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A Review of Tariffs and Services for Smart Charging of Electric Vehicles in Europe

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Abstract: Smart charging of electric vehicles (EVs) is an essential approach to reduce the costs and maximise the benefits of increasing numbers of EVs being connected to the power grid. This article analyses 139 tariffs and services for smart EV charging available in Europe. It finds that while the market for smart EV charging services is growing, there is a lack of consumer information on the savings and broader environmental benefits it offers, such as integration of renewables. Offers are also unevenly distributed across the continent, resulting in unequal access to smart EV charging. The article outlines six strategies to establish framework conditions in energy markets that would address these gaps and establish smart charging as a standard means of charging, to ensure the beneficial integration of EVs into power grids.

Keywords: electric vehicle; BEV; EV; utility; electricity; grid; smart charging; smart meter; tariff design; beneficial electrification

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1. Introduction

The electric vehicle [EV] market is growing fast: In 2021, almost 10% of global car sales were electric, four times as many as in 2019 [1]. Direct electrification of passenger vehicles has been confirmed to deliver the highest reduction in greenhouse gas (GHG) emissions to help cut transport emissions [2] to meet overall climate targets [3]. In order to maximise the contribution EVs can make to the energy transition, it is crucial to understand how they can best be integrated into the power grid at least cost, and with most societal benefits [4]. EVs charging at home also represent an underexplored resource of demand-side flexibility services to balance the power grid [5]. There is a growing body of research showing that across global EV markets, the costs of EV grid integration—and in consequence societal costs overall—will be higher if EVs are charged in an unmanaged way [6,7]. 'Unmanaged' charging tends to happen at hours of high overall electricity consumption; for example, in mornings or evenings, and to exacerbate existing peaks. Inversely, managed or 'smart' charging can significantly reduce investment costs in networks. By moving charging to hours when renewable energy is available, e.g., when excess wind energy is available during the night or solar energy during the day, EV charging helps to integrate more renewable energy in the grid and to reduce the need for curtailment [8]. As a result of more efficient management and utilisation, this frees up EV hosting capacity of distribution grids [9]. Smart EV charging can be defined as charging at times when costs for the user, the power grid and climate change mitigation are lowest, without compromising the user's needs, and is helped by automation [10]. The automated actions included in smart EV charging make it particularly efficient in responding to price signals: EV drivers sign up to a service for charging their EV that automatically adjusts (within the user's preferences) the timing and speed of the charging process following signals from the power system, as illustrated in Figure 1.

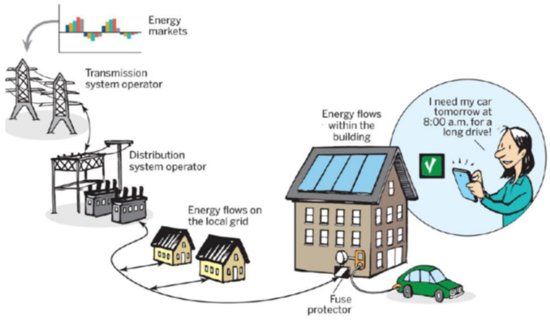

Figure 1. The elements of smart charging.

An essential ingredient of smart charging services is electricity tariffs, i.e., pricing for purchasing energy and using power networks. If tariff prices vary based on different times of use, they send signals to customers which show when it is most cost- and system-efficient to charge. The more precise the information transferred via these input signals, the more closely smart charging can be matched with user preferences. This article provides new analysis on how smart charging services and tariffs are designed, and how optimisation of charging is achieved, from a large sample of available services in Europe.

2. Materials and Methods

Research for this study focused on a qualitative method of data collection with the objective of providing an updated overview and analysis of smart charging tariffs and services available for consumers, as no systematic monitoring is currently available. Research was therefore based on a comprehensive primary data collection on available smart charging services, including commercial offers as well as projects at pilot stage across European markets. For a full list of services researched, see Appendix A. Evidence was collected between April and February 2022, and included review and documentation of available material as well as in-depth interviews with field experts and stakeholders to gather supportive evidence. Where enough information was available, case studies were conducted to enable a more detailed understanding of the services on offer. Consistent with case study-based methodology [11], categories of analysis were created and refined throughout, e.g., allowing a categorisation based on signals against which a smart charging service optimises.

3. Results

This section analyses 139 smart charging tariffs and services on offer in Europe, and considers their implications for availability and optimisation of EV grid integration. Note that EVs are only one type of distributed resource that can provide demand-side flexibility to the grid alongside, e.g., heat pumps and other flexible household appliances, which also benefit from the availability of time-of-use pricing [12]. For analytical purposes, it is useful to distinguish between two types of tariffs, both of which are further explained in the following section:

- Tariffs and services targeting EV charging specifically, e.g., through device integration;
- Generic time-of-use tariffs that encourage consumers who own flexible devices such as EVs, heat pumps, etc., to optimise their electricity consumption, but are not specifically marketed as EV charging tariffs/services.

