European Distribution System Operators for Smart Grids

Position paper on Electric Vehicles Charging Infrastructure

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Executive Summary

The decarbonisation of the transport sector and particularly the mass deployment of electric vehicles will be one of the most important challenges for the decades to come. One fourth of European emissions of carbon dioxide is related to the transport sector, of which 60 percent is related to passenger transports. Consequently, the deployment of electric vehicles will have a very important impact on the European 2020 goals.

The customer will be the key enabler for the commercial success of electric transport. EDSO for Smart Grids and its members share a common vision to realise truly interoperable roll-outs of electric vehicle charging infrastructures, with the goal to "allow all electric vehicles to be charged and to communicate with the electricity grid anywhere in the EU". Common standards is key and EDSO for Smart Grids is certain that so called Mode 3, according to IEC 61851 standards, is necessary for safety reasons and that there is an urgent need for a European standard for a common plug for public and private charging spots.

With wide spread electric mobility, the electricity system will be dramatically affected, facing new consumption patterns and congestions at the same time as vast amounts of new renewable and distributed energy resources is to be incorporated into the grids. EDSO for Smart Grids believes that a sustainable win-win solution is integrating smart electric vehicle charging infrastructure as any other electricity demand into the distribution system operators' network management systems and where regulation allows this, direct involvement of the distribution system operator in the management of the infrastructure as an extension of the regulated role. This would enable cost-efficient local load management, help the deployment of charging spots, guarantee open access and support standardisation.

In the initial phase it is expected that Electric Vehicle charging will mostly take place at home, enabling the possibility to choose electricity supplier. To improve customer's confidence and awareness, also public charging spots should enable the possibility to choose electricity supplier in the future, but since this will require big investments at the same time as the electricity price needed to charge the electric vehicle will only be a minor part of the total cost for the charging service, EDSO for Smart Grids recommends that the first step should be to enable charging without focusing on the possibility to choose electricity supplier.

EDSO for Smart Grids has as one of its main goals to pave the way for electric mobility – the biggest opportunity to turn smart grids into reality, pushing for the deployment of smart charging infrastructure and smart management systems in the years to come.

In this paper different approaches are described and it is of great importance to follow the development closely, gathering practical experiences of best practices.

1. Background

The European Commission and most of the EU member states' leading industries are mobilising to develop electrification of cars and bringing forward e-mobility concepts in order to fulfil the major EU targets on emissions of greenhouse gases, energy efficiency and renewable energy to 2020 and beyond.

EDSO for Smart Grids fully supports the European Commission's and member states' initiatives that consider distribution system operators (DSOs) to play a key role in the development of e-mobility, ensuring the deployment of a technically and economically sustainable charging infrastructure for Electric Vehicles (EVs). EDSO and its members **share a common vision** and take initiatives to realize the European convergence, while ensuring the achievement of EV eco-environmental objectives, including the economy of the upstream electrical system.

EDSO for Smart Grids will contribute to the European Commission's vision and its mandates on standardization, as a specific action in order to "*allow all electric vehicles to be charged and to communicate with the electricity grid anywhere in the EU*".

Recognising the leading role of the DSOs, EDSO for Smart Grids outlines recommendations based on the analysis of the current situation and insights on future developments and needs to turn plug-in electric and hybrid vehicles into a market success.

The differences and similarities regarding the DSO roles, expectations and adopted technology solutions has been analysed within four of the EU countries; France, Holland, Italy and Spain. Also experiences from EU founded projects, e.g. the Green e-Motion project, has been considered to take into account the situation in most of the EU countries.

According to the Electricity Directive (2009/72/EC) the DSO is "*responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system"*, hence the DSO is also responsible for meeting the new demand that the EVs will bring. The strong development regarding distributed and intermittent energy supply, the empowerment of customers and roll-out of smart meters and the introduction of EV charging will dramatically change the DSO work introducing the need for local energy dispatching, peak and congestion management at the distribution networks level.

The DSO will have a very important role as a neutral market facilitator, enabling this important development, how to make it successful is discussed hereafter.

