European electricity industry views on charging Electric Vehicles

A EURELECTRIC position paper

April 2011

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Dépôt légal: D/2011/12.205/6

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Key Message

Smart charging is indispensable to deliver the benefits of electric vehicles. Coordinating and managing electrical loads for charging electric vehicles will:

- facilitate the integration of renewable energy sources into the electricity system;
- enable grid management that introduces flexibility into the system;
- optimise the efficient use of generation capacity;
- ensure a cost-effective solution by avoiding unnecessary grid investments;
- maximise consumer convenience through use of available infrastructure.

Introduction

EURELECTRIC is convinced that electricity is a solution for making transport more sustainable. Using low-carbon electricity in the transport sector can decrease greenhouse gas emissions, encourage energy-efficiency gains through the greater efficiency of electric drive-trains, decrease the EU's oil dependence, improve the situation in cities with regard to air pollution and noise, and help to maintain the EU's competitiveness by taking the lead in these new technological developments.

Cross-industry understanding and cooperation are needed to turn these opportunities into reality and foster the amalgam of conditions that will ensure the success of this new transport technology. Reaping the full benefits of electricity as a transport fuel will require the efficient integration of electric vehicles into the European electricity system, with regard to both generation and distribution.

The existing European electricity system already provides end-users with a very efficient infrastructure for generation, transmission, distribution and commercialisation of electricity. The equilibrium of this very complex system is managed in real time, across all borders of Europe. While EURELECTRIC is convinced that the existing European electricity system is a true asset for making transport more sustainable, general recommendations for an optimal integration of electric mobility are important in order to avoid technical bottlenecks and unnecessary investments in the electricity network.

The commercial success of electric transport will, of course, largely depend on the customer. Common standards will help to ensure that drivers enjoy a convenient recharging solution across Europe that avoids a multiplicity of different cables and adaptors and/or retrofit costs for adapting to new charging systems. Moreover consumers should be able to charge their vehicle at any publicly accessible charging station across Europe. A standardised interface between the distribution grid and electric vehicles will ensure the required safety and security level for the consumer.

Commonly agreed standards will generate cost benefits and help to create economies of scale for both electricity companies and the automobile industry. Standards for both hardware (connectors and cables) and communication software are a prerequisite for a secure investment climate for the required infrastructure. As well as encouraging the sharing of development costs, such standards will help to avoid the risk of stranded assets resulting from interim solutions. However, these new standards should not make charging from domestic plugs more difficult, as this charging method facilitates early market introduction of electric vehicles. In general, at the early stage of market development, it is important to leave room for further market improvements and refrain from overcomplicating market models and imposing a regulatory minefield.

1. Policy background: standardisation at the fore

The European electricity industry welcomes the European Commission's recognition, in its Communication on *"a European Strategy on clean and energy efficient vehicles"*, of the need for electric vehicle standardisation and the identification of specific action fields in this regard. The Communication identifies the purpose of standards as follows: "*to allow all electric vehicles to be charged and to communicate with the electricity grid anywhere in the EU and also with all types of chargers. Investment in electric charging points based on different standards should be avoided as far as possible. Compatibility problems that prevent drivers from charging at any available point could undermine confidence in electric vehicle technology*[1]*"*.

In June 2010, the European Commission mandated the European standardisation bodies (CEN, CENELEC and ETSI) to develop European standards or to review existing standards in order to:

- ensure interoperability and connectivity between the electricity supply point and the charger of electric vehicles, including the charger of their removable batteries, so that this charger can be connected and used in all EU member states. In doing so, the fact that domestic sockets are not harmonised in the EU should be taken into account: adaptors should be used for domestic charging.

- ensure interoperability and connectivity between the charger of electric vehicles – if the charger is not on board – and the electric vehicle and its removable battery, so that a single charger can be used to connect to and re-charge all types of electric vehicles and their batteries.

- appropriately consider any smart-charging issue with respect to the charging of electric vehicles.

- appropriately consider safety risks and electromagnetic compatibility of the charger of electric vehicles in the field of Directive 2006/95/EC (LVD) and Directive 2004/108/EC (EMC).

