Electric Vehicles Demonstration Projects - An Overview Across Europe

Mattia Marinelli, Lisa Calearo
Technical University of Denmark
Roskilde, Denmark
matm@elektro.dtu.dk

Sabrina Ried
Karlsruhe Institute of Technology
Karlsruhe, Germany

Xaver Pfab
BMW group
Munich, Germany

Julio Cesar Diaz Cabrera
Instituto Tecnologico de la Energia (ITE)
Valencia, Spain

Christian Spalthoff
Fraunhofer IEE
Kassel, Germany

Martin Braun
Fraunhofer IEE & University of Kassel
Kassel, Germany

Hanne Sæle, Bendik Nybakk Torsæter
SINTEF Energy Research
Trondheim, Norway

Poria Hasanpor Divshali, Seppo Hänninen
VTT Technical research center of Finland
Espoo, Finland

Massimo Ceraolo, Stefano Barsali
University of Pisa
Pisa, Italy

Mats Larsson
IUC Syd
Malmo, Sweden

Annika Magdowski
Stromnetz Hamburg GmbH.
Hamburg, Germany

Laura Gimenez, Gregorio Fernández
Circe Foundation
Zaragoza, Spain

***Abstract*—This paper gathers experiences and results from several demonstration projects in the field of grid integration of electric vehicles. The analyzed research projects are selected among research institutes and universities that are part of the European Energy Research Alliance Joint Program on Smart Grids. The paper provides an overview of recent trends in the field of electric vehicles integration issues and then dives deeper into specific aspects of each project. Twelve research projects are presented in general terms, while detailed information can be retrieved from the references and the websites. Although each project has its focus, a common element that can be devised is that the charging process can be technically controlled based on different interests and algorithms, but its role in the market is still under development. Particular focus is always given to the behavior of the user, which ultimately determines the possible level of flexibility that the electric vehicle can provide to the grid.**

Keywords—Ancillary services, Demonstration projects, Electric vehicles, Grid integration, User behavior.

I. INTRODUCTION

It is necessary to increase the amount of renewable energy to achieve a sustainable energy system [1]. Nevertheless, exploiting the potential of fluctuating renewable sources in the electrical grid requires flexibility: storage is regarded as the "holy grail" of the electricity sector, since it allows compensating for the intrinsic non-controllability of solar and wind power [2]. However, in order not to increase the final price of electricity, storage has to be inexpensive, reliable and durable. In this respect, controllable domestic appliances, such as electric vehicles (EVs), which offer a large and barely exploited source of storage, can play a critical role [3]-[5]. In Denmark, EVs are on average parked 97% of the time with a battery capacity, which spans between 30 and 90 kWh, against a daily average driving requirement of 9 kWh (approx. 45 km/day) [6]. Similarly, in other European Countries, users drive between 40 and 80 km/day [7]. Uncontrolled charging from a large amount of EVs may cause congestion problems in the distribution grid, which is the most sensitive section of the grid [8]-[10].

On the other hand, by controlled or smart charging, the EV can become a large asset to the power system, being used for example as a flexible consumption for multiple grid services [11]-[14]. The integration of EVs into the power system may serve to limit the self-induced adverse effects of EVs in terms of additional grid loading, and make the EV an active component in supporting a stable, cost-efficient power system based on renewable energy sources (RES) [15], [16].

An EV can interact with the grid in two ways in order to provide ancillary services. Firstly, it can use an external DC charger directly connected to the battery: this gives the possibility of both charging and discharging, which allows the usage of the full capacity of the battery, though with a potential negative impact on its lifetime [17]. In a second way, it can use the internal charger present inside the vehicle and control it with a charge controller to modulate the power: all EVs have for example the possibility of adjusting the charge between 1.4 and 3.6 kW [18]. If the base charging power is set in the middle of the 1.4-3.6 kW range, it means that it is possible to provide power modulation equal to ±1.1 kW (in steps of 230 W). Since the onboard charger can either increase or decrease the EV's power consumption, it can emulate a similar bi-directionality that an external charger can provide.

The rest of the paper will present examples of demonstration projects where the above-mentioned grid issues are investigated and solutions are demonstrated by either using bidirectional or unidirectional chargers for the provision of various types of ancillary services. Common features and key points of the projects are summarized in the conclusions.