2. The role of the DSO, business models and regulation

There are mainly two different approaches to installation, operation and management of charging spots:

1. The DSO performs the installation and runs the operations, either in a public or private area, as an extension of the regulated DSO role – **the DSO model**;
2. Installation and operations are performed by public bodies (e.g., municipalities) or private undertakings (e.g., parking space owners) and managed within a competitive market.

EDSO for Smart Grids believes that approach 1 above will be cost-efficient, accelerate deployment of charging spots and guarantee open access and support standardisation, avoiding heterogeneous technologies. Consequently, DSO remuneration schemes have to be adjusted in order to cover extra-investments beyond a common consumer grid connection. Regardless of approach it is of importance from that the DSO is in control. Investments are needed both upstream and downstream the delivery point:

- *The connection from the distribution network to the delivery point, see pictures below*

The regulation sets the DSO cost, including connection and network reinforcement, and revenue (generally through annual asset based remuneration). The DSO tries to minimize the cost, especially regarding the reinforcement of the network. The total cost financed by DSOs, to be recovered through an asset based remuneration, has been estimated[1] as 1 billion EUR per million Electric Vehicles.

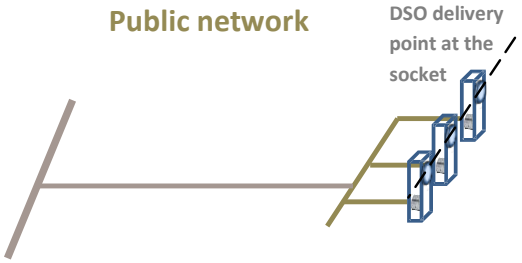
- *The power circuits and charging spots downstream the delivery point*

Here the cost may vary from hundreds to several thousand EUR per charging spot, depending on the specific design and situation. Reimbursement of these costs is a real challenge and will be handled by regulated revenue adjustment (approach 1) or through revenues from a charging service (approach 2).

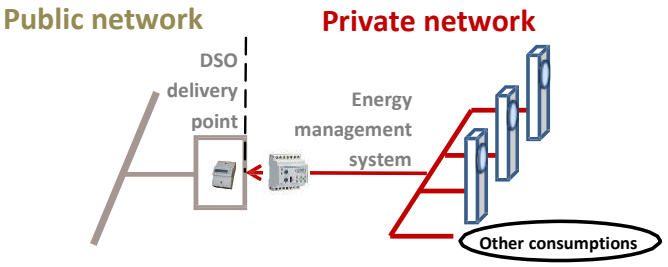
Regardless of how the installation is configured, the business model must be reliable, valuable and handle the economic constraints. The pictures below show different configurations (note that these are examples, different configurations are possible; regarding the number of charging spots, with or without an energy management system and with or without other electricity usage).

- For the sake of the distribution system economy, the DSO must be able to control the load curve directly on each charging point, as in Configuration 1, or globally at the delivery point, by communicating with the energy management system, as in Configuration 2.
- The energy management in Configuration 2 is under the responsibility of the private network owner and can be either locally or remotely managed according to the adopted solutions and regulation.

Configuration 1



Configuration 2



[1] E. Brun, P. Sevault, C. Gaudin, *Low carbon policies: possible medium term impacts on distribution network*, CIRED Workshop Lyon, June 2010, paper 0042

3. Pricing of the electricity supply and of the EV charging service

For public charging spots there will be a possibility to choose electricity supplier in the future, in order to improve customer's confidence and awareness.

- If the DSO model is applied and the meter is inside the charging spot, see Configuration 1, it will be possible to choose between different electricity suppliers.
- Since there is not a separate meter for every charging spot in Configuration 2, the delivery point is the only point associated with an energy supply contract, hence the energy supplier must be the same for all users of the charging services; accordingly, the charging spot owner cannot sell electricity but only a charging service.

The possibility for each EV driver to choose a specific electricity supplier at any given charging spot will require big investments and be in compliance with the electricity sector regulation. This has to be considered in relation to the cost of the electricity needed to charge the EV, which is only a minor part of the total cost for the charging service.

