V2G Integration in Europe

A comparison of the implementation of bidirectional charging in France, the UK and Germany

Summary

Electric vehicles that are capable of bidirectional charging can be used as decentralized storage, as most users only need a small proportion of the battery capacity for everyday driving. If the vehicle battery is used to feed electricity into the public grid, this is referred to as vehicle-to-grid (V2G). The potential that V2G offers for the energy system through various applications is huge. For users of bidirectionally chargeable electric vehicles, V2G also offers a potential new source of revenue.

The motivation and approach as to why and how bidirectionally chargeable electric vehicles are integrated into the energy system differ greatly from country to country. We have therefore taken a close look at **the approaches and priorities for integrating V2G into the energy systems** of the three largest economies in Europe - France, the UK and Germany. In addition to analyzing the status quo of V2G, our findings also include the motivations behind each country's V2G integration strategy and possible further developments in this area.

Our findings from research and a large number of interviews with experts from France, the UK and Germany show that commercial offers of V2G are currently available in France and the UK. In Germany, implementation is limited to pilot projects. Overall, France and the UK offer more regulatory leeway for pilot projects than Germany. **The UK in particular is focusing on the market integration** of small-scale flexibility, which also includes V2G. In France, the grid operators have many alternative controllable generators or consumers that are preferably used for grid and system stability. **France is not currently planning to incentivize V2G on the market**, the implementation here was driven by car manufacturers. In **Germany, there is currently no overarching strategy** regarding the utilization of small-scale flexibility for the energy system.

In particular, the marketing of V2G on the spot market already offers added value in all three countries, both for users and from an economic perspective, as long as it does not place an additional burden on the electricity grids. To enable an economical and scalable implementation of V2G on-the-spot markets, **the standardized technical connection should be promoted across countries**. Both the respective regulatory authorities and the providers of technical solutions for the implementation of V2G should focus on corresponding framework conditions.

1 V2G: context and potential

Bidirectionally chargeable electric vehicles are characterized by the ability to not only charge the vehicle battery but also discharge it for a purpose other than mobility. For example, electricity from the photovoltaic (PV) roof system can be temporarily stored and used later in the household (vehicle-to-home, V2H). However, the electricity from the vehicle battery can also be fed into the public power grid to generate added value. In this case, we speak of vehicle-to-grid (V2G).

Possible applications of V2G: market, system and grid perspective

V2G offers the opportunity to implement various energy-related applications, which have been developed and tested in FfE's "BDL", "unIT-e²" and "BDL-Next" projects, among others.

The more than 1.5 million electric vehicles in Germany already **theoretically offer more storage capacity than all German pumped storage power plants combined**. Simulations by FfE show in a scenario for 2040 that **more electricity from renewable energies** (RE) can be integrated into the system across Europe by marketing V2G on the spot market of the electricity exchange. At the same time, **fewer fossil-fuel power plants are required and the number of large-scale battery storage systems needed is reduced**. Overall, **economic system costs are saved** [1]. In times of low electricity prices due to high electricity generation from wind and/or PV, renewable electricity can be charged and stored in the vehicle battery. At times of high electricity prices, this can be discharged into the public grid and consumed elsewhere. In future, bidirectionally chargeable vehicles could be integrated into **ancillary services** and thus participate in the balancing power market or be used for redispatch measures.

Apart from this, bidirectionally chargeable vehicles offer decentralized flexibility. Accordingly, targeted control of the vehicles can support the integration of decentralized renewable energy systems or be used for **grid-supporting measures** to relieve the distribution grids. In order to prevent overloads in the distribution grid, there is, for example, the option in Germany of temporarily dimming the charging power of electric vehicles in accordance with Section 14a of the Energy Industry Act (EnWG) [2].

This approach is important: **To leverage the described added value for the grid and system, V2G must also be financially attractive for users.**

V2G in implementation: technical challenges and need for (further) development

V2G applications are not yet ready for mass use. Interoperability - meaning that the charger works with different electric vehicles and vice versa, including all upstream and downstream processes - is not yet a given. To use V2G instead of large generation plants for grid and ancillary services, further technical, procedural and regulatory developments are necessary. These are described in detail in [3-5] and are summarized below.

