DTU Library

Barriers and Solutions for EVs Integration in the Distribution Grid

Striani, Simone; Sevdari, Kristian; Calearo, Lisa; Andersen, Peter Bach; Marinelli, Mattia

Published in:
Proceedings of 2021 International Universities Power Engineering Conference

Link to article, DOI:
10.1109/UPEC50034.2021.9548235

Publication date:
2021

Document Version
Peer reviewed version

Barriers and Solutions for EVs Integration in the Distribution Grid

Simone Striani, Kristian Sevdari, Lisa Calearo, Peter Bach Andersen, Mattia Marinelli
Center for Electric Power and Energy, Department of Electrical Engineering
Risø Campus, Technical University of Denmark
4000 Roskilde, Denmark
email: {sistri; krisse; lica; matm; pba}@elektro.dtu.dk

***Abstract*—The mass penetration of electric vehicles (EVs) could develop grid stability problems due to the increase of peak loads created by coincident charging factors. Smart charging is the control of the EV charging loads and has long been identified as a potential solution. Smart charging could also contribute to grid stability by mitigating the intermittent nature of renewable energy generation. This paper describes the current status of EV flexibility services at the distribution level. The analysis of the smart charging status is done considering the technological, economic and regulatory frameworks, and presenting what the different barriers of each of these aspects are. Additionally, the paper introduces the ACDC project (Autonomously Controlled Distributed Charger), which aims at developing an EV clustering method based on distributed smart charging control logic for flexibility services. For divulgation purposes, the scheduled test case scenario of the parking lot at the Technical University of Denmark is described. The paper concludes on some of the most relevant actions to overcome the most imminent barriers and to push further the roll-out of EV charging infrastructure towards the target EV penetration planned by policymakers.**

***Index Terms*—Electric Vehicle, Distribution Grid, Smart Charging, Flexibility**

I. Introduction

In order to achieve draw-down of CO_2 emissions, the governments are trying to hinder the reliance on fossil fuels for energy production and transportation, in favor of sustainable technologies. On the energy production front, this means promoting renewable energy systems (RES), while regarding the transportation sector, this consists of speeding up the electrification of private and public transportation systems through the roll-out of electric vehicle (EV) technologies. The global scheduled roll-out of EVs aims at reaching 50 million EVs by 2025 and 140 million by 2030 [1]. Charging large EV fleets can result in stability and security challenges in the distribution grid, associated with grid components not being properly dimensioned to stand the resulting increased power required [2]. However, thanks to smart charging, EVs have the potential of adapting their power consumption to the current needs of the distribution grid. The provision of such distribution grid services could delay, or even set aside, the necessity for costly grid updates [3].

Many demonstration projects [4] are currently working on the feasibility of different grid services through smart charging, providing test cases to gain experimental data. EV clusters can be deployed both behind the meter (BTM) and in front of the meter (FTM) [5]. BTM services are services provided to the users and they consist of load coordination among different EVs, buildings (residential, commercial or industrial) and eventual distributed energy resources (DER) at the connection point. FTM services are provided to the Distribution System Operators (DSOs). In this case the EVs can be coordinated in groups by aggregators and provide their flexibility directly to the grid. Smart charging could contribute to the supply adequacy and quality, reduction of peak loads and transformer congestion, reduction of curtailment and allowance for higher usage of low-cost RES electricity [6], [7]. The challenges associated with the integration of EVs in the power system can be categorized in technological, economics, and policy related [8]. The objective of this paper is to identify and list the most relevant challenges in each of these categories, and to conclude by suggesting a set of actions that could be taken for overcoming such obstacles. Furthermore, this paper introduces the ACDC (Autonomously Controlled Distributed Charger) project providing an overview of its demonstration layout.

Firstly, section II provides a conceptual basis including the definition of different EV flexibility services. Secondly, section III describes the status of technological maturity of EV smart chargers. Section IV, provides a description of the economic framework for flexibility while in section V there is a description of the regulatory status of EV infrastructures. Finally, section VI introduces the ACDC project and section VII concludes with some general recommendations deduced from the literature review in each of the described field.

