Project acronym: eVolution2Grid

Project full title:

Innovative Vehicle to Grid model for electric mobility deployment in Europe Nanomaterial based

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Disclaimer

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List of abbreviations and Definitions

Abbreviation	Definition
BEV	Battery Electric Vehicle
CO_2	Carbon dioxide
AFID	Alternative Fuel Infrastructure Directive
DSO	Distribution System Operator
EC	European Commission
EM	European Member
EU	European Union
EV	Electric vehicle
FCEV	Fuel Cell Electric Vehicle
LCA	Life Cycle Analysis or Life Cycle Assessment
MSs	Member States
PEV	Plug-In Electric Vehicle
PNIRE	Piano Nazionale Infrastrutturale per le Ricariche dei veicoli ad alimentazione Elettrica
RES	Renewable Energy Sources
TSO	Transmission System Operator
US	United States
V2G	Vehicle To Grid

Definitions

- ***Electric Vehicles*****:** (EVs), according to EU Directive 2014 94 UE means "a motor vehicle equipped with a powertrain containing at least one non-peripheral electric machine as energy converter with an electric rechargeable energy system, which can be recharged externally".
- ***Charging infrastructure*****:** supplies electric energy for the recharging of electric vehicles, such as plug-in electric vehicles, including electric cars, neighborhood electric vehicles and plug-in hybrids.
- ***Smart grids*****:** intelligent interconnected network which allows distribution and exchange of energy in a bidirectional way.
- ***Vehicle 2 Grid (V2G)*****:** describes a system in which electric vehicles, communicate with the power grid to sell demand response services by either returning electricity to the grid or by throttling their charging rate.

Summary

This deliverable provides an analysis of the current policies and regulatory schemes for the electromobility services in Europe, identifying and assessing regulatory gaps and limits with a main focus on the V2G paradigm, i.e. the bidirectional energy exchange between vehicle/charging station and electrical network, which is the core subject of study of the "V2G" EME project. In doing so, IREN has focused on the evaluation of electric network and energy market related constraints to be taken into account when defining future legislative requirements and suggestions.

The main objectives of the eVolution2G - V2G project is to develop, test and optimize an integrated V2G solution, contributing to reduce air pollution, assessing and evaluating benefits and obstacles and defining new business opportunities. The V2G project is currently in its initial phases and this deliverable (D1.1) will be used as guidance to describe the state of the art of legislation, regulation and policy about e-mobility and V2G in Europe, to be taken into account in the project's activities.

More specifically, the objectives of this document are:

- To highlight the market of e-mobility (EVs and Smart Grids) in Europe;
- To provide a clear picture of the policy and legislation and its evolution about e-mobility, particularly focusing on V2G in Europe;
- To outline the constrains and give recommendations for future plans about regulation design.

The document is articulated in 6 main chapters:

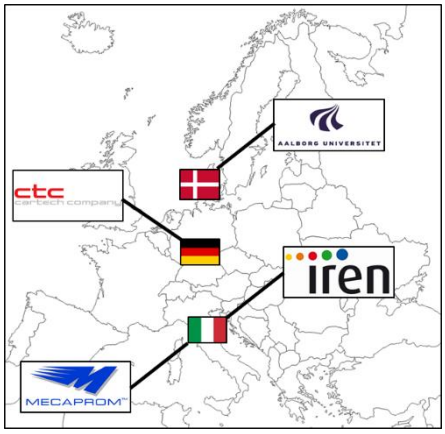
- In Chapter 1 is briefly recapped the aim of the project, as context in which this document has been structured;
- Chapter 2 describes the main market, legislations and policies in Europe on e-mobility;
- Chapter 3 explains the key elements of the V2G paradigm;
- Chapter 4 describes the situation in Italy analysing its current legislation;
- Chapter 5 analyses the current situation of V2G in other European Countries included in the "eVolution 2 Grid" project: Germany and Denmark;
- Chapter 6 gives possible suggestions and constraints to be considered for future regulation framework design and implementation.

It is worth noticing that in the present document the current legislation in general at EU level is reported, as well as for different European Countries. Special focus has been given to Italian legislation due to the fact that the pilot for the "eVolution2Grid" project will be carried out in Italy, and two of the main partners of the project (IREN-Coordinator and MECAPROM) are both from Italy. In addition, two specific paragraphs have been added on Germany and Denmark, to study the situation of the other two Countries represented in the consortium.

The partners of the EME-V2G project will take the information of this document as a reference basis for the deployment of the activities and pilots foreseen in the project and will monitor the eventual progression of the legislative landscape in Europe, so as to consider eventual major changes during the life of the project.

1. V2G project

"V2G-eVolution 2 grid" project is a research innovation project funded under the Programme Electric Mobility Europe 2016 and coordinated by IREN. The overall objective of the project is to contribute to a zero CO_2 emissions future, developing testing and optimizing an integrated V2G solution composed by a light quadricycle enabling V2G, a bidirectional V2G-enabling charging infrastructure and an Energy Management and Control System. During the project, the novel integrated solution will be tested in real simulated conditions in two real case studies (public and household), evaluating benefits and obstacles at technological and regulatory level, assessing its business potential and creating awareness about the results of the project, engaging stakeholders, public administrations, car owners, etc. The consortium is composed by 3 companies (1 large company and 2 SMEs) and a research group, all coming from Countries and Regions directly participating to the EME Programme. In particular, the partners are: IREN (coordinator, Large company, ITA), MECAPROM (SME, ITA), CTC (SME, GER) and Aalborg University (research group, DEN). The project activities are divided into 5 complementary and interlinked work packages and 14 Tasks, with a coherent timing, and distribution of roles and responsibilities among all partners.



In particular, WP1 focusses on defining all technical, functional and market requirements (i.e. grid, vehicle, charging stations, integrated system) and analysing the status quo of legislations and regulatory schemes on EM in Europe and the existing pilot testing solutions.

The present document addresses the latter objective, by providing an analysis of the current legislation, market and trend about electromobility services in Europe, identifying and assessing potential regulatory gaps and limits, with a main focus on the V2G paradigm.

2. E-mobility: market, policy and legislation in Europe

The role of Electric-mobility is essential to achieve a sustainable mobility with zero CO_2 emissions. It involves numerous players and components, which include electric vehicles, charging infrastructure, grids (and smart grids), energy distributors and in general the whole energy market. Global cumulative sales of PEVs reached 2 million units at the end of 2016 [1], 3 million in November 2017 [2], and the 4 million milestone in September 2018 [3]. In this context, Europe covers the 26% of the global market, second only to China with almost 50% and followed by U.S with 18% [4]. In European Countries the highest penetration of EVs is registered in Norway with almost 275,000 PEVs out of one million sold until June 2018, followed by France, United Kingdom, Germany and The Netherlands [5]. In order to increase the development of EVs, reducing the environmental pollution, more charging infrastructures are needed to supply electric energy for the recharging of EVs at home, at work and in the cities through the grids. To achieve the goal, policies and legislations are progressively being changed and adapted both at European and Member State level in several Countries of Europe.

