Regulatory Issues in the Development of Electro-Mobility Services: Lessons Learned from the Italian Experience

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***Abstract* — E-mobility represents a promising technology but is still in an early-development phase, especially in Italy. The design, installation and operation of the charging infrastructure, in particular, presented many open issues in the last years. The Italian regulatory Authority for energy, gas and water (AEEGSI) decided yet in 2010 to address this topic, promoting some demonstration projects on EVs charging infrastructure. This paper presents some general results of these projects and the regulation activities carried out by AEEGSI based on those results and on the analysis of the parallel evolution of the sector (market, technologies, legislation, etc.) in Italy and in Europe.**

Keywords–component: Electric vehicles, electro-mobility, demonstration project, regulatory issues, DSO role, pricing

I. INTRODUCTION

The diffusion of electric vehicles (EV) and charging infrastructure poses several challenges not only in terms of technological innovation and standardization but also for regulatory and competition aspects. New business players may arise, a new role is expected for grid operators and new services may provide opportunities to final customers that progressively satisfy their mobility needs through electro-mobility.

In particular, in this field the most interesting regulatory and competition issues as for EV recharge infrastructure in public places are the following:

- ensuring that competition may develop as much as possible;
- defining the roles of actors and business models involved in electro-mobility;
- evaluating how electricity network tariffs can contribute to the kick-start of electro-mobility;
- integrating electro-mobility in the wider transformation of power system (e.g. renewable development, storage technology, increase in energy efficiency, new challenges for system stability).

The Italian regulatory Authority for energy, gas and water (*Autorità per l'Energia Elettrica, il Gas e il Sistema Idrico*, AEEGSI) has shown over the years a particular attention on changes and innovation in energy sector. One of the instruments that European regulatory Authorities can use to understand the potential and the risks of technological innovation is the promotion of in-field demonstration projects [1]. This approach, already used for smart grids [2] was applied also for electro-mobility area.

In addition to pilot projects for EV recharge in public places, since 2010 the Authority had intervened on the issue of recharge in private places (specially at home or at workplace), in order to remove the obstacles that the old tariff for household posed at the adoption of e-mobility; although this issue is not treated in this paper due to space limits, it's worthy to note that the old "progressive" structure of the household tariff has been in the meanwhile suppressed by AEEGSI, in the context of the transposition of the Energy Efficiency Directive [3].

In Section II of this paper, main results of demonstration projects launched by AEEGSI in 2010 and carried out in 2011-15 are reported. In Section III, the evolution of the role of electricity Distribution System Operators (DSOs) for EV charging is analyzed, in the light also of principles introduced by the European Directive 2014/94/EU. In Section IV, some regulatory issues like pricing, metering and connections are described according to the regulatory practice in Italy, while in Section V further topics for near future development of e-mobility are sketched out and Section VI concludes.

II. DEMONSTRATION PROJECTS

In 2010, in Italy, the e-mobility legislative framework was yet not defined and there weren't neither stable technological solutions nor widely adopted industrial and organizational models. In consideration of that, the Italian regulatory Authority decided to launch a call for demonstration projects in order to develop electric vehicle charging infrastructures in public places, with the aim of

analysing efficient and pro-competitive solutions for this new activity, under a regulatory point of view.

With the regulatory decision ARG/elt 242/10 [4] the Authority defined procedure, selection criteria of demonstration projects and the related incentive treatment to be applied for five years to the selected projects (2011-2015).

A. *Objectives and selection process*

The aim of demonstration projects was on-field test of different business models for EV charging activity, in order to gather useful elements for both guiding legislative developments and setting up the regulatory framework needed to support the large-scale development and diffusion of electro-mobility in Italy.

