands is an example of a mixed situation. It experienced high electricity price volatility in 2022, however, current feed-in tariffs for domestic renewables reduce the incentive for behind the meter solutions such as V2H, and V2B technologies. Feed-in tariffs will be phased out between 2025-2031 which is expected to make for a better environment for V2X. There is currently little appetite for dynamic contracts despite them being offered to consumers from multiple retailers. As a result, 95% of Dutch households pay the same electricity tariff, which results in very little incentive to use the flexibility for grid purposes.

In Poland there are currently no dynamic tariffs available for consumers however they are set to be introduced in 2024, which will encourage V2G. Similarly, Belgium falls behind with little to no dynamic tariffs offered although in the Flemish region a law that requires dynamic tariffs to be offered to all consumers was passed in March 2023 and is pending implementation.

On a different note, several of the countries, including France, GB and Germany, introduced emergency measures to shield consumers from electricity price spikes in 2022 and 2023. These mechanisms do have the consequence of removing real price signals which are important for the development of V2X. Measures such as the French "Bouclier tarifaire", will be phased out progressively by the end of 2024, demonstrating that their impact may only be temporary.

Summary: TOU tariffs are currently available in the majority of assessed countries, or in the case of Poland, will be introduced in 2024, while fully dynamic tariffs are only available in a select few. Overall, for each country, there are either not many time-differentiated tariffs on offer or the uptake of these tariffs is low and it is important that tariffs are designed in way that is appealing to consumers. Consumer protection mechanisms have, shielded consumers from price spikes but also reduced incentives for flexibility.

4.2.2. CAN V2G PARTICIPATE IN WHOLESALE ENERGY AND BALANCING MARKETS?

Relevance: Market access is fundamental for the development of V2G since they enable EVs to be rewarded for the flexibility and benefits they offer to the system. V2G can participate explicitly in wholesale energy markets, provided there is an aggregation framework in place. Aggregated EV's are also well suited to participate in balancing markets, redispatch markets and local constraint markets.

Country standings: The leading countries, including France and Belgium, have an independent aggregation framework in place for V2G and other DERs to participate in wholesale energy and balancing markets. However, there are not many publicly available examples where V2G is participating in these markets outside of pilot programmes (such as in those in Italy and GB); only one case was found in Denmark where V2G is used to provide frequency regulation.

In GB, a recently approved standard (P415) now allows behind the meter, aggregated assets to access the wholesale market through Virtual Lead Parties (VLP). Balancing markets in GB are technology agnostic so V2G can, in theory participate. However, some energy products have certain requirements that makes it very difficult for aggregated DSR to participate. For example, the dynamic containment service has to be delivered at one of 14 grid supply points (i.e. very limited geographical area), this makes it challenging for aggregators to get sufficient capacity from smaller residential loads. Despite these challenges, V2G recently participated in the balancing market through the Powerloop trial[23]. The trial highlighted the difference between current metering standards for the balancing market and the standard of metering being installed at charge points today as a key challenge. In particular, the Operational Metering Standards pose a barrier to entry for domestic assets since they are overly onerous when applied to smaller assets.

In Germany, there is currently no legal framework or adequate infrastructure for V2G to explicitly participate in wholesale energy markets. Poland and Sweden also do not currently allow V2G access wholesale and balancing markets.

Summary: In several countries, DERs, including V2G, can technically participate explicitly in wholesale energy markets and balancing markets, however participation so far has predominantly been through pilot projects. Market rules, such as minimum bid sizes and metering requirements, must be designed in a way that is accessible to V2G.

23. Powerloop: Trialling Vehicle-to-Grid technology.

4.2.3. WHAT CAPABILITIES DO SMART METERS HAVE AND ARE THEY WIDELY ADOPTED?

Relevance: Smart meters offer V2X users and energy suppliers near real-time information on energy use and access to the broader range of tariffs described in Section 4.2.1. They provide information about electricity prices that are an essential component for providing implicit flexibility and form part of the business case for V2H and V2B by highlighting when to switch from powering buildings from the grid to powering from electric vehicles to avoid peak electricity prices.

Smart meters in combination with sub-meters and/or dedicated metering devices also give consumers the ability to receive electricity for their older, less flexible assets from one supplier and the electricity for their EV heat pump through another (split suppliers). This allows suppliers to develop tariffs that are more tailored to the behaviours of certain assets (e.g. V2X).

Country Standings: Denmark, Italy, Spain, Norway and Sweden stand out when it comes to the successful deployment of smart meters, having all achieved a near 100% roll out (Table 8), however, many of these are older meters that do not include the newest functionalities. In Sweden, there are already plans to upgrade existing meters with more advanced features by 2025. Germany has by far the lowest smart meter penetration followed by Poland and Belgium.

Table 8 – Smart Meter Penetration Across Assessed Countries in 2022[24]

	BE	DK	FR	DE	GB	IT	NL	NO	PO	ES	SE
Penetration of smart meters	22%	100%	92%	<1%	56%	98%	89%	99%	19%	99%	100%

In terms of capabilities, Denmark's utilization of Eloverblik, and Italy's proactive measures to adapt smart meters for energy management systems demonstrate their forward-thinking approach. Similarly, The Netherlands, France and Sweden's smart meters are equipped with local interfaces that promote data access by consumers and third-party energy management systems.

Conversely, Germany's stringent smart meter requirements have discouraged market actors and DSOs from installing units due to higher costs and deterred several energy management systems from attempting interoperability. However these requirements are expected to change starting in 2025 with the implementation of a new law. Poland's approach, which centralizes the data acquisition system without support for high-speed system services, further highlights areas of improvement.

Summary: The majority of assessed countries have large smart meter penetrations, that will allow consumers to access price signals which in turn incentivise the adoption of V2X. However, many of these meters are older models that do not comply with all the requirements in the EU Directive 2019/944 which are expected to be replaced by newer meters with more functionalities once their lifetime expires. Countries with low smart meter penetration should consider using dedicated metering devices and sub-meters as a work around ahead of any future rollout of smart meters or upgrade of boundary meters with full smart functionalities.

4.2.4. CAN WHOLESALE SETTLEMENT AND CUSTOMER BILLING BE BASED ON METERING DEVICES BEHIND THE CONNECTION POINT?

Relevance: Dedicated measurement devices (DMDs) and sub-meters[25] enable consumers to offer flexibility from individual assets of their choice and can provide accurate and granular measurements for calculating flexibility services. Sub-metering can help facilitate the explicit activation and implicit use of EVs by complementing data from smart meters or as an alternative to smart meters in countries where these are not yet available.

24. 2023_MMR_Energy_Retail_Consumer_Protection.pdf (europa.eu).
25. Definitions: a dedicated measurement device is a device relating to or embedded in an asset that provides electricity measurements that inform the settlement of flexibility services and transactive control activities. A sub-meter is a measurement device installed behind the boundary meter at the connection point to provide electricity measurements for retail or flexibility services. Smart meters provide electricity measurements at the boundary/connection point.

They can also facilitate multiple suppliers per connection point, as stipulated by the Electricity Market Directive. DMDs facilitate the explicit activation of DERs, notably by independent aggregators, without the need for installing a second (DSO) smart meter or a sub-meter and offer the possibility for flexibility service providers to conduct transactive control activities[26].

Country standings: At present the Measuring Instruments Directive (MID) in the EU and the equivalent Measurement Instruments Regulation (MIR) in the UK, require measuring instruments to indicate their result in a display in the instrument itself, contain other requirements for metering manufacturing processes and put limitations on over-the-air updates to firmware. However, these requirements were designed for different type of measuring assets (electricity meters). Most EV charge points have an embedded meter that does not have an external display and current state of the art practices assume the possibility of over-the-air updates of firmware, which means that sub-meter settlement is not possible.. Some countries have additional rules that further impede V2G operation, such as Germany's calibration regulation ("Eichrecht") which would require all meters to be re-certified for bidirectional purposes.

In terms of technical feasibility, however, countries like the UK, and The Netherlands have been more proactive towards integrating sub-metering/DMDs into some practices such as balancing.

Aside from the technical requirements that apply to sub-meters and DMD, to allow V2X to explicitly participate in flexibility services and wholesale markets, the meter data value chain has to be organised. The meter data value chain refers to the entire process involved in the collection, transmission, analysis, and usage of data from meters. In most countries the boundary meters are operated by the DSO, however when sub-meters or DMDs are to be used, the data has to be extracted by a market party and sent (in bulk) to the wholesale settlement and retail processes. This chain has not yet been regulated or organised in any country.

Conversely, France, Poland, Spain, and Sweden haven't fully embraced the use of sub-metering and DMDs for wholesale settlement. While Denmark does allow customers to access their consumption data through platforms like Eloverblik, it hasn't fully integrated sub-metering into wholesale settlement and billing. France, although experimenting with the concept, has yet to establish it as a standard practice. Poland, Spain, and Sweden also currently have no framework in place to support sub-metering in wholesale settlement.

Summary: While sub-meters and DMDs can provide accurate measurements for a wide variety of activities, including V2X services, both the current requirements in the MID and MIR, and the lack a mechanism for third-parties to collect meter data create a barrier for the use of such measurement devices.

4.2.5. CAN V2G PARTICIPATE IN LOCAL FLEXIBILITY MARKETS?

Relevance: Local flexibility markets by DSOs offer an additional revenue stream for V2G alongside other markets. These markets use flexibility from DERs for congestion management, to minimise power outages and defer network reinforcements. Regulatory practices that allow V2G to access local flexibility markets improve the business case for V2G and ensure that electricity networks benefit from this additional flexibility.

Country standings: Leading in this matter are Great Britain, France and The Netherlands. All three countries have market-based procurement of flexibility that V2G can access. There is limited publicly available information on how much V2G is currently participating in these markets outside of major trials; however, in GB for instance, the majority of EVs participating in these markets do so through smart charging.

The size of these local flexibility markets varies between countries. In 2022, Great Britain's electricity distribution networks tendered record levels of local flexibility (~ 4GW). France, however, started with some local long-term tenders for flexibility as of 2019, and have remained only at a small scale.

In The Netherlands, DSOs are currently implementing market-based congestion management to facilitate more customer connection requests in congested areas. The

26. Transactive control activities refers to activities where a flexibility service provider sends a price signal profile to a DMD for the purpose of controlling the device. It is used for settlement of flexibility service transactions between the consumer and the flexibility service provider, not for the settlement of the energy consumed.
27. What is GOPACS?- GOPACS.

GOPACS[27] platform is intended to facilitate the coordination of the TSO and DSOs in the procurement of flexibility to solve network constraints on the medium and high voltage network. This joint TSO/DSO procurement of flexibility means network are able to solve issues in the grid more effectively while facilitating market parties to participate in different markets.

Middle of the list are Denmark, Norway, and Sweden, which are currently running local flexibility market trials that have not yet reached commercial scale, although the latter two already have high traded volumes.

There are no local flexibility markets in Belgium, Germany, Poland, and Spain. In particular, in Germany, market-based procurement of flexibility is not supported by authorities and DSOs rely on Redispatch2.0 which is a cost-based approach to re-dispatching and limited to generation. Furthermore, there are currently proposals that allow loads to be managed remotely by system operators, which is not conducive for V2X as it is best to procure flexibility in competitive markets before resorting to remote control of loads to ensure that consumers are fairly rewarded for the system benefits they provide.

Summary: There are only three countries that have established local flexibility markets that are set up for V2G to access, however participation in these markets from V2G is only in small amounts due to the limited installed base of V2G chargers. These markets are locationally specific and already target DER, therefore, their rules should inherently be more accessible for V2G. However, it is important that DSOs recognise the unique attributes of V2G when defining rules (e.g. on baselining and portfolio bidding) and that a strategic review of grid services is conducted to identify where aggregated consumer flexibility could be incorporated.

4.2.6. ARE NETWORK TARIFFS AN OPPORTUNITY OR BARRIER TO DER?

Relevance: The structure of network tariffs should be cost-reflective and could, therefore, encourage the efficient operation of the electricity system. Volumetric energy-based components provide a price signal to reduce the overall consumption of energy but not necessarily a reduction in the peak, which provide very low incentives for V2X. Capacity-based components of network tariffs provide customers with incentives to reduce their peak load, which means a larger incentive for V2X. However, V2X also implies charging at maximum power when energy prices are low and therefore capacity tariffs that only consider demand peaks are not as stimulating. The best incentives are provided by network tariffs that also include a time differentiated component to encourage consumers to shift their load away from peak times. V2X, and other flexible assets, benefit from time-differentiated network tariffs with a strong capacity-based component that does not solely contemplate demand peaks.

