Facilitating e-mobility: EURELECTRIC views on charging infrastructure

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Facilitating e-mobility:

EURELECTRIC views on charging infrastructure

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Key points

A. EURELECTRIC stresses the importance of finding European solutions that enable a single EU-wide e-mobility market, strengthening Europe's competitiveness while paving the way for a decarbonised European economy and securing its energy supplies. Europe has to seize the opportunity of its first-mover advantage on e-mobility.

B. EURELECTRIC therefore calls for a close dialogue between European industrial actors and policymakers to turn e-mobility into a market success. In the absence of a voluntary European industrial agreement on the type of connectors (both AC and DC), European policymakers have to undertake appropriate actions and decisions **now** to enable a stable investment climate and ensure the deployment of a well-functioning EU-wide e-mobility market, corresponding to customer requirements.

C. Evolving towards low-carbon mobility requires electric vehicles to be charged in a smart way that exploits synergies with renewable electricity generation and allows load management in a smart grid context.

D. EURELECTRIC supports the mass market deployment of electric vehicles. To this end, it sees the already available infrastructure (domestic and industrial plugs and sockets, as well as charging in Modes 1 and 2) as a bridging solution to facilitate market up-take of electric vehicles.[1]

E. Electric vehicles represent controllable mobile loads that can prepare the ground for smart grid deployment. To make the most of their potential, EURELECTRIC recommends shifting over time to Mode 3 charging as the preferred solution in all types of locations. The necessity of charge management has also been emphasised by the association of the European engineering industry (Orgalime).

F. European car manufacturers (ACEA) recommend installing Type2/Type Combo inlet/connector, as of 2017, for charging electric vehicles. For EURELECTRIC it is important that Europe decides to adopt a single connector, but it does not have a preference on the specific type as it does not influence the distribution of the electricity. EURELECTRIC takes note that different infrastructural choices are being made across Europe. This situation needs to be resolved now before it endangers further market deployment.

G. In response to customer requirements, a high-power charging option has to be offered. This charging option should, however, not be promoted as the main way to charge electric vehicles. Instead, EURELECTRIC believes that the bulk of the charging can be done through low-power charging when the vehicles are plugged into the grid every time they are parked.

H. EURELECTRIC encourages further field tests to reach a commonly accepted and cost-effective solution for high-power AC and DC charging.

[1] Given the standard outlets (domestic/industrial) are abundantly available, they may remain as an "occational solution"even in future.

Foreword

The success of electric mobility depends on meeting certain requirements of the electricity system. Only then will customers be able to reap e-mobility's full environmental and economic benefits. The European electricity generation mix is changing significantly: it now includes an increasing share of decentralised and intermittent renewable energy sources. This change affects the distribution of the electricity to the final customer. Increased electrification of society (in heating & cooling and in transport) requires proper preparation in order to deliver a secure supply of electricity.

The introduction of electric cars on a mass scale raises a number of issues that need to be addressed. In this position paper EURELECTRIC:

- Stresses the need to offer a user-friendly e-mobility product. EURELECTRIC therefore calls for a single plug for charging electric vehicles in Europe.
- Sets out the electricity industry's interests while taking into account the challenges of integrating an increasing share of intermittent renewable energy sources, which will enable low-carbon mobility and pave the way for a smart energy distribution system.
- Refers to the work done within the European standardisation organisations in the framework of Mandate 468 and international standardisation work. All references to standardisation technology refer to the official standardisation work, both at European (CEN/CENELEC) and international level (IEC/ISO).
- Relies on today's state-of-the-art technology and R&D cycles of the different technologies related to electric vehicles.
- Underlines the differentiation of charging infrastructure requirements depending on the charging location: private or public.
- Emphasises the importance of electromagnetic compatibility (EMC) and calls upon the European standardisation organisations to monitor this issue closely.
- Takes note of the position paper of other important industry associations involved in e-mobility – ACEA and Orgalime – and welcomes the common positions on some aspects while calling for a close dialogue with the European institutions to resolve open issues.