The pilot projects were therefore opened to three different business models, all related to charging service in public places:

- the *model of Distribution System Operators (DSO)* in which the recharging infrastructure for EVs in public places could be developed and managed by the electricity DSO in its concession area. This model needs specific requirements in order to ensure adequate competition at least in the electricity supply retail market. The regulatory Authority set therefore two special requirements: "multivendor" approach, that means freedom of choice for the EV driver of its electricity supplier at each recharge transaction, and "accounting separation" between recharge activity and electricity distribution activity within the DSO company structure. This impedes to merge the assets of EV recharge in the regulatory asset base (RAB) for electricity distribution;
- the *model of Area-licensed Service Provider* in which the recharging of electric vehicles in public places is carried out by a single industrial player in a given area, different from the DSO, that has been selected by a public tender and that operates in a defined area according to a local license for public service;
- the *model of Service Provider in Competition* in which the recharging of electric vehicle can be carried out by many industrial players, different from the DSO, that provide the service in the same area in competition among each other, as currently happens with traditional fuel stations.

Ten proposals were submitted and evaluated, with the help of experts from RSE (general-interest research institute in the power sector) according to the following criteria, identified by the Authority:

A. Technological interest and completeness of the project;

B. Economic burden posed on the electrical system;

C. Relevance of the information made available to the electrical system;

D. Minimizing of the transaction costs in the contractual relationships of the various persons involved.

Eventually, 5 projects were selected [5] and 4 of them have been actually carried out.

B. *Projects general data and results*

The selected demonstration projects started in 2011-12 and lasted till the end of 2015. The Authority asked to project operators to produce a detailed Report each six months, containing relevant information about number of charging events, recharged energy, duration and occupation time of the charging points. A Final Report, to be issued at the end of the whole demonstration period, was also required.

It has to be noticed that the selected operators decided autonomously the localization and the power of recharging stations. Typically, mono-technology AC 3 kW and 22 kW charging stations, with a single socket or two sockets (and two standards), were installed, while no "high power" dual-technology (AC or DC) station was installed.

In the following Table I the summary data emerged from the final Reports are reported. A synthesis of all Final reports is available [6].

TABLE I. DEMONSTRATION PROJECTS SUMMARY DATA

Project	Business model	No. of charging point	No. of charging transactions	Total energy recharged [MWh]	Avg. energy recharged [kWh]
ENEL-HERA	DSO	302	38.420	284,0	7,4
A2A (pub.+ workplace)	Area-licensed SP	100	102.278	705,1	6,9
Class Onlus	SP in	85	6.573	26,8	4,1
Enel Energia	competition	26	780	6,5	8,3
Total		513	148.051	1.022	6,9

From the analysis of Table I emerges that the average energy recharged was less than 7 kWh per charging transaction, quite limited with respect to EV batteries capacity. The reason for the limited value in energy recharged can be explained by low familiarity that users had with electric vehicles (cars, vans, quadricycles, motorbikes and mopeds with different battery and charging power capacities). EV users were oriented in topping-up the charge wherever parking during the day to prevent range anxiety. By the point of view of operators, the low values entail a difficulty in building a real business on modest quantity of recharged energy.

The next graph shows the cumulated energy recharged by each pilot project for each year of experimentation. In the same graph, the annual sales of EV in Italy are reported [7].

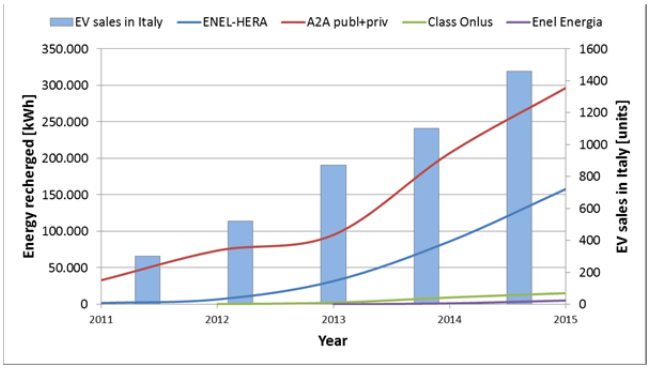

Figure 1: Cumulated recharged energy by each project

The analysis of the graph together with the final Reports has permitted some general remarks:

- At the starting date of the demonstration period, some projects were already in an advanced stage of planning and had already signed agreements with electric vehicle manufacturers to ensure usage of the infrastructure. These projects could immediately benefit from the introduction of vehicles and had a good level of energy recharged from the first year.
- On the contrary, other projects were completely new at the date of the selection of pilot projects and that caused a slower start, due to a series of contractual, bureaucratic and administrative actions that lasted longer than expected, compared to projects that were ongoing.
- During 2013, the A2A project had a slight decrease in both the number of recharging events and the energy recharged. This could be explained by the ending of the experimentation involving vehicles from an OEM which were given back to the manufacturer in conclusion of life cycle tests.
- Starting from the first months of 2013 and more noticeably in 2015, all projects have showed a remarkable increase in the number of recharging events and the energy recharged. The reason for this trend could be found both in the degree of progress or completion of the infrastructure installation and in a more tangible diffusion of electro-mobility for a 2 years transitional grant with new vehicles issued by the Government (2013-2014).