Country standings: Norway and Spain lead the list for network tariffs incentivising V2X, having tariffs that complement flexible assets. As of 2022 Norway's network operators have had to include a variable capacity charge for all users, while Spain has a balanced mix of capacity and volumetric components.

Denmark and France are in the middle of the list. While network tariffs are still heavily volumetric based in both countries, some Danish DSOs offer time differentiated network tariffs to support EVs to charge at appropriate times. France has capacity-based components in its tariffs that may incentivise a more efficient use of the network. Network tariffs in Sweden are not standardised and vary between DSOs, creating a challenge for universal flexibility. Furthermore, the main indicator for the tariffs is currently the size of the connection which is not conducive to effective use of the network. In Germany, network tariffs are very high and almost completely volume based, lowering the incentive for efficient network use and therefore V2X, though a more dynamic pricing structure is set to be introduced in 2025.

Summary: A few countries seem to be making headway in developing network tariffs that encourage V2X, however there is still room for improvement for all. Countries that include a combination of volume and capacity-based charges that are time-differentiated provide the versatility and encouragement needed for DER such as EVs.

5. GRID AND SYSTEM CONSIDERATIONS

This section outlines the main findings from our review into the grid and system considerations that impact V2X deployment. This review was conducted via case study of three countries: Great Britain, Germany, and Sweden.

These countries were selected as a representative sample of the studied categories. While all three of them have advanced and well-developed strategies on a few aspects, they also demonstrate some areas for improvement in others, providing a good example for others to avoid or follow.

In the first sub-section, the use of standards by each country was analysed. Clear, uniform requirements of grid codes, differentiation of each V2X function from regular EV charging and clear delineation of differences between generation, storage systems and V2X are desirable to further its adoption.

Following this, the requirements of system operators was looked into. System operators set the guidelines that V2X must follow in order to connect to the network. In this aspect, it is important to consider whether DSOs have specific requirements for V2X in their connection agreements and whether registration is tied to a specific grid connection, which may limit opportunities for EV's to provide grid services in different locations.

5.1. Use of Standards

There appears to be a gap in the inclusion of V2X in national standards and guidelines across the three countries assessed. However, there are some instances where V2X shares standards with regular EV charging installations, storage systems and generating infrastructure, providing a framework for trials to follow when implementing V2X. While organisation such as ACER, ENTSEO-E and the DSO Entity, are actively working to clarify the requirements for V2X, there is still a need for further development in this area.

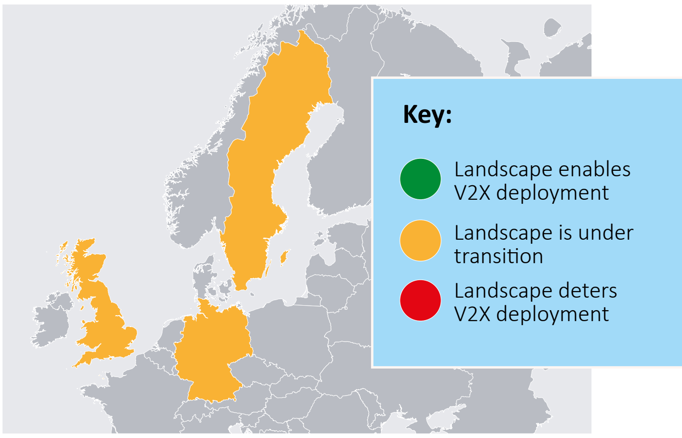


Figure 9 – Use of Standards Country Assessment

Table 9 – Government Policy and Regulations Detailed Question Scoring

Detailed Question	DE	GB	SE
Are there barriers in national standards where V2X is specifically mentioned? *	● (yellow)	● (yellow)	● (yellow)
Are there standards related to off grid power storage and usage for buildings or dwellings creating barriers to V2X deployment?	● (yellow)	● (yellow)	● (red)
Are there barriers to V2X deployment in national electrical safety standard requirements for charging infrastructure?	● (yellow)	● (green)	● (yellow)
Is bidirectional charging included in regulations for charging communication protocols?	● (yellow)	● (yellow)	● (yellow)

* Due to their impact on the development of V2X, some key questions were given a higher weighting during scoring.

5.1.1. ARE THERE BARRIERS IN NATIONAL STANDARDS WHERE V2X IS SPECIFICALLY MENTIONED?

Relevance: As part of the harmonization process by the EU, Sweden and Germany are aligned regarding the grid connection requirements, and the Requirements for Generators (RfG) forms the basis for this. Electric vehicles and BESS were excluded in the RfG, but BESS is included in the EN 50549 standard, therefore several countries now have included BESS in their national implementation.

However, there is still a gap for the integration of V2G technology, and ACER's view is that the requirements in the RfG for type A generators are applicable also for V2G. The European Commission, ACER, and ENTSO-E have identified the need for updating the network codes to account for the technical requirements of EVs and charging points, including V2G capabilities. These new requirements should include grid connection codes being applied at EV level and not at grid tie point. This would allow harmonisation of industrial equipment, not dependent on the configuration of the installation behind the connection point.

ACER and ENTSO-E are actively promoting the adaptation and have several recommendations for a successful implementation. They have also identified important benefits such as V2G being a resource that can support the grid with flexibility services and enhance the possibilities for greater penetration of renewable energy sources.

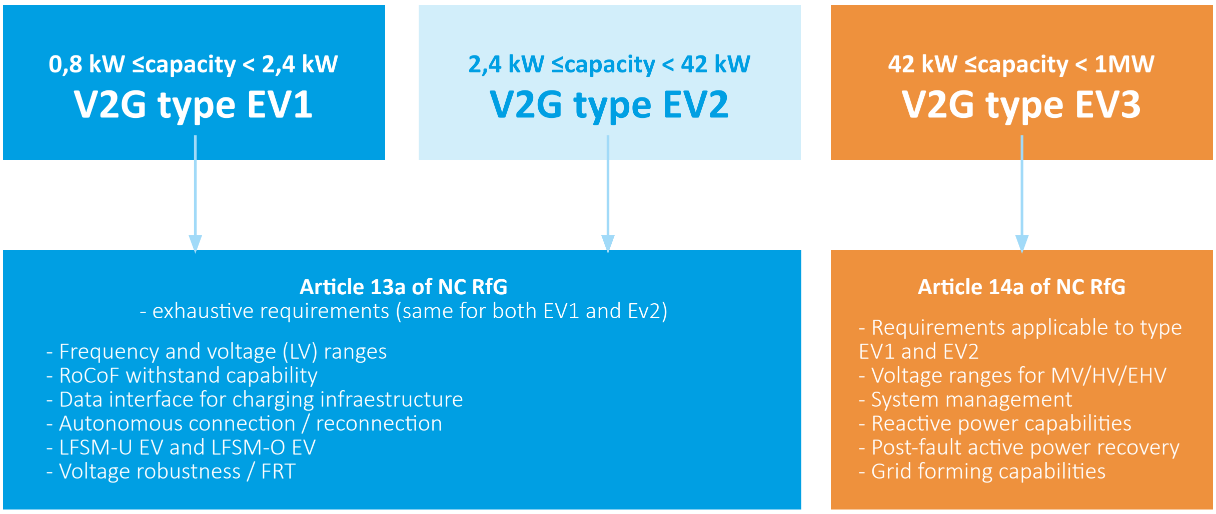


Figure 10 – ACER Classifications of V2G Charging Types and their Applicability of the Network Codes of RfG[28]

Country Standings: In GB, V2G charging does not have its own standards but shares them with normal EV charging installations and generating infrastructure. The British Standards Institution has reduced barriers to V2G implementation by publishing two standards (PAS 1878 and 1879), developed by industry, which set a technical framework for small-scale DSR, such as V2G, guided by the principles of interoperability, data privacy, grid stability and cyber security, and which is compatible with the GB Smart Metering system.

Germany does not have specific V2X standards in place either. The implementation of V2X services is currently limited to small scale pilot projects to demonstrate the feasibility of grid services provision from electromobility. Assessing integration of V2X concepts to micro-grids may be the scope of upcoming studies.

As for Sweden, while no specific standards or guidelines for V2X applications currently exist, most existing standards in the country are developed for unidirectional charging and will need to be updated. However, it is recommended that suppliers get an equipment certificate for type A generators which can be used to show compliance with the RfG requirements.

One potential barrier being discussed is the decision on which device takes the lead for bi-directional power transfer: the EV or the charger. Since the charge point is the main connection point (directly to the grid or via

28. Empowering the Next Level of e-mobility

energy management to the household), decision making to dispatch power from vehicle to home or grid should be based on safety (isolation) measurements in the charge point. However, it also requires feedback and information from the EV to make informed decisions about whether to charge such as information influencing the state of battery health and ways of optimising it. Additionally, it is likely to be different for AC and DC bidirectional charge points.

Future options for introducing V2X into National Standards include establishing V2X capability standards for vehicles that make capabilities mandatory for manufacturers, and standards that govern cycling of battery that are aligned with standardized battery warranty rules where V2X is used that can give consumers reassurance regarding battery degradation.

Summary: None of the countries assessed have specific V2X standards in place, however, the UK has advanced the most in the path towards creating V2X standards by means of setting a technical framework for small-scale DSR. However, ACER has recently conducted a public consultation and will issue a recommendation to amend EU grid connection network codes. The aim is to update the network codes to further support the EU power grid, embracing emerging developments such as e-mobility and storage and are likely to embrace V2X as well.

5.1.2. ARE THERE STANDARDS RELATED TO OFF GRID POWER STORAGE AND USAGE FOR BUILDINGS OR DWELLINGS CREATING BARRIERS TO V2X DEPLOYMENT?

Relevance: Energy stored in EVs can provide power to off-grid buildings and dwellings within a vehicle-to-home set up. The installation and operation of these arrangements may be subject to standards that restrict the use of V2X as a source of remote power.

Country standings: In Germany, how off-grid storage capacity is defined in terms of bidirectional charging remains unclear. The charging pole regulation (Ladesäulenverordnung) lacks definitions or technical requirements of bidirectional charging. The Electromobility Act (2015) lacks definition of the various back feed options or labelling of bidirectional charging stations. The Renewable Energy Sources Act (EEG) does not consider electric vehicles as mobile storage devices or for energy storage in general and the Energy Industry Act (EnWG) and the EEG have different definitions of the end consumer. Hence, it is not possible to estimate whether regulation of off-grid power storage will generally stand in the way of the deployment of bi-directional charging.

The UK does not have specific standards or regulations that define the operations or compliance of off-grid V2H and V2B solutions. Electrical safety standards, such as BS 7671, will apply regardless of whether there is a grid connection. Users will need to make sure that systems are installed safely and do not pose a risk to themselves or others (e.g., from fires).

Currently in Sweden, there are no regulations or standards in this category, however as with the other countries, electrical safety standards will continue to apply.

Summary: There are no specific standards related to the off-grid powering of buildings or dwelling via vehicle-to-home. Electrical safety standards will always apply and are an important consideration in the design and operation of these systems.

5.1.3. ARE THERE BARRIERS TO V2X DEPLOYMENT IN NATIONAL ELECTRICAL SAFETY STANDARD REQUIREMENTS FOR CHARGING INFRASTRUCTURE?

Relevance: Existing safety standards for charging infrastructure form the starting point for bidirectional charging standards. If current standards need a lot of re-working to include V2X or are in direct contradiction with it, time of adoption for the technology will increase. Having un-flexible standards could lead to a technological lock-in for unidirectional charging.

Country standings: GB has the most developed electrical safety standards for bidirectional charging. Electrical installations on premises must be compliant with The Institution of Engineering and Technology (IET) Wiring Regulations (BS 7671) and an application for connection of a distributed generator to the grid (following ENA's ERECs G99/G98) must be submitted, these are the key areas to consider as part of a V2G solution. The revised Code of Practice for EV Charging Equipment Installations 4th Edition and BS7671 Amendment 2 both detail basic requirements for the safe design of bidirectional charging.

In Sweden, Energiforsk has supported Swedish participation in the international group IEC/TC69: Electrical power/ energy transfer systems for electrically propelled road vehicles and industrial trucks. The group has started working with standardization of V2G. One area that they need to address is that there are currently no regulations regarding how the charge point and vehicle must be certified when the power electronics are installed in the vehicle for conversion to AC. Another point of concern among manufacturers is if there are changes in the network codes that require hardware to be replaced.