Introduction

European electricity companies, especially distribution system operators, are investing in the necessary infrastructure to foster a single European market for electric vehicles. Commonly European accepted standards are therefore indispensable to ensure that drivers enjoy a convenient EU-wide recharging solution that avoids a multiplicity of cables and adaptors and/or retrofit costs[2]. EURELECTRIC stresses the important role distribution network operators will play to efficiently accommodate the additional demand for electricity into the distribution grids both from an environmental as an economical point of view.

In June 2000, the European Commission issued a standardisation mandate to the European standardisation bodies CEN, CENELEC and ETSI (M/468) concerning the charging of electric vehicles. The mandate stresses the need for interoperable plugs and chargers to promote the internal market for electric vehicles and to discourage the imposition of market barriers. The Focus Group set up to respond to M/468 delivered a comprehensive and valuable report. However, given that the mandate's objective was to achieve interoperability, not the adoption of a single connector, no recommendation has been made with regards to the choice of the AC mains connector. As a consequence, two types of connectors have been assessed as appropriate for the European situation. The choice between them is left to the market and will depend on the different national regulatory frameworks.

EURELECTRIC is concerned that the existence of two types of connectors hampers the development of a European e-mobility market. There are three reasons for this concern. Firstly, and most importantly, offering different type of connectors and/or possible adapters is not convenient for customers. Secondly, EURELECTRIC notes that, in the absence of a European agreement, some of its members are delaying investments in e-mobility charging infrastructure while waiting for such an agreement to be found. Thirdly, different, incompatible infrastructure solutions are now being implemented in Europe, delaying mass-scale market development.

In this paper EURELECTRIC sets out the electricity industry's views on the development and deployment of e-mobility, including the requirements and conditions which need to be taken on board while setting the standards, to optimise synergies with renewable electricity.

[2] Declaration by the European Electricity Industry on standardisation of electric vehicle charging infrastructure, Oct. 2009

I. EURELECTRIC vision: electric vehicles as an integrated part of the future smart distribution network

Electric vehicles will become an integrated part of tomorrow's smart electricity grids: they will act both as **mobile consumers** and **electrical storage possibilities**. Hence the charging infrastructure for electric vehicles will have to comply with certain technical requirements. Indeed, an intelligent connection between the grid and the car is necessary to smoothly integrate the additional loads into the distribution networks, while coping with an increasing share of intermittent and decentralised renewable energy sources. Grid stability is an indispensable aspect that needs to be carefully addressed.

As a result, a **standardised communication protocol** is required between the charging infrastructure, the electric vehicle, the energy management system of the private network (if existing) and the electricity distribution grid. Such communication will enable **load management**, while making efficient use of the electricity generation capacity, especially electricity generated from intermittent renewable energy sources. Consequently, ICT standards are a prerequisite in this future **smart energy system** to maximise the number of electric vehicles powered by zero-emission electricity.

Under mass market conditions, grid constraints will be inevitable when all vehicles are plugged into the distribution network simultaneously because no electric grid would be able to sustain the resulting peak load. This situation can, however, be easily avoided through **smart charging**[3], i.e. by coordinating and managing the additional electrical loads. In future, electric vehicles will also be able to modulate the charging power on a wide range (1-22kW, possibly even more) which provides the distribution system operator (DSO) with a **power balancing tool**. The smart charging system will dynamically regulate the charging speed based on the overall grid utilisation. The DSO will set the boundary limits to safeguard the distribution network. A control mechanism can be enabled by the grid, by the energy management system of the private network, by the charging point, or by the vehicle itself, while communication between the electric vehicle and the grid will allow the charging process to take actual grid capabilities into account. Price or control signals can be communicated through an ICT infrastructure in order to allow intelligent charging algorithms that take generation and grid constraints into consideration and allow consumers to benefit from price opportunities.

In sum, smart charging is indispensable to optimise the usage of the distribution grid and the electrical energy available. In doing so, additional network investments are minimised and renewable electricity integration is facilitated. In the near future when electric vehicles have reached mass market deployment, **EURELECTRIC therefore recommends that new e-mobility infrastructure is equipped for mode 3 charging** (IEC 61851), which paves the way for controllable charging processes, i.e. load management, within a smart grid context.