European Commission has worked on emissions reduction for years, designing policies aimed at establishing the long-term goal of 80%-95% of emissions reduction by 2050, compared to 1990 baseline [6]. The main strategies and related "policy packages" adopted by the European Commission are:

- Europe 2020 [7] – focusing on measures and instruments that EU members must improve to guarantee an intelligent and efficient energy use, promoting sustainability and/with inclusive development.
- Transport 2050 [8] – which established the roadmap that transportation sector must follow, with different challenging goal at the end of the path, such as enrolment of ecologic mobility, exploiting low impact CO_2 emission technologies.

In this context, the development of EVs is essential to achieve these goals, but in order to make the shift from petroleum-based engines to electric mobility possible, several actions are needed and relevant laws/decrees have been issued starting from 2009, the main ones being:

- Directive 2009/28/EC [9] - Renewable Energy Directive (RED) - European commission (EC) initiated the promotion of the use of energy from renewable sources, indicating the mandatory minimum quota of 20% of RES in the gross national consumption and 10% of RES in transport.
- Directive 2009/33/EC [10] - The objectives of the directive are i) promoting and stimulating the market for clean and energy-efficient vehicles and ii) improving the contribution of the transport sector to the environment, climate and energy policies of the Community. According to this Directive, all operators must take into account lifetime energy and environmental impacts of vehicles, including energy consumption and emissions of CO_2 and of certain pollutants (according to LCA standards), when producing and purchasing road transport vehicles.
- Regulation (EC) No 443/2009 [11], EC sets the average CO_2 emissions for new passenger cars at 130 g CO_2/km, by means of improvement in vehicle motor technology. From 2020 onwards, this Regulation sets a target of 95 g CO2/km as average emissions for the new car fleet. Moreover, it proposes a system of emissions credits and super-credits for the eco-innovation of vehicles manufacturers.

Following this trend, the EVs represent the evolution of the "engine mobility" which allow to drastically reduce CO_2 emissions from a technical and performance point of view, but being EVs engines users of electricity and connected to the electricity grid , in order to have a fast and large implementation of their use a more specific legislation is needed involving all different players within Energy market.

So, new regulation has been issued concerning common rules for the internal market in electricity, that specifically deals with the trade and supply of energy and involves DSO and TSO, including:

- Directive 2009/72/EC [12] establishes common rules for the generation, transmission, distribution and supply of electricity, together with consumer protection provisions, with a view to improving and integrating competitive electricity markets in the Community.

According to several sources, one of the main constraints is the lack of charging infrastructures for EVs.

- As a fact, CARS 21 high-level group presented on 6 June 2012 its final report, describing the lack of an EU-wide harmonised alternative fuel infrastructure as one of the major factors which hampers the market introduction of vehicles using alternative fuels [13].

To fill this gap and to allow the diffusion of EVs, in 2014 the European Commission issued:

- Directive 2014/94/EU [14] of Alternative Fuel Infrastructure (AFID), which establishes a common framework of measures and minimum requirements for the deployment of

alternative fuels (including electricity) infrastructure in the Union, including recharging points for electric vehicles. Then AFID has to be implemented by single Member States within their respective National plans. According to AFID an appropriate number of recharging points accessible to the public have to be put in place by 31 December 2020. Moreover, the directive foresees a competitive market for the development and use of AFI and a neutral role of electric DSOs, which have to cooperate with recharging operators without any discrimination.

In addition to the above, it is worth reporting here that the European policy and vision about the energy market is clear;

- On 30th November 2016 the EC published "Clean energy for all Europeans" the so-called "Winter package" [15] which includes eight legislative proposals (some of which are waiting for approval) covering:
    - Energy Performance in Buildings;
    - Renewable Energy;
    - Energy Efficiency;
    - Governance;
    - Electricity Market Design (the Electricity Regulation, Electricity Directive, and Risk-Preparedness Regulation);
    - Rules for the European Regulator agency ACER.

  with the aim to facilitate the transition to a 'clean energy economy' and to reform the design and operation of the European Union's electricity market. More specifically, the objectives of the package include:

    - The decarbonization of the transport sector and the promotion of renewable energy (modifying RED 2009/28/CE);
    - The role of DSOs in the e-mobility (New Electricity Market Design);
    - The creation of a new network of DSOs and the promotion of the collaboration between DSOs and TSOs;
    - The use of least 27% of renewable energy UE by 2030 in the European energy mix.

On the other hand, in order to improve a sustainable mobility, starting from 2017 the EC issued the "Mobility Package". It is a collection of 3 initiatives concerning the governance of commercial road transport in the European Union and intends to address a number of problems or support specific developments within the European road transport sectors, including e-mobility, i.e.:

- Mobility Package 1, "Europe on the Move" [16], is aimed at making traffic safer, encouraging smart road charging, reducing CO2 emissions.
- Mobility Package 2, "Clean Mobility Package" [17], includes:

  A communication:

    - to highlight actions to complement and better implement national policy frameworks (NPFs), to close the gap with the trans-European transport network (TEN-T) and stimulate investments for alternative fuel infrastructures in urban areas.

  Two proposals for directives revision:

    - Revision of Directive 2009/33/EC on the promotion of clean and energy-efficient road transport vehicles.
    - Revision of Directive 92/106/EEC on combined transport of goods between Member States.

  Two proposals for regulation:

- Regulation No 1073/2009 on common rules for access to the international market for coach and bus services.
- Specific emissions target post-2020 for cars and vans (-15% by 2025; -30% by 2030 compared with 2021).

Improvement of AFID by:

- Additional EU financial support of up to EUR 800 million.
- A 200 M€ fund to promote the creation of a European Battery Alliance, to create a competitive manufacturing value chain in Europe with sustainable battery cells at its core.

- Mobility Package 3, "Europe on the Move III" [18] includes:
  - A dedicated communication on Connected and Automated Mobility to make Europe a world leader for autonomous and safe mobility systems;
  - Two legislative initiatives on vehicle and pedestrian safety, and on infrastructure safety management;
  - Legislative initiatives on CO_2 standards for trucks;
  - A strategic Action Plan for European Battery Alliance, adopting a comprehensive set of concrete measures to develop an innovative, sustainable and competitive battery 'ecosystem' in Europe.

Confirming the aim of increasing e-mobility to achieve a stronger CO_2 emission reduction by 2050, relating to the "Winter Package", the EC issued the directive 2018/844/EU - Energy Performance of Building Directive [19] (modifying the 2010/31/EU – EPBD) with regard to non-residential buildings (new or in renovation) with more than ten parking spaces, Member States shall ensure the installation of at least one recharging point and the set-up of electric infrastructures for future charging points implementation.