In Germany, although a legal framework for bidirectional charging is currently absent, any future standards should comply with the VDE application rules VDE-AR-N 4105. This rule outlines the requirements for distributed power generation in the low voltage network, which is crucial for electric vehicles designed to return energy to systems linked to the public grid in the future. The current versions VDE-AR-N 4105 (Low-voltage) and the VDE-AR-N 4110 (Medium-voltage) demand that battery storage systems (including EVs) must in principle be designed with controllable power in order to support frequency stability. These requirements in the most important standards in Germany are expected to be the most relevant to future V2G infrastructure. The next regular revision of this application rule is 2030, however, VDE wants to implement a more agile standard, so V2X applications may be installed earlier than 2030.

Furthermore, the DIN VDE 0701-0702 and VDE 0701-0702:2008-06 regulate the testing after repair or modification of electrical equipment and it implies repeat testing. Charging stations, charging cables, and associated electrical installation must be tested under this regulation. It generally can be assumed that the same standards for the testing and modification of electrical equipment will also be applied to bidirectional charging as for unidirectional charging once a legal framework has been created for this.

Summary: Headway has been made to develop proper safety standards and requirements for charging infrastructure in all three countries. However, the UK has the most advanced standards of the three countries in this regard while Germany is still missing a proper legal framework for bidirectional charging.

5.1.4. IS BIDIRECTIONAL CHARGING INCLUDED IN REGULATIONS FOR CHARGING COMMUNICATION PROTOCOLS?

Relevance: Regulations for charging communication protocols are necessary to ensure that communication is standardized, interoperable, and compatible with different types of EVs, charge points, and grid operators. They also help to ensure that the communication protocol is secure against cyber threats and that data privacy is protected. International standards such as the IEC 61851-1, which contains the basic principles for communication for controlling charging processes in electric vehicles and ISO 15118-20 which is a standard for V2G communications, allow for more complex communication between the vehicle and the charging infrastructure. Additionally, zero-emission buildings being planned will need to have the ability to communicate with bidirectional chargers in order to optimise their energy consumption.

The introduction of the ISO 15118-20 standard has made a big improvement on EV communication protocols. Some of its benefits include the introduction of a "dynamic" control mode delegated to an off-board system which facilitates provision of ancillary services and mandatory Transport Layer Security (TLS) for all use cases to increase data security.

Country standings: At a national level, in GB, Appendix A2 of PAS1878/79 lists the relevant standards and regulations for energy smart appliances (ESAs), including charge points, to provide DSR services to domestic consumers and grid-side actors. The list includes the Open Charge Alliance (OCA), which is a global consortium of public and private organizations that promotes open standards for EV charging infrastructure. The OCA has developed the Open Charge Point Protocol (OCPP), which is a communication protocol that allows charge points to communicate with other entities like a local gateway or a remote cloud. The OCPP is open-source and vendor-neutral that allows for advanced features such as dynamic pricing, and V2G capabilities.

Germany has no legal framework for bidirectional charging in place at present. Therefore, the IEC 61851-1 is the most relevant standard containing the basic principles for communication to control charging processes in electric vehicles. Germany's latest funding requirements for EV's state that the components must have a secure digital, bidirectional communication interface and support common, standardised communication protocols as well as have a secure software update capability, Furthermore, the components must allow a secure and interoperable connectivity to the smart meter gateway.
Currently there are limited possibilities for the remote control of bidirectional charging in Sweden. However, the implementation of the communication protocols in IEC/ISO 15118 is a pre-requisite for smart and meaningful implementation of V2G.

Summary: Germany and GB seem to be making headway regarding communication standards, being one step ahead of Sweden. However, V2G requires proper regulation to access relevant vehicle data and implement cyber security measures for vehicle owners, as well as a right for consumers to consent to third party access to their data. The European Commission is already addressing these issues through the new EU regulation on batteries and the upcoming Access to In-Vehicle Data Initiative, which will be key to developing V2G business cases.

The United Nations Economic Commission for Europe (UNECE's) World Forum for Harmonization of Vehicle Regulations has published minimum performance requirements for batteries of light-duty vehicles and is developing a standard for heavy-duty vehicles. These requirements will be crucial to have a harmonised way of getting access to the Battery State of Charge.

However, there is a need for harmonization of security measures to prevent hacking of the energy system and ensure proper handling of EV owner's data. The development of future V2G communication standards must strike a balance between the advantages of standardization in promoting V2X implementation and the need to allow room for innovation in this area.

5.2. Requirements of System Operators

The uptake of V2X requires explicit integration into a country's grid planning and energy ecosystem. Therefore, requirements set by system operator can either facilitate or hinder the deployment of V2X technology. This study examines connection agreements, and the requirements for grid connections to be tied to a specific location. The findings show that there is still a need for further work in these areas to explicitly integrate V2X into DSO planning and operations.

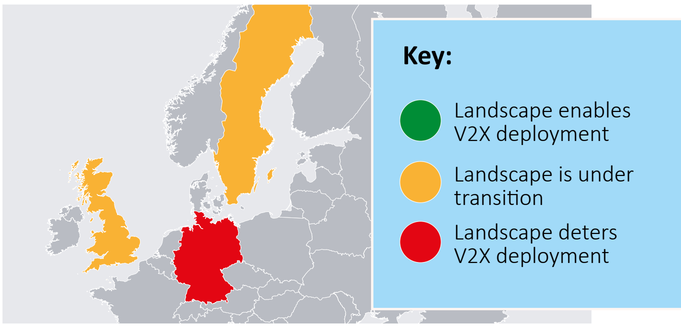


Figure 11 – Use of Standards Country Assessment

Table 10 – Requirements of System Operators Detailed Question Scoring

Detailed Question	DE	GB	SE
Do the DSOs have specific requirements defined in their connection agreements regarding bidirectional charging? *	Red	Green	Amber
Is the registration of export capability and generation linked to a specific grid connection?	Amber	Red	Red

* Due to their impact on the development of V2X, some key questions were given a higher weighting during scoring.

5.2.1. DO THE DSOS HAVE SPECIFIC REQUIREMENTS DEFINED IN THEIR CONNECTION AGREEMENTS REGARDING BIDIRECTIONAL CHARGING?

Relevance: An expert panel from ENTSO-E have concluded that EV charging, both unidirectional and bidirectional, should fall under the standard connection network codes and do not require any special treatment. V2G functions, which allow EVs to generate electricity, are treated as generation, according to the requirements for generators. Meanwhile, smart charging functions, which let EVs consume electricity, are classified as demand, in accordance with the Demand Connection Code. The regulations lack mention of specific requirements for EVs, both as demand and generation, with regard to their state of charging, particularly in relation to accessing charging flexibility in the future.

Country standings: In Sweden, V2G applications are, from the grid operators' point of view, considered as intermittent power energy facilities similar to PV facilities. As such, the DSO must be notified about all new and modified production units in advance of connection. There is no interpretation of the requirements that state that the inverter cannot be within the vehicle, however, breakers must be installed on both the DC and AC sides of converter. Therefore, this will be governed by the needs of the customer.

In Germany, EVs intended to feed to the public grid, need to consider the requirements of norm VDE-AR-N 4105. For standard unidirectional charge points, facilities must be registered with the responsible grid operator in accordance with Section 19 (2) of the Low-Voltage Connection Ordinance (NAV) before they are put into operation. Charging devices with a power consumption exceeding 12 kVA or 11 kW also require the prior consent of the grid operator. Therefore, it is likely that V2G will be required as a minimum to do the same.

A G99 application in GB relates to any apparatus which produces electricity connecting to the distribution network. This includes any micro-generators and electricity energy storage devices. V2G under G99 is classed as energy storage and should follow the same requirements that energy storage must follow. From amendment 7 of the document, V2G was defined as a separate asset type but is still considered as energy storage for the purposes of the document. Where an electric vehicle and/or its charger have been configured so that the electric vehicle cannot operate in a V2G mode, then it can be considered as demand only and is not included in the requirements of G99. Most domestic chargers for electric vehicles in the UK have a capacity of 7kW, necessitating a G99 application for grid connection since they exceed the 3.68kW limit set for simpler G98 applications. G99 is geared toward larger, more complex installations and comes with more stringent requirements, making it the appropriate standard for these 7kW chargers if export to the grid is supported.

For larger connections to the distribution network, DNOs in GB offer flexible connections. These types of connections allow consumers (such as V2X owners) to connect and provide flexibility without the need for a firm connection, ahead of network reinforcement. In GB, this often involves real-time control of assets the manage the import and export of electricity based on agreed principles. There is currently no opportunity for consumers with flexible connections to purchase flexibility from other grid users in a local flexibility market, enabling them to rather pay the disconnection of another grid user than be disconnected at an inconvenient moment.

Summary: V2X enables EVs to work as generator, storage and demand at different times. DSOs must determine how to class V2G given these multiple use cases. Sweden and the UK have made good progress defining what role V2G plays within their energy system, while Germany is still lacking in that regard.

5.2.2. IS THE REGISTRATION OF EXPORT CAPABILITY AND GENERATION LINKED TO A SPECIFIC GRID CONNECTION?

Relevance: A key point of differentiation for electric vehicles compared to other static energy storage is that it is mobile. This means that the point of connection to the grid is subject to change. Connection agreements that have been developed for stationary infrastructure and are location specific will limit the ability of EVs to move around and provide V2G services at different locations.

Country standings: In both GB and Sweden, there is currently no process to allow generators to roam between DSO or transmission connection points. If a vehicle is required to provide service in multiple locations it is likely that it will require registration for each location as a generation source. A number of hardwire protection systems will likely also need to remain in the EV charge point meaning V2G will require both a compatible vehicle and charger combination to operate. For DC V2G as the inverter is off-board and the vehicle is not part of the registration process, any vehicle which supports DC charging can be plugged in and provide V2G services.
In Germany, although there is currently no framework for V2G in place, securing a network connection for V2G that is not linked to a specific location is unlikely to be a barrier. According to the EnWG, operators of energy supply networks are obliged to connect end consumers on reasonable, non-discriminatory, and transparent terms, provided the consumers follow rules set out by the energy networks. The network connection and its use are a prerequisite for network access, which enables the network operator's transport service.

Summary: Both GB and Sweden have current regulations based around stationary generation which means registration may be required at each location where the vehicle performs V2X services, which is not ideal for AC V2X. Germany have more flexible legislation in this field, although still requires a legal framework for V2X to confirm this.

6. FINAL CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

In this study, we have examined the regulatory framework for bidirectional EV charging in various European countries in relation to government policy, access to markets and supporting infrastructure. Whilst current participation in bidirectional charging for electric vehicles is still in the early stages with limited commercial activity, all major EV OEMs either have V2X models or have announced launch dates in the near future. To support this roll out, our review showed there are widespread trials throughout the assessed countries with a view to rolling it out to business-as-usual if successful.

The need for flexibility in the energy transition has been made evident, as has the ability of EVs to meet these needs, alongside providing other services. Despite regulatory efforts made at a European level and many pilot projects, the uptake of V2X still faces numerous challenges that must be addressed ahead its commercial adoption.

Some of these challenges relate to taxation, limited access to additional revenue streams (such as electricity or flexibility markets) and complicated uncoordinated technical requirements across countries:

- There are certain countries that tax energy stored in a battery when they charge and again when they discharge due to the complexity surrounding electricity storage taxation. This additional cost on the operation of battery acts a barrier to technologies, such as V2X, getting fairly rewarded for the system benefits they are able to bring.

- Another barrier is inconsistent non-discriminatory access to markets that offer diverse revenue opportunities across the EU. Electricity market design should ensure a level playing field for all flexible technologies. Since the value from flexibility can fluctuate significantly, value propositions that allow stacking of several revenue streams to mitigate risk are crucial for V2X.

- The burdensome MID compliance requirements for sub-metering and DMD as well as technical requirements to participate in certain markets using such assests for measurement and verification is also likely to be a barrier to distributed energy resources such as V2X. Requirements designed for boundary smart meters, like the need to have a digital display, preventing over-the-air updates of hardware and production line certification were introduced more than a decade ago and do not correspond to the current technologies state of the art, preventing sub-meters and DMD from being used for V2X. Additionally, the meter data value chain that establishes the process for collection, transmission, analysis, and usage of data from sub-meters has not been defined or organised in any European country.