The authors are grateful to the various funding agencies listed in TABLE 1 for the financial support to the projects.

II. Summary Information About the Selected Projects

Most of the partners in the selected projects are part of the European Energy Research Alliance (EERA). The alliance brings together universities and public research centers in almost all European countries in order to align and synchronize their research and fulfill the Strategic Technology Plan adopted by the European Union in 2008.

A. ACES (Across Continents Electric Vehicle Services)

The project investigates techno-economic system benefits of large-scale EVs integration in Bornholm, augmented by real usage patterns, grid data and field-testing for across continents replicability. A full scale penetration scenario of EVs at Bornholm is simulated in order to assess how new aggregating functionalities - both technically and economically - can support a successful integration of electric vehicles into the energy system. The simulation activities are complemented by a pilot project involving publicly and privately owned Nissan vehicles and V2G chargers to prove that EVs can be used to balance the system.

The results cover different areas starting from specification of EV user behavior in Denmark and Japan in order to quantify realistic loading patterns on the grid [19], [20]: by considering a combination of Japanese charging patterns and Danish driving behavior, it is derived that a 100% EV penetration would determine an evening peak concurrency factor equal to 40% for a 3.7 kW charge level.

Profitability of service provision is also assessed with particular focus on frequency control which is market regulated in the Nordic countries. More specifically, primary frequency control is the most valuable at the moment and, as described for Denmark in [17], it could yield a profit of more than 1000 €/year per EV with a 10 kW bidirectional charger. The efficiency of the bidirectional charger, market conditions and price per service could however severely reduce the profit. Looking at the distribution level, depending on the specificity of the grid, an interesting revenue stream can be also found for congestion or grid deferral services [23].

Degradation of the storage while performing grid services is modelled and validated throughout measurements (still ongoing at the time of writing) in order to quantify the amount of degradation due to the passing of time, usage for driving and usage for grid services [21], [22]. Early results show that the additional wear due to the intense bidirectional power flow during grid provision, such as frequency control, amounts to only few additional percent compared to the natural degradation of the storage. Ratio between power bid in the service and energy capacity, as well as high ambient temperature can however negatively impact on the estimated lifetime.

Twenty-one 10 kW bidirectional chargers and Nissan leaf and E-NV200 and one 22 kW controllable charger, all located in Bornholm, are used in the demonstration phase. Their performance in terms of response characteristics is firstly assessed in the lab [23] and then analyzed at the system level in order to evaluate the stability of the system, with particular focus on the response time and other key characteristics of the power system [24]. Results show that the response time is the critical factor that needs to be addressed in order to ensure a stable service provision in an EV-dominated power system.

B. ACDC (Autonomously Controlled Distributed Chargers)

The ACDC project will develop two new technologies: an electric vehicle autonomous smart charge controller and a virtual aggregator. The autonomous charge controls a set of electric vehicles chargers in order to ensure the fulfillment of specific grid services. The virtual aggregator broadcasts a signal to the set of autonomous chargers in order to coordinate their action. Both technologies will be developed and demonstrated in the project by using up to 5 vehicles in Risø campus and up to 20 vehicles in Bornholm. Simultaneously with the development of the hardware, power systems stability studies will be performed to analyze the effect of aggregated charging on the large-scale. The project builds on the results of the ACES project by developing autonomous unidirectional chargers and focusing on their aggregated behavior on the grid.

C. BDL (Bidirectional Charging Management)

The BDL project develops bidirectional systems for EVs and wallboxes, technologies for energy management systems and controlled charging, as well as digital services. The development is focused to push international standards, e. g. the CCS-standard (Combined Charging System). The developments will be applied in a field test with 50 BMW i3s and 50 bidirectional, controllable chargers. Different V2X use cases in the field of home and workplace charging will be implemented. Thereby, the EVs act as mobile energy storages that can be charged and discharged according to the use case and the users' requirements. Moreover, the project uses energy systems analyses to explore interactions of bidirectional charging with electricity markets and grids and investigates legal and regulatory framework conditions, as well as user acceptance and user-friendliness.

The field test will start in 2021, when 20 bidirectional EVs are used in households and another 30 BDL-EVs in company fleets. Besides primary frequency control and redispatch, the EVs will be operated to provide intraday-trading, peak-shaving, and CO_2-minimal charging.