Following our *Standardisation Declaration on electric vehicle charging infrastructure*[2], EURELECTRIC, on behalf of the European electricity industry, agrees with the European Commission's identification of standardisation as a specific action to "*allow all electric vehicles to be charged and to communicate with the electricity grid anywhere in the EU*". EURELECTRIC will support and contribute to the European Commission's mandate requesting CEN, CENELEC and ETSI to develop or review existing standards in order to ensure the interoperability of electric vehicles throughout Europe.

[1] Communication from the European Commission to the European Parliament, the Council and the European Economic and Social Committee, *"A European Strategy on clean and energy efficient vehicles"*, Brussels, 28.04.2010, COM (2010)186 Final, p. 10.

[2] Declaration by the European electricity industry, *Standardisation of electric vehicle charging infrastructure*, EURELECTRIC, October 2009.

Standardisation requires full cooperation of all stakeholders at the international and European level in order to attain stable and commonly accepted standards. Keeping in mind the need to reach a rapid consensus on common European solutions, we propose that the CEN-CENELEC Focus Group on Electro-Mobility should be able to analyse and propose the technical solutions that seem best-suited to the European situation in terms of interoperability and the optimum use of the electric infrastructure already in place.

Recognising the leading role that the electricity industry has to play in this matter, this EURELECTRIC paper outlines several recommendations for turning plug-in electric and hybrid vehicles into a market success. The following section first clarifies some basic terms to facilitate a proper and clear understanding of the issues at hand.

2. Terminological clarification

2.1. Defining different charging methods

Much of the discussion on electric vehicles (EVs) focuses on their range and charging times, particularly in contrast to the relatively high range of internal combustion vehicles and the quick filling of the car at a petrol station. Fuelling an electric vehicle means charging the battery. Hence the fuelling of an electric vehicle will depend on the combination of:

- charging power (i.e. the voltage/amperage and the number of phases of the plug),
- battery characteristics.

We therefore feel that expressing the charging process in terms of power is more accurate than in time-related terms. In general one could use the following classification:

Power nomination	Mains connection	Power in kW	Power in Amps	Recharge range/hour[3]
Normal power[4]	1-Phase AC connection	≤ 3.7kW	10-16 amps	<20 km
Medium power	1- or 3-phase AC connection	3.7 -22 kW	16-32 amps	20 – 110 km
High power	3-phase AC connection	> 22 kW	> 32 amps	>110 km
High power	DC connection	> 22 kW	> 32 amps[5]	>110 km

[3] Assuming an average consumption of 20 kWh/100km.

[4] This single phase connection corresponds to the typical domestic plug connection dependent on country specific characteristics.

[5] 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.

It should be noted, however, that there is a major difference in terms of usage between the normal and medium-power modes on the one hand and the high-power mode on the other: whereas normal and medium power allow the cable to be loose, using high power means that the charging cable has a fixed connection to the charging station.

The charging method of electric vehicles will depend on where EV customers want to charge their vehicles. A strict, future-proof categorisation is difficult. However, a general, simplified picture of usage could be imagined as follows:

Normal power charging would generally take place in domestic settings like home and office buildings, but could also take place in public locations like curb-side charging poles and public car parks.

Figure 1 is an example of a vehicle charging and using its onboard charger at normal power level. The onboard charger can be compared to a high power mobile phone charger, as it also normally relies on a high frequency transformer to make it compact and lightweight and is unidirectional in power transformation. This charger is part of the vehicle and allows it to charge at any normal socket.