Therefore, EDSO for Smart Grids considers that the first step should be to enable charging without focusing on the possibility to choose electricity supplier.

Still the charging infrastructure should be designed to provide a seamless integration and interoperability with electrical system services and considering the possibility to launch the possibility to choose electricity supplier in the longer perspective. This way it will also be possible to study the technical, economical and regulatory aspects of the further development.

The DSO must be involved in the design and construction of the first solutions for settlement, between different providers (charging service providers and e-mobility service providers). These services require standardisation of data and coordination between all charging infrastructure and mobility management systems, thus enabling cost efficient solutions.

The DSO role is fundamental for an undiscriminating access to the electric mobility marketplace. The definition of a seamless and integrated processes, starting from regional or national level, paving the way towards a pan-European "clearing house", will open up for services for the settlement between companies and enable an open market for consumers.

Clearly the traditional DSO role is foreseen to be extended to also include the EV charging infrastructure, building on the DSO experience of network management and operations. This development will be supported and reinforced by the common experience and insights gathered through EDSO for Smart Grids.

4. Smart charging, goal and design

The DSOs will develop systems for EV charging control to avoid increasing peak demand. The future charging patterns are still fairly unknown, but as the number of EVs increases, experiences and statistics will allow for better prognoses. The number of charging spots will be much higher than the number of EVs and the reinforcement of the networks will take into account that all charging spots are not used at the same time.

The EV charging profile can be very flexible considering the two parameters time and power and although the total energy to be provided is not controllable (the battery has to be filled up), the increase of battery capacity could introduce further flexibility (current real autonomies are enough to drive for 100 km). It will also be possible to take into account that a battery is generally not empty when the charging process begins, and a complete charge is often not necessary. As a further addition, for new vehicles it will be possible to modulate the charging power within a given range (e.g., from 1 to 22 kW).

Existing solutions tailored to avoid production peaks and network congestions, e.g. time of use tariffs, can be applied to EV charging (e.g. using clock systems or ripple control when available). This solution could be adopted in a very first phase, with a low EV penetration rate. In the longer perspective, charging could create grid congestion (during the night) and sharp demand increases if the system is not accurately managed. Full flexibility of the charging processes has to be considered as a main target. If the charging process is systematically long, 8 hours or more, there will be less need for flexibility. Therefore it is at least initially, recommended to charge every night to reduce unnecessary system stress.

Accurate and flexible smart charging is a cornerstone in the smart grid development and core in the DSO work; here active demand will play an important part. Today dynamic control of demand by network utilities is not considered by regulators. It is of utmost importance that the DSOs are part of such process, since they are responsible for guaranteeing the distribution network stability. For this reason it is important that the DSOs have the role of controlling and approving of any design and organisation considered for EV demand modulation.

Until we have an efficient rollout of the active demand technology, the DSO alone can apply basic and straightforward load management policies; by implementing communication between the grid and the delivery point to minimise peak demand (delaying or avoiding network investments) or by taking part in a demand response market.

DSOs can deploy a smart charging infrastructure, control the impact on the grid and implementing smart grid services. This is likely to speed up EV deployment and minimize network costs. The regulated revenues of the DSOs have to consider the economic effort of introducing such control systems

Several players will be involved in electric vehicle charging business:

- The customer/car owner.
- Charging spots operators, with their private networks

Regulated network tariff signal is a basis. On top of this, considering the limits of too elaborated tariff schemes, demand response signals (the price on electricity) have to be considered and legitimated from a consumer point of view.

- The mobility service providers

They provide services in line with customer needs and operate the EV or at least its energy storage functionalities (i.e., managing batteries guaranteeing technical parameters as power capacity and life time) eventually leading to completely new business opportunities.

- Electricity suppliers.
- Aggregators for demand response.

In such a multi-player market the DSOs will be enablers of interoperable services for smart charging. Consequently, there is a need to develop and adopt the regulatory framework in regard to the role of DSOs in demand response and by deploying specific incentives, at least in the early adopters' phase of introducing demand response technology, since if the DSO is the owner of the charging spots, these must be integrated into the asset base.