- Local flexibility markets are a great use case for V2X where EV flexibility can dramatically reduce the cost of building and maintaining the distribution network. However, only three of the eleven studied countries have a commercially operational flexibility market. Further work is therefore required to establish these markets as common place across Europe. Network operators and regulators must also make sure that future markets are designed in a way to maximise the benefit of electric vehicles.

The performance of each individual country varied across the different categories explored in this report. This variation highlights the need for a more coordinated and strategic approach to promote V2X and remove the barriers that prevent its widespread adoption.

6.2. Policy Recommendations

Following the review of the enablers and barriers for each country, we have brought together the following list of policy recommendations:

1. EV and Charging Development Considerations

1.1. Define and quantify the necessary requirements for charging infrastructure, considering bidirectional charging, to ensure V2X is installed where it can provide value.

2. Regulatory Considerations

2.1. Mandate requirements for public buildings and public fleets with long duration parking to have V2X capable charge points particularly where there is a renewable energy source on-site. The aim of this recommendation is to lower the cost of V2X-enabled chargers by leveraging economies of scale.

2.2. If no EU agreement is possible on the revision of the EU Taxation Directive, keep introducing national laws to remove double taxation of stored electricity and ensure consistency in the tax treatment of losses in the storage cycle across Member States.

2.3. Encourage Member States to have a strategic development plan (market for participation, access to affordable technology, suitable grid infrastructure, consumer engagement) for the adoption of EVs and V2X, that is consistent with other flexible technologies.

2.4. Include V2X in national resource adequacy assessments methodologies.

3. Commercialisation Streams

3.1. Ensure key markets where V2G can provide significant system value are open to aggregated consumer flexibility with accessible metering requirements and response times. These markets include:

3.1.1. Redispatch-type markets to manage constraints
(e.g., UK's Balancing Mechanism, and Germany's Redispatch 2.0).

3.1.2. Balancing-type markets to maintain system balance.
(e.g., UK's Balancing Mechanism).

3.1.3. Local flexibility markets.

3.2. Ensure that DSOs procure flexibility in competitive markets (before resorting to control of devices), thereby providing a monetisation stream for V2G.

3.3. Support the development of electricity pricing and grid tariff methodologies that stimulate grid-friendly behaviour and are symmetric for intake and offtake.

3.4. Accelerate the rollout of smart meters and allow the use of dedicated metering devices and sub-meters, to unlock flexibility in countries with lower smart meter penetrations.

3.5. V2X must be able to participate in the same mechanisms that are open to other technologies (e.g. stationary storage), including capacity renumeration mechanisms (CRMs) and specific tendering and subsidies (e.g. flexibility support schemes and via the Net-Zero Industrial Act).

4. Use of Standards

4.1. Accelerate the roll-out of ISO 15118-20 as this has higher support for smart charging and V2X and enables aggregators and suppliers to receive the relevant energy and power data.

4.2. Improve access to data by bringing forward measures that regulate communication protocols which are needed to support the backend interoperability of V2X systems.

4.3. Ensure battery warranties do not exclude the possibility of V2X by implementing measures such as increasing the number of charging cycles covered within the warranty or explicitly include V2X operation as an activity covered by the warranty.

5. Requirements of System Operators

5.1. Harmonise grid connection rules across Member States to simplify the operation of portfolios that extend across multiple countries.

5.2. Ensure that V2G functions are recognized and treated on par with other DERs in grid codes, enabling EVs to function both as flexible demand (V1G) and storage (V2G) entities.

5.3. Undertake a strategic review of grid services to identify where aggregated consumer flexibility can provide useful assets across the system, and how they could be effectively incorporated.

6.3. Study Limitations and Further Work

This study has focused on the policy, regulatory and market aspects related to V2X deployment across Europe and does not consider the impact of socioeconomics on V2G uptake. Consumer engagement and behaviour change will have a strong influence on the development of V2X and, therefore, warrant further work to understand how these might vary across European countries.

7. APPENDIX A – COUNTRY BY COUNTRY FINDINGS

7.1. Belgium

Section	Category	Detailed Question
EV and Charging Development Considerations	EV and Charging Development Considerations	What is the total fleet share for EVs and charging infrastructure in 2022? *
		What are the government goals for charging station buildout by 2030?
		What is the percentage of net electricity generation based on VRES and are there any mechanisms to credit EV charging from renewables?
Regulatory, Policy and Market Considerations	Regulatory Considerations	Are there specific national V2X policies in place?
		Are there double taxes or levies charged for V2G? *
		Do system operators consider V2G as a part of their resource adequacy assessment?
	Commercialisation Streams	Do electricity prices encourage V2G, V2H and V2B? *
		Can V2G participate in wholesale energy and balancing markets?
		What capabilities do smart meters have and are they widely adopted?
		Can wholesale settlement and customer billing be based on metering devices behind the connection point?
		Can V2G participate in local flexibility markets?
		Are network tariffs an opportunity or barrier to DER?

Response	Score
In 2022, the electric vehicle market showed significant growth and diversification. There are various types of charging stations available, including 872 single-phase Slow AC stations, 34,657triple-phase Medium-Speed AC stations, 204 triple-phase Fast AC stations, 125 Slow DC stations, 535 Fast DC stations, 1,006 Level 1 Ultra-Fast DC stations, and 96 Level 2 Ultra-Fast DC stations. As for new vehicle sales, BEVs account for 14.32% and PHEVs make up 15.17%. The overall existing fleet share indicates that BEVs comprise 1.41% and PHEVs hold a 2.67% share.	
The government aims to have 22,000 charging stations by 2035.	
In Belgium, there are multiple schemes for tracing the origin of electricity (Guarantees of Origin for electrical capacities greater than 10 kW and VEA for all other types of electricity), however no credit mechanism for EV charging from renewables has been established. 26% of Belgium's net electricity generation is based on Renewable Energy, 18% of which come from variable sources.	
In Belgium, there are no clear government policies in place for V2X. There is an ongoing trial with the Belgian TSO, where DC V2G charge points have been installed to charge a company fleet.	
Double taxation for energy storage connected to the distribution grid is the general rule for all storage.	
V2G technology is not currently a part of Belgium's business-as-usual resource adequacy assessment, however a 2022 Elia study looked at the impact of flexibility on resource adequacy. It is currently under exploration as a potential avenue for increasing grid flexibility. Furthermore, storage can already participate in resource adequacy in Belgium.	
Retail tariffs for domestic customers are either flat rate or time of use (generally day/night tariff). Dynamic tariffs are not yet available for domestic customers; however, a law was implemented in March 2023 that requires dynamic tariffs in the Flemish part of the energy market. For industrial customers, dynamic supply tariffs are available but are not very common.	
V2G technologies and other DSR can particate in wholesale energy and balancing markets, implicitly and explicitly. However, so far, no public announcement of V2G accessing markets outside of trials has been made.	
Smart meters in Belgium are capable of interfacing with home energy management systems, such as Octopus's Kraken. As for their prevalence, as of April 2022, 22% of Belgium's meters were smart.	
At present the MID requires measuring instruments to indicate their result in a physical display. However, most EV charge points have an embedded meter that does not have an external display, which means that submeter settlement is not available for EVs. Nonetheless, Belgium's data transparency and management initiatives have made submetering technically feasible for wholesale settlement.	
DSOs in Belgium do not yet perform market-based procurement at the flexibility level but are considering the benefits of integrating small Flexible Points (FPs) in the future.	
Grid users under 56kVA are able to choose between flat and peak/off-peak (day/night) tariffs as distribution tariff and they are mostly based on energy volume. From 2022, the network tariffs in the Flanders region have incorporated a capacity component.	

7.2. Denmark

Section	Category	Detailed Question
EV and Charging Development Considerations	EV and Charging Development Considerations	What is the total fleet share for EVs and charging infrastructure in 2022? *
		What are the government goals for charging station buildout by 2030?
		What is the percentage of net electricity generation based on VRES and are there any mechanisms to credit EV charging from renewables?
Regulatory, Policy and Market Considerations	Regulatory Considerations	Are there specific national V2X policies in place?
		Are there double taxes or levies charged for V2G? *
		Do system operators consider V2G as a part of their resource adequacy assessment?
	Commercialisation Streams	Do electricity prices encourage V2G, V2H and V2B? *
		Can V2G participate in wholesale energy and balancing markets?
		What capabilities do smart meters have and are they widely adopted?
		Can wholesale settlement and customer billing be based on metering devices behind the connection point?
		Can V2G participate in local flexibility markets?
		Are network tariffs an opportunity or barrier to DER?

Response	Score
In Denmark, the charging infrastructure includes 424 single-phase Slow AC stations, 12,953 triple-phase Medium-Speed AC stations, 3,601 triple-phase Fast AC stations, 37 Slow DC stations, 340 Fast DC stations, 1,259 Level 1 Ultra-Fast DC stations, and 56 Level 2 Ultra-Fast DC stations. New vehicle sales indicate that 27.38% are BEVs and 8.67% are PHEVs. The existing fleet share for BEVs is 3.21% and for PHEVs, it's 3.1%.	
Denmark has only expressed financial investments for 2035 but has not set a specific goal for the number of charging stations by 2030.	
Denmark offers Guarantees of Origin for electricity, gas, and hydrogen, allowing the tracing of energy sources; however, no specific mechanisms to credit EV charging from renewable sources has been established yet. In terms of electricity generation, 78% of Denmark's net electricity comes from renewable energy. 52%, the highest in this report, from variable sources which is a big incentive for V2G.	
There are no specific government policies for V2X in Denmark. However, there have been large successful V2X projects implemented in the country.	
Yes, Denmark imposes double taxes for V2G operations.	
Although V2G is not yet a part of Denmark's resource adequacy assessment, trial projects are underway to explore its implementation.	
Denmark experiences medium volatility in its day-ahead electricity prices for 2022. The presence of dynamic electricity contracts could potentially encourage V2G, V2H, and V2B implementations.	
V2G technologies can legally participate in wholesale energy and balancing markets, although full-scale implementation has not been achieved yet.	
In Denmark, smart meters can connect to home energy management systems through a platform called Eloverblik. The penetration rate for smart meters was 100% in 2022.	
At present the MID requires measuring instruments to indicate their result in a physical display. However, most EV charge points have an embedded meter that does not have an external display, which means that dedicated measurement device settlement is not available for EVs.	
Danish DSOs are currently running trial projects for market-based procurement.	
Denmark presents a more favourable environment than some other countries. While network tariffs are still heavily volumetric based, some DSOs offer time differentiated tariffs, as opposed to flat tariffs, to support EVs to charge at appropriate times. Lower marginal night tariffs incentivise a smarter use of flexible technologies.	

7.3. France

Section	Category	Detailed Question
EV and Charging Development Considerations	EV and Charging Development Considerations	What is the total fleet share for EVs and charging infrastructure in 2022? *
		What are the government goals for charging station buildout by 2030?
		What is the percentage of net electricity generation based on VRES and are there any mechanisms to credit EV charging from renewables?
Regulatory, Policy and Market Considerations	Regulatory Considerations	Are there specific national V2X policies in place?
		Are there double taxes or levies charged for V2G? *
		Do system operators consider V2G as a part of their resource adequacy assessment?
	Commercialisation Streams	Do electricity prices encourage V2G, V2H and V2B? *
		Can V2G participate in wholesale energy and balancing markets?
		What capabilities do smart meters have and are they widely adopted?
		Can wholesale settlement and customer billing be based on metering devices behind the connection point?
		Can V2G participate in local flexibility markets?
		Are network tariffs an opportunity or barrier to DER?