Recently (December 2018) the European Parliament has approved the revised Energy Efficiency Directive, the revised Renewable Energy Directive and the new Governance Regulation [20]. Now a formal signature will take place.
This will be followed by the publication of the texts in the Official Journal of the European Union in December 2018, with the new legislation entering into force 3 days later.
The main achievements of these three laws are:

- Renewable Energy Directive II (RED II):
  - target of renewable energy (from 27%) to 32% by 2030 (with review clause in 2023);
  - target 14% by 2030 of renewable energy for transport consumption;
  - clear and stable regulatory framework on self-consumption;
  - improvement of the sustainability of the use of bioenergy;
- Energy Efficiency:
  - new energy efficiency target for the EU for 2030 of at least 32.5%, with an upwards revision clause by 2023;
  - duty of annual saving of energy consumption of 0.8% for the period 2021 to 2030;
- Governance of the Energy Union and Climate Action:
  - duty for each Member State of preparing a national energy and climate plan for the period 2021 to 2030.

EU has now adopted four of the eight legislative acts which make up the Clean Energy for All Europeans package, published by the European Commission on 30 November 2016.

All the above-mentioned EU actions go towards a sustainable future reducing greenhouse gas emissions and energy consumption. These are the most important motivations for the electrification of transport. Electricity does not only allow delivering energy from renewable sources to the vehicles, but also the possibility to use vehicle batteries connected to the smart grid for temporary storage of energy from fluctuating sources such as solar and wind. The next step will be the development of V2G technology that allow to reduce pollution, saving energy and money by enabling a bidirectional flow of energy between the grid and the vehicles, that become part of the new "distributed energy production and storage" paradigm being promoted by the European Commission policy makers (see next paragraph for more details).
Even if huge efforts have been done from European policy makers in the last decade, it is difficult to predict at this moment if and how much the V2G model will be implemented in Europe, also due to the very recent timing in important developments and the fact that the application of major policy packages is still at its beginning. Authors think that probably at the end of the EU process about Winter Package and Mobility Package it will be possible to know the real development – or not – of a sustainable mobility and of V2G.

Only the attention and the effort of all the States in European Union will make possible the achievement of an European regulatory framework really environment and safe – oriented.

3. The future of e-mobility: the V2G paradigm

Vehicle-to-grid (V2G) allows electric vehicles to charge and discharge electricity to and from the grid in a bidirectional flow of energy. In this way V2G vehicles, working as high power batteries, can provide power to help balance loads by "valley filling" (charging at night when demand is low) and "peak shaving" (sending power back to the grid when demand is high) contributing to the energetic balance and bringing economic advantages to the EVs owners. In the last decade, consumer demand is shifting in favour of e-mobility, thanks to government support for electric vehicles (EV), investments in EV-charging infrastructure, purchase subsidies, tax exemptions, increase in OPEX of traditional private mobility, decrease of EV costs (Fig. 1) [21]. A recent study conducted by ABI Research, a market-foresight advisory firm providing strategic guidance on the most compelling transformative technologies, found that V2G could enable consumers to save as much as 272 US$ per year on their energy bill as well as bring significant cost-savings and additional revenues of 2 billion US$ to global energy suppliers in 2025. V2G will not only enable consumers to make cost savings of up to 15% on their household energy bill but will also critically load shift demand from peak to off-peak [22].

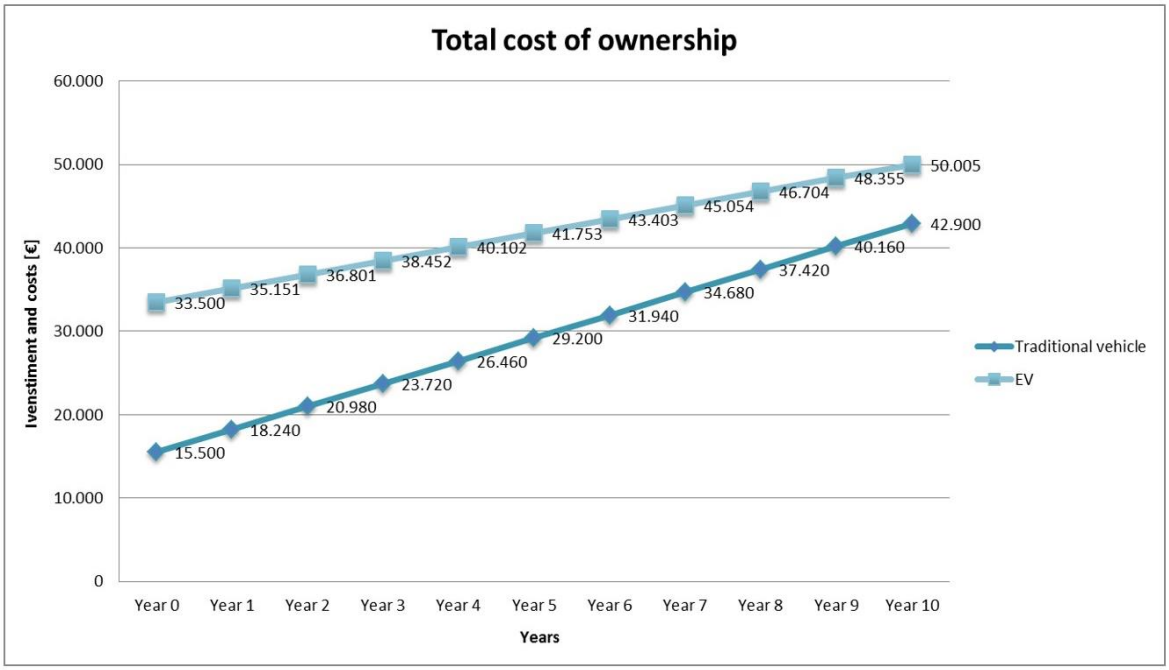


Figure 1: Comparison between traditional and electric vehicles

In the last decade there has been an increasing interest in the research and development of technologies enabling the V2G from a technological point of view, i.e. the scientific production achieved the number of 200 publications per year during the last four years (Fig. 2) [23].

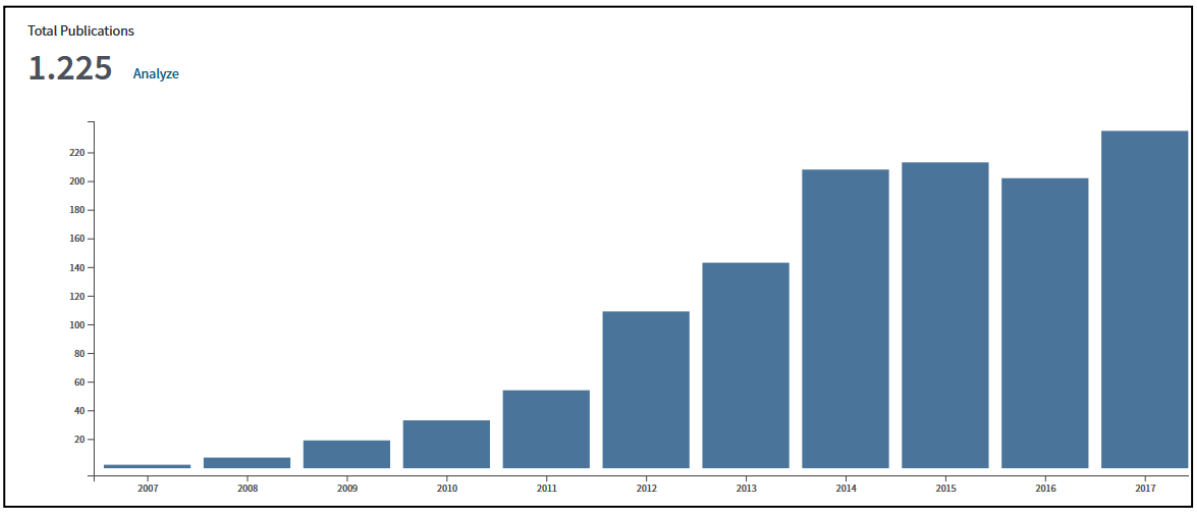


Figure 2: Citation report for 1.225 results about V2G technology from Web of Science Core Collection between 2007 and 2017.

