Combined Charging System 1.0 Specification - CCS 1.0

Change History

Version	Date	Author	Changes
V0.1	2013-09-09	Steffen Schneider	Document creation
V0.2	2013-10-10	Steffen Schneider	Revision of Structure
V0.3	2013-10-22	Steffen Schneider	Further refinements
V0.4	2013-10-28	Steffen Schneider	Further refinements
V0.5	2013-10-29	Steffen Schneider	Further refinements
V0.6	2013-11-07	Steffen Schneider	Incorporation of Expert Comments from 31.10. and 04.11.
V0.7	2013-11-28	Steffen Schneider	Incorporation of Expert Comments from Review of First Draft
V0.7.1	2014-01-20	Steffen Schneider	Incorporation of Expert Comments from 04.12.13
V0.7.2	2014-02-18	Steffen Schneider	Revision of Feature Sets, Update of Normative References and further changes
V0.7.3	2014-03-04	Steffen Schneider	Incorporation of Expert Comments from first Workshop on 2014-03-04.
V0.7.4	2014-03-19	Steffen Schneider	Incorporation of comments from Dr. Heinrich and further revision based on resolutions from Workshop on 2014-0-04.
V0.7.5	2014-03-24	Steffen Schneider	Incorporation of Expert Comments from first Workshop on 2014-03-24.
V0.8	2014-05-21	Steffen Schneider	Incorporation of Resolutions of Expert Telko from 2014-05-20.
V0.9	2014-05-26	Steffen Schneider	Incorporation of changes of Expert Telko on May 26th. Approved on Expert Level on May 26th.
V0.9.1	2014-06-25	Steffen Schneider	Adopted to Approach 2 “CCS 2.0 will inherently include CCS 1.0”
V1.0	2014-12-01	Steffen Schneider	Approved
V1.1	2015-01-19	Steffen Schneider	Figures 1, 2, 3 and Clause 2.1 editorial revised. Release month of DIN SPEC 70121 added.
V1.2	2015-06-09	Steffen Schneider	Figure 1 editorial revised.
V1.2.1	2015-09-07	Steffen Schneider	Figure 1 editorial revised (correct Figure for Combo 2 Inlet incorporated).

Content Overview

Abbreviations

A	Ampere
AC	Alternating current
AC BS	Alternating current Basic Signaling
AC HLC	Alternating current High Level Communication
AWI	Approved Work Item
BS	Basic Signaling
CCS	Combined Charging System
CDV	Committee Draft on Voting
CP	Control Pilot
DC	Direct current
DC HLC	Direct current High Level Communication
DIN	German Institute for Standardization
SPEC	Specification
DIS	Draft International Standard
Ed	Edition
EIM	External Identification Means (External payment)
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
FDIS	Final Draft International Standard
HLC	High Level Communication
IC-CPD	In-cable Control Protection Device
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
kW	Kilowatt
OEM	Original Equipment Manufacturer, here automotive manufacturers
PE	Protective Earth
PnC	Plug and Charge
PLC	Power Line Communication
PWM	Pulse Width Modulation
RCD	Residual Current Device
RFID	Radio Frequency Identification
TS	Technical Specification
US	United States of America
V	Volt

1 Purpose of document

1.1 Overview

The automotive manufacturers Audi, BMW, Daimler, Porsche and Volkswagen together with Chrysler, Ford and GM have jointly driven the standardization of CCS together with partners from the electric industry and utilities. These automotive manufacturers have committed themselves to the use of CCS which allows AC-charging as well as ultra-fast DC-charging.

It contains a set of features which are described in several international and national standards. As standards usually evolves, a need is given to fix a set of features with the corresponding releases of standards as an Implementation Baseline for series production of EV and EVSE's.

This document

- defines the system for charging EVs named CCS,
- defines the set of features with reference to relevant standards as CCS 1.0 for the first generation of EV and EVSE's and
- gives an overview of the set of features with reference to relevant standards for CCS 2.0.

For information on the relation of CCS 2.0 and CCS 1.0 see Clause 4.3.

1.2 Validity of Document

The CCS 1.0 Specification replaces the Implementation Baseline 2012. It remains valid until the publication of a successor and is the basis for market ready products since 2013.