Vehicles and CI - like battery storage systems - must **fulfill technical connection rules** to be allowed to feed into the public grid. These are intended to prevent overvoltages and harmonics to protect the public grid. Every combination of vehicle and CI must be certified, especially when charging with alternating current. In the status quo, the complexity of the certification processes represents an obstacle to the scaling of V2G solutions.

Processes for marketing flexibility must be fully developed and tested. To this end, reliable forecasts, mechanisms for coordinating the needs of different players and IT communication processes must be designed to be scalable.

The **charging and consumption behavior** of the vehicle must be traceable in **high temporal resolution** for the correct processing of various applications. This requires measurement

systems and an infrastructure to control the charging behavior of the vehicles and the provision of evidence.

V2G in Europe: motivation for standardization

Despite ongoing efforts by the EU to harmonize the energy industry process of the member states as much as possible, these differ greatly in some cases, primarily for historical reasons and due to the different national energy systems and power plant portfolios. For example, markets and mechanisms that are developed to access decentralized flexibility also differ, as they are tailored to the needs of the national electricity system [6].

Since V2G providers want to develop scalable, mass-capable and cross-border solutions, national peculiarities pose a major challenge and can make it difficult or even impossible to exploit the potential.

2 A look at the three countries France, Great Britain and Germany

The role of V2G in different European countries is analyzed below and parallels and differences are identified. In this way, interfaces can be prioritized where standardization should start. To this end, the strategies of Europe's three largest economies, Germany, the UK and France, are compared. The findings described are based on extensive research and a large number of interviews with experts from the automotive and energy industries in the three countries. In the expert interviews, the focus was on the relevance, the country-specific strategy, existing challenges and the status quo of V2G implementation. **Fehler! Verweisquelle konnte nicht gefunden werden.** summarizes the most important characteristics of these three countries about V2G.

Need for demand side flexibility	Flexibility from **industry**, **hydropower** and **large-scale battery storage** is prioritized	Market design is adapted **with high priority for small flexibilities.**	**No strategy for V2G.** Planning of large-scale battery storage and H2 power plants.
Solutions for V2G integration	**Maximum connection power and time-variable grid charges** for private customers	**Maximum connection power and time-variable grid charges** common	§ Section 14a EnWG on the **dimming of charging sessions** by DSOs in the event of imminent overload
Spot market (Revenue per year and vehicle)*	**260 – 370 €**	**290 – 480 €**	**200 – 440 €**
Network and ancillary services	**No integration planned**	**Standardized flexibility products** in planning	So far, **no adjustments** for V2G integration
Acces to flexibility	Indirect control by DSO via **price signals via smart meters**. Direct control with **proprietary solutions permitted.**	No direct control by DSO possible. **Central role of the aggregator**. Control with **proprietary solutions permitted**.	**Coexistence**: Direct control by DSO strictly regulated (**SMGW**), price control & access by aggregators also **permitted with proprietary solutions**.

Figure 1: Overview of the framework conditions for the integration of V2G into the French, English and German energy system (*FfE's own calculations of realistic additional revenues from V2G today compared to uncontrolled charging without remuneration for aggregators/providers)

France: no major integration of V2G into grid and ancillary services

Power system and smart meter rollout
France differs from most member states in Europe in that around 70 % of its electricity generation is accounted for by nuclear power plants [7]. In addition, France has a comparatively large amount of water storage capacity. This combination means that the pressure on the French energy system, and on the electricity grid in particular, is still low.

Furthermore, RTE is the only company to operate the transmission grid and Enedis operates 95 % of the distribution grid. Enedis is also the metering point operator for all users of its grid. In 2007, Enedis was commissioned by the state to develop and install smart metering systems [8]. The rollout of the French *Linky* was completed in 2021.

Available electricity tariffs
Variable electricity tariffs and variable and seasonal grid charges are already common in France. In addition, private individuals in France usually have an electricity contract that defines a maximum power consumption. This is usually 6, 9 or 12 kW; for users of electric vehicles, it can be up to 36 kW. The basic price depends on the maximum power consumption, which encourages the avoidance of peak loads. Vehicle charging processes are controlled independently of the smart meter infrastructure. However, this must be used for billing-relevant data.

Status quo of V2G
In France, there have been initiatives for V2G based on the CHAdeMO charging protocol since 2020. Bilateral contracts between RTE and the provider of V2G solutions and aggregator Dreev enable bidirectionally chargeable vehicles to participate in balancing mechanisms [9].