Thanks to the detailed information gathered by the project operators, also more specific analyses can be carried out. Some examples are reported in the following graph.

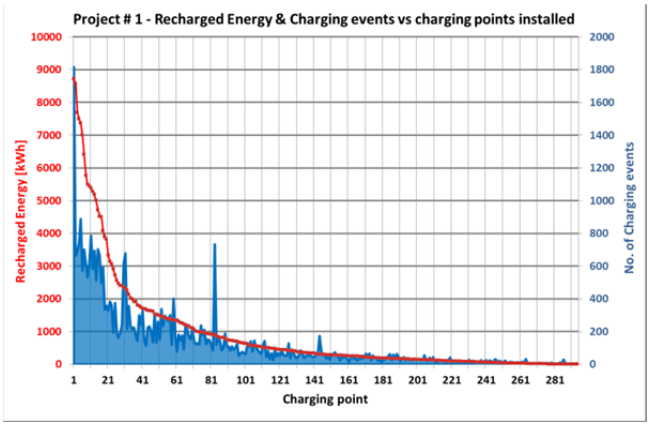

Figure 2: No. of charging points, recharged energy and charging events points (Project #1)

The graph in Fig. 2 shows the energy recharged and the number of charging transactions for each charging point installed in Project #1. The most noticeable aspect is that not all the charging points have the same rate of use and that for some charging points, despite a rather high value of energy recharged, the number in charging events is not as high.

Analyzing in more detail the rate of use, it can be seen that the 50% of the total energy recharged during the demonstration Project #1 is given by just the 9% of the charging points (27 charging points on a total of 302). For these points, also average duration has been evaluated and compared with average energy and number of charging events, as shown in Fig. 3. The graph shows that some charging points have high duration of the charging events but a low recharged energy: this may mean that some charging points are mainly used as parking or by AC low charging power EV (e.g. two-wheelers). Such evaluation may be useful for public administrators and e-mobility operators interested in developing of different kind of recharging infrastructure and in its optimal localization.

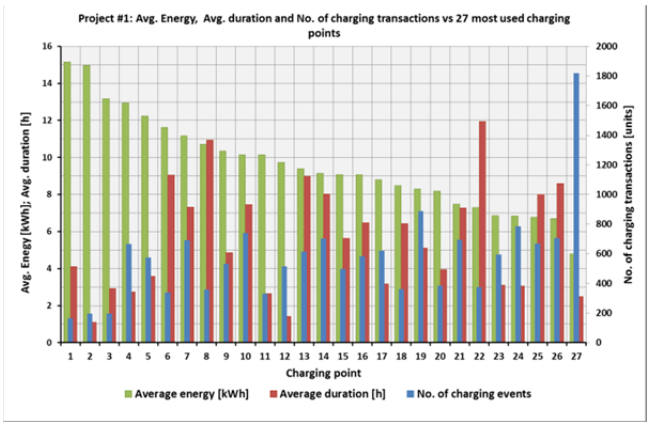

Figure 3: Avg. energy, avg. duration and No. of charging transaction for the 27 most-used charging points (Project #1)

This demonstrates that choosing the sites where the charging points are to be localized is extremely important: a profitable scenario requires stations highly frequented and with high number of expected charging transactions. This evaluation is even more important when considering fast charging points that require higher investments (e.g. motorway's nodes or "EV corridors").

III. DSO ROLE IN EV CHARGING FRAMEWORK

The role of the electricity DSO in the framework of EV charging passed through relevant discussions in the last years. As owner and manager of the distribution grid in its concession area, the DSO could be seen as a privileged actor to plan, build and safely operate a network of charging points, which could be seen just as new points-of-delivery (PODs) connected to the grid, though *power-intensive*. On the other side, the DSO operates under particular conditions, i.e. a local monopoly under regulated rules and tariffs, which could be unsuitable for e-mobility and seriously damage the development of this new market.