D. WiseGRID (Wide scale demonstration of Integrated Solutions and business models for European smartGRID)

WiseGRID's main objective is to provide a set of solutions and technologies to increase the smartness, stability and security of an open, consumer-centric European energy grid. The project combines an enhanced use of storage technologies, a highly increased share of RES and the integration of charging infrastructure to favour the large-scale deployment of electric vehicles. It places citizens at the center of the transformation of the grid. Three pilot sites (Crevillente, Flanders, Terni) involved demonstrating an EV platform used by vehicle-sharing companies and EV vehicles fleet managers (such as taxi companies), to optimize the activities related with smart charging and discharging of the EVs and reduce energy billing. Through this platform they can plan and control the charging/discharging schedule of all EVs of the fleet.

A tool has been developed to be used by e-fleet managers and electric vehicle supply equipment (EVSE) operators in order to optimize the activities related with the smart charging and discharging of the EVs, making it possible to use EVs as dynamic distributed storage devices, feeding electricity stored in their batteries back into the local distribution network when needed (V2G) and responding to the flexibility requests of the grid. In order to manage an EV power flexibility market hub, a Flexibility Forecast module has been developed and introduced to estimate allowed energy storage over time for each connected EV which charging session is scheduled [26], [27].

Field tests and deployment activities developed on pilot sites have demonstrated technical feasibility and benefits of the implementation of this approach. For example, they have been useful to increase RES and distributed energy resources (DER) hosting capacity. Different key parameters have been evaluated as: RES curtailment, ancillary services cost, energy generation capability per investment ratio, penetration of dynamic energy tariffs or demand response campaign penetration. The technical results indicated a relation between fleet typology and distribution system operator (DSO) operation characteristics that can affect impact assessment. Therefore, it would be relevant to define priorities among flexibility resources with respect to the economic revenues of the DSO. It is an important factor to taking account to replicate and scale the project solutions as suggested in [28].

The following equipment was part of the demonstration: 11 charging stations (3 SPOTLINK – EVO, 4 EVLink2 Wallbox, 1 EVLink2 Parking, 2 RVE-WBS-Smart, 1 V2G fast charging station (developed under project)) and 53 EVs: 44 Renault Zoe R240 (22 kWh), 6 Nissan e-NV200 (24 kWh), 2 Nissan Leaf (40 kWh), 1 Hyundai Ioniq (28 kWh).

E. Charging Infrastructure 2.0

An optimal electric mobility infrastructure requires the integration of requirements from vehicle owners, component manufacturers, grid operators and electricity providers. The projects forecasts energy production and demand from a whole-system-view down to single customer level. Load flow calculations predict possible grid overload and flexibility potential. Prototypes for charging hardware and integrating IT infrastructure are developed to provide system services, self-sufficiency and market interaction. The costs and benefits of different options are combined into a multi-factor evaluation. The charging hardware prototype, planning tools and operation software will be evaluated in two field tests with distribution grid operators starting 2021.

The field test in Hamburg will include 40 electric home chargers and vehicles coupled via ISO 15118 which communicate with the grid operator’s backend via OCCP 2.0. Results focus on how interaction between grid forecast and individual profiles can be utilized for optimal grid operation.

A second field test in Braunschweig connects 40 single family houses as prosumers equipped with HEMS and smart meters to a SCADA system and smart meter gateway. The various software components are connected using IEC 61851, 15118, 61850 and 61870 protocols to evaluate customer behavior, different grid operation strategies and possibilities for IT architecture

F. FuChar (Grid and Charging Infrastructure of the Future)

The aim of the FuChar project is to minimize investment and operating costs related to the grid integration of electric transport. This will be done through research on transport patterns, user behavior and charging profiles for EVs, alternative system configurations and control systems for increasing utilization of flexibility in charging infrastructure, and methods for optimal planning and operation of charging infrastructure in the distribution grid. The FuChar project mainly focuses on high-power charging and other aggregated charging interfaces with a large electric charging demand. FuChar will provide increased knowledge about electrical charging and user behavior, as well as new methods and tools for optimizing grid and charging infrastructure.

In the first phase of the project, the research activities have been focusing on reviewing state of the art for analyzing grid impact from high-power charging, as well as optimal grid integration of high-power charging infrastructure for EVs. In order to understand the grid impact from high-power charging, high-resolution load profiles for charging of all modes of transport must be developed. So far detailed 1-minute resolution load profiles for fast charging of electric cars at public charging stations have been developed using historic traffic flow data and stochastic modeling. These models are currently being validated using real measurement data from Norwegian fast charging stations.