This analysis is focused on the first-mentioned type, i.e., those specifically marketed as ‘EV tariffs’, meaning those labelled as such and/or which require (proof of) the use of specific vehicle or charging equipment. It does not include generic time-of-use tariffs, which are, if available to all consumers, an important context feature for the development of smart EV charging (see Section 4 Discussion). Dynamic time-of-use tariffs follow the day-ahead wholesale prices and therefore have hourly changing prices that are known a day in advance. Dynamic time-of-use tariffs are widely available in some European regions, for example, in Scandinavian and Baltic countries.

3.1. Distribution of Smart EV Charging Tariffs and Services across Europe

Figure 2 maps the availability of these two tariff types across Europe. The digits indicate how many EV-specific tariffs and services are on offer in a country, and the colours indicate the state of advancement of dynamic time-of-use tariffs for all types of (flexible) consumption.

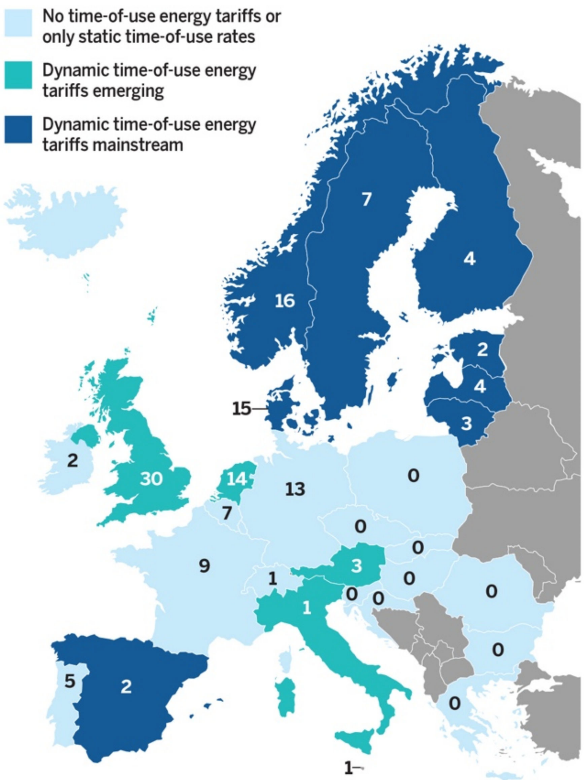

Figure 2. Number and distribution of smart charging tariffs and services across Europe. Source: own research, see Appendix A for details.

One main finding is that EV tariffs and services are unevenly distributed across Europe, with a large variation that ranges between 0, mostly in Central and Eastern European countries and Greece, 16 in EV market leader Norway, and up to 30 in the UK, where consumers even have access to a tool to compare prices. Some countries offer important favourable framework conditions that support the development of a market for EV smart charging tariffs and services. Where generic dynamic pricing is more common, often paired with advanced rollout of smart meters (for example in the Scandinavian and Baltic countries), consumers can choose between various smart tariffs and services that are dynamic, i.e., that are connected to the Nord Pool day-ahead energy spot market and thus reflect real-time energy prices. The following chapter discusses how the specific EV tariffs and services work, based on the different input signals through which they help to optimise consumption.

3.2. Different Types of Smart Tariffs and Services

For the analysis, tariffs and services are classified into five categories, according to the input signals on which they are based. They are listed below, and range from simple to more complex designs:

- Dynamic time-of-use pricing is at the basis of smart charging services, which follow day-ahead wholesale energy market prices. Most of the offers identified in this category are from the Nordic region, which has high availability of generic dynamic pricing and smart meter availability, both of which are ideal framework conditions for smart charging offers to develop;

- Dynamic charging based on other (near) real-time inputs: dynamic charging adjustments also allows consumers to optimise EV charging to different dynamic inputs, such as the carbon intensity of the electricity grid or the amount of renewable energy available;
- Static time-of-use pricing: in these tariffs, prices are lower for charging outside of peak hours of power demand or network load. These are defined in advance, e.g., annually;
- Balancing mechanism-based tariffs are based on the need to balance energy and supply within a market zone (often a country), with either direct signals in real time and/or procurement of flexibility from a transmission system operator (TSO) or through a market participant. As a result, EV charging is optimised to support the grid's balance;
- The local network or distribution system operator (DSO) can send price signals or other inputs to reflect conditions on a distribution system level. These can be static, dynamic or a combination.

Findings on tariffs and services are summarised in Figure 3 below, which shows the highest to the lowest number of service offers on the market.