3 EURELECTRIC position paper, April 2011, p.10

I. Towards a single European charging solution for e-mobility

Contrary to internal combustion vehicles, electric vehicles do not require dedicated refuelling stops: electric vehicle drivers should be able to plug their car into the grid while it is parked. Connection points should be made abundantly available so that customers can recharge their vehicle at home or at the office, in a parking lot or at the shopping mall or supermarket, or at a dedicated high-power charging station on public roads. These different locations matter because the parking time, in addition to the remaining range of the battery, determines the customer's charging requirements. Electric vehicle customers should be able to recharge in all these different locations without any interoperability, identification and billing obstacles.

In general, three categories of locations[4] can be distinguished: domestic areas, semi-public areas and public areas. In some locations, especially in domestic settings and to some extent also semi-public settings, existing domestic sockets and/or industrial sockets mean that charging infrastructure is already in place, albeit with limited capabilities. In contrast, new charging infrastructure has to be installed in public and partly in semi-public locations. In addition, outdoor infrastructure requires additional functionalities than indoor infrastructure.

EURELECTRIC encourages the installation of standardised e-mobility infrastructure (both connector and communication protocol) **in all the above-mentioned locations as of 2017**[5]. This will allow electric vehicles to play their part in a future smart electricity distribution system.

1. Private charging with today's infrastructure

Private settings refer to locations on private property with a connection to the electricity distribution grid and where existing domestic or industrial sockets can already be used for e-mobility purposes. Examples include home and office buildings.

In these domestic locations, EURELECTRIC defines the charging process as normal power charging (1-phase connection, ≤ 3.7kW). This can be seen as a default connection which can in fact take place at any location (private, semi-public and public) because it is the minimum power level sustained by the connection to the grid. Normal power charging will, however, mostly take place in locations where the vehicle is parked for a significant period of time, like home and office buildings (especially for fleets)[6].

[4] The type of location also influences the market model of the e-mobility market. See EURELECTRIC's concept paper on Market Models for rolling-out public charging infrastructure, published in September 2010. Available on www.eurelectric.org/positions

5 As this corresponds to the deployment of electric vehicles supporting mode 3 charging as mentioned in ACEA's position paper of September 2011.

6 See annex 1: range/hour for each type of power nomination

This may suit a lot of e-mobility customers' needs, as many daily trips fall within today's battery capacity. If customers are encouraged to charge their vehicles regularly while they are parked at the office or at home, not much power is needed to fully recharge the battery. Moreover, with the infrastructure already installed today and at a low rate of electric vehicle penetration, off-peak charging can already be encouraged through tariff systems. This avoids additional pressure on the distribution network while enabling synergies with renewable electricity generation.

While it is difficult to predict market developments, EURELECTRIC encourages e-mobility customers to charge predominantly in domestic locations (home and office) because this normal power charging goes hand in hand with smart charging. Nonetheless, infrastructural differences between EU member states may influence the charging location possibilities. For instance, access to charging possibilities on private property is not common in all countries and/or cities, e.g. the Netherlands. In these countries, charging in public locations may be used more extensively.

Although domestic and industrial sockets were not originally designed[7] to charge electric vehicles, their availability facilitates early market up-take. EURELECTRIC therefore believes that **standardised domestic and/or industrial plugs that charge electric vehicles in mode 1 and Mode 2 should be seen as a bridging solution to support initial market up-take** and foster market penetration of electric vehicles. To ensure best use of intermittent renewable energy sources, recharging should take place as much as possible during hours of low electricity demand.

2. Ensuring e-mobility charging infrastructure (AC) at all locations

Balancing the daily load profiles on the grid will become a major challenge as the electrification of the transport sector continues. In addition, the electricity will increasingly be generated from decentralised and intermittent renewable energy sources. The electricity distribution system will change drastically with the empowerment of customers (demand side management and participation) through the smart meter roll-out and the introduction of electric vehicles. Under mass market conditions, the charging of electric vehicles must therefore be done in a coordinated and smart way to avoid unsustainable peak loads. Network operators have a crucial role in ensuring that this is done in a sustainable way.

Electric vehicles and the corresponding charging infrastructure will be part of the future **smart home/smart building system that interacts with the electricity grid**. In such a system, private households and electric vehicles will take part in power balancing through automated systems that consume, store, produce and re-distribute energy. Adequate infrastructure is necessary to enable such advanced features. Therefore, in future, e-mobility infrastructure that offers mode 3 charging enabling communication will be required in private settings (households and office buildings).