On the other hand, global R&D organizations are working to improve and promote this technology also through the development of several pilot projects, some of which are already close to the commercialization or with high TRLs (Technology Readiness Level). Globally, there are 50 V2G projects, of which 25 are in Europe, 18 in North America, and 7 in Asia. In Europe, Northern European states dominate the presence of pilots with the Netherlands, Denmark, UK and Germany (Fig. 3) [24].

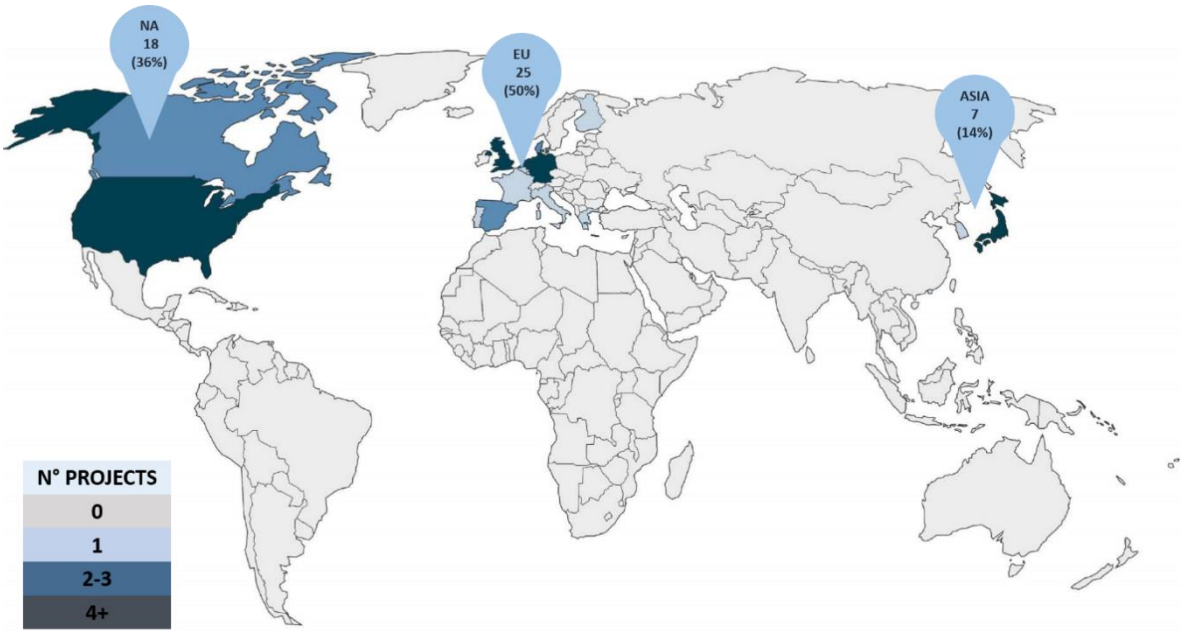


Figure 3: Revised picture from "V2G Global Roadtrip: Around the World in 50 Projects" report

We present here a list of some European pilot projects which have demonstrated to play a crucial role in the V2G development, focusing the attention on DSO services, impact on the customers, with more information on the Country, years of the project, status of development (TRL) and brief description [24]:

- *"Smart Solar Charging"*, Netherlands, 2014-2019: TRL 7. It is a pioneering AC V2G project with 22 chargers installed as part of city car share scheme and solar in Lombok neighbourhood. The core focus of this project, coordinated by Lomboxnet, is developing an AC standard for V2G and developing a system that facilitates and speeds up the rollout of electric vehicle, in particular using the Renault Zoe as vehicle, Stedin as DSO and solar power. Chargepoint will be market ready by end of 2018.
- "City-zen Smart City", Netherlands, 2014-2019: TRL 7. It has a pioneering focus on DSO services and adopts a holistic commercial, social and technical approach, with multiple power sector use cases. The network is composed by the charging station supplier NewMotion (4 chargers installed), the network specialist Alliander, the tech company Enervalis and the innovation platform Amsterdam Smart City.
- *"Parker",* Denmark, 2016-2018: TRL 9. The technology used by the project has been thoroughly tested and validated and it is ready for the commercialization, using high number of charger infrastructures (50). It includes Nissan vehicles (and others), charging infrastructure ENDESA and aggregation software NUVVE. Project sought to test ability of electric vehicles to provide grid services using real world fleets to Identify and address barriers to commercialisation and to compare capability of different cars. Parker builds on two previous projects, the EDISON and Nikola projects, which have already laid the foundation for understanding the electric vehicle's potential in balancing the Danish power system.
- *"Grid Motion",* France, 2017-2019: TRL 9. The project, ready for the market, with 15 chargers installed, is intended to evaluate the savings EV users could achieve under real-life conditions with the implementation of smart charging and discharging. The project uses Peugeot iOn or Citroën C-ZERO vehicles with Enel bidirectional charging stations testing "smart" charging and discharging (V2G services) and NUVVE as aggregator.

- *"Network impact",* UK, 2017-2020: TRL 7. The project aims to understand impacts (negative and positive) and interconnection process for V2G-enabled EVs on the distribution network. Scope also includes investigation of commercial options for connection offers and customer usage behaviour. Northern Power Grid (NPG) monitors the installation of chargers commercially installed by NUVVE, with 16 chargers installed.
- "Re-dispatch", Germany, 2018-2021: TRL 8. Partners of the project are the transmission system operator TenneT, the energy service provider The Mobility House and the automotive manufacturer Nissan. This is a demonstration project proving technical ability to use TSO's own field service fleet in addressing transmission constraints in Germany. Highly distributed chargepoint locations with 10 chargers installed.

Although other OEMs participate in V2G projects, Mitsubishi, Nissan and Renault clearly dominate the market and the R&D and piloting efforts, with Mitsubishi iMiev, Mitsubishi Outlander, Nissan Leaf 2. ZERO, Nissan eNV200/Evalia, Renault Zoe.
What is clear from these pilot projects is that the electricity network and market services are underrepresented in the V2G field since the market value is unclear and the service specification and route to market are not normally well understood. This appears to reflect lack of service maturity more than inherent V2G model gaps. Moreover, DC solutions have dominated to date, with DC chargers featured in 93% of projects (Fig. 4) [24] However, there remains significant interest in AC, with more AC compatible vehicles expected to be tested and validated over the coming years. DC chargers use the CHAdeMO protocol. CHAdeMO is a DC charging standard for electric vehicles and it was the first ever global fast charging protocol for EVs. It enables seamless communication between the car and the charger [25].

