

Focus Group on European Electro-Mobility

Standardization for road vehicles and associated infrastructure

Report

**in response to Commission Mandate M/468
concerning the charging of electric vehicles**

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1 Executive summary

1.1 Introduction

The enormous potential of the electric vehicle has attracted serious attention over the last two or three years. Ensuring that the appropriate standards are set in place at European level is a pre-requisite to mass-market take-up. Charging an electric vehicle is in essence making a “system” work.

CEN and CENELEC, as European Standards Organisations, have sought to provide a comprehensive overview of the multiple standards issues associated with “electro-mobility”, as we are terming it. This has not been an easy task, for several reasons – standardization of all aspects of electro-mobility involves a marriage between different standards communities with different perspectives (those dealing with vehicles, those responsible for the electrical system and its components, even the ICT community); the international work already done necessarily has to accommodate different rules and requirements in different regions of the globe; at European level there are (still) national regulations that make the application of single solutions difficult ; some of the requirements are still evolving; some technical solutions are still not fully mature. As the market is in its infancy, some of the technical options of the stakeholders are still divergent. The optimum solutions for Europe are subject to intense discussions.

We created a short-term stakeholder group (“Focus Group”) to prepare the present report. The Focus Group comprised representatives of the CEN and CENELEC national members (standards organisations at national level) and of European-level associations with an interest in electro-mobility. Participation was also sought from representatives of international standardization committees dealing with issues related to the electric vehicle, and from the rather fewer European-level standardization committees, from the different services of the European Commission, and so on. We believe this resulted in a representative group able to produce a report.

The Focus Group’s role has been only advisory – its report has been subjected to the approval of the CEN and CENELEC Technical Boards, which will decide about the implementation for the various recommendations addressed to them. The necessary standards work is in fact already largely under way, at both the International Electrotechnical Commission (IEC) and the International Organization for Standardization (ISO), of which CENELEC and CEN are the respective counterparts at European level. There remain many issues of detail that need to be resolved in this ongoing work. This particularly raises some questions on the adaptation of some of these standards to European conditions - if necessary - and the selection of particular options that are relevant for Europe. The compatibility of some of the solutions presented in the international standards with some of the regulations at national levels has to be closely studied and solutions found, prioritisation needs to be adjusted, and finally, some, additional standards are needed. In general the stakeholders, especially the automotive industry, are aiming at international standards as the highest priority.

After the list of recommendations and introductory background material, the report states the positions of different stakeholder communities concerning electro-mobility standardization before embarking on the “headline” issue of connectors and charging systems. The report then briefly considers the issue of “smart charging”, in essence a future development that links the vehicle intimately with the electricity grid. Communication between the vehicle and the infrastructure then merits a chapter to itself. The vehicle batteries are next considered – their

technology is fast-developing; but issues such as safety of the installation must remain in the forefront of standards consideration. We have then given some consideration to issues relating to the electromagnetic compatibility (EMC) of the electric vehicle and its charging system with other items of electrical apparatus. The final chapter of the substantive report concerns the regulatory aspects proper. A number of annexes provide the essential technical detail.

1.2 Connectors and charging systems

In order to facilitate the adoption of electro-mobility, the charging should be as convenient and as low cost as possible while providing an acceptable level of safety. This inherently implies the implementation of simple uniform charging systems both for the home and for publicly accessible charging places.

Efficient off-peak charging should clearly be preferred to charging in peak hours. However, accelerated charging may be a complement, as it will also help to support off-peak charging. Fast-charging systems, though possibly minor at the start in terms of real usage, may contribute to the client acceptability of the electric vehicle and are therefore also projected into the present electric infrastructure taking into account smart grid developments and the increasing amount of renewable energy sources.

Standards should be set that will contribute to the ease of use of electric vehicles while at the same time contributing to an efficient integration into the present electric infrastructure.

The ideal situation of having a single standard for all applications is not possible in practice. There will likely be a variety of standards to meet the needs of different vehicle types, different charging situations and different environments. We note in particular that both alternating and direct current charging will be used. The needs of small two-wheel vehicles will be different to that of larger passenger vehicles. The international community has accordingly already defined different “modes” of charging for each of the four principal cases, which are explained in 3.2.

Mode 1 Charging an electric vehicle from a domestic or an industrial socket-outlet without additional specific protective devices is defined as “mode 1”. Connecting an electric vehicle to a household socket-outlet using mode 1 is the same as connecting any electric device using a plug and socket-outlet. Note mode 1, as all other modes of recharging, requires a residual-current device (RCD). However, household installations may not have been designed for permanent loads close to the maximum rated power and protective devices like RCDs might not exist as required; therefore mode 1 should not be used in these circumstances. These issues are considered in specific recommendations in the report.

Mode 2 implies the use of additional protection mechanisms in the charging cord-set, thus overcoming the safety risk of using old installations without RCDs. This solution is at present proposed by automobile manufacturers for occasional charging, in the initial phase making use of the wide installation base.

Mode 3 concerns a dedicated charging station for AC. These charging stations or devices offer all protective measures itself and may be used for the public infrastructure but also in business or even domestic environments. Mode 3 offers the potential for a safe, user-friendly, powerful and harmonised smart charging infrastructure in Europe based, for both single and three-phase supply, on dedicated charging devices. For this purpose a single solution for plugs and socket-outlets should be defined.

Mode 4 defines DC charging using an external battery charger and is mainly intended for rapid charging. Even though Mode 4 charging capability is presently available only on some vehicles in the market, there is a strong interest of the automotive industry to establish DC charging. Technical concepts are still under development, including the standardization of a harmonised solution. The Focus Group considers that a single solution should be provided in the mid-term.

In addition to fast charging, the batteries the exchange of empty batteries with charged ones (called battery switching) is another method to power the car in a short time.

Accompanying all these connector and charging system issues are a number of detailed standards considerations relating to electrical safety. These include the existence of some national regulatory requirements, for instance concerning whether or not shutters should be present on socket-outlets (presently mandatory only in some countries). This problem needs to be addressed with some urgency through a further analysis of the technical alternatives with respect to the regulations, followed by a decision by the European Commission and national authorities.

1.3 Smart charging

Smart charging is seen as a necessity to optimise the use of the electrical grid for efficient EV charging, while maximizing the use of renewable energy. It is considered that the customer should be encouraged to charge at the best possible moment in terms of available energy, by providing a smart charging mechanism, based on information supplied by the electric grid and on the physical environment (Energy Management System, EMS). This would help to avoid the need for extensive new investment in Europe for the grid. The active interaction of the vehicle with the grid could even be beneficial for global energy usage.

1.4 Communication

The communications arena raises a variety of issues, not all mature. The communication in the form of control signals between the vehicle and the electrical supply is, in essence, being addressed at international level.

Wider communications between the vehicle or the user and the infrastructure - for instance concerning data communication, safety issues, billing/payments, even information to drivers on availability of nearby charging stations - are addressed in the ISO/IEC 15118 standard and may be further addressed in a number of standards contexts, for instance those relating to the Intelligent Transport Systems and Smart Grids, on both of which the European Standards Organisations are already working. Such communication can use any one of a number of existing data channels including information transfer through the AC supply cable, airborne radio communication, or even hand held devices

1.5 Batteries

New standardization activities are recommended, especially in relation to the requirements for storage, labelling, and battery switching stations. The possibility of standard battery designs and the re-use of batteries in alternative applications may be an interesting possibility that could be explored. This would require additional standardization work.

1.6 Electromagnetic compatibility (EMC)

EMC standards are needed to ensure that electrical and radio apparatus does not cause interference to other such equipment, and that it is adequately protected against such interference. This is a heavily-regulated area, the relevant EU Directives being “new approach” where European Standards are agreed to meet the essential legal requirements. However, the various standards that are available in this domain were not usually designed with mass-market use of equipment for electric vehicle charging in mind, or for the high concentrations of EVs in one place that may result from such a deployment. This may imply the need for a number of detailed amendments to the standards portfolio. The present Directive 72/245/EEC defines provisions for the whole vehicle and for the electrical and electronic sub-assemblies, but does not cover the connection of an EV to the grid. UN-ECE Regulation 10 is presently under revision and will cover these same requirements and take account of all the EMC aspects for the EV.

1.7 Regulation

Our report contains some complementary considerations regarding the interface between standardization and regulation at European level, for instance the Low Voltage Directive, as well as European vehicle type approval Directives and the UN-ECE regulations relating to vehicles.

2 Scope

This document is the final report of the Focus Group on European Electro-Mobility standardization to the CEN and CENELEC Technical Boards (BTs) as required in the Terms of Reference and is proposed as an initial answer to European Commission/EFTA mandate M/468.

The mandate identifies the following subjects to be treated:

- a) 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 be interoperable in all EU States¹.
- b) Ensure interoperability and connectivity between the charger of electric vehicle- if the charger is not on board- and the electric vehicle and its removable battery, so that a charger can be connected, can be interoperable and re-charge all types of electric vehicles and their batteries.
- c) Appropriately consider any smart-charging issue with respect to the charging of electric vehicles.
- d) 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).

The introduction of electro-mobility as a major economic activity in the international market and for Europe will however require additional standards efforts on aspects not covered in the mandate. The aim of the present document is to provide a strategic and nevertheless technically-oriented report that represents the specific standardization requirements for European electro-mobility. It provides an overview of current activities, necessary fields of action, international cooperation and strategic recommendations.

The document makes proposals to the standardization organizations for the further development of existing standards, or in respect of standardization activities under way, or concerning the creation of new standards.

The Focus Group that prepared this report has had a very wide participation. It includes representatives of the CEN and CENELEC national members – often from local industry or Governments - and of all major European associations of stakeholders in the field. Observers fully participating have included representatives of technical standards committees in CEN, CENELEC, ISO and IEC, from some other standards organizations and from the European Commission services.

The Terms of Reference of the Focus Group are contained in **Annex A**, and the EU/EFTA mandate in **Annex B**.

¹ Considering that domestic sockets are not harmonised in the EU, existing adaptors should be used for domestic charging.

This document concerns all electric vehicles, including mopeds, two- and three-wheel vehicles and quadricycles (category L1 – L7) as well as four-wheel vehicles (category M1 and M2) and light delivery vehicles (category N1). Despite the fact that certain aspects will also be applicable to larger vehicles (category M3 and N2), these categories are in general out of scope of this report (see recommendation 4.2 below proposing future studies in this respect). In addition, electric-assisted pedal cycles are also not covered in detail. For a definition of the different categories, see **Annex C**.

It is to be noted that the Focus Group is not destined to itself create standards documents nor create regulatory requirements. This remains the competence of the relevant standardization organizations and regulatory authorities.

3 Terms and abbreviations

Although standards and other documents drafted by different bodies - be they in ISO, IEC, UN-ECE or other bodies - do use the same or similar terms, the related definitions are sometimes different or even conflicting, which may lead to misunderstanding. While deciding on exact terms and definitions is beyond the scope of the Focus Group, it strongly recommends that terms and definitions be harmonised urgently.

Recommendation 3.1: Terms and definitions related to electro-mobility should be harmonised

This Chapter of the report only indicates some principal terms that are necessary for the understanding of the document as well as the relevant abbreviations.

3.1 Common terms used in this document

Note that the generic terms often used in standards, publications and habitual language use are not consistent and may be inappropriate as too general. Such generic terms include “charging system”, “EVSE”, “charging equipment”. They should be avoided in favour of more specific terms. The terms below should be used in preference wherever appropriate.

3.1.1 Charging system

Figure 1 shows some of the commonly defined terms used to designate the different parts of the charging system and identify the connecting elements that are used for charging. Two cases exist:

- the AC to DC conversion is outside the vehicle. This will be DC charging;
- the AC to DC conversion is on board the vehicle. This will be AC charging.

NOTE The socket-outlet may be part of a complete charging station or charging installation

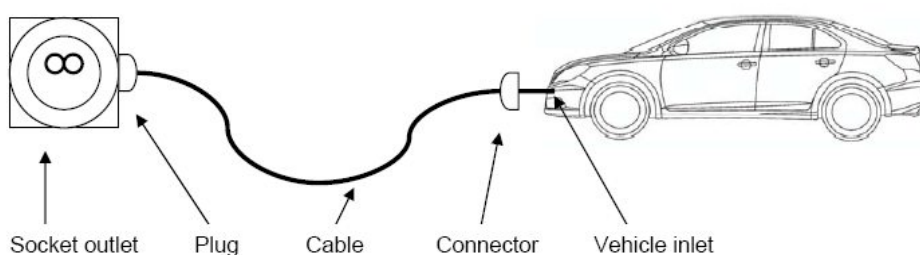


Figure 1 – Identification of connecting elements used for charging

3.1.2 AC charge station

Equipment that is part of the fixed installation and supplies AC current to the vehicle. This generally includes all the AC protection equipment and can also include a simple safety control circuit for mode 3 charging (see later). It includes the charging cable if the cable is fixed to the equipment.

3.1.3 DC charge station

Equipment that is part of the fixed installation and supplies DC current to the vehicle. This generally includes the AC supply protection devices, an isolating transformer and power electronic equipment that rectifies the current to DC current with a control of the output current. The charging cable is generally fixed to the equipment and is part of the charging station.

3.1.4 socket-outlet

Any outlet that is located on a charging station, irrespective of the charging modes

NOTE Some installations use cables that are attached to the charging station. They will not have a socket-outlet or plug.

3.1.5 cable / charging cable / cord-set

The cord-set is defined as a cable with the plug and vehicle connector. It includes the in cable control box for mode 2. However, in order to avoid ambiguity in this text the word "cord" with the word "attached" is also used to define the cable and vehicle connector if it is attached to the charge station and has no plug. The word "cable" is used only to define the actual set of conducting wires between the vehicle and the charging station.

3.2 Charging modes

The IEC 61851 standard requires that all charging installations be protected by a residual current device (RCD), which will protect persons against electric shock in case of failure of the isolation. It should be at least equivalent to type A as defined in IEC 61008-1 or IEC 61009-1, or IEC/TR 60755, and be used in conjunction with an over-current protection device (typically a fuse or a circuit breaker).

The following text which describes the different charging modes is copied from subclause 6.2 "EV charging modes" of IEC 61851-1:2010. The applicative notes have been removed:

<quote>

Mode 1 charging: connection of the EV to the a.c. supply network (mains) utilizing standardized socket-outlets not exceeding 16 A and not exceeding 250 V a.c. single-phase or 480 V a.c. three-phase, at the supply side, and utilizing the power and protective earth conductors.

Mode 2 charging: connection of the EV to the a.c. supply network (mains) not exceeding 32 A and not exceeding 250V a.c. single-phase or 480 V a.c. three-phase utilizing standardized single-phase or three-phase socket-outlets, and utilizing the power and protective earth conductors together with a control pilot function and system of personnel protection against electric shock (RCD) between the EV and the plug or as a part of the in-cable control box. The inline control box shall be located within 0,3 m of the plug or the EVSE or in the plug.

Mode 3 charging: connection of the EV to the a.c. supply network (mains) utilizing dedicated EVSE where the control pilot function extends to control equipment in the EVSE, permanently connected to the a.c. supply network (mains).

Mode 4 charging: connection of the EV to the a.c. supply network (mains) utilizing an off-board charger where the control pilot function extends to equipment permanently connected to the a.c. supply.

<unquote>

3.3 Abbreviations

AC	alternating current
ACEA	European Automobile Manufacturers Association
ACEM	The Motorcycle Industry in Europe
BCU	battery control unit
BMS	battery management system
BSS	battery switching station
BT	Technical Board (of CEN or CENELEC)
CAN	controller-area network
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardization
CECAPI	European Committee of Electrical Installation Equipment Manufacturers
CISPR	Comité International Spécial des Perturbations Radioélectriques (within the IEC)
CS	charging spot
DC	direct current
DER	distributed energy resources
EFTA	European Free Trade Association
EMC	electromagnetic compatibility
EMS	energy management system
EN	European Standard
ESO	European Standards Organisations
ETRA	European Twowheel Retailers' Association
ETSI	European Telecommunications Standards Institute
EV	electric vehicle
EVSE	electric vehicle supply equipment

HMI	Human-machine interface
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
ITS	intelligent transport systems
ITU	International Telecommunication Union
NFC	near field communication
NWIP	new work item proposal
OEM	original equipment manufacturer
ORGALIME	European Engineering Industries Association representing the interests of the Mechanical, Electrical, Electronic, Metalworking & Metal Articles Industries
PLC	power line communication
PTW	powered two wheelers
PWM	pulse width modulation
RCD	residual-current device
RFID	radio-frequency identification
SC	sub-committee
TC	Technical Committee
V2G	vehicle to grid
V2H	vehicle to home

4 Recommendations for and future co-ordination of electro-mobility standardization in Europe

4.1 List of recommendations

Generally, international standardization work and harmonisation has to have priority. The development of European standards, as proposed in this report, intends to complement international standards or to meet special European requirements only as far as necessary.

Recommendation 3.1: Terms and definitions related to electro-mobility should be harmonised – addressed to the future CEN-CENELEC Co-ordination Group

Recommendation 4.1: Establish a CEN-CENELEC Electro-Mobility Co-ordination Group with the aim to support coordination of standardization activities during the critical phase of writing new standards or updating existing standards on Electro-Mobility, and make recommendations accordingly – addressed to the Technical Boards

Recommendation 4.2: The proposed new Co-ordination Group should embark on an in-depth study of the requirements for larger vehicles – addressed to the future CEN-CENELEC Co-ordination Group

4.1.1 Recommendations concerning charging

Recommendation 7.1: All aspects of reverse energy flow (safety and control) should be addressed by IEC TC 64 (safety) and TC 57 (smart grid) CEN TC 301 (vehicle aspects) and other relevant TCs – addressed to relevant TCs

Recommendation 7.2: EV of categories M and N charged at home should be done using dedicated socket-outlets. Home charging of such vehicles should preferably be done using mode 3 – general recommendation

Recommendation 7.3: Occasional charging should preferably be done using mode 2 to ensure RCD protection – general recommendation

Recommendation 7.4: Public AC charging of vehicles in the M and N categories should be done using mode 3 - general recommendation

Recommendation 7.5: CEN TC 301 to evaluate the possible application of fast charging arrangements by mobile recovery vehicles

Recommendation 7.6: Charging stations used by the general public should offer at least mode 3 AC charging to ensure interoperability. Additionally high power AC and/or DC charging might be offered – general recommendation

Recommendation 7.7: The specific requirements of light electric vehicles in the L1 to L5 category could warrant specific standards for interoperable charging systems. These could take account of the EnergyBus proposition. The Coordination Group is to decide on which Technical Committee(s) should be involved - addressed to the future CEN-CENELEC Co-ordination Group

Recommendation 7.8: The characteristics of assemblies for specific installations at public sites need to be defined. It is proposed that the work of IEC/SC17D concerning standardization project IEC 61439-7 is actively supported. There is no need for further action at the European level at the moment – *addressed to stakeholders*

Recommendation 7.9: The use of charging mode 1 should be allowed for small vehicles such as scooters or quadricycles. The maximum value of the allowable current must be defined (see 7.6.5.2) – *general recommendation*

Recommendation 7.10: As the presence of RCDs cannot be guaranteed in all cases, the use of mode 1 charging on larger vehicles should not be considered unless adequate supplementary protection is supplied (e.g. Class 2 isolation or equivalent, ground check system inside the vehicle) – *general recommendation*

Recommendation 7.11: Mode 2 is not recommended for publicly accessible places, except for locations specifically destined to be used by small vehicles in the L1 to L7 category – *general recommendation*

Recommendation 7.12: The characteristics of the in-cable RCD must be defined. The Focus Group requests that the proposed standards activity (IEC 23E/716/NP) be actively supported. There is no need for further action at the European level – *addressed to stakeholders*

Recommendation 7.13: Further precisions are required on the timing diagrams of Annex A of IEC 61851-1. Coherence with the evolving SAE 1772 standards should be ensured. IEC 61851-1 having been ratified as EN 61851-1, it is recommended that the new CENELEC TC 69X launch an amendment procedure immediately in Europe to correct the text in accordance with ongoing discussions and in close harmony with IEC. This should consider the results of ongoing developments – *addressed to CENELEC TC 69X*

Recommendation 7.14: An urgent study is required into the effect of different national wiring rules and other regulatory requirements on the technical propositions made for cross-border interoperability of socket-outlets for charging. The results should be taken into account by regulators, as required – *addressed to European Commission*

Recommendation 7.15: The question of the type of protection needed for three-phase charging systems is to be analysed in order to fix requirements on the vehicle charger and/or the charging station (CENELEC TC 64, CEN TC 301, CENELEC TC 69X), investigating all possible protection means against DC leakage on the vehicle and/or the charging station side, including alternatives to the Type B RCD – *addressed to relevant TCs*

Recommendation 7.16: UN-ECE Regulations and existing standards must be checked and possibly updated concerning safety at the vehicle inlet. The safety of energy feedback requires close correspondence between IEC 61851-21 (presently under revision) and ISO 6469-3-2. At European level, very close relations should be established between CENELEC TC 64, TC 23BX, TC 69X and CEN TC 301. This is an urgent question – *addressed to Co-ordination Group, relevant TCs and UN-ECE*

Recommendation 7.17: Additional requirements for functional safety of the charging station should be considered by the appropriate TCs (CENELEC TC 64 and TC 69X) in future work on IEC 61851-1 and/or IEC 61851-22 (AC) and IEC 61851-23 (DC) – *addressed to relevant TCs*

Recommendation 7.18: Relevant TCs (CENELEC TC 64, CLC TC 69X, CEN TC 301) to consider the possible need for further earth quality verification of the installation for electric vehicle charging, considering the specific needs of electric vehicle usage and different mains network configurations that use different earth and neutral connection schemes (TN, TT, IT) – addressed to relevant TCs

Recommendation 7.19: An inspection of installations - as already mandatory in some EU countries - is strongly recommended. Wiring rule standards should provide information concerning the use of older installations for EV charging - general recommendation

Recommendation 7.20: When developing the EN 61851 series, CENELEC TC 69X should consider the detailed issues related to current limitation for socket-outlets used for modes 1 and 2, as described in section 7.6.5.2 of this report. This is an urgent matter to be resolved before electric vehicles appear on the European market on a large scale - addressed to CENELEC TC 69X

Recommendation 7.21: Establish a common European Standard for public DC charging systems. Such a standard could use the “CHAdeMO” proposition as a basis and attempt to ensure backward compatibility with EVs and infrastructure already deployed – addressed to CENELEC TC 69X

Recommendation 7.22: The issues of current and voltage limitations for DC charge should be examined by CENELEC TC64 and CEN TC 301 – addressed to CENELEC TC64 and CEN TC 301

Recommendation 7.23: CENELEC TC69X to be requested to consider specific requirements of different network configurations in Europe including three-phase networks without neutral and networks with 230 V triangle configuration, and specific requirements for neutral systems, and to propose solutions to ensure safety and interoperability – addressed to CENELEC TC 69X

Recommendation 7.24: Additional requirements for charging specifications and testing procedures have to be discussed and agreed based on experience gained in the ongoing development process and demonstration projects and have to be brought into amendments to the IEC 61851/EN 61851 series without delay – addressed to CENELEC TC 69X

4.1.2 Recommendations concerning connectors, plugs and socket-outlets

Recommendation 8.1: The applicability, relevance and outcomes of national wiring rules on EV charging applications (Mode 1, 2, 3 and 4) in general and for the use of EN 60309-2 accessories should be considered and transposed into standards by CENELEC TC 64

Recommendation 8.2: EN 60309-2 could be used as an interim solution for mode 1 and 2 as it is transposed as a European Standard. The system is useable immediately. Extra standard text should be introduced to the next edition of EN 61851-1 immediately if deemed necessary by CENELEC TC 69X

Recommendation 8.3: The Focus Group recommends to define one unique footprint with five power contacts covering applications from 1 phase to 3 phases & neutral (from 16 to 63 A minimum) with protective earth and additional 2 auxiliary contacts for control system according to mode 3 of a future EN 61851-1. Type 2 or Type 3-c of the future EN 62196-2 will correspond to this definition. However, small compact connector designs for vehicles of category L1 to L5 should also be considered. – addressed to CENELEC TC 64

Recommendation 8.4: For the short term, the DC configurations of type 2 or type 1 connectors and the integration of CHAdeMO, as well as the requirements for charging stations and vehicles should be finalised for standardization in Europe by the relevant TCs - addressed to the future CEN-CENELEC Co-ordination Group

Recommendation 8.5: Europe should endeavour to define a combined solution for a unique vehicle inlet (“combo”). The solution should be harmonised with the US market. For this purpose a speed up of the related standardization activities is demanded - addressed to the future CEN-CENELEC Co-ordination Group

Recommendation 8.6: Since CHAdeMO-compliant vehicles are on the market in Europe a satisfactory solution for these vehicles should be sought urgently – addressed to the future CEN-CENELEC Co-ordination Group

Recommendation 8.7: Since future parts of IEC 62196 will most likely be “catalogue standards”, and also IEC 61851-1 will not specify the type of accessories to be used for mode 4 charging, it will be necessary to specify which accessories are required on a European level by an appropriate standardization group - addressed to the future CEN-CENELEC Co-ordination Group

4.1.3 Recommendation concerning smart charging

Recommendation 9.1: For the optimisation of electro-mobility and energy use, it is deemed to be indispensable to move toward charging electric vehicles in a smart way. Standardization issues should be addressed by the CEN-CENELEC-ETSI Smart Grid Coordination Group, in liaison with the CEN-CENELEC Electro-Mobility Coordination Group

4.1.4 Recommendations concerning communications

Recommendation 10.1: It is recommended that end-to-end scenarios are considered between the involved ESOs in order to have a harmonised and interoperable link between the different communication standards for electro-mobility, security, safety and ITS. Co-operation on data communication and data security - between EV, smart grid and ITS, is needed - addressed to the CEN and CENELEC BTs and to ETSI

Recommendation 10.2: Electro-mobility-to-infrastructure for data communication and data security should be defined by: CEN and ETSI ITS committees (co-operative systems), ETSI M2M , ETSI SCP (Smart card Platform), ISO (road vehicles) and IEC TC 57 for DER communication - addressed to the CEN and CENELEC BTs and to ETSI

Recommendation 10.3: Electro-mobility control signal and control pilot signal related communication should be defined by CLC TC 69X, CEN TC 301, IEC SC 65A and CLC TC 64 and ISO TC 22/SC3 – addressed to relevant TCs

Recommendation 10.4: It is recommended that user groups be established between the different ESOs and the market stakeholders, in order to specify conformance tests and implementation guidelines between the different domain areas – *addressed to the CEN and CENELEC BTs and to ETSI*

Recommendation 10.5: standardization is required for the diagnosis protocol, human-machine interface and energy management system for the complete charging system. This new work has to be done in close relation to user groups and electro-mobility system integration (technical reports or white papers from user groups can be very useful for the ESOs) – *addressed to the CEN and CENELEC BTs and to ETSI*

Recommendation 10.6: It is recommended that a standards work be established concerning an “interoperability hub”, which can be a generic and neutral concept for mediating between two partners to provide validation services for exchange of technical information, contract relations or security certificates. A joint working group including service providers should be formed within the ESOs to define a cross-border European concept for this hub - *addressed to the CEN and CENELEC BTs and to ETSI*

Recommendation 10.7: The work done in the European Commission Smart Grids Task Force should be expanded to create a security architecture also taking into account issues in relation to the interoperability hub and security issues for communication between charging system and electric vehicles – *addressed to the ESOs Smart Grids Co-ordination Group*

4.1.5 Recommendations concerning batteries – to be considered by the future CEN-CENELEC Co-ordination Group unless stated otherwise

Recommendation 11.1: Parameters for state of health should be defined in standards to allow for re-use of batteries

Recommendation 11.2: Standardization of battery module sizes could be undertaken when the automobile industry considers the subject to be mature. This may lead to a need for standardization of interfaces. Standardization could also be undertaken for battery packs for battery exchange stations as well as for batteries for light electric vehicles (L1 to L5)

Recommendation 11.3: A set of minimum requirements for battery information should be collected, stored and extracted from the battery by BMS/BCU. Stored battery data should follow a standard format/coding specification to allow access and correct interpretation. Data should be stored according to agreed guidelines by manufacturers respecting fully the private nature of data. Definition of the retrievable data and the handling of such data must be defined in order to protect the rights of the manufacturer and the private individual

Recommendation 11.4: A European Standard should be drafted for battery safety labelling (applying the Dresden Agreement)

Recommendation 11.5: ID should be considered for each part/component that can be removed from the battery pack without destroying it. Integration of second life batteries with grid applications can only be made possible under a clear and EU internal market-compliant policy. Specific performance tests should be developed for re-useable batteries (second life) in their intended applications

Recommendation 11.6: The definition of “recycling rate” in the framework of the Battery Directive 2006/66/EC should be reviewed with the EV application in mind – to be addressed by the EU regulatory authorities

Recommendation 11.7: The inclusion of fast charge profiles should be considered in the new work item on charging battery systems under development by ISO TC 22/SC 21 (ISO 12405-2) – to be addressed by ISO TC 22/SC 21

Recommendation 11.8: Create a battery switch station standard with safety, energy needs, exchangeability, accessibility, data and communication framework. Also, battery switching station storage of batteries of different vehicle models should be included (including dimensions and mechanical /electrical /communication interfaces for integration, as well as environmental requirements)

Recommendation 11.9: Create a unique standard that clearly defines the interfaces of removable batteries, to allow for battery switching on electric vehicles that have been designed for this application. Such interfaces should define the mechanical fixation points, the electric power connectors, the data connectors, the cooling fluids and their interfaces and the data formats that could be used during the charging of the batteries

Recommendation 11.10: Appropriate measures should be taken to improve emergency services awareness with respect to eventual battery hazards caused by the use of EVs (mechanical impact to batteries, batteries’ exposure to water or fire)

4.1.6 Recommendations concerning EMC

Recommendation 12.1: Ensure that the electrical industry is represented in UN-ECE WP 29 where the EMC aspects are concerned. In particular, the frequency range 2 kHz to 150 kHz should be considered carefully for conductive emission during charging – addressed to the electrical industry

Recommendation 12.2: The regulatory framework and unifying testing methods to the latest standards (CISPR, IEC and ISO) should be simplified – addressed to the future CEN-CENELEC Co-ordination Group

Recommendation 12.3: CEN-CENELEC, ISO and IEC should work together for the improvement and completion of the EMC standards for electric vehicles - addressed to the future CEN-CENELEC Co-ordination Group

Recommendation 12.4: Update and complete the EMC requirements in order to take into account the current status of the electric vehicle, communications and power distribution technologies - addressed to the future CEN-CENELEC Co-ordination Group

Recommendation 12.5: The adjustments listed in the following sections should be considered by the relevant Technical Committees at IEC and CENELEC levels, and changes brought into the harmonised standards as appropriate

Recommendation 12.6: IEC SC77A should address the frequency range 2kHz to 150 kHz as soon as possible

Recommendation 12.7: For the frequency range below 2 kHz, the requirements on control methods, measurement methods and test conditions are very important for the application of the emission limits given in existing standards (EN 61000-3-2, -3-3, -3-11, -3-12). Instead of copying parts of the EMC standards into EN 61851-xy and Regulation 10, it is recommended to make simple references to existing standards and to add the necessary additional information only to adequately address EV conductive charging system. In addition, the type of charging mode shall be taken into account when defining specific test conditions for harmonics and flicker emission assessment

Recommendation 12.8: For the application of EN 61000-3-12, only the limits given in Tables 2 and 3 for $R_{sce} = 33$ should be used, because EV may be connected at any available supply

Recommendation 12.9: Voltage fluctuations and flicker emissions should be properly covered, especially in the case of fast charging mode. In particular, a reference to IEC 61000-3-3 and IEC 61000-3-11 should be addressed in EN 61851-21

Recommendation 12.10: At present, harmonic emission limits are given by IEC 61000-3-2 and IEC 61000-3-12. Where there is a high concentration of electric vehicles in the same neighbourhood, it needs to be established if current emission limits will ensure EMC. This new situation, especially during the fast charging mode, should be investigated

Recommendation 12.11: Analyse the coherence of regional regulations on grid connections relative to perturbations

4.1.7 Recommendations concerning regulatory issues

Recommendation 13.1: Reconsider the fragmentation of categories during the revision of Directive 2002/24/EC

Recommendation 13.2: To amend Directive 78/316/EC as, well as to propose amendment of regulation UN-ECE 121, concerning identification of controls, tell-tales and indicators, taking into account three categories of information:

- for the attention of driver and passengers;
- for the attention of personnel for vehicle maintenance;
- for the attention of rescuers in case of an accident

In addition, the provisions of UN-ECE 100 in the EU Type approval system should be considered and included in Directive 2007/46/EC

Recommendation 13.3: To update the EMC requirements of Directive 72/245/EC as well as to propose amendment of regulation UN-ECE 10, in consideration of the whole electrical vehicle specificities, when connected to the network or not

Recommendation 13.4: To develop provisions within type approval regulations for traction battery safety

Recommendation 13.5: To develop dedicated provisions within type approval regulations for electrical safety of the vehicle when connected to the grid

Recommendation 13.6: The following standardization activities should be given priority:

- safety of charging installations;
- plug-in interoperability;
- EMC provisions for charging station and vehicle;
- communication protocols for V2G;
- quick battery exchange (as soon as reference dimensions are available)

4.2 Future European co-ordination of electro-mobility standards issues

There are various different standards committees relevant to this domain, at both European and international levels. Different groups of stakeholders come together for different purposes, most often with requirements to consider aspects that are wider than the electro-mobility domain.