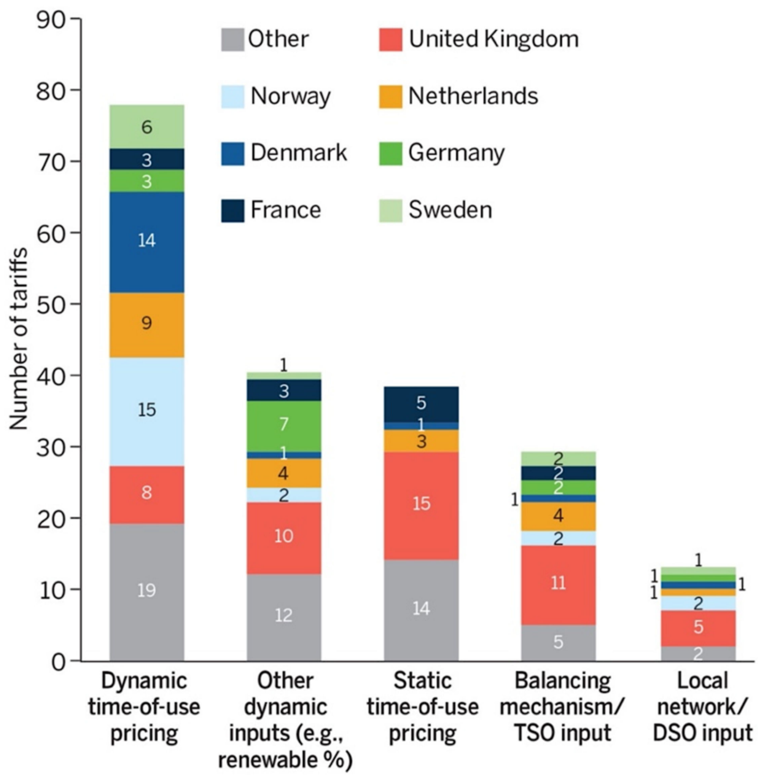

Figure 3. Input signals for smart tariffs and services for EV charging in Europe.

Most (77) smart charging services are based on dynamic prices. Most of these services offer automation for adjusting EV charging to the hours with the cheapest energy prices within the user's preferences.

Forty-four of the services analysed are based on other dynamic inputs, such as the share of renewables in the grid. This means they make it easier to charge EVs at times when energy has the lowest carbon intensity. Services are based on different forecast mechanisms or time horizons to manage the charging, either adapted to national forecasts or to local production—for example, the actual solar output.

The third-largest category of services (38) are based on static time-of-use signals. This means predefined times, typically set on an annual basis, in which a certain price is valid.

The fourth-largest category of services (29) are based on signals from the national grid operators (TSO) and other energy system actors, based on the balance of supply and demand. These inputs are processed by services that adjust EV charging. The degree to which real-time-based input signals are available (and services can emerge) depends on whether favourable energy market conditions for so-called demand-response services are in place. These conditions include EVs being available, and consumers having the right to join flexibility and efficiency schemes, as well as there being a mechanism through which they can participate in energy markets.

Only 13 services in our sample use signals from local distribution grids to adjust their use in order to reduce stress on those grids, by avoiding adding to peak demand and/or by consuming at times of higher renewables feed-in. This finding suggests there is room for development, as local grids are where EVs have most potential impact (see Section 4 Discussion).

It is important to note that 38 services are based on input signals from more than one input category. For example, tariffs can combine a demand-response programme for efficient network operations with dynamic (wholesale) energy prices. This reinforces the signal to consumers to steer their EV charging into the times most beneficial for the system. Depending on consumers' flexibility, this can enable stacked benefits such as higher savings. Services can also add value by offering flexibility from EVs on a near-real-time basis to system operators through demand-response schemes, both on a national and local level: 10 of the offerings researched operate on both levels.

3.3. Country Examples

Selected examples illustrating the different types of tariffs and services are summarised in Table 1 and detailed below.

Table 1. Examples of smart EV charging tariffs and services.

Location	Tariff (Input Signal)	Main Features
Nordic region	Dynamic time-of-use	Compatible with various smart charging services
UK/Netherlands	Other dynamic input	Optimised for renewable energy use [1]
Ireland	Static time-of-use	80% reduction for off-peak charging
UK	Balancing mechanism	Aggregates EVs to stabilise power grid
UK/Denmark	Local network input	Aggregates EVs to reduce local network congestion

[1] Services use different data sources for optimisation.

3.3.1. Nordic Region—Smart Charging Based on Generic Dynamic Tariffs

In the Nordic region, comprising Scandinavian and Baltic countries, generic dynamic price energy contracts are available to a large consumer base. Most of them are built on hourly changing prices following the Nord Pool day-ahead energy spot market. The Nord Pool market provides a platform for price-setting that smart charging service providers can easily connect to. This works across different energy suppliers, as most generic dynamic tariffs are similarly designed. For example, smart charging service providers Gridio [13], True Charge [14] and Monta [15] can work with any generic dynamic price contract a consumer may already have in place for their general electricity consumption. True Charge and Jedlix [16] follow the spot market price as the basis for their smart charging services, bundled with services to balance the grid at the national level and (in pilots only) local level. Monta also accounts for the critical peak network tariff in some regions in Denmark, which includes a surcharge for high congestion hours on the grid during winter.