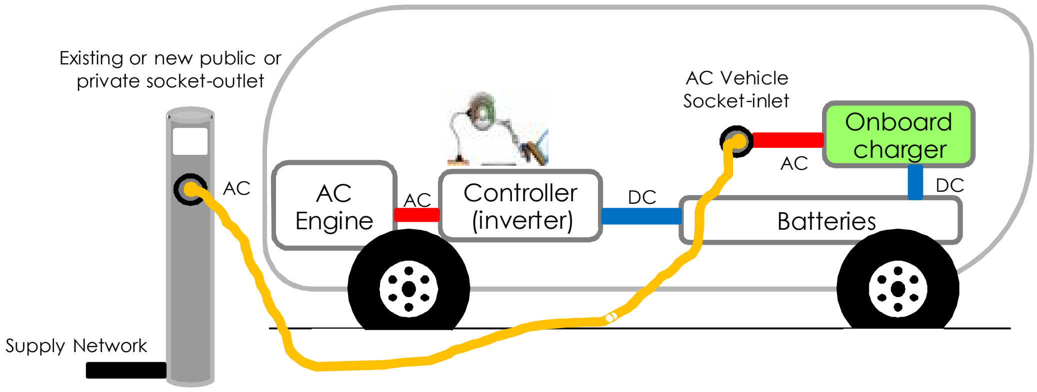

Figure 1 – The picture shows the main EV components involved in charging and locomotion. When charging at normal power level, the onboard charger receives AC power and transforms it into DC on the way to the battery. The power from the onboard charger can range between 1.5 and 3.5kW. The controller of the vehicle drive train converts DC energy from the battery to AC energy to feed the AC engine. The controller is composed of a bidirectional inverter, as it also regenerates energy from braking back to the battery, using the engine as a generator. Some electric vehicles use DC instead of AC engines, in which case the controller is simply a DC-DC converter.

Medium power with a one- or three-phase AC connection would be used by customers who park their vehicle while shopping or in a parking lot in a city area. A high-power 3-phase AC infrastructure can be erected on public roads to be used by EV customers who park their car on a public street. Figure 2 is an example of how charging at the power level could work.

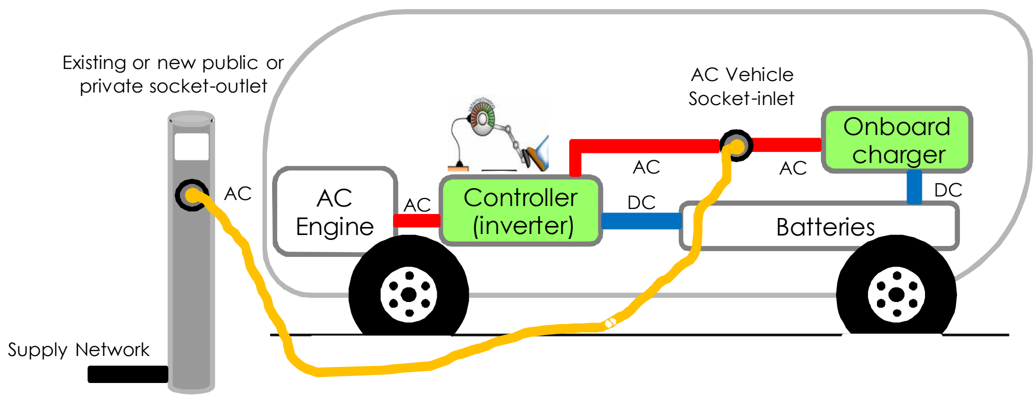

Figure 2 – The picture displays the charging scenario for either medium or high power AC charging. In this case the vehicle can use either a high power onboard charger for currents higher than 16A, or use the drive train controller inverter (with additional components) to achieve the conversion of AC energy into DC energy to the battery. In that case the vehicle could be able to charge at a power equivalent to the engine power, for example 75kW for a 100 horse powered vehicle.

A **high power** DC connection would satisfy customer expectations for longer journeys, for instance when they would like to continue a motorway journey after a relative short recharging stop. Figure 3 provides an illustration of this example.

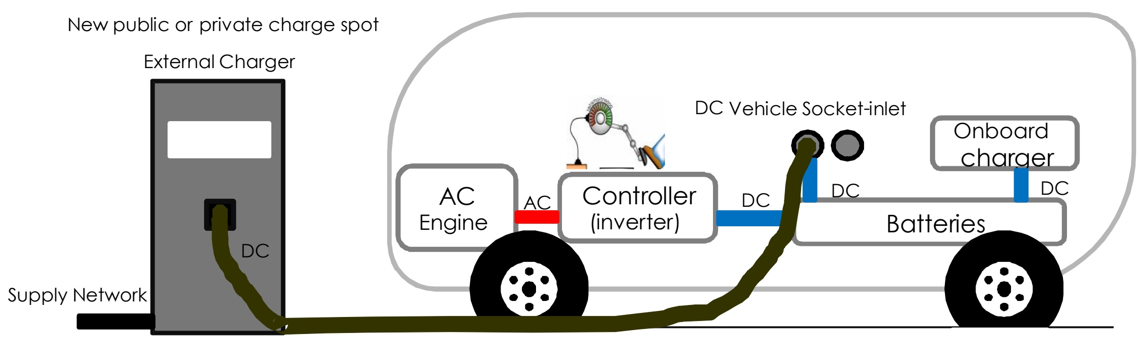

Figure 3 - Example of a high power DC charge using an external charger which converts AC power from the grid to DC voltage and current appropriate to the vehicle battery. The charger is directly connected to the battery but the voltage and current are controlled by the vehicle Battery Management System (BMS), which tells the charger what to do in each instant of the charging session.