As mentioned in the previous section, in Italy the DSO model was admitted to AEEGSI demonstration projects, but special requirements were set, as the "multivendor" approach (freedom of electricity supplier at each transaction) and the "accounting separation". The idea was that thanks to these requirements it would have been possible to maintain the competition in the area of energy retail and to avoid that DSO investments in the recharging infrastructure could affect regulated electricity tariff towards final energy consumers.

The DSO model trialed in pilot projects was based on payment through long-term contract and access to the charging station with RFID cards. Despite the requests, the respect of the "multivendor" requirement generated several complications to operators and was mostly disregarded. The

infrastructure remained not interoperable with the other financed projects and this represented a hurdle for the users, who faced the need to have more RFID cards in order to access to a wider infrastructure. It can be said that the results emerged from the demonstration projects have not evidenced for the DSO model any particular advantage capable to compensate the just mentioned difficulties, with respect to business models where private operators could manage the infrastructure in a competitive way.

Besides, during the last period of the pilot projects, the Directive 2014/94/EU on Alternative Fuel Infrastructure (AFI) has been published and entered into force. The Directive has the general aim to establish a common framework for the implementation of an alternative fuels infrastructure in the Union, in order to minimize the dependence on oil and to mitigate the environmental impact of transportation. The AFI Directive provides specific guidance regarding the issue of e-mobility and in particular countries that the activity of EV charging should be carried out under competitive conditions (recital 30). Furthermore, Article 4 of the same Directive declares that Member States shall ensure that:

- the operators of charging points in public places must be able to purchase electricity from any supplier in the Union;
- the users of recharging points must be able to access the service (charging) without the need to enter into a contract with the electricity vendor or with the charging point operator (and settle the transaction through a so called "ad hoc" payment);
- prices for the recharging service must be reasonable, easily and clearly comparable, transparent and non-discriminatory;
- distribution system operators must cooperate on a non-discriminatory basis with any operators of recharging points;
- recharging of electric vehicles at recharging points should, if technically and financially reasonable, make use of intelligent metering systems.

On the basis of AFI Directive provisions, the Italian Authority took the position that the "DSO model", identified as an experimental exception for pilot projects from decision ARG/elt 242/10, did not have to be further adopted for the development of the electric vehicle charging network, as stated in its consultation document no. 5/2015 [8], recital 10.19. The choice was driven also by the fact that in the last period of the demonstration projects, a growing number of commercial players appeared on the market as service providers, demonstrating the willingness of private companies to invest in this field according to their own business strategy. In this situation, the Authority considered that:

- the competitive framework of EV recharge in public places calls for the presence of multiple players (Charging Point Operators – CPOs) in this new activity, i.e. EV recharge must not be a monopoly activity with fully regulated actors as DSOs;
- the industrial players active in EV recharge in public places have a strong interest in localize the charging stations according to the final users' needs, so to maximize the usage of charging points and therefore the revenues of CPOs. DSOs choices could instead be driven by other aspects, as needs and constraints of the distribution network.

On November, 30th 2016, the European Commission addressed the topic again, while presenting a legislative proposal for a recast of the Directive on common rules for the internal market in electricity, as a part of a comprehensive legislative package entitled "*Clean Energy for All Europeans*". The proposal clarifies the tasks of distribution system operators in Article 33 "Integration of electro-mobility into the electricity network", stating that "*Member states may allow DSOs to own, develop, manage or operate recharging points for electric vehicles only if the following conditions are fulfilled:*

a) other parties, following an open and transparent tendering procedure, have not expressed their interest to own, develop, manage or operate recharging points for electric vehicles;

b) the regulatory authority has granted its approval."

It can be easily seen that the path followed by Italy in the last years is perfectly in line with what stated in the proposed recast of the Directive. In 2010, when there weren't operators able to develop a charging infrastructure network, the Authority opened this possibility also to DSOs. When, in the last period of demonstration projects, a growing number of commercial players appeared on the market as service providers, the Authority decided to no longer consider the DSO model as applicable for further development of the recharging network for electric vehicles.