5. Design of installations, from the delivery point to the plug

There is a need for common recommendations:

- From a security point of view, Mode 3 – according to IEC 61851 definitions, should be the standard for connecting vehicles to the grid.
- Public charging spots should be installed as three phase level to allow for higher charging power, whereas private charging is usually single phase.
- There is an urgent need to decide a unique European EV plug, common for public and private use. The locations and types of charging spots – public and private, shared and single-user – are numerous.

Firstly, affordable charging solutions for single users should be deployed. Secondly, there will be shareable charging spots in private parking places, both in residential and professional premises (e.g. customers, visitors, employees). Finally, there is a need for spots in public parking places for people who cannot park at their own premises.

It is expected that in the very first phase, charging will mostly take place at home, or nearby. Still it is crucial to deploy the same technology and business organisation to all shareable charging spots. Considering that the uptake of EVs requires financial efforts, a value assessment of the technology must be done in order to achieve the best cost-effectiveness, especially for private charging spots. The cost of an installed charging spot has to be considered as reasonable by the user/the customer not to represent a barrier to electric mobility.

EDSO for Smart Grids recommends that EV users should be encouraged to plug their car every day and avoid peak time demand in order to promote habits enabling to minimize their eco-environmental impact.

In the very first phase the average charging power will be 3 kW[2] and the charging time will be 2-3 hours, since most of the EVs are used for shorter distances than 40 km. Very soon, cars with more powerful chargers, up to 22 kW, will be introduced, decreasing the average charging time in high power charging spots together with better controllability of the charging process.

DSOs must be in compliance with national and international standards and supportive of the updating of the existing rules, having a fully interoperable charging infrastructure as the final goal.

Finally, it is of utmost importance to ensure the needs of the driver/the customer in order to build and maintain confidence in the Evs and EV charging.

[2] The average charging for a night is 8 kWh according to our calculation (20.000 km/year), 3kW is considered too low by some car manufacturers.

Annex 1 – Guidelines for large scale roll-out of electric vehicles

The future smart energy systems have to be developed with new requirements for a large scale roll-out of electric vehicles. EDSO for Smart Grids is convinced that DSOs will play the key role here, bearing in mind that this new development directly and indirectly will affect the medium and low voltage grids from a technical and economic aspect.

New technical requirements

1. The charging process must be controlled according to time and power parameters, with the possibility to invert the charging power flow providing electricity to the private network (Vehicle-to-Home services –V2H), or to the grid (Vehicle-to-Grid – V2G).

2. Mode 3, according to IEC 61851, is necessary for safety reasons and for allowing an accurate control of the charging load profile (time and power control). EDSO foresees the use of charging infrastructures with embedded intelligence as the key enabling factor for future advanced services related to electric mobility.

3. Mode 3 should be designed to allow maximum flexibility regarding time and power regulation, and EVs should comply with this possibility.

4. Price signals cannot be the only solution for load control, since this may result in sharp increase or decrease in the electricity demand.

5. A public charging service operator has to give access to all mobility service providers.

6. There is a need for cost-benefit assessments to reach a reasonable cost for private EV charging spots.

EDSO for Smart Grids recommends that each actor in electric mobility tailors their own solutions in order to fulfill initial cost-effectiveness and the possibilities to deliver future smart services.

7. There is an urgent need for a European standard on a Mode 3 plug – interoperability is key.

8. As battery capacity increases, the charging process for any vehicle can be managed over a longer period than one day and on multiple charging spots.

9. The massive development of EVs gives a good opportunity to optimize the integration of distributed generation from renewable energy sources with a smart charging control system. To develop this in the view of global system balance needs R&D.