Since 2024, V2G has also been offered with the Renault 5 based on an AC charger and the ISO 15118-20 charging protocol [10]. Nevertheless, only certain combinations of vehicles and chargers are currently permitted, meaning that large-scale implementation of V2G is not expected in the short term.

Renault's V2G implementation is subject to a temporary exemption approved by the regulatory authority CRE concerning the grid charges, which means that feeding into the grid at peak load times results in a reduction of the grid charges [11].

Drivers, hurdles and future developments
In principle, it is the task of the grid operators to enable the integration of V2G into the energy system. However, both Enedis [12] and RTE [13] currently see no need to develop processes for the mass integration of bidirectionally chargeable electric vehicles into grid and ancillary services and prefer investments in grid expansion or alternative flexibility, such as from electrolysers, large-scale batteries or industrial applications. Enedis estimates that time-variable grid charges provide a sufficient incentive for electric vehicle owners to adopt grid-friendly charging behavior [12].

The motivation for the development of V2G in France therefore lies primarily with the automotive industry and energy suppliers, who see an interesting business model in the marketing of flexibility on the spot market in particular. Simulations by FfE indicate a revenue potential for users in France of around 260 - 370 € per vehicle and year through marketing on the spot market with current regulations and current market prices. This does not take into account the aggregator's margin.

Despite the wishes of V2G providers for adjustments at the regulatory level - such as clear grid connection conditions, regulatory exemptions from taxes, levies, surcharges or grid charges on temporarily stored, fed-back electricity - V2G tends to be economical in France with the

current exemptions from grid charges. Future developments can also benefit from the small number of players with large national market shares and the central organizational structure.

The United Kingdom: central role of flexibility, procurement exclusively via the market

Power system and smart meter rollout

Around one third of electricity generation in the UK is accounted for by gas-fired power plants, around one third by wind, PV and hydropower and around 14 % by nuclear power plants. Around 10 % of electricity demand is covered by imports. Due to the decommissioning of a large number of nuclear power plants by 2028, the decreasing number of gas-fired power plants and the reduced integration into the European interconnected grid due to the island's location, the use of flexibility from other sources will play a strategic central role in the future. As a result of the aforementioned developments, grid operators and the system operator NESO in particular are seen as consumers of flexibility for grid and system-supporting applications. The system operator NESO, which is responsible for system security, is planning to adapt the existing markets for grid and ancillary services to the marketing of flexibility [14].

Unlike in Germany and France, the energy suppliers in the UK are responsible for the rollout of smart meters [15], which currently stands at 65 % [16]. The installation of a smart meter is not mandatory by law but is a prerequisite if customers want to use non-static electricity tariffs or have their flexibility marketed by a third party [17, 18].

Available electricity tariffs

Both variable and dynamic tariffs are already in practice in the UK, although they are not yet widespread. Just under 15% of users state that they use a non-static tariff [19]. There are also variable grid charges that are geared towards the import and export of electricity, which means that they are not only assigned a grid-serving role. As in France, a maximum power consumption is also part of the electricity contract in the UK.

Status quo of V2G

V2G has been tested in several (pilot) projects [20-25]. A few commercial offers already exist, such as in France, in connection with the Renault 5. Due to the low supply, no large-scale implementation of V2G is expected in the UK in the short term. One of the reasons for this is the high cost of certifying the charger with a connection power of over 3.5 kW and the need to prove compliance with the technical connection regulations, which does not promote the widest possible range of products.

However, further development can benefit from an already established, nationwide standardized process for the grid connection of certified chargers as well as from the growing experience of users with variable and dynamic tariffs. As in France, the marketing of flexibility on the spot market is not handled via the smart meter infrastructure, but via proprietary solutions. The smart meter is still required for billing.

Drivers, hurdles and future developments

The utilization of further flexibility potential is key in the UK to compensate for the decreasing flexibility available from gas-fired power plants and to enable the further integration of renewable generation. Added to this is the current dependence on electricity imports, the costs of which can be reduced through flexibility. As a result, both grid and ancillary services as well as marketing on the spot market represent sales markets for V2G as aggregated flexibility.

In general, flexibility is incentivized and handled with purely market-based solutions. Distribution system operators are already procuring various flexibility products via jointly operated platforms. In future, aggregators are to submit offers for grid-supporting flexibility provision at 300 defined grid points. The system operator NESO plans to leverage small-scale flexibility

with standardized products for ancillary services. However, high demands on the metering concept still represent a hurdle.