7 The possible danger of overheated domestic sockets while charging electric vehicles is an issue that needs to be monitored with care.

To ensure customer convenience, the e-mobility socket should then be the same for all possible charging locations (domestic and publically accessible charging points), allowing electric vehicle drivers to charge their electric vehicle at any connection point without any adapters or extention-cables. EURELECTRIC strongly recommends a cost-effective infrastructure solution that corresponds to customer needs.

2.1. Finding European agreement on the AC mains connector

The Focus Group set up under the umbrella of the European standardisation organisations to respond to the European Commission's standardisation mandate (M/468) has not reached agreement among European stakeholders on the choice of the AC mains connector for charging passenger vehicles in Mode 3. At the moment, two European infrastructural solutions exist ("Type 2" and "Type 3"), both of which have been standardised at the international level within the catalogue of IEC 62196-2 standards, approving them in terms of safety and security.

Given that both connectors are standardised within the catalogue of IEC 62196-2 standards, the choice of the AC connector is left to the market and national regulatory circumstances. EURELECTRIC believes that this situation is not beneficial for e-mobility development and market deployment in Europe.

In the absence of any European agreement concerning the AC connector, **European countries are either installing e-mobility infrastructure that is incompatible with other solutions** (interoperability problems between Type 2 and Type 3) **or are delaying investments until a European agreement is reached. EURELECTRIC is very concerned that this situation endangers successful market deployment of electric vehicles,** because a) no convenient recharging solution is being offered to the customer and b) investment insecurity (stranded investments) is hampering the infrastructure roll-out.

The decision on a single AC connector in Europe is further complicated by differing national safety regulations for connecting household electrical loads to the distribution network. Some European countries[8] explicitly require ordinary domestic sockets – which are usually under live voltage – to comply with shutters and/or IPXXD (*Figure 1*).

8 The following countries have a regulation for shutters on ordinary domestic sockets: Belgium, Cyprus, Denmark, Finland, France, Italy, Malta, Norway, Portugal, Spain, Sweden, and United Kingdom.

Based on input from EURELECTRIC members, the map below shows which European countries have to comply with shutters in domestic settings. The map also shows which countries are installing which type of connector. Unmarked countries are awaiting European agreement before starting the roll-out of e-mobility infrastructure.

From this map and the input of EURELECTRIC members, we conclude that countries like Belgium, Switzerland and Norway are rather hesitant to start the roll-out of e-mobility infrastructure in the absence of an agreed European connector type. Other countries like Sweden, Greece and Finland have not yet deployed e-mobility infrastructure but intend to install the Type 2 connector once e-mobility infrastructure is installed, as they perceive Type 2 as a 'de facto standard'.