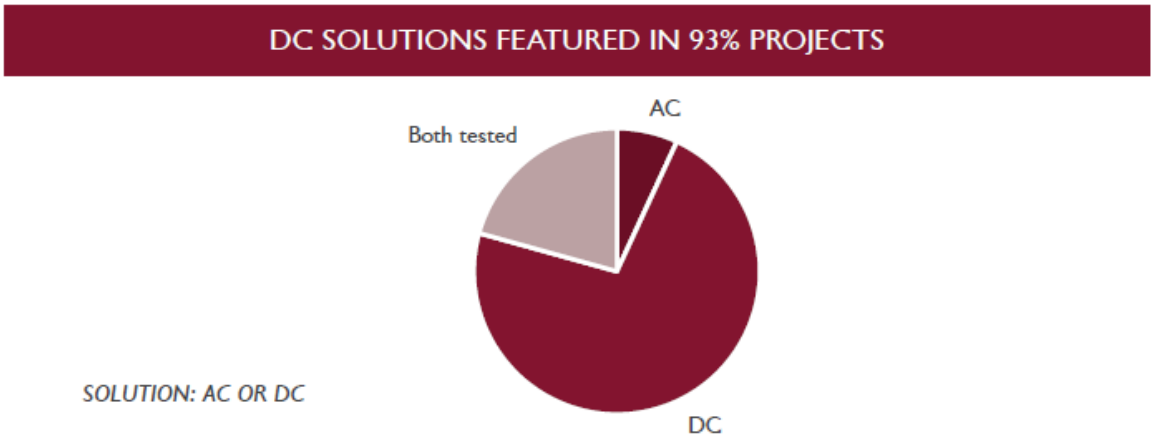


Figure 4: DC solution have dominated to date with DC chargers featured in 93% of projects. However there remains significant interest in AC, with more AC compatible vehicles expected over the coming years.

Although the V2G can be considered a game-changer technology in the field of sustainable mobility and energy, it is still in an early development phase and there is no defined legislation and standard policy. It is subjected to the laws of e-mobility, and includes EVs, charging infrastructures, smart grids, energy distribution and transmission, energy market. Regulation must be changed at European and National level to remove blocking points and accommodate for emerging business models and new ways of interaction with the grid. In the following paragraphs is reported the current legislation for different European Countries, with a special focus on Italian legislation due to the fact that the pilot for the "eVolution2Grid" project will be carried out in Italy.

4. Current situation in Italy

The current situation about V2G technology sees Italy in delay in the application, compared with the other MSs which involve several aspects of e-mobility. Italy started recently to put resources to reduce CO_2 emissions in the field of renewable energies in general, providing 3 tranches of 40 million euros (2013-2014-2015) for the purchase of not polluting vehicles in the country. Only 15% of the whole incentives was directed to EVs (up to 5.000 euros per vehicle with emission declared under 50 g of CO_2/Km). 35 % of the fund, instead, it was allocated for vehicle with emission lower than 90 g of CO_2/Km. The remaining 50% of the fund, has been allocated for companies which have purchased vehicles with emission not greater than 120 g of CO_2/Km. This allowed the development of several alternative fuels such as methane and liquefied petroleum gas vehicles, fostering their diffusion in comparison with EVs.

Italy did a lot of little steps along the EM, but not enough. The future definition of European Regulatory Framework and a strong political national position about EM might address the development of Italian Legislation, and so really promote a more ecological and sustainable mobility with important economic and social benefits.

The first law concerning sustainable mobility was the D.lgs. 28/2011 [26], that adopted the Directive 2009/28/EC (Renewable Energy Directive) and so defined the incentive schemes for renewable energy sources in transport.

After that, it is important to report here the Law 134/2012 [27] that imposes the 'National Infrastructure Plan for Charging Vehicles fed by Electricity' "PNire" (updated in 2015 by a Decree of President of Ministers' Council of 26th September 2014), which defines the guidelines for guaranteeing the united development of electric vehicle charging services in Italy. Given the not yet consolidated scenario about the national e-mobility market, PNire divides development period into two main and consequential phases until 2020:

- First phase (2013-2016): definition and development of EVs, identifying the dimension of EV reality in Italy and the minimal number of public and private charging points to install. Moreover, there are defined technological standards and policy development to incentive the EVs;
- Second phase (2017-2020): stabilization, which provides norms for municipalities according to EU's directives and the consolidation of installation of such infrastructure needed. In the updated version there are present the definition of type of recharging point and electric sockets.

In order to incentivize the development of e-mobility, PNire provides funds for Metropolitan and Non-metropolitan areas for:

- Public charging infrastructures;
- Plants for fuel distribution;
- Household charging infrastructures providing incentives for the installation

PNire National objectives by 2020 about fast and ultrafast charging points is to install around 2.000-6.000 charging stations and 4.500-13.000 slow/accelerate charging points along national roads (approximately 1 charging point every 10 EV).

Later, the Legislative Decree n. 257/2016 [28], adopting the Directive 2014/94/EU (Alternative Fuel Infrastructure Directive), contains measures for promoting the building of alternative fuel infrastructures, in particular:

- By 31st December 2020 it will be the building of an adequate number of charging stations;

- The 25% of new vehicles of Public Administrations has to be powered by alternative fuels;
- Since 2018 the new/renovated non-residential buildings with more than 500 sm and the new/renovated residential buildings with more than 10 apartments have to predispose the placement of recharging points;
- At least 20% of parking spaces must have a recharging point.

A Ministry Decree of 4th August 2017 (transposition of Legislative Decree n. 257/2016) intends to promote a coordinated application of Guidelines for the drafting of UPSM, the (10 years) Urban Plan for Sustainable Mobility that Municipalities with more than 100,000 inhabitants have to draw by October 2019 and update every 5 years.

Integrated Text for Construction (transposition of Legislative Decree n. 257/2016) obliges the predisposition of recharging points for new buildings since 2018 for obtaining a compliance certificate, but only some Municipalities are currently compliant.

The Law n. 205 [29] of 27th December 2017 establishes a Ministry Decree by 30th June 2018 (not yet issued) verified by ARERA (Italian Regulatory Authority for Energy, Networks and Environment) concerning criteria for the diffusion of the Vehicle to Grid (V2G) technology, also defining rules to electric market participation.

At the end of 2017 Italian Government presented a Ten-years Plan about National Energetic Strategy (the so-called "SEN") [30] to anticipate and manage the change in the energy system, with the aiming of making it:

- More competitive: make Italian energetic prices similar to the European ones, open new market for innovative companies, create new work possibilities, incentive research and development;
- More sustainable: contribute to decarbonisation according to long-term objectives of the Paris Agreement, improve energy-savings and efficiency, promote a sustainable mobility;
- Safer: improve the security of energy supply, increase the energetic Italian independence.