In FuChar, real measurement data from high-power charging stations in Norway is being collected and used for analysis and development/validation of methods and load models. This includes measurements of aggregated load profiles for public fast charging stations, i.e. charging stations with 2-50 charging points with a capacity of 50-350 kW each. In addition, measurement data from depot and opportunity charging of buses and trucks, as well as ferry charging (MW scale), will be available to the project. Thus, several case studies of high-power charging in Norway can be performed.

G. ModFlex (Modelling Flexible Resources in Smart Distribution Grid)

The objective of the ModFlex project is to develop dynamic models representing the consumption and production profiles for different flexible resources in smart distribution grid, for example EVs and home charging.

Home charging of the most common EV types in Norway have been metered with 1-minute resolution of the data. The EV types that have been metered are Think, Tesla X, Mitsubushi iMiev, BMW i3, Nissan Lief, Kia Soul and eGolf. Information about the time of charging has been collected from a national survey performed in cooperation with the Norwegian EV association. Results from the survey show that 63.4% of the users charge their EV at home from a normal socket (10 A). Approx. 30% of the users have a charging station of either 16 A or 32 A at home. According to the survey, 90% of the respondents are willing to postpone the time of charging if this does not affect the user negatively, but only 56.5% are willing to postpone the time of charging if the driving distance for the next day is reduced to 80% [29].

H. EU-Sysflex (Pan-European system with an efficient coordinated use of flexibilities for the integration of a large share of RES)

The EU-SysFlex project tests a high level of integration of RES in the pan-European electricity system. The aim of the EU-SysFlex project is to identify issues and solutions associated with integrating large-scale renewable energy and create a plan to provide practical assistance to power system operators across Europe. In the Finnish Demonstration, the potential of public (non-domestic) EV charging stations (EVCS) to provide flexibility, particularly frequency regulation, was investigated. In this regards, a tool to estimate stochastic bidding profiles in a day-ahead frequency containment reserves (FCR) market is developed to maximize the expected profit of EVCS. The stochastic bidding strategy using technical requirements of Nordic FCR market is detailed in [30], [31].

The results show that although FCR-N (normal) has 5 times higher remuneration for available capacity than FCR-D (disturbance), it will lead to much lower profit due to the difficulties for charging stations to provide down-regulation reserve. The most profitable choice of the electricity reserve market for charging stations is a combination of FCR-N and FCR-D products. The average daily profit per 1 kWh energy consumed by EVCS demonstrates that it can cover about half of the charging energy cost. The behavior analysis of these EVs performed in [32] for Helsinki area shows their flexibility provision will be increased by 20 times.

The EV charging data of 60 charging stations with different charging rates in the Helsinki area from 2014 till 2019, having about 2500 customers is used for this project.

I. *SUMA (Struttura Urbana Multifunzionale attiva)*

The objective of SUMA project is the optimisation of traditional distribution systems of electricity, alternative energy sources, and the use of alternative urban mobility. This optimisation has the main purpose to enhance the efficiency in the exploitation of energy resources, and to make the usage of RES in urban environments more attractive from the economical point of view. Fundamental for this purpose is the correct utilisation of energy storage systems. Therefore, theoretical and experimental studies are carried on modern electrochemical storage systems also evaluating the services they can offer to the electric grid.

One of the battery technologies to be tested is Lithium Iron Phosphate (LFP). Its purpose in a SUMA station will be to reduce grid power when SUMA is supplying relatively high power to cars, in short times: the typical SUMA usage for car supply would be a “biberonage” 15-30 min recharge: it would just add some additional range during a short stop. Therefore, for cycle-life evaluation, cells will be subject to constant-power 15-30 min discharges followed by charges at the same power. The considered cell is a 60 Ah Winston LFP. We first estimated that the maximum power to be allowed by the cell for a reasonable number of cycles (a few hundreds), should be 500 W. Therefore, tests started using that power level, next, a 250 W discharge/charge aging test is started.