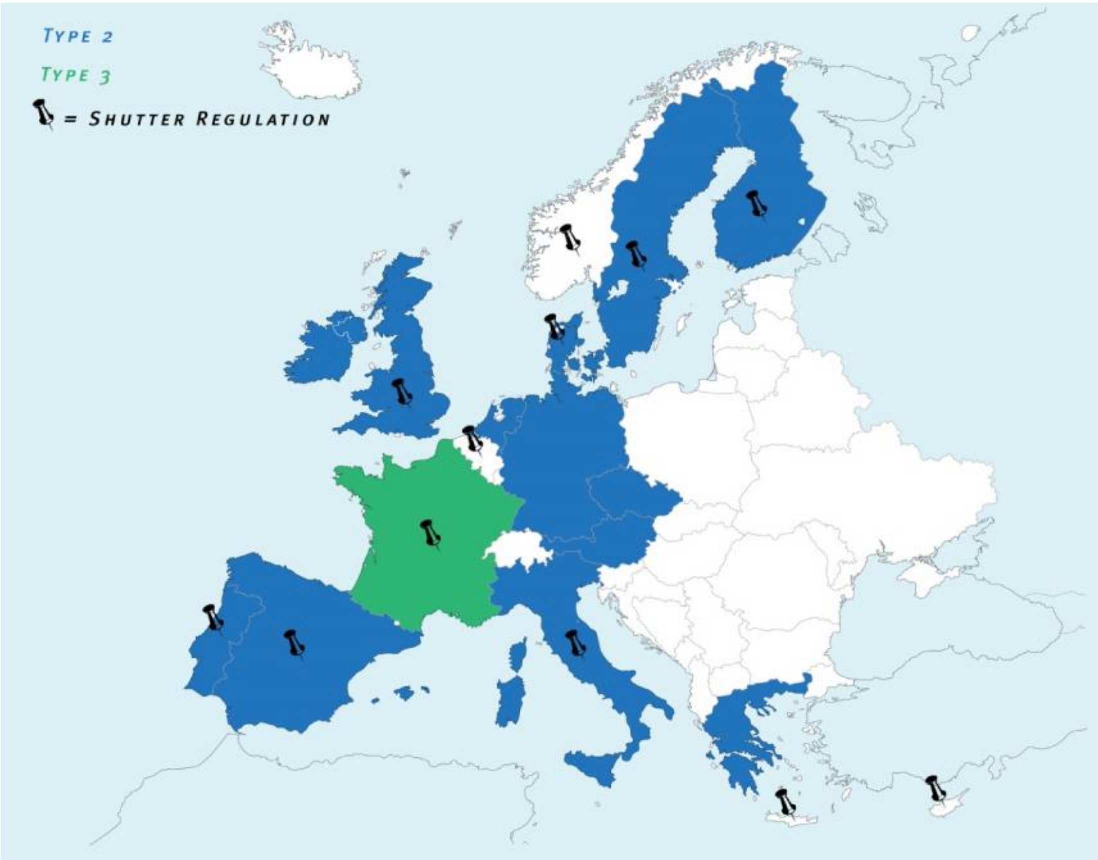

Figure 1: Shutter regulation, choice of AC connector, and undecided countries

Information box: How several European countries have adopted Type 2 although regulation requires compliance of shutters/IPxxD for domestic locations

United Kingdom: The electrical wiring regulations require that every socket outlet in domestic installations shall be of the shuttered type preferably complying with BS1363. However, the regulations also permit variations provided that it is noted in the installation certificate and that the variation gives the same or better protection. In this case there are two options:

1. Using the Type 2 connector, (noting the variation) but also noting that the Mode 3 charging arrangement does not allow the socket to become live unless there is an electric vehicle connected, which means that all the live parts of the socket are inaccessible.

2. Using a Mode 3 charger unit with the cable and connector permanently attached. In this case there is no socket outlet as defined by the regulations. This is the type of installation that is being widely rolled out with the Nissan Leaf.

Sweden: In Sweden, fixed socket outlets in low-voltage buildings shall either have shutters or be assembled or placed in a way that restricts the risk of accidents with children, by being placed at least 1.7m above the ground, or protected with fixed equipment, or interlocked, or protected with a locking cover, or protected in another way.

Spain: legislation for residential low-voltage infrastructure prescribes the IPXXB as protection level, with which Type 2 is compliant.

Portugal: Approval of the installation of Type 2 sockets was given by the electrical installationscertification authority, based on the fact that live contacts of the socket are not accessible, as of Mode 3 working principle. A general approval is not yet included in the technical regulations.

Italy: Enel is collaborating with equipment manufacturers to develop a Type 2 socket that complies with the shutter/IPxxD regulation for installations in domestic areas. They expect to have the product available by July 2012.

Denmark: Electric vehicle sockets (IEC 62196) are exempted from the shutter requirement. If the electric vehicle is connected to a household socket in compliance with DS 60884-2-D1, a shutter is required, as it is in other countries. Household sockets with a degree of protection higher than IPX0, e.g. sockets for outdoor use, do not require shutters.

Based on an internal EURELECTRIC survey, Table 1 gives an indication of the number of dedicated e-mobility installations (Type 2 or Type3) across Europe, including those already installed and those commissioned for 2012. The figures only include specific e-mobility infrastructure, not domestic and industrial connection points that could also be used for other purposes. The table only provides an indicative impression based on available information.