II. Smart Charging as grid flexibility service

This section describes in more details the different smart charging configurations and explains what are the flexibility services. The section ends with a description of the properties of flexibility services useful for the following sections.

A. Smart charging

In Fig.1 the possible smart charging configurations are illustrated. The unidirectional power flow (V1G) chargers allow the car to adjust its rate of charging. Additionally, the vehicle-to-grid (V2G) technology allows to inject power back to the grid. These configurations are FTM because the charger interacts directly with the grid and can be directly controlled by the DSO or aggregator.

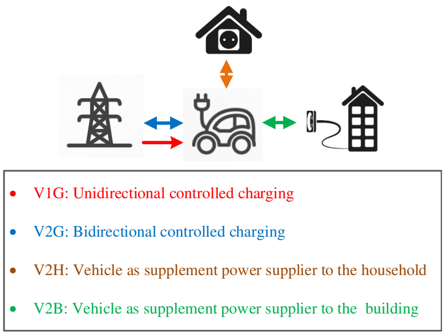

Fig. 1. Illustration of different smart charging configurations adapted from [9].

The other two are vehicle-to-home (V2H) and vehicle-to-building (V2B), both BTM configurations: in these last two configurations the car is connected to a house or a building and it adjusts its consumption to generate services for the household/building (V2H/V2B).

B. *Possible flexibility services from EVs*

In the power grid, flexibility services are power regulations performed by either supply or demand, with the scope of maximising the security and stability of energy supply. Fig. 2 describes the main services that can be provided with EVs. Such services can be categorized in system flexibility and local flexibility. The first category consists of services that target the system as a whole, including the transmission and the production side of the grid. The local flexibility, which is the main focus of this paper, consists of DSO services (also called FTM services) and BTM services. The DSO services are directly managed and controlled by the DSO through contracts with aggregators or directly with the user. They aim at reducing voltage unbalances (voltage magnitude regulation, phase voltage unbalance reduction), solving the grid instabilities related with the capacity of transformers and lines cables (congestion prevention, capacity management), optimizing the loads to reduce losses (loss reduction) and increase the power quality by active or reactive power injection (power quality correction). Smart chargers available today are still not capable of power quality correction, although studies showed that it could need little development effort and be profitable [10].

BTM services aim at minimizing the electricity cost by importing the least possible energy from the grid and schedule charging at times where the cost of electricity is lower.

In order to clearly define the quantity and the quality of a flexibility service, we follow the definition of theoretical and practical attributes given by the authors in [11]. Theoretical attributes are the attributes that characterize the ideal load modulation set point. Practical attributes are additional attributes introduced due to the unideality of the systems (e.g. delays, tolerances, etc.), and they describe the actual performance with which the charger can follow those set-points. These attributes are described below.

Theoretical Attributes:

- *Direction*: Unidirectional or Bidirectional power adjustment capabilities (V1G or V2G).
- *Power Capacity*: Maximum active power possible.
- *Starting time*: Starting time of the service.
- *Duration*: Duration of the service.
- *Location*: Location of the electric vehicle supply equipment (EVSE) or EV related to the grid topology.

Practical Attributes:

- *Accuracy*: Maximum allowed tolerance between required and delivered power response.
- *Precision*: Maximum allowed tolerance between the power setpoint and the actual power erogation.
- *Activation Time*: Time between setpoint reception and flexibility activation.
- *Ramp-up time*: Time that it takes for the charger to adapt to a higher set-point.
- *Ramp-down time*: Time that it takes for the charger to adapt to a lower set-point.

These attributes need to be assessed to be within standardized tolerances, and to be transparently communicated among the stakeholders for the provision of flexibility services. Such communication is crucial for the establishment of quality and therefore value of the different products provided.