Response	Score
France boasts 36,201single-phase Slow AC stations, 56,134 triple-phase Medium-Speed AC stations, 1,569 triple-phase Fast AC stations, 2,038 Slow DC stations, 6,080 Fast DC stations, 4,896 Level 1 Ultra-Fast DC stations, and 2,373 Level 2 Ultra-Fast DC stations. BEVs account for 13.97% of new vehicle sales and PHEVs for 7.12%. The existing fleet share is 1.67% for BEVs and 0.91% for PHEVs.	
France aims to have 7 million public and private charging points by 2030, with a government objective of 400,000 public charging points in 2030.	
France has established a financial incentive called TIRUERT, which allows for certificates to be claimed for green energy charging. Additional schemes like the Guarantees of Origin that can be traded to offer green tariffs are in place. 25% of France's net electricity generation comes from renewable energy, however, only 10% of this is from variable sources.	
France lacks a legal basis for V2X policies. There are no regulatory definitions, tax exemptions, or grid fee reductions specifically for energy storage in the V2G context. However, the first mentions of V2G have been included in DSO process definitions and other documents, and there is a large-scale V2X project currently on-going.	
While there is no specific taxation policy for V2X the principle that energy stored to be reinjected should not be taxed twice is agreed by the government and a process is already in place to address this issue regarding stationary storage.	
In France, V2G is considered by the Transmission System Operator RTE in its resource adequacy scenarios, albeit with very conservative assumptions. For instance, the central assumption for 2035 is that only 2% of vehicles in France will enable V2G. Nonetheless, at present, storage is already able to participate in resource adequacy in France.	
In France, households can choose between regulated or non-regulated tariffs. Regulated tariffs, only applicable for EDF, are the most common choice. There are three available regulated tariffs: base and peak/off-peak.. 'Tempo' is the most dynamic of the regulated tariffs, it is peak/off-peak with a very light dynamic component, ie the "white" (higher tariff) and "red" "ultra-peak) days that are decided only one day ahead,, whereas Tarif Bleu (the peak/off-peak tariff) is the most popular among residential customers. A set of emergency measures price shields against the consequence of the 2022 energy crisis was implemented for all residential retail consumers, the "Bouclier Tarifaire". It will be phased out progressively until end of 2024, nonetheless these regulated tariffs do not expose consumers to market prices and there is little incentive for behind-the-meter optimization at the residential level.	
Independent aggregation framework is in place for V2G and other DSR to participate in wholesale energy and balancing markets.. Additionally, RTE announced the first aggregator in 2022 to qualify for ancillary service provision with V2G technology. In 2022, RTE launched an experimental flexibility tender in January 2022 for a 5-year service for batteries to reduce transmission congestion.	
Smart meters in France support a protocol that allows them to connect to energy management systems. The penetration rate for smart meters was 92% in 2022.	
At present the MID requires measuring instruments to indicate their result in a physical display. However, most EV charge points have an embedded meter that does not have an external display, which means that submeter settlement is not available for EVs. Currently, France is experimenting with the technical feasibility of wholesale market settlement based on submetering through a collaboration between TSO RTE and DSO Enedis; however, it has not yet been implemented and involves a separate MID-meter (installed and operated by the aggregator) that is not the embedded meter of the charger.	
France already has markets-based procurement of flexibility that V2G can access which started with some local small-scale long-term tenders for flexibility in 2019.	
France network tariffs have a static TOU component and a subscribed power level that is fixed, reducing profitability for symmetric services like frequency regulation. Although the volumetric term is still predominant, France has included a capacity term that may incentivise a more efficient use of the network, but disadvantage grid services based on power.	

7.4. Germany (1/3)

Section	Category	Detailed Question
EV and Charging Development Considerations	EV and Charging Development Considerations	What is the total fleet share for EVs and charging infrastructure in 2022? *
		What are the government goals for charging station buildout by 2030?
		What is the percentage of net electricity generation based on VRES and are there any mechanisms to credit EV charging from renewables?
Regulatory, Policy and Market Considerations	Regulatory Considerations	Are there specific national V2X policies in place?
		Are there double taxes or levies charged for V2G? *
		Do system operators consider V2G as a part of their resource adequacy assessment?
	Commercialisation Streams	Do electricity prices encourage V2G, V2H and V2B? *

Response	Score
Germany has 1,426 single-phase Slow AC stations, 99,562 triple-phase Medium-Speed AC stations, 2,109 triple-phase Fast AC stations. On DC it has 2,048 Slow DC stations, 5,137 Fast DC stations, 13,464 Level 1 Ultra-Fast DC stations, and 1,221 Level 2 Ultra-Fast DC stations. New vehicle sales include 13.35% of BEVs and 5.1% PHEVs. The existing fleet share is 1.99% for BEVs and 1.79% for PHEVs.	
Germany aims to have 1,000,000 public charging stations by 2030 and grants a right for charging infrastructure to tenants and apartment-owners in the Building Electric Mobility Infrastructure Act	
In 2018, Germany adapted its THG Quote (main instrument to reduce carbon intensive fuels) to credit emissions savings from electricity charged by BEVs, both in public and private charging stations. Additionally, Germany employs an electronic document known as HKN to certify the origin of electricity with framework stated in the EEG and the EnWG and its Federal Environment Agency oversees the German register of Guarantees of Origin. Renewable energies accounted for 44% of Germany's gross electricity production in 2022, 33.2% was covered by variable sources, being the second highest VRES number in this report.	
Germany has plans for V2X outlined in the coalition agreement of the current federal government. They aim to enable bidirectional charging and have set a new target within the Master Plan Charging 2.0 for Q2/23 to examine how to make the flexibilities of electric vehicles usable for the electricity system. There is a financing priority named "bidirectional fleet power plant 2025" aimed at taking bidirectional charging from the pilot phase to widespread application. With a new strategy paper (Q3 2023) of the federal government, it will release further bonus payments for combined private solar- battery-storage- EV-charging-post plus EV systems in order to promote the overall expansion.	
The German Energy Financing Act (EnFG) mentions that some levies (offshore- and CHP levies) for electricity storage and energy loss shall be reduced to zero for intermediate storage that is withdrawn from and injected into the grid within the same year, explicitly including charging points for EVs.	
At present, Germany has several resource adequacy mechanisms; however, they all have limited participation of demand-side resources except for the interruptibility scheme. Distribution system operators like Tennet, TransnetBW, and 50Hertz are conducting pilot tests for bidirectional charging. While V2G is considered beneficial, operators uniformly agree that significant progress must be made before its universal implementation.	
Germany exhibits medium electricity price volatility in 2022 and is in the early stages of rolling out smart meters. Dynamic electricity tariffs are legally required for larger suppliers. Residential users still have static tariffs, however, starting in 2025 all electricity suppliers will be required by law to offer their customers dynamic electricity tariffs. However, electricity and gas price brakes have been applied to all electricity customers since January 2023. The aim of the German Government is to relieve citizens and companies from the sharp rise in energy costs, but they remove real price signals which are important for V2G to develop. The electricity price is capped at 40 cents per kWh for private consumers and small businesses but will be removed once the European emergency framework expires.	

7.4. Germany (2/3)

Section	Category	Detailed Question
Regulatory, Policy and Market Considerations	Commercialisation Streams	Can V2G participate in wholesale energy and balancing markets?
		What capabilities do smart meters have and are they widely adopted?
		Can wholesale settlement and customer billing be based on metering devices behind the connection point?
		Can V2G participate in local flexibility markets?
		Are network tariffs an opportunity or barrier to DER?
Grid and System Considerations	Use of standards	Are there barriers in national standards where V2X is specifically mentioned?
		Are there standards related to off grid power storage and usage for buildings or dwellings creating barriers to V2X deployment?
		Are there barriers to V2X deployment in national electrical safety standard requirements for charging infrastructure?
		Is bidirectional charging included in regulations for charging communication protocols?

Response	Score
In Germany, there is currently no legal framework or adequate infrastructure for V2G to explicitly participate in wholesale energy markets.	
Smart Meter Gateways in Germany are capable of connecting to home energy management systems, although not all systems attempt interoperability due to high requirements. The penetration rate for smart meters was less than 1% in 2022, mainly due to the high requirements resulting in high annual costs. Some changes in the costs splitting mechanism might increase the uptake in the future.	
At present the MID requires measuring instruments to indicate their result in a physical display. However, most EV charge points have an embedded meter that does not have an external display, which means that submeter settlement is not available for EVs.	
There is currently no market-based procurement of flexibility by DSOs in Germany at this stage as it is not supported by the authorities. DSOs rely on Redispatch 2.0 which is cost-based. There have been trials with the possibility of a market in the near future.	
In Germany, network tariffs are very high (around 20% of the total cost per kWh) and almost completely volume based, lowering the incentive for efficient network use and therefore V2G.	
The implementation of V2G services in Germany is currently limited to small scale pilot projects to demonstrate the feasibility of grid service provision from electromobility. Assessing integration of V2G concepts to micro-grids may be the scope of upcoming studies.	
How off-grid storage capacity is defined in terms of bidirectional charging in Germany remains unclear. The charging pole regulation (Ladesäulenverordnung) and the Electromobility Act lacks definition of various terms regarding bidirectional charging. Furthermore, the EEG does not consider electric vehicles for energy storage in general. Finally, the EnWG and the EEG have different definitions of the end consumer. Hence, it is not possible to estimate whether regulation of off-grid power storage will generally stand in the way of the deployment of bi-directional charging.	
In Germany the DIN VDE 0701-0702 VDE 0701-0702:2008-06 regulates the testing after repair or modification of electrical equipment and it implies repeat testing. Charging stations, charging cables and associated electrical installation must be tested under this regulation. It can be assumed that bidirectional charging will have to undergo similar testing as soon as a legal framework has been created. The VDE application rule VDE-AR-N 4105 is also relevant for EVs intended to feed energy into a customer system connected to the public grid. The current versions VDE-AR-N 4105 (Low-voltage) and the VDE-AR-N 4110 (Medium-voltage) demand that battery storage systems (including EVs) must in principle be designed with controllable power in order to support frequency stability. These requirements in the most important standards in Germany are expected to be the most relevant to future V2G infrastructure.	
No legal framework for bidirectional charging is in place in Germany at present. However, the IEC 61851-1 standard contains the basic principles for communication to control charging processes in electric vehicles. Furthermore, Germany's latest funding requirements for EV's state that the components must have a secure digital, bidirectional communication interface and support common, standardised communication protocols as well as have a secure software update capability, Furthermore, the components must allow a secure and interoperable connectivity to the smart meter gateway.	

7.4. Germany (3/3)

Section	Category	Detailed Question
Grid and System Considerations	Requirements of system operators	Do the DSOs have specific requirements defined in their connection agreements regarding bidirectional charging?
		Is the registration of export capability and generation linked to a specific grid connection?

Response	Score
Due to their mode of operation as generating plants, bidirectional EV facilities can cause a higher load on lines, transformers, and other operating equipment of the grid compared to unidirectional equipment. Therefore, the network operator shall verify the transmission capability of the network at the connection point regarding other connected actors within close electrical proximity. For this, the maximum apparent power of the sum of all generation units and storage units must be assumed. For EVs intended to feed to the public grid, the requirements of the norm VDE-AR-N 4105 should also be considered.	
According to the EnWG, operators of energy supply networks are obliged to connect end consumers and energy supply networks at the same or downstream level; generation and storage facilities must be connected to their network on reasonable, non-discriminatory, and transparent terms. The network connection and its use are a prerequisite for network access, which enables the network operator's transport service.	

7.5. Great Britain (1/3)

Section	Category	Detailed Question
EV and Charging Development Considerations	EV and Charging Development Considerations	What is the total fleet share for EVs and charging infrastructure in 2022? *
		What are the government goals for charging station buildout by 2030?
		What is the percentage of net electricity generation based on VRES and are there any mechanisms to credit EV charging from renewables?
Regulatory, Policy and Market Considerations	Regulatory Considerations	Are there specific national V2X policies in place?
		Are there double taxes or levies charged for V2G? *
		Do system operators consider V2G as a part of their resource adequacy assessment?
	Commercialisation Streams	Do electricity prices encourage V2G, V2H and V2B? *
		Can V2G participate in wholesale energy and balancing markets?
		What capabilities do smart meters have and are they widely adopted?