IV. Regulatory issues in a future-proof perspective

The experience gathered through the demonstration projects promoted by the Italian regulatory Authority lets now to highlight some issues, both technical and regulatory, which need some attention not only by the regulator itself but also by Government, standardization bodies and industrial players.

The challenge for the national energy regulator is to perform choices that can be as far as possible future-proof and therefore suitable to support different technologies and standards in the perspective of protecting the quality of the service offered to the EV driver. In the following part of this section, some issues and the related decisions taken by Italian Authority are reported.

A. Pricing (Tariffs)

1) Monomial tariff

In order to simplify the management of the charging infrastructure, and at the same to provide an incentive to the kick-off of EV recharge in public places, the Italian Authority stated in decision ARG/elt 242/10 that for low-voltage (LV) PODs dedicated exclusively to EV charging, the tariff components related to "network tariff" and "system charges" (levies mainly due to RES incentives) should be expressed considering as unique volume driver the absorbed energy and not (as usual in Italy) on the basis of three volume drivers (point of connection, maximum capacity and absorbed energy).

This tariff was called "monomial tariff" (being the ordinary one called "trinomial") and its value has been updated every three months during the period of validity of the pilot projects. Being the equivalence between "monomial" and ordinary "trinomial" tariff reached at 3.500 kWh in a year, it implies that monomial tariff for low-voltage PODs dedicated to EV charging is of some help for kicking off this new activity.

More recently, the Italian Regulator with the decision 654/2015 [9] has issued the "Tariff regulation of electricity transmission, distribution and measurement services for the regulation period 2016-2023". In this regulation, the Authority expresses its general approach for the near-future with regards to this topic:

- maintain the "monomial tariff" for LV connections till around 100 kW dedicated to stand alone charging points in public places, for further 4 years at maximum, in order to support the initial development of the infrastructure;
- as for MV connections (typically needed for large and high power charging stations), avoid any discounted tariff for large charging stations that will mostly be installed inside "fuel stations" or near other facilities as hotel or resort that have other electricity usages that EV recharge and therefore MV PODs are not likely to be dedicated to EV recharge; a special tariff would entail an aid to ordinary activities within the fuel station and is therefore not applicable.

2) Pay for the service and not for the energy

As already mentioned, Article 4, paragraph 3, of the AFI Directive states that the prices charged by the operators of recharging points accessible to the public have to be reasonable, easily and clearly comparable, transparent and non-discriminatory.

According to Italian Regulator, the concept expressed by this paragraph has to be widened considering that the price of EV charging should not be considered just a price for energy off-take, but the price for the whole service of EV charging. By this point of view, EV charging is not just electricity re-selling, but a more complex "mobility service". It indeed includes many "added-values aspects", such as power/speed of the charger, occupancy of place, mapping of the charging stations and booking of charging points, possibility of smart charging or other innovative services as V2G. Prices expressed only in €/kWh can be misleading; a fixed (monthly) payment is likely to be a structural part of the pricing, excluded the "ad hoc" payment according to Article 4, paragraph 9 of the AFI Directive: "*All recharging points accessible to the public shall also provide for the possibility for electric vehicle users to recharge on an ad hoc basis without entering into a contract with the electricity supplier or operator concerned*".

3) Pricing as an instrument for inducing optimal usage of the EV recharge infrastructure

The fact that the tariff for EV charging is not related only to the absorbed energy, gives the operators the possibility to adopt different strategies in order to attract or maintain customers and to better manage charging sites occupancy. In the vision of Italian Authority, this could lead to an easier development of the sector.

As example of possible strategies, we can recall loyalty programs or flat-rate subscriptions, currently adopted in several European countries. Some operators decided also to "use" the price to encourage the user not to abuse of the charging service, introducing specific fares due by the customer in case the vehicle remains connected to high power stations when the battery is almost full (over 80% level of the battery) or when the charging process is already ended.