More results can be found in [33]. The results show that, as expected, the 500W power implies a cell life of 450 cycles, the end-of-life adopted criterion being reaching the lowest acceptable cell voltage. The preliminary 250 W results show, as expected, that the cell life would be much larger than 900 cycles, therefore the energy globally delivered will be larger than 500 W’s test. For SUMA project, where the battery is expected to cycle a few times per day, battery lives of several thousand cycles are needed, 250 W cycling seems in line with that objective. Next tests will involve 30 min cycles, with power to be defined.

J. *CAR (Creating Automotive Renewal)*

The project Creating Automotive Renewal (CAR) is a project financed by the South Baltic Interreg program, involving 10 partners around the South Baltic, in Sweden, Denmark, Germany, and Poland. The progress of e-mobility has been very different in the countries, where Sweden has the largest number of electric and hybrid cars, Denmark is the leader in the research of the interface between electric car fleets and the power grid, Germany has limited growth in the region of Mecklenburg-Vorpommern, and car buyers in Poland are starting to take an interest in electric cars and infrastructure aspects.

In the program, six partners are making pilot installations in charging infrastructure and one is developing a recycling solution for lithium-ion batteries. The pilot installations range from Lund municipality that is building charging infrastructure for its municipal vehicles, Bornholm that is building infrastructure for the charging of the cars of visitors, inhabitants, and municipality employees, RISE that is developing a charging solution for a housing cooperative, and the municipal transport company PKT in Gdynia that is building infrastructure for the charging of buses.

The project also includes activities for the building of a network of companies and public organizations that want to become pioneers of electric mobility. Partners in all the countries organize seminars and network meetings aimed at informing about the experiences from CAR and about the challenges of building infrastructure. A manual that can be used by organizations that want to build infrastructure has also been developed by DTU in collaboration with the other partners [34].

K. *ELBE (Electrifying Buildings for EVs)*

The goal of the project is to enable a high adoption of charging stations within the city of Hamburg; up to 7,400 charging points are to be set up in the non-publicly accessible area. To integrate these charging stations into the distribution grid while guaranteeing an efficient, safe and resource-saving operation of the electrical distribution network, an interface for grid-compatible charging is developed between the distribution system operator (DSO) and several charging point operators (CPOs) to react to possible grid congestions. This system comprises - besides the DSO and the CPOs - a software platform for low voltage condition monitoring and an incentive system for the end user.

Within several distribution grid station in the low voltage network, voltage, current and power of the feeders are measured. The data are analyzed within the software assistance system “Intelligent Grid Platform” (IGP) by envelio that supports distribution grid operators in digitizing and automating grid planning and grid operation processes. In case of a grid overload located downstream of the distribution grid station, the IGP sends a request to the DSO to reduce the charging power of the charging infrastructure. The DSO forwards this information to the corresponding CPO, who has to reduce the power at the selected grid connection point to a given limit. For communication between the DSO and the CPOs the OpenADR protocol is used (also known as IEC 62746-10-1 ED1). The communication protocol between CPO and charging station is not fixed within the project; a typical protocol used could be OCPP.

At the beginning of 2020, the ELBE project was supplemented by the subproject ElbeSecure. Here the project goal is to be expand the ELBE system in such a way that a secure loading, control and accounting of the charging process is made possible via the Smart Meter Gateway.

L. INSULAE (Feasibility analysis and development of on-road charging solutions for future electric vehicles)

The EU-funded INSULAE project aims to help islands find locally produced, sustainable and low-cost sources of energy. They will develop interventions linked to seven replicable use cases at three Lighthouse Islands (in Croatia, Denmark and Portugal). The goal is to demonstrate their capability to evolve RES-based systems up to 70 % cheaper than diesel. To assist Europe's policymakers, the project will design an investment planning tool to be displayed at four Follower Islands in Germany, Greece, Spain and the Netherlands Antilles for the improvement of related action plans.

With particular focus on the Portuguese demonstration taking place in Madeira, there are 26 available EV public sockets/plugs and out of these, 11 are from public fast chargers. Recently, private companies that work in the energy sector started to offer also public charging stations installation as part of their services. There are approximately 100 EVs in Madeira, most of which are Renault Zoe or Nissan Leaf models. Madeira intends to increase the share of electric mobility in the following years by contributing to the expansion of the EV charging infrastructure, powered by RES and enabling the introduction of over 90 new EVs. This will be done in two ways, first with a grid connected fully silicon carbide 50 kW AC to DC converter with high frequency isolation, for dual application, as a EV V2G Fast Charger and as a Stationary Battery Charger. The second way will be the implementation of a management system for the V2G chargers in order to become electric vehicles an active element of the grid and contribute to its stabilization prioritizing.