Country	AC connector	# installed		# Commissioned in 2012	
		Private	Public	Private	Public
AT[9]	Type 2	50	100	/	/
CZ[10]	Type 2	3	20	/	61
DK[11]	Type 2	0[12]	280		
DE[13]	Type 2	385	1 750	/	97
ES	Type 2	*To follow*			
FR[14]	Type 3	3 500	4 000	10 500	10 000
IE[15]	Type 2	358	202	750	1 000
IT[16]	Type 2	233	120	8 000	2 000
NL[17]	Type 2	>1 000	>2 000	>1 000	>1 500
PT[18]	Type 2	0	525	/	675
UK[19]	Type 2	0	250	/	4 000

Table 1: indicative number of installations per country for the AC connector

Two conclusions can be drawn from the map and the table. First, European member states with a clear e-mobility target, such as Germany, France, Ireland, the Netherlands and Denmark, are – despite the absence of a European agreement – installing a significant amount of e-mobility infrastructure. Secondly, the absence of a European agreement is hampering the roll-out in European countries such as Belgium, Norway and Switzerland. Hence, the present situation is characterised by a lack of European coordination not only regarding the interoperability of the infrastructure, but also its availability.

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[9] The figures reflect efforts of Verbund.
[10] Figures represent efforts of CEZ, PRE and Eon in Czech Republic
[11] The figures reflect national situation in Denmark.
[12] Private locations are equipped with standardised domestic sockets (“schuko”) charging in Mode 2.
[13] For public, figures reflect German electricity industry efforts, private installatins reflect RWE installlations.
[14] Figures reflect the national French roll-out plan
[15] The figures reflect the National Irish Roll-Out Plan
[16] The figures represent Enel’s installations
[17] The figures reflect the national situation in the Netherlands.
[18] The figures reflect the national Portuguese situation.
[19] Private installations are equipped either with a standard connector for Mode 2, or a Mode 3 charger with a tethered cable. The figures reflect the national UK situation.

The absence of a European agreement increases costs due to possible stranded investments and/or retrofitting costs of installed charging infrastructure. EURELECTRIC therefore advises anticipating possible retrofitting (of both AC and DC infrastructure) until a European solution has been agreed. Current experience shows that retrofitting costs could range between €250 – when retrofitting is anticipated and it is only necessary to change the socket – and, in a worst case scenario, €3,000 per charging station, should these need to be changed. Economies of scale have to be encouraged to drive costs down.

A clear European agreement is indispensable: for the industry to secure investments and for the consumer to benefit from a common user-friendly product**. EURELECTRIC therefore calls on the European institutions to guide European member states in order to ensure agreement on a European solution and allow a coordinated and harmonised infrastructure roll-out across Europe**. This will encourage a well-functioning single market for e-mobility and offer European citizens a convenient e-mobility recharging infrastructure.

3. Public charging: High-power AC or DC connections

Public locations such as curb sides or motorway charging stations differ from private locations in that they are accessible by anyone at any time. Publically accessible charging infrastructure therefore requires additional features to ensure public safety, enable certified billing/payment procedures, protect the infrastructure from vandalism, allow operation under harsh weather conditions, etc.

EURELECTRIC recognises that there is a need to offer customers a high-power charging possibility that allows them to recharge the battery within a limited timeframe. A high-power connection would satisfy customer requirements for longer journeys, for instance by enabling relatively short recharging stops during longer motorway journeys. However, EURELECTRIC strongly recommends that this charging method does not become the dominant way of charging electric vehicles, as electric vehicle customers would then probably not accept load management.

Two technologies are at hand for high-power charging: DC off-board charging or AC on-board charging. DC off-board charging is more common today, due to the introduction of the first generation of Japanese electric cars on the European automotive market. Nevertheless, European automotive manufacturers have expressed their intention to launch a passenger car with an on-board charger which would be compatible with a high-power range AC supply arrangement.

For the DC connection, CHAdeMO – with a maximum power level of 50kW – is currently the only available product on the market and is thus being rolled out in several European countries (see Table 2) although it is not internationally standardised. The European automotive industry (ACEA) is however promoting the combined charging system with the

Combo connector,[20] which features a single inlet for AC and DC charging on the side of the vehicle and can potentially deliver high-power charging of up to 100kW in future.

The Combo connector is currently under development and going through the IEC standardisation process. It is expected to be available on the market by end 2012 depending on the progress made in standardisation.