The charging power levels outlined above are related to different modes of charging, as defined in IEC standard IEC61851 for conductive charging of EVs. Mode 1 is defined as connecting the vehicle to the supply network or mains, utilising a standardised socket outlet at the supply side, with single or three-phase, neutral and protective earth conductors. Charging Mode 3 uses dedicated Electric Vehicle Supply Equipment (EVSE), with a dedicated socket outlet for charging the vehicle and also includes a control-pilot functionality for additional safety. Mode 2 is an intermediate solution to charge a Mode 3 vehicle on a standardised socket outlet not dedicated to EVs. For this to be possible, the charging cable is fitted with an In-Cable Control Box (ICCB) at the cable supply side ending, allowing it to act as an EVSE. From the ICCB a standardised plug is then used to connect to the standardised socket outlet. Finally, Mode 4 is defined as an indirect connection to the mains using an EVSE. An example of this is DC charging where the DC charger is connected to the mains and then feeds the vehicle with DC voltage and current directly to the vehicle battery.

A great deal of discussion and work in the standardisation bodies and between EURELECTRIC members has developed around the implementation of Mode 3 and the public utilisation of Mode 1 to charge electric vehicles, as it is a very important subject for standardisation and the market take-up of electric vehicles.

EURELECTRIC believes that all class M and N vehicles coming into the market should be fitted with Mode 3 charging. Mode 3 is a safer and more reliable option to charge an EV in all available locations and should be the preferred long-term infrastructure solution. In order to facilitate EV market penetration, a transitory phase, depending on the market take-up, should be allowed in which existing infrastructure can be used in a safe way. Mode 2 charging (a Mode 3 vehicle charging at an existing socket with an ICCB) is an example of safe charging and should be allowed during the transitory phase at least in private locations. The same applies to other safe charging cases with existing Mode 1 EVs .

2.2. What is “smart” charging?

EURELECTRIC has defined smart charging as follows: “*smart charging refers to a controlled charging process that optimises the use of the grid and the available electrical energy to minimise additional investments in the grid and facilitate the integration of RES*.” The control mechanism can be enabled by the grid, by the charging point or by the vehicle itself, while a communication system with the grid allows the charging process to take actual grid capabilities into account. Price or control signals can be communicated through an ICT infrastructure (e.g. intelligent metering system) in order to allow intelligent charging algorithms to take generation and grid constraints into consideration and to allow the consumer to benefit from price opportunities.

3. What are the benefits of smart charging?

The European electricity industry deems it indispensable to charge electric vehicles in a smart way. Coordinating and managing the loads will:

- facilitate the integration of renewable energy sources into the electricity system specially with regard to decentralised generation connected to the distribution grid;
- enable grid management that introduces flexibility into the system;
- optimise the efficient use of generation capacity;
- ensure a cost-effective solution by avoiding unnecessary grid investments;
- maximise consumer convenience through use of available infrastructure.

3.1. Preparing the electricity system for mass market electric vehicle applications: generation and grid capabilities

3.1.1. Electricity generation capacity

Given the energy and climate goals set by the European Union in 2009, electricity generation is to change drastically. Renewable energy sources (RES) will become a significant part of the EU electricity generation mix. Moreover the European electricity industry has set itself the challenging objective of achieving a carbon-neutral power supply by 2050.

Changing generation sources affect the transmission and distribution of electricity. RES differ significantly from conventional electricity sources due to their volatility, which causes peaks in the electricity grid. Bi-directional communication between electric vehicles and charging spots is therefore necessary to streamline demand and the available electricity. This bi-directional communication enables controlled charging procedures: the vehicle will be charged “off peak” and utilising available grid capacity. Smart charging therefore not only enables optimal use of RES capacity, but is also indispensable to avoid additional demand for electricity, which would in turn require additional generation capacity, especially during peak times. Indeed, electric vehicle applications could be used as an enabler for future bi-directional communication in the electricity grid (smart grid) which will be key in future smart city concepts.