It has to be reminded that an effective charging infrastructure in public places can be obtained only if handled by the operators through flexible forms as smart applications for mobile devices, compatible with continental roaming systems, and avoiding non-interoperable solutions. On this direction, the AFI Directive states that, at least and as a minimal solution, an "ad-hoc" solution to charge without any contract has to be provided by the operators, in order to give access to occasional users; it implies that payment can be arranged on-site, and this could be difficult for so small transactions. Of course, advanced levels interoperability may imply much more complex arrangements, as described in the next sub-section.

B. Interoperability and metering issues

1) Interoperability

Interoperability is a key challenge for the global electro-mobility industry. From the EV driver's perspective view, interoperability is the capability to use the EV charging infrastructure (in public places) wherever it is located, whichever EV the driver uses, whoever the operator of the charging point [10]. Interoperability issues are at the core focus of DG Move (European Commission) which constituted, within the Sustainable Transportation Forum, a Subgroup of experts on the electro-mobility services (SGEMS).

Many kind of actors are involved in interoperability, and many levels of this aspect may be envisaged. The "ad hoc" settlement required by the AFI Directive is the simplest interoperability level; SGEMS explored also the way for more advanced "contract-based" interoperability levels, that requires contractual interactions among actors. As electro-mobility merges the complexity of two main systems (energy and transportation), both kind of actors are implied.

On the energy side, main actors are the DSO and the electricity retail supplier; on the transportation side, a new kind of market players is now emerging, the Mobility Service Providers (MSPs), that may stipulate contracts with many CPOs in order to allow to its EV drivers a wide range of options for recharging. In the most advanced interoperability levels, settlement of charge transactions in operated through "roaming" platforms. Contract-based interoperability can simplify the life of the EV driver, as he/she can charge at different charging stations (operated by different CPOs) having only a single contract with MSP, in a fully competitive framework.

Fig. 4 shows the contractual relationships between the various players involved in the recharging service in public places.

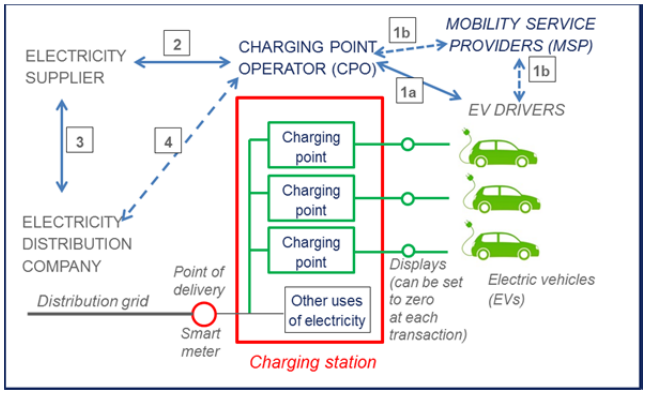

Figure 4: Contractual relationship diagram at charging station [11]

The EV driver may settle the recharge transaction either directly with the CPO (relation n. 1a in Fig. 4, including "ad hoc" settlement as required by AFI Directive) or indirectly via a MSP (relation n. 1b). As the charging station is the "final customer" for the power system, CPO has an ordinary electricity supply contract with the retail supplier of his own choice (relation n. 2) and the retail supplier has an electricity transport contract with the DSO (relation n. 3). The direct relation between DSO and CPO (relation n. 4, dotted line) is only for connection. This conceptual framework of contract-based relationships among e-mobility actors can enable high-level of interoperability, provided that some minimum requirements are met, as for instance a unique Identification Numbers (IDs) for charging points, CPOs and MSPs.

2) Metering and fiscal aspects

Interoperability requires as well a robust metering infrastructure. Concerning the possible use of intelligent metering systems at recharging points, the Italian transposition of AFI Directive contains an important clarification. The article 4 of the Legislative Decree n. 257/16 [12] states that smart meters must be installed at the point of connection of each charging station with the electricity distribution network, whereas each single charging point shall be equipped with a resettable display in order to provide full information to the driver of each recharging transaction (see again Fig. 4).

Moreover Legislative Decree n. 257/16 states that for all fiscal aspects the legal metering is that at the point of connection with the electricity distribution grid.