Some targets of SEN, in numbers are:

- reduction of 10Mtep in accumulated final consumption up to 2030;
- 28% of electric consumption covered by RES;
- phasing out the use of coal in electricity generation by 2025.

In the 2018, the Legislative Decree n. 21/2018 [31] (implementation of Directive 2016/2284/EU) imposes a National Plan of Check Air Pollution (to be approved by Prime Minister by 28th February 2019).

By the end of this year (2018) Italy has to present to the European Commission a draft of National Integrated Plan on Energy and Climate (to be approved by 2019), which should allow a clear national legislative framework about electric mobility and will define specific measures to promote the development of electric vehicles, recharging infrastructures, electric networks.

After that, it could will be the evolution of specific regulation (implementing national plans) for operators in electric sector (producers, consumers, TSO, DSO, …), especially about electric networks, with ARERA's provisions.

Since 2010, in fact, ARERA has:

- Defined the regulation of network tariffs for private recharging and public recharging of EV;

- Fixed the deadline for connection to the grid;
- Promoted some experimental projects about public recharging of EV (they finished in 2015);
- Expressed several opinions to Italian Parliament about EM and Alternative Fuel Infrastructure.

but the Authority has to implement regulation for clearing – and defining - the activities of the electric operators, in particular for smart cities, activities of DSO, Distributed Generation, etc.

About Distributed Generation (DG), the increase in recent years of various types of power plants (wind, PV, hydro, biomass, geothermal, CHP) for self-consumption or rather connected to the grid has caused a profound evolution to the Italian power system.
Figures provided by the Italian Authority show how the DG amounts to 22% of the whole national power production and this energy is produced in rather small power plants. This increase in DG has resulted in a growing difficulty to forecast the generation profile and to modulate the power available on the grid.
Starting from this scenario, the Authority, with **Resolution No 300/2017/R/eel** [32] as amended, **has defined the criteria to allow Demand, Generation not already enabled (non-programmable renewable sources, distributed generation) and Storage to participate in the Dispatching Service Market (MSD) as part of pilot projects**.
The Resolution defines that the pilot projects may concern:

- The participation in the MSD of the Demand and Generation not yet authorized (including the accumulation systems that are equated with the production units);
- The use of Storage systems, in particular in combination with relevant production units enabled to participate in MSD in order to optimize the supply of dispatching resources in compliance with the requirements set by the Network Code;
- The aggregation modalities of the production and consumption units, according to geographical aggregation perimeters consistent with the network model used by the algorithm for the selection of the offers accepted on the MSD in such a way that the movement of the units does not violate the network constraints. With reference to the possible aggregations, the Resolution provides that aggregates called UVA (enabled virtual units) may be established, in compliance with the perimeter defined by Terna (National TSO in Italy) and, in particular:
  - Production-enabled virtual units (UVAP), characterized by the presence of only not relevant production units (whether they are programmable or not), including storage systems;
  - Consumption-enabled virtual units (UVAC), characterized by the presence of only consumption units;
  - **mixed enabled virtual units (UVAM)**, characterized by the presence of relevant production units (either programmable or not) including storage systems, and consumption units;
  - nodal enabled virtual units (UVAN), characterized by the presence of relevant production units subject to voluntary enabling and/or not relevant (whether programmable or not programmable), and possibly also consumption units, subtended to the same node of the national transmission network;
- the modalities for the remuneration of ancillary services currently not explicitly remunerated (for example, voltage regulation); therefore, primary reserve services, secondary reserve, tertiary reserve, Resolution of congestion and balancing are excluded;

The Resolution also defines, for each case, the counterparty for the supply of dispatching resources (coinciding or not with the aggregator, i.e. the Balancing Service Provider – BSP) and the methods for the valuation of actual imbalances are made explicit.
The approach of aggregating Generation, Storage and Demand enabled to the Dispatching Service Market (MSD) by means of pilot projects of Virtual Aggregates is among the solutions adopted to address the constraints in terms of reliability and safety of the power grid. The UVAs are a mean to enable the **organic reform of the dispatching service regulation** started by the Authority in 2016.

Such an approach – internationally known as Virtual Power Plant Management (VPPM) – **allows operators to optimize their revenues through best performing practices** such as an efficient use of Renewable Energy, the introduction of new technologies as power Storage and Smart Grids, **and to meet the needs of greater sustainability and efficiency of the "energy system" in general**.

As a consequence of the regulatory input, Terna (the national TSO) has developed several pilot projects to enable different subjects to supply resources on the MSD. Among the pilot projects, the **UVAM** one also **includes the storage systems functional to electric mobility**, since these are completely comparable – with reference to the points of connection to the network where the charge/discharge takes place – to other storage systems: this pilot project is configured, therefore, also **as an enabler of "*vehicle to grid*" technology to the MSD**.

The UVAM pilot project allows resources to be enabled:

- For participation in the MSD;
- For the **forward procurement** of a quantity of resources made available by consumer facilities that have been qualified for participation in MSD.

In the second case, the mechanism is structured similarly to the capacity market, i.e. with the conclusion of forward contracts – in the form of options – "***guaranteeing a fixed premium in the face of the commitment to offer spot market resources at prices below a certain value (strike)***".

In addition to what reported above on the efforts of the Italian Government, Agencies and regulators, there are also several piloting initiatives worth to mention as pilot V2G projects, the main one being:

- *"Genoa pilot"* [33]*,* Italy, 2017, TRL 7: the first V2G electric car recharging facilities in Italy. Thanks to an agreement signed between Enel Energia, Nissan Italia and the Italian Institute of Technology (IIT), a pilot corporate electric car sharing project has started with V2G chargers at the IIT headquarters in Genoa. At the moment two cars trial testing V1G are running but it is waiting for definition of regulatory framework for V2G in Italy to test the cars also under this model. The pilot includes the Nissan LEAF car model, as well as an App Management Platform called Glide, as well as two V2G charging stations installed by Enel Energia.

5. Current situation of V2G in other Countries included in the "EME-V2G" project: Germany and Denmark

In this paragraph we report a summary of the legislation and regulatory situation in the other two Countries covered by the V2G project, i.e. Germany and Denmark.

5.1 Current situation in Germany

The German Federal Government has set itself a target of putting 1 million electric vehicles on the road by 2020, possibly reaching over 5 million by 2030 [34].

Due to that, the Electric Mobility Act (Elektromobilitätsgesetz - EmoG) came into force on the 6th of June 2015 and it is applicable until the 31st of December 2026. The aim of the law is to facilitate privileges to owners of electric vehicles in road traffic in order to promote their use and to reduce the climate-damaging and environmentally harmful effects of private motorised transport [35].