TABLE 1 – Projects administrative information

Project name (and number of partners)	**Website**	**Duration**	**Budget**	**Funding agency**
ACES (4)	www.aces-bornholm.eu	42 months (April 2017 – September 2020)	1.4 M€ of which 0.7 M€ of public support	Danish agency for development and demonstration (EUDP)
ACDC (5)	www.acdc-bornholm.eu	36 months (April 2020 – March 2023)	2.4 M€ of which 1.3 M€ of public support	Danish agency for development and demonstration (EUDP)
BDL (8)	https://www.iip.kit.edu/english/1064_4835.php	36 months (May 2019 – April 2022)	21.7 M€ of which 10.3 M€ of public support	German Federal Ministry for Economic Affairs and Energy (BMWi)
WiseGrid (21)	https://www.wisegrid.eu/	42 months (November 2016 – April 2020)	17.6 M€ of which 13.9 M€ of public support	European Horizon 2020
Charging infrastructure 2.0 (7)	https://www.iee.fraunhofer.de/de/projekte/suche/laufende/ladeinfrastruktur2-0.html	48 months (November 2018 – November 2022)	12.0 M€ of which 9.0 M€ of public support	German Federal Ministry for Economic Affairs and Energy (BMWi)
FuChar (13)	https://www.sintef.no/projectweb/fuchar/	42 months (February 2019 – July 2023)	2.6 M€ of which 2.0 M€ of public support	Research Council of Norway – ENERGIX
ModFlex (7)	https://www.sintef.no/en/projects/modelling-flexible-resources-in-smart-distribution/	60 months (January 2016 - December 2020)	1.5 M€ of which 1.2 M€ of public support	Research Council of Norway – ENERGIX
EU-Sysflex (34)	https://eu-sysflex.com/	48 months (November 2017 – October 2021)	26.5 M€ of which 20.3 M€ of public support	European Horizon 2020
SUMA (8)	https://www.destec.unipi.it/ricerca/progetti-nazionali-ed-internazionali/far-fas-2014/568-progetto-suma	24 months (November 2018 – November 2020)	4.5 M€ of which 2.4 M€ of public support	Tuscany (Italy) region on Italian FAR-FAS funds
CAR (10)	www.sbcar.eu	45 months (January 2018 – September 2021)	2.0 M€ of which 1.5 M€ of public support	European Interreg South Baltic
ELBE (9)	www.elbe-hh.de	48 Months (December 2018 – November 2022)	29.2 M€ of which 20.2 M€ of public support	German Federal Ministry for Economic Affairs and Energy (BMWi)
INSULAE (26)	http://insulae-h2020.eu/	48 months (April 2019 – March 2023)	12.0 M€ of which 10.0 M€ of public support	European Horizon 2020

III. CONCLUSIONS

This paper presented twelve European demonstration projects that investigate the integration of electric vehicles in the power grid. Although European countries have different characteristics regarding car usage, electricity prices, energy production, etc., the projects show similar interests on electric vehicles as a possible solution to the uncontrollability of renewable energy production. The projects highlight the importance of having controllable chargers, that fulfill both grid and user needs. The bi-directionality of the charger allows enhancing the amount of flexibility of the individual vehicles, although with higher investment costs and risk of not being accepted by the user due to potential wear of the battery. Initially, the interest in controlled chargers rose from the problem of fluctuating renewable production, but the solution cannot stand only on the grid interests, as it has to meet also the user requirements. For this reason, most of the projects have in common two characteristics: field tests with different electric vehicles and chargers and economic investigations. Both of them aim at finding solutions considering both grid and users perspectives. Users are active components of the technology transition, and the technical feasibility is not enough for their acceptance. There is a need for a market, where users can earn something in return of the provided service. Related to this open question, another investigated topic is battery usage and its degradation. Users buy electric vehicles with the purpose of driving. For this reason it is important to ensure that, even though they provide grid regulation with their battery, they will still be able to use the vehicle in the same way and for the same amount of time, otherwise an economic remuneration for the additional battery degradation has to be considered. It is a common understanding that the electric vehicle grid integration is technically feasible, but there are still many uncertainties for what concerns the technical standards, market perspective and the user acceptance.