3.1.2. Electricity grid capacity

The discussion so far has focused on the integration of electric vehicles into the electricity grid under mass market conditions. However early electric vehicle market introduction will take time: until 2020, the feasible market share of electric vehicles is expected to lie below 5-10%. Under these circumstances, controlling and managing the charging patterns of EVs and other loads can be ensured with today’s existing technologies. For instance, off-peak price signals and programmed charging could ensure a load-efficient charging process of electric vehicles based on RES.

However, these basic measures might not be sufficient under mass market conditions, especially given increased electrification of applications (amongst others heating and cooling) due to more energy-efficient systems such as heat pumps. In a second step – beyond 2020 – a mass market share of electric vehicles will therefore require an intelligent connection between EVs and the electricity distribution grid, thereby ensuring their optimised integration and security of supply for all customers under mass volume conditions.

Connecting a mass market share of electric vehicles to the electricity grid can expose the grid to a dramatic increase in maximum power demand. In that case heavy investments will be required with regard to reinforcing the cables between households and transformers, the transformers themselves as well as investments in the upstream grid.

Such consequences can, in general, be minimised by coordinating the additional loads, i.e. by smart charging, thereby avoiding additional costly or at least non-profitable investments in the grid through a better smoothing of the load curve. Due to long lead times, an 'intelligent connection' and the required standards need to be developed now.

However, generalising the situation across Europe might not be appropriate, as grid characteristics differ significantly among European countries. An overview of different European grid characteristics can be found in Annex 1.

Finally, safety aspects and a stable power supply are of utmost importance for both customers and distribution system operators (DSOs); therefore the influence of battery charger characteristics on the electricity network has to be properly addressed. Protection against electric shocks and effects of short circuit has to be carefully assessed to ensure safe use for consumers. When charging, the vehicle should at a minimum comply with the standards that apply to electrical equipment used in similar circumstances. Electro-mobility will introduce new constraints on the grid and electric vehicles in particular with regards to Electromagnetic compatibility which should be minimised by employing state-of-the-art technology.

3.2. Ensuring a cost-effective and customer-oriented charging infrastructure

3.2.1. The charging infrastructure for electric vehicles is already available

To a large extent, the infrastructure for charging electric vehicles, i.e. the electricity distribution grid, is already in place. Numerous customers in Europe already have access to an AC infrastructure in domestic settings. Hence using this infrastructure for charging electric vehicles will significantly reduce the overall costs of rolling out further necessary infrastructure.

Off-peak charging with normal power is the most cost-effective solution for charging electric vehicles. This is consistent with the large majority of user needs, as a great proportion of daily car uses lies within the range of electric vehicles' current battery capacity. This charging method should therefore be promoted consistently so as to become the dominant charging method. The infrastructure already available in domestic spaces can be complemented by charging equipment of the same technical specifications in parking lots and office buildings. Catering to the needs of professional fleets and of users parking their car outside their home, this charging equipment will boost consumer confidence and facilitate the use of electric vehicles. Further AC-charging modes up to 22 kW, with smart charging, could be introduced in certain public areas, offering the possibility to have the same interface connection between the grid and the vehicle.

Despite the benefits of AC charging, the European electricity industry nevertheless also recognises the advantage of low-density high-power charging[6] through AC (3-phase) or DC charging infrastructure, in accordance with standard car design by different manufacturers. This can serve to alleviate psychological hurdles for electric vehicle customers by overcoming range anxiety and addressing certain high daily kilometer needs. In addition to the normal AC infrastructure already available, a low density of high-power DC or AC (3-phase) charging posts in public areas, used occasionally, will therefore help to further boost customer confidence. However, public charging should ultimately rely on a single solution, recognised by car manufacturers, to ensure interoperability. High-power charging stations should only be installed after careful evaluation of their impact on local grids and with due attention to their density. The costs of erecting charging infrastructure depend on the location and include grid connection costs and grid reinforcements.

EURELECTRIC believes that the choice of AC/DC high power infrastructure should be based on the real future mix of electric vehicles. The electricity industry should make the decision taking into account the real global cost structure of these solutions when deployed, including the extra cost on the vehicle and on the charging infrastructure.

Finally, the impact of charging cycles and possible future reverse energy flows on battery lifetimes is also an area in which additional research and development are crucial in order to optimise the process and ensure a cost-efficient outcome.