C. *Bilateral contracts DSO-Charging Point Operators (in case of massive connection plans)*

It is worth mentioning another regulatory action that has been set up by Italian Authority in order to facilitate the modernization of the country's technological systems. The specific aim is to make easier for operators to obtain points of connections to the grid, especially in the case there is the need of multiple PODs requested by the same person. For these cases (which characteristics are specifically defined), the Authority introduced a "derogation" from the ordinary connection procedures and quality standards (request, charge quotation and execution time). In case of massive connections plans at a given location, the Regulator leaves indeed the DSO free to agree directly with service providers, as the CPOs for EV charging infrastructure in public places.

This derogation is defined in the Article 123 of the recent update of quality of service Italian regulation for electricity DSOs [13] which states that if certain conditions are met and following an optimal planning, the charging point operator can agree with the local electricity DSO to simplify mass installations of charging devices (POD connections and activations). The DSO and the person requesting massive connections may also enter into bilateral agreements or contracts through the electricity vendor, for the purpose of defining custom times for the realization of connections and/or activations, according to the parameters specified in the same contracts (e.g.: number of connections per time interval, power available for individual connection points, etc). Such bilateral agreements or contracts must anyway ensure non-discriminatory conditions with respect to possible different applicants and equal conditions throughout the country.

D. *Charging power and plug/connector*

When the demonstration projects were submitted, the most common type of charging point was the one-phase "normal power" (3 kW). The three-phase 22 kW power was considered sufficiently "high" and only two demonstration projects indicated the possibility of installing two "high power" charging station (DC 50 kW). Just over 6 years from the beginning of the experimentation, it is becoming clear that high power charging stations are a really promising technological solution for a consistent diffusion of e-mobility thanks to the possibility to charge in less than 30 minutes and to serve up to 40 vehicles in a day (instead of only about 3, 8 or 16). Next future frontier will probably be ultra-fast charging stations, with power beyond 50 kW and up to 350 kW.

The time needed to recharge the 80% of the vehicle's battery capacity at public places, together with easiness for installing a private recharge point, is one of the key factor to convince users to adopt electro-mobility. Also the Italian national plan for recharging the electric vehicles "PNIRE" (*Piano Nazionale Infrastrutturale per la Ricarica dei veicoli alimentati a energia Elettrica* [14]) acknowledges the importance of high power charging stations and indicates an optimal ratio of normal power to high power charging points must be between 2:1 and 4:1.

However, regulation shall not affect the operator's choice of providing well-placed sites with adequate power. By the way, the fact that Italian demonstration projects were conceived in a context where the importance of DC high power charging was not developed yet, conditioned the technical scenario of the developing recharge services. It is now in the scope of the regulatory Authority to monitor the development of a high-power infrastructure in Italy, as already happened in many other European countries. However, it's worth to note that the situations is going to change in respect of a few years ago: at the end of 2016 Enel, Verbund and some of the most important EV carmakers have started the "EVA+" project [15], funded within the European program CEF (Connecting Europe Facility), aimed at realizing an interoperable cross-border network on highway corridors between Italy e Austria through the deployment of 200 fast multi-standard charging stations.

It has to be reminded that another critical issue that emerged during the first years of the demonstration project was the choice of plugs/connectors for AC and DC charging stations. This problem finally found a solution with the AFI Directive: the Annex II of the Directive indicates indeed that for interoperability purposes, the charging points for AC shall be equipped with, at least, socket outlet or connectors of Type 2, (which may be provided with mechanical shutters) while high power DC charging points shall have at least a "Combo2" connector. This last requirement, combined with the need of permitting the recharging of CHAdeMO vehicles, fostered the deployment of fast multi-standard charging systems.

V. HOT TOPICS FOR NEAR FUTURE DEVELOPMENT OF ELECTRO-MOBILITY

One of the most relevant aspects about e-mobility is the fact that the electric vehicles need connection and connectivity. Grid connection (through charging points, not only those in public places but also, and above all, in private places) is obviously necessary to charge the batteries, and this implies that the vehicle may become a part of a most complex ecosystem: the power grid. Electric vehicles can be therefore seen both as a challenge for the grid (significant loads to satisfy, especially for fast recharge in public places, that are not *energy*- but *power-intensive*) and as an opportunity ("on-wheel" storage systems distributed along the grid, especially for slow recharge including in private places, like at home and parking at workplace, also with limited band of power usage, as for instance 10 kW even on EVs with higher power battery capacity).