III. Current Technology and Infrastructures

A. *Electric Vehicle Supply Equipment*

Nowadays smart charging technologies have reached market roll-out in Europe. The overview of the commercially available chargers carried out in [12] concludes that, in 2020, more than 50% of the available EVSE presented smart charging functionalities. The most common functionalities reported in the paper are load modulation (dynamic load management and limitation of power setpoints) and power sharing with the household/building. Here, some of the capabilities of the top-end smart chargers available today are described:

- *BTM functionalities*: These capabilities refer to the ability to coordinate the charging between the vehicles and the household/building demand and eventual DER production. The charging can be coordinated via power sharing, scheduling and charging prioritization (using state-of-charge (SOC), driving plan or pattern).
- *Inter-connectivity*: In order to provide the above-mentioned distribution services and BTM functionalities, smart chargers are able to have multiple communication channels: they are connected locally with the building energy meter, but also they are connected to the internet, from which they could be coordinated by aggregators in order to provide flexibility. Moreover, their status is usually available via the internet or Bluetooth so that the user can interact remotely with the EV, the charger and easily plan his trip.
- *System recognition*: ID number of the individual EVSE, or alternatively of the EV, must be defined to ensure that the proper user is procured and remunerated for the delivered flexibility. Further information

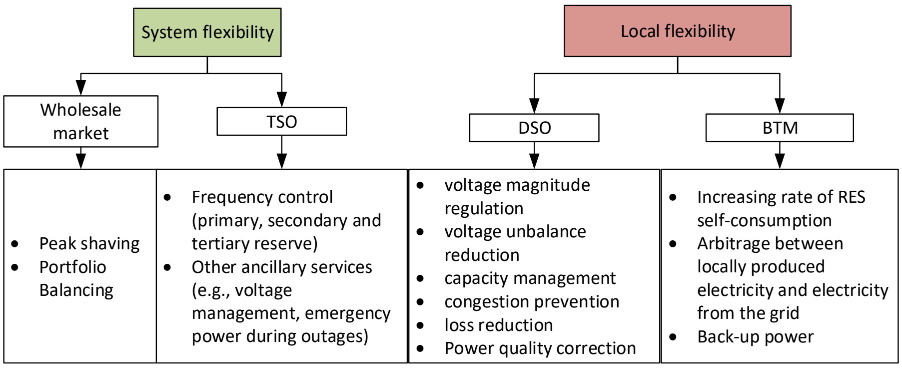

Fig. 2. Description of the different flexibility services that EVs can provide.

should also be made accessible by the EV manufacturers, which is, e.g., currently not the case for the SOC data. Naturally, user privacy must be ensured by regulations so that all collected data are treated as confidential and kept private.

It is important to notice that the capabilities listed describe the top-end chargers available, and therefore the characteristics are not representative of the average of the chargers in the market and even less of the chargers currently deployed. Indeed the majority of the chargers in European cities are not capable of any smart function, thus also called ”dumb” chargers.

B. Control architecture

The coordination and control of different clusters of smart chargers need to be performed effectively by the DSO, user or aggregator. Different control architectures have been proposed and investigated in the literature [13]. They can be categorized into centralized, decentralized or distributed control architectures. The centralized architectures rely on a central intelligence called Cloud Aggregator (CA), which controls directly all the chargers. In the decentralized approach, the intelligence is called Virtual Aggregator (VA). The VA resides in each charger and is therefore sensitive to local measurements. Since the centralized control relies on a single server, it is prone to disconnection errors and delays. On the other hand, the decentralized system is very robust, although its controlling capacity is less efficient due to the limited data it receives from the system. Finally, the distributed control approach combines the benefits from both architectures. It is able to coordinate between local control and global control because it communicates both with VA and CA.

C. Grid observability and smart metering

One of the most important factors in the prompt development of charging infrastructures is the development of smart metering and grid observability. Direct measurements from EVSE or other local metering systems could provide the DSO with more knowledge about the grid, making it capable of judging if flexibility procurement or grid reinforcement are necessary.

Countries where the adoption of smart chargers is combined with experimental demonstration campaigns are leading the way towards the generation of invaluable lessons on user behaviours, the correct planning of charging infrastructures as well as economic and policies suggestion for aggregators, DSOs and governments [14].

In the majority of the countries where smart meters are deployed, all units are certified and installed by the DSO, which is also responsible for data collection and management.