Whilst the main burden of the activity required is already taking place at international level, in the committees of ISO and IEC, some European work will also be needed. This is to ensure that the necessary adjustments for Europe – for example choosing options existing in international standards – can be put in place, or, occasionally, to enable specific standards required for Europe to be prepared rapidly.

CEN and CENELEC now have committees in this domain that broadly match those internationally. CEN Technical Committee TC 301 deals with vehicle standardization, whilst CENELEC has several TCs, Sub-Committees and Working Groups dealing with different aspects. Although the topics relevant to Electric Vehicle are complex and concern different TCs, changing this situation by creating new groups or merging existing ones is not going to make it any simpler and would enhance confusion.

A more detailed proposal for how the technical effort should be managed, in terms of the different TC responsibilities, is at **Annex D** of this document.

On the other hand, it is essential that a coherent overview of the implementation of this report be maintained, and that there is a proper co-ordination of these activities. We therefore propose to create a dedicated Co-ordination Group reporting to the CEN and CENELEC Technical Boards (BTs). This Group will not produce draft standards or indeed make any formal technical decisions; its main task will be to make recommendations in order to:

- monitor the implementation of the recommendations of the present report;
- coordinate the standardization activity of the relevant TCs in Europe and make recommendations concerning any work at international level;
- avoid conflicts between relevant standards activities;
- recommend “co-operation modes” between relevant TCs (the ESOs and their international counterparts have developed a formalised system for this);

- ensure consistency with other European and international projects including also in other regions;
- identify needs for new standardization projects.

We propose that this Co-ordination Group be limited in size, though it should certainly contain representatives of each of the relevant TCs at European level and if possible (through European participants) of the international TCs. In order to ensure continuity, we propose that the present Focus Group maintain its activities for one meeting or so whilst the BTs are approving the new Group.

The detailed Terms of Reference of the Co-ordination Group are a procedural issue and outside the scope of this report; proposals have been drawn up with the participation of interested national members of the Focus Group and will therefore be submitted parallel to the CEN and CENELEC Technical Boards for consideration.

In addition, the present report recommends that the communications aspects of electro-mobility be handled in future in other existing Groups – the CEN-CENELEC-ETSI Smart Grids Co-ordination Group and the similar CEN-CENELEC-ETSI Group for Intelligent Transport Systems. Of course these activities should ensure correct dialogue with the Electro-mobility Co-ordination Group.

Recommendation 4.1: Establish a CEN-CENELEC Electro-Mobility Co-ordination Group with the aim to support coordination of standardization activities during the critical phase of writing new standards or updating existing standards on Electro-Mobility, and make recommendations accordingly

Recommendation 4.2: The proposed new Co-ordination Group should embark on an in-depth study of the requirements for larger vehicles

5 Context

5.1 Economic context

Electro-mobility will certainly contribute towards a reduction of the dependence of Europe on fossil fuels, with a consequent contribution to the reduction of greenhouse gases. As a result, it will create a number of new markets and employment opportunities in Europe. The switch to electro-mobility will however also require important investments, so it is a major concern to find an industrial and regulatory environment that will make these possible. To promote the development of the internal market for electrical vehicles, to increase client acceptance, to optimise energy use and to discourage the imposition of market barriers, it is imperative that common standards be established for these vehicles, and for the electrical equipment for supplying energy to them. The equipment and the vehicle itself should be interoperable and interchangeable across frontiers in Europe and – preferably – worldwide and be designed to allow optimal usage of infrastructure and power generation.

This concerns not only the electric passenger car, but includes all other forms of personal electric mobility. We could particularly mention the two-wheel vehicles that are already present on the roads in significant numbers. This document therefore addresses the major issues concerning all the variety of electrically powered road transport.

5.2 The international situation

The increased pressure on energy resources and the new potential offered by recent developments in battery technology have created a new, intense interest in electric transport throughout the world. Almost all automobile manufacturers are now heavily engaged in the preparation of a new generation of battery electric vehicles and plug-in hybrid electric vehicles that will derive their energy from the electricity supply. Both of these vehicle types will be available worldwide in the future and it is now necessary that the basis of the charging infrastructure and the electric grid be prepared for this future need.

5.3 The market for electric vehicles

The electric vehicle market is far from being mature and market studies give very different results. There does however seem to be a consensus on the great potential for electro-mobility and the fact that electric vehicles should have a significant share of the automobile market from 2025 onwards (figures ranging from 5% to 20% of total sales are often quoted).

Many experimental programmes are starting in Europe, to test the vehicles that will start to be commercialised at the end of 2011 and during 2012. Similar projects and objectives are being announced all over the world.

Amongst other facts, we can note that:

- new generation electric vehicles are already being delivered to clients in Europe;
- across the world governments have taken major initiatives. In China, in particular, the automobile manufacturers are gearing up to supply their very major internal market. The size of this internal market will contribute to the competitiveness of these vehicles in Europe;
- orders for new electric vehicles in 2011 already exceed the total production of EVs over the last 15 years;

- powered two- and three-wheelers and quadricycles are particularly well adapted to electric propulsion. Their reduced need for range, light weight and limited legal maximum speed (if they belong to the moped administrative category) simplify the technical solutions and allow manufacturers to start marketing products relatively close to consumer expectations, and thus ensure a potentially quick market uptake;
- the European market of powered two and three-wheelers was estimated around 10 000 units in 2010. 80% belong to the moped administrative category (which includes scooters with a maximum speed of 45 km/h). However, as mopeds are not officially registered in all Member States, this figure is underestimated. Despite the relatively modest volume, the future market appears promising (figures supplied by ACEM).

5.4 Standardization activities

Significant standardization work started in the early 1990s, concurrent with the initial industrial development of electric vehicles at that period. This activity never ceased, although its intensity reduced for some years. The currently accelerating industrial development, oriented to the production of large numbers of commercially viable products, has created a need for major involvement in electric vehicle standardization by all the relevant stakeholders, which frequently come from different industries and standards traditions. This has inevitably led to a certain confusion, even of duplication of work, with the result of a certain number of inconsistencies that should be corrected, with varying degrees of priority. The following sections indicate the principal bodies that are concerned by this standardization effort.

5.4.1 The principal international standards organisations

IEC The International Electrotechnical Commission (IEC) is primarily concerned with the standards related to electrical equipment and electric components. Work on EV charging is done in Technical Committee (TC) 69. Specific components of vehicles are treated in the relevant TCs.

ISO The International Organization for Standardization (ISO) is a “horizontal” standards body that covers a multitude of topics. The ISO work on all road vehicles including EVs and vehicle components is concentrated in Technical Committee 22.

Two sub-committees – TC 22/SC 21 and TC 22/SC 3, cover subjects associated with electrical road vehicles. The sub-committees SC 22 and SC 23 respectively cover subjects on motor cycles and mopeds

ITU-T The International Telecommunication Union (ITU) is a United Nations agency for communications issues, the global focal point for governments and the private sector in developing networks and services. Apart from organising radio spectrum usage, its ITU-T function is the global standardization body in the telecommunication domain

A recently negotiated memorandum of understanding (MoU) on the international standardization of electrotechnology for road vehicles between ISO and IEC will ensure a close cooperation. We recommend that the majority of requirements for electro-mobility standardization should be met by international standardization activities in ISO or IEC, with however a need to adjust some activities to take in due account specific European needs, and following the detailed recommendations of the present report.

5.4.2 European Standards Organisations

CEN, CENELEC, and ETSI are the three recognised European Standards Organisations. CEN is the European counterpart of ISO; CENELEC is the European counterpart of IEC; ETSI is more or less the European counterpart of ITU-T (but like its other European counterparts is non-governmental). Apart from the specific communications aspects, broadly the responsibility of ETSI, electro-mobility issues are the responsibility of CEN and CENELEC, as well as their respective global counterparts ISO and IEC.

At European level, the mandate for electric vehicle standardization is addressed to the three European Standards Organisations

There is presently no standards work specifically relating to electric cars at the European level. European Standard EN 15194 ² has been developed to cover certain assisted pedal cycles.

5.4.3 Coordination between European and International standards and regulations

CEN and CENELEC have special agreements (respectively the Vienna and Dresden Agreements) that ensure collaboration on most standardization subjects and avoid overlapping activities. In particular, where there is international work that can be adopted in Europe, preference is given to the work at the international level. International Standards may be adopted through parallel processes as European Standards (ENs) – this confers the major advantage that ENs must be adopted as national standards by all CEN and CENELEC member countries, and conflicting national standards withdrawn. On the other hand, sometimes by agreement, standards activities can be initiated in Europe and taken up at international level.

In accordance with the normal practice of the ESOs, specific standardization activities at European level in this domain should therefore be confined to cases where:

- existing or proposed international standards do not meet European requirements; or
- these cannot be updated or completed in a reasonable time to ensure European electro-mobility roll-out; or
- the requirements are purely European in character and where ISO or IEC have no current interest in the topic.

The standardization activities will also require to take due account of regulation, for instance global (UN-ECE Regulations), European (Low-Voltage or EMC Directives), or national (local wiring rules). In the last-mentioned case, we need to take care to ensure any conflicting national rules do not constitute a barrier to the implementation of standards across Europe, with resulting barriers to trade, and we make some relevant recommendations.

² This EN, developed by CEN TC 333, covers “cycles with pedal assistance which are equipped with an auxiliary electric motor having a maximum continuous rated power of 0,25 kW, where the output of the motor is cut off when the cyclist stops pedalling and is otherwise progressively reduced and finally cut off as the vehicle reaches a speed of 25 km/h”.

5.4.4 Other international standardization work

A number of other standardization bodies are working on the different domains that concern the electric vehicle. These include many national or industry consensus groups, which leads to difficulties in ensuring coherence between their documents.

For example:

- the US standard institute, ANSI – through its accredited Standards Developing Organisation (SDO), the Society of Automotive Engineers (SAE), is particularly active in the domains that concern the electric vehicle with committees that treat the definition of charging and the data exchange between the vehicle and the charging station;
- Underwriters Laboratory (UL), another ANSI-accredited SDO and an independent product safety certification organisation, is developing test specifications focusing on safety;
- China is in the process of adopting a large number of national standards that are similar to some international standards (and is expected to contribute to ISO and IEC work in the future);
- the committees working in ISO and IEC on electric vehicles work maintain an active contact with the principal consortia in order to maintain a maximum of coherence between their ongoing international standards work and specific documents that are produced by the consortia. This concerns more particularly the collaboration between the SAE and the IEC TC 69 and ISO TC 22 for charging infrastructure and communication standards.

5.5 Regulations and Directives

The European Union and UN-ECE are the two principal bodies concerned with regulations for Europe on the issues of electro-mobility. See Chapter 13 for details.

6 Stakeholder requirements

This section includes position statements made by various associations of stakeholders in Europe; it represents the views of those providing them and therefore not necessarily the consensus of the Focus Group. In some cases, detailed positions are contained in annexes to the report.

6.1 Identified consumer requirements (ANEC and Going-Electric)

See **Annex E.1** for the full text of the European consumers' position.

From consumer organisations' perspectives, the following are the major identified needs to be met by standardization:

- 1) Adequate level of safety
- 2) Possibility of charging at homes and in residential areas on adequate domestic socket-outlets and private charging stations
- 3) Availability of charging in public places
- 4) Affordability and ease of use which involves affordable, light and easy to connect cables and plugs and simple and consistent user interfaces
- 5) Interoperability of connectors and billing mechanisms throughout Europe
- 6) Security concerning data privacy, authentication, protection against vandalism and cable theft
- 7) Durability and robustness especially of the charging cables and connectors
- 8) Accessibility regarding elderly and disabled people

6.2 Manufacturing sector requirements

6.2.1 European Automobile Manufacturers Association (ACEA)

The full texts of the ACEA position (version September 2011) and recommendations for the standardization of the charging of electrically chargeable vehicles are at **Annex E.2**.

6.2.1.1 Summary:

The current joint position and recommendation are based on today's best knowledge of the current situation and state of technical development. That applies both for connectors/modes and communication. Certain technical solutions may still need to be validated in detail (and possibly changed in time), as the technical specifications have not yet been finalised in the different international standardization groups.

ACEA is strongly supporting the ISO and the IEC standardization process for a global solution.

ACEA continues and stresses the need to divide the timeframe into two fundamental phases:

- Ongoing period until approval of relevant standards (Phase 1);

- and approval of relevant standards with sufficient lead-time for implementation (Phase 2) – as from 2017.

In line with the joint EU-US TEC discussions, ACEA presents a definition of global vehicle inlet "envelope" as a key step for a global solution, enabling simple switch between US and EU standards.

6.2.1.2 Basic charging (covers “basic AC charging” up to 3,7 kW)

Phase 1:

ACEA agreement for the vehicle inlet:

No restrictions on type of vehicle inlet as vehicles with different types are already on the market or in a late development phase. Manufacturers will provide at least one cable with Type 2 plug (Mode 3) or standard domestic plug (Mode 2) to connect to infrastructure.

ACEA recommendation for public charging (infrastructure side):

Type 2 (Mode 3)

ACEA recommendation for home charging (infrastructure side):

Type 2 (Mode 3), standard home socket-outlet (Mode 2) or industrial socket-outlet (IEC 60309-2; Mode 2).

Phase 2:

As for harmonised solutions, ACEA strongly recommends to unify national regulations concerning socket-outlet types without shutter.

ACEA agreement for the vehicle inlet and connector:

Type 2 (Mode 3) uniform EU solution, in global “envelope” if opted by manufacturer. Manufacturers should provide at least one cable with Type 2 plug (Mode 3) to connect to infrastructure.

ACEA recommendation for public charging (infrastructure side):

Type 2 (Mode 3) uniform EU solution

6.2.1.3 Fast charging (including and “fast AC charging” above 3,7 kW up to 43 kW, “fast DC charging” up to 43 kW and “ultra fast DC charging” above 43 kW)

General recommendation:

ACEA strongly recommends those infrastructure/charging points to be equipped with fixed attached cable in line with existing standards. ACEA also see this network as a charging “safety net”.

ACEA recommendation for vehicle inlet:

Type 2 or Combo2 in global “envelope”

ACEA recommendation for public and fleet charging:

Charging points equipped by fixed cables with Type 2 or Combo2 connector.

ACEA recommendation for home charging:

Charging points equipped by fixed cables with Type 2 or Combo2 connector.

6.2.2 ACEM – The Motorcycle Industry in Europe

The full text of the ACEM position is at **Annex E.3**.

Industrial and economic factors specific to the relatively small and fragmented powered two-wheeler market, would clearly plea for the development of international standards. EU standards may be considered as short term pragmatic alternatives, especially in case of unreasonable or incompatible constraints imposed by the international level.

Specific requirements

- Mode 1 is an efficient re-charging means for powered two- and three-wheelers. Powered two- and three-wheelers and Quadricycles do not always need very sophisticated and fast charging systems as battery capacity is much lower than for cars;
- Charging infrastructure must be easy and cheap in order to allow it to be installed at enough places with public access (e.g. parking places).

6.2.3 European Twowheel Retailers' Association (ETRA)

What is required above all at this moment in time is a regulatory framework for these vehicles that does not obstruct their market development as is the case today. Hopefully, ETRA's lobby for the benefit of electric cycles and light electric vehicles in the framework of the review of Directive 2002/24/EC will have this result. If the lobby work is successful than many more types of electric cycles and light electric vehicles than today may become subject to standardisation through CEN.

A more appropriate regulatory framework should also result in further clarification of the classification of electric cycles and light electric vehicles. Some manufacturers, for instance Segway, have been struggling with this problem for as long as 10 years.

The current charging solution offered by the manufacturers for electric cycles and light electric vehicles provides the user with a maximum of flexibility. In other words, he can charge his vehicle anywhere at any time. This results in easy access to easy-to-use vehicles and it is extremely important to safeguard this also in view of the price-levels currently in place.

In other words, the combination of a domestic plug and a household socket-outlet is the most effective and efficient solution for electric cycles and light electric vehicles.

As for the chargers and connectors, there are voluntary efforts to establish standardised products. However, so far there is not majority in the electric bicycles business in favour of this standardisation process.

As for safety issues, we believe that it is of utmost importance to encourage manufacturers to provide consumers with complete and correct information on the battery, battery use, charging, all aspects related to charging as well as on how to manage energy use.

6.3 Identified requirements of the electrical infrastructure and equipment manufacturers (Orgalime, CECAPI)

The European engineering industry is the one and only industrial sector possessing system level expertise in all parts of the system chain – from power generation and the transport and distribution of electric power, to the control and drive elements fitted to vehicles.

The electric car is part of the new world of energy. The car and the associated charging infrastructure must be regarded as part of this whole system.

The EV charging infrastructure is an integral part of the electrical installation, notably in a home or in a building

Safety is the most important requirement, for users when they charge their car; charging mode definition and their conditions of use must be based on this absolute requirement, before any other consideration.

For the successful deployment (in term of CO₂ reduction and infrastructure cost optimisation), energy management must be promoted from the beginning, hence managed charging modes (Modes 3 and 4) are to be preferred for the purpose of energy management.

Solutions selected for charging infrastructure must be simple and cost effective, to allow for mass deployment, in order not to delay market start; at home, the safe use of adequate domestic socket-outlets with mode 2 charging must be possible.

It is important that infrastructure can serve all electric vehicles without discrimination due to different types of connector used on the car.

So, for charging in mode 3³ (1) where several types of inlets will be used by car OEMs (type 1, type 2), Orgalime recommends that "pure case C" (i.e. only attached cord-set) be avoided for public infrastructures.

6.4 Identified requirements from the electrical supply sector (EURELECTRIC)

The full text of the EURELECTRIC position is at **Annex E.4**.

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, reap energy-efficiency gains through the greater efficiency of electric drive-trains, decrease the EU's oil dependence, improve the situation in cities with regards to air pollution and noise, and help to maintain the EU's competitiveness by taking the lead in these new technological developments.

³ Excepting AC fast charge at 43 kW, where only type 2 connectors will be used by car OEMs and where the weight of the cable could be too important for a detached cable.

The existing European electricity system already provides to end-user consumers a very efficient infrastructure for generation, transmission, distribution and commercialisation of electricity. The equilibrium of this very complex system is managed in real-time, internationally across all borders of European Union. EURELECTRIC is convinced that the existing European electricity system is a true asset for making transport more sustainable. EURELECTRIC believes it is important to issue general recommendations for an optimal integration of electro-mobility in order to avoid technical bottlenecks and corresponding unnecessary investments in the electricity network.

Common standards will help to ensure that the driver enjoys a convenient recharging solution across Europe that will avoid a multiplicity of different cord-sets and adaptors and/or retrofit costs for adapting to new charging systems. Moreover, consumers should be able to charge their vehicle at any public accessible charging station across Europe. A standardized interface between the distribution grid and the electric vehicle will ensure the required safety and security level for the consumer.

6.4.1 Modes of charging and charging level

Much of the discussion on electric vehicles 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.

EURELECTRIC therefore feels 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 ⁴ in km
Normal power ⁵	1-phase AC connection	≤ 3,7	10-16	< 20
Medium power	1- or 3-phase AC connection	3.,7 - 22	16-32	20 – 110
High power	3-phase AC connection	> 22	> 32	> 110
High power	DC connection	> 22	> 32 ⁶	> 110

⁴ Assuming an average consumption of 20 kWh/100km.

⁵ This single phase connection corresponds to the typical domestic plug connection dependent on country specific characteristics.

⁶ 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.

In order to facilitate EV market penetration, a transitory phase, depending on the market take-up, should be allowed in which existing infrastructure with adequate domestic and industrial socket-outlets can be used in a safe way. However, since it cannot be guaranteed in all European countries that all these socket-outlets are equipped with a RCD it is not recommended to use Mode 1 charging.

Therefore, Mode 2 charging (a Mode 3 vehicle charging at an existing socket-outlet with an in cable control box (ICCB) having an integrated RCD) should be used during the transitory phase at least in private locations.

With respect to the integration of the electrical vehicles as controllable consumers and storage systems in the smart grid, in the future all class M and N vehicles coming into the market should be fitted with a Mode 3 charging. Mode 3 is a more reliable option to charge an EV in all available locations and should be the preferred infrastructure solution for long term at least for public locations with high density of charging infrastructure to allow load management.

6.4.2 EMC during charging of electric vehicles

When charging, the vehicle is connected to the low voltage network together with a lot of other electrical equipment and it has to be ensured that the different devices do not disturb each other. Therefore, the vehicle should at least comply with the standards that apply to electrical equipment used in similar circumstances according to IEC 61000-3 series. Electro-mobility will introduce new constraints on the grid and electric vehicles in particular with regards to EMC, which should be minimised by employing state of the art technology.

6.5 European Commission requirements

The Commission considers it desirable to have harmonised standards with respect to the interoperability of the electric vehicle charger as early as possible, as this will be in the best interests of the producers of electrical vehicles and of relevant appliances as well as the users of electric vehicles.

There are currently three (one single phase and two three phase) options for plugs for dedicated EV charging (see Chapter 8) in addition to the existing industrial standard EN 60309-2, none of which are interoperable. In order to promote the development of the internal market for electrical vehicles and to discourage the imposition of market barriers, it is imperative that plugs, chargers and electric vehicles be interoperable. This will allow users to use the same charging spot for a range of electric vehicles. It would also allow consumers to charge their vehicles easily when driving across borders or travelling within their own Member State. It would also facilitate charging at public access points as well as the roll-out of charging infrastructures. Finally, it would dissuade Member States from taking action individually because this might lead to overlapping solutions.

For these reasons, the Commission submitted a Mandate to the European Standards Organisations (ESOs) in June 2010 requesting them to issue new standards or review existing standards in order to ensure interoperability for electric vehicle charging devices/equipment and address any safety risks, EMC risks and smart charging issues related to the electric vehicle charger. The Commission standardization mandate, which was approved by the 98/34 Committee, was the result of consultations with the European Standards Organisations, Member States and stakeholders.

The timeframe for ESOs to prepare the standards, as set by the mandate, is very tight, as the results must be delivered within 18 months from the date of acceptance of the Mandate. This is in line with the Conclusions of the Competitiveness Council of 25 May 2010⁷ and the Resolution of the European Parliament of 6 May 2010⁸.

⁷ Conclusions on clean and energy-efficient vehicles for a competitive automotive industry and decarbonised road transport, 3016th Competitiveness Council meeting, Brussels, 25 May 2010.

⁸ European Parliament Resolution of 6 May 2010 on electric cars.

7 Electrical vehicle charging modes

7.1 A brief state of the art

7.1.1 Retrospective

Electrical vehicle experimentation has been carried out over the last 20 years with the installation of a limited number of public and private charging points. European normal charge installations have been mostly limited to 16 A and 230 V in mode 1. Some DC fast-charge systems have also been installed.⁹ Definitions of charging modes are given in Chapter 3.

7.1.2 Present context

The evolution of battery technology now allows vehicles with reliable ranges of 150 km to 200 km. This is to be compared to the average daily travel distance in France of some 40 km (French National Statistics), which typically requires 4 kWh to 8 kWh of energy. Efficient off-peak charging should clearly be preferred to charging in peak hours (e.g. around 6 p.m. in the wintertime). However, accelerated charging may be a complement as it will also help to support off-peak charging. In addition to new AC charge stations (generally limited to 16A) a number of AC and DC fast charge stations are being installed. Fast-charging systems will reduce concerns about drivers running out of power and thus alleviate client anxiety, which will thus also allow maximum use of available battery range.

7.1.3 Trend and international situation

Mode 3 seems to have consensus in particular for new public installations. Some countries wish to retain mode 1 for short-term client acceptability, and to ensure market during the intermediate phase. There is also the possibility of using mode 2 for occasional charging.

Some stakeholders insist on the need to maintain mode 1 in public installations for charging of electric vehicles.

The United States and Japan would seem to direct their policy to the single-phase AC supply in mode 2 and 3 below 7,2 kW and to DC in mode 4 above 7,2 kW.

NOTE Powered two/three-wheelers and quadricycles, as well as some current Japanese passenger vehicles, are mode 1.

A number of European countries have domestic 3-phase supply installed and require 3-phase for AC over 20 A. 3-phase allows 22 kW with a 32 A supply and even 44 kW with 63A. According to IEC 62196-2, specific EV 3-phase socket-outlets may also supply single phase. In Europe, some OEMs propose to start DC (mode 4) from low power (e.g. 10 kW), other OEMs and some utilities propose to keep AC for high power (e.g. 43 kW). There is an overlap in these power levels for AC and DC charging. See also section 7.3 below, supply power levels.

For AC charging, it is to be noted that mode 3 charging has been obligatory in Italy since 2001 for all roadside charging. Bimodal operation of vehicles (mode 1 or 2 + mode 3) may certainly be of interest. On the contrary, it should also be noted that mode 1 (with current < 16 A) has been used for decades in the Nordic countries for car engine and cab preheating.

⁹ There is no reliable information available on the exact number of charge spots that have been installed in Europe over the years. In France alone there were some 800 16A – 230V AC public charge spots and some 30 fast DC charge stations installed between 1990 and 2000 (EDF figures). New AC and DC stations are now being installed.

7.1.4 Probable evolution of EV charging

Lithium-ion battery technology is evolving with expected increases in power and energy densities. Standardization has to account for a possible evolution towards very high charging power solutions. Improvements in power electronics for onboard systems may open a new class of high power charger (e.g. integrated charger).

Inductive charging is handled at the IEC project 61980 at a "basic level". An application of inductive charging is not expected before 2015 for electric road vehicles at a significant scale. At present, we see no requirement for establishing a pan-European interoperable infrastructure in the introduction phase of electro-mobility.

Reverse energy flow from the battery (V2G) is proposed as a possibility to optimise energy control and to facilitate the use of renewable energy on the grid provided battery life cycle and degradation questions are solved.

Smart grid services will influence charging patterns and contribute to the optimisation of energy use, for example, by:

- aggregation of the power generated by a vehicle fleet.
- management of energy and power balance (including EV).

This requires information transfer between the EV and the grid, which is treated in Chapter 10. Specific safety aspects must also be addressed.

Recommendation 7.1: All aspects of reverse energy flow (safety and control) should be addressed by IEC TC 64 (safety) and TC 57 (smart grid) CEN TC 301 (vehicle aspects) and other relevant TCs

7.2 Charging scenarios covered

7.2.1 Home charging

Home charging includes any charging regularly at the same place (e.g. home, office or other regular charging).

For some vehicles, charging time could reach 8 hours with a 16 A single phase on board charger. This time may increase in case of additional functionalities, such as pre-heating the car interior. As household socket-outlets are not generally meant to be used at maximum rating over long periods, the installation of a specific and dedicated wiring and socket-outlet is to be preferred. Some countries distribute 3 phase AC to dwellings allowing higher levels of power.

While some stakeholders representing consumer interests and EV associations feel that mode 1 is adequate for home charging, others like manufacturers and charging infrastructure operators, who are responsible for product safety and reliability, prefer mode 3 with dedicated socket-outlets as the better technical solution, with the possibility of using mode 2 for occasional charging. See also section 7.5 and recommendations 7.9 and 7.10 below.

Charging with EN 60309-2 type socket-outlets as currently used in Europe does not allow for mode 3 earth wire detection and energy control as presently proposed by the automobile manufacturers (alternative methods are presented in the IEC 61851-1 but have not been implemented).

The problems related to the use of adequate domestic socket-outlets and adaptors are treated in 7.6.5; the use of socket-outlets of type EN 60309-2 is treated in 7.6.6.

Recommendation 7.2: EV of categories M and N charged at home should be done using dedicated socket-outlets. Home charging of such vehicles should preferably be done using mode 3

7.2.2 Occasional charging at non-dedicated charging socket-outlets

Occasional charging implies the use of socket-outlets that are not specifically designed for EV charging. The presence of RCD protection cannot be guaranteed under these circumstances. This can be overcome by using charging cord-sets with an integrated RCD (mode 2 charging).

The requirements for such charging are treated in 7.6.5. See also section 5 and recommendations 7.11 and 7.12 concerning mode 2 charging.

Recommendation 7.3: Occasional charging should preferably be done using mode 2 to ensure RCD protection

7.2.3 Public charging (or charging in private places accessible to the public)

The time of parking in public places is very variable. It covers long-duration charging (e.g. overnight) and opportunity charging (e.g. while shopping).

For opportunity charging, if the power of the spot allows it and the vehicle has a high power charge capability, it may be possible to charge the vehicle significantly in a short time. This will permit the customer to charge the vehicle when stopped without having to stop only for the purpose of charging.

Major utilities and new business start-ups as future charging operators will likely orient their policy in this direction.

Mode 3 and Mode 4 are adapted to this situation:

Mode 3 has the following advantages:

- a charging cord-set devoid of any electronic system (mode 3 needs the use of a simple cord-set for interconnection);
- verification of earth continuity between the installation and the vehicle ;
- possibility of modulating the charging power by the use of PWM modulation on the pilot line thus enabling power management;
- ability for the vehicle to interrupt the voltage at the socket-outlet at any time thus ensuring supplementary protection;
- a dedicated socket-outlet, designed for possible high current rating.

See also section 7.5 and recommendation 7.13 below. In public places accessible to motorcycles or quadricycles, mode 1 charging should be also offered.

Recommendation 7.4: Public AC charging of vehicles in the M and N categories should be done using mode 3

7.2.4 Fast charging

This scenario implies an intentional stop for the purpose of charging in a short time at a dedicated station.

Fast charging may overcome range anxieties related to the use of electric vehicles.

Some OEMs are proposing fast AC charging, others are opting for fast DC charging. However, some vehicles will not have fast charging capability. For the applicability of the different systems in Europe, see 6.2.1.3.

7.2.5 Breakdown recovery/roadside assistance

The possible application of both fast AC and fast DC charging by mobile recovery vehicles should be evaluated by CEN TC 301.

Recommendation 7.5: CEN TC 301 to evaluate the possible application of fast charging arrangements by mobile recovery vehicles

7.3 Supply power levels

This concerns the identification of the ranges of power levels that will be installed for AC and DC charging on public charging or private accessible to public infrastructures, and whether they will be single or three phases.

The power of charging installations is defined by the maximum available power at the spot. Common terminology refers to slow, normal, accelerated and fast charging. Maximum available power is determined by the nominal voltage and nominal current. For a given supply voltage, it is limited by the over-current protection device installed.

The levels presently considered are:

- 10 A 230 V = up to 2,3 kW
- 13 A 230 V = up to 3,0 kW
- 16 A 230 V = up to 3,7 kW
- 32 A 230 V = up to 7,4 kW (not applicable for all EU countries)
- 16 A 400 V 3 Phase = up to 11 kW
- 32 A 400 V 3 Phase = up to 22 kW
- 63 A 400 V 3 Phase = up to 43 kW
- AC or DC charge = up to 86 kW (all intermediate values are also possible according to IEC 61851-1)

Higher AC and DC power levels can be considered (e.g. for heavier vehicles) with the appropriate connection and protection systems.

These power ranges overlap, which may pose problems of interoperability, especially for charging stations used by the general public. Stations with both AC and DC charge could provide an intermediate solution (as currently proposed in France).

Recommendation 7.6: Charging stations used by the general public should offer at least mode 3 AC charging to ensure interoperability. Additionally high power AC and/or DC charging might be offered

7.3.1 Charging requirements for light electric vehicles in the L1 to L5 category

The specific requirements of light electric vehicles in the L1 to L5 range are not necessarily covered by these definitions and power ranges. Such vehicles generally have detachable batteries that are charged separately from the vehicle. The non-manageable number of different chargers, connectors and batteries has led to the standardization of an external low power DC charger (limited to 48 V) managed by the EnergyBus consortium, which may be considered as a basis for more formal standards.