Our analysis also highlights that all smart charging offers in this category are based on energy prices only. None of the services in the sample include dynamic pricing of the network component, i.e., the part of the electricity bill that covers network cost. One exception is a pilot in Germany with grid operator Mitnetz [17]. This trial offers dynamic time-of-use network prices designed to reduce the local grid's peak load from EV charging, but also with a view to better integrate locally produced renewable energy. There is an additional benefit: to the latter approach: while EV users gain extra savings on the network part of their electricity bill, all electricity consumers, including non-EV owners, pay lower network costs as a result of more efficient grid management. The implications of this finding are discussed further below.

3.3.2. UK and Netherlands—Dynamic Charging Tariffs Optimising Renewable Energy Consumption

Examples of charging services that optimise the use of renewable energy and/or low-carbon electricity can be found in the UK or the Netherlands. These smart charging services optimise EV charging according to inputs such as the carbon intensity of the electricity grid or the amount of renewable energy available at a certain time. These inputs can be based on forecasts and are provided typically a day in advance, near-real-time or as a combination. In the UK, the WhentoPlugIn [18] service uses daily alerts to inform EV users when they can charge most beneficially in terms of cost and carbon savings; so does GreenCaravan [19] in some European markets. While these examples require consumers to adjust charging manually, other services use automation to adjust charging to optimal times. Some apps are based on forecasts or measurements for wind or solar energy, including locally produced solar.

3.3.3. Ireland—Static Time-of-Use Rates Offer 80% Savings for Overnight Charging

While static time-of-use EV tariffs do not follow real-time energy prices or other real-time conditions, instead relying on prices for a predefined time of day, they offer predictable savings to EV consumers and are less subject to power price fluctuations. Examples of static time-of-use rates for EV charging can be found in several countries, including France and Spain. In Ireland, Pinergy's EV Drive Time Tariff [20] offers drivers savings of up to 80% if they have access to off-street parking and charge their EVs between 2:00 a.m. and 5:00 a.m.: this allows them to benefit from a preferential rate of EUR 0.0568/kWh. During the rest of the day, the price for charging is EUR 0.3214/kWh. A typical EV driver, assuming 2500 kWh of home charging, will save EUR 661 annually if using the cheaper off-peak rate only.

3.3.4. UK—Smart Charging Services to Balance the National Grid

In the UK, OVO energy [21] offers a service that optimises EV charging for wholesale day-ahead markets, intraday markets and the balancing mechanism. The service can also learn from the user's preferences, for instance, charging times and energy needs, to optimise further. Participating consumers pay a low preferential rate of GBP 0.05/kWh. If users decide to opt out of participating in these services (they can do so at any time), the standard tariffs then apply. With 2500 kWh of home charging, a typical EV driver can save around GBP 225 per year compared to a standard tariff.

3.3.5. UK/Denmark—Smart Charging Services to Balance the Local Grid

Smart charging services can use flexibility from EVs, either directly or by collaborating with suppliers and independent aggregators, to help grid operators avoid grid congestion and manage local grids more effectively. This reduces costs for the entire system. However, electricity market reforms across Europe are progressing at different rates (see Discussion in Section 4), and the UK is so far the only European country where all DSOs regularly use flexibility procurement. Here, ev.energy, for example, offers a smart charging service by acting as an aggregator, matching aggregated EVs' flexibility with DSOs' information on the state of the grid [22]. When signing up to this service, consumers are rewarded for participating in a demand-response scheme. The smart charging service can provide flexibility from households (where EV charging is typically a large and often the most flexible end use) in response to flexibility requests from the DSO for specific areas. This is an innovative approach: households are still underused as a resource for flexibility, which tends to be procured from larger industrial consumers. In Denmark, in a pilot in the Copenhagen area, EVs using True Energy's smart charging service are reducing congestion for grid operator Radius.

Outside of the above analytical categories, some countries feature other types of smart charging services due to the specific regulatory framework in which they operate. In Germany, for instance, time-of-use-based rates are very rare; instead, a specific 'controllable loads' network tariff is in place, which in essence allows the grid operator to control consumption at certain times of the day in exchange for a reduced network fee. In practice, however, this approach limits benefits from charging for users, creating a system that effectively discourages transparency and further innovation. [23].