Response	Score
Great Britain has a different classification, with 8,932 Slow stations, 21,427 Fast stations, 4,607 Rapid stations, and 2,295 Ultra-Rapid stations. BEVs make up 16.6% of new vehicle sales, and PHEVs account for 6.3%. The existing fleet share based on the total number of vehicles in the UK is 1.999% for BEVs and 1.355% for PHEVs.	
The UK aims to have 300,000 public charge points by 2030.	
Great Britain utilises Renewable Energy Guarantees of Origin (REGOs) to certify the source of renewable electricity, however no credit mechanisms for EV charging from renewables is in place yet. Regarding renewable energy, 41% of GB's net electricity generation comes from renewables, however only 24.9% from variable sources.	
The United Kingdom has not included bidirectional V2X charge points within the scope of the 2021 smart charging legislation. However, it is part of the EV Smart Charging Action Plan, committed to delivering the Vehicle-to-X Innovation Programme by 2025.	
As of 2020, the UK has not yet eliminated double network charges for active customers owning an energy storage facility.	
In Great Britain, the Electricity System Operator (ESO) does consider the impact of V2G in their resource adequacy assessments for the 2030s, specifically looking at the effects of demand-side response. Furthermore, storage can participate in resource adequacy mechanisms, although they are limited to little participation at present.	
Residential customers who have half-hourly meters can choose a TOU tariff, however those contracts are not common and there is little choice compared to some other European countries. Only one retail tariff in GB offers a dynamic setting. Dynamic tariffs are also available to industrial customers. There is electricity price volatility to encourage flexibility.	
Standard P415 has recently been approved (October 2023), which seeks to allow behind the meter, aggregated assets to access the wholesale market through VLPs. Previously third-party aggregated DSR had no access to the wholesale markets; only a customer's supplier can make wholesale transactions. This limited the potential for V2G participation in such markets. Balancing markets are technology agnostics so V2G can, in theory participate. Some energy products, however, have certain requirements that makes it very difficult for aggregated DSR to participate. For example, the dynamic containment service has to be delivered at grid supply point (i.e., very limited geographical area), this makes it impossible for aggregators to get sufficient capacity from smaller/residential loads.	
Legislation in Great Britain stipulates that new smart metering systems must be interoperable with energy management systems and smart grids. The penetration rate for smart meters was 56% in 2022.	

7.5. Great Britain (2/3)

Section	Category	Detailed Question
Regulatory, Policy and Market Considerations	Commercialisation Streams	Can wholesale settlement and customer billing be based on metering devices behind the connection point?
		Can V2G participate in local flexibility markets?
		Are network tariffs an opportunity or barrier to DER?
Grid and System Considerations	Use of standards	Are there barriers in national standards where V2X is specifically mentioned?
		Are there standards related to off grid power storage and usage for buildings or dwellings creating barriers to V2X deployment?
		Are there barriers to V2X deployment in national electrical safety standard requirements for charging infrastructure?
		Is bidirectional charging included in regulations for charging communication protocols?

Response	Score
In GB, submetering technology is sufficiently advanced to allow for real-time reading of energy quantities consumed, which serves as the basis for digital utility billing for both landlords and tenants. Current legislation allows for all balancing services to be settled through sub-meters, though this does not extend to wholesale energy settlements yet. However, the MIR requires meters to have a physical display to conduct submetering and since most EV charger have embedded meters, EV settlement cannot be conducted through submetering yet.	
Yes, there is market-based procurement of flexibility that V2G can access. These markets are scaling up, however the majority of electric vehicles participating in these markets is through smart charging.	
Distribution tariffs, known as Distribution Use of System (DUoS) charges are TOU tariffs that vary per region and are based on the consumed energy volume. The time banding mechanism (green, amber, red) is designed to encourage customers to spread their network usage across the day and avoid network usage during times of peak demand. Currently there are no specific variable network components for residential assets.	
In GB, V2G charging does not have its own standards but shares them with normal EV charging installations and generating infrastructure. Two standards (PAS 1878 and 1879) developed by industry and published by the British Standards Institution set a technical framework for small-scale DSR, guided by the principles of interoperability, data privacy, grid stability and cyber security. These standards are compatible with the GB Smart Metering system and could therefore be beneficial for V2G.	
The UK does not have specific standards or regulations that define the operations or compliance of off-grid V2H or V2B solutions. Electrical safety standards, such as BS 7671, will apply regardless of whether there is a grid connection. Users will need to make sure that systems are installed safely and do not pose a risk to themselves or others (e.g., from fires).	
GB has the most developed electrical safety standards for bidirectional charging. Electrical installations must be compliant with The IET Wiring Regulations (BS 7671) and an application for connection of a distributed generator to the grid (following ENA's ERECs G99/G98) must be submitted, which are key areas for V2G. The revised Code of Practice for EV Charging Equipment Installations 4th Edition and BS7671 Amendment 2, both detail basic requirements for the safe design of bidirectional charging.	
In GB, Appendix A2 of PAS1878/79 lists the relevant standards and regulations for ESAs. This list includes the OCA, since the OCPP communication protocol is also based on the same documents. Furthermore, the ISO 15118 standard for vehicle to grid communications, allows for more complex communication between the vehicle and the charging infrastructure. This provides a secure communication method for multiple use cases including V2G.	

7.5. Great Britain (3/3)

Section	Category	Detailed Question
Grid and System Considerations	Requirements of system operators	Do the DSOs have specific requirements defined in their connection agreements regarding bidirectional charging?
		Is the registration of export capability and generation linked to a specific grid connection?

Response	Score
In GB the Engineering Recommendations G98 and G99 provide the requirements for the connection of generation equipment. G99 relates to any apparatus which produces electricity connecting to the distribution network. It includes micro-generators and electricity energy storage devices. V2G under G99 is classified as energy storage and should follow the same requirements that energy storage must follow. From Amendment 7 of the document, V2G was defined as a separate asset type but is still considered as energy storage for the purposes of the document. If an EV is configured in a way that it cannot operate in V2G mode, then it can be considered as demand only and is not included in the requirements of G99. For smaller installations with bi-directional charging up to 16 A export per phase, G98 applies. It is a simpler process to G99 with the requirement on the DNO to ensure export capability is possible if requested. It is noted however this export capacity includes any other generation at the site such as solar PV. If a site includes generation, then it is likely that any combination of generation and V2G charging will exceed 16 A per phase and require G99.	
Current regulations in GB are based around stationary generation, therefore the registration of export capability and generation is linked to a specific grid connection. This means that registration may be required at each location where the vehicle performs V2G services.	

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7.6. Italy

Section	Category	Detailed Question
EV and Charging Development Considerations	EV and Charging Development Considerations	What is the total fleet share for EVs and charging infrastructure in 2022? *
		What are the government goals for charging station buildout by 2030?
		What is the percentage of net electricity generation based on VRES and are there any mechanisms to credit EV charging from renewables?
Regulatory, Policy and Market Considerations	Regulatory Considerations	Are there specific national V2X policies in place?
		Are there double taxes or levies charged for V2G? *
		Do system operators consider V2G as a part of their resource adequacy assessment?
	Commercialisation Streams	Do electricity prices encourage V2G, V2H and V2B? *
		Can V2G participate in wholesale energy and balancing markets?
		What capabilities do smart meters have and are they widely adopted?
		Can wholesale settlement and customer billing be based on metering devices behind the connection point?
		Can V2G participate in local flexibility markets?
		Are network tariffs an opportunity or barrier to DER?

Response	Score
In Italy, there are 473 single-phase Slow AC stations, 27,416 triple-phase Medium-Speed AC stations, 5,942 triple-phase Fast AC stations, 222 Slow DC stations, 2,849 Fast DC stations, 1,992 Level 1 Ultra-Fast DC stations, and 261 Level 2 Ultra-Fast DC stations. New vehicle sales include 3.85% BEVs and 4.03% PHEVs. The existing fleet share is 0.42% for both BEVs and PHEVs.	
Italy aims to have 3 million public and private charging points of which 32,000 public fast and ultra-fast charge points by 2030 to charge 6 million EVs.	
Italy employs a Guarantees of Origin scheme, wherein for every MWh from a recognised plant, the energy services authority awards a certificate that can be traded on Italian or European markets, however there are no mechanisms in place to credit EV charging from renewable sources. In Italy, 40% of net electricity generation is based on renewable energy, however variable sources only account for 16%.	
Italy does not have a clear V2X policy, although there are relatively large pilot projects underway. One such example is a Fiat Chrysler V2G pilot project with ENGIE. This project is set in Turin and consists of 700 Fiat vehicles, each electrically equipped with a 40kWh battery.	
Italy has eliminated double taxes for V2G.	
In Italy, resource adequacy assessments currently focus solely on the growing demand from electric vehicles and not explicitly V2G. Currently, storage and DSF resources may participate in resource adequacy mechanisms, however, only very limited storage capacity has been contracted this far.	
Italian energy retailers are proposing variable price offers based on historical (last month) energy market prices, for example indexed to the National Single Price (PUN, the reference price). These tariffs are based on historical averages in three time slots, which represent a combination of static, ToU and close-to-dynamic pricing that is challenging to optimise flexible assets against. There are also offerings where the price of energy is lower in a specific timeframe (night-time) than in daytime; in some cases, it is set at zero for a few hours of each day. Furthermore, the low cost of export remuneration for those who have rooftop PV plants, (0.06 Euro/kWh) is an incentive for V2G; by implementing the technology they can consume most of the in-house produced energy to save against a 0.15-0.30 Euro/kWh purchase energy price. Italy had medium electricity price volatility for 2022.	
In Italy, V2G and DSR can participate in pilot projects UVAM and Fast Reserve, as well as the capacity market. They may also participate in the wholesale market through aggregators if the threshold of 10 MW is exceeded.	
The penetration rate for smart meters in Italy was 98% in 2022. Of those, some are 2nd generation Smart meters that can also supply data to Energy Management Systems through a dedicated Power Line Communication (PLC) channel.	
At present the MID requires measuring instruments to indicate their result in a physical display. However, most EV charge points have an embedded meter that does not have an external display, which means that submeter settlement is not available for EVs. Nonetheless, in Italy's pilot project UVAM the execution of the dispatch order is verified using metering data of the points of delivery of the resources which supply the service, as provided by the network operator.	
Flexibility services in Italy are procured through the Transmission System operator via the MSD electricity market, while DSO's do not perform market-based procurement at large scale, Resolution 352/2021 introduced the possibility for DSOs to implement pilot projects with the aim of acquiring flexibility services. Additionally, the "Integrated Electricity Dispatching Act (TIDE)" approved in July 2023 (and which will enter in force starting from 2025), states that all resources (including DSR and V2G) can provide flexibility services.	
Italy has a combination of capacity-based and energy-based charges, and according to a report by the ACER , its tariffs are highly capacity-based. .	

7.7. Netherlands

Section	Category	Detailed Question
EV and Charging Development Considerations	EV and Charging Development Considerations	What is the total fleet share for EVs and charging infrastructure in 2022? *
		What are the government goals for charging station buildout by 2030?
		What is the percentage of net electricity generation based on VRES and are there any mechanisms to credit EV charging from renewables?
Regulatory, Policy and Market Considerations	Regulatory Considerations	Are there specific national V2X policies in place?
		Are there double taxes or levies charged for V2G? *
		Do system operators consider V2G as a part of their resource adequacy assessment?
	Commercialisation Streams	Do electricity prices encourage V2G, V2H and V2B? *
		Can V2G participate in wholesale energy and balancing markets?
		What capabilities do smart meters have and are they widely adopted?
		Can wholesale settlement and customer billing be based on metering devices behind the connection point?
		Can V2G participate in local flexibility markets?
		Are network tariffs an opportunity or barrier to DER?

Response	Score
The Netherlands has 5,328 single-phase Slow AC stations, 132,734 triple-phase Medium-Speed AC stations, 2,734 triple-phase Fast AC stations, 206 Slow DC stations, 709 Fast DC stations, 2,357 Level 1 Ultra-Fast DC stations, and 83 Level 2 Ultra-Fast DC stations. New vehicle sales show 23.03% BEVs and 11.51% PHEVs. The existing fleet share is 3.44% for BEVs and 1.88% for PHEVs.	
The Netherlands aims to have over 1.7 million charging stations by 2030.	
The Dutch Hernieuwbare Brandstof Eenheden (HBE) is a credit mechanism established in 2015 that allows fuel suppliers to also buy credits for renewable electricity charged by BEVs at public charge points. Additionally, renewable energy producers can apply for and obtain Guarantees of Origin certificates for each MWh of electricity they produce from eligible renewable sources. These certificates can be traded separately from the physical electricity. The proportion of net electricity generated from renewables is 37%, while 25% comes from variable sources.	
The Netherlands does not currently have a V2X or bidirectional charging policy in place. However, incentives for pilot projects are being offered, with financial support reaching millions of Euros.	
There are no double taxes charged for large-scale grid connected BESS. However, for V2G double taxation is solved by the (implicit) netting of taxes, but this will change once net-metering is phased out which will require another way to address this issue.	
The Netherlands does not operate any resource adequacy mechanisms, relying on energy-only markets. In its resource adequacy assessment V2G is not explicitly factored in, however, smart charging is. TenneT, the system operator in The Netherlands, uses a simplified approach to EV demand, assuming that 20% of the hourly demand for charging can be shed if market prices reach a certain threshold.	
The Netherlands experienced high electricity price volatility in 2022. However, current feed-in tariffs for domestic renewables reduce the incentive for behind the meter solutions such as V2H, and V2B technologies, and there is little appetite for dynamic contacts. Feed-in tariffs will be phased out between 2025-2031. Since 95% of Dutch households pay the same tariff, there is very little incentive to use the flexibility for grid purposes.	
Demand-side flexibility, including V2G, can participate in the wholesale energy and balancing markets, within the portfolio of energy suppliers. While independent aggregation is permitted, market parties that wish to aggregate using the flexibility resources of an end-user in their portfolio must agree on the terms and conditions with the supplier that is active on that connection	
Smart meters in The Netherlands come equipped with a local interface, typically a physical port like a P1 port, which allows for data access by consumers and third-party home energy management systems. This in turn could allow for in-home optimisation where V2H could be applied. The penetration rate for smart meters was 89% in 2022.	
At present the MID requires measuring instruments to indicate their result in a physical display. However, most EV charge points have an embedded meter that does not have an external display, which means that submeter settlement is not available for EVs.Nonetheless, currently in The Netherlands customers can participate in some balancing services based on submeter data. The New Energy Law indicates that it is not necessary for the DSO to operate and collect submeter data, this is done by the Balance Service Provider (BSP).	
In the Netherlands DSOs are currently implementing market-based congestion management to facilitate more customer connection requests in congested areas. The GOPACS platform is intended to facilitate the coordination of the TSO and DSOs in the procurement of flexibility to solve network constraints on medium and high voltage. However, participation is still fairly limited.	
Network tariffs are fully capacity-based and are determined by the size of the connection (rather than peak consumption). This creates a moderate incentive for V2G. While capacity-based tariffs are incentives, if they are fixed based on the size of connection rather than on peak consumption, the incentive to reduce said peak is lowered and thus the need for V2G is not as strong.	