Recommendation 7.7: The specific requirements of light electric vehicles in the L1 to L5 category could warrant specific standards for interoperable charging systems. These could take account of the EnergyBus proposition. The Coordination Group is to decide on which Technical Committee(s) should be involved

7.4 Charging architecture

Charging of batteries from the AC mains requires the following apparatus: an AC/DC converter (rectifier and power factor control), a DC/DC converter for the regulation of the current, and an isolating system (often a transformer for external charging systems).

For AC charging (mode 1, mode 2 and mode 3) all the above-mentioned power equipment is located on the vehicle. The electronics may use part of propulsion or traction electronics. Current standards do not require insulation between grid and battery; however this may add extra technical constraints to ensure low leakage currents (both AC and DC)

For DC charging (mode 4) all or part of the equipment is located outside of the vehicle in the charging installation. Two options can be considered:

- Controlled current charging. This method is presently used for all DC charging. The isolating transformer and all the power equipment are located in the charging station.
- Constant voltage or unregulated DC charging: The isolating transformer and the AC/DC converter are off-board and the vehicle electronics are used to regulate the current to the battery. This topology is presently in the prototype stage, which means no standardisation recommendations are needed at the moment.

Requirements on the charging station assemblies will be defined in the project IEC 61439-7.

Recommendation 7.8: The characteristics of assemblies for specific installations at public sites need to be defined. It is proposed that the work of IEC/SC17D concerning standardization project IEC 61439-7 is actively supported. There is no need for further action at the European level at the moment

7.5 Additional recommendations for the use of charging modes

Mode 1

As mode 1 requires that the socket-outlet be protected by an over current device and an RCD but the presence of such RCDs cannot be ensured in old installations.

Recommendation 7.9: The use of charging mode 1 should be allowed for small vehicles such as scooters or quadricycles. The maximum value of the allowable current must be defined (see 7.6.5.2)

Recommendation 7.10: As the presence of RCDs cannot be guaranteed in all cases, the use of mode 1 charging on larger vehicles should not be considered unless adequate supplementary protection is supplied (e.g. Class 2 isolation or equivalent, ground check system inside the vehicle)

Mode 2

Mode 2 may be used by all vehicles, provided the limits of the socket-outlets are respected (see section 8.2). As such mode 2 boxes are very exposed they should be designed to be small, robust and light. A new work item proposal has been submitted to IEC TC 23E/WG 7 with the working title "In-Cable Residual Current Device for mode 2 charging of electric road vehicles (IC-RCD)" to specify requirements for mode 2 charging.

Recommendation 7.11: Mode 2 is not recommended for publicly accessible places, except for locations specifically destined to be used by small vehicles in the L1 to L7 category;

Recommendation 7.12: The characteristics of the in-cable RCD must be defined. The Focus Group requests that the proposed standards activity (IEC23E/716/NP) be actively supported. There is no need for further action at the European level

Mode 3

This mode of operation is destined to be used in all places for AC charge.

The standard IEC 61851-1 defines the basic characteristics of the mode but needs some further precisions or amendments.

NOTE Stakeholders representing EV users oppose this provided solution and request mode 1/mode 2 charging in public places

Recommendation 7.13: Further precisions are required on the timing diagrams of Annex A of IEC 61851-1. Coherence with the evolving SAE 1772 standards should be ensured. IEC 61851-1 having been ratified as EN 61851-1, it is recommended that the new CENELEC TC 69X launch an amendment procedure immediately in Europe to correct the text in accordance with ongoing discussions and in close harmony with IEC. This should consider the results of ongoing developments

7.6 Electrical safety of charging

Some interoperability problems clearly result from the existence of different wiring requirements at national level in different European countries. The IEC sub-committee concerned carried out a survey of its "P" (permanent) members in a bid to ascertain what the exact differences were but the results were confined to a small number of countries. As the Focus Group itself began work, the questionnaire was extended to other CEN and CENELEC Member countries, but without a detailed clarification being obtained as a result.

This issue is a regulatory one – i.e. the requirements in question are laid down by national regulatory authorities. At the very least, the existence of different requirements in different European countries imposes a cost burden on those supplying charging equipment; at worst it could lead to interoperability problems, which can affect the ability of vehicles to recharge in countries other than the one where they are based.

This situation needs to be addressed rapidly through a study of the detailed legislation and the different requirements that exist, to be followed as appropriate by European regulatory action to remedy the problems demonstrated. It is only when armed with the full and correct information, including on the actions being undertaken that the appropriate selection of interoperable standards options can be completed. An earlier request from the Focus Group for such a study failed however to obtain sufficient support.

See also section 8.7 below.

Recommendation 7.14: An urgent study is required into the effect of different national wiring rules and other regulatory requirements on the technical propositions made for cross-border interoperability of socket-outlets for charging. The results should be taken into account by regulators, as required

Standards should be as self-contained as possible but need to cross-refer to other standards where EU harmonisation is established. Safety requirements covering protection against electric shock should be based on CENELEC HD 60364.

7.6.1 DC current leakage

For three-phase supply, special consideration to DC current leakage needs to be given for both the vehicle and the charging station.

Noting that a single external event (e.g. penetration of water, electric damage after crash, strong overvoltage as a result of lightning strike) may cause multiple defects in the electrical system of both the vehicle and the charging station. Overall electrical safety should be guaranteed by either the vehicle or the charging station or both. Potential technical solutions to this problem that have been proposed and could warrant further investigation include the possibility of including a part of the protection scheme on the vehicle and a part of the protection on the fixed installation.

This issue has to be addressed by the relevant TCs, in particular concerning the case where a Type A RCD is used.

NOTE Present standards indicate the need for Type B RCDs or similar for some three-phase installations with conversion to DC

Recommendation 7.15: The question of the type of protection needed for three-phase charging systems is to be analysed in order to fix requirements on the vehicle charger and/or the charging station (CENELEC TC 64, CEN TC 301, CENELEC TC 69X), investigating all possible protection means against DC leakage on the vehicle and/or the charging station side, including alternatives to the Type B RCD

7.6.2 Electrical safety at the vehicle inlet

The electric vehicle is a potential source of electrical power that can energise the cable or an object inserted into the EV inlet. This may occur even if the vehicle is not connected to the mains. The coherence between regulations and requirements of electrical safety standards should be checked and the texts updated if necessary.

International standards IEC 61851-1 and ISO 6469 include requirements partly addressing this situation. Existing standards for distributed power systems and uninterruptible power supplies may also be applicable.

Recommendation 7.16: UN-ECE Regulations and existing standards must be checked and possibly updated concerning safety at the vehicle inlet. The safety of energy feedback requires close correspondence between IEC 61851-21 (presently under revision) and ISO 6469-3-2. At European level, very close relations should be established between CENELEC TC 64, TC 23 BX, TC 69X and CEN TC 301. This is an urgent question.

7.6.3 Electrical safety at the charging station

Failures in the control unit of a charging station can lead to the situation that voltage is present at the socket-outlet in the absence of a vehicle. In such a case, protection against electric shock should be ensured by the RCD in the charging station. However, further protective methods could be required.

This failure could also exist in mode 4 systems.

Recommendation 7.17: Additional requirements for functional safety of the charging station should be considered by the appropriate TCs (CENELEC TC 64 and TC 69X) in future work on IEC 61851-1 and/or IEC 61851-22 (AC) and IEC 61851-23 (DC)

7.6.4 Earth quality verification

Earth connection is considered as a vital safety requirement for the protection against electric shock.

NOTE Earth quality requirements are subject to national regulation and may differ from country to country.

Recommendation 7.18: Relevant TCs (CENELEC TC 64, CLC TC 69X, CEN TC 301) to consider the possible need for further earth quality verification of the installation for electric vehicle charging, considering the specific needs of electric vehicle usage and different mains network configurations that use different earth and neutral connection schemes (TN, TT, IT)

7.6.5 Current rating of the charging installation and the connecting socket-outlets

The complete charging system should have the corresponding overcurrent and short circuit protection. This means that the vehicle charging profile should be adapted to the safe current carrying capacity of the circuit supplying the socket-outlet (for example 10 A) and should be limited if the socket-outlet not able to safely supply its rated current for long periods.

The vehicle charging profile can exceed this limit if the socket-outlet can be identified as having a higher current capacity.

7.6.5.1 Current limitations due to the installation

Most final circuits within the electrical installation across Europe are 16 A radial circuits that supply 16 A socket-outlets. If the AC charging current is 16 A then the whole circuit capacity is used for one load and no further current can safely be provided by that circuit.

Electrical installations in Europe can be old and not capable of meeting EV charging needs. Therefore, it is proposed to have the installation inspected by a skilled person before using it for EV charging purposes. Especially, old installations were not planned to supply such a long term high amp loading. Otherwise the risk of fire is very high because of aged and probably bad contacts in combination with high current. Periodic inspection is already mandatory in some countries of the EU.

Recommendation 7.19: An inspection of installations - as already mandatory in some EU countries - is strongly recommended. Wiring rule standards should provide information concerning the use of older installations for EV charging

7.6.5.2 Current limitations due to the connecting devices

Domestic socket-outlets

There are many rated currents of domestic socket-outlets across Europe e.g. 10 A, 13 A, 16 A and probably some others in between so the rated currents vary from country to country. The present European domestic socket-outlet systems were never designed with electric vehicle charging in mind, particularly across many countries for long charging periods.

At least, if EVs are to be charged from adequate domestic socket-outlets in other countries then there is a need to limit the AC charging current through domestic socket-outlets as it is inevitable that adaptors (see below) will be used across Europe for charging vehicles in other countries.

Socket-outlets complying with IEC 62196 or EN 60309-2

It will not be necessary to limit the charging current through adequate socket-outlets complying with IEC 62196 or EN 60309-2, which are used in domestic installations below their rated value, as these socket-outlets have been designed for long current carrying periods. Hence, there is no safety problem when such socket-outlets are used across Europe, as the charging current can be the same in all European countries provided the installation is checked regarding its capacities.

NOTE Such socket-outlets are either already harmonised across Europe (EN 60309-2) or will soon be harmonised (IEC 62196)

Current limitations due to the use of adaptors

Although the use of adaptors should be discouraged as a potential source of danger, it is inevitable that adaptors – or cord extension sets with an adaptor function – will be used across Europe for charging vehicles in other countries. This would result in some domestic socket-outlets being overloaded if there is no agreed, harmonised maximum AC charging current limit imposed by the vehicle.

The use of adaptors constitutes a potential risk if they are not appropriate for the purpose. In particular this applies to adaptors that allow transitions from domestic socket-outlets to plugs complying with IEC 62196 or EN 60309-2.

When developing the EN 61851 series, CENELEC TC 69X should consider the following:

- considering the worst case of use, the rating limitation will have to be more related to the charging mode (1 and 2) rather than to the kind of plug considered at the wall side cord-set terminal. If reasonable countermeasures are found to avoid misuse of adaptors between household and industrial plug and socket systems, this position could be reconsidered;
- the vehicle charging current profile should be limited to provide a maximum AC charging current from the installation for mode 1 and mode 2 (e.g. 10 A or 13 A). However, currents for connector types EN 60309-2 may exceed 10 A or 13 A if specific means are used to identify the current carrying capacity of the overall circuit;
- charging currents in modes 1 and 2 on household socket-outlets must be adapted to the effective capacity allowed by the installation to avoid risk of overheating. Some specific means may be required to achieve this.

The following methods of limiting the current should be evaluated:

- for mode 1 there is a requirement to enable adjustment of the charging current in the vehicle to the known capacity of the socket-outlet used. Such an adjustment could be permanent if the current is below that which is considered to be the safe value for all European countries;
- for mode 2 there is a request (from some OEMs) to enable adjustment of the charging current if the current capacity of the station is identified. The TC will have to decide if and how this can be done (in the vehicle or the ICCB).

Recommendation 7.20: When developing the EN 61851 series, CENELEC TC 69X should consider the detailed issues related to current limitation for socket-outlets used for modes 1 and 2, as described in section 7.6.5.2 of this report. This is an urgent matter to be resolved before electric vehicles appear on the European market on a large scale

7.7 Fast charge solutions

7.7.1 Options for fast charging: AC, DC and mixed AC/DC

Different OEM fast charge options will exist in the near future. Vehicles presently circulating in Europe, provide Mode 3 (AC) up to 7 kW and a separate connector for Mode 4 (DC) fast charge. Connectors allowing for both AC and DC charge at a unique vehicle inlet (termed “Combo”) are also being studied and proposed for future use but are not presently exploited.

Utilities can deliver AC at three-phase, but remain reserved on the impact of numerous mobile charging requirements for high power AC three-phase charging on the grid. Indeed, harmonics rejection and low frequency conducted emissions, even if contained in a standardized EMC gauge, could make apparent additional constraints for the converters to ensure grid stability. DC charging stations are fixed installations, and will comply with existing standards and regulations with respect to their integration into the mains supply, and should therefore not require specific standards for grid interface.

7.7.2 DC Charging

DC charging (mode 4) has been selected by some car manufacturers for fast-charge. Consequently, corresponding standards need to be drawn up.

The DC charging system presently exploited in Europe on new EVs with such an option is proposed by a not-for-profit association¹⁰ (CHAdeMO), and will be integrated into the upcoming IEC 61851-23 and 61851-24 standards presently discussed as a WD.

Other propositions for DC charge and control systems are being introduced into these same standards, with proposals from USA and Germany. These use different control wires and propose high frequency modulation for data transfer on the pilot wire or phase/neutral wire instead of the CAN (controller-area network) signals. DC systems have very specific needs for interlocks (e.g. to avoid disconnect under load). Internal protection against DC charge may require specific protection devices with respect to external short circuits.

Recommendation 7.21: Establish a common European Standard for public DC charging systems. Such a standard could use the “CHAdeMO” proposition as a basis and attempt to ensure backward compatibility with EVs and infrastructure already deployed

7.7.3 DC voltage and current limitations

The DC charging systems presently used in Europe employs a specific separate 9-contact connector, with CAN data channels and a small section earth connection that thus imposes a specific control system. Several connector designs and higher contact currents are proposed (200 A, 600 V). Voltages over 500 V require a large PE conductor due to rules on earthing procedures of high voltage transformers. The present “CHAdeMO” design is therefore rated at 500V maximum. The full description of the connectors is to be found in Chapter 8.

Recommendation 7.22: The issues of current and voltage limitations for DC charge should be examined by CENELEC TC 64 and CEN TC 301

7.8 Mains network configuration

In some countries, three-phase networks exist, without neutral and/or with a low voltage level (230 volts) between phases. Systems without neutral could possibly be covered by specific regional solutions and would not be truly interoperable

The different neutral systems of the mains supply distributed in Europe (TN, TT, IT) may have different requirements for protection and control.

¹⁰ Membership of the association is a requirement for those wanting to implement the specification.

Recommendation 7.23: CENELEC TC 69X to be requested to consider specific requirements of different network configurations in Europe including three-phase networks without neutral and networks with 230 V triangle configuration, and specific requirements for neutral systems, and to propose solutions to ensure safety and interoperability

7.9 Additional requirements for interoperability and conformance testing

Currently available standards and regulations do not include all necessary requirements to achieve the necessary interoperability for charging all over Europe.

This more particularly concerns all the conditions that apply to the control pilot and the way it intervenes in the practical vehicle operation. Experience must be collected by the interested partners in order to prepare a complete set of test specifications for this operation.

Several other similar topics also have to be addressed.

Recommendation 7.24: Additional requirements for charging specifications and testing procedures have to be discussed and agreed based on experience gained in the ongoing development process and demonstration projects and have to be brought into amendments to the IEC 61851/EN 61851 series without delay

8 Connection systems for charging

8.1 Introduction

Interoperability for AC charging implies the definition of unique footprints for each connecting accessory (one footprint for vehicle inlet – vehicle connector; one footprint for plug and socket-outlets) in each charging mode and vehicle groups so that there will be interoperability through all European countries.

The following cases are covered:

- charging from the AC mains with standard voltages available in Europe. This includes charging from¹¹:
 - standardized (industrial and adequate domestic) socket-outlets for mode 1 and 2
 - dedicated socket-outlets with 1-3 phases for mode 3;
- charging of the vehicle traction battery from an off-board DC charger (mode 4);
- charging of electric vehicles of all considered categories such as passenger cars, powered two- and three-wheelers, quadricycles, light trucks, buses, and others. The immediate need for interoperability in Europe lies with the four-wheel vehicles of the M1 and M2 category

The following charging levels are considered in this Chapter:

- “low power DC” (typically for safety extra-low voltage; e.g. 48 V DC): < 1 kW – not considered in this report;
- “low power AC”: ≤ 3,7 kW single phase (as maximum charging power);
- “medium to high power AC”: > 3,7 kW (requires 3-phase in some European countries);
- “medium power DC”: 20 – 50 kW;
- “high power DC”: above 50 kW.

The case of charging of electric vehicles with inductive charging devices does not impact the selection of connectors.

The low voltage DC charging of scooters has not been dealt with in detail by the Focus Group. It is to be noted that a consortium is presently proposing the EnergyBus for such applications that can deliver up to 48V DC and uses a specific connector, as discussed in section 7.3.1 above.

¹¹ For charging modes, see Chapter 3

8.2 Candidates for connection to the AC mains for mode 1 and 2: plug and socket-outlets

Existing domestic socket-outlets and industrial socket-outlets (EN 60309-2) will prevail at least during the initial phase of EV introduction¹². Ordinary domestic socket-outlets are limited in current carrying capacity, and are not uniform in Europe, thus it is foreseeable that adaptors and short cord extension sets with adaptor function will be used by customers. The use of adaptors constitutes a potential risk if inappropriate adaptors are used. This aspect is fully treated in section 7.6.5.2.

8.2.1 Use of national domestic/household socket-outlets (mode 1 and mode 2 charging)

- According to several stakeholders' requirements (see Chapter 6), it should be possible for electric vehicles to be charged from household socket-outlets in all European countries. There are different national household socket-outlets in Europe, some are rated for maximum currents at 16A but some are only rated to 10A, 13A;
- some of these socket-outlets are not intended for long charging periods every day with the maximum rated current of these accessories. This aspect is fully treated in section 7.6.5.

In old installations there is a risk of the absence of an RCD in many European countries. There will be no way of ensuring that the vehicle is effectively charging in mode 1 (as described in EN 61851-1). The corresponding requirement for safety will not be attained.

In Italy, relevant standards (CEI 69-6 and CEI 312-1) require the use of mode 3 charging rather than mode 1 or 2 in public areas. .

In other European countries, modes 1 or 2 charging are allowed in public areas, for example in Sweden, which has a long experience of connection for electric car heating in public areas and car parks. The current may be limited for these applications (16 A at the most).

8.2.2 Use of industrial plugs and socket-outlets (EN 60309-2) on the infrastructure side

- Accessories according to EN 60309-2 are harmonised for all European countries and are indeed the commonly adopted standardized solution for camp sites (HD 60364-7-708) and marinas (HD 60364-7-709). It is possible for electric vehicles to be charged from EN 60309-2 socket-outlets in all European countries using mode 1 and mode 2;
- there may however be issues with the high insertion and withdrawal forces required to use these devices especially for high-current charging;
- according to some national installation rules industrial (non-specific) 3-phase socket-outlets must have all three phases connected so different outlets would be required for single and three phase supply. Therefore, EN 60309-2 will not be able to cover all defined voltages/currents with a unique footprint (mating face). This renders such a device incompatible with an interoperable charging infrastructure for single and three phases.
- see also the issues concerning use of adapters as considered in section 7.6.5.2 above.

¹² However, also note the issues with wiring rules discussed in sections 7.6.5.1 and 8.2.2

In some countries national wiring rules for buildings and homes in Europe require shutters or adequate measures (for example interlock) for socket-outlets. Therefore, it is necessary to clarify the applicability of these wiring rules, taking into account the applicability of the EU Low Voltage Directive- (LVD), for EV charging considering the specified charging modes. Otherwise, it will not be possible to achieve the interoperability all over the EU that is requested by the EU mandate and specific designs must therefore be employed in some countries.

NOTE The use of EN 60309-2 for mode 3 is treated in section 8.3.

Recommendation 8.1: The applicability, relevance and outcomes of national wiring rules on EV charging applications (Mode 1, 2, 3 and 4) in general and for the use of EN 60309-2 accessories should be considered and transposed into standards by CENELEC TC 64

Recommendation 8.2: EN 60309-2 could be used as an interim solution for mode 1 and 2 as it is transposed as a European Standard. The system is useable immediately. Extra standard text should be introduced to the next edition of EN 61851-1 immediately if deemed necessary by CENELEC TC 69X

8.3 Candidates for a unique connection to the AC mains for passenger vehicles in mode 3: plug and socket-outlets

8.3.1 Requirements

For dedicated AC charging stations (charging mode 3 as described in IEC 61851-1) there is a need for a unified connection solution that will fit all European needs and that will be acceptable for all European countries.

Several different mains connectors for AC charging up to three phases and up to 63 A with control wires are defined in the draft for IEC 62196-2 (presently at FDIS stage). However, for Europe only two types are relevant, since both single and three-phase requirements may apply.

Currently, for passenger cars, light trucks and buses category, two types as described in IEC 62196 series are under discussion for socket-outlets and plugs:

- Type 2
- Type 3-c

It is to be noted that the choice of the connection to the AC mains, and consequently the choice of the connecting device, needs to take into account all of the requirements of standard IEC 61851-1.



Figure 2 – Type 2 plug and socket-outlet (left) and type 3-c plug and socket-outlets (right)

The above two types could be used for light electric vehicles (EPAC, powered two and three-wheelers and quadricycles), where the standard domestic plug (using mode 1) is expected to be a widely used option in most European countries.

However a small, compact design that will allow mode 3 connection is also requested (including in Italy – see section 8.2.1 above). This could be fulfilled by type 3-a connectors.

Several standards and regulations define boundary conditions for the choice of plugs and socket-outlets. The Low Voltage Directive (2006/95/EC) is fully harmonised, and defines common requirements for devices, which need to be considered according to the mandate M/468. However, in some countries national wiring rules for buildings and homes in Europe require shutters or adequate measures (for example interlock) for the socket-outlets, and these are not required in others.

Several relevant standards are in the process of being finalised:

- EN 61851-1 defines Mode 3 charge requirements;
- EN 60364-7-722 (under preparation) specifies general provisions for the installation and electrical safety for fixed installations of charging stations;
- EN 62196-1 and EN 62196-2 (under revision, at FDIS stage) define the plugs, socket-outlets (infrastructure), connectors and inlets (vehicle) to be used in mode 3. These standards allow for the use of the same socket-outlet format for all applications from 1 phase to 3 phases, and from 16 A to 63 A with auxiliary contacts;
- EN 60309-2 defines the plugs, socket-outlets (infrastructure), connectors and vehicle inlets which can be used in mode 3, assuming that interlock features ensure that the socket-outlet tubes are not live when accessible and provided a safe communication system is standardized. The present standard provides interoperability between plugs and socket-outlets of the same rated current and voltage and requirements for one auxiliary (pilot) pin contact for plugs & socket rated for currents 63 A and higher.

Experts could not clearly identify major safety differences between the types of connector, as all provide adequate safety level as long as the basic safety rules according to IEC 61851-1 are applied. Cost considerations were not taken into account to compare the merits of the different plug and socket-outlet solutions and different types. The Focus Group extensively discussed adaptations conforming to national regulations, but could not agree to the way forward in the absence of the detailed study discussed in section 7.6 above (Recommendation 7.14 refers).

The following propositions are all potential solutions to reach interoperability:

- use of an additional charging cord-set in border districts (considering both socket-outlets feature a similar pin out, which means that with an adapted cord-set it will always be possible to charge in mode 3 on any charge spots either with a type 2 or a type 3c socket-outlet);
- an exchangeable head plug on the cord-set, so that users can simply switch on a same base different plug heads when crossing a border;
- in public charging spots, including an additional attached cord-set, secured to the spot (through a fixed ring or similar) to be plugged on the spot socket-outlet and connected to the car, for cross-border users (the secured attached cord-set to the spot could also be used by the drivers who forgot their own charging cord-set). This has been supported by some experts, whereas some other stakeholders have rejected this proposal, since a fixed cord-set on public charging station is strongly subjected to vandalism, thus reducing the availability and compromising interoperability;
- to use the type 2 socket-outlets as specified in IEC 62196-2 in combination with appropriate means to comply with existing and applicable (national) regulations. This might be achieved by adding external supplementary elements to existing charging station designs;
- for captive fleet vehicles in a mode 3 context, EN 60309-2 may be used, but this is not recommended as a candidate for a unique mode 3 charging system.
- appropriate requirements and test for the robustness of accessories need to be investigated to achieve a high availability especially for outdoor applications. These requirements should be added to IEC 62196 standards by CENELEC SC 23BX and/or IEC SC 23H based on the experiences of field operational tests.

8.3.2 Proposed actions

- A number of different actions are possible to improve short-term interoperability and meet different safety or other requirements at the same time: Since IEC 62196-2 will most likely be a “catalogue standard”, and also because EN 61851-1 does not specify only one type of accessory to be used for mode 3 charging it will be necessary to specify this on a European level by an appropriate standardization group;
- no consensus was found to select one socket-outlet against the other, between type 2 and Type 3-c for Europe. It was unanimously decided by the Focus Group that the configuration of the unique plug and socket-outlet for this purpose should be directly addressed by this standardization group;
- the need for a dedicated plug and socket-outlet for light electric vehicles should be studied (type 3-a is proposed by the Italian delegation);
- as indicated in recommendation 7.14, the Focus Group recommends that an urgent study be realised concerning the impact of national regulatory requirements in Europe on these socket-outlets, bearing in mind the need and call from industry for a quick harmonised EU-wide solution”;

- as a unique socket-outlet selection is not so far possible, because of the above reasons, several potential propositions are made for solutions to reach interoperability through appropriate use and design of cord-sets;
- as regards timescales, publication of IEC 62196-1 & 2 (Type 1, 2, 3) as European Standards should be undertaken by Q1/2012. The relevant TCs should analyse the interoperability solutions proposed above. In the start up phase of EU electro-mobility set up, the CEN-CENELEC WGs should follow if modifications or additions are needed to relevant European Standards are needed.

Recommendation 8.3: The Focus Group recommends to define one unique footprint with five power contacts covering applications from 1 phase to 3 phases & neutral (from 16 to 63 A minimum) with protective earth and additional 2 auxiliary contacts for control system according to mode 3 of a future EN 61851-1. Type 2 or Type 3-c of the future EN 62196-2 will correspond to this definition. However, small compact connector designs for vehicles of category L1 to L5 should also be considered.

8.4 Candidates for AC coupling to the vehicle: vehicle inlet and connector

Current drafts of the IEC 62196 series describe three basic types of vehicle inlet and connectors and two variants of two of these accessories:

- type 1
- type 2: three phase up to 63 A
 - short version (for modes 2 and mode 3 only);
 - long version (inlet enables modes 1 – 3; long connector just for mode 1 cord-sets)
- types 3-a and c
 - type 3-a: single phase up to 16 A
 - type 3-c: three phase up to 63 A

Note the two versions of coupler type 2 allow differentiation between mode 1 on the one hand and mode 2 + mode 3 on the other. Mode 1 cord-sets would use the long vehicle connector. Vehicles not prepared for mode 1 charging will use the short vehicle inlet, which prevents contact with mode 1 cord-sets. The mating faces of both types are identical.

The automobile industry is presently considering mounting both type 1 and type 2 couplers. for passenger cars and light trucks (vehicle categories Mx and Nx). The Focus Group has not taken a position on this question.

8.5 Connection to an off-board DC charger

It has been generally accepted by industry that mode 4 DC charging stations for passenger vehicles will have an attached cord-set.

Therefore, there is no need for DC plugs and socket-outlets (at the wall side) in Europe.

8.6 Candidates for DC coupling to the vehicle: “vehicle inlet and connector”

For the vehicle inlet and connector, different candidates – both with combined AC/DC connectors and pure DC connectors – are described in the working documents of IEC SC 23H (PT 62196-3). This standardization project is at an early stage (prior to Committee Draft).

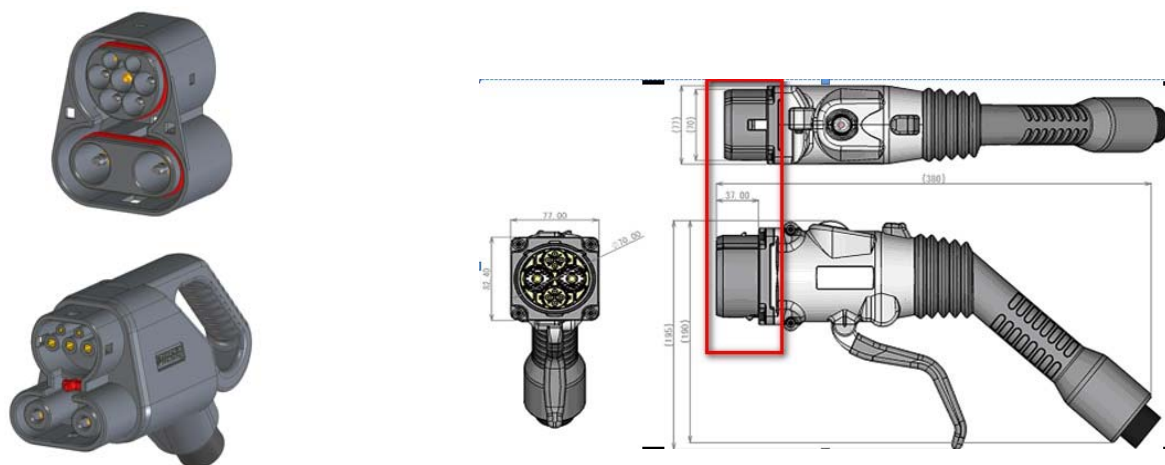
The following solutions are under consideration in this project for enabling mode 4 charging:

- DC configuration based on a type 2 connector (480 V / 70 A maximum);
- DC configuration based on a type 1 connector (600 V / 80 A maximum);
- extension of Type 2 to a combined DC and three-phase AC “Combo Coupler” (850 V / 200 A);
- extension of Type 1 to a combined DC and single-phase AC “Combo Coupler” (600 V / 200 A).

Some other solutions are presently commercialised or tested and proposed for standardization:

- A pure DC connector promoted by the “CHAdeMO” association (500 V/125 A) . This product is presently commercialised in Europe on DC charge stations. It has been indicated that a 200 A rated version can be envisaged;
- A pure DC connector proposed by China (750 V / 250 A).

DC charging stations based on the CHAdeMO system are available in different regions.



The type 2 photograph is copyright © Phoenix

Figure 3 – Type 2 “combo-coupler” (left) and CHAdeMO connector (right)

The “combo connector” shown in Figure 3 (left side) is one example of the type of device studied. Other solutions that combine the AC and DC supply on a single inlet but allow separate AC and DC mobile connectors are also being studied. The 9 pin DC connector shown is one example of a commercially available device. It is only the connecting face plane (rectangle in red) that is to be standardized.

For the short-term, the CHAdeMO DC charging system is the only solution available on the market. Some European and American OEMs planning to introduce an EV in near future strongly request to use a new inlet combining the supply of AC and DC power.

Recommendation 8.4: For the short term, the DC configurations of type 2 or type 1 connectors and the integration of CHAdeMO, as well as the requirements for charging stations and vehicles should be finalised for standardization in Europe by the relevant TCs

Recommendation 8.5: Europe should endeavour to define a combined solution for a unique vehicle inlet (“combo”). The solution should be harmonised with the US market. For this purpose a speed up of the related standardization activities is demanded

If there is a significant delay in international standardization projects caused by non-European contributions, a transfer and accelerated finalisation at European level could be envisaged.

Recommendation 8.6: Since CHAdeMO-compliant vehicles are on the market in Europe a satisfactory solution for these vehicles should be sought urgently

Recommendation 8.7: Since future parts of IEC 62196 will most likely be “catalogue standards”, and also IEC 61851-1 will not specify the type of accessories to be used for mode 4 charging, it will be necessary to specify which accessories are required on a European level by an appropriate standardization group

8.7 Assessment of the legal situation

A major challenge for the specification of a pan-European charging system is the existence of different national regulatory requirements.

In order to get an overview of the legal situation in Europe two questionnaires were issued during 2010. The following answers have been obtained:

- The questionnaire issued by SC 23H to ask for national preferences and/or requirements regarding the use of shutters for mode 3 charging stations (document SC23H/(238B)/INF – available via the CEN and CENELEC websites) showed that, under specific conditions, some member states require shutters for socket-outlets used for charging; whereas others indicated there were no such requirements (see section 7.6 and recommendation 7.14);
- A study on the applicability of LVD for the application of EV charging, which was accompanied by a questionnaire set to all CENELEC members, in order to ascertain if there are national regulations that specifically regulate EV charging installations. No such specific regulations were identified.