3.4. Smart Charging Services at Public Stations

A large share of European citizens, especially inhabitants of urban areas, rely on public infrastructure to park their vehicles. Yet drivers who rely on public charging can rarely access the benefits of cheaper off-peak or dynamic electricity rates, as these rates are often not available to them [24]. For example, in Ireland, off-peak charging rates are as low as EUR 0.06/kWh, while public charging rates are almost four times as high at EUR 0.23/kWh. This can negatively affect EV affordability for users who rely on on-street charging. It also creates a disadvantage for consumers who drive second- or third-hand EVs where the operational costs are a larger share of the car cost [25].

An example of a country where public smart charging is developed at scale is Portugal. In Portugal, all public charging stations are connected to a central operating platform known as EGME (Entidade Gestora da Rede de Mobilidade Elétrica, Electric Mobility Network Managing Entity) [26]. The provider of the e-mobility service pays fees for using the grid, the operator running the charge point also procures the energy, and EGME manages these transactions. The network costs are volumetric only, and are divided into time blocks depending on the grid area. This market design allows smart charging service providers to combine these costs into a price offer for public charging customers that includes time-varying elements and encourages off-peak charging. Portuguese EV drivers can save around EUR 0.06/kWh by charging during cheaper hours.

European energy market reforms, adopted in 2019 but not yet fully implemented, aim to make customers aware sooner of power market price volatility and network use costs to enable them to make better-informed decisions and react more swiftly to market signals. Advancing these reforms remains a key condition for dynamic pricing to become broadly available, which will in consequence encourage a market for smart EV charging tariffs and services and more choice for consumers. However, at the time of writing, many European countries have not yet advanced energy market reforms to the level at which flexible consumption can be sufficiently rewarded. By implementing such reforms, more countries will be able to create the market conditions for a broader—and more evenly distributed—offer of smart charging services. The following section discusses what the analysis suggests about building a suitable framework for smart charging services to allow low-cost integration of EVs into electricity grids.

4. Discussion

We have analysed six potential strategies for increasing the availability and use of smart EV charging in Europe. Below, we provide brief summaries of what the evidence suggests regarding each of them. These intend to inform the debate around smart EV charging, and point out further research needs regarding EV grid integration.

4.1. Smart EV Charging as Default

As the analysis shows, regulatory frameworks underlying the market for smart charging services in Europe do not provide the same access conditions for market actors to develop services in the same way across different markets. Similarly, levels of consumer choice and access to smart EV charging vary across Europe. The best regulatory practices for developing smart charging as a default setting for consumption are those in the UK, where the Smart Charge Points Regulations (2021) requires installers of smart charging equipment to set the home charger to off-peak charging as its default mode (and to connect it to a smart service), and therefore encourages users to optimise charging from the start. However, in order not to restrict users' needs, it allows users to overrule the optimisation settings for charging at all times. It also requires that consumers be informed about the advantages of smart charging. As a consequence, the law helps to lower the threshold for EV adoption as new EV drivers have guaranteed access to information on how to charge optimally.

4.2. Public Smart Charging as Default

Our analysis suggests that the market for public smart charging services needs development, to avoid disadvantaging EV users who rely on on-street charging. Creating easy access for a broader range of consumers—including those relying on on-street charging, public fleet users, and lower-income groups who often rely on second or third-hand vehicles—will be a critical element in driving the electrification of road transport.

4.3. Improved Consumer Information

Many EV drivers are not aware of the economic advantages of smart charging tariffs and services: if they were, it would be likely to increase the beneficial integration of EVs into power grids, along with benefits to the system more broadly (see Introduction). To address this gap, service providers can increase their efforts to raise awareness of the benefits of smart charging, and make them clearer to users by improving the design of customer interfaces such as smart charging apps. Policymakers and planners can support better consumer information by running education campaigns and providing backing for innovative pilots; for instance, trials in which service providers test new smart charging tariffs or services, involving local grid operators in selected areas or with smaller customer groups, and thus create learning opportunities and encourage quicker adoption of smart charging services.

4.4. Rewards for Consumer Flexibility

Analysis has shown that smart charging services can either be enhanced through specifically designed tariffs, or by increasing the general availability of generic tariffs. Both require energy markets that reward consumer flexibility according to its real value to the system. Current electricity market designs across many European countries do not enable these reward systems (in particular for flexible residential resources) to realise their full potential on energy markets, nor do they support network optimisation. Thresholds for size of bids for participating in flexibility markets, metering and interoperability should also be addressed.

4.5. Multiple System Benefits

A key advantage of smart charging services is that they deliver multiple benefits to the consumer and to the system at the same time. This is confirmed by our analysis, which showed 38 services that optimise for more than one input. For example, we found services that adjust charging according to the carbon intensity of the electricity used, and at the same time allow connected EVs to participate in balancing markets. In a growing market for such services, it will be important for providers to stack the benefits they can offer—for instance, enabling better use of local solar production or improved load management in multi-dwelling buildings can be the basis for other energy services that aggregators can offer, helped by dynamic pricing. Such services can also help develop energy communities and models of local production and consumption which support the broader transition to more sustainable energy production and consumption patterns [27,28].