References

[1] G IPCC, 2018: Summary for Policymakers. V. Masson-Delmotte, et al. (eds.). World Meteorological Organization, Geneva, Switzerland.

[2] US Department of Energy, Global Energy Storage Database. Available online: https://www.energystorageexchange.org/

[3] H. Lund, W. Kempton, “Integration of renewable energy into the transport and electricity sectors through V2G,” Energy policy, vol. 36, pp. 3578-3587, Sep. 2008.

[4] N. O’Connel, P. Pinson, H. Madsen, M. O’Malley, “Benefits and challenges of electrical demand response: A critical review,” Renewable and Sustainable Energy Reviews, vol. 39, pp. 686-699, 2014.

[5] N. S. Pearre, H. Ribberink, “Review of research on V2X technologies, strategies, and operations,” Renewable and Sustainable Energy Reviews, vol. 105, pp. 61-70, 2019.

[6] A. Thingvad, L. Calearo, P. B. Andersen, M. Marinelli, M. Neaimeh, K. Suzuki, K. Murai, “Value of V2G Frequency Regulation in Great Britain Considering Real Driving Data,” Innovative Smart Grid Technologies (ISGT Europe), 2019 IEEE PES International Conference and Exhibition on, pp. 1-6, Bucharest, 29 Sep. - 02 Oct. 2019.

[7] G. Pasaoglu, D. Fiorello, A. Martino, G. Scarcella, A. Alemanno, A. Zubaryeva, C. Thiel, “Driving and parking patterns of European car drivers – a mobility survey,” Joint Research Center Scientific and Policy report, pp. 1-112, 2012.

[8] K. Clement-Nyns, E. Haesen, J. Driesen, “The impact of vehicle-to-grid on the distribution grid,” Electric Power Systems Research, vol. 81, no. 1, pp. 185–192, 2011.

[9] A. Rodriguez-Calvo, R. Cossent, P. Frías, “Integration of PV and EVs in unbalanced residential LV networks and implications for the smart grid and advanced metering infrastructure deployment,” International Journal of Electrical Power and Energy Systems, vol. 91, pp. 121–134, 2017.

[10] G. Lacey, G. Putrus, E. Bentley, “Smart EV charging schedules: supporting the grid and protecting battery life,” IET Electrical Systems in Transportation, 2017, vol. 7, p. 84-91.

[11] K. Knezović, S. Martinenas, P. B. Andersen, A. Zecchino, M. Marinelli, “Enhancing the role of EVs in the grid: field validation of multiple ancillary services provision,” Transportation Electrification, IEEE Transactions on, vol. 3, no. 1, pp. 201-209, Mar. 2017.

[12] P. B. Andersen, T. Sousa, A. Thingvad, L. S. Berthou, M. Kulahci, "Added Value of Individual Flexibility Profiles of Electric Vehicle Users For Ancillary Services," 2018 IEEE International Conference on Communications, Control, and Computing Technologies for Smart Grids (SmartGridComm), Aalborg, 2018, pp. 1-6.

[13] J. Hu, H. Morais, T. Sousa, M. Lind, “Electric vehicle fleet management in smart grids: A review of services, optimization and control aspects,” Renewable and Sustainable Energy Reviews, vol. 56, pp. 1207-1226, 2016.

[14] P.B. Andersen, S. Hashemi Toghroljerdi, T. Sousa, T. M. Sørensen, L. Noel, B. Christensen, “Cross-brand validation of grid services using V2G-enabled vehicles in the Parker project EVS 31 and EVTeC 2018, Kobe, 30 Sep. – 03 Oct 2018

[15] K. Knezović, M. Marinelli, A. Zecchino, P. B. Andersen, C. Træholt, “Supporting involvement of electric vehicles in distribution grids: Lowering the barriers for a proactive integration,” Energy, vol. 134, pp. 458-468, Sep. 2017.

[16] T. Kaschub, P. Jochem, W. Fichtner, “Interdependencies of Home Energy Storage between Electric Vehicle and Stationary Battery,” World Electric Vehicle Journal, 6 (4), 1144–1150, 2013.

[17] A. Thingvad, C. Ziras, M. Marinelli, “Economic Value of Electric Vehicle Reserve Provision in the Nordic Countries under Driving Requirements and Charger Losses,” Journal of Energy Storage, vol. 21, pp. 826-834, Feb. 2019.