Table 2 below gives an overview of installed DC charging infrastructure in different European countries, based on input from EURELECTRIC members. The future infrastructural solution for DC charging remains very uncertain: only CHAdeMO installations are available for the moment, but the European car manufacturers' expressed preference for the Combo charging solution has left the future infrastructure solution open. Indeed, the technological choice between on- or off-board chargers will be determined by what suits the vehicles on the market and the relative cost of both systems for the infrastructure provider.

For the electricity industry, it does not matter much whether the conversion from AC to DC is done on- or off-board. In any case, high-power charging is likely to be a premium-priced service (peak demand pricing) for the electric vehicle driver, the use of which should be encouraged only when charging time is critical, i.e. in the middle of a journey. In such cases, limiting or interrupting charging for load management purposes (except for emergencies) is unlikely to be acceptable to electric vehicle customers. For the electricity industry, the limited possibilities of load management therefore make high-power charging less attractive.

Country	DC connector	#installed	# commissioned in 2012
AT	CHAdeMO	5	
BE	CHAdeMO	12	/
CZ	CHAdeMO	1	5
DE[21]	CHAdeMO	10	11
DK	CHAdeMO	5	
ES	CHAdeMO	10	40
FR	CHAdeMO	30	100
IE	CHAdeMO	28	60
IT	*No DC charging, preference goes to AC 3-phase 43kW*		
NL	CHAdeMO	25	25
NO	CHAdeMO	27	/
PT	CHAdeMO	6	44
SE	CHAdeMO	5-10	/
UK	CHAdeMO	25	/

Table 2: Overview of DC infrastructure across Europe

20 ACEA position and recommendations, 14 September 2011

21 There are "Combi stations"meaning that there is one Type 2 inlet and 1 CHAdeMO inlet

To ensure a European-wide solution, **EURELECTRIC** calls for further tests to gain experience with both AC and DC high-power connections, and **stresses the need for one European standardised infrastructure solution for high-power connections**. EURELECTRIC urges all relevant stakeholders to avoid a prolonged debate of different infrastructural solutions in the coming years. In this respect, **the Green eMotion[22] demonstration outcomes are warmly encouraged** to bring further insights into technical performance as well as customer expectations and **to clearly recommend one type of infrastructure.**

It is important that the electricity industry has the responsibility for integrating and maintaining control of the high-power charging stations because electric vehicle charging might influence the electromagnetic compatibility of the distribution network. Charging electric vehicles may create disturbances on the network for several reasons:

I) the power increase, ranging from low voltages in rural areas that are not dimensioned for such powerful loads,
II) typical power quality disturbances like flickering, due to interruptions in the charging process for battery management,
III) the harmonics of the AC to DC conversion (on-board or off-board),
IV) the higher frequency disturbances (in the range of 2-150 kHz) due to power electronics used in the charger.

Although there are regulations that limit the allowed amount of disturbance (e.g. total harmonic distortion), none of these regulations were designed to take electric vehicle charging into account. Moreover there is no standard regarding higher frequency disturbances, and the standardisation process is only starting to assess possible impacts. If both the cars and the off-board chargers that come onto the market include adequate provisions to limit network disturbances, utilities will show little preference for DC or AC charging.

22 Green eMotion is a European demonstration project, funded under the 7th Framework Programme, that will demonstrate an interoperable market for e-mobility in Europe. EURELECTRIC is one of the 42 consortium partners of Green eMotion. More information on the project can be found at http://www.greenemotion-project.eu

Overview summary

Description of today's situation

	Private domestic socket	Private dedicated E-mobility socket	Semi-Public AC	Public AC	Public DC
Power connection	≤ 3.0 kW/ [1] ≤ 3.7 kW [1] 1-phase AC	Up to 22 kW	Up to 22 kW[6]	Up to 22 kW[6]	50 kW (ChadeMo)
Plug (Infrastructure side)	Domestic [1]	IEC 60309-2[5] Type 2/ Type3[8]	Type 2/ Type3[8]	Type 2/ Type3[8]	Yazaki (ChadeMo)
Charging mode	Mode 2	Mode 2[5] Mode 3	Mode 2[5] Mode 3	Mode 2[5] Mode 3	Mode 4
Communication Vehicle to Charging station	no com. for domestic [1] IEC 61851-1 annex A (pilot function)	IEC 61851-1 annex A (pilot function) ISO/IEC 15118 where applicable	IEC 61851-1 annex A (pilot function) ISO/IEC 15118 where applicable	IEC 61851-1 annex A (pilot function) ISO/IEC 15118 where applicable	communication is always required acc. to the standard
Communication Charging station to Grid	not applicable	not applicable	not required as long as authorisation and billing is done otherwise	at least for authorisation and billing	IEC61850-420