4.6. Improved Local Grid Utilisation

Our analysis found that few smart charging offers—only 13 out of 139—are based on information from local grid operators about the inherent fluctuations in their distribution grids. Yet local grids are where EVs have the most potential impact as a grid resource. This finding suggests that grid operators can make better use of market-based smart charging services to optimise grid use. This, in turn, is likely to help reduce the need for investments to increase grid capacity. Specifically, regulators can support DSOs in digitalising grids and grid management, and thereby increase the use of grid data. Such a regulatory framework would require system operators to share data on local grid utilisation so aggregators can create smart charging services that reduce congestion (e.g., that optimise against grid usage data). Regulators can develop flexibility markets at a local level in which EVs can participate. Both strategies need to be supported by designing network tariffs in a dynamic way that reflects conditions on the network as a whole as well as locally.

5. Conclusions

This article presents and discusses a Europe-wide in-depth analysis of tariffs and services targeted at EV smart charging. Key findings of the analysis are:

- EV smart charging tariffs and services are unevenly distributed, resulting in unequal access for EV users across Europe;
- Smart EV charging is most accessible where generic time-of-use pricing for other types of flexible consumption, such as electric heating, is already available;
- Therefore, smart EV charging does not necessarily require specific tariffs; it can also be encouraged by generic time-of-use tariffs. However, this is only the case in a few countries;
- Generally speaking, encouraging the market for specific smart EV charging tariffs and services will help governments to encourage the integration of EVs into the power grid and power system, minimising costs and maximising societal benefits as EV sales grow;
- Transparent information and more data on the state and use of local grids is needed, and needs to be shared by grid operators, to enable more EV charging services to develop services which optimise local grid integration.

This research has provided comparative analysis on the emerging European market for smart charging tariffs and services. More research is needed to quantify the economic value of smart EV charging with these services broadly deployed, in terms of avoided investments in power grids resulting from lower peak demand, saved grid operation cost, or avoided renewables curtailment. Note also that analysed services are designed to support residential charging or public charging at parking areas equipped with charging stations. It does not include mobile on-road charging/electric road systems, tested in some parts of Europe [29], for which other contractual models may be necessary [30]. Additionally, the services analysed in this paper can be combined, if available, with discharging energy from vehicle batteries (V2G) or with additional storage options such as storage units (in case of residential charging), allowing users to benefit from savings through additional flexibility that can be offered to the grid.

Author Contributions: Conceptualisation, J.B. and J.H.; project administration, J.H. and J.R.; supervision, J.R.; data collection and analysis, J.B.; validation, J.R. and A.J.; writing—original draft, J.B. and J.H.; writing—review and editing, J.R. and A.J. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

The following tariffs and services were considered for the analysis:

Provider	Product Name
adapt	adapt
Agva	Agva Spotpris
Andrae	LadeChecker
aWATTar	Hourly
Barry Energy	Barry
Bluecharge	Bluecharge
Bornholms Energi & Forsyning	TIME-FLEX
British Gas	Electric Drivers
Bulb	E V tariff
cDiscount Énergie	cDiscount Énergie
Corrently	Autostrom + GrünstromBonus
E.On	Drive
E.On	E.ON Next Drive
Ecotricity	Fully Charged
EDF	Vert Électrique Auto
EDFenergy	GoElectric 35
EDFenergy	GoElectric 98
ekWateur	ekWateur
Electric Miles	Electric Miles
Ellevio	Smart Laddabonnemang
Enemalta	EV Charging
Energeia	EV
EnergyZero	ANWB Energie
EnergyZero	EnergyZero
EnergyZero	Laadje
Engie Electrabel	other tariffs
Engie Electrabel	Dynamic
eprimo	Öko Zuhause & eMobil
Equiwatt	Equiwatt
Essent	LaadVoordeel
ev.energy	ev.energy
Factorenergia	Factorenergia Card
Fjordkraft	Fjordkraft
FlexifAI	Youree
Fortum	Fortum 360
Frank Energie	Frank Energie
Freeloadr.io	Freeloadr.io
GenGame	EV app
GenGame	Home & Roam
GNP Energy	Fordel plus el
GNP Energy	Marked Web
go-energi	GO SPOT ENERGI
Good Energy	EV Driver 4
Good Energy	Zap Flash
Green Caravan	CO2smartcharging
Green Energy UK	TIDE
Greenpeace Energy	Mobilstrom Plus