It is of particular importance to clearly define the requirements on the specific measurement parameters, such as the sampling rate, which must be chosen as a trade-off between the information speed on the one hand, and the installation and data management cost on the other.

The European Clean Energy Act requires that all member states assess the cost-benefit of smart meters and ensure that at least 80% of consumers are equipped with smart meters by 2024, if the cost-benefit analysis is positive [15]. It is also stated that smart meters functionalities should include remote reading with two-way communication and a sampling rate not greater than 15-min. Yet, there are no international standards that would ensure these functionalities, so the status across Europe considerably varies.

However, several European countries have plans for a wide-scale roll-out of smart meters supported by the national regulatory framework. Yet, there is still a relatively large share of countries that has not started their deployment due to negative or inconclusive results of the cost-benefit analysis [2].

As a result, many of the consumers still buy ”dumb chargers” because they are cheaper and countries do not incentivize the purchase of smart options. The additional cost of retrofitting the older EVSEs once EV smart charging becomes a common practice should be considered.

The EV chargers and models need to show their internal parameters to DSOs and aggregators to be managed correctly in the flexibility service. There is still a lack of experimental data on the practical attributes of the EV capabilities, and authors in [16] state that there might be a difference in EVs response accuracy based on the external conditions.

Smart meters characteristics and functions need to be standardized as their varying performances is observed to be one of the major barriers towards flexibility procurement.

D. Information and communication technologies

Information and communication technology (ICT) ensures advanced metering, control and transactional communication among different stakeholders: EVs, EVSEs, DSOs, TSOs, market operators/players and the end-user. ICTs are crucial to provide grid monitoring for the actual research and development of flexibility services. EV-related communication protocols can be divided into front-end and back-end protocols, and they are respectively between the EV and EVSE and between the EVSE and a third party, such as an aggregator. Nowadays, the vast majority of contemporary EVs are compliant with IEC 61851 or SAE J1772 standard, according to which the EV charging current can be limited between the minimum charging current of 6 A and the maximum one, which is the EVSE rated current (10 A, 16 A, 32 A, etc.). One of the present limits of the existing protocols is the lack of communication of fundamental EV information, such as battery size and SOC. Moreover, there are not protocols that support entirely V2G functions. Standard ISO/IEC 15118 covers communication between EVSE and EV, as well as among all stakeholders involved in the supply process [17]. It takes into account the data encryption for both confidentiality and data integrity purposes and it is currently being revised to include V2G functionalities if used together with OCCP 2.0 or IEC 63110 (between EVSE and aggregator or charge point operator).

IV. Economic framework for flexibility

The economic framework for flexibility services is a central barrier hindering the development of a flexibility value chain. The economic and regulatory frameworks are hugely interconnected. This section will illustrate different economic tools currently under development for creating flexibility value on the DSO perspective that are proposed by the literature [18].

A. Grid codes

This approach proposes to update grid codes for grid connection of flexible loads or DER with the scope of imposing flexibility requirements. There are discussions on what should be strategical requirements to facilitate the development of market-based flexibility services.

B. Connection agreements

These are agreements between DSOs and consumers for flexibility provision. There are two main types of smart connection contracts: interruptible contracts and variable capacity contracts (VCCs) [8]. Interruptible contracts entitle the DSOs to control EV charging energy consumption based on the grid conditions. This type maximizes grid stability at the expense of user comfort and acceptance. In VCCs, the DSOs provide scheduled or dynamic max power allowance for charging necessities and related dynamic prices.

C. Electricity tariffs

This mechanism generates an indirect provision of flexibility because it encourages end-users to adapt their consumption. Network tariffs are paid by the consumers, together with other taxes. They consist of roughly 25% of the electricity bill and resemble the planning and operational costs of the network. There are different kinds of tariff structures/components: energy component (€/kWh), capacity component (€/kW), grid connection component (€). Currently, not all countries are deploying network tariffs to encourage the use of flexibility. Although some of the above-mentioned tariffs are still under development, every country should update the electricity tariff to include at least two components: the capacity and an energy one [11].

The ToU (Time-of-Use) tariff is a simple price mechanism to incentivize off-peak consumption that could result in reduced congestion. However, with high-penetration scenarios the charging synchronization of large fleets during off-peak hours is a potential risk.