2 Description of CCS

2.1 General

The Combined Charging System (CCS) is based on open and universal standards for electric vehicles. The CCS combines single-phase with rapid three-phase charging using alternating current at a maximum of 43 kilowatts (kW), as well as direct-current charging at a maximum of 200 kW and the future perspective of up to 350 kW – all in a single system. The charging station products available on the market today can offer a maximum of 100 kW.

The CCS includes the connector and inlet combination as well as all the control functions. It also manages communications between the electric vehicle and the infrastructure. As a result, it provides a solution to all necessary charging requirements.

The key features of the Combined Charging System include the following:

- AC charging:
  - With the electrical interface specification for power transmission, which includes safety-related signaling for AC charging that complies with the international IEC 61851-1 standard.
  - With a Type 2 connector in Europe that is compliant with the international IEC 62196-2 standard.
- DC charging:
  - With the electrical interface specification for power transmission, which includes safety-related signaling for DC charging that complies with the international IEC 61851-23 standard.
  - With the Combo 2 connector in Europe, compliant with the international IEC 62196-3 standard.
- The communication interface between the electric vehicle and the charging point, based on the international standard ISO/IEC 15118 and the German DIN SPEC 70121.

For the US market the Combined Charging System contains of the connectors Type 1 and Combo 1 as well as the corresponding inlet, which are described in the same standardization documents.

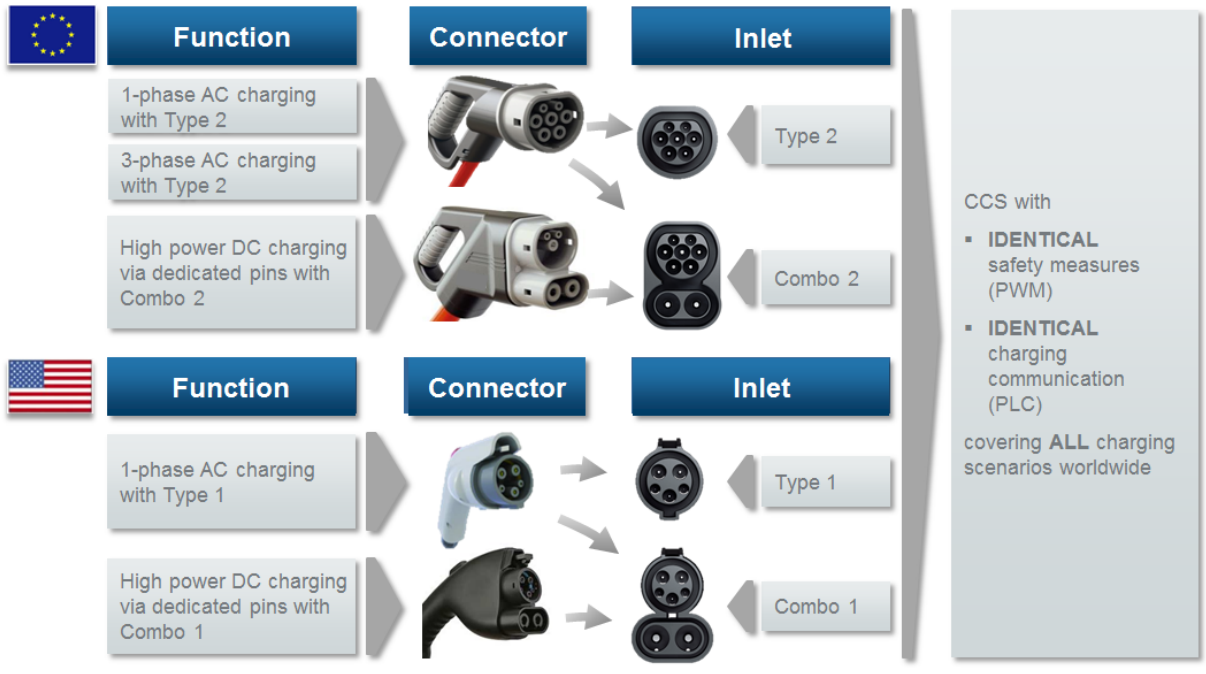

Figure 1 – Charging Interface of CCS