The EmoG entitles municipalities to take measures to prioritize designated E-vehicles in road traffic and the preferential rights are mentioned in law § 3 paragraph 4 Nr. 1-4 as follows [35]:
Parking on public roads or paths;

- The use of public roads or paths dedicated to specific purposes (special lanes);
- The admission of exceptions to access restrictions or transit prohibitions;
- The (partial) remission of fees for public parking space management.

- According to law § 3 paragraph 4 Nr. 1: municipalities are allowed to provide owners of qualified and marked electric vehicles with the option of parking on public roads or streets. This means, on the one hand, that parking spaces are exclusive to LIS (Charging Infrastructure) and, on the other hand, that regular parking spaces are to be made available especially for electric vehicles.
  - Law § 3 paragraph 4 Nr. 2: allows local authorities to partially or completely open public roads or roads to electric vehicles, which are otherwise reserved for a particular purpose or only for certain types of vehicles.
  - Law § 3 paragraph 4 Nr. 3: provides that municipalities may grant holders of qualified and marked electric vehicles exceptions to access restrictions or transit prohibitions on public roads and streets.
  - Law § 3 paragraph 4 Nr.4: allows local authorities to waive, in whole or in part, the charging of parking fees for qualified and marked electric vehicles.

These advantages are only valid for electric cars that can have:

- A pure electric range of 40 km or more
- Ar a CO2 emission of 50 g / km or less

In order to get electric mobility onto the roads, the Federal Government is also funding research and development via practical, technology-neutral programmes. Since 2009 and in total, it has provided over €1.5 billions to these type of projects [36].

On the other hand, the Federal Ministry for Economic Affairs and Energy is providing incentives to boost the demand for electric vehicles such as [36]:

- The Federal Government has earmarked a maximum of €600 million to support the purchase of at least 300,000 electric vehicles by 2019. The carmakers are contributing an equal amount. A bonus of €4,000 is paid for the purchase of a new all-electric vehicle. Buyers of plug-in hybrid vehicles receive a bonus of €3,000.
- The Federal Government is providing €300 million in funding to promote the roll-out of rapid and standard recharging points. The goal: many more rapid recharging points, which are particularly expensive, are to be available along the major transport routes and in the big cities by 2020.
- Increase the number of electric vehicles in the public-sector vehicle fleet. The share of electric vehicles to be purchased by the Federal Government is to rise to at least to 20% by 2019 and €100 million has been earmarked for this.

- As of April 2016, electric vehicles and plug-ins in Germany are exempt from the annual circulation tax for a period of five years from the date of their first registration. In 2016, the annual circulation tax exemption was extended from five to ten years, backdated to 1 January 2016.

To the best of authors' knowledge, there is no specific regulation in Germany about the V2G.

Regarding the charging infrastructure, the Federal Government has adopted in 2016 the Charging Station Ordinance (Directive 2014/94/EU) which specifies the technical requirements for charging plugs and connectors of electric vehicles to guarantee technical safety [37]. In June 2017, further provisions of the Directive concerning authentication and payment at charging points have been implemented [38].

According to § 12 and 13 of the German energy industry act ("Energiewirtschaftsgesetz" abbreviated as "EnWG") TSOs are obliged to maintain a secure and reliable network and to ensure that sufficient transmission capacity is provided at any given time [39]. In addition, an amendment to § 17 paragraph 1 [40], EnWG clarifies that EV charging points will not qualify as network systems in Germany and will not be installed/operated by DSOs. Instead, EV charging points will qualify as end customers under the EnWG [38]. As a result, various investors from different industries and with different market objectives will contribute to the development of the EV charging infrastructure. Accordingly, the location of EV charging points will generally be subject to the decision of investors [38].

Until the end of 2020, the Federal Ministry of Transport and Digital Infrastructure will provide financial assistance of 300 million euros for the deployment of at least 15,000 charging stations [41].

For what it concerns pilot V2G projects in Germany, we list here the main ones [42]:

- INEES: This research project stands for 'Intelligent integration of electric vehicles into the power grid for the provision of system services'. It started in June 2012 and ended in December 2015. Bt this project, the partners – Volkswagen AG (using 20 Volkswagen UP), Lichtblick SE, SMA Solar Technology AG and the Fraunhofer Institute Wind Energy and Energy System Technology (IWES) – demonstrated the technical feasibility of absorbing power fluctuations by connecting electric vehicles to the power supply.
- Vehicle2Coffee: This project started in 2015 as a practical demonstration of the integration of a Nissan LEAF into the grid, charging station from ENDESA and supplying an office & coffee machine with electricity.
- Honda, Offenbach: In 2017, Honda invested in advanced bi-directional charging technology at its European R&D site in Offenbach in order to test the V2G application.
- Redispatch V2G: TenneT, The Mobility House & Nissan started a V2G project in 2018 in order to prove the 'dispatchability' of 10 EVs in order to manage network constraints, reduce curtailment of renewable resources and reduce upgrades in grid.

5.2 Current situation in Denmark

The transition to e-mobility in Denmark has been somewhat inconsistent in recent years although there seems to be political willingness now to accelerate the transition. The legislation is still at its early stages with regard to electric vehicles and V2G though the interest in this matter, reflected in

the number of V2G projects and chargers installed in recent years, linked to the small mobile fleet existing in Denmark, will predictably lead to a legislation easier to implement and a faster transition than in other countries.

The first law regarding sustainable energy was the Law 1392 of 27/12/2008 or Law on the Promotion of Renewable Energies [43], modified by the Executive Order No. 1074 of 08/11/2011 [44] that adopted the Directive 2009/28/EC (Renewable Energy Directive) and aims to promote the production of energy from renewable energy sources. However, this law does not approach the development of renewable energy sources in transport.

The first law to undertake the development of renewable energies in transport is the Executive Order 29 of 01/10/2014 [45], which exempt electric vehicles from the registration tax (not HEV). This was a very important incentive since in Denmark the registration fee for passenger cars is between 85 and 150% of the vehicle cost.

From 2016, the Law 1889 of 29/12/2015 [46] included battery electric vehicles in the same tax scheme of petrol and diesel cars. The resulting increase in the registration tax was planned to be gradually phased in, at 20% of the full tax in 2016, 40% in 2017, 65% in 2018, 90% in 2019 and 100% in 2020.
This law also includes EV in the green vehicle tax scheme, which depends on the fuel and/or electricity consumption of the vehicle.
This measure caused a sharp drop of 60% in the sale of electric cars from 2017.

On the other hand, the Law 716 of 25/06/2014 [47] establishes in article 5 that the Ministry of Climate, Energy and Building must create a climate committee to draft an annual report of climate policy. This report must include, among others, planned climate measures and devices with expected future impact, and description and state of fulfilment of national and international climate objectives, as well as recommendations of the Climate Council, etc. to the Minister of Climate, Energy and Building.
The following committee recommendations stand out from the last year's reports:

- The 2016 climate committee statement [48] recommended new exemptions in the EV registration tax based on the battery's capacity, as well as similar exemptions for vehicles powered by hydrogen or biofuels.
- The 2017 committee statement [49] advised the need to establish regulations in order to incorporate infrastructure for electric vehicles in buildings.