In addition, the applicability of the LVD to the charging devices socket-outlets of a mode 3 charging device has been considered. Here it is unclear if a mode 3 (as well as a mode 4) charging device falls under the scope of the LVD as shown in Figure 4 if its components are installed as separate devices. Some experts are convinced the LVD is applicable to charging devices in any case. And then AC energy supply device with non-shuttered socket-outlets cannot be forbidden by national regulation. This viewpoint is backed up by a legal opinion from law firm Noerr LLP (available via the CEN and CENELEC websites). Some experts are convinced the use of accessories covered by LVD must also fulfil national regulation when used.

Some experts of the Focus Group have expressed the opinion that the vehicle inlet should also be considered as falling under the LVD Directive due to the fact that the connector is under its scope, and that needs to be connected to a dedicated inlet manufactured according to the same connector standard (IEC 62196-2).

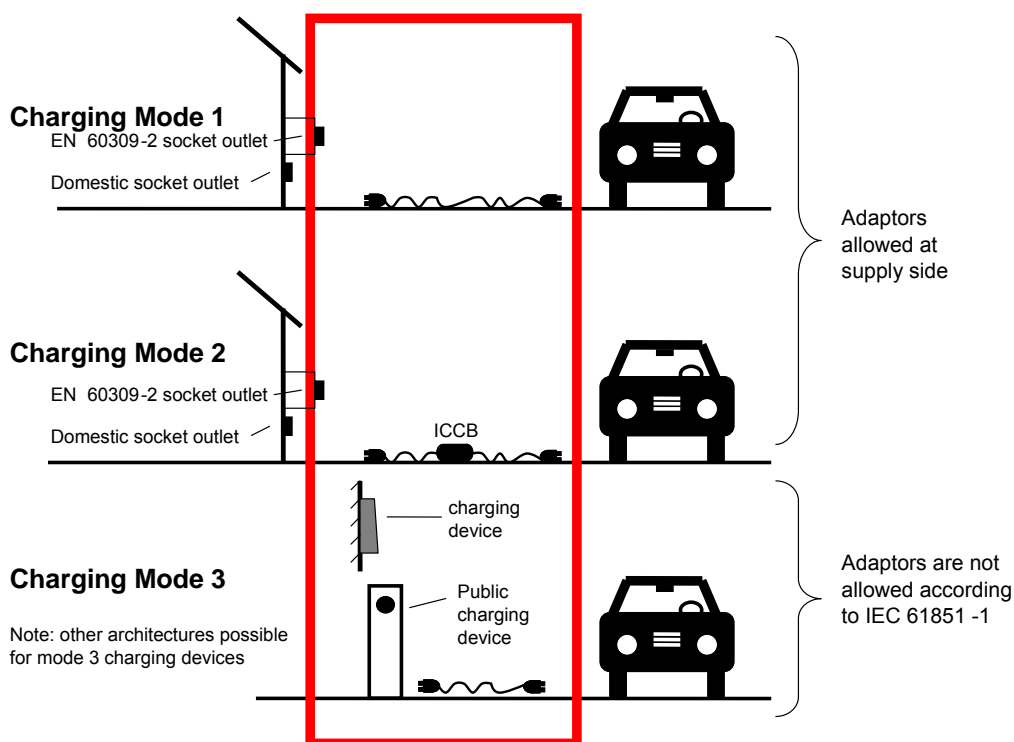


Figure 4 – Scope of LVD with respect to charging modes 1 to 3 for EVs

NOTE The above drawing excludes the vehicle coupler from the LVD, the inclusion of the mobile connector in the LVD does however imply that there will be an interaction of the vehicle inlet with the LVD. Vehicles with attached cord-sets are completely covered by the UN-ECE Regulations.

9 Smart charging

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 sources for generating electricity 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 needed to streamline demand and make the best use of the available electricity. This bi-directional communication enables controlled charging procedures: the vehicle will be charged “off peak” using available grid capacity. Smart charging therefore not only enables optimal use of RES capacity, but also is indispensable to avoid additional demand for electricity, which in turn requires 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.

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 in order to allow intelligent charging algorithms to take into consideration generation and grid constraints and to allow the consumer to benefit from price opportunities. Smart charging should respect the customer's needs and charging requirements regarding vehicle availability as long as there are no critical limitations by the grid or the energy supply.

Coordinating and managing the loads will:

- facilitate the integration of renewable energy sources into the electricity system, especially with regard to decentralised generation connected to the distribution grid;
- enable grid management that introduces flexibility into the system;
- ensure a cost-effective solution;
- optimise an efficient charging process taking into account generation capacity;
- maximise consumer convenience through user-friendliness.

Recommendation 9.1: For the optimisation of electro-mobility and energy use, it is deemed to be indispensable to move toward charging electric vehicles in a smart way. Standardization issues should be addressed by the CEN-CENELEC-ETSI Smart Grid Coordination Group, in liaison with the CEN-CENELEC Electro-Mobility Coordination Group

10 Communication

10.1 Introduction

This Chapter focuses on technologies and standards regarding data communication between the electric vehicle and the charging infrastructure.

Data communication inside the electric vehicle is out of its scope.

Other identified data channels existing today or known to be planned will be included in a catalogue and their pertinence evaluated. Recommendations on these data channels will be made only if considered pertinent to the particular case of electro-mobility.

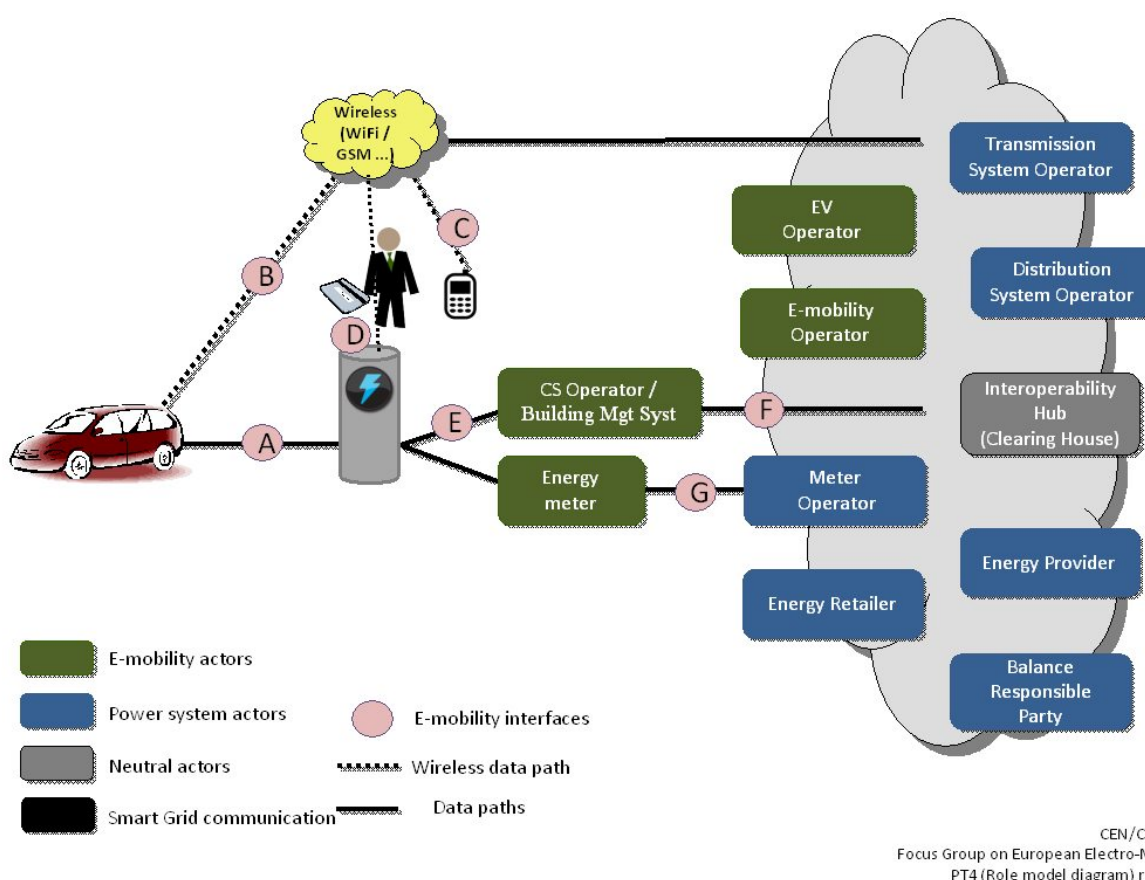


Figure 5 – Overview of functions in electro-mobility data communication

An important part of the work regarding data communication has been to define what technologies and standardisation activities are within scope of the M/468.

The above generic role model diagram with actor definitions has been developed to highlight the related standards and communication interfaces to smart grids, smart meter and ITS, all covered by other mandates.

The main focus has been the interface marked 'A' in the diagram and to identify issues related to interoperability.

10.2 General considerations

Communication between the EV and the charging infrastructure concerns all the available channels that can be used to this effect.

Control signals that transit on the charging cables concern principally the signalling for mode 3 and mode 4 charging contained in the IEC 61851-xx standards. This includes the pulse width modulation (PWM) information that defines the maximum available current. Many initial systems will use these forms of communication, and for interoperability reasons vehicles should as a minimum conform to this level of communication.

High-level communication digital signals that transit through the charging cables and are capable of providing digital data that may be used for a large number of different applications (mobility service, vehicle information, charging state, contract, etc. - indicated by line A on diagram). This is the principal scope of the IEC/ISO 15118 series of standards.

High-level communication data channels may use alternative paths such as radio frequency transmission (indicated by line B on diagram). This has not been explicitly treated by the Focus Group, but recommendations has been made for cooperation between intelligent transport and electro-mobility standardization on this matter.

Data supplied by the EV user directly to the charge spot (indicated by line D on the diagram) can use any of the possible data channels, e.g. direct keyboard input, specific data cards (RFID chips, NFC, credit card) or any other means. Further data may be generated within the charge spot. These data may be further transmitted to the grid by any one of the available data channels including wire or wireless transmission. Such systems will normally be used for payment of specific services (including energy, parking, etc.). The physical means used have not been discussed in the Focus Group.

The communication between the charge spot and the rest of the grid is considered to be treated by the corresponding inter-ESO collaboration group on smart grid, and has not been explicitly dealt with in this Focus Group. Load control, as obtained from the smart grid can use any of the available data channels to reach the EV. This clearly shows that there must be a homogeneous data structure to achieve interoperability in Europe.

10.3 AC charging communication

10.3.1 Basic communication control signals

Annex A of IEC 61851-1 [Pilot function through a control pilot circuit using PWM modulation and a control pilot wire] proposes a simple PWM (pulse width modulated) signal system for mode 3-type charging that allows the charge spot to signal the available electric power to the vehicle, thus enabling simple load control by an external energy controller.

NOTE Other systems are also allowed by the standards but have not been adopted by the majority of OEMs (e.g. Annex C of IEC 61851-1 which combines high and low level communication without the use of a pilot wire)

10.3.2 High level communication

High level communication using IP would be required for more sophisticated services including: exchange of contract-ID, charging schedules, price signals and added value services.

A Joint Working Group between ISO/TC 22/SC 3 and IEC/TC 69, Vehicle-to-Grid communication interface (V2G CI), is presently preparing a new standard ISO/IEC 15118 for EV-to-charge spot communication destined to establish common data structures that should be used for EV needs using high level communication. The standard will also propose the physical layer for communication using the charging cable.

Europe is well represented on this JWG. It can be supposed that the specific problems posed in Europe will be treated in the international standard. Parallel work is being carried out by the SAE which is developing the J.2836 series of standards for the American market. The joint ISO/IEC Working Group is in contact with SAE and the SAE technical leaders intervene on the JWG.

10.4 DC charging communication

DC charging is proposed to enable high power (50 kW and more) charging when necessary. The major parts of the required charging components will be off-board the vehicle at a charging station. Energy is transferred to the vehicle as DC voltage and current and directly fed into the battery. During this process, the vehicle will control voltage and current output from the off-board charger. To ensure a sufficient level of safety at these high power levels, the vehicle controller and the off-board charger controller must exchange charging control parameters with low latency (within milliseconds) and high reliability.

IEC TC 69 has two work items listed for DC charging. Both address the technical aspects of charging, such as transfer of vehicle status and charge requests. The development of IEC 61851-23 intends to specify the general requirements of the DC off-board charger

In the standard ISO/IEC 15118 it is planned to specify the general communication services for charging including additional information regarding identification and authentication. The exact relation between the definitions in ISO/IEC 15118 and IEC 61851-24 concerning the control messages is still to be established, since the scope of IEC 61851-24 does include the control messages. The initial draft of this contains a description based on the CAN protocol. Both CAN and high frequency modulated communication (derived from PLC systems) are to be considered in this standard as possible physical layers. CAN requires two signal wires whereas PLC technology may use existing wires. The CAN protocol is already widely used within the automotive industry and has been proven extremely reliable. PLC is still to be validated for this application.

The scope of IEC 61851-24 includes the relevant messages that control the charge current to the car from an external DC charger. In the standard ISO/IEC 15118, it is planned to specify the general communication services for charging including additional information regarding identification and authentication. The exact relation between the definitions in IEC/ISO 15118 and IEC 61851-24 concerning the control messages is still to be established.

10.5 Combined communication channel for AC and DC charging

The drafts for both IEC 61851-23 and IEC 61851-24 also include a transatlantic (EU and US) contribution on PLC in line with ISO/IEC 15118. The advantage of this proposal is the possible usage of one PLC System either for AC or DC. The reliability and the requested data rate of PLC in a high power DC charging environment is however still to be proven. Since separate signal paths (signal pins and power lines) are used, both PLC-derived and CAN may coexist both in vehicle and charging equipment if necessary.

10.6 Interoperability and roaming

“Roaming” is defined as the ability for a client who already has a service contract to obtain the same service at any location, without the requirement to have a specific contract with the operator of that local service. It is of particular interest for telephony and similar technologies, where roaming is obtained by simple bilateral or multilateral relations between service providers.

The concept is also being proposed for the charging of electric vehicles, which should be able to charge in any city.

The roaming for electro-mobility is based on business-to-business agreements and roaming could be defined from both the charging spot operator’s and the electro-mobility operator’s points of view:

- from the electro-mobility operator’s point of view, subscribers can be given the freedom to connect to charging spots and get charging services using subscribers’ credentials;
- from a charging spot operator’s point of view, the subscribers with the appropriate credentials can connect to his charging network, and benefit from using the charging he provides.

An interoperability hub (“clearing house”) could be the neutral entity mediating between two partners, to provide validation services for exchange of technical information, contract relations or security certificates.

10.7 Interface to the power system (smart metering and smart grid)

The fact that vehicles are parked most of the time offers the possibility to concentrate charging of electric vehicles on those periods when the power grid has the greatest free capacity. Additionally, in the future electric vehicles and charge spots may be designed to provide energy for the home or even provide energy back to the grid, with the objective of improving reliability and decreasing the variability of the load.

Standardization requirements on the communication between the electric vehicle and the smart grid will need to be coordinated with the ESOs’ Smart Grid Coordination Group. Initially, this would be based on CENELEC TC 13 standardization activities for energy metering (mandate M/441), and IEC TC 57 for distributed energy resources (DER) with demand response, in accordance with CENELEC TC 205 in charge of Home and Building Electronic Systems.

In the power system there can be a fine separation between the data communication for the legal metering responsible parties and then the parties that will manage the charging. This separation will allow for open marked concepts and cross-border interoperability, which is essential in a future smart grid infrastructure.

10.8 Identification and billing (and payment)

Identification could be necessary for several services:

- to release a cover which protects a socket-outlet (ID will be necessary prior to the charge);

- to deliver an appropriate charging service (charge priority could change depending of the ID);
- to deliver some value added services.

Where services have to be paid for by the electric vehicle subscriber there is a need for identification of the EV subscriber to the supply equipment operator. As alternatives the charging energy could be included in the parking fee, the charging could be free, or it could be carried out from a private home outlet.

The EV subscriber will have to provide the supply equipment operator with a contract-ID, which is a unique number known by the operator or as part of a pre-payment registration.

Payment methods are very system-dependent and different business models will be implemented, but in relation to interoperability it will be advisable to have a global standardization covering at least the identification numbering for the contract-ID/subscriber-ID and maybe the EV and the electricity meter/energy provider.

Identification needs cannot be neglected, although several identification issues such as identification of a contract in case of payment are today being addressed, but identification of an EV service user could be of primary benefit for grid management, such as charge priority, or simply to get the authorisation to access to the charge spot or to release the socket-outlet.

Today's work on identification has to be further considered and addressed by the standards organisations without re-inventing the wheel.

10.9 Perceived gaps in the existing standards

10.9.1 Wireless communication directly between EV and operator

Future vehicles – electrical or otherwise – will be connected with external services through mobile communication for various purposes (e.g. communication for co-operative systems, Mandate M/453). The standards related to communication of whatever kind could be equally applicable for vehicle charging and related needs (e.g. billing). Coherence with current standards for charging should be ensured.

10.9.2 Identification and standards in relation to roaming

Requirements for identification methods in relation to interoperable EV charging will have to be identified. Current standards within telecommunication, security or ITS may be used for electro-mobility.

10.10 Recommendations

The communications arena is complex and involves multiple standards committees in several bodies, including the involvement of ETSI as the third ESO. The communications part is also less mature than other EV standardization issues and requires more definitional work. We therefore recommend in the next phase that the CEN-CENELEC-ETSI JWG on smart grids, assuming its proposed continuation as a co-ordination platform is agreed, assume the responsibility for co-ordination concerning EV communication issues, with the JWG creating short-term WGs as required to define specific work required, as proposed below:

Recommendation 10.1: It is recommended that end-to-end scenarios are considered between the involved ESOs in order to have a harmonised and interoperable link between the different communication standards for electro-mobility, security, safety and ITS. Co-operation on data communication and data security - between EV, smart grid and ITS, is needed

Recommendation 10.2: Electro-mobility-to-infrastructure for data communication and data security should be defined by: CEN and ETSI ITS committees (co-operative systems), ETSI M2M , ETSI SCP (Smart card Platform), ISO (road vehicles) and IEC TC 57 for DER communication

Recommendation 10.3: Electro-mobility control signal and control pilot signal related communication should be defined by CLC TC 69X, CEN TC 301, IEC SC 65A and CLC TC 64 and ISO TC 22/SC3

Recommendation 10.4: It is recommended that user groups be established between the different ESOs and the market stakeholders, in order to specify conformance tests and implementation guidelines between the different domain areas

Recommendation 10.5: Standardization is required for the diagnosis protocol, human-machine interface and energy management system for the complete charging system. This new work has to be done in close relation to user groups and electro-mobility system integration (technical reports or white papers from user groups can be very useful for the ESOs)

Recommendation 10.6: It is recommended that a standards work be established concerning an “interoperability hub”, which can be a generic and neutral concept for mediating between two partners to provide validation services for exchange of technical information, contract relations or security certificates. A joint working group including service providers should be formed within the ESOs to define a cross-border European concept for this hub

Recommendation 10.7: The work done in the European Commission Smart Grids Task Force should be expanded to create a security architecture also taking into account issues in relation to the interoperability hub and security issues for communication between charging system and Electric Vehicles

NOTE See also the report of the CEN-CENELEC-ETSI JWG on standards for smart grids, version 1.11 section 5.1.2.1.4 and recommendation Ref. 4.

11 Batteries: Battery switching station and supply chain for electric vehicles

This Chapter has the following objectives:

- to propose, if needed, additional standards or regulations for the efficient and safe usage of fixed and removable battery systems for EVs during their life cycle;
- to describe the needs for standardization of battery systems in order to create an efficient supply chain;
- to describe the criteria for battery switching stations (as one of the solutions for extended range) to comply with the needs of vehicles and infrastructure.

The members of the Focus Group Project Team for batteries have provided a detailed descriptive text, which will be placed on the CEN and CENELEC websites for information.

11.1 Applications of batteries for EVs and grid use

The battery, fixed or removable, is an essential element of the total cost and viability of electric vehicle technology.

However, other uses for batteries may also be envisaged, including their use to temporarily balance the grid (Vehicle-to-Grid reverse energy applications) or the re-use of these batteries at the end of their "vehicle" life for applications that may be outside the domain of electro-mobility. Switchable batteries may also add further possibilities for the increase of range, and should therefore be an integral part of the standardization work to be considered.

These additional technical aspects would impose supplementary requirements in terms of standards, such as supply chain and infrastructure interfaces, as the batteries will have an existence inside and outside of the vehicles.

In the case of battery switching stations, however, their removal during the life of the vehicle will be complemented by an immediate replacement battery (switching). In this case, the removed battery is connected to the grid and charged (slow or fast). While awaiting its next switch into a vehicle it may be functioning as a storage battery with a direct impact on the grid. The EU mandate for the Focus Group on eMobility does not necessarily cover that stage, but as noted in the previous chapter this may fall to be considered in the CEN-CENELEC-ETSI Smart Grids Co-ordination Group.

11.2 General: EV battery technology

The battery technology (both fixed and removable) for electric vehicles has evolved tremendously over the last decade with the introduction of lithium-based batteries complementing the lead-based, nickel-based and sodium-based technologies. These technologies will all continue to have a significant impact on electro-mobility as they may give cost and/or performance advantages for specific applications, for example as start-stop and hybrid solutions. It is however expected that the lithium technology will deliver the majority of EV mobility applications in the next years as it allows for significant improvements in terms of performance and range for identical battery weights.

Batteries, as generally proposed for automobile applications today, are composed of elementary cells that contain the electrochemical components in a metallic or plastic container. These cells are often, but not necessarily, assembled into modules that make up the building blocks of the complete battery. A typical lithium automobile battery will have more than 100 elementary cells in series, but some vehicles may have even more than 1000 such elementary cells in the complete battery (using a combination of parallel and series assemblies). The modern lithium battery requires extensive electronic control for optimum operation and safety which is ensured by an battery management system (BMS) or battery control unit (BCU). Which may be integrated into the box that contains the assembled cells or modules, or may be external to it. Present technology generally requires measurement and control of the individual cells and much of the measurement system is generally contained within this box. The complete battery system including the BMS is here termed battery. It is to be noted that such a battery may or may not be composed of several sub units that themselves contain individual cells or modules.

Such batteries may be charged by electronic power systems inside or outside of the vehicle which are generally not considered to be part of the battery system but will require control using information from the BMS.

Battery switch stations are also being proposed for recharging batteries. Such battery switch stations (BSS) as proposed by some stake holders are electro-mechanical installations of robotics, electrical and mechanical drives presently used for the switching of batteries for electrical vehicle of the M1 to O categories. They will include battery charging devices and telecommunication ports.

11.3 State of Health (SOH) of electric vehicle fixed and removable batteries

The state of health of an EV battery reflects the general conditions of a battery and its ability to store electric energy and deliver specified performance, compared with a new battery. The SOH of a battery is usually related to charge acceptance, internal resistance, voltage, self-discharge and temperature. It is in general difficult to define and calculate SOH as it is highly dependent on the understanding of a battery's chemistry and environment. For EV and other applications (e.g. energy storage and smart grid), where the battery is required to deliver high performance during its long operational life, it is important to have a commonly adopted state of health requirement and measurement.

Recommendation 11.1: Parameters for state of health should be defined in standards to allow for re-use of batteries

11.4 Standardization of dimensions

Standardization of battery cell dimensions is an ongoing activity at the international IEC and ISO levels in close liaison with the automobile industry (ISO/IEC PAS 16898 under preparation). There should not be any need for specific European Standards on this subject.

Standardization of battery modules should be considered as a long-term objective. Market needs evolve and stabilise. Such standardization could imply considerable simplification for battery repair, and would allow the possibility of easy re-use for second life applications if that concept proves to be possible. However, such standardization will require the definition of requirements from the automobile industry and a more mature market - there is presently no demand from the automobile industry for this. It is noted that this question is already being

addressed for both public transport vehicles and passenger vehicles. For light electric vehicles (L1 to L5) too, exchange of batteries is becoming common practice.

Recommendation 11.2: Standardization of battery module sizes could be undertaken when the automobile industry considers the subject to be mature. This may lead to a need for standardization of interfaces. Standardization could also be undertaken for battery packs for battery exchange stations as well as for batteries for light electric vehicles (L1 to L5)

11.5 Battery information and traceability

The complete set of use cases for re-use, switching or recycling of batteries should be studied. This will require the availability of different data for traceability and efficient re-use. The following list is an indication of data that could be stored on the battery, either as written or electronically recorded data:

- basic data (battery capacity and voltage ratings, manufacturer, production date, etc.)
- battery ID, amount of energy stored in battery in percentage and kWh (percentage should be with respect to battery maximum energy capacity)
- indication of unique battery ID, which also appears on the battery exterior
- temperature monitoring, Indication of the highest and lowest temp measured by the battery
- total km driven with pack (needed to evaluate usage of battery, as well as Indication of total number of kilometres from the day the battery was manufactured irrespective to the car it was assembled on)
- accumulated amount of Ah and kWh for Indication of total number of kWh the battery was charged with during current charging process and during full life
- total kWh discharged from pack as well as Indication of total number of kWh the battery has discharged during current discharge process and during full life
- alerts history (needed for failures investigation)
- battery parameters status when alert was received
- charge and discharge cycle counts
- correlated SOC, time and temp data (e.g. temp and time at max. and min. SOC throughout the service life of the battery to provide data for SOH and aging evaluation. This is required for normal operation and autonomy calculation)
- historic impedance/resistance data or battery history data allowing calculation of impedance/resistance
- a log file with battery maintenance information.

Recommendation 11.3: A set of minimum requirements for battery information should be collected, stored and extracted from the battery by BMS/BCU. Stored battery data should follow a standard format/coding specification to allow access and correct interpretation. Data should be stored according to agreed guidelines by manufacturers respecting fully the private nature of data. Definition of the retrievable data and the handling of such data must be defined in order to protect the rights of the manufacturer and the private individual

11.6 Battery labelling information

The information for the customer is presently based on the Waste Battery Directive 2006/66/EC and on testing methods described in European Standards (see the accompanying detailed report on battery issues). But no "unified language" exists for safety labelling that should for instance support first responders' directions and activities.

Recommendation 11.4: A European Standard should be drafted for battery safety labelling (applying the Dresden Agreement)

11.7 Battery End-of-Life (including second life, collection and recycling)

The secondary life of both fixed and removable electro-mobility batteries at pack level might be: reuse for other electro-mobility applications, grid applications, low-power applications and etc. Specific industrial batteries exist which can fulfil different grid functionalities all at once for the purpose to store energy and to stabilise grids with high penetration of renewable energy. The second life market is in its initial stage and has a great potential to lower the cost of electro-mobility and enhance environmental protection through materials retention and energy efficiency (see EU mandate on smart grid). The basic conditions that have to be fulfilled are minimum requirements for safe handling and use and adequate labelling and traceability to monitor the value chain. However, utilities are already investigating the use of batteries for load management purposes and if this becomes economically feasible they will use this technology with first life batteries and not only with already exhausted resources.

Batteries are highly recyclable and are highly energy efficient during use. Waste management and recycling is regulated in the Battery Directive 2006/66/EC¹³. Automotive batteries inside road vehicles are also regulated under the End-of-Life Vehicle (ELV) directive 2000/53/EC.

Automotive and industrial batteries and accumulators used in vehicles should meet the requirements of Directive 2000/53/EC, in particular Article 4¹⁴.

Under the Battery Directive 2006/66/EC the starting, lighting, and ignition (SLI) batteries are defined as automotive batteries, and hybrid and EV batteries as industrial batteries¹⁵.

¹³ The primary objective of this Directive is to minimise the negative impact of batteries and accumulators and waste batteries and accumulators on the environment, thus contributing to the protection, preservation and improvement of the quality of the environment. It also aims to ensure a proper functioning internal market.

¹⁴ The Directive lays down measures which aim, as a first priority, at the prevention of waste from vehicles and, in addition, at the reuse, recycling and other forms of recovery of end-of life vehicles and their components so as to reduce the disposal of waste, as well as at the improvement in the environmental performance of all of the economic operators involved in the life cycle of vehicles and especially the operators directly involved in the treatment of end-of life vehicles.

Recommendation 11.5: ID should be considered for each part/component that can be removed from the battery pack without destroying it. Integration of second life batteries with grid applications can only be made possible under a clear and EU internal market-compliant policy. Specific performance tests should be developed for re-useable batteries (second life) in their intended applications

11.8 Issues identified with the current Battery Directive 2006/66/EC framework

As for the current Battery Directive 2006/66/EC framework, there exist several issues to be clarified to ensure consistency with other relevant EU legislative acts in relation with vehicle handling and recycling.

Recommendation 11.6: The definition of “recycling rate” in the framework of the Battery Directive 2006/66/EC should be reviewed with the EV application in mind

Under this framework:

- use the revision of the Directive to review the need to define the battery as a "product" – whether it is the efficiency of recycling for packages, for modules or for cells
- clearly specify the level of consideration for calculating recycling rates, methods and concepts
- clarify the provisions in the Directive with relation to waste production (such as for defective batteries not yet put on the market)

11.9 Batteries challenges: energy for range

The limited range of current pure electric vehicles is an obstacle when it comes to consumer adoption. The current estimated range of battery powered EVs is around 200 km. Although this range enables drivers to use the vehicle daily in standard urban conditions, it does not provide the ability to drive long distances, hence the need for range extension. This range can be achieved by the use of charge networks covering homes, offices, large parking and shopping areas and industrial areas, in which a car will be connected to charging via cable, or through inductive charging.

Having a European-wide extended range system will change and accelerate the adoption rate of electric vehicles, making this a mass market and affordable product without the need to delay for new battery technology (further range capacity), and without compromising on the principle that a car should be fully electric. Allowing different EVs to use the same extended range systems such as BSS or fast charge will lower the cost for the introduction of these new technologies.

Further development and demonstration activities such as planned by the European project "Green e-Motion" (2011-2015) will deliver further strategic guidance.

¹⁵ <http://ec.europa.eu/environment/waste/batteries/index.htm> The website of DG Environment contains a Q&A explaining the relations between the ELV and Battery Directives.

11.9.1 Fast charge

Extremely high charging rates are proposed (see Chapter 7) which will influence battery design and testing. A new work item on charging battery systems is under development by ISO TC 22/SC 21.

Recommendation 11.7: The inclusion of fast charge profiles should be considered in the new work item on charging battery systems under development by ISO TC 22/SC 21 (ISO 12405-2).

11.9.2 Battery switching stations (BSS)

A battery switching station (BSS) is an electro-mechanical installation of robotics, electrical and mechanical drives used for the switching of batteries for electrical vehicle of M1 to O, as defined in UN-ECE Regulation 100, and that may include battery charging devices and telecommunication ports. This technology exists today (see China BSS) and has been used in niche segments for many years, enabling the replacement of a depleted battery with a fully charged one in fewer than five minutes. The fully automated process removes the battery from the vehicle and moves it to a battery rack, so the battery can be charged in optimal conditions. A fully charged battery is taken from the battery rack and inserted into the vehicle, providing the driver with full driving range within minutes. Such stations could be located along all key highways or major roads, thus enabling electrical vehicles to drive in extended ranges.

Recommendation 11.8: Create a battery switch station standard with safety, energy needs, exchangeability, accessibility, data and communication framework. Also, battery switching station storage of batteries of different vehicle models should be included (including dimensions and mechanical /electrical /communication interfaces for integration, as well as environmental requirements)

11.10 Removable battery interfaces with the vehicle and with the range infrastructure (charging and switching)

For removable batteries, further implications need to be explored, mainly the supply chain and interfaces with applications that connect with the battery outside the vehicle. Electric vehicle batteries are currently significantly heavy, which requires specific ways to handle them in a secure way that resembles the way it is held within the vehicle.

The integration between the vehicle and the battery has various aspects which are very important for vehicles with switchable batteries in order to allow the switch in different locations for different vehicle models the same way we currently fuel ICE vehicles, as standard fuelling stations containing standard pumps and nozzles. In order to define standard interfaces for future EVs, we will have to pinpoint the ones which might create an optimal solution although for long term.

The switching of batteries is a possible way of rapidly extending the range of vehicles without the need of very high power local electrical installations. These batteries could, eventually, also be integrated into the grid as energy storage elements while positioned in the battery exchange stations. Such a use would require dimensional and electrical definitions that would limit the number and types of switch stations that would have to be built. Battery switching would probably initially be limited to a small number of vehicle models but could become more generalised in the future, indeed even as a fully-automatic process with no human intervention.