[18] M. Marinelli, S. Martinenas, K. Knezović, P. B. Andersen, “Validating a centralized approach to primary frequency control with series-produced electric vehicles,” J. of Energy Storage, vol. 7, pp.63-73, Aug. 2016.

[19] L. Calearo, A. Thingvad, K. Suzuki, M. Marinelli, “Grid Loading due to EV Charging Profiles Based on Pseudo-Real Driving Pattern and User Behaviour,” Transportation Electrification, IEEE Transactions on, vol.5, Sep 2019.

[20] A. González-Garrido, A. Thingvad, H. Gaztañaga, M. Marinelli, “Full-Scale Electric Vehicles Penetration in the Danish Island of Bornholm – Optimal Scheduling and Battery Degradation under Driving Constraints,” *Journal of Energy Storage*, vol. 23, pp. 381-391, June 2019.

[21] A. Thingvad, M. Marinelli, “Influence of V2G Frequency Services and Driving on Electric Vehicles Battery Degradation in the Nordic Countries,” EVS 31 and EVTeC 2018, Kobe, 30 Sep. – 03 Oct 2018

[22] L. Calearo, A. Thingvad, M. Marinelli, “Modelling of Electric Vehicles for Degradation Studies,” Universities Power Engineering Conference (UPEC), 2019 Proceedings of the 54th International, pp. 1-6, Bucharest, 3 Sep. – 6 Sep. 2019.

[23] L. Calearo, A. Thingvad, H. H. Ipsen, M. Marinelli, “Economic Value and User Remuneration for EV Based Distribution Grid Services,” *Innovative Smart Grid Technologies (ISGT Europe), 2019 IEEE PES International Conference and Exhibition on*, pp. 1-6, Bucharest, 29 Sep. - 02 Oct. 2019.

[24] A. Zecchino, A. Thingvad, P. B. Andersen, M. Marinelli, “Test and Modelling of Commercial V2G CHAdeMO Chargers to Assess the Suitability for Grid Services,” World Electr. Veh. J., 2019, Vol 10

[25] A. Zecchino, A. M. Prostejovsky, C. Ziras, M. Marinelli, “Large-scale Provision of Frequency Control via V2G: the Bornholm Power System Case,” *Electric power system research*, vol. 170, pp. 25-34, May 2019.

[26] A. Mesbah, "Stochastic model predictive control: An overview and perspectives for future research." IEEE Control Systems Magazine Vol. 36 (6), pp. 30-44. 2016.

[27] P. Palensky, et al. "Modeling intelligent energy systems: Co-simulation platform for validating flexible-demand EV charging management." IEEE Transactions on Smart Grid Vol 4 (4), pp 1939-1947. 2013.

[28] G. Anestis Anastasiadis, et al. "Economic benefits from the coordinated control of Distributed Energy Resources and different Charging Technologies of Electric Vehicles in a Smart Microgrid," Energy Procedia vol. 119, pp. 417-425. 2017.

[29] H. Saele and I. Petersen, "Electric vehicles in Norway and the potential for demand response," 2018 53rd International Universities Power Engineering Conference (UPEC), Glasgow, 2018.

[30] P. Hasanpor Divshali, C. Evens, “Stochastic bidding strategy for Electrical Vehicle Charging Stations to Participate in Frequency Containment Reserves Markets,” *IET Gener. Transm. Distrib.*, 2020.

[31] P. Hasanpor Divshali, C. Evens, “Optimum Day-ahead Bidding Profiles of Electrical Vehicle Charging Stations in FCR Markets”, 29th Power Systems Computation Conference (PSCC 2020), Porto, 2020.

[32] P. Hasanpor Divshali, C. Evens, “Behaviour Analysis of Electrical Vehicle Flexibility Based on Large-Scale Charging Data,” in IEEE PES Powertech 2019, Milan, 2019.

[33] M. Ceraolo, G. Luzemberger, D. Poli, C. Scarpelli, L. Sani: “Experimental analysis of LFP lithium cells aging”. Accepted for publication to EEIC 2020, International conference on environment and electrical Engineering, Madrid, June 2020

[34] L. Calearo, M. Marinelli, “Strategic manual for EV charger installations,” CAR Deliverable, Jul 2019.