A tariff structure trending in current research is the Distribution Locational Marginal Prices (DLMPs), where the cost of electricity is dependent on the particular nodes of the distribution grid. There are different variations of such tariff, which can include local constraints such as voltage, losses, power quality, etc. These structures, although promising, raise some important concerns regarding the difficulty of implementation as well as inequality and transparency issues.

Dynamic capacity tariffs could be a very efficient framework. These tariffs would force consumers to adapt their maximum consumption to the grid conditions for a given period of time. The drawbacks of the capacity tariffs are that they could hinder the development of fast-charging stations.

D. Flexibility markets

In recent years some markets for different EV flexibility services were developed (for example, system balancing and energy management) and started being used by aggregators. EV flexibility markets at the distribution level are still far from sufficient, since there is not a market structure and digital infrastructure [19]. Regulators should incentivize the creation of a larger number of smaller local flexibility markets based on nodal pricing systems [20]. With a Market-based approach, DSOs explicitly procure flexibility services from a market. The penetration of the EV-based services in flexibility markets will increase the value of such services and allow their trading among different stakeholders. Again, there are various viable approaches: Long or Medium-term bilateral contracts or short terms Market Platforms. The role of the DSO is to define the flexibility requirements, which can be offered by different aggregators or prosumers.

Market frameworks have a strong potential to generate value for all stakeholders [21] and are the preferred approach by regulators.

V. Regulation

A. Redefining the role of DSOs

Before the beginning of the transition towards renewable energy resources the grid was easier to operate. This is because it had a virtually radial shape with the consumers at the center and the producers at the outer radiuses. The flow was unidirectional and the loads and production were easier to forecast and control. Therefore the DSO approach to congestion and voltage issues was simply reinforcing the grid when needed (the so-called ”fit-and-forget” approach). The economic and regulatory frameworks were therefore built around this model and the DSOs were remunerated based on the capital expenditures (CAPEX) for grid renovation.

Nowadays, the evolution towards smart grids requires a shift towards a TOTEX-based (total expenditure) framework, where the DSOs need to minimize their OPEX (operational expenditure) as well as the CAPEX. This need is at the moment only partially met and there is still need for a reform of the regulatory framework to push the DSOs to manage their expenditures proactively and to deploy the value of load flexibility [22].

B. *Standardization of EV connections*

Because of its technological novelty, there are often some administrative problems related to V2G technology. In more details, V2G chargers installation imply additional and often redundant administrative procedures that discourage their adoption by the user. The cause of these obstacles is that connection requirements, classification and standardization of V2G connections are not fully developed yet. Regulators, system operators, EV and EVSE manufacturers need to work on the standardization of interconnection requirements in order to reduce the administrative processes and ensure safety for both end-user and the system itself. On the other hand, V1G, V2H and V2B are more technologically mature and their connections have already been standardized in the previous years [17].

C. *Interaction between actors*

As previously stated, there are different approaches for DSOs to provide flexibility: Grid codes based, contract based and market based approaches. The grid codes based approach requires the DSOs to stipulate direct obligations for flexibility provisions or contract arrangements directly with the EV user so that they can directly control the EV charging process. The market-based approaches require an additional interaction between DSOs and TSO. The interaction between DSOs and EV users often requires the mediation of aggregators, which can cluster different EVs and manage their flexibility into tradeable services packages.

The interaction between DSOs and TSOs is considered a key aspect in the European Clean Energy Package as the penetration of RES and DER increases. This is because the distribution network and the transmission network often have different needs that could be in contrast. Often the needs of the transmission network need to be prioritized compared to the ones of the distribution network.