Recommendation for mass market deployment

	Private domestic socket	Private dedicated socket	Semi-Public AC	Public AC	Public DC
Power connection	≤ 3.0 kW/ [1] ≤ 3.7 kW [1] 1-phase AC	Up to 22 kW	Up to 22 (43) kW	Up to 43 kW	up to 100 kW
Plug (Infrastructure side)	Domestic [1]	single plug[8]	single plug[8]	single plug[8]	single plug[7] complying with upcoming IEC 62196-3
Charging mode	Mode 2	Mode 3	Mode 3	Mode 3	Mode 4
Communication Vehicle to Charging station	no com. for domestic IEC 61851-1 annex A (pilot function)	ISO/IEC 15118	ISO/IEC 15118	ISO/IEC 15118	IEC 61851-24 ISO/IEC 15118 [2])
Communication Charging station to Grid	EV is subjected to smart home and smart grid integration as this is introduced for households	IEC 61850-7-420 [3]	IEC 61850-7-420 [3]	IEC 61850-7-420 [3]	not required as grid connection has to consider max load and usage scenario does not comply with load management[4] IEC61850-420

Comments

1) For the domestic socket at least in some countries the current has to be limited to 13 A (3.0 kW)), 10 A (2.3 kW) or even down to 8 A (1.8 kW) due to the fact that the domestic sockets are not designed for repeated use at maximum rated current over long periods. Meanwhile there have been some publications reporting dangerous situations due to overheated plugs and sockets when charging 16 A at domestic sockets.

   The safest way would be to install charging stations (wall boxes) for single phase 16 A with the type 2 plug or at least to use industrial plugs (IEC 60309-2) at the infrastructure side instead of domestic sockets.

2) It is intended to use the communication protocol ISO/IEC 15118 independent of the charging technology. For AC it is clear, for DC all necessary actions for integration are performed and even for inductive charging this is under consideration.

3) IEC 61850-7-420 for management of distributed energy resources is actually seen as the best standard to integrate the load management related information for EV charging infrastructure. Work undergone under European mandate M/490 on smart grids will extend it.

4) From a technical point of view DC charging can satisfy load management as such function could be easily added to existing DC charging technology. The Grid could adequately follow the command signal from utility companies. Nevertheless, given the usage pattern of DC public charging, i.e. battery charging with shortest duration possible (meaning maximum power) this charging pattern does not suit load management issues, but can be submitted to price signal.

5) This reflects the actual situation today in Portugal

6) Max amps/phase = 32 A.

7) EURELECTRIC has no own preferences except that there shall be a single type of DC connector complying with an IEC standard.

8) EURELECTRIC has no own preferences except that there shall be only a single AC type of connector. Europe has to steer the European countries to decide on a unique AC mains connector for eMobility. Currently Type 2 and Type 3 are being implemented across Europe due to different regulatory requirements in European countries (shutters/ IPxxD). The currently available Type 2 does not comply with this regulatory requirement whereas Type 3 does meet the requirements. Nonetheless, a Type 2 that would meet the regulatory requirement of shutters/ IPxxD is under development.

ANNEX I - Power Classification

Power nomination	Mains connection	Power in kW	Power in Amps	Recharge range/hour[23]	Location
Normal power[24]	1-Phase AC connection	≤ 3.7	10-16	<20 km	Domestic
Medium power	1- or 3-phase AC connection	3.7 -22	16-32	20 – 110 km	Semi-Public
High power	3-phase AC connection	> 22	> 32	>110 km	Public
High power	DC connection	> 22	> 32[25]	>110 km	Public

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[23] Assuming an average consumption of 20 kWh/100km.
[24] This single phase connection corresponds to the typical domestic plug connection dependent on country specific characteristics.
[25] With a DC connection the power to the vehicle is fed at the vehicle battery DC voltage, which normally ranges from 150-350 volts, so the amperage is related to the DC power and voltage.

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