With regards to connectivity, the still limited range of some vehicles and the lack of capillary infrastructure ask for a complete control of the route and of charging stations localization. Moreover, to obtain an easy access to the infrastructure mobile apps are needed, as well as to control the charging process. That means that the car, the driver and the charging station need to be constantly connected to mobility service providers (MSPs).

In such a situation, the tasks of the Regulator don't look to be ended. Many aspects will need the attention and the intervention of the Authority in the years to come.

As a simple example, considering that electric vehicles are normally parked for more than 90% of the time, it is not unreasonable to think that the EVs could provide, in a near future, flexibility services to the power system. The suggested use of intelligent metering systems indicated in AFI Directive points in the same direction, as well as the suggestion to support flexible consumption and energy storage through dynamic pricing. The following topics will then probably require the Authority attention:

- Smart charging and the possibility to control the process of recharging providing information and services in a bidirectional way;
- Vehicle to Grid (V2G) and Vehicle to Home (V2H) technologies, where EVs are used to store power in excess produced, for example, by renewable energies and to give back electricity to the grid during "high demand" situations.
- Frequency Regulation and participation of EVs (also through an aggregator) to the Italian market for dispatching services.

The recent regulatory decision 300/2017 [16] defines the criteria to allow all demand and production units (including those powered by non-programmable renewable sources and distributed generation) to actively participate to the market for dispatching service. Given the reduced size of these resources, aggregation has now been allowed in order to constitute enabled "virtual" units. Experimental modes of using storage systems are also defined in combination with enabled generation units. AEEGSI has lastly approved the detailed regulation prepared by the TSO for participation of the Distributed Generation to the market for dispatching service starting with 5 MVA minimal size (aggregated also combining different kinds of load and storage units).

In the next future, therefore, even small charging points at home (private charge) could be aggregated in order to provide flexibility services, fitting as better as possible the slow charging process with power system needs, that are shaving peaks and filling troughs: hence, even in presence of huge diffusion of EVs in the far future, smart charging could allow to keep both electricity prices at peaks and the need for new thermo-generation units as lower as possible [17].

VI. CONCLUSIONS

One of the most controversial topic emerged in these years is the role of the DSO in the deployment of the charging infrastructure in public places. The results of the demonstration projects promoted by the Italian regulatory Authority for electricity gas and water (AEEGSI) and the rationale of the AFI Directive (EV charging in public places is a competitive activity) brought the Italian regulatory Authority to clearly state that DSO are no longer allowed to own and manage a charging infrastructure in public places under a monopolistic and regulated approach, although a DSO-based business model has been trialled in the first years of e-mobility development in Italy. It was important to see that the proposal of European Commission in the "*Clean Energy for All Europeans*" package somehow confirms this approach.

Also other aspects were addressed by the Authority in order to guide and facilitate a proper development of e-mobility in Italy. Network tariff structure for LV points of delivery (PODs) dedicated to EV recharge was simplified till around 100 kW, as well as the procedure to request connection of multiple PODs by a single operator, allowing direct bilateral contracts with the DSO in derogation to ordinary regulation of connections. The critical issue of metering (related to fiscal aspects) has also been considered, by accepting the AFI Directive suggestions and also overcoming them with more specific indications to operators.

Despite of the intense activity carried out in the last years, the work that will be needed in the next future seems to be relevant. E-mobility sector is still "fluid" and new technological solutions are already sprouting, as smart charging or V2G solutions. It is therefore important that the Regulators continue to focus on this topic (see the aforementioned Decision 300/2017). Moreover, the evolution of the sector goes in the direction of

multidisciplinary topics, given the high relation with many other sectors as ICT or Electronics. It will so be crucial that also the regulatory Authorities of different involved sectors (not only energy, but also transportation and telecom) work in a cooperative framework and with a cross-sectorial approach, in order to generate a fruitful environment for an effective technological development, in the perspective of the environmental sustainability goals.

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DISCLAIMER

(*) The opinions expressed in this paper are the personal opinions of the authors; they do not necessarily represent the official position of the Authority and do not commit the Authority to any course of action in the future.

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