VI. The ACDC Project

Some of the aspects discussed in this paper are analysed by the ACDC project. The ACDC (Autonomously Controlled Distributed Charger) is a Danish project that aims at developing a clustering method for autonomous smart charging with distributed control architecture and a virtual aggregator. The cluster contains a set of EV chargers controlled to provide FTM and BTM grid services. The global grid status is communicated via a Cloud Aggregator, through which FTM services can be provided. Furthermore, the local coordination between the chargers for BTM services is handled by the virtual aggregator. The development of the clustering method is ongoing, although a more detailed description of the control logic is available in [23] together with the simulation results of a V2H scenario with 2 EVs. As part of the demonstration campaign, the designed technology will be installed in one of the parking lots of the Risø research campus of the Danish Technical University (DTU). A satellite picture of the parking lot is shown in Fig. 3. The scope is to validate the charging performances in a V2B office case. The parking lot will host 8 smart chargers with 2 type-2 plugs each. Each plug can support a maximum charge rate of 11 kW from a 3 phase charger. The parking lot could potentially charge with a max power of 88 kW. However, the grid capacity of the parking is limited to 43 kW (63 A, 3 phase). The parking lot will serve to develop and demonstrate ACDC's distributed charging control logic for BTM and FTM services under limited grid capacity.

Fig. 3. Satellite picture of the parking lot location. The red dots indicate the chargers.

VII. Conclusion

An overview of the current development status of the EV integration in the distribution grid was provided. Many authors believe that smart chargers could potentially be an important component of the future smart grid. Smart charging could drastically reduce the drawbacks related to EV integration and, at the same time, solve the increasing grid instability problems due to other sources, like DER. However, there are still many barriers before the smart charging technology is fully mature. In this paper, the authors described the current status of EV flexibility services at the distribution level, including the technological, economic and regulation perspectives. Moreover, the

TABLE I
FUTURE STEPS NEEDED TO PUSH THE DEVELOPMENT OF ROBUST EV INFRASTRUCTURES FOR DISTRIBUTION GRID SERVICES IN EACH OF THE FIELDS ANALYZED

Technical	Economic framework	Regulatory framework
Further R&D on smart charging capabilities.	Keep or introduce temporary incentives for cars, shared mobility and Mobility-as-a-service	Enhance active management requirement to DSOs
Standardize and ensure interoperability between different EVs and EVSE.	Research on business models for aggregators and charge point operators	Standardize cost-benefit analysis for smart meters
Develop and test ICT and standards (especially V2G)	Develop and test new Network tariff structures	Ensure a clear classification and standardization of V2G connection requirements for V2G prosumers
User interactivity and interconnectivity	Strategical location for different types of chargers to ensure trust in EV infrastructures investors	Create incentives for smart chargers purchase
Continue the demonstration project campaigns to gather data.	Establish local flexibility platforms with increasingly competitive approaches.	Define DSO-TSO priorities and the interaction between every stakeholder
Increase grid observability	Continuous revision and improvement of economic framework of flexibility based on the lessons learned	Set ambitious targets (CO_2 reduction, targets for different transport types)

authors introduced the ACDC project and a test case of its demonstration campaign to explain part of the ongoing research and development on clustering methods for smart charging functionalities. In conclusion, recommendations on possible steps to be followed in each of the analyzed perspectives are summarized in table I: From a technical point of view, the bottleneck for the roll-out of smart charging is the related ICT: Development of the existing standards and protocols is needed to ensure EVSE-EV interoperability, user-EVSE interactivity and grid observability. From an economic point of view, the focus should be on two aspects: developing market platforms to provide trading of services and developing business models to assure profitability for investors of EV infrastructures, as well as aggregators and prosumers. Finally, the regulatory framework should set ambitious targets and stimulate technical and economic value-chain development. This can be done by standardizing and including the different technologies, defining their available products and regulating the interaction between stakeholders along the value chain.

ACKNOWLEDGMENT

The work in this paper is supported by the research projects ACDC (EUDP grant number: 64019-0541) and FUSE (EUDP grant number: 64020-1092).