3.2.2. A convenient charging option for customers

Charging options also vary with regard to customer convenience. For instance, the high-power option, whether through an AC or a DC connection, involves a high amount of voltage or amperage. Moreover such fast-charging stations might be directly connected to the medium voltage network. A conventional mass market solution will therefore require designing and ensuring a convenient, safe and secure handling for consumers.

Furthermore customers will require a charging method which is convenient to use – just like customers are now used to fuelling their internal combustion cars. Smart charging, enabling communication between the grid and the vehicle, requires investments in intelligent charge systems, including a control system and communication units. These investments are relatively low and do not disadvantage the consumer: the installation of communication facilities allows for additional customer convenience (automatic payment, value-added services, and future smart grid applications) as well as for a faster pay-back time. As the economic value of a charging session is limited, the overhead cost to allow the charging process should be kept as low as possible in order to avoid excessive transaction costs per charging session.

[6] Often referred to as fast charging (> 44kW).

CONCLUSION

The European electricity industry believes that the charging process that takes place between electric vehicles and charge spots has to be coordinated, taking electricity grid and electricity generation capacities into account. Normal power charging, already available in domestic settings (home and work), should be the dominant charging method – not only due to the possibility of integrating RES into the existing electricity system, but also as a means of stabilising the grid through "smart", i.e. controlled, charging processes. This will also minimise the costs for rolling out additional infrastructure and provide a user-friendly solution.

Provided that electric vehicles are charged in a smart, controlled way, we see no reason to doubt that the functioning of market forces will turn electric vehicles into a competitive transport technology. Over time, the market will signal which charging functionalities and facilities EV customers' desire and are willing to pay for.

ANNEXES

		AT	BE	BG	CH	CY	CZ	DE	DK	EE	ES	FI	FR	GB	GR	HR
Typical Household connections																
Voltage	3 phase 1 phase	400 V 230 V	400 V 230 V	400 V 230 V	400 V 230 V	400v 230v	400 V 230 V	400 V 230 V	400 230	400 V 230 V	400 230	400 V 230 V	400 V 230 V	400V 230V	400 V 230 V	380/400 220/230
At the connection point* **	3 phase	20A - 63A	max 240A	x	x	x	x	x	x	6-100 A	x	x		x	x	x
	1 phase	16A-20A	max 63A	x		x				6-25 A			x		x	
	current per phase*	(35A, 50A)... 63 A	max 250A	up to 63A	63A	unlimited	25-32A	63A	25A	6-100 A	Variable	25 A - 63 A	60	80A	1x40, 1x63, 3x40, 3x63 A	mostly 35A
In the house	3 phase	x	x	x	x	x	x	x	x	yes	x	x			x	40%
	1 phase	x	x	x	x	x	x	x	x	yes	x	x	x	x	x	60%
	current per phase**	10A, 16A, (20A)	10A-63A	10 - 50A	10-16A	40A(1phase) 30 A (3phase)	10-16A	10-16A	10-16A	10-16 A	7-75 A	10 A, 16 A	10-16A	10-32 Amps	1x35, 1x50, 3x35, 3x50 A	10A, 16A, 20A
RCD installed	always		x (300mA)			X (300mA)			x		x	since 1995	x 500 mA	new	new	
	usually yes	x		since 2004	x			x		for instalation since 09/2009 RCD must be installed			x 30 mA		x	x
	usually no						x									
Voltage	3 phase 1 phase	400 V 230 V	400 V 230V	400 V 230 V	400 V 230V	400v 230v	400 V 230 V	400 V 230V	400V 230V	400 V 230 V	400V 230V	400 V 230 V	400 V 230V	400V 230V	400 V 230 V	380/400 220/230
Line from station to household	3 phase 1 phase	x	x	x	x	x	x	x	x	max. size of fuse in transformer station		x	x	x	x	x
	current per phase	63 A, 150A - 400A	max 250A	63 - 400A	400A	300A(o/h network), 400A (u/g network), 200A PM trfr	250A	400A	200A	50-400 A	415A	63 A - 400 A	400A	400A	250A/315A	250A
Type rating of the station	Power	(50,100,160, 200,250,400kV A é) 630kVA (800kVA)	(50,100,160, 200,250,400k VA..) 630kVA (800kVA)	rural 50 - 400 kVA urban 250 - 1000 kVA	Rural :160-250 kVA Urban: 400-1000 kVA	urban 630KVA rural 200KVA (PM)	400-630 urban 50-250 kVA rural	630KvA	400 kVA	50-400 kVA	rural 100 - urban 1000 kVA	50 kVA - 800 kVA	1000kvA	500kVA	urban is 630kVA rural is 160kVA	50 - 250 kVA rural 250 - 630 (1.000) kVA urban
	no. of households	30 é 100	80	20 - 200	100-140	150-200 (urban), 50 (from PM in rural)	180	120	75	houses + flats we are not able to differentiate from each other			180	150	100-150	120 - 160 max rural 180 - 300 max urban