Mechanical dimensions could be defined in such a way that different sizes could be accommodated in one battery switch station.

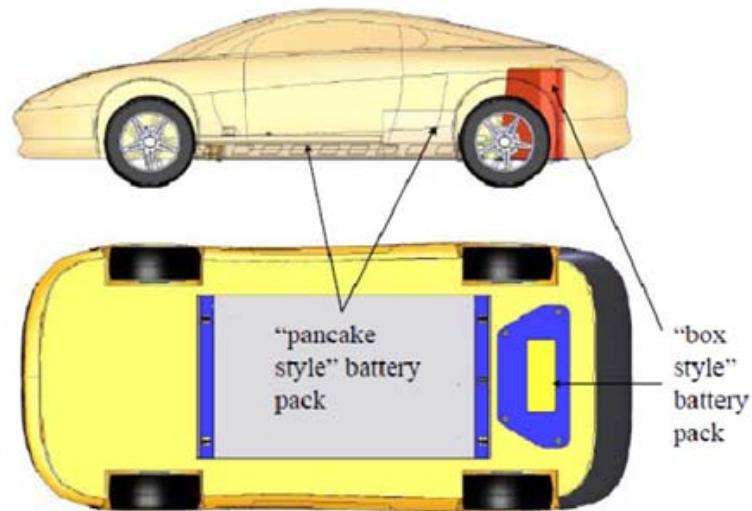


Figure 6 – Example of positioning of battery pack in the vehicle for battery exchange

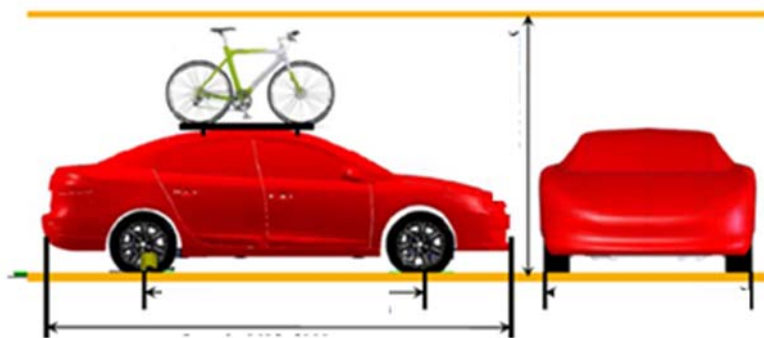


Figure 7 – Vehicle geometry limits for compatibility with battery switching station

Recommendation 11.9: Create a unique standard that clearly defines the interfaces of removable batteries, to allow for battery switching on electric vehicles that have been designed for this application. Such interfaces should define the mechanical fixation points, the electric power connectors, the data connectors, the cooling fluids and their interfaces and the data formats that could be used during the charging of the batteries

11.11 Emergency services (first responders)

Since a battery-based full EV is a new technology, efforts should be in place to ensure that emergency services are able to respond appropriately with respect to battery hazards in the following cases caused by the use of EVs: mechanical impact to batteries, batteries exposure to water or fire in its surroundings.

Recommendation 11.10: Appropriate measures should be taken to improve emergency services awareness with respect to eventual battery hazards caused by the use of EVs (mechanical impact to batteries, batteries' exposure to water or fire)

12 Electromagnetic compatibility of electric vehicles and charging stations

12.1 Introduction

All electronic devices emit some electromagnetic interference either in the form of radiated electromagnetic waves or as conducted interference on the interconnecting cables. If such interference is significant it may influence other devices. EMC is the ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment.

This Chapter gives a general overview of the current regulatory framework – including of course the related standards issues - on the electric vehicles and on charging stations from the electromagnetic compatibility (EMC) point of view. After summarising the current status of this framework, some proposals are presented in order to improve this framework.

12.2 Overview

At present, Directive 72/245/EEC (and its amendments, in particular 2004/104/EC from the EMC point of view) establishes the requirements for the whole vehicle and for the electrical and electronic sub-assemblies (ESA):

- Vehicle test: radiated emission, radiated immunity
- Electronic sub-assemblies (ESA) test: radiated emission, conducted emission, radiated immunity, conducted immunity

However, this Directive does not as yet cover the EMC aspects related to connections to the power grid.

Recommendation 13.3 below concerns possible updating requirements to Directive 72/245/EEC concerning EMC issues.

UN-ECE Regulation 10 is equivalent to this Directive, and includes almost identical requirements. Regulation R10 is currently under revision, as it cannot be ensured that it will cover all the EMC aspects for the EV.

Directive 72/245/EEC covers vehicle types M, N and O, while those of L type are covered by Directive 97/24/EEC.

UN-ECE Regulation 10 covers vehicle categories L (two or three wheel motor vehicles), M (passenger vehicles), N (goods vehicles) and O (trailers).

It must be noted that, according to Regulation (EC) No 661/2009 of the European Parliament and of the Council (13 July 2009), Directive 72/245/EEC will be repealed on 1 November 2014.

In future, EC automotive type approval for EMC purposes will thus be obtained only through application of the revised UN-ECE Regulation 10, which will include all relevant EMC aspects for EV's related to connections to the power grid.

Recommendation 12.1: Ensure that the electrical industry is represented in UN-ECE WP 29 where the EMC aspects are concerned. In particular, the frequency range 2 kHz to 150 kHz should be considered carefully for conductive emission during charging.

It is also to be noted that Directive 2004/108/EC is the EMC Directive for electric and electronic equipment.

Just for information, if it is researched what other standardization bodies have been doing on electric vehicle in some countries, it can be found, as an example, that the Society of Automotive Engineers developed SAE J.551-5 for EMC related to electric vehicles.

12.3 Electric vehicle regulatory details

Current measurement techniques and procedures have been based on and developed for internal combustion engines, and the engine state is probably one of the most important aspects of the test method. However, electric vehicle drive systems are very different from conventional automotive electrical systems components.

On electric vehicles, power electronic systems are likely to be the main source of electromagnetic interference within electric drive systems. On hybrid vehicles, combustion and electrical engines produce different type of interferences that must be measured separately or with a combined procedure.

Directive 72/245/EEC and UN-ECE Regulation 10 do not include specific provisions for vehicles with an electrical power train, but refer to standards from IEC/CISPR (Comité International Spécial des Perturbations Radioélectriques) and ISO when describing the test methods. Some of those standards have been amended to take into account electric vehicles.

Due to the different timing of the evolution of both Directive and Regulation, they refer to different standards (the Directive refers to CISPR 12:2001 and the Regulation refers to CISPR 12:2001+A1:2005). At present, the most up-to-date version of CISPR 12 is the sixth edition (CISPR 12:2007+A1:2009). Amendment A1:2005 introduces a specific requirement for hybrid vehicles to operate both drive systems (electric and internal combustion engine) when it is possible.

Electric vehicles can generate high electric and magnetic fields (e.g. during acceleration and deceleration, regenerating brake systems, charging the batteries...) and transients (high voltages and currents...), but ISO 7637-X standard was not developed with EV operation in mind.

Regarding the SAE J.551-5 standard, it was initially published in 1995 and its latest revision was issued in 2004, including:

- radiated measurements of electric and magnetic fields from 9 kHz up to 30 MHz;
- conducted measurements of the electric vehicle while charging (only if the charger is on the vehicle, the switching frequency of the charger is above 9 kHz and if the power is transferred by conduction).

12.4 Conductive charging systems regulatory and standards details

12.4.1 Harmonised standards

The list of harmonised standards for the Low Voltage Directive 2006/95/EC includes following standards related with electric vehicle conductive charging system and charging stations:

- EN 61851-1:2001; Electric vehicle conductive charging system – Part 1: General requirements
- EN 61851-21:2002; Electric vehicle conductive charging system – Part 21: Electric vehicle requirements for conductive connection to an AC/DC supply
- EN 61851-22:2002; Electric vehicle conductive charging system – Part 22: AC electric vehicle charging station

These harmonised standards give requirements for the conductive connection of an electric vehicle charging system to AC (< 690 V) and DC (< 1 000 V) supply. In future editions of these standards, it is supposed that voltage range will be extended up to 1 000 V AC and 1 500 V DC. Currently, no specific product standard is harmonised under the EMC Directive 2004/108/EC to cover battery charger requirements.

EN 61851-21 and EN 61851-22 include EMC requirements; but as these standards were published in 2002 by CENELEC, they consider the usual EMC requirements sought at that time. However electric vehicles evolution and the worldwide intensive use of communications technologies (wireless -2G/3G/WiFi/Zigbee,...etc. - and conducted (PLC, CAN)) demand an update of the EMC requirements to take into account the current state of the art on the electric vehicle and power distribution grid.

12.4.2 Standards in IEC 61851/EN 61851 series

IEC 61851-1 Ed. 2.0 was published on 2010-11-25, and now includes a brief reference to EMC matters, referring to IEC 61000-6-3 and IEC 61000-6-1 (generic emission and immunity standard for residential, commercial and light-industrial environments). It has been ratified as EN 61851-1 on 2011-04-12.

IEC Technical Committee 69 (Electric road vehicles and electric industrial trucks) is currently working on Edition 2.0 of IEC 61851-21 and IEC 61851-22. The texts presently under discussion contain significant references to EMC.

12.5 Proposed actions for EV and charging stations

From the regulatory point of view, EMC matters are covered by Directive 72/245/EEC and UN-ECE Regulation 10 and those Regulations refer to CISPR and ISO standards (currently IEC standards are under consideration).

Recommendation 12.2: The regulatory framework and unifying testing methods to the latest standards (CISPR, IEC and ISO) should be simplified

12.5.1 EMC relative to the vehicle

The following tasks should be defined:

- the current test procedure for radiated emissions considers the reference point for the measurement distance with respect to the internal combustion engine. It is not clear what to do when the electric motors are located in a central position or near each wheel. Engine idle state has no sense in electric motors and motion as well as load conditions have to be defined.
- the antenna position when performing emission tests is aligned with the centre of the engine, presumably because the engine is likely to provide the main source of disturbance, but for electric vehicles the electric motor may not be the main source of emission, e.g. compared with the power switching systems and the power cabling distributed along the vehicle;
- current EMC tests assume vehicles to have 12 V or 24 V batteries, but actual voltages used in electric vehicles are much higher, so test methods shall be adapted. In addition, either AC or DC electric motors may be used, and this will need to be considered while testing.

Special consideration requires immunity test according to ISO standards as AC and DC with voltages above 30 V AC / > 60 V DC severity levels have not been addressed (this is under consideration in ISO).

AC and DC voltages may require the definition of a different artificial network when testing components of the Electric Vehicle (this is under consideration in UN-ECE).

At present, there is no specific test procedure for assessing vehicle in the charging mode.

UN-ECE Regulation 10 should include requirements for EMC of the charger while the vehicle is being charged.

At present, when the vehicle is connected to the grid, the Focus Group recommends that the provisions on type approval regulation for all on board equipment connected to the mains be aligned with the 2004/108/EC technical requirements.

The Focus Group considers it is necessary to define the vehicle functional mode for each test, taking into account the type of noise to be measured, the possible noise sources and the energy storage capacity of batteries. In relation with the range capability of the vehicle, some possibilities are currently under consideration (replacement of same type batteries, fast charging, etc.).

Recommendation 12.3: CEN-CENELEC, ISO and IEC should work together for the improvement and completion of the EMC standards for electric vehicles

12.5.2 EMC relative to the charging system

Current IEC and CENELEC EMC standards are established as being collateral to electrical safety standards but there is no EMC-specific standard for automotive components and charging stations harmonised in the framework of 2004/108/EC (the EMC Directive).

As an example, current safety standards define requirements as “under consideration”, and most of the EMC requirements are equal to those requested for household appliances, including ESD and immunity testing that, as it is very well known, are usually much more severe at the vehicular environment than at household or industrial environments. As a matter of fact, an EMC standard needs to be developed to consider EMC matters with regard to the vehicle environment for emission and immunity aspects (continuous and transient phenomena).

Different charging modes can generate different types of electromagnetic issues, so a different approach may be required, and this is not currently considered for the EMC requirements.

In addition, present EMC standards were designed for power devices operating on their own in an existing environment, and do not include the possibility to perform in situ testing for fast charging facilities.

The fast charging mode is not considered in the standards although they may cause major interferences on the power grid.

Recommendation 12.4: Update and complete the EMC requirements in order to take into account the current status of the electric vehicle, communications and power distribution technologies

12.6 EMC standard recommendations

Recommendation 12.5: The adjustments listed in the following sections should be considered by the relevant Technical Committees at IEC and CENELEC levels, and changes brought into the harmonised standards as appropriate

12.6.1 Standard recommendations for low frequency phenomena

The current set of EMC standards covers most of the EMC needs for low frequency phenomena, except in the frequency range between 2 kHz and 150 kHz. In this regard, a recent report by CENELEC SC 205A (SC 205A/Sec0260/R) showed that the number of electromagnetic interference cases in this frequency range is growing quickly. These phenomena may become a real issue with EV, due to possible high concentration of high power semiconductor controlled charging systems.

Recommendation 12.6: IEC SC77A should address the frequency range 2kHz to 150 kHz as soon as possible

Recommendation 12.7: For the frequency range below 2 kHz, the requirements on control methods, measurement methods and test conditions are very important for the application of the emission limits given in existing standards (EN 61000-3-2, -3-3, -3-11, -3-12). Instead of copying parts of the EMC standards into EN 61851-xy and Regulation 10, it is recommended to make simple references to existing standards and to add the necessary additional information only to adequately address EV conductive charging system. In addition, the type of charging mode shall be taken into account when defining specific test conditions for harmonics and flicker emission assessment

Recommendation 12.8: For the application of EN 61000-3-12, only the limits given in Tables 2 and 3 for $R_{s_{ce}} = 33$ should be used, because EV may be connected at any available supply

Recommendation 12.9: Voltage fluctuations and flicker emissions should be properly covered, especially in the case of fast charging mode. In particular, a reference to IEC 61000-3-3 and IEC 61000-3-11 should be addressed in EN 61851-21

Recommendation 12.10: At present, harmonic emission limits are given by IEC 61000-3-2 and IEC 61000-3-12. Where there is a high concentration of electric vehicles in the same neighbourhood, it needs to be established if current emission limits will ensure EMC. This new situation, especially during the fast charging mode, should be investigated

12.6.2 Additional recommendations for grid connection

It is recommended to analyse the rules for grid connection at national level. Over the most countries in Europe, there are regulations for the grid connection of electric equipment. As some examples, in Austria this is the TOR D (Technical and Organisational Regulations), in Switzerland, Germany, Czech Republic and Austria the DACH CZ Rules are used to estimate the system perturbation of electric equipment. All phenomena below 10 kHz such as flicker, unbalance, or harmonics are usually studied. It is important to deal with this topic, otherwise EV charging will not be permitted on a large scale.

Recommendation 12.11: Analyse the coherence of regional regulations on grid connections relative to perturbations

12.6.3 Additional remarks for related phenomena

This document does not take into account the effects of EMF (Electromagnetic Fields) on human health. Electric vehicles may generate higher fields than internal combustion engine vehicles during driving and during charging, especially in case of fast charging, especially in the low frequency range, due to the switching power systems and high voltages and high currents considered. Inductive charging will probably be also a significant contributor to such fields, which should remain within the levels specified by the relevant regulations. These subjects are not covered by this report.

13 Regulations and standards

13.1 Introduction

Taking into account that the vehicle is a product intended for the international market, the analysis of the present situation of regulations and standards concerning electric vehicles has been oriented to international information at first. Nevertheless, as noted in recommendation 7.14 above, a European inventory of domestic regulations would be also necessary to highlight differences between national laws relating to EV & HEV and their conditions of use. Then, if necessary, in Europe it will be possible to advisedly use the tools envisaged in the treaty in order to remove obstacles to free movement of the products.

13.2 Regulations

13.2.1 Technical regulations applying to vehicles of Categories M, N, O and special purpose vehicles

The vehicle and its components are subjected to the legal process of type approval, together with conformity of the production and some controls in use.

In addition the regulation of Periodic Technical Inspection (PTI) of the vehicles, as well as the regulation on recycling (End of Life of Vehicles Directive, 2000/53/CE) and the specific Directive 2006/66/CE on battery recycling, place this product in a very strict system of administrative control. In Europe, Directive 2007/46/EC defines the framework for the approval of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles (Categories M, N O and special purpose). For the corresponding UN-ECE regulations, which are of international application, see **Annex F**, Table F.1.

The electric vehicle is subjected to the same lawful constraints as the traditional thermal engine vehicles. However, there are dedicated provisions to take into account EV and HEV specificity, for example:

- braking
- power
- energy consumption
- frontal crash
- lateral crash
- functional safety
- protection against electrical shocks.

13.2.2 Application of contiguous framework Directives 2006/95/EC (LVD) and 2007/46/EC (type approval of vehicles)

- 1) Member states can presume that the LVD is not applicable to both electrical vehicles and on-board chargers. Directive 2007/46/EC is applicable

- 2) Chargers of the batteries of electrical vehicles, except those on board the vehicles, shall always be considered as an electrical equipment falling within the scope of application of the (LVD)
- 3) Regulation UN-ECE R.100, applicable to M and N categories of vehicles, covers the high voltage components connected to power train. These include the traction motors, and may include the “rechargeable energy storage system” (RESS), the electric conversion system, the electronic converters, the associated wiring harness and connectors, and the coupling system for charging the RESS.

13.2.3 Technical regulations applying to vehicles of Category L

Similarly, the two or three-wheel motor vehicles are considered under the framework of Directive 2002/24/EC relating to the type-approval of vehicle category L. See **Annex F**, Table F.2.

Directive 2002/24/EC is actually under complete revision, with a forecast of 2013 for completion. As for the M and N categories of vehicle, electrical safety requirements will be included.

However, cycles with pedal assistance which are equipped with an auxiliary electric motor having a maximum continuous rated power of 0.25 kW, are not included. These are at present considered in Europe through a European Standard, EN 15194 (see section 5.4.2 above).

13.2.4 Recommendations for vehicles of Categories L and Cycles

The on-going revision of Directive 2002/24/EC offers to interested parties the opportunity to reconsider the fragmentation of categories.

It should be noted that the regulations in force cover primarily the requirements and methods of evaluation concerning general safety for the users and environmental aspects for all categories L, M, N, O and special purpose vehicles.

However, it should be noted that there are no provisions to settle the question of electric vehicles interoperability.

Recommendation 13.1: Reconsider the fragmentation of categories during the revision of Directive 2002/24/EC

13.2.5 Recommendations for vehicles of Categories M, N and O

Several regulatory amendments appear desirable.

Recommendation 13.2: To amend Directive 78/316/EC as, well as to propose amendment of regulation UN-ECE 121, concerning identification of controls, tell-tales and indicators, taking into account three categories of information:

- **for the attention of driver and passengers;**
- **for the attention of personnel for vehicle maintenance;**
- **for the attention of rescuers in case of an accident**

In addition, the provisions of UN-ECE 100 in the EU Type approval system should be considered and included in Directive 2007/46/EC.

Recommendation 13.3: To update the EMC requirements of Directive 72/245/EC as well as to propose amendment of regulation UN-ECE 10, in consideration of the whole electrical vehicle specificities, when connected to the network or not

Recommendation 13.4: To develop provisions within type approval regulations for traction battery safety

Recommendation 13.5: To develop dedicated provisions within type approval regulations for electrical safety of the vehicle when connected to the grid

13.3 Main standards dealing with specific areas of electric vehicles

Standards are reference documents that are established by a recognised organisation, providing solutions to technical or commercial problems. They are established by consensus.

The standards define the minimum technical requirements necessary to achieve the required level of safety, interchangeability or interoperability and to define the functions.

These standards may be used as a basis for tests – either by the manufacturers or by independent third parties - to confirm the conformity of a product. They are of a voluntary application unless included in regulations or Directives.

Regulations are often derived directly from standards or make direct reference to standards. The automobile industry has a history of referring to regulations, whereas the electricity industry generally refers to standards.

More particularly the road vehicles are subject to type approval based on regulations that are mostly established at the international UN-ECE level. European regulations may also apply, but these European are more and more closely replicating the international UN-ECE regulations.

Components within the vehicle are subject to OEM approval using internal specifications that are generally based on existing standards with a clear view to safety, client requirements and costs.

The electrical industry has a tradition of standards, and conformity is judged with respect to such standards. Certain regulations make specific reference to standards, for example the Low Voltage Directive and the EMC directive. Regulations or local laws may also make direct reference to standards. The electric industry now uses self certification and uses little third party certification except for specific.

The lists in Annex F.1 and F.2 identify the main standards and regulations that apply to the specific nature of the electric vehicle. The large number of standards that exist may be a handicap for industry, and there the automobile industry feels the need for more self-contained standards, that clearly address the specific requirements of this industry, and allow for easy integration into international standards. If needed “double branded standards” (ISO and IEC) produced in joint working groups that unite the main technical experts can simplify such applications. The automobile industry could be a major requirements-setter for electro-mobility topics.

We have provided an overall inventory of standards developed within Technical Committees in CEN, CENELEC, ISO, IEC, SAE, UL etc. at Table F.3. A column in the table seeks to demonstrate how important each standard might be in terms of electro-mobility requirements. We observe that the standards demonstrate an over-abundance of normative references, i.e. forcing users to cross-refer to other standards in order to meet the full requirements.

This document was first drawn up to demonstrate the full list of standards, then it , shows an over-abundance of normative references.

Knowing that this report provides precise recommendations related to each aspect of electric vehicle standardization, and taking into account ongoing ISO-IEC standardization developments, along with the overall list, we can attempt to prioritise the topics that need to be addressed most urgently:

Recommendation 13.6: The following standardization activities should be given priority:

- **safety of charging installations;**
- **plug-in interoperability;**
- **EMC provisions for charging station and vehicle;**
- **communication protocols for V2G;**
- **quick battery exchange (as soon as reference dimensions are available)**

Focus Group on European Electro-Mobility

Standardization for road vehicles and associated infrastructure

Report

**in response to Commission Mandate M/468
concerning the charging of electric vehicles**

Annexes

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Annex A

Terms of Reference of the Focus Group

(Version approved in the first Plenary meeting, with minor amendments)

1 Title

“Focus Group on European Electro-Mobility - standardization for road vehicles and associated infrastructure”

2 Status

The Group will be an informal joint WG of CEN-CENELEC. It will report to the CEN and CENELEC Technical Boards.

3 Scope

The Group will consider in the first instance European requirements relating to standardization for road vehicles and associated infrastructure, and assess ways to address them.

This Group will not develop standards itself.

4 Tasks

The Group's initial tasks are to:

4.1 Prepare an overview of European requirements concerning:

- batteries (including life cycle)
- charging infrastructure, and relevant range-extending aspects
- connecting devices
- vehicles themselves (including definitions of requirements for different classes of vehicles)
- issues relating to communication between vehicle and grid
- issues relating to payment infrastructures, roaming etc.
- load control and reverse energy flow
- electro-magnetic compatibility and electrical safety

4.2 Match the requirements against existing international standards and regulations and all relevant work in progress in standards bodies

4.3 Make recommendations as to how missing issues should be covered by standardization, by whom and on what timescale

4.4 Propose to the European Standards Organisations how to respond to the current European Commission mandate

5 Timescale

The Group shall provide its initial overview and roadmap before 30 September 2010 and shall complete its work before 31 March 2011.

6 Participation

The Group will comprise:

- Representatives of the CEN and CENELEC national members with an interest
- Representatives of European associations representing interested stakeholders
- Representatives of interested Technical Bodies in CEN & CENELEC and in ISO and IEC
- Representatives of the European Commission DGs and of the EFTA Secretariat
- Observers from IEC, ISO, UN-ECE, ITU-T and ETSI

Additional Participants may participate in meetings and be included in electronic discussions where agreed by the Chairman and the Secretariat. The Group shall take account of related activities in other regions.

The Chairperson shall be nominated by the core participants and approved by the CEN and CENELEC Technical Boards. The CEN-CENELEC Management Centre will provide the Secretariat. The Chairperson will be advised by a Steering Group appointed by the Focus Group, comprising one representative of the automotive sector, one from the electro-technical sector, a regulator, consumer groups, and others by agreement of the Focus Group. The Chairperson will ensure that the Focus Group is consulted over questions of balance.

7 Working methods

As far as possible, the Group will work on specific topics electronically, through e-mail, telephone conference and web conference. However, some physical meetings may be required.

For particular topics, the Group may agree to set up ad hoc WGs to consider and report back. The Group may organise open stakeholder consultative meetings where required.

Participation will be on a voluntary basis.

The Group will work by consensus of the participants. Its Recommendations will be non-binding on participants' organisations.

The Group Secretariat shall provide full electronic working facilities.

This Focus Group will closely liaise with the CEN-CENELEC-ETSI Joint WG on smart grids.

Annex B

European Commission/EFTA mandate



EUROPEAN COMMISSION
ENTERPRISE AND INDUSTRY DIRECTORATE-GENERAL
New Approach Industries, Tourism and CSR
Mechanical, Electrical and Telecom Equipment

Brussels, (signed): 29/6/2010
M/468 EN

STANDARDISATION MANDATE TO CEN, CENELEC AND ETSI CONCERNING THE CHARGING OF ELECTRIC VEHICLES

1. PURPOSE-SCOPE

To develop or 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 be interoperable in all EU States¹.
- Ensure interoperability and connectivity between the charger of electric vehicle- if the charger is not on board- and the electric vehicle and its removable battery, so that a charger can be connected, can be interoperable 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)².

For the purposes of this Mandate:

‘electric vehicle’ includes the electric vehicle (EV) and the plug-in hybrid electric vehicle (PHEV), as well as the electric scooters and electric bicycles; for the issues of interoperability, the priority should be for the four-wheel electric vehicles.

¹ Considering that domestic sockets are not harmonised in the EU, existing adaptors should be used for domestic charging.

² The Guides or Decisions of the relevant WPs clarify the legal framework applicable to electric vehicle chargers.

2. RATIONALE

Given the importance of reducing carbon emissions from road transport and the long run price of oil and security of oil supply, there is increased interest in the potential of electric vehicles. More and more companies are developing electric vehicles.

With respect to the applicable EU legal framework for electric vehicles, working documents were prepared by the European Commission which were discussed and approved by the relevant WPs (the LVD WP and TCMV – Technical Committee Motor Vehicles). These Working Documents define the legal framework applicable to electric vehicles by specifying that Directive 2007/46/EC (the Framework Directive on Motor Vehicles) is applicable to electric vehicles (including the electric power train of vehicles) when placed on the EU market while chargers of the batteries of electric vehicles shall be always considered as electrical equipment falling within the scope of application of the LVD. In the near future the legal framework applicable to on board chargers will be discussed and clarified in the relevant WPs.

Recently, meetings took place between the European Commission, industry, CEN and CENELEC to assess the need for common EU standards for the charger of electrical vehicles as regards safety, interoperability and performance. The conclusion that can be drawn from these brainstorming meetings is that various solutions and alternatives are discussed at international level (IEC) both for safety and interoperability. Although for safety, IEC is heading towards one single solution, for interoperability there is a danger that IEC will not reach a single and harmonised approach. If this happens a fragmentation of the market would be inevitable. For example, at least three different models of plugs are currently under consideration. Also various propositions with respect to the power levels for charging are considered and lastly three different modes for the charging are proposed.

In order to promote the development of the internal market for electrical vehicles and to discourage the imposition of market barriers, it is imperative that plugs, chargers and electric vehicles be inter-operable. This will allow users to use the same charger for a range of electric vehicles. It would also allow consumers to charge their vehicles easily if they are driving across borders or when travelling within their own Member State. It would also facilitate charging at public access points and would facilitate the roll-out of charging infrastructures. Finally it would dissuade member states from taking action individually because this might lead to overlapping solutions.

For the European Commission, it is important that a joint EU solution on interoperability is ensured in order to avoid a fragmentation of the market for these products from the beginning (for example different plugs for the electric interface of these vehicles). A number of Member States have started, individually, action to get electrical vehicles on the market.

The target is to adopt a European harmonised approach for the interoperability of the charger of electric vehicles with all types of electric vehicles and the interoperability of the charger of electric vehicles (including their removable batteries) with the electricity supply point. This harmonisation would allow users to use the same charger for a range of electric vehicles and it would ensure that chargers of electric vehicles can be connected and operated in all EU States.

As part of the harmonisation, any other related issue, with respect to the charging of electric vehicles which can ensure safety, electromagnetic compatibility and better use, should be considered. Especially for better use, smart-charging issues should be addressed so that users of a charger are in the position to measure the amount of electrical energy thereby making it easier for them to save energy and money. Smart-charging can take advantage of “off-peak” hours of low energy demand late at night and so avoid peak loads. In some areas, the electric rates are higher during certain times of day to encourage reduction in use and so smart-charging can help the user to know these times. In summary, smart-charging would be the mode for determining the best and cheapest time to recharge electric vehicles.

This harmonisation can be addressed by European standard(s).

3. DESCRIPTION OF THE WORK TO BE MANDATED

CEN, CENELEC and ETSI are requested to develop European standards or to review existing standards in order to:

- a) 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 be interoperable in all EU States³.
- b) Ensure interoperability and connectivity between the charger of electric vehicle- if the charger is not on board- and the electric vehicle and its removable battery, so that a charger can be connected, can be interoperable and re-charge all types of electric vehicles and their batteries.
- c) Appropriately consider any smart-charging issue with respect to the charging of electric vehicles.
- d) 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)⁴.

4. EXECUTION OF THE MANDATE⁵

2 months after acceptance	Time schedule for the execution of the mandate
8 months after acceptance	Presentation of a full work programme of standard(s) to be developed
18 months after acceptance	Adoption of standard(s).

³ Considering that domestic sockets are not harmonised in the EU, existing adaptors should be used for domestic charging.

⁴ The Guides or Decisions of the relevant WPs clarify the legal framework applicable to electric vehicle chargers

⁵ For smart-charging, the responsible standardisation organisations may discuss with the Commission the possibility to extend these periods.

Where appropriate, alignment with equivalent activities planned and already undertaken in IEC and ISO should be ensured.

Due account should be taken of initiatives taken in other economies so as to ensure a global market for equipment.

Acceptance of this mandate by the responsible standardisation organisations starts the standstill period referred to in Article 7 of Directive 98/34/EC of the European Parliament and of the Council of 22 June 1998

European standards (EN) shall be adopted by the target dates specified. On these dates the three linguistic versions (English, French and German) shall be available. For the purposes of paragraph 3(d), the correct titles in all the other European Union languages shall be available.

5. ORGANISATIONS TO BE INVOLVED

As appropriate, CEN, CENELEC and ETSI will invite the representative organisations of consumers' interests (ANEC), environmental protection (ECOS), workers (ETUI-REHS), small and medium-size enterprises (NORMAPME), electrical industry (ORGALIME), automotive manufacturers and suppliers and market surveillance authorities to take part in the standardisation work.

Annex C

Vehicle categories

Vehicle categories are defined by international regulations on the basis of the text that follows. It is to be noted that vehicle categories do not depend on the energy used and, in the case of electric vehicles, the categories do not depend on the power of the charging system or the energy that must be transferred to the battery during the charge.

C.1 Category L – Motor vehicles with less than four wheels

C.1.1 Category L1

A two-wheeled vehicle with an engine cylinder capacity in the case of a thermic engine not exceeding 50 cm³ and whatever the means of propulsion a maximum design speed not exceeding 50 km/h.

C.1.2 Category L2

A three-wheeled vehicle of any wheel arrangement with an engine cylinder capacity in the case of a thermic engine not exceeding 50 cm³ and whatever the means of propulsion a maximum design speed not exceeding 50 km/h.

C.1.3 Category L3

A two-wheeled vehicle with an engine cylinder capacity in the case of a thermic engine exceeding 50 cm³ or whatever the means of propulsion a maximum design speed exceeding 50 km/h.

C.1.4 Category L4

A vehicle with three wheels asymmetrically arranged in relation to the longitudinal median plane with an engine cylinder capacity in the case of a thermic engine exceeding 50 cm³ or whatever the means of propulsion a maximum design speed exceeding 50 km/h (motor cycles with sidecars).

C.1.5 Category L5

A vehicle with three wheels symmetrically arranged in relation to the longitudinal median plane with an engine cylinder capacity in the case of a thermic engine exceeding 50 cm³ or whatever the means of propulsion a maximum design speed exceeding 50 km/h.