Provider	Product Name
Gridio	Gridio
Gudbrandsdal Energi	Gundbrandsdal Energi
Hiven	smart charging
Iberdrola	Plan Vehículo Eléctrico
Igloo Energy	Pioneer
Jedlix	BW
Jedlix	Jedlix
Krafthem (now: Flower)	Virtual Power Plant
Krafthem (now: Flower)	Krafthem
Kraftriket	Kraftriket
Lampiris	eMobility
LeasePlan Energy	LeasePlan Energy
LOS	spotpris
MijnDomeinEnergie (EnergyZero)	Flex
Mobilitectric	Kilo
Mobismart	Plano Power
Modstrøm	Klimapakke
Moixa	e:PROGRESS
Monta	Monta
nationalgrid	WhenToPlugIn
newmotion	newmotion
Niewe Stroom	FullFlex Stroom
NRGi	KØR-VEL-EL
ø-strøm	SpotEL
Octopus Energy	Octopus Go
Octopus Energy	Intelligent Octopus
Octopus Energy	Agile Octopus
Octopus Energy	CrowdFlex
Ohme	Ohme
Ovo Energy	Ovo Drive
Ovo Energy	Drive Anytime
Øvre Eiker Strøm	Eiker Smart
Pinergy	Drive
Plüm énergie	Plüm énergie
Polarkraft	Polarkraft
Polarstern	Autostrom
Prio	Prio Electric
Re.alto	Connect EV
Samstrøm	REN SPOT
Schlaustrom	Spot-Plus
ScottishPower	SmartPower EV Tariff
SEF Energi	EL FleksVIND
SENEC	SENEC Cloud to go
Shell Energy	Charge and Drive
Smart Energi	Spot Time
SO Energy	EV
Stekker.app	Stekker.app
Tibber	Tibber
TotalEnergies	Plan Vehículo Eléctrico
TotalEnergies	Heures Super Creuses pour votre véhicule électrique
True Energy	True Charge
vandebron	SlimLaden
Virta	Virta Home
Volkswagen	Elli Naturstrom Connect