REFERENCES

[1] International Energy Agency, "Global ev outlook: Entering the decade of electric drive," tech. rep., 2020.
[2] K. Knezović, M. Marinelli, A. Zecchino, P. B. Andersen, and C. Traeholt, "Supporting involvement of electric vehicles in distribution grids: Lowering the barriers for a proactive integration," *Energy*, vol. 134, pp. 458–468, 2017.
[3] L. Calearo, A. Thingvad, H. H. Ipsen, and M. Marinelli, "Economic value and user remuneration for ev based distribution grid services," *Proceedings of 2019 IEEE PES Innovative Smart Grid Technologies Europe, ISGT-Europe 2019*, 9 2019.
[4] M. Marinelli et al., "Electric vehicles demonstration projects-an overview across europe," *UPEC 2020 - 2020 55th International Universities Power Engineering Conference, Proceedings*, 9 2020.
[5] International Renewable Energy Agency, "Behind-the-meter batteries: innovation landscape brief," tech. rep., 2019.
[6] P. Hanemann, M. Behnert, and T. Bruckner, "Effects of electric vehicle charging strategies on the german power system," *Applied Energy*, vol. 203, pp. 608–622, 2017.
[7] M. V. D. Berg, I. Lampropoulos, and T. AlSkaif, "Impact of electric vehicles charging demand on distribution transformers in an office area and determination of flexibility potential," *Sustainable Energy, Grids and Networks*, vol. 26, p. 100452, 2021.
[8] F. G. Venegas, M. Petit, and Y. Perez, "Active integration of electric vehicles into distribution grids: Barriers and frameworks for flexibility services," *Renewable and Sustainable Energy Reviews*, vol. 145, p. 111060, 7 2021.
[9] The International Renewable Energy Agency, "Innovation outlook: Smart charging for electric vehicles," tech. rep., 2019.
[10] S. Martinenas, K. Knezovic, and M. Marinelli, "Management of power quality issues in low voltage networks using electric vehicles: Experimental validation," *IEEE Transactions on Power Delivery*, vol. 32, pp. 971–979, 4 2017.
[11] K. Knezović, M. Marinelli, P. Codani, and Y. Perez, "Distribution grid services and flexibility provision by electric vehicles: A review of options," *Proceedings of the Universities Power Engineering Conference*, vol. 2015-November, 2015.
[12] K. Sevdari, "Electric vehicle chagers market outlook," tech. rep., 2020.
[13] X. Han et al., "Taxonomy for Evaluation of Distributed Control Strategies for Distributed Energy Resources," *IEEE Transactions on Smart Grid*, 2018.
[14] C. Hecht, S. Das, C. Bussar, and D. U. Sauer, "Representative, empirical, real-world charging station usage characteristics and data in germany," *eTransportation*, vol. 6, 11 2020.
[15] European commission, "Regulation (eu) 2019/943 on the internal market for electricity," 2019.
[16] K. Knezovic, S. Martinenas, P. B. Andersen, A. Zecchino, and M. Marinelli, "Enhancing the role of electric vehicles in the power grid: Field validation of multiple ancillary services," *IEEE Transactions on Transportation Electrification*, vol. 3, pp. 201–209, 3 2017.
[17] H. S. Das, M. M. Rahman, S. Li, and C. W. Tan, "Electric vehicles standards, charging infrastructure, and impact on grid integration: A technological review," *Renewable and Sustainable Energy Reviews*, vol. 120, 3 2020.
[18] Council of European Energy Regulators, "Flexibility use at distribution level," tech. rep., 2017.
[19] T. Pallesen and P. H. Jacobsen, "Solving infrastructural concerns through a market reorganization: A case study of a danish smart grid demonstration," *Energy Research and Social Science*, vol. 41, pp. 80–88, 7 2018.
[20] J. Ostergaard et al., "Energy security through demand-side flexibility: The case of denmark," *IEEE Power and Energy Magazine*, vol. 19, pp. 46–55, 3 2021.
[21] A. Gadea, M. Marinelli, and A. Zecchino, "A market framework for enabling electric vehicles flexibility procurement at the distribution level considering grid constraints," *20th Power Systems Computation Conference, PSCC 2018*, 8 2018.
[22] Transport & Environment, "How implementing the clean energy package can foster electromobility," tech. rep., 2020.
[23] K. Sevdari, L. Calearo, S. Striani, L. Rønnow, P. B. Andersen, and M. Marinelli, "Autonomously distributed control of electric vehicle chargers for grid services," 2021, under-review.