C.1.6 Category L6

A vehicle with four wheels whose unladen mass is not more than 350 kg, not including the mass of the batteries in case of electric vehicles, whose maximum design speed is not more than 45 km/h, and whose engine cylinder capacity does not exceed 50 cm³ for spark (positive) ignition engines, or whose maximum net power output does not exceed 4 kW in the case of other internal combustion engines, or whose maximum continuous rated power does not exceed 4 kW in the case of electric engines.

C.1.7 Category L7

A vehicle with four wheels, other than that classified for the category L6, whose unladen mass is not more than 400 kg (550 kg for vehicles intended for carrying goods), not including the mass of batteries in the case of electric vehicles and whose maximum continuous rated power does not exceed 15 kW.

C.2 Category M – Power-driven vehicles having at least four wheels and used for the carriage of passengers

C.2.1 Category M1

Vehicles used for the carriage of passengers and comprising not more than eight seats in addition to the driver's seat).

C.2.2 Category M2

Vehicles used for the carriage of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass not exceeding 5 tonnes.

C.2.3 Category M3

Vehicles used for the carriage of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass exceeding 5 tonnes.

C.2.4 Vehicles of category M2 and M3 belong to:

- (i) one or more of the three classes (Class I, Class II, Class III) in accordance with Regulations Nos. 36 and 107.
- (ii) one of the two classes (Class A, Class B) in accordance with Regulation No. 52.

(i) Class I

Vehicles constructed with areas for standing passengers, to allow frequent passenger movement.

Class II

Vehicles constructed principally for the carriage of seated passengers, and designed to allow the carriage of standing passengers in the gangway and/or in an area which does not exceed the space provided for two double seats.

Class III

Vehicles constructed exclusively for the carriage of seated passengers.

(ii) Class A

Vehicles designed to carry standing passengers; a vehicle of this class has seats and may have provisions for standing passengers.

Class B

Vehicles not designed to carry standing passengers; a vehicle of this class has no provision for standing passengers.

C.3 Category N – Power-driven vehicles having at least four wheels and used for the carriage of goods**C.3.1 Category N1**

Vehicles used for the carriage of goods and having a maximum mass not exceeding 3,5 tonnes.

C.3.2 Category N2

Vehicles used for the carriage of goods and having a maximum mass exceeding 3,5 tonnes but not exceeding 12 tonnes.

C.3.3 Category N3

Vehicles used for the carriage of goods and having a maximum mass exceeding 12 tonnes.

Annex D

Proposal for the management of European standardization activity in response to the European Commission Mandate M/468

D.1 General structure

Generally, international standardization work and harmonisation has to have priority. The development of European standards, as proposed in this report, intends to complement international standards or to meet special European requirements only as far as necessary.

CEN and CENELEC are structured with Technical Committees (TCs), with technical experts participating in the TC activities. These experts attend the meetings as delegates of National Standardization Bodies/National Electrotechnical Committees.

Although the topics relevant to electric vehicle are complex and concern different TCs, there is no reason to modify the general structure and methodology of working within CEN and CENELEC, with technical work being allocated to the existing relevant TCs.

However, it is considered necessary to have a dedicated structure, comprising the principal TCs involved, for coordinating the standardization activity and fulfilling the following tasks:

- List the needs of industry in this area and identify standardization tasks;
- Identify the TCs (Technical Committees) and SCs (sub-committees) concerned;
- Analyse the current level of TC/SC activities and identify where future activity is required;
- Set up a work programme that includes a structure for the coordination of cross-TC/SC work, where required.

D.2 Principal Technical Committees involved

The nature of the work concerns a large number of TCs; however the following three TCs have been identified as playing a central role :

D.2.1 CEN/TC 301 Road vehicles

CEN/TC 301 is responsible for all questions of standardization concerning road vehicles and their equipment which includes also all standardization related to the electrical and electronic equipment of road vehicles as well as electrically propelled road vehicles.

D.2.2 CLC/TC 64 Electrical installations and protection against electric shock

TC 64 is generally responsible for all questions

- concerning protection against electric shock arising from equipment, from installations and from systems without limit of voltage;

- for the design, erection and verification of all kinds of low-voltage electrical installations, except those installations covered by the following CENELEC Technical Committees: TC 9X, TC 44X;
- in co-ordination with CLC/TC 99X, concerning requirements additional to those of TC 99X for the design, erection and verification of electrical installations of buildings above 1 kV up to 35 kV.

The objects of the standards shall be

- to lay down requirements for the safety aspects of the design, erection and verification of electrical installations and co-ordination of electrical equipment;
- to lay down safety requirements for protection against electric shock;
- to lay down safety requirements for protection against other hazards arising from the use of electricity and
- to facilitate European exchanges that may be hampered by differences in national regulations. The standards will not cover individual items of electrical equipment other than their selection and erection in an installation.

D.2.3 CLC/TC 69X Electrical systems for electric road vehicles

This TC has been recently reactivated with the following scope of activity as defined by the CENELEC Technical Board:

"To prepare European standards related to electrical systems for road vehicles, totally or partly propelled from self-contained power sources".

It is to be noted that CLC/TC 69X and CEN/TC 301 need to discuss the correct alignment of their scopes, with particular attention to additional standards developed within Vienna and Dresden agreements to be transformed to EN standards.

D.3 Associated TCs

The following TCs are actively working on sub-elements of electrical mobility and will inevitably contribute to standards on electro-mobility in Europe.

- CLC/TC 23BX working on socket-outlet - connector configuration related to electric vehicles
- CLC/TC 23E – protection elements (circuit breakers ...)
- CLC/TC17D – electric equipment
- CLC/TC 20 – electric cables
- CLC/TC 21X – secondary cells and batteries
- CLC/TC 13 – metering equipment
- CLC/TC 57 – smart grid

- CLC/TC 210 – EMC

NOTE The above list is not intended to be exhaustive.

Figure D.1 gives a first approach view of the way that different responsibilities could be divided within each group. It is to be noted that the TC identified as "Topic Coordinator" has no role other than to report on progress and to maintain a running knowledge of ongoing work. It does not necessarily have a direct influence on the writing of the standardization documents.

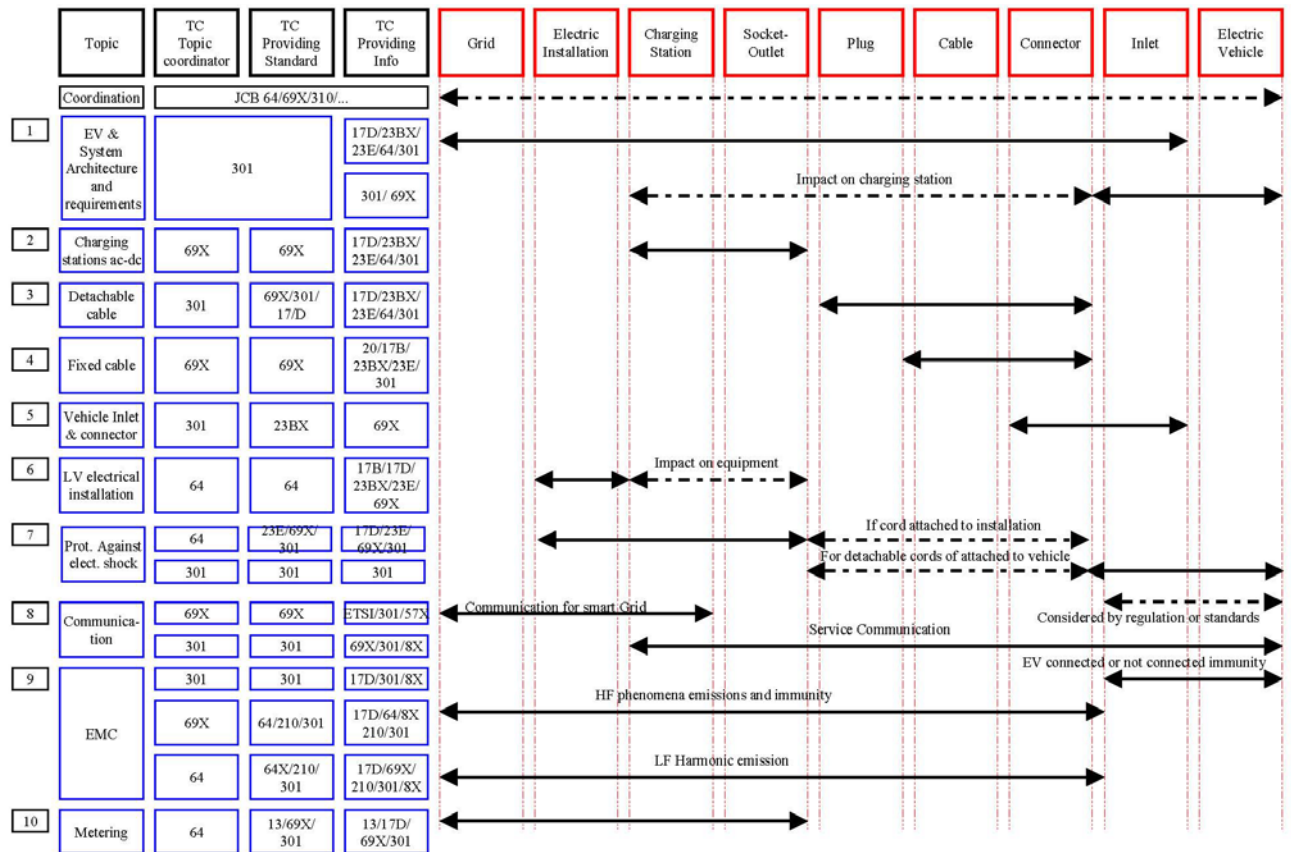


Figure D.1 – Examples of TC activity in the context of charging for electric vehicles¹

¹ CENELEC TC20 may provide advice on all cabling matters, not simply those relating to fixed cables

Figure D.2 gives a view of the different topics that are covered with an indication of the topic coordinator overview

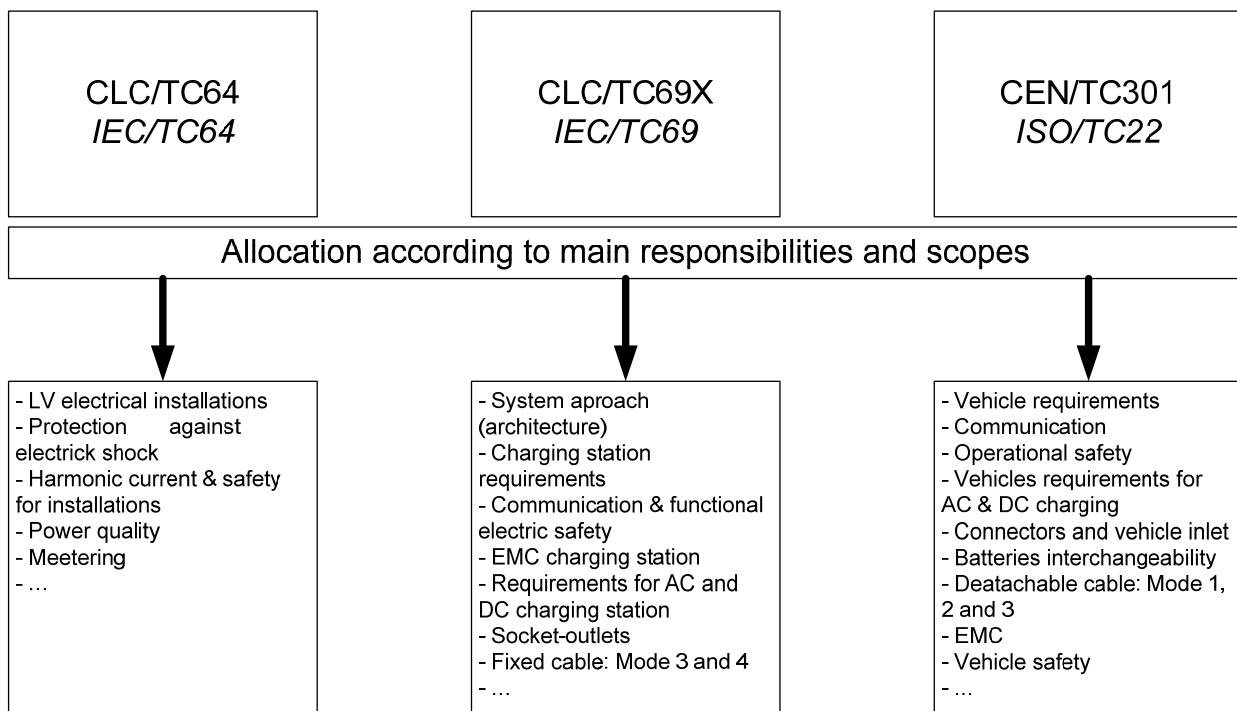


Figure D.2 – Proposal for distribution of topics to be addressed by the Mandate M/468, following allocation according to main responsibilities and scopes

D.4 Specific issues

It should be noted that CEN/TC 301 is fully responsible for the specifications of all component/system on board the vehicle. This includes the choice of the inlet for connecting the cord-set of the charging system. The associated connector is part of the cord-set covered for instance by CLC/TC 23BX. The requirements concerning the inverter, where installed on board the electric vehicle is under the responsibility of CLC/TC 21X. CEN/TC 301 needs to refer to this standard while making the appropriate choices, if any.

CLC/TC 64 will have a major role as it has the horizontal safety function concerning the protection of persons against electric shock. Consequently, the responsibility of this TC is fully involved from the origin of the electrical installation down to the connection of the electric vehicle. Any insulation fault within the electric vehicle once connected to the fixed electrical installation for loading and resulting in a hazardous situation needs to be eliminated.

Annex E

Stakeholder positions at greater length

E.1 Identified consumer requirements (ANEC & Going-Electric)

E.1.1 Introduction

This annex is intended to illustrate and clarify the statements given in 6.1 regarding the identified consumer requirements on electro-mobility.

In order to determine the user requirements, two types of needs have to be noted: "real needs" and "perceived needs". While real needs can be determined rationally, "perceived needs" which might be largely influenced by misconceptions and/or fashion, can be difficult to predict, especially when new technologies are involved. Therefore, this paper concentrates on the "real needs" of consumers regarding electro-mobility.

The main focus of these user requirements lies on electric cars. Basically two types of electric cars or "EVs" will need charging: Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs):

- Because of their limited range, BEVs will essentially be used for commuting and short urban trips, mostly driven at slow speed (urban and congested traffic) with only one occupant. Small and ultra-small BEVs with proportionally small battery-packs (around 10 kWh) and limited range (50 –150 km) can ideally satisfy consumers real needs for this usage and may therefore have a wide market, especially in two-car families (25-30% in Europe).
- However, some other users will prefer larger BEVs with more driving range, using bigger battery-packs (up to 50 kWh and more when batteries become smaller and cheaper).
- For long trips and mixed usage, consumers will prefer PHEVs, which will tend to be bigger and faster cars, capable of transporting comfortably a family for weekend and holiday trips.

E.1.2 Explanation of the individual requirements

1) Adequate level of **safety**

Electric vehicles can pose a significant electrical hazard not posed by conventional petroleum-powered vehicles to users, especially when misused, not maintained or after an accident. Therefore, the electrical safety of EVs as well as of the charging infrastructure (incorporates range from household outlet to public charging station) is of utmost importance. Due to potentially lethal effects on the human body the possibility of an electric shock has to be prevented by technical means. No matter whether this electric shock might occur during normal operation or through foreseeable misuse.

2) **Possibility of low power charging** on adequate domestic sockets at homes and in residential areas

3) Availability of fast charging

Obviously, no consumer will buy an EV if it couldn't be charged. Furthermore, no-one will drive far away to a remote charging station and wait for the EV to recharge. Therefore, potential EV users need to be able to charge their car where it is parked most of the time: at or near their home. Additionally, in order to load-balance the main power grid and benefit from low off-peak prices, EVs should be charged at night, using off-peak electricity. Due to the comparatively low charging power needed to replenish the energy used while driving the average daily mileage, overnight normal charging on a single-phase domestic socket at a limited charging power (for instance 2 to 3 kW) is more than sufficient.

Besides, charging with a domestic socket gives EV users the opportunity to get an additional charge wherever they are. Therefore, the priority for many individual EV drivers is to be able to safely charge (at a safe, limited power) on a local domestic socket. It should be allowed in all countries where domestic socket's power rating is sufficient.

However, some EV users, such as owners of larger EVs covering longer daily distances, or those subject to "range anxiety", will need more charging power at or near home. Public charging stations outside residential districts e.g. at the workplace or in the city centre may be useful on weekdays, but they are useless during the night respectively at weekends and holidays. They are necessary mainly to address "range anxiety". While normal charging power (around 2 to 3 kW) is sufficient for pedelecs, scooters and some EV users (providing 10 to 25 km additional range per hour), many EV users will prefer higher charging power ("accelerated" or "fast").

Using BEVs for very long trips requires either "quick" charging stations on freeways, capable of offering a 200 km+ range in less than 10-15 minutes or a battery switching mechanism.

4) **Affordability and ease of use** which involves affordable, light and easy to connect cables and plugs and simple and consistent user interfaces

5) **Interoperability** of connectors and billing mechanisms throughout Europe

EV users will not want to carry along more than 2 charging cord-sets (including one with a domestic plug). Additionally, EVs should not have more than one or two standardised inlets on the vehicle side. Since domestic sockets are already standardised for each country, only a single high power connector needs to be standardised at the European – and ideally worldwide – level. However, in the absence of a "combo" connector, one connector for AC charging and one for DC charging is unavoidable. High-power connectors should have the functionality to connect the EV to any charging station in Europe. It should also be easy to handle concerning push-in and pull-out forces as well as weight of the cable. If the publically accessible charging station is equipped with a graphic user interface (GUI) to control the charging, it should be consistent and simple to use. In order to promote transnational electro-mobility, the language of the GUI should be changeable.

Customer authentication, access keys, and billing mechanisms must be made compatible at a European level, so that users can use any charging station without preregistration and pay with standard methods (such as credit card or mobile phone) and/or have their consumption invoiced by their local utility company.

6) **Security** concerning data privacy, authentication, protection against vandalism and cable theft

7) **Durability and robustness** especially of the charging cables and connectors

All data communication between the EV and the charging station as well as the electricity provider which could be linked directly to the user have to ensure data privacy in accordance with ISO/IEC 27000 series.

The publically accessible charging station and the charging cable itself should have sufficient protection against vandalism and fraud. For instance this could be achieved through a locking mechanism of the plug and connector as well as a robust cable which could prevent malfunctions due to a broken cable core.

8) **Accessibility** regarding elderly and disabled people

As written in ISO/IEC Guide 71 and CEN/CENELEC Guide 6, it has to be an important goal for the whole of society that all people have access to products, services and environments. Accessibility and usability does not only concern older people. It can affect everybody who is disabled for instance by disease or injury. The CEN/CENELEC Guide 6 gives an overall framework to support the need for more accessible products and services. It identifies the problem areas which need to be considered when drafting standards and should therefore be noted in the standardization of electro-mobility.

In order to understand the accessible design principles of ISO/IEC Guide 71 regarding design considerations and ergonomic data related to human abilities, ISO/TR 22411 can be used.

E.2 European Automobile Manufacturers' Association



Brussels, 14 September 2011

ACEA position and recommendations for the standardization of the charging of electrically chargeable vehicles

Following the previous commitments made and updated ACEA position from 2 March 2011 (http://www.acea.be/news/news_detail/acea_members_address_the_challenge_of_standardising_the_charging_of_electri/) ACEA members are continuing to contribute to the on-going debate within EU institutions on standards for electrically chargeable vehicles.

Having recognised the progress made during last months, namely in the CEN/CENELEC Focus Group and progress made in TEC (Trans-Atlantic Economic Cooperation), ACEA members present final agreement and joint recommendations on interface between cars and relevant infrastructure.

ACEA members express their urgent need to finalise European agreement for standard AC charging and present vision for common agreement on quick charging that also creates a room for global solution and simplification

From the perspective of the automotive industry, presented agreement and solutions will have positive effects for the consumers (having unique EU wide solution, cost reduction for all stakeholders and fulfilling all safety requirements), for the infrastructure providers to have clear indication about the future development and for the OEMs to reduce costs and progress more quickly on the market uptake of electrically chargeable vehicles. Quick progress and EU-wide agreement for standard charging is a pre-requisite for quicker market uptake of electric vehicles and higher investment into quick charging network.

However, **it is important to note, that the current joint position and recommendation is based on today's best knowledge of the current situation and state of technical development.** That applies both for connectors/modes and communication. Certain technical solutions may still need to be validated in detail, as the technical specifications have not yet been finalised in the different International Standardization Groups. Also learnings and outcomes of demonstration projects and testings could eventually result in a set of different recommendations.

Concerning Europe, ACEA members call upon the European Commission and relevant standardization bodies and other stakeholders to support those recommendations and use it as a basis for the development of common European standards. Concerning global view, ACEA is strongly supporting the IEC standardization process for a global solution. In this framework, ACEA recommends one defined "envelope"¹ for vehicle inlet supporting single phase AC, three phase AC and DC charging, including safety requirements as well and ACEA members will fully respect agreed global solution if found in the future.

¹ See Annex III of the position

Annex I [to ACEA position]**ACEA position and recommendations on connector types (IEC 62196), charge modes (IEC 61851) and communication standards for the charging of electrically chargeable vehicles (passenger cars and light-commercial vehicles)****Executive summary:**

- ACEA continues and stresses the need to divide the timeframe into two fundamental phases - Ongoing period till approval of relevant standards (Phase 1) and approval of relevant standards with sufficient lead-time for implementation (Phase 2).
- Current agreement covers both Phase 1 and Phase 2 for passenger and light-commercial vehicles only for AC and DC charging.
- **Phase 1 reflects current situation** and should be seen as a preparatory step for a broader introduction of electrically chargeable vehicles in the EU. Public authorities are welcomed to consider the voluntary agreement made by the industry and pilot projects in urban areas should be streamlined on the infrastructure side accordingly.
- **Phase 2 suggests an uniform EU solution enabling global charging standards to be applied** that reduces the variety of solutions in the market.
- Harmonised rules for phase 2 should apply for new vehicle types starting 2017, providing the industry with needed lead time to implement these new solutions in their vehicle development programs and to make necessary adaptation in the infrastructure.
- In line with the joint EU-US TEC discussions ACEA presents a definition of global vehicle inlet “envelope” as a key step for global solution, enabling simple switch between US and EU standards (see annex III).
- Concerning the connector types/modes and communication, ACEA agrees on following key principles and recommendations:
 - i) As for proposed uniform EU solution (Phase 2 starting in 2017 for all new vehicle types on vehicle side), ACEA suggest **Type 2/Type 2 Combo to be used in the EU** as a standard for AC/DC charging both on the vehicle and public charging side as long as it meets required national safety requirements
 - ii) Standardisation of joint “envelope” profile paves the way to real global solution. Having in mind too different operational conditions (namely from the side of grid and electricity power in grids), simple single solution cannot work between US and EU. **Joint “envelope” profile** facilitates the exchange of Combo 1/Combo 2 solutions and will lead to significant simplification of charging mechanisms for consumers and cost reductions for the industry.
 - iii) No direct communication between vehicle and grid is foreseen for the moment
 - iv) Preference **PLC communication** between EV and EVSE shall be ISO/IEC 15118 compliant
 - v) If in the future communication between EV directly to the grid will be established, it shall follow an international standard (to be defined, but it should be compliant at least with ISO/IEC 15118)

- vi) **International standards** ISO/IEC 15118 and IEC 61851-23/-24 shall cover the needs of communication for most modes of charging.
- vii) As for the communication technology, ACEA decided to **concentrate all efforts on of IEEE 1901 Profile Green PHY on CPLT/PE, with a demand for further tests needed to confirm this direction.**
- viii) For the wireless communication, industry decided to select a PLC technology for the communication, **wireless solutions should be developed in the future** or for the moment will represent additional company specific extensions and business cases

Justification:

- Concerning vehicle inlet, electrically chargeable vehicles are entering the market and there is no possibility to have unified vehicle inlets for the moment. But having in mind the need to have standardised solution, European manufactures are committed to accept one “envelope” solution for vehicle inlet once it is set by legislation or standard (with sufficient lead time).
- Proposed Type 2/Type 2 Combo provides background for unified solution for different AC and DC charging powers and enables compatibility among solutions.
- Both for the vehicle inlet and public infrastructure side, Type 2/Type 2 Combo is the only solution for the moment in Europe that can combine standard AC and fast AC and DC charging in short future.
- Type 2 fulfils all safety requirements of ISO/IEC and can be equipped with shutters as well.
- Therefore from the perspective of automotive industry, Type 2/Type 2 Combo, is the only solution that can be used both on vehicle and public infrastructure side and is ready for all kinds of charging and can ensure interoperability EU-wide.
- Type 2 Combo give as opportunity for global solution and fits to proposed “envelope” profile as well.
- Proposed “envelope” profile creates a solution that streamlines EU and US charging systems.
- Type 2 is also open for future development and global harmonisation of charging standards.

A Basic charging

(covers “basic AC charging” up to 3,7 kW)

Phase 1:**ACEA agreement for the vehicle inlet:**

No restrictions on type of vehicle inlet as vehicles with different types are already on the market or in a late development phase. Manufactures will provide at least one cable with Type 2 plug (Mode 3) or standard domestic plug (Mode 2) to connect to infrastructure.

ACEA recommendation for public charging (infrastructure side):

Type 2 (Mode 3)

ACEA recommendation for home charging (infrastructure side):

Type 2 (Mode 3), standard home socket outlet (Mode 2) or industrial socket (IEC 60309-2 - Mode 2).

Remarks:

Remark 1: Industrial sockets (IEC 60309-2 – Mode 2) should be allowed for this transitional period.

Remark 2: As vehicles from Phase 1 product launches will be equipped with different kinds of vehicle inlets, it is important that all public charge spots which use attached cables have an additional Type 2 infrastructure socket outlet (Type3 where nationally required). If the vehicle inlet is of a different type than the connector on the fixed cable, the customer must be able to use its own cable delivered with the vehicle. (Any adaptors on the vehicle side are forbidden by IEC 61851 due to safety concerns).

Remark 3: Standard home sockets (mode 1) are widely available and well known to customers making them easy to use; therefore they should remain a valid solution for the market uptake. However, a third party certification of the household electricity grid should be conducted before the electrically chargeable vehicle is first charged.

Phase 2:

As for harmonised solution, ACEA strongly recommends to unify national regulations concerning socket outlet Types without shutter. Proposed solutions should fit to the global solution ensuring different ways of charging (single and three phase AC). Harmonised rules for phase 2 will apply for new vehicle types starting 2017.

ACEA agreement for the vehicle inlet and connector:

Type 2 (Mode 3) uniform EU solution in global “envelope” if opted by manufacturer. Manufacturers should provide at least one cable with Type 2 plug (Mode 3) to connect to infrastructure.

ACEA recommendation for public charging (infrastructure side):

Type 2 (Mode 3) uniform EU solution

Note: In case of charging spots with fixed cable with Type2 vehicle connector only, ACEA recommends that those charging points are for transitional period also equipped with standard Type2 outlet (Type3 socket outlet if national differences still remain).. Standard home charging should be still allowed as in phase 1.

B Fast charging

(including and “fast AC charging” above 3,7 kW up to 43 kW, “fast DC charging” up to 43 kW and “ultra fast DC charging” above 43 kW)

General recommendation: ACEA strongly recommends those infrastructure/charging points to be equipped with fixed attached cable in line with existing standards. ACEA also see this network as a charging “safety net”.

ACEA recommendation for vehicle inlet:

Type 2 or Combo2 in global “envelope” as defined in Annex III

ACEA recommendation for public and fleet charging:

Charging points equipped by fixed cables with Type 2 or Combo2 connector.

ACEA recommendation for home charging:

Charging points equipped by fixed cables with Type 2 or Combo2 connector.

Remark: The development of public infrastructure shall not ban vehicles already equipped with other existing DC charging devices (e.g. CHAdeMO) and backward compatibility solutions for those vehicles should be considered.

C Communication protocols for fast AC/DC charging

Communication is essential for charging electric vehicles. Once integrated into the smart grid, the vehicle to grid communication should enable reaching particular objectives:

- Controlling charging procedure by infrastructure and vehicle
- Providing convenient charging for all customers, e.g. to achieve reliable charging in absence of driver
- Enabling certified payment and billing systems
- Safeguarding high-voltage safety and personal privacy
- Ensuring interoperability of certified value-adding vehicle-to-grid accessories.

Communication must safeguard the personal privacy of the user and communication technology must be general and future proof. The PLC communication interface shall be established via the charging connector.

If a unique communication paradigm guaranteeing low latency in DC mode and sufficient specifications for the AC high-end communication, it shall be applied to all existing charging connectors which support all modes of AC and DC charging. If such a solution cannot be strongly proven to work properly, then 2 different communications, one for DC and one for AC, shall be proposed.

A large number of communication options are being discussed and implemented for in-home communication and “smart home” functions. This includes several wireless and PLC systems. These solutions are expected to rapidly evolve and change over time. To provide a stable interface for EVs, the work on the ISO/IEC 15118 standard for EV charging communication and parallel activities which focus on DC charging communication in IEC 61851-24 is closely followed by automotive industry.

Specific issues:**i) Direct V2G communication (without EVSE)**

As possible far future options are concerned, the vehicle battery may be used to feed energy back into the grid whenever the price for control energy or balancing energy is particularly high. Many technological, safety and legal issues still have to be resolved (e.g. negative effects on the durability of the battery, the power grid and consumer convenience) up till then. Therefore no communication between vehicle and grid is foreseen for the first stage. The charging has to be in-line with all safety standards, through harmonised hardware.

ACEA agreement: No communication between vehicle and grid is foreseen for the moment.

Options available for advanced stage:

If future use cases require a direct EV to grid communication without an EVSE, the ISO/IEC 15118 charge communication provides a flexible base for adaptations to future infrastructures due to usage of common TCP/IP communication in a layered architecture. This allows a wide range of topology for the charging infrastructure, from a local centralised controlling instance within an EVSE up to a distributed system with a decentralised controlling instance in the internet.

ACEA agreement: If future use cases require a direct EV to grid communication without an EVSE, specific and agreed international ISO/IEC standard shall be applied allowing both wire and wireless solutions (ISO/IEC 15118 should be included at least).

ii) V2G communication using EVSEOptions available:

The standard for charging communication ISO/IEC 15118 is the baseline for V2G communication with EVSE. The standard is currently developed in an international cooperation with strong support by the automotive industry. IEC 61851-24 extends ISO/IEC 15118 by additional messages for DC charging. Both standards are comprehensive and sufficient for the definition of V2G communication using an EVSE.

ACEA agreement: The standard for charging communication ISO/IEC 15118 together with IEC 61851-23/24 defining additional messages for both AC and DC charging shall be applied.

iii) Communication technology (data link layer) and physical layerOptions available are represented by two major technologies:

- G3-PLC (with frequencies below 500 kHz) and
- IEEE P1901.2 HomePlug Green PHY (with frequencies between 2 and 30 MHz).

These technologies appear as convenient and available sufficiently soon. The two possible communication links are

- power wires between EV and EVSE (called “mains” link),
- the pilot line (CPLT) / Protective Earth (PE).

Decision on both layers need to be done together because they will influence each other. Preliminary theoretical analysis, simulation and physical tests show that HP GP on the pilot line is seen as the most promising technology. This technology provides a high level of robustness for a reliable communication together with future oriented high data rate.

ACEA agreement: Concentrate all efforts on of IEEE 1901 Profile Green PHY on CPLT/PE to be operational as soon as possible with a demand for further tests needed to confirm this direction.

Note: No such communication should be mandatory to enable charging. Indeed, it is important to enable AC charging as soon as the vehicle is compliant with IEC 61851-1 standard, in terms of pilot line notably, in all countries and places.

iv) **Wireless communication for conductive charging**

For launching the market, the OEMs have decided to select a PLC technology for the EV/EVSE communication. Deeper investigations are required for the future for introducing a wireless communication for this communication.

Wireless communication may be a solution for the future (e.g. for inductive charging) or for company specific extensions and business cases, so it should be left to the competitive area of additional services offer by each OEM. It also represents existing technology that may be carried out over from conventional vehicles.