References

1. International Energy Agency. *Global EV Outlook*; International Energy Agency: Paris, France, 2022. Available online: https://www.iea.org/reports/global-ev-outlook-2022 (accessed on 3 November 2022).
2. Bieker, G. A Global Comparison of the Life-Cycle Greenhouse Gas Emissions of Combustion Engine and Electric Passenger Cars. 2021. Available online: https://theicct.org/wp-content/uploads/2021/12/Global-LCA-passenger-cars-jul2021_0.pdf (accessed on 3 November 2022).
3. IPCC. Summary for Policymakers. In Global Warming of 1.5 °C; An IPCC Special Report on the Impacts of Global Warming of 1.5 °C above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty. 2018. Available online: https://www.ipcc.ch/sr15/chapter/spm/ (accessed on 3 November 2022).
4. Hildermeier, J.; Kolokathis, C.; Rosenow, J.; Hogan, M.; Wiese, C.; Jahn, A. Smart EV Charging: A Global Review of Promising Practices. *World Electr. Veh. J.* **2019**, *10*, 80. [CrossRef]
5. Yule-Bennett, S.; Sunderland, L. The Joy of Flex: Embracing Household Demand-Side Flexibility as a Power System Resource for Europe. Regulatory Assistance Project. 2022. Available online: https://www.raponline.org/wp-content/uploads/2022/06/rap-yule-bennett-sunderland-joy-flex-household-demand-side-flexibility-2022-june.pdf (accessed on 3 November 2022).
6. Anwar, M.B.; Muratori, M.; Jadun, P.; Hale, E.; Bush, B.; Denholm, P.; Ma, O.; Podkaminer, K. Assessing the Value of Electric Vehicle Managed Charging: A Review of Methodologies and Results. 2022. Available online: https://pubs.rsc.org/en/content/articlelanding/2022/ee/d1ee02206 (accessed on 3 November 2022).
7. Mangipinto, A.; Lombardi, F.; Sanvito, F.; Pavičević, M.; Quoilin, S.; Colombo, E. Impact of mass-scale deployment of electric vehicles and benefits of smart charging across all European countries. *Appl. Energy* **2022**, *312*, 118676. [CrossRef]
8. Guthoff, F.; Klempp, N.; Hufendiek, K. Quantification of the Flexibility Potential through Smart Charging of Battery Electric Vehicles and the Effects on the Future Electricity Supply System in Germany. *Energies* **2021**, *14*, 2383. [CrossRef]
9. Xue, L.; Jian, L.; Ying, W.; Xiaoshi, L.; Ying, X. Quantifying the Grid Impacts from Large Adoption of Electric Vehicles in China. 2020. Available online: https://www.wri.org/research/quantifying-grid-impacts-large-adoption-electric-vehicles-china (accessed on 3 November 2022).
10. Burger, J.; Hildermeier, J.; Jahn, A.; Rosenow, J. *The Time is Now. Smart Charging of Electric Vehicles*; Regulatory Assistance Project: Brussels, Belgium, 2022. Available online: https://www.raponline.org/wp-content/uploads/2022/04/rap-jb-jh-smart-charging-europe-2022-april-26.pdf (accessed on 3 November 2022).
11. Yin, R.K. *Case Study Research Design and Methods*, 5th ed.; Sage: Thousand Oaks, CA, USA, 2014.
12. Lowes, R.; Rosenow, J.; Qadrdan, M.; Wu, J. Hot stuff: Research and policy principles for heat decarbonisation through smart electrification. *Energy Res. Soc. Sci.* **2020**, *70*, 101735. [CrossRef] [PubMed]
13. Gridio. 2022. Available online: https://www.gridio.io/ (accessed on 3 November 2022).
14. True ChargeX. 2022. Available online: https://www.trueenergy.io/ (accessed on 3 November 2022).
15. Monta. 2022. Available online: https://monta.com/uk/ (accessed on 3 November 2022).
16. Jedlix. Smart Charging with Jedlix. Available online: https://www.jedlix.com/en/ (accessed on 20 October 2022).
17. Mitnetz/E-Bridge. Time-Variable Network Tariffs and Intelligent Energy Energy Management for Flexible Grid Customers. Innovative Concept for the Promotion and Use of Flexibility in the Distribution Network. 2020. Available online: https://www.enviam-gruppe.de/presse/pressemitteilungen/2020/mitnetz-strom-und-e-bridge-veröffentlichen-studie-für-die-umsetzbarkeit-zeitvariabler-netztarife (accessed on 3 November 2022).
18. Whentoplugin. 2022. Available online: https://www.nationalgrid.com/cop26/when-to-plug-in-app (accessed on 3 November 2022).
19. GreenCaravan. 2022. Available online: https://www.greencrvn.com/ (accessed on 3 November 2022).
20. Pinergy Electricity Prices Ireland. 2022. Available online: https://pinergy.ie/terms-conditions/tariffs/ (accessed on 3 November 2022).
21. OVO Energy. 2022. Available online: https://www.ovoenergy.com/ (accessed on 21 November 2022).
22. EV Energy. 2022. Available online: https://ev.energy/ (accessed on 3 November 2022).
23. Jahn, A.; Burger, J.; Rosenow, J. Trust, Not Control: Germany, EVs and the Power of Consumer Choice. Euractiv. 2021. Available online: https://www.euractiv.com/section/electricity/opinion/trust-not-control-germany-evs-and-the-power-of-consumer-choice (accessed on 3 November 2022).
24. Element Energy. Electric Cars: Calculating the Total Cost of Ownership for Consumers. Final Report for BEUC (The European Consumer Organisation). 2021. Available online: https://www.beuc.eu/sites/default/files/publications/beuc-x-2021-039_electric_cars_calculating_the_total_cost_of_ownership_for_consumers.pdf (accessed on 3 November 2022).
25. Element Energy. Charge Collective Final Report UK Power Networks. 2020. Available online: https://innovation.ukpowernetworks.co.uk/wp-content/uploads/2022/03/Charge-Collective-Final-Report_UKPN-external-version-V3.pdf (accessed on 3 November 2022).
26. EGME (Entidade Gestora da Rede de Mobilidade Elétrica, Electric Mobility Network Managing Entity) Portugal. 2022. Available online: https://www.mobie.pt/quemsomos/a-mobi.e (accessed on 3 November 2022).
27. Claeys, B. *Energy Communities with Grid Benefits. A Quest for a Blueprint*; Regulatory Assistance Project: Brussels, Belgium, 2021. Available online: https://www.raponline.org/wp-content/uploads/2020/12/rap-community-energy-January-2021.pdf (accessed on 3 November 2022).

28. Baker, P. *Challenges Facing Distribution System Operators in a Decarbonised Power System*; Regulatory Assistance Project: Brussels, Belgium, 2020. Available online: https://www.raponline.org/wp-content/uploads/2020/05/rap-baker-dso-challenges-june-2020-final.pdf (accessed on 3 November 2022).
29. Taljegard, M.; Thorson, L.; Odenberger, M.; Johnsson, F. Large-scale implementation of electric road systems: Associated costs and the impact on CO2 emissions. *Int. J. Sustain. Transp.* **2020**, *14*, 606–619. [CrossRef]
30. Knezevic, G.; Grosse, B.; Claes, F.; Hartwig, M.; Radeisen, A.; Bußmann-Welsch, A. *Teilstudie 1—Rechtlich Kohärentes Betriebs- und Marktszenario eines Akteursmodells für Electric-Road-Systems*; Version 2.0. Erstellt im Rahmen des Durch das BMWK Geförderten Projektes AMELIE 2; Institut für Klimaschutz, Energie und Mobilität e.V.: Berlin, Germany, 2022; Available online: https://usercontent.one/wp/www.ikem.de/wp-content/uploads/2022/08/Amelie-II-Teilstudie-1.pdf?media=1667839188. (accessed on 21 November 2022).

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