7.8. Norway

Section	Category	Detailed Question
EV and Charging Development Considerations	EV and Charging Development Considerations	What is the total fleet share for EVs and charging infrastructure in 2022? *
		What are the government goals for charging station buildout by 2030?
		What is the percentage of net electricity generation based on VRES and are there any mechanisms to credit EV charging from renewables?
Regulatory, Policy and Market Considerations	Regulatory Considerations	Are there specific national V2X policies in place?
		Are there double taxes or levies charged for V2G? *
		Do system operators consider V2G as a part of their resource adequacy assessment?
	Commercialisation Streams	Do electricity prices encourage V2G, V2H and V2B? *
		Can V2G participate in wholesale energy and balancing markets?
		What capabilities do smart meters have and are they widely adopted?
		Can wholesale settlement and customer billing be based on metering devices behind the connection point?
		Can V2G participate in local flexibility markets?
		Are network tariffs an opportunity or barrier to DER?

Response	Score
Norway has a total of 25,102 stations with 6,808 being rapid charge points. A staggering 79.3% of new vehicle sales are BEVs, and 8.7% are PHEVs. Notably, 21% of registered vehicles in Norway are BEVs.	
Norway has not set specific goals for charging stations by 2030. However, a right to access charging infrastructure for people living in apartments was established in 2021.	
Norway is part of the Guarantees of Origin system, allowing for the tracing of renewable energy sources, however no specific EV charging from renewables credit mechanism is in place due to most of the country's electricity coming from renewables. Though Norway boasts an impressive 99% of net electricity generation coming from renewables, less than 10% comes from variable sources.	
Norway does not have specific V2X policies in place but does have pilot projects such as SEEV4City.	
Norway does not charge double taxes for V2G.	
In Norway, demand-side response is not currently included in Statnett's resource adequacy assessment, meaning V2G is not yet considered. However, the Norwegian regulator NVE estimates a Norwegian flexibility potential in 2030 of 2 GW from electric vehicles.	
Dynamic tariffs are offered. Effect tariffs are in place ensuring that you will pay extra for high consumption when the load on the grid is high (typically in the afternoon or in the morning). If you e.g., charge your vehicle at night, when the load on the grid is lower, the cost will be lower. Norway has low electricity price volatility due to its reliance on hydropower, which might not provide strong incentives for the adoption of V2G, V2H, and V2B technologies. Furthermore, from 1st of September 2023 new temporary legislation for support for high electricity prices was introduced. Through the scheme, a household receives support for electricity consumption of up to 5,000 kilowatt hours per month per metering point.	
Aggregating flexibility to access wholesale energy markets and participation in the balancing markets is allowed today, however an independent aggregator framework is required in national legislation to facilitate access to a wider range of consumers. This will be facilitated when minimum bid size is reduced to 1MW bids in 2024.	
Smart meters in Norway are designed to connect to monitoring and control systems. The penetration rate for smart meters was 99% in 2022.	
Wholesale settlement and customer billing through submetering in technically feasible in Norway. However, at present the MID requires measuring instruments to indicate their result in a physical display and most EV charge points have an embedded meter that does not have an external display, which means that submeter settlement is not available for EVs.	
V2G technologies cannot participate directly in local flexibility markets, although there are advanced trial offerings with high traded volumes.	
Starting in 2022 Norway's network operators have had to include a variable capacity charge for residential users. Commercial and industrial customers also have variable tariffs. These capacity-based tariffs incentivise DER. There are special tariffs for prosumers where they do not pay a fixed charge for feed-in and do not have to pay grid rent for consumption covered by self-generated electricity up to 100 kW. A system for sharing self-produced electricity is also currently under consultation.	

7.9. Poland

Section	Category	Detailed Question
EV and Charging Development Considerations	EV and Charging Development Considerations	What is the total fleet share for EVs and charging infrastructure in 2022? *
		What are the government goals for charging station buildout by 2030?
		What is the percentage of net electricity generation based on VRES and are there any mechanisms to credit EV charging from renewables?
Regulatory, Policy and Market Considerations	Regulatory Considerations	Are there specific national V2X policies in place?
		Are there double taxes or levies charged for V2G? *
		Do system operators consider V2G as a part of their resource adequacy assessment?
	Commercialisation Streams	Do electricity prices encourage V2G, V2H and V2B? *
		Can V2G participate in wholesale energy and balancing markets?
		What capabilities do smart meters have and are they widely adopted?
		Can wholesale settlement and customer billing be based on metering devices behind the connection point?
		Can V2G participate in local flexibility markets?
		Are network tariffs an opportunity or barrier to DER?

Response	Score
In Poland, the charging stations are distributed as follows: 72 single-phase Slow AC stations, 3,629 triple-phase Medium-Speed AC stations, 86 triple-phase Fast AC stations, 186 Slow DC stations, 910 Fast DC stations, 144 Level 1 Ultra-Fast DC stations, and 42 Level 2 Ultra-Fast DC stations. New vehicle sales consist of 3.33% BEVs and 2.2% PHEVs. The existing fleet share is 0.09% for both BEVs and PHEVs.	
Poland aims to have 100,000 charging stations by 2030.	
Poland participates in the Guarantees of Origin system as part of the European Union's environmental policy. However, it has not established credit mechanisms for RES-E for EVs and only 20% of its net electricity generation comes from renewable energy and only 11% from VRES.	
Poland does not have any V2X policies in place. However, there are V2X pilots underway. Additionally, a V2G technology program has been proposed, but it will require significant changes to the Polish Energy Law.	
Double taxation for stored energy is still in place.	
Poland is yet to incorporate V2G technology into its resource adequacy assessments. However, trial projects are in place to explore this avenue. At present, DSF may participate in Resource Adequacy Mechanisms; however, their participation is still very low (around 4%).	
Dynamic tariffs are set to be introduced in 2024, which will incentivise V2G. Poland had medium electricity price volatility in 2022.	
Poland is not yet ready for V2G to participate explicitly in wholesale energy and balancing markets.	
In Poland, the measurement data acquisition system is centralized and run by the transmission system operator. This data can be shared, but the system does not support high-speed services requiring a sampling period of less than 15 minutes. The penetration rate for smart meters was 19% in 2022.	
Submetering for wholesale settlement and customer billing is currently not practiced in Poland.	
DSOs in Poland do not perform market-based procurement of flexibility.	
Currently in Poland, network tariffs have a mixed design with a capacity-based and a volume-based component.	

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7.10. Spain

Section	Category	Detailed Question
EV and Charging Development Considerations	EV and Charging Development Considerations	What is the total fleet share for EVs and charging infrastructure in 2022? *
		What are the government goals for charging station buildout by 2030?
		What is the percentage of net electricity generation based on VRES and are there any mechanisms to credit EV charging from renewables?
Regulatory, Policy and Market Considerations	Regulatory Considerations	Are there specific national V2X policies in place?
		Are there double taxes or levies charged for V2G? *
		Do system operators consider V2G as a part of their resource adequacy assessment?
	Commercialisation Streams	Do electricity prices encourage V2G, V2H and V2B? *
		Can V2G participate in wholesale energy and balancing markets?
		What capabilities do smart meters have and are they widely adopted?
		Can wholesale settlement and customer billing be based on metering devices behind the connection point?
		Can V2G participate in local flexibility markets?
		Are network tariffs an opportunity or barrier to DER?

Response	Score
Spain has 4,303 single-phase Slow AC stations, 17,921 triple-phase Medium-Speed AC stations, 2,382 triple-phase Fast AC stations, 436 Slow DC stations, 2,980 Fast DC stations, 992 Level 1 Ultra-Fast DC stations, and 213 Level 2 Ultra-Fast DC stations. New vehicle sales include 3.79% BEVs and 5.01% PHEVs. The existing fleet share is 0.41% for BEVs and 0.47% for PHEVs.	
Spain has a government target of 250,000 – 300,000 by the close of 2030. It is expected that 5 million electric vehicles will require 320,000 EV charging stations.	
Spain participates in the Guarantees of Origin system, adhering to the European Union's environmental policy for tracing renewable energy sources however, it has not implemented a credit mechanism for renewable EV charging yet. Regarding renewable energy, 45% of Spain's net electricity generation comes from renewable sources with variables amounting to 33%. Spain's current electricity mix may provide a big driver for V2G.	
Spain does not have any V2X policies in place.	
Spain has eliminated the double charge that could affect V2G with the publication of Circular 3/2020.	
In Spain, V2G technology is not currently incorporated into the country's resource adequacy assessments.	
There is one dynamic tariff available to domestic consumers. Spain experiences low electricity price volatility due to capped natural gas prices. However, the PVPC price (for contracted power under 10kW) can vary sufficiently to incentivize arbitrage, providing some encouragement for V2G, V2H, and V2B technologies.	
Minimum bid size to participation in Restricciones market is 1MW. So, when regulated, if V2X is under 1 MW, could participate in restricciones técnicas through an aggregator.	
In Spain, smart meter systems are already interoperable in terms of sharing data at the central system layer. Datadis serves as a national data hub platform, collating all national DSO smart meter information. The penetration rate for smart meters was 99% in 2022.	
In Spain, submetering is technically feasible but cannot be used as billing is made by the measurement device registered by DSO.	
DSOs does not perform market-based procurement for flexibility.	
Spain offers an opportunity for DER as the pricing methodology has low off-peak and high on-peak prices. Furthermore, its network tariffs have a balance of volumetric and capacity-based components.	

7.11. Sweden 1/2

Section	Category	Detailed Question
EV and Charging Development Considerations	EV and Charging Development Considerations	What is the total fleet share for EVs and charging infrastructure in 2022? *
		What are the government goals for charging station buildout by 2030?
		What is the percentage of net electricity generation based on VRES and are there any mechanisms to credit EV charging from renewables?
Regulatory, Policy and Market Considerations	Regulatory Considerations	Are there specific national V2X policies in place?
		Are there double taxes or levies charged for V2G? *
		Do system operators consider V2G as a part of their resource adequacy assessment?
	Commercialisation Streams	Do electricity prices encourage V2G, V2H and V2B? *
		Can V2G participate in wholesale energy and balancing markets?
		What capabilities do smart meters have and are they widely adopted?