New procedural requirements

10. In order to speed up development and interoperability and achieve global optimisation the DSO should be in charge.

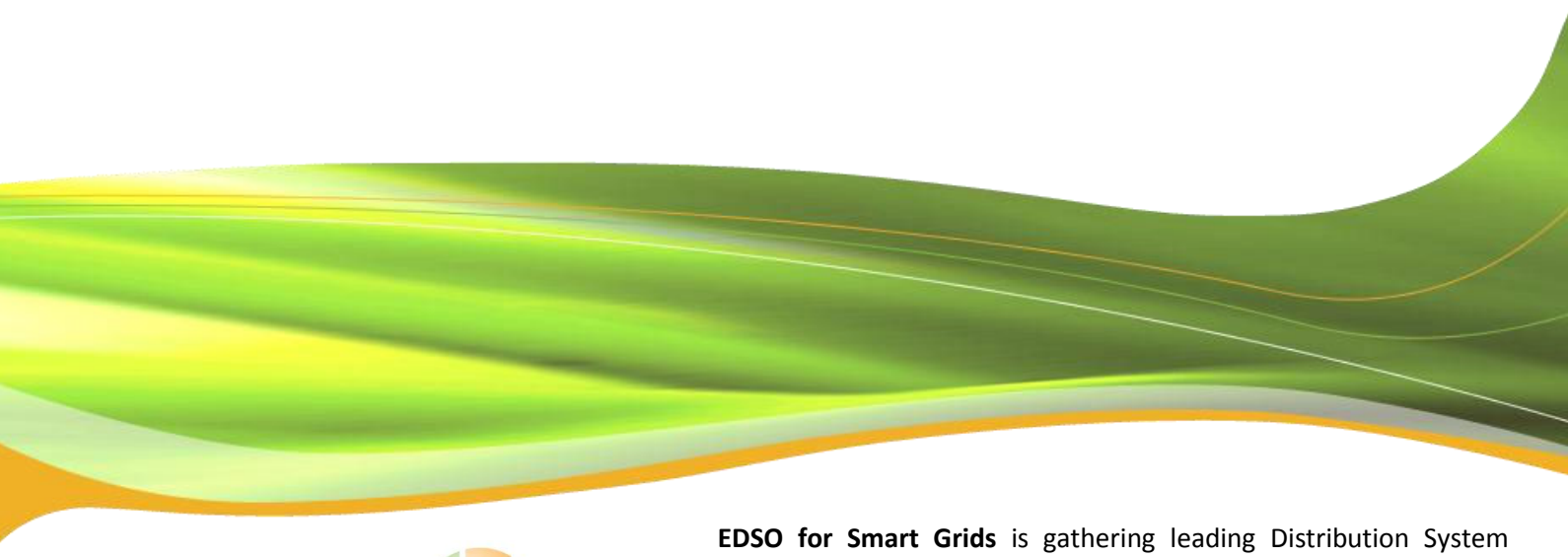
11. When the DSO is investing in and operating public charging spots, costs and benefits involved should be included in the regulated asset base and be regulated accordingly.

12. The organisation of EV load management should be an integrated part of the ordinary DSOs energy system management and control. TSOs are responsible for the overall system balance and in order to handle the system cost-efficiently any TSO request relating to a specific distribution grid should be transmitted to that DSO to be fulfilled according also to the distribution network requirements. Not doing so, e.g. TSOs passing requirements directly to commercial agents or users, could create undesirable and costly unbalances in the distribution network.

13. If it will be mandatory to give the EV car drivers the possibility to choose electricity supplier at every public charging spot, this has to be an official point of electricity supply equipped with a meter. This solution has to be considered in the future, when the cost and complexity is justified. For the first phase, charging should be to enabled without focusing on the possibility to choose electricity supplier.

14. A communication infrastructure has to be developed to allow data exchange between energy market actors (e.g. customers, DSOs, TSOs, suppliers, aggregators), EV charging service suppliers (e.g. e- mobility service providers and charging spot operators). The DSOs' involvement in the design and construction of the first solutions for settlement between different service providers is crucial.

15. DSOs can harmonise the European charging infrastructure, providing seamless access for any EV to any charging spot and allow pan-European business development by all mobility service operators.



EDSO for smart grids

EDSO for Smart Grids is gathering leading Distribution System Operators, covering more than 70 percent of the EU points of electricity supply, and cooperating to bring Smart Grids from vision to reality.

www.edsoforsmartgrids.eu