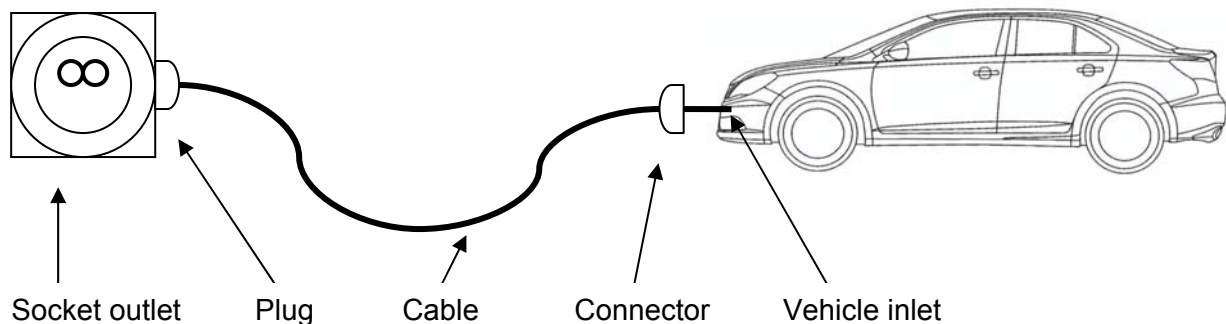
As a complement of conductive charging, the wireless communication does not cover the charge and control mechanism, neither in AC (61851-1) nor in DC (61851-23/24).

Nevertheless, according to the current state of the art, the PLC communication is seen as the main path of the EV/EVSE communication, when the EVSE is equipped.

ACEA agreement: Keeping PLC technology for main vehicle-EVSE communication.

Annex II [to ACEA position]**Vocabulary and abbreviations**

To ensure clear communication, ACEA stressing the use of common language with following terminology:

**Explanatory notes:**

AC – alternating current (movement of electric charge in periodically reverses direction)

DC – direct current (movement of electric charge in one direction)

ISO/IEC 15118 – international standard for EV charging communication protocol between electric vehicle and grid, focusing on providing a solution for link between the EV and the charge spot.

IEC 61851-24 – international standard which focus on DC control communication protocol between off-board DC charger and electric vehicle.

IEC 61851-1 – IEC standard on general requirements for electric vehicle conductive charging system

V2G – vehicle-to-grid

PLC – Power Line Communication

EVSE – Electric Vehicle Supply Equipment - conductors, including the phase, neutral and protective earth conductors, the EV couplers, attachment plugs, and all other accessories, devices, power outlets or apparatuses installed specifically for the purpose of delivering energy from the premises wiring to the EV and allowing communication between them if required (according to ISO/IEC 61851-1 standard).

“G3” and **“HP GP - Home Plug Green PHY”** – two different power line communication technologies

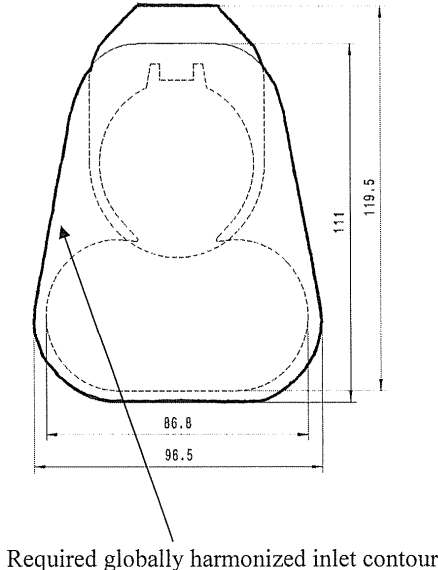
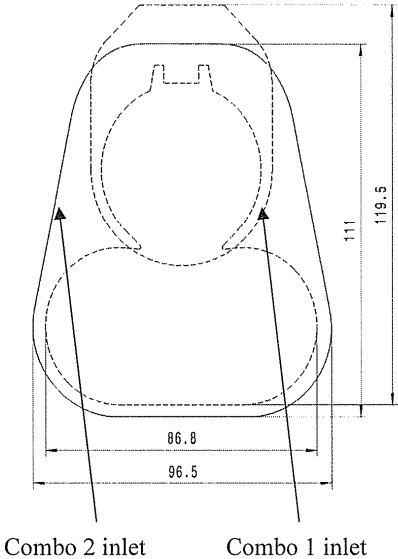
CPLT – Control PiLoT line used for control and safety signals

PE – Protective Earth

Annex III [to ACEA position]

Definitions of a global envelope profile

Global technical specification on "envelope" – vehicle inlet – for global solution



E.3 ACEM – The Motorcycle Industry in Europe

ACEM, the Motorcycle Industry in Europe, is the association representing the interests and combined skills of 12 manufacturers producing a total of 25 motorcycle, scooter, and moped brands. The members of ACEM account for 90% of the production and up to 80% of the European powered two-wheeler market. The powered two-wheeler sector employs 150.000 people in the EU. ACEM also represents main manufacturers of tricycles and quadricycles. (More info on www.acem.eu)

ACEM members are willing to contribute to the debate on standards for electrically chargeable powered two- and three-wheelers, and quadricycles.

ACEM members firmly support the development of standards with their expected positive effects in terms of comfort for the consumers, cost reduction for all stakeholders, optimum safety, and ensuring level playing field among manufacturers. Industrial and economic factors specific to the relatively small and fragmented PTW market, would clearly plea for the development of international standards. EU standards may be considered as short term pragmatic alternatives, especially in case of unreasonable or incompatible constraints imposed by the international level.

The following requirements are based on today's best knowledge of the current situation and state of technical development.

General requirements

Standardization activities should clearly distinguish between requirements applicable for vehicles (type approval) and infrastructure (LVD, EMC, ...), especially for electrical safety.

The standards should define the responsibilities when EV batteries are connected to the grid and are being used as buffer to cater for imbalance on the grid.

Standardised communication protocols for the vehicle to grid connection should allow swift charging, billing, etc.

Clear position of which safety and EMC standards (or elements of standard) should be applicable for on and off-board chargers.

Application of the battery requirements for minimum and maximum charging levels when connected to the grid.

Specific requirements

Mode 1 is an efficient re-charging means for powered two- and three-wheelers. Powered two- and three-wheelers and quadricycles do not always need very sophisticated and fast charging systems as battery capacity is much lower than for cars.

ACEM Members will seek for common specifications for on-board chargers as well as for standardised specifications for off-board chargers and connectors to the vehicles. This harmonisation should be achieved as quickly as possible in order to have appropriate and safe battery charging.

If no uniform charging system can be developed, the infrastructure should ensure interoperability of different charging systems. The use of adapters for low power charging should also be considered.

Charging infrastructure must be easy and cheap in order to allow it to be installed at enough places with public access (e.g., parking places).

The wall box should have the following characteristics:

- Domestic/home socket-outlet (4 pieces), lockable during charging process;
- ≥ 3 kW charging power;
- space for 4 powered two-wheelers in front of a wall box (safe and flat base compatible with vehicle stand, with security anchor to attach antitheft devices);
- Connection cord-set protected from vandalism.

E.4 Eurelectric

European electricity industry views on charging Electric Vehicles

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 cord-sets 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 technology¹*".

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

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.

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.

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/ampereage 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:

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

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

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 cord-set to be loose, using high power means that the charging cord-set 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 curbside 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.

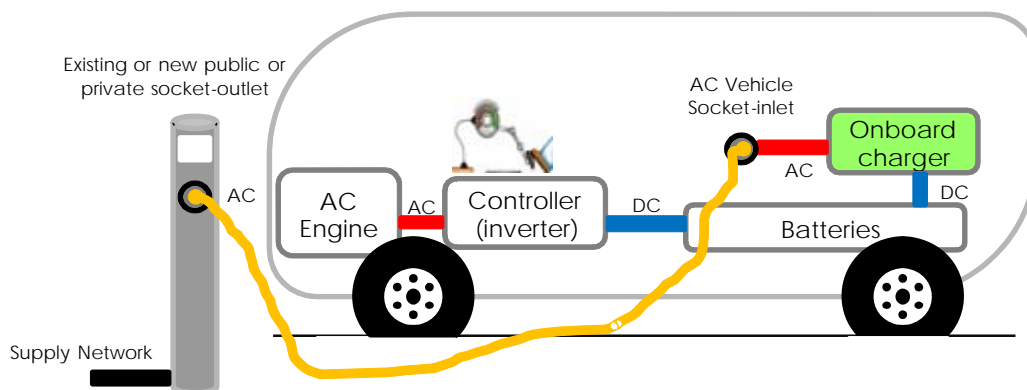


Figure 1 – The picture shows the main EV components involved in charging and locomotion. When charging at normal power level, the onboard charger receives AC power and transforms it into DC on the way to the battery. The power from the onboard charger can range between 1.5 and 3.5kW. The controller of 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

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.

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.

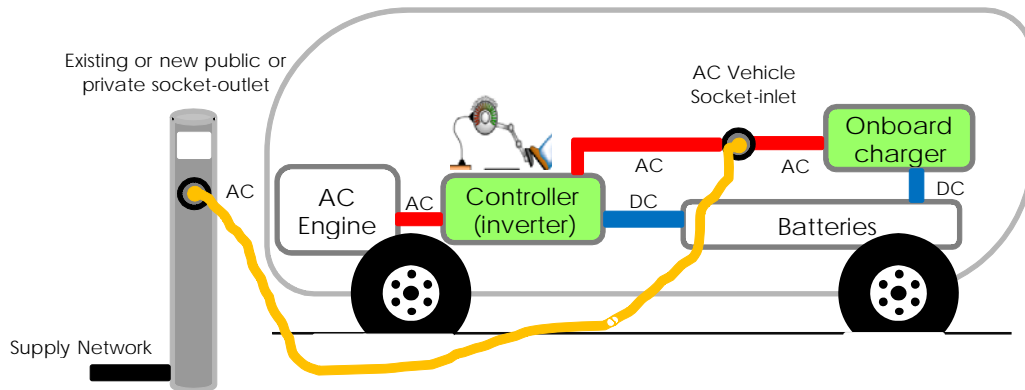


Figure 2 – The picture displays the charging scenario for either medium or high power AC charging. In this case the vehicle can use either a high power onboard charger for currents higher than 16A, or use the drive train controller inverter (with additional components) to achieve the conversion of AC 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.

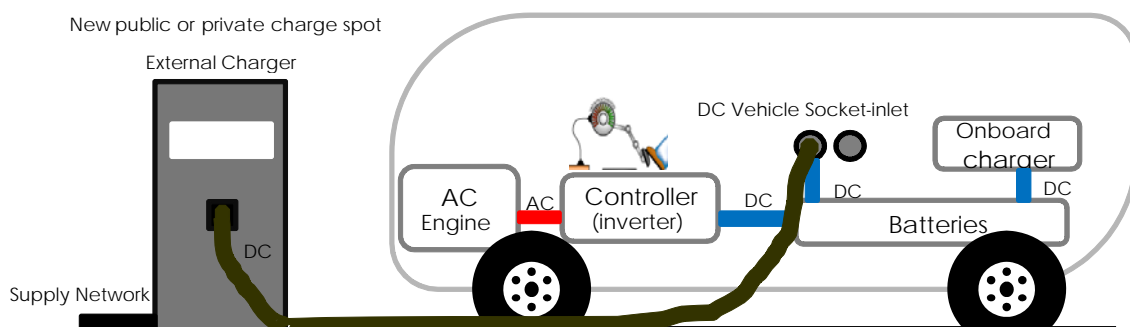


Figure 3 - Example of a high power DC charge using an external charger which converts AC power from the grid to DC voltage and current appropriate to the vehicle battery. The charger is directly connected to the battery but the voltage and current are controlled by the vehicle Battery Management System (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 cord-set is fitted with an In-Cable Control Box (ICCB) at the cord-set 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 charging⁶ 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.

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

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.

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	400 V	400 V	400 V	400 V	400v	400 V	400 V	400	400 V	400	400 V	400 V	400V	400 V	380/400
	1 phase	230 V	230 V	230 V	230 V	230v	230 V	230 V	230	230 V	230	230 V	230 V	230V	230 V	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	x
	1 phase	16A-20A	max 63A	x		x				6-25 A			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		x 500 mA	new	new	
	usually yes	x		since 2004	x			x				since 1995	x 30 mA		x	x
	usually no						x									
Voltage																
Voltage	3 phase	400 V	400 V	400 V	400 V	400v	400 V	400 V	400V	400 V	400V	400 V	400 V	400V	400 V	380/400
	1 phase	230 V	230V	230 V	230V	230v	230 V	230V	230V	230 V	230V	230 V	230V	230V	230 V	220/230
Line from station to household	3 phase	x	x	x	x	x	x	x	x			x	x	x	x	x
	1 phase									max. size of fuse in transformer station						
	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 ...) 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 ... 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	usually 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	A(since 1995) 1000V	x(since 1995)	x	x	x	x	x
Voltage	3 phase	400V	400V	400 V	400 V	400-420v	400 V	400 V(all new)	400 V	400 V	400 V	400 V	400 V	400 V
	1 phase	230V	230V	220 - 230 V		220-230v	230 V	230 V	230 V	230V	230 V	230 V	230 V	230 V
line from station to household	3 phase			x	x	x	x	x	x	x	400V	x	x	x
	1 phase	x	x ⁴			(x) rare in rural area					230V			
	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(rurban) 250A; R(ural) 125A	80 - 250A	80 A - 250 A
typ rating of the station	power	100-400 rural 400-630kVA urban	200/400kV A	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 ... 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)

Annex F

List of regulations and standards

F.1 Main regulatory texts in regard to vehicles M & N categories

Table F.1 lists the main regulatory texts setting the EC requirements for type-approval of vehicles and UN-ECE Regulations recognised as an alternative to an EC type-approval granted under the relevant directive in regard to vehicles of M & N categories.

F.2 Requirements for type approval of motorcycles and scooters

A system of mandatory EC "whole vehicle" type approval was originally framed under Directive 92/61/EEC, as repealed and replaced by **Directive 2002/24/EC** (consolidated to 2005/30/EC).

The Directive requires all motorcycles and scooters to be approved in to a selection of separate technical directives in respect of various systems and components, and then approved in complete form as a whole vehicle.

This will allow the registration of an approved vehicle in all EU Member States.

The Framework Directive covers 2, 3 and some light 4 wheeled vehicles.

Table F.2 lists the requirements for the purpose of vehicle type-approval for motorcycles and scooters.

F.3 Standards addressing specific topics related to EV-HEV

Table F.3 lists (international) standards developed within the main technical committees of CEN, CENELEC, ISO, IEC, SAE and UL related to EV components, EV performance and safety specifications. Apart from identifying standards that are essential for electric vehicle development, this list will also make it possible to identify fields requiring complementary developments following the latest technological developments.

Table F.1 – List of main regulatory texts setting the EC requirements for type-approval of vehicles and UN-ECE Regulations recognised as an alternative to an EC type-approval granted under the relevant directive in regard to vehicles of M & N categories

	Subject	EU Directives	UNECE Regulations deemed to be equivalent		Requirements for the approval of vehicles and/or separate technical units		Comments
		Mother Directive	Basic UNECE Regulation	Series of amendments	Same requirements as applied to internal combustion engine vehicle	Specific requirements applied to electrical vehicle	
1	Permissible sound level	70/157/EEC	51	R02 S07	X		
	Replacement silencing systems		59	00			NOTE 1
2	Emissions	70/220/EEC	83	06			NOTE 1
	Replacement catalytic converters		103	00			NOTE 1
2a	Emissions (Euro 5 and 6) light-duty vehicles/access to information	Reg. (EC) 715/2007			X	X	
3	Fuel tanks/rear protective devices	70/221/EEC	34	02			NOTE 1
	LPG tanks		67	01			NOTE 1
	CNG tanks		110	00			NOTE 1
	Rear protective device		58	01			NOTE 1
4	Rear registration plate space	70/222/EEC			X		
5	Steering effort	70/311/EEC	79	R02 C01	X		
6	Door latches and hinges	70/387/EEC	11	R03 C01	X		
7	Audible warning	70/388/EEC	28	R00 S03	X		
8	Indirect vision devices	2003/97/EC	46	R03 C01	X		
9	Braking	71/320/EEC	13	R11 S05	X	X	
	Braking		13H	R00 S11	X	X	
	Brake linings		90	R02 C01	X		

	Subject	EU Directives	UNECE Regulations deemed to be equivalent		Requirements for the approval of vehicles and/or separate technical units		Comments
		Mother Directive	Basic UNECE Regulation	Series of amendments	Same requirements as applied to internal combustion engine vehicle	Specific requirements applied to electrical vehicle	
10	Radio interference (electromagnetic compatibility)	72/245/EEC	10	R03 S01	X	X	
11	Diesel smoke	72/306/EEC	24	03			NOTE 1
12	Interior fittings	74/60/EEC	21	R01 S03	X		
13	Anti-theft	74/61/EEC	18	R03 S02	X		
	Anti-theft and immobiliser		116	R00 S03	X		
	Vehicle Alarm Systems		97	R01 S06	X		
			116	R00 S03	X		
14	Behaviour of steering device under impact	74/297/EEC	12	R04	X	X	
15	Seat strength	74/408/EEC	17	R08	X		
16	Exterior projections	74/483/EEC	26	R03 S01	X		
17	Speedometer and reverse gear	75/443/EEC	39	R00 S05	X		
18	Plates (statutory)	76/114/EEC			X		
19	Seat-belt anchorages	76/115/EEC	14	R07 S01	X		
20	Installation of lighting and light signalling devices	76/756/EEC	48	R05	X		
21	Retro reflectors	76/757/EEC	3	R02 S12	X		
22	End-outline, front-position (side), rear-position (side), stop, side marker, daytime running lamps	76/758/EEC	7	R02 S18	X		
	Daytime running lamps		87	R00 S15	X		
	Side marker lamps		91	R00 S13	X		

		EU Directives	UNECE Regulations deemed to be equivalent		Requirements for the approval of vehicles and/or separate technical units		Comments
	Subject	Mother Directive	Basic UNECE Regulation	Series of amendments	Same requirements as applied to internal combustion engine vehicle	Specific requirements applied to electrical vehicle	
23	Direction indicators	76/759/EEC	6	R01 S21	X		
24	Rear registration plate lamps	76/760/EEC	4	R00 S14	X		
25	Headlamps (including bulbs)	76/761/CEE	1	R03	X		
	Headlamps (sealed beam)		5	R02 S07	X		
	Headlamps (H1, H2, H3, HB3, HB4, H7, and/or H8, H9,HIR1, HIR2 and/or H11)		8	R05	X		
	Headlamps (H4)		20	R03	X		
	Headlamps (halogen sealed beam)		31	R02 S07	X		
	Filament lamps for use in approved lamp units		37	R03 S36	X		
	Headlamps with gas-discharge light sources		98	R01	X		
	Gas-discharge light sources for use in approved gas-discharge lamp units		99	R00 S06	X		
	Headlamps (asymmetrical passing beam)		112	R01	X		
	Adaptative front-lighting systems		123	R01 C01	X		
26	Front fog lamps	76/762/EEC	19	R04	X		
27	Towing hooks	77/389/EEC			X		
28	Rear fog lamps	77/538/EEC	38	R00 S15	X		
29	Reversing lamps	77/539/EEC	23	R00 S17	X		
30	Parking lamps	77/540/EEC	77	R00 S14	X		
31	Seat-belts and restraint systems	77/541/EE	16	R06 S01	X		
	Child restraints		44	R04 S04	X		

	Subject	EU Directives	UNECE Regulations deemed to be equivalent		Requirements for the approval of vehicles and/or separate technical units		Comments
		Mother Directive	Basic UNECE Regulation	Series of amendments	Same requirements as applied to internal combustion engine vehicle	Specific requirements applied to electrical vehicle	
32	Front/Forward vision	77/649/EEC	125	R00 S03	X		
33	Identification of controls, tell-tales and indicators	78/316/EEC	121	R00 S04	X		
34	Defrost/demist	78/317/EEC			X		
35	Wash/wipe	78/318/EEC			X		
36	Heating systems	2001/56/EC	122	R00 S02	X		if fitted
37	Wheel guards	78/549/EEC			X		
38	Head restraints	78/932/EE	25	R04	X		
	Head restraints (combined with seats)		17	R08	X		
39	CO2 emissions/fuel consumption	80/1268/EEC	101	R01	X	X	
40	Engine power	80/1269/EEC	85	R00 S5	X	X	
41	Emissions (Euro IV and V) heavy duty vehicles	2005/55/EC	49	04			NOTE 1
42	Lateral protection	89/297/EEC	77	00			NOTE 1
43	Spray-suppression systems	91/226/EEC			X		
44	Masses and dimensions (cars)	92/21/EEC			X		
45	Safety glazing	92/22/EEC	43	R00 S13	X		
46	Tyres, motor vehicles and their trailers	92/23/EEC	30	R02 S16	X		
	Tyres, commercial vehicles and their trailers		54	R00 S17	X		
	Temporary-use spare wheels/tyres		64	R02 C01	X		
	Rolling sound		117	R02 C01	X		

	Subject	EU Directives	UNECE Regulations deemed to be equivalent		Requirements for the approval of vehicles and/or separate technical units		Comments
		Mother Directive	Basic UNECE Regulation	Series of amendments	Same requirements as applied to internal combustion engine vehicle	Specific requirements applied to electrical vehicle	
47	Speed limitation devices	92/24/EEC	89	R00 S02	X		
48	M and D (other than vehicles referred to in item 44)	97/27/EC					NOTE 1
49	External projections of cabs	92/114/EEC					
50	Couplings	94/20/EC	55	R01 S02	X		
	Close-coupling device		102	R00	X		
51	Flammability	95/28/EC	118	R01 A1	X		
52	Buses and coaches	2001/85/EC	107	03			NOTE 1
	Strength of superstructure (buses and coaches)		66	02			NOTE 1
53	Frontal impact	96/79/EC	94	R02	X	X	
54	Side impact	96/27/EC	95	R03	X	X	
55	empty						
56	Vehicles intended for the transport of dangerous goods	98/91/EC	105	R05	X		if dedicated to DGT
57	Front under-run protection	2000/40/EC	93	R00			
58	Pedestrian protection	Reg. (EC) 78/2009			X		
59	Recyclability	2005/64/EC			X		
60	empty						
61	Air-conditioning system	2006/40/EC			X		
62	empty						

	Subject	EU Directives	UNECE Regulations deemed to be equivalent		Requirements for the approval of vehicles and/or separate technical units		Comments
		Mother Directive	Basic UNECE Regulation	Series of amendments	Same requirements as applied to internal combustion engine vehicle	Specific requirements applied to electrical vehicle	
63	General safety	Reg. (EC) 661/2009			X		
	Uniform provisions concerning the approval of battery electric vehicles with regard to specific requirements for construction and functional safety		100	R01		[X]	
	Measurement of the maximum speed		68	R01 C1	X		
	Replacement wheels for passenger cars		124	R00 S01	X		
	Uniform provisions concerning the approval of partitioning systems to protect passengers against displaced luggage, supplied as non original vehicle equipment		126	R00	X		
NOTE 1 Not consistent for EV							

Table F.2 – List of requirements for the purpose of vehicle type-approval for motorcycles and scooters

The vehicle components and characteristics on the exhaustive list below are followed by "CONF" if their conformity with the manufacturer's data has to be checked or by "SD" if their conformity with requirements laid down in Community legislation has to be checked.

N°	Subject	Term	Directive (if applicable)	Comments
1	Make	CONF		
2	Type/variant/version	CONF		
3	Name and address of vehicle manufacturer	CONF		
4	Name and address of vehicle manufacturer's authorised representative, if any	CONF		
5	Category of vehicle (*)	CONF	2002/24/EC	
6	Number of wheels and their position in case of three-wheel vehicle	CONF		
7	Outline drawing of frame	CONF		
8	Name and address of engine manufacturer (if different from vehicle manufacturer)	CONF		
9	Make and description of engine	CONF		
10	Type of engine ignition	CONF		
11	Engine operating cycle (**)	CONF		
12	Type of engine cooling	CONF		
13	Type of engine lubrication (**)	CONF		
14	Number and configuration of cylinders or stators (in the case of rotary-piston engine) in the engine (**)	CONF		
15	Bore, stroke, cylinder capacity or volume of combustion chambers (in the case of rotary-piston engine) in the engine (**)	CONF		
16	Full diagram of the engines induction system (**)	CONF		
17	Engine compression ratio (**)	CONF		
18	Maximum torque and maximum net power of engine, whether this is: - of the spark-ignition or compression-ignition type, or - electric	SD CONF	95/1/EC	

N°	Subject	Term	Directive (if applicable)	Comments
19	Anti-tampering measures for mopeds and motorcycles	SD	97/24/EC C7	
20	Fuel tank (**)	SD	97/24/EC C6	
21	Traction battery/ies	CONF		
22	Carburettor or other engine fuel supply system (type and make) (**)	CONF		
23	Electric system (nominal voltage)	CONF		
24	Generator (type and maximum output) (**)	CONF		
25	Maximum design speed of the vehicle	SD	95/1/EC	
26	Masses and dimension	SD	93/93/EEC	Special prov. for EV
27	Coupling devices and their attachment	SD	97/24/EC C10	
28	Anti-air pollution measures (**)	SD	97/24/EC C5	
29	Tyres	SD	97/24/EC C1	
30	Transmission	CONF		
31	Braking system	SD	93/14/EEC	
32	Installation of lighting and light-signalling devices on the vehicle	SD	93/92/EEC	
33	Lighting and light-signalling devices on the vehicle the mandatory or optional presence of which is laid down in the installation requirements under heading No 32	SD	97/24/EC C2	
34	Audible warning device	SD	93/30/EEC	
35	Position for the mounting of rear registration plate	SD	93/94/EEC	
36	Electromagnetic compatibility	SD	97/24/EC C8	
37	Sound level and exhaust system (**)	SD	97/24/EC C9	
38	Rear-view mirror(s)	SD	97/24/EC C4	
39	External projections	SD	97/24/EC C3	
40	Stand (except in case of vehicles having three or more wheels)	SD	93/31/EEC	
41	Devices to prevent unauthorised use of the vehicle	SD	93/33/EEC	

N°	Subject	Term	Directive (if applicable)	Comments
42	Windows; windscreen wipers; windscreen washers; devices for de-icing and de-misting for three-wheel mopeds, motor tricycles and quadricycles with bodywork	SD	97/24/EC C12	
43	Passenger hand-hold for two-wheel vehicles	SD	93/32/EEC	
44	Anchorage points for safety belts and safety belts for three-wheel mopeds, motor tricycles and quadricycles with bodywork	SD	97/24/EC C11	
45	Speedometer	SD	2000/7/EC	
46	Identification of controls, tell-tales and indicators	SD	93/29/EEC	
47	Statutory inscriptions (content, location and method of affixing)	SD	93/34/EEC	
<p>(*) In the case of twin-propulsion vehicles, if the two systems of propulsion are such that the vehicle falls within the definition either of a moped or of a motorcycle, motor tricycle or quadricycle, the latter definitions shall apply to it.</p> <p>(**) Electrically-propelled vehicles are not subject to the requirements relating to this heading. This does not apply to twin-propulsion vehicles in which one of the systems of propulsion is electric and the other thermic.</p>				
<p>NOTE The separate directives will lay down specific requirements for low-performance mopeds, i.e. mopeds with pedals, with an auxiliary engine of power not exceeding 1 kW and a maximum design speed not exceeding 25 km/h. These specific characteristics will apply in particular to the components and characteristics covered by heading N° 18, 19, 29, 32, 33, 34, 41, 43 and 46.</p>				

Table F.3 – Identified existing standards impacting EV-HEV with indication of sector relevance**Key**Column 1, **Type** of standard:

- A - General Information
- B - Test Methods
- C - Safety or EMC requirements
- D - Miscellaneous

Column 2, **Classification**:

- 1 Utmost important
- 2 Important
- 3 May have some interest
- 4 Superseded

Type	Class.	Technical domain / Standardisation corpus	EN (CEN)	EN (CENELEC)	ISO	IEC	SAE	UL	Comments
		Electric road vehicle – Vocabulary							
A	2	Electric road vehicles – Vocabulary			ISO 8713:2005 under revision				
A	3	Electrically propelled road vehicles - Terminology	EN 13447:2001		ISO 8713				
A	2	Graphical symbols for use on equipment				IEC 60417			
A	2	Basic and safety principles for man-machine interface, marking and identification. Identification of conductors by colours or numerals.		EN 60446		IEC 60446			
A	3	Degrees of protection provided by enclosures (IP Code)		EN 60529		IEC 60529			
		Cycles, mopeds and motorcycles applications							
A	1	Electrically propelled mopeds and motorcycles — Terminology			ISO/WD 13062				Vehicles of Category L
A	1	Electrically propelled mopeds and motorcycles - Safety specifications			ISO/WD 13063				Vehicles of Category L
A	1	Battery-electric mopeds and motorcycles, Performance - Reference energy consumption and range			ISO/WD 13064-1				Vehicles of Category L
B	1	Battery-electric mopeds and motorcycles, Performance - Road operating characteristics			ISO/WD 13064-2				Vehicles of Category L
B	1	Cycles - Electrically power assisted cycles - EPAC Bicycles	EN 15194:2009						Vehicles of Category L

Type	Class.	Technical domain / Standardisation corpus	EN (CEN)	EN (CENELEC)	ISO	IEC	SAE	UL	Comments
C	2	Safety requirements for secondary batteries and battery installations – Part 4: Batteries for use in portable appliances		EN 50272-4					Vehicles of Category L
A	2	Secondary cells and batteries containing alkaline or other non-acid electrolytes Mechanical tests for sealed portable secondary cells and batteries		EN 61959		IEC 61959			Vehicles of Category L
A	2	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Secondary lithium cells and batteries for portable applications		EN 61960		IEC 61960			Vehicles of Category L
C	2	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications		EN 62133		IEC 62133			Vehicles of Category L
A	2	Secondary cells and batteries containing alkaline or other non acid electrolytes – Design and manufacturing recommendations for portable batteries made from sealed secondary cells				IEC/TR 62188			Vehicles of Category L
		Batteries							
A	2	General requirements for battery powered trucks	EN 1175-1						
C	3	Safety requirements for secondary batteries and battery installations – Part 1: General safety information		EN 50272-1					
C	3	Safety requirements for secondary batteries and battery installations – Part 2: Stationary batteries		EN 50272-2					
C	2	Safety requirements for secondary batteries and battery installations – Part 3: Traction batteries		EN 50272-3					
C	1	Electric road vehicles - Safety specifications - Part 1: On-board rechargeable energy storage system (RESS)			ISO 6469-1: 2009 Ed. 2				
B	1	Electrically propelled road vehicles — Test specification for lithium-ion traction battery packs and systems — Part 1: High power applications			ISO/DIS 12405-1 under revision				

Type	Class.	Technical domain / Standardisation corpus	EN (CEN)	EN (CENELEC)	ISO	IEC	SAE	UL	Comments
B	1	Electrically propelled road vehicles — Test specification for lithium-ion traction battery packs and systems — Part 1: High energy applications			ISO/WD 12405-2 under development				
C	3	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for large format secondary lithium cells and batteries for use in industrial applications				IEC 62619			
A	2	International Electrotechnical Vocabulary (IEV) - Part 482: Primary and secondary cells and batteries				IEC 60050-482			
A	2	International Electrotechnical Vocabulary (IEV) - Chapter 486:Secondary cells and batteries				IEC 60050-486			
A	3	Secondary cells and batteries containing alkaline or other non-acid electrolytes Sealed nickel-cadmium prismatic rechargeable single cells		EN 60622		IEC 60622			
A	3	Secondary cells and batteries containing alkaline or other non-acid electrolytes Vented nickel-cadmium prismatic rechargeable single cells		EN 60623		IEC 60623			
A	2	Secondary cells and batteries containing alkaline or other non-acid electrolytes Guide to the designation of current in alkaline secondary cell and battery standards		EN 61434		IEC 61434			
D	1	Marking of secondary cells and batteries with the international recycling symbol ISO 7000-1135 and indications regarding directives 93/86/EEC and 91/157/EEC		EN 61429		IEC 61429			
A	3	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Portable sealed rechargeable single cells – Part 1: Nickel-cadmium		EN 61951-1		IEC 61951-1			
A	2	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Portable sealed rechargeable single cells– Part 2 :Nickel-metal hydride		EN 61951-2		IEC 61951-2			