In February 2017, the National Program for the Implementation of the AFI Directive [50] (Directive 2014/94 / EU) was published. This resulted in the Law 1537 of 19/12/2017 [51], which contains measures encouraging the purchase of electric vehicles and the construction of alternative fuel infrastructures, specifically:

- Progressive transition towards the end of the tax exemption between 2015 and 2020.
- Reduction of the registration tax beyond 2020.
- Achievement of the 10 EV ratio for each charging point.

Currently there is a ratio of 1 to 5, so it is not expected that it will be necessary to modify the installation rate until 2020, when it is expected to have at least 3.000 recharge points.

The Executive Order 57 of 25/01/2018 [52] in compliance with Law 1537 of 19/12/2017 establishes technical specifications and requirements for public available charging points for electric vehicles.

Executive Order 491 of 2018 [53], which modifies its preceding E.O 138 of 2017, regulates the accomplishment of national programs to combat air pollution and guidance reports to achieve the emission reductions established in the Directive 2016/2284 / EU (NEC-Directive).
The Ministry of Environment will present the first national program to combat air pollution to the EU Commission before April 1, 2019.

Recently, the Danish government has submitted the Climate an Air Plan (klima- og luftudspil) [54], which contains 38 measures, including the sales ban for IC vehicles beyond 2030 and HEV in 2035. It is also intended to electrify the entire network of public transport, including taxis for 2030.
This transport electrification plan includes the installation of fast charging points in the national and urban road network, for which 80 million kroner will be assigned (10.7 million euros).
It also extends the registration fee exemption for electric and hybrid vehicles with a price below 400,000 kroner (€ 54,000) until 2020, which represents a change of direction with respect to the measures taken in previous years.

There is not a specific regulation for V2G systems to operate in the Danish electricity system yet, so the market access regulation depends on the market player. In general, V2G systems are having the aggregator role. The TSO (Energinet [55] in Denmark) establishes five market models that define the relationships between DSO, TSO, aggregator and consumer / prosumer [56].
Energinet also set the requirements for a power plant to be connected to the net. A V2G charger or group of chargers is considered a temporary battery plant and regulated by the "Technical regulation 3.3.1 for battery plants" [57]. This document contains the minimum requirements that the battery plant must comply before to be connected to the Danish grid.

In recent years, Denmark has made progress in research on e-mobility and V2G, with projects that have resulted in the installation of multiple charging points. These charger hubs are located mainly in Frederiksberg (Copenhagen) and Bornholm.

The main pilot V2G projects worth to be mentioned in Denmark are:

- The Parker project [58] builds on two previous projects, the EDISON and Nikola projects and accounts for 10 Enel (Endesa) 10 kW chargers, Nissan vehicles and aggregation software NUVVE.

- The ACES project [59] is being developed in the Bornholm Island from the insights of the Parker Project. This pilot project will involve up to 50 vehicles (Nissan vehicles) and chargers that will be used to balance the electric system. NUVVE provides technical support an aggregation services for both projects. The local utility Bornholm Energi & Forsyning (former Østkraft) participates into the project in order to provide data and benefit from the analysis and small scale pilot run in the project.

6. Conclusions and recommendations for future regulation framework design

From this document, clearly appear the efforts put at different levels in Europe towards a sustainable mobility aimed at zero-emissions. This important and challenging objective can be achieved only by further developing electric mobility. In the authors' view, this process would be sustainable and economically competitive if the paradigm "Vehicle to Grid" will be spread and introduced in the

market and accepted from the European society. V2G could be one of the “demand-response” use cases that could spread out, also at residential level, and result in technical and economic benefits for all the involved stakeholders. “Demand response” is a complex and articulated paradigm that can have different applications based on the local energy markets rules but also on energy costs and tariffs: V2G, as a vertical application of this paradigm, is impacted both at technical and financial level (for the definition of possible business plans) by this variability.

Main “road blocks” hampering a real deployment of the V2G solution include: battery’s technology, smart meters and smart grids, cost and complexity of the distribution system (bidirectional converter), absence of a basic dedicated legislation in most of Europe, problems in term of decisions on when to take the energy for the grid from vehicles. One of the most important aspect to deal with, concerns the battery of the electric vehicle. Only when this component will be able to provide the electric car performances in line with those of traditional cars, we might witness an incremental growth of the market. Dramatic improvements have been reached in this sense by battery manufacturers and Battery Management System providers. Moreover, the technologies enabling V2G are also proceeding well, with a large number of pilot projects being deployed in Europe in recent years, with high TRL.

Another fundamental service to a real deployment of V2G (and EV in general) is the availability of charging infrastructures. The main discriminant here is the involvement of the Public Authorities and Governments: the actions needed by these entities entail a greater support in terms of provision of incentives but also it is necessary to create an efficient and reliable charging infrastructure. From this point of view, it can be inferred from the information presented in this document that there are several planning and implementation efforts in the shaping of policy and legislation packages in Europe, but their effective influence on a real implementation of EM in general (and V2G in particular) is yet to be fully understood.

Although several actions have been carried out, the lack of a defined legislation about V2G represents the main obstacle to the V2G diffusion in Europe today.

The situation is fragmented in different Countries, with some MS having a more advanced legislation framework (e.g. Italy that is also regulating the energy market in detail) but lag behind in the practical implementation, to other Countries (e.g. Germany) which take a more hi-level, generalist approach with no specific regulations for V2G, finally to other Countries where legislative efforts have been inconsistent over the years, but implementation on the ground of V2G is somehow happening, thanks to a favourable business and consumer ecosystem.

An open and transparent communications should be stimulated within the V2G value chain and the government representatives. This can be done through participating in study visits, establishing relations with partner regions or cities involved in V2G technology pilot and implementation projects, networking activities, and active creation and participation in international V2G research projects.

The V2G value chain and the governments must encourage the investment in the V2G technology, through the implementation of targeted financial instruments to reduce the risk for private investors. At the same time, focus on finding and creating additional financing other than EU funds, including earmarked funds and public-private partnership mechanisms.

Prepare a compendium of best practices related to the unknown V2G technology to secure trust and acceptance of the public. Nevertheless, in order to identify the economics, the social and the environmental benefits of the V2G technology, an establishment of information campaigns and other communication tools is required by the V2G value chain.

In order to grant a full rollout of V2G potentiality globally (or at least at European Level), the needs for a common set of rules and standards is essential.

This is true, as stated above, on the energy markets and development side but also, of course, on the common regulation and incentive program for e-mobility development in Europe. The full rollout of e-mobility is the pre-requirement for the V2G development and consolidation.

Only with a strong cooperation among all the players, from battery manufactures, automotive producers to utilities and Public authorities, it will be possible to give a strong boost and determine a straight trajectory toward a greener future.

The partners of the EME-V2G project will take the information of this document as a reference basis for the deployment of the activities and pilots foreseen in the project, and will monitor the eventual progression of the legislative landscape in Europe, so as to consider eventual major changes during the life of the project.

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