Response	Score
In Sweden, there are 5,900 single-phase Slow AC stations, 21,840 triple-phase Medium-Speed AC stations, 286 triple-phase Fast AC stations, 60 Slow DC stations, 887 Fast DC stations, 2,554 Level 1 Ultra-Fast DC stations, and 280 Level 2 Ultra-Fast DC stations. New vehicle sales include 33.31% BEVs and 23.1% PHEVs. The existing fleet share is 3.97% for BEVs and 4.91% for PHEVs.	
Sweden does not have clear targets but has various incentive programs for the development of charging infrastructure. For instance, "Trafikverket", the Swedish Transport Administration, offers funding for public fast charging stations along major roads in 2023 and 2024 to improve the charging infrastructure across the country.	
In Sweden, Elkraft System administers Guarantees of Origin, and there are also voluntary green electricity labelling schemes, however it has not yet established a credit mechanism for EV charging from renewables. Approximately, 69% of Sweden's net electricity generation comes from renewable energy, though variable sources only account for 17%. This number is low compared to other countries within the report.	
At the moment there are several policies that do not support bi-directional charging in Sweden, these would need to be resolved prior to V2X implementation. However, there are a number of projects that aim to identify what developments are needed within laws, policies, and standards to enable V2X, such as project V2X-MAS, which is supported by Energimyndigheten (the Swedish Energy Agency) and started its demonstration phase in 2023.	
Sweden proposed changes to the energy tax system in 2018 to prevent double taxation on electricity storage.	
In Sweden, proposals for future capacity mechanisms to ensure resource adequacy post-2025 will be open to demand-side management and energy storage, potentially paving the way for V2G. However, at present Sweden only operates a strategic reserve and technical requirements de facto exclude any demand participation.	
There are dynamic electricity prices offered on the electricity market. However, the most dynamic part of the electricity cost is only a fraction of the total cost, making the price signal not as strong as it could be. More generally, whether electricity prices will encourage V2G, V2H and V2B will depend on the bidding zone of the assets. For an area such as SE4 with high wind power and usually more demand that generation, the option to balance this through V2G could be an attractive option. Furthermore, 2022 exhibited high day-ahead price volatility.	
Sweden does not currently allow V2G technologies to participate directly in wholesale energy and balancing markets.	
Swedish smart meters come equipped with a data port that allows customers to retrieve their consumption data in real-time and connect devices. The penetration rate for smart meters was 100% in 2022. There are plans to upgrade them with more advanced features by 2025.	

7.11. Sweden 2/2

Regulatory, Policy and Market Considerations	Commercialisation Streams	Can wholesale settlement and customer billing be based on metering devices behind the connection point?
		Can V2G participate in local flexibility markets?
		Are network tariffs an opportunity or barrier to DER?
Grid and System Considerations	Use of standards	Are there barriers in national standards where V2X is specifically mentioned?
		Are there standards related to off grid power storage and usage for buildings or dwellings creating barriers to V2X deployment?
		Are there barriers to V2X deployment in national electrical safety standard requirements for charging infrastructure?
		Is bidirectional charging included in regulations for charging communication protocols?
	Requirements of system operators	Do the DSOs have specific requirements defined in their connection agreements regarding bidirectional charging?
		Is the registration of export capability and generation linked to a specific grid connection?

Response	Score
In Sweden, traditional wholesale energy market settlement is based on grid supply point metering, meaning submetering is currently not used for this purpose.	
DSOs do not perform market-based procurement for flexibility, however there are advanced trial offerings with high traded volumes.	
Network tariffs in Sweden are not standardised and vary between DSOs, creating a challenge for universal flexibility. Furthermore, the main indicator for the tariffs is currently the size of the connection which is not conducive to effective use of the network and does not benefit V2G adoption.	
There are currently no specific standards or guidelines for V2G applications in Sweden. Nonetheless, most existing standards are developed for unidirectional charging and will need to be updated for V2G.	
Currently in Sweden no regulations or standards in this category exist.	
Though currently no advanced safety standards exist for V2G, Energiforsk has supported Swedish participation in the international group IEC/TC69: Electrical power/energy transfer systems for electrically propelled road vehicles and industrial trucks. The group has started working with standardization of V2G. Furthermore, the Swedish Electromobility Centre has carried out research on V2X where they have some challenges for charging infrastructure.	
Currently there are limited possibilities for the remote control of bidirectional charging in Sweden. However, the implementation of the communication protocols in IEC/ISO 15118 is a pre-requisite for smart and meaningful implementation of V2G.	
In Sweden, grid operators consider V2G applications as intermittent power energy facilities similar to PV facilities. The DNO must be notified about all new and modified production units in advance.As an example, Vattenfall (one of Sweden's larger DSO's) have the following requirements for producing own solar energy: 1. Main fuses that are maximum 63A, or alternatively total solar capacity of 43.5 kW 2. The seller must buy more electricity than they sell as an average over a 12-month period. An agreement must be signed with a buyer for the surplus solar energy produced.	
The current guidelines in Sweden are designed for generators at fixed locations. For a vehicle battery unit, it depends on how the facility is designed and what the customer needs it to do. A fixed connection applies where the charger connects to the respective property.	

8. APPENDIX B – SCORING METHODOLOGY PER QUESTION

Category	Detailed Question	Scoring Approach		
EV and charging development considerations	What is the total fleet share for EVs and charging infrastructure in 2022?	🟢 Over 5 CP per 1,000 vehicles and more than 6% total EV share.	🟠 2-6% EV fleet share and over 2 CP per 1,000 vehicles.	🔴 Under 2% EV fleet share or less than 2 CP per 1,000 vehicles.
	What are the government goals for charging station buildout by 2030?	🟢 Goal for over 100,000 charging stations or its equivalent by 2030.	🟠 Goal of less than 100,000 charging stations by 2030 or later.	🔴 No specific goals set.
	What is the percentage of net electricity generation based on VRES and are there any mechanisms to credit EV charging from renewables?	🟢 Over 20% VRES and credit mechanism in place.	🟠 Over 15% VRES or 25% RES or credit mechanism in place.	🔴 Under 25% RES, 15% VRES and no credit mechanism in place.
Regulatory, Policy and Market Considerations	Are there specific national V2X policies in place?	🟢 Specific policies for V2X exist and are detailed in an official plan or document.	🟠 No specific policies for V2X exist, however there are pilot projects underway.	🔴 No policies and no pilot projects exist.
	Do electricity prices encourage V2G, V2H and V2B?	🟢 Consumers have access to dynamic tariffs and there is medium to high volatility in electricity prices.	🟠 Not all consumers have access to dynamic tariffs or there is low volatility in electricity prices.	🔴 Mostly static tariffs are available.
	Can V2G participate in wholesale energy and balancing markets?	🟢 Yes, V2G can participate in wholesale and balancing markets.	🟠 V2G can participate in wholesale and balancing markets, however only trials are conducted at this stage or efforts are being made to allow for V2G participation in markets.	🔴 There is no legal framework to allow V2G to participate in wholesale and balancing markets.
	What capabilities do smart meters have and are they widely adopted?	🟢 75-100% smart meter penetration with connection to home energy management system possible.	🟠 25-75% smart meter penetration with some ability to connect to home energy management system.	🔴 0-25% smart meter penetration with no ability to connect to home energy management system.

Category	Detailed Question	Scoring Approach		
		🟢	🟡	🔴
Regulatory, Policy and Market Considerations	Can wholesale settlement and customer billing be based on submetering?	Wholesale settlement and customer billing may be done through submetering for EVs.	Due to MID/MIR it is not legally feasible to implement EV settlement through submetering, however it is technically feasible in the country for other applications.	Wholesale settlement and customer billing are not used in the country at all.
	Can V2G participate in local flexibility markets?	Market-based procurement for flexibility exists and V2G can access it.	Trial projects for market-based procurement of flexibility are being carried out.	There is no market-based procurement of flexibility.
	Are network tariffs an opportunity or barrier to DER?	Network tariffs are capacity based and include TOU components.	Network tariffs have a combination of volume-based and capacity-based components or are not fully dynamic.	Network tariffs are almost completely volume-based and static.
	Are there double taxes or levies charged for V2G?	No double taxes are charged.	N/A	Double taxes are charged.
	Do system operators consider V2G as a part of their resource adequacy assessment?	Yes, V2G is fully considered in resource adequacy assessments.	V2G is not totally considered, however storage or some other of its capabilities are considered or there are projects evaluating how best to integrate it.	Neither V2G nor DSR are considered within resource adequacy assessments.
Use of Standards	Are there barriers in national standards where V2X is specifically mentioned?	Country has specific national standards with no significant barriers.	There are no specific standards for V2X, however there is relevant guidance for similar technologies. Moderate barriers to implementation.	There is no mention of V2X in national standards or guidelines. Significant barriers to implementation.
	Are there standards related to off grid power storage and usage for buildings or dwellings creating barriers to V2X deployment?	Country has specific national standards for off-grid power storage with no significant barriers.	There are no specific standards for off-grid power storage, however there is relevant guidance for similar technologies. Moderate barriers to implementation.	There are no specific standards for off-grid power storage. Significant barriers to implementation.
	Are there barriers to V2X deployment in national electrical safety standard requirements for charging infrastructure?	No barriers in national electrical safety standards.	Moderate barriers in national electrical safety standards.	Significant barriers in national electrical safety standards.
	Is bidirectional charging included in regulations for charging communication protocols?	Bidirectional charging is included in regulations for charging communication protocols.	Bidirectional charging is partially included in regulations for charging communication protocols.	Bidirectional charging is not included in regulations for charging communication protocols.

Category	Detailed Question	Scoring Approach		
Requirements of System Operators	Do the DSOs have specific requirements defined in their connection agreements regarding bidirectional charging?	🟢 No barriers in specific requirements for bidirectional charging in connection agreements	🟠 Moderate barriers in specific requirements for bidirectional charging in connection agreements	🔴 Significant barriers in specific requirements for bidirectional charging in connection agreements
	Is the registration of export capability and generation linked to a specific grid connection?	🟢 Registration of export capability is not limited to a specific grid connection.	🟠 Registration of export capability is somewhat limited to a specific grid connection.	🔴 Registration of export capability is tied to a specific grid connection.

9. ABBREVIATIONS

Abreviation	Meaning
AC	Alternating Current
ACER	Agency for the Cooperation of Energy Regulators
AFID	Alternative Fuels Infrastructure Directive
AFIR	Alternative Fuels Infrastructure Regulation
AR	Automatic Regulation (or Augmented Reality)
BESS	Battery Energy Storage System
BEV	Battery Electric Vehicle
BSP	Balancing Service Provider
CCS	Carbon Capture and Storage
CEER	Council of European Energy Regulators
CHP	Combined Heat and Power
DC	Direct Current
DCC	Data Communications Company
DER	Distributed Energy Resource
DIN	Deutsche Industrienorm (German Industrial Standard)
DNO	Distribution Network Operator
DSF	Demand Side Flexibility
DSO	Distribution System Operator
DSR	Demand Side Response
EDF	French utility company (in French: Électricité de France)
EEG	Renewable Energy Act (in German: Erneuerbare-Energien-Gesetz)
EMD	Electricity Market Directive

Abreviation	Meaning
ENA	Energy Networks Association
ENTSO-E	European Network of Transmission System Operators
EnWG	Energy Industry Act (in German: Energiewirtschaftsgesetz)
EPBD	Energy Performance of Buildings Directive
EREC	European Renewable Energy Council
ESO	Electricity System Operator (GB)
EV	Electric Vehicle
FCR	Frequency Containment Reserves
FES	Future Energy Scenarios
GHG	Greenhouse Gas
GOO	Guarantee of Origin
GOPACS	Dutch Congestion Management Platform
HBE	Dutch credit mechanism for fuels (Hernieuwbare Brandstof Eenheden)
ICE	Internal Combustion Engine
IEC	International Electrotechnical Commission
IET	Institution of Engineering and Technology
ISO	International Organization for Standardization
OCPP	Open Charge Point Protocol
PAS	Publicly Available Specification (UK)
PHEV	Plug-in Hybrid Electric Vehicle
PV	Photovoltaic
RED	Renewable Energy Directive
REGO	Renewable Energy Guarantees of Origin
RES-E	Renewable Energy Source Electricity
RfG	Requirements for Generators
RTE	Réseau de transport d'électricité (French TSO)
SMHAN	Smart Meter Home Area Network

Abreviation	Meaning
TIDE	Integrated Electricity Dispatching Act
TIRUERT	French Tax incentive for Renewable Energy
TOU	Time of Use
TSO	Transmission System Operator
UNECE	United Nations Economic Commission for Europe
V1G	Smart (Unidirectional) Charging
V2B	Vehicle-to-Building
V2H	Vehicle-to-Home
V2G	Vehicle-to-Grid
V2L	Vehicle-to-Load
V2X	Vehicle-to-Everything
VDE	Association for Electrical, Electronic & Information Technologies
VLP	Virtual Lead Party
VRES	Variable Renewable Energy Source

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