The flexibility potential of V2G offers advantages for grid operators and marketers and supports the political vision of the future energy system. The target vision of the system operator NESO that flexibility can be used across markets supports the developments [14]. Simulations by FfE show that flexibility marketing on the spot market in the UK can already be economically viable for customers with suitable use patterns. The calculated revenues amount to approx. 290 – 480 € per vehicle and year with current regulations and current market prices. A margin for the aggregator is not taken into account here. The order of magnitude is also confirmed by the "Sciurus" project, which shows revenue potentials of various marketing combinations of £340/a to £725/a [25].

Although there is still potential for improvement in the area of regulation, especially in the certification of chargers for grid connection and the high requirements regarding measurements for ancillary services, V2G can already be potentially economical for suitable customers with appropriate usage patterns. The much-discussed issue in Germany of the lack of an exemption of taxes, levies, surcharges and grid charges on electricity fed in and fed back to the grid is also being discussed in the UK but is not seen as a hurdle to the economic viability of V2G.

Germany: great potential for V2G, but no standardized access to flexibility

Power system and smart meter rollout
Around 63 % of electricity in Germany is currently (as of 2024) generated from renewable energy sources. The share of lignite and hard coal in electricity generation is around 23 % and around 12 % is generated from gas [26]. As part of the German coal phase-out [27], around 15 GW of lignite-fired power plants and 16 GW of hard coal-fired power plants will be taken off the grid by 2038 at the latest. As the majority of future generation is to be provided by wind energy and PV systems and the potential of hydropower storage has already been exhausted, flexibility in the form of flexible consumers, producers and storage systems will be required in the German electricity system. This includes hydrogen-capable - so-called "H2-ready" - gas-fired power plants, 10 GW of which will be put out to tender as part of the power plant strategy. It can be assumed that grid storage and small-scale flexibilities, such as electric vehicles, will also contribute to flexibilization, even if there is no fixed strategy or target for this at the federal level.

With less than 10 % of devices installed to date [28], the smart meter rollout does not yet enable the large-scale use of small-scale flexibility. Germany also differs from France and the UK in that it has a large number of distribution system operators (DSOs), some of which are small. Decisions must be made in consultation with the 888 DSOs [29].

Available electricity tariffs
Although dynamic and variable tariffs are available in Germany, they are not yet widespread. Fixed-price tariffs are currently still the standard. Section 14a of the Energy Industry Act allows a flat-rate grid fee reduction, a percentage reduction in the energy price or a time-variable grid fee for controllable consumption facilities [2].

Status quo of V2G
The use of V2G is limited to projects and pilots. Commercial offers do not yet exist and the delayed smart meter rollout is also an obstacle to large-scale implementation. As a result, large-scale implementation is unlikely in the short to medium term. To make matters worse, V2G applications are often not economically viable with the current electricity price regime. Efforts are currently being made at a political level to enable bidirectional charging and to incentivize it on the condition that it serves the grid.

So far, Section 14a of the Energy Industry Act has only created an emergency instrument to prevent grid overloads. An increase in flexibility potential via market mechanisms has not yet been implemented.

Drivers, hurdles and future developments

Due to the growing demand for storage, both marketing on the spot market and participation in grid and ancillary services, such as redispatch, represent relevant sales markets. The flexibility potential of V2G in Germany offers the opportunity to integrate more electricity from RE into the system more quickly.

Many of the technical hurdles of V2G have already been overcome, particularly with regard to communication in the property (behind the meter). However, the implementation of V2G is currently still being held back by insufficiently implemented standards. The number of market players, especially DSOs in Germany, underlines the central importance of standards and at the same time makes the national implementation of these standards more difficult than in other countries. The unrealized smart meter rollout represents a further hurdle to the large-scale implementation of V2G for the foreseeable future.

In addition, several options for accessing the flexibility of the vehicles are currently being developed in parallel. One option is to implement communication for controlling charging sessions via the smart meter infrastructure. This is mandatory in Germany for grid or ancillary services but is not common practice in any other country. Alternatively, access can also be provided via proprietary solutions, for example for marketing on the spot market. It is therefore currently not foreseeable whether a standardized control channel for flexibility marketing will become established in Germany and whether this can be used outside of Germany.