* Fuse at origin of the installation (where the service line is connected to the local distribution network)
**Fuse in final circuit (last fuse upstream the electrical load)
***Main fuse at delivery point (the electricity meter is often installed at the main fuses)

		HU	IE	IT	LU	LV	NL	NO	PL	PT	RO	SE	SI	SK
Typical Household connections **Voltage**	3 phase	400V	400V		400	400v	400 V		400V	400 V	400 V	400 V	400 V	400 V
	1 phase	230V	230V	220-230 V		220-230v	230 V	230 V	230V	230 V	230 V	(230 V) 1*	230 V	230 V
at the connection point* **	3 phase				x	x	x	x	x	x	x	x	20 - 63 A	x
	1 phase	x	x	x		x	x						16 - 35 A	x
	current per phase*	x		12 - 63 A	40	40A	7.31M connections: 1 x 25A 43% 1 x 35A 20% 1 x 40A 5% 3 x 25A 32%	50 A	–	varies but 63A is normal	10-32 A	50 or 63 A	16 - 63 A	typically varies 25 A - 63 A
in the house	3 phase	16-32A	63A		98	x			0,45		0,05	x	0,495	x
	1 phase	0,1		x	only few connections still 1 phase and <0.5% on 110V	x	x	x	0,55	23% are three-phase connection, 73% are single phase	0,95	(x)	0,505	x
	current per phase**	0,9	x[1]	12-16 A	10-16 A	1phase<32A 3phase unlimited, but typical 16A	16A	10-16 A	1phase-20A 3phase unlimited, but typical 25A	Depending contract, biggest market segment= 16A	10-16A 16A	16-25 A	10A, 16A, 20A	ussualy 16 A - 50 A
RCD installed	always usually yes usually no	10A, 16A x	16A[2] x[3]	x	x	new since 1995 until 1995	since 1975 before 1975	x(since 1995)	x(since 1995)	x	 x	x	x	 x
Voltage	3 phase 1 phase	400V 230V	400V 230V	400 V 220 - 230 V	400 V	400-420v 220-230v	400 V 230 V	400 V(all new) 230 V	400 V 230 V	400 V 230V	400 V 230 V	400 V	400 V 230 V	400 V 230 V
line from station to household	3 phase 1 phase	 x	x[4]	x	x	x (x) rare in rural area	x	x	x	x	400V 230V	x	x	x
	current per phase	200A/315 A	200A/400 A	250 A	250-355 A	<100A rural (typical) >100A urban (typical)	160 - 250 A	350 A	<100A rural (typical) >200A urban (typical)		25-125 A rural 70-250 A urban	G(eneral)200 A U(rban)+SU(burban) 250A; R(ural) 125A	80 - 250A	80 A - 250 A
typ rating of the station	power	100-400 rural 400-630kVA urban	200/400kVA	250 - 400 kVA	125-400 rural 400-1000 kVA urban	160KVA rural 250..400kVA urban	<=160kVA rural 250..630kVA urban	100-1600 kVA	<160kVA rural, 200-630kVA urban	urban is 630kVA rural is 150kVA	40-250 kVA rural 160-630 kVA urban	G 200 kVA U+SU 800 kVA R 100 kVA	50-1000 kVA	Standard:100;160;250 & 400kVA. Existing from 25to1600kVA
	no. of households	70 é 300	100/200	80 - 120	80-100	10 urban 100 urban	10-75 rural 50-300 urban	10-250	35 rural 150 urban	some urban cases 300	50-250	G 20-200; U 200; SU 50; R 20	50 rural 140 urban	20 - 200

* Fuse at origin of the installation (where the service line is connected to the local distribution network)

**Fuse in final circuit (last fuse upstream the electrical load)

***Main fuse at delivery point (the electricity meter is often installed at the main fuses)

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