Type	Class.	Technical domain / Standardisation corpus	EN (CEN)	EN (CENELEC)	ISO	IEC	SAE	UL	Comments
A	3	Secondary cells and batteries containing alkaline or other non-acid electrolytes Mechanical tests for sealed portable secondary cells and batteries		EN 61959		IEC 61959			
A	2	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Secondary lithium cells and batteries for portable applications		EN 61960		IEC 61960			
B	2	Secondary batteries (except lithium) for the propulsion of electric road vehicles - Part 1: Performance and endurance tests		EN 61982-1		IEC 61982-1 under revision			
B	1	Secondary batteries for the propulsion of electric road vehicles - Part 2: Dynamic discharge performance test and dynamic endurance test		EN 61982-2		IEC 61982-2			
B	1	Secondary batteries for the propulsion of electric road vehicles - Part 3: Performance and life testing (traffic compatible, urban use vehicles)		EN 61982-3		IEC 61982-3			
B	2	Secondary batteries for the propulsion of electric road vehicles – Part 1: Test parameters				IEC 61982-4			IEC 62660-1
B	2	Secondary batteries for the propulsion of electric road vehicles – Part 5: Safety testing for lithium-ion cells and batteries				IEC 61982-5			IEC 62660-2
C	2	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications				IEC 62133			
A	2	Secondary cells and batteries containing alkaline or other non acid electrolytes – Design and manufacturing recommendations for portable batteries made from sealed secondary cells				IEC/TR 62188			
A	3	Secondary cells and batteries containing alkaline or other non-acid electrolytes Nickel-cadmium prismatic secondary single cells with partial gas recombination		EN 62259		IEC 62259			
C	1	Safety of primary and secondary lithium cells and batteries during transport		EN 62281		IEC 62281			

Type	Class.	Technical domain / Standardisation corpus	EN (CEN)	EN (CENELEC)	ISO	IEC	SAE	UL	Comments
B	1	Secondary lithium-ion cells for the propulsion of electric road vehicles - Part 1: Performance testing		EN 62660-1		IEC 62660-1			
B	1	Secondary lithium-ion cells for the propulsion of electric road vehicles - Part 2: Reliability and abuse testing		EN 62660-2		IEC 62660-2			
B	1	Electric double-layer capacitors for use in hybrid electric vehicles -Test methods for electrical characteristics		EN 62576		IEC 62576			
C	3	Safety requirements for secondary batteries and battery installations – Part 2: Stationary batteries				IEC 62485-2			
C	1	Safety requirements for secondary batteries and battery installations – Part 3: Traction batteries				IEC 62485-3			
		Safety requirements for secondary batteries and battery installations - Part 4: Batteries for use in portable appliances				IEC 62485-4			
A	2	Possible safety and health hazards in the use of alkaline secondary cells and batteries - Guide to equipment manufacturers and users				IEC/TS 61438			
B	2	Life Test for Automotive Storage Batteries					J 240		
A	2	Storage Batteries					J 537		
B	2	Test Procedure for Battery Flame Retardant Venting Systems					J 1495		
A	2	Recommended Practice for Packaging of Electric Vehicle Battery					J 1797		
A	2	Recommended Practice for Performance Rating of Electric Vehicle					J 1798		
A	3	Battery Modules					J1766:2005		
B	3	Life Test for Heavy-Duty Storage Batteries					J 2185		
B	2	Comprehensive Life Test for 12 V Automotive Storage Batteries					J 2801		
B	2	Life Cycle Testing of Electric Vehicle Battery Modules					J 2288		
A	2	Electric Driver Battery Pack System Functional Guidelines					J2289:2000		
B	2	Electric Vehicle Battery Abuse Testing					J 2464:1999		

Type	Class.	Technical domain / Standardisation corpus	EN (CEN)	EN (CENELEC)	ISO	IEC	SAE	UL	Comments
B	2	Vibration Testing of Electric Vehicle Batteries					J 2380		
C	1	Electric and Hybrid vehicle propulsion battery system standard - Lithium based rechargeable cells					J2929		
B	1	Safety of Lithium-Ion Batteries – Testing						UL1642:2005	
A	1	Outline of Investigation for Batteries for use in Electric Vehicles						UL 2580:2009	
		Charging systems							
C	1	Low-voltage switchgear and controlgear assemblies		EN 60439 & EN 61439 series		IEC 60439 & IEC 61439 series			60439 being replaced by 61439
A	1	Low-voltage switchgear and controlgear – Part 1: General rules		EN 60947-1		IEC 60947-1			
A	1	Low-voltage switchgear and controlgear – Part 2 : Circuit-breakers		EN 60947-2		IEC 60947-2			
A	1	Low-voltage switchgear and controlgear - Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units		EN 60947-3		IEC 60947-3			
A	1	Electric vehicle conductive charging system - Part 1: General requirements		EN 61851-1		IEC 61851-1			EMC requirements are included into this standard and part of them are safety requirements
C	1	Electric vehicle conductive charging system - Part 21: Electric vehicle requirements for conductive connection to an a.c./d.c. supply		EN 61851-21		IEC 61851-21 under revision			
C	1	Electric vehicle conductive charging system - Part 22: AC electric vehicle charging station		EN 61851-22		IEC 61851-22 under revision			EMC requirements are included into this standard and part of them are safety requirements
A	1	Electric vehicle conductive charging system - Part 23: d.c. electric vehicle charging station				IEC 61851-23 New Work Item approved			

Type	Class.	Technical domain / Standardisation corpus	EN (CEN)	EN (CENELEC)	ISO	IEC	SAE	UL	Comments
A	2	Electric vehicle conductive charging system - Part 24: Communication protocol between off-board charger and electric vehicle				IEC 61851-24			W project
D	3	Uninterruptible power systems (UPS) - Part 2: Electromagnetic compatibility (EMC) requirements		EN 62040-2		IEC 62040-2			
A	1	Plugs, socket-outlets, vehicle couplers and vehicle inlets - Conductive charging of electric vehicles - Part 1: Charging of electric vehicles up to 250 A a.c. and 400 A d.c.		EN 62196-1:2003		IEC 62196-1 under revision			
A	1	Plugs, socket-outlets and vehicle couplers – Conductive charging of electricity vehicles – Part 2: Dimensional interchangeability requirements for a.c. pin and contact-tube accessories				IEC 62196-2 under development			
A	1	Conductive charging for electric vehicles - Part 1: D.C. charging station		CLC/TS 50457-1:2008					
A	1	Conductive charging for electric vehicles - Part 2: Communication protocol between off-board charger and electric vehicle		CLC/TS 50457-2:2008					
D	3	Industrial battery chargers						UL 1564: 2006	
A	2	Electric vehicle Charging System Equipment (2nd edition)						UL 2202: 2009	
D	2	Outline of Investigation for Electric Vehicle Supply Circuit						UL 2594: 2009	
A	2	Vehicle On-Board Charging Power Quality					J 2894		
		Wiring, connectors, controllers, rotating machines							
	1	Semiconductor converters - General requirements and line commutated converters - Part 1-1: Specification of basic requirements	EN 60146-1-1			IEC 60146-1-1			
C	1	Road vehicles – 60 V and 600 V single-core cables – Dimensions, test methods and requirements			ISO 6722				
C	1	Multi-core connecting cables – Part 1: Test methods and requirements for basic performance sheathed cables			ISO 4141-1				

Type	Class.	Technical domain / Standardisation corpus	EN (CEN)	EN (CENELEC)	ISO	IEC	SAE	UL	Comments
C	1	Multi-core connecting cables – Part 2: Test methods and requirements for high performance sheathed cables			ISO 4141-2				
A	1	Multi-core connecting cables – Part 3: Construction, dimensions and marking of unshielded sheathed low-voltage cables			ISO 4141-3				
C	1	Multi-core connecting cables – Part 4: Test methods and requirements for coiled cable assemblies			ISO 4141-4				
C	1	Road vehicles – Round, unshielded 60 V and 600 V multicore sheathed cables – Test methods and requirements for basic and high performance cables			ISO 14572				
D	2	Road vehicles – Data cables – Test methods and requirements			ISO/TS 16553				
C	1	Road vehicles – Circuit breakers – Part 1: Definitions and general test requirements			ISO 10924-1				
A	1	Road vehicles – Circuit breakers – Part 4: Medium circuit breakers with tabs (blade type), Form CB15			ISO 10924-4				
A	1	Electric cables - Low voltage energy cables of rated voltages up to and including 450/750 V		EN 50525 series-					Cables for general applications Superseding HD21 and HD22 series which correspond to IEC 60227 and IEC 60245 series
A	2	(all parts) Plugs, socket-outlets and couplers for industrial purposes		EN 60309		IEC 60309			
A	1	Plugs, socket-outlets and couplers for industrial purposes – Part 1: General requirements		EN 60309-1		IEC 60309-1			
A	1	Plugs, socket-outlets and couplers for industrial purposes – Part 2: Dimensional interchangeability requirements for pin and contact-tube accessories		EN 60309-2		IEC 60309-2			:

Type	Class.	Technical domain / Standardisation corpus	EN (CEN)	EN (CENELEC)	ISO	IEC	SAE	UL	Comments
A	1	Plugs, socket-outlets and couplers for industrial purposes – Part 4: Switched socket-outlets and connectors with or without interlock		EN 60309-4		IEC 60309-4			
A	1	Wiring and connectors for electric road vehicles				IEC/TR 60783			
A	1	Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests		EN 60664-1		IEC 60664-1			
A	1	Wiring and connectors for electric road vehicles				IEC/TR 60783			
A	1	Instrumentation for electric road vehicles				IEC/TR 60784			
A	1	Rotating machines for electric road vehicles				IEC/TR 60785			
B	2	Common test methods for insulating and sheathing materials of electric cables and optical cables		EN 60811 series		IEC 60811 series			
A	1	Plugs and socket-outlets for household and similar purposes				IEC 60884			
A	3	Conductors of insulated cables – Data for AWG and KCMIL sizes				IEC/TR 62602			
		60 V and 600 V Single Core Cables					J2183:2006		
A	2	High Voltage Primary Cable					J1654:2004		
A	2	High Voltage Automotive Wiring Assembly Design					J1673:1996		
A	2	Connections for High Voltage On-Board Road Vehicle Electrical Wiring					J1742:2005		
A	2	SAE Electric Vehicle Conductive Charge Coupler					J1772:2010		
A	2	SAE Electric Vehicle Inductively Coupled Charging					J1773:1999		
B	2	60 V and 600 V Single Core Cables – Test Methods					J2183:2006		
A	2	Round, Screened and Unscreened, 60 V and 600 V Multi-Core Sheathed Cables					J2501:2007		
A	2	Plugs, Receptacles and Couplers for EVs						UL 2251:2002	
A	2	Electric Vehicle Inductively Coupled Charging					J 1773		

Type	Class.	Technical domain / Standardisation corpus	EN (CEN)	EN (CENELEC)	ISO	IEC	SAE	UL	Comments
C	2	Electric equipment for the supply of energy to electric road vehicles using an inductive coupling – Part 1: General requirements				IEC 61980-1			
A	2	Electric equipment for the supply of energy to electric road vehicles using an inductive coupling – Part 2: Manual connection system using a paddle				IEC 61980-2			
A	2	On board electric power equipment for electric road vehicles				IEC 61981			
A	1	Road vehicles - Intelligent power switches - Part 1: High-side intelligent power switch			ISO 10483-1				
A	1	Road vehicles – Intelligent power switches – Part 2: Low-side intelligent power switch			ISO 10483-2				
A	1	Controllers for electric road vehicles				IEC/TR 60786			
		Electric road vehicles : Communication							
A	1	Road vehicles - Vehicle to grid communication interface - Part 1: General information and use-case definition			ISO/IEC 15118-1				2CD
A	1	Road vehicles -- Vehicle to grid Communication Interface -- Part 2: Technical protocol description and open systems interconnections (OSI) requirements			ISO 15118-2				CD
A	1	Information technology - Open Systems Interconnection - Basic Reference Model - Part 1: The Basic Model			ISO/IEC 7498-1	ISO/IEC 7498-1			
C	1	Information processing systems - Open Systems Interconnection -Basic Reference Model - Part 2: Security Architecture			ISO 7498-2				
A	1	Information technology - Open Systems Interconnection –Basic Reference Model - Part 3: Naming and addressing			ISO/IEC 7498-3	ISO/IEC 7498-3			
A	1	Information technology – Telecommunication and information exchange between systems – Power line communication (PLC) – High speed PLC medium access & control (MAC) and physical layer (PHY) – Part 1: General requirements			ISO/IEC 12139-1	ISO/IEC 12139-1			
A	1	Road vehicles – Extended data link security			ISO 15764				

Type	Class.	Technical domain / Standardisation corpus	EN (CEN)	EN (CENELEC)	ISO	IEC	SAE	UL	Comments
A	1	Coupling devices for power line carrier systems				IEC 60481			
A	1	Communication networks and systems in substations		EN 61850 series		IEC 61850 series			
A	1	IntelliGrid methodology for developing requirements for energy systems				IEC/PAS 62559			
A	2	Energy Transfer System for Electric Vehicles–Part 1: Functional Requirements and System Architectures					J 2293-1		
A	2	Energy Transfer System for Electric Vehicles–Part 2: Communication Requirements and Network Architecture					J 2293-2		
A	2	Power Line Carrier Communications for Commercial Vehicles					J 2497		
A	2	Use Cases for Communication between Plug-in Vehicles and the Utility Grid					J 2836/1		
A	2	Use Cases for Communication between Plug-in Vehicles and the Supply Equipment (EVSE)					J 2836/2		
A	2	Use Cases for Communication between Plug-in Vehicles and the Utility Grid for Reverse Power Flow					J 2836/3		
A	2	Communication between Plug-in Vehicles and the Utility Grid					J 2847/1		
A	2	Communication between Plug-in Vehicles and the Supply Equipment (EVSE)					J 2847/2		
A	2	Communication between Plug-in Vehicles and the Utility Grid for Reverse Power Flow					J 2847/3		
		Vehicle safety & personnel protection							
C	1	Electrically propelled road vehicles - Specific requirements for safety - Part 1: On board energy storage	EN 1987-1:1997						See ISO 6469 series below
C	2	Electrically propelled road vehicles - Specific requirements for safety - Part 2:Functional safety means and protection against failures	EN 1987-2:1997						
C	2	Electrically propelled road vehicles - Specific requirements for safety - Part 3: Protection of users against electrical hazards	EN 1987-3:1998						

Type	Class.	Technical domain / Standardisation corpus	EN (CEN)	EN (CENELEC)	ISO	IEC	SAE	UL	Comments
A	3	Proposals for the braking of electrical vehicles	CR 1955:1995						
		Electrically propelled road vehicles -- Safety specifications -- Part 1: On-board rechargeable energy storage system (RESS)			ISO 6469-1: 2009				
C	1	Electric road vehicles - Safety specifications - Part 2: Vehicle operational safety means and protection against failures			ISO 6469-2: 2009				
C	1	Electric road vehicles - Safety specifications - Part 3: Protection of persons against electric hazards			ISO 6469-3: 2001 + ISO 6469-3:2001/Cor 1:2003				
C	1	Electric road vehicles - Safety specifications - Part 3: Protection of persons against electric hazards			ISO 6469-3* ed. 2 under publication				
B	1	Road vehicles - Fuse-links - Part 1: Definitions and general test requirements			ISO 8820-1: 2008				
A	2	Road vehicles - Fuse-links - Part 2: User's guide			ISO 8820-2: 2005				
A	1	Road vehicles - Fuse-links - Part 3: Fuse-links with tabs (blade type) Type C (medium), Type E (high current) and Type F (miniature)			ISO 8820-3: 2010				
A	1	Road vehicles - Fuse-links - Part 4: Fuse-links with female contacts (type A) and bolt-in contacts (type B) and their test fixtures			ISO 8820-4: 2010				
B	1	Road vehicles - Fuse-links - Part 5: Fuse-links with axial terminals (Strip fuse-links) Types SF 30 and SF 51 and test fixtures			ISO 8820-5: 2007				
A	1	Road vehicles - Fuse-links - Part 6: Single-bolt fuse-links			ISO 8820-6: 2007				
A	1	Road vehicles - Fuse-links - Part 7: Fuse-links with tabs (Type G) with rated voltage of 450 V			ISO 8820-7: 2007				
A	1	IEC standard voltages				IEC 60038			
A	1	EC standard current ratings				IEC 60059			

Type	Class.	Technical domain / Standardisation corpus	EN (CEN)	EN (CENELEC)	ISO	IEC	SAE	UL	Comments
A	1	Basic and safety principles for man-machine interface, marking and identification – Coding principles for indicators and actuators				IEC 60073			
C	1	Protection against electrical shock – Common aspects for installation and equipment		EN 61140		IEC 61140			
A	1	Effects of current on human beings and livestock				IEC/TS 60479 series			
A	1	Low-voltage fuses – Part 1 : General requirements		EN 60269-1		IEC 60269-1			
A	3	Uninterruptible power systems (UPS) - Part 1: General and safety requirements for UPS		EN 62040-1		IEC 62040-1			
C	2	Uninterruptible power systems (UPS) - Part 2: Electromagnetic compatibility (EMC) requirements		EN 62040-2		IEC 62040-2			
B	3	Uninterruptible Power Systems (UPS) - Part 3: Method of specifying the performance and test requirements		EN 62040-3		IEC 62040-3			
A	1	Circuit breakers – Switched protective earth portable residual current devices for class I and battery powered vehicle applications				IEC 62335			
A	1	General requirements for residual current operated protective devices				IEC 60755			
A	1	Electrical accessories - Portable residual current devices without integral overcurrent protection for household and similar use (PRCDs)		HD 639		IEC 61540			
A	3	requirements for UPS used in operator access areas					J 2344:1998		
C	2	Personnel Protection Systems for EV Supply Circuits: Part 1: General Requirements						UL 2231-1:2002	
C	2	Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: Particular Requirements for Protection Devices for Use in Charging Systems						UL 2231-2:2002	
		Functional safety (Road vehicles)							
A	1	Road vehicles - Functional safety - Part 1: Vocabulary			ISO 26262-1				

Type	Class.	Technical domain / Standardisation corpus	EN (CEN)	EN (CENELEC)	ISO	IEC	SAE	UL	Comments
A	1	Road vehicles – Functional safety – Part 2: Management of functional safety			ISO 26262-2				
A	1	Road vehicles – Functional safety – Part 3: Concept phase			ISO 26262-3				
A	1	Road vehicles – Functional safety – Part 4: Product development :system level			ISO 26262-4				
A	1	Road vehicles – Functional safety – Part 5: Product development : hardware level			ISO 26262-5				
A	1	Road vehicles – Functional safety - Part 6: Product development : software level			ISO 26262-6				
A	1	Road vehicles – Functional safety - Part 7: Production and operation			ISO 26262-7				
A	1	Road vehicles – Functional safety - Part 8: Supporting processes			ISO 26262-8				
C	1	Road vehicles – Functional safety - Part 9: ASIL-oriented and safety-oriented analyses			ISO 26262-9				
A	1	Road vehicles – Functional safety - Part 10: Guideline			ISO 26262-10				
		EMC (Electro-magnetic compatibility)							
B	1	Road vehicles - Test methods for electrical disturbances from electrostatic discharge			ISO 10605				
A	1	Road vehicles - Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 1: General principles and terminology			ISO 11451-1				
B	1	Road vehicles - Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 2: Off-vehicle radiation sources			ISO 11451-2				
B	1	Road vehicles - Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 3: On-board transmitter simulation			ISO 11451-3				
A	1	Road vehicles - Vehicle test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 4: Bulk current injection (BCI)			ISO 11451-4				

Type	Class.	Technical domain / Standardisation corpus	EN (CEN)	EN (CENELEC)	ISO	IEC	SAE	UL	Comments
B	1	Road vehicles - Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 1: General principles and terminology			ISO 11452-1				
B	1	Road vehicles - Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 2: Absorberlined shielded enclosure			ISO 11452-2				
B	1	Road vehicles - Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 3: Transverse electromagnetic mode (TEM) cell			ISO 11452-3				
B	1	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 4: Bulk current injection (BCI)			ISO 11452-4				
B	1	Road vehicles - Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 5: Stripline			ISO 11452-5				
B	1	Road vehicles - Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 7: Direct radio frequency (RF) power injection			ISO 11452-7				
B	1	Road vehicles - Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 8: Immunity to magnetic fields			ISO 11452-8				
B	1	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 9: Portable transmitters			ISO 11452-9				
B	1	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 10: Immunity to conducted disturbances in the extended audio frequency range			ISO 11452-10				
B	1	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 11: Reverberation chamber			ISO 11452-11				

Type	Class.	Technical domain / Standardisation corpus	EN (CEN)	EN (CENELEC)	ISO	IEC	SAE	UL	Comments
C	1	Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)		EN 61000-3-2: 2006 + A1:2009+ A2:2009		IEC 61000-3-2			
C	1	Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage systems for equipment with rated current ≤ 16 A per phase and not subjected to conditional connection		EN 61000-3-3: 2008		IEC 61000-3-3			
C	4	Electromagnetic compatibility (EMC) - Part 3-4 Limits – Limitation of emission of harmonic currents in low-voltage power supply systems for equipment with rated current > 16 A				IEC/TS 61000-3-4			This technical report is replaced by IEC 61000-3-12 for equipment ≤ 75 A
C	1	Electromagnetic Compatibility (EMC) – Part 3-11 – Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage systems - Equipment with rated current ≤ 75 A per phase and subjected to conditional connection		EN 61000-3-11: 2000		IEC 61000-3-11			
C	1	Electromagnetic Compatibility (EMC) – Part 3-12 – Limits for harmonic current emissions produced by equipment connected to public low-voltage systems with input current > 16 A and ≤ 75 A per phase		EN 61000-3-12: 2005		IEC 61000-3-12			
A	2	Electromagnetic compatibility (EMC) – Part 4-1 – Testing and measurement techniques – Overview of IEC 61000-4 series		EN 61000-4-1		IEC 61000-4-1			
B	1	Electromagnetic compatibility (EMC) – Part 4-2 – Testing and measurement techniques – Electrostatic discharge immunity test		EN 61000-4-2		IEC 61000-4-2			
B	2	Electromagnetic compatibility (EMC) – Part 4-3 – Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test		EN 61000-4-3		IEC 61000-4-3			

Type	Class.	Technical domain / Standardisation corpus	EN (CEN)	EN (CENELEC)	ISO	IEC	SAE	UL	Comments
B	1	Electromagnetic Compatibility (EMC) – Part 4-4 – Testing and measurement techniques – Electrical fast transients/burst immunity test		EN 61000-4-4		IEC 61000-4-4			
B	1	Electromagnetic Compatibility (EMC) – Part 4-5 – Testing and measurement techniques – Surge immunity test		EN 61000-4-5		IEC 61000-4-5			
B	2	Electromagnetic Compatibility (EMC) – Part 4-6 – Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields		EN 61000-4-6		IEC 61000-4-6			
B	2	Testing and measurement techniques – General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto		EN 61000-4-7		IEC 61000-4-7			
B	1	Electromagnetic Compatibility (EMC) – Part 4-8 – Testing and measurement techniques – Power frequency magnetic field immunity test		EN 61000-4-8		IEC 61000-4-8			
B	1	Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests		EN 61000-4-11		IEC 61000-4-11			
B	1	Electromagnetic compatibility (EMC) - Part 4-13: Testing and measurement techniques - Harmonics and interharmonics including mains signalling at a.c. power port, low frequency immunity tests		EN 61000-4-13		IEC 61000-4-13			
B	2	Electromagnetic compatibility (EMC) - Part 4-15: Testing and measurement techniques – Flickermeter – Functional and design specifications		EN 61000-4-15		IEC 61000-4-15			
B	2	Electromagnetic compatibility (EMC) – Part 4-21: Testing and measurement techniques – Reverberation chamber test methods		EN 61000-4-21		IEC 61000-4-21			
A	2	Electromagnetic Compatibility (EMC) – Part 6-1 – Generic standards Immunity for residential, commercial and light-industrial environments		EN 61000-6-1:2007		IEC 61000-6-1:2005			

Type	Class.	Technical domain / Standardisation corpus	EN (CEN)	EN (CENELEC)	ISO	IEC	SAE	UL	Comments
A	1	Electromagnetic Compatibility (EMC) – Part 6-2 – Generic standards Immunity for industrial environments		EN 61000-6-2: 2005+ AC:2005		IEC 61000-6-2			
A	1	Electromagnetic Compatibility (EMC) – Part 6-3 – Generic standards Emission standard for residential, commercial and light-industrial environments		EN 61000-6-3: 2007		IEC 61000-6-3:2006			
A	2	Electromagnetic Compatibility (EMC) – Part 6-4 – Generic standards Emission standard for industrial environments		EN 61000-6-4: 2007		IEC 61000-6-4:2006			
A	1	Signalling on low-voltage electrical installations in the frequency range 3 kHz to 148,5 kHz. General requirements, frequency bands and electromagnetic disturbances		EN 50065-1:2001 +A1:2010					
A	1	Signalling on low-voltage electrical installations in the frequency range 3 kHz to 148,5 kHz - Part 2-1: Immunity requirements for mains communications equipment and systems operating in the range of frequencies 95 kHz to 148,5 kHz and intended for use in residential, commercial and light industrial environments		EN 50065-2-1: 2003 + A1:2005+ AC:2003					
A	1	Signalling on low-voltage electrical installations in the frequency range 3 kHz to 148,5 kHz - Part 2-2: Immunity requirements for mains communications equipment and systems operating in the range of frequencies equipment and systems operating in the range of frequencies 95 kHz to 148,5 kHz and intended for use in industrial environments		EN 50065-2-2: 2003 + A1:2005 + AC:2003					
A	1	Signalling on low-voltage electrical installations in the frequency range 3 kHz to 148,5 kHz - Part 2-3: Immunity requirements for mains communications equipment and systems operating in the range of frequencies 3 kHz to 95 kHz and intended for use by electricity suppliers and distributors		EN 50065-2-3: 2003+A1:2005+ AC:2003					
A	3	Road vehicles - Electrical disturbances from conduction and coupling - Part 1: Definitions and general considerations			ISO 7637-1				

Type	Class.	Technical domain / Standardisation corpus	EN (CEN)	EN (CENELEC)	ISO	IEC	SAE	UL	Comments
C	2	Road vehicles - Electrical disturbances from conduction and coupling - Part 2: Electrical transient conduction along supply lines only			ISO 7637-2				
C	2	Road vehicles - Electrical disturbances from conduction and coupling - Part 3: Electrical transient transmission by capacitive and inductive coupling via lines other than supply lines			ISO 7637-3				
C	1	Information Technology Equipment - Radio Disturbance Characteristics - Limits and Methods of Measurement.		EN 55022		CISPR 22			
C	1	Industrial, Scientific and Medical (ISM) Radio-Frequency Equipment - Electromagnetic disturbance characteristics - Limits and methods of measurement.		EN 55011		CISPR 11			
B	1	Specification for radio disturbance and immunity measuring apparatus and methods		EN 55016-X-X		CISPR 16-X-X			
C	1	Vehicles, boats and internal combustion engine driven devices - Radio disturbance characteristics - Limits and methods of measurement for the protection of receivers except those installed in the vehicle/boat/device itself or in adjacent vehicles/boats/devices.		EN 55012		CISPR 12			
C	1	Radio disturbance characteristics for the protection of receivers used on board vehicles, boats, and on devices - Limits and methods of measurement		EN 55025		CISPR 25			
A	2	Low-Voltage Power Supplies, D.C. Output – Part 3: Electromagnetic Compatibility (EMC)				IEC 61204-3			
C	2	Uninterruptible power systems (UPS) – Part 2: Electromagnetic compatibility (EMC) requirements		EN 62040-2		IEC 62040-2			
D	3	International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility				IEC 60050 (161)			
A	2	Telecontrol equipment and systems – Part 2: Operating conditions – Section 1: Power supply and electromagnetic compatibility		EN 60870-2-1		IEC 60870-2-1			EMC of socket => IEC 61851-22
B	3	EMC measurements					J 1113-i		

Type	Class.	Technical domain / Standardisation corpus	EN (CEN)	EN (CENELEC)	ISO	IEC	SAE	UL	Comments
B	3	GB/T 18387 : Limits and test methods of magnetic and electric field strength from electric vehicle, broadband, 9 kHz to 30 MHz.							
B	2	SAE J551-5 Performance Levels and Methods of Measurement of Magnetic and Electric Field Strength from Electric Vehicles, Broadband, 9 kHz to 30 MHz					J551-5		
		Environmental conditions							
B	1	Environmental conditions and testing for electrical and electronic equipment – Part 1: General			ISO 16750-1				
B	1	Road vehicles – Environmental conditions and testing for electrical and electronic equipment – Part 2: Electrical loads			ISO 16750-2				
B	1	Road vehicles - Environmental conditions and testing for electrical and electronic equipment – Part 3: Mechanical loads			ISO 16750-3				
B	1	Road vehicles – Environmental conditions and testing for electrical and electronic equipment – Part 4: Climatic loads			ISO 16750-4				
B	1	Road vehicles – Environmental conditions and testing for electrical and electronic equipment – Part 5: Chemical loads			ISO 16750-5				
A	2	Environmental testing		EN 60068 series		IEC 60068 series			
A	2	Classification of environmental conditions		EN 60721 series		IEC 60721 series			
B	2	Electric and optical fibre cables – Test methods for non-metallic materials		EN 60811 series		IEC 60811 series			
		Measurements of electrical vehicle performance							
A	1	Electric road vehicles - Road operating characteristics			ISO 8715:2001				
B	1	Electric road vehicles - Reference energy consumption and range - Test procedures for passenger cars and light commercial vehicles			ISO 8714:2002				

Type	Class.	Technical domain / Standardisation corpus	EN (CEN)	EN (CENELEC)	ISO	IEC	SAE	UL	Comments
B	1	Electrically propelled road vehicles - Measurement of road operating ability - Part 1: Pure electric vehicles	EN 1821-1:1996		ISO 8715				
B	1	Electrically propelled road vehicles – Measurement of road operating ability – Part 2: Thermal electric hybrid vehicles	EN 1821-2						
B	1	Electrically propelled road vehicles - Measurement of energy performances - Part 1: Pure electric vehicles	EN 1986-1:1997		ISO 8714				
B	1	Electrically propelled road vehicles – Measurement of energy performances – Part 2: Thermal electric hybrid vehicles	EN 1986-2						
B	1	Electrically propelled road vehicles - Airborne acoustical noise of vehicle during charging with on-board chargers - Determination of sound power level	EN 12736:2001						
B	1	Electrically propelled road vehicles – Measurement of emissions of hybrid vehicles – Part 1: Thermal electric hybrid vehicles	EN 13444-1						
B	1	Hybrid-electric road vehicles – Exhaust emissions and fuel consumption measurements – Part 1: Non-externally chargeable vehicles			ISO 23274-1				
B	1	Hybrid-electric road vehicles – Exhaust emissions and fuel consumption measurements – Part 2: Externally chargeable vehicles			ISO 23274-2				
B	1	Hybrid-electric road vehicles – Exhaust emissions and fuel consumption measurements – Part 3: Forced charge mode			ISO 23274-3				
B	2	Recommended Practice for Measuring the Exhaust Emissions and Fuel Economy of Hybrid-Electric Vehicles					J 1711		
B	1	Electric road vehicles – Reference energy consumption and range Test procedures for passenger cars and light commercial vehicles			ISO 8714				
A	1	Utility Factor Definitions for Plug-In Hybrid Electric Vehicles Using 2001 U.S. DOT National Household Travel Survey Data					J 2841		

Type	Class.	Technical domain / Standardisation corpus	EN (CEN)	EN (CENELEC)	ISO	IEC	SAE	UL	Comments
		Hybrid Electrical Vehicles							
A	1	Hybrid-electric road vehicles - Guidelines for charge balance measurement			ISO/TR 11955:2008				
B	1	Hybrid-electric road vehicles - Exhaust emissions and fuel consumption measurements - Non-externally chargeable vehicles			ISO 23274:2007				
B	1	Hybrid-electric road vehicles - Exhaust emissions and fuel consumption measurements - Part 2: Externally chargeable vehicles			ISO/DIS23274-2				
B	1	Electric double-layer capacitors for use in hybrid electric vehicles - Test methods for electrical characteristics		EN 62576		IEC 62576			
B	2	Electrically propelled road vehicles - Measurement of emissions of hybrid vehicles - Part 1: Thermal electric hybrid vehicles	EN 13444-1:2001						
B	2	Electrically propelled road vehicles - Measurement of road operating ability - Part 2: Thermal electric hybrid vehicles	EN 1821-2:1999						
B	2	Electrically propelled road vehicles - Measurement of energy performances - Part 2: Thermal electric hybrid vehicles	EN 1986-2:2001						
A	2	Hybrid Terminology					J 2787		
A	2	Hybrid Electric Vehicle (HEV) & Electric Vehicle (EV) Terminology					J 1715		
B	2	Recommended Practice for Measuring the Exhaust Emissions and Fuel Economy of Hybrid-Electric Vehicles					J 1711		
A	1	Definition of the Utility Factor for Plug-In Hybrid Electric Vehicles Using NHTS Data					J 2841		