Furthermore, the issue of a regulatory-defined exemption from parts of taxes, levies, surcharges or grid charges on temporarily stored and fed-back electricity is being discussed. The current regulatory framework does not allow for secure economic integration into grid or ancillary services, nor does it always allow for economic marketing on the spot market. Simulations by FfE show that under optimal conditions, i.e. for very suitable customers with appropriate usage patterns, V2G today offers revenue potential of between 200 € and 440 € per vehicle per year, from which all actors involved must benefit.

The combination of complex regulatory requirements and the uncertain economic viability inhibits the spread of V2G, which means that there is no incentive for the few existing manufacturers to invest in the further development of technical solutions.

It can be assumed that the system of grid charges will be revised in the medium term for the coming regulatory period, thus encouraging grid-friendly behavior. In addition, it is likely that aggregated flexibility will be marketed on the electricity market or to transmission system operators (TSOs).

3 Conclusion

Three perspectives on V2G: spot market marketing as a common overlap

V2G offers the potential to make a positive contribution to the stability of the energy system in all the countries considered. However, the procedure for integrating V2G into grid and ancillary services differs greatly in the countries considered.

In France, framework conditions are to be created for a **grid-neutral integration of V2G**, i.e. that the grid is neither positively nor negatively influenced. This is made possible by the grid operators, but V2G is not seen as added value given alternative, less complex flexibility options. Accordingly, grid operators are not yet interested in actively controlling the charging sessions of electric vehicles or buying flexibility in any other way. As a result, **broad implementations of pragmatic solutions** that enable bidirectional charging with little technical effort are preferred. If required, more complex V2G solutions could also be developed in the future.
Legislation makes it relatively easy to pilot innovative solutions. The small number of players, who usually cover almost the entire national market (especially grid operators), simplifies standardized implementations.

In the UK, the **flexibilization of consumption is a central component of the strategy** for the future energy system. To replace flexibility from conventional gas-fired power plants, small-scale flexibility, such as V2G, is to be encouraged and integrated into grid or ancillary services. The focus here is on **purely market-based procurement of flexibility**. In the target scenario, grid operators and aggregators should be able to trade **standardized flexibility products across markets.**
Regulation offers new technologies a high degree of freedom. In general, the regulator tends to take corrective action if developments are not compatible with the system or do not correspond to the strategy.

In Germany, there is currently **no overarching strategy for developing flexibility**. In the future, V2G can provide the necessary flexibility for the energy system. Germany has invested heavily in the **standardization of communication protocols for V2G**. This has encouraged close cooperation between numerous players in the automotive and energy sectors. These initiatives have the potential to become the industry standard across Europe if required. So far, however, control via the smart meter infrastructure has not been planned or implemented in either France or the UK.
The high level of complexity, the slow smart meter rollout and the fact that a defined regulatory framework precedes implementation have so far hindered or **prevented implementation** in Germany.

The different approaches to V2G mean that it is **currently not possible to offer standardized products for grid and system-supporting applications for V2G across all countries.**

However, **marketing on the spot market with bidirectionally chargeable electric vehicles offers attractive revenues in all countries and is comparatively easy to standardize**. At least the following players are dependent on each other for implementation: Car manufacturers, manufacturers of chargers, V2G service providers (e.g. aggregators or energy managers) and energy suppliers. These players should advocate standardized framework conditions for this application in Europe.

Prospects and further need for action

The standardization of communication in the property and the harmonization of grid connection conditions, which form the basis for the implementation of marketing on the

spot market, should be prioritized by the EU, the member states and providers of V2G solutions.

Numerous working groups at the EU level are already working on these issues and should be supported. The DSO entity is developing proposals for minimum requirements for the grid connection of chargers and the Smart Energy Expert Group is consolidating improvements in standards and laws. The results should ultimately be brought together.

Despite national differences in grid or system-serving applications of V2G, in a second step, interfaces that enable these applications should also be standardized as far as possible across Europe to reduce the effort on the manufacturer side and facilitate implementation in different countries.

A systematic description of the strategies and organization of access to flexibility would be helpful, as national markets, products and mechanisms for flexibility marketing can only be understood and compared if the energy industry context is taken into account. A comprehensive comparison of the energy systems of the largest European countries, based on which further options for action to harmonize the integration of V2G are to be derived, will be developed by FfE and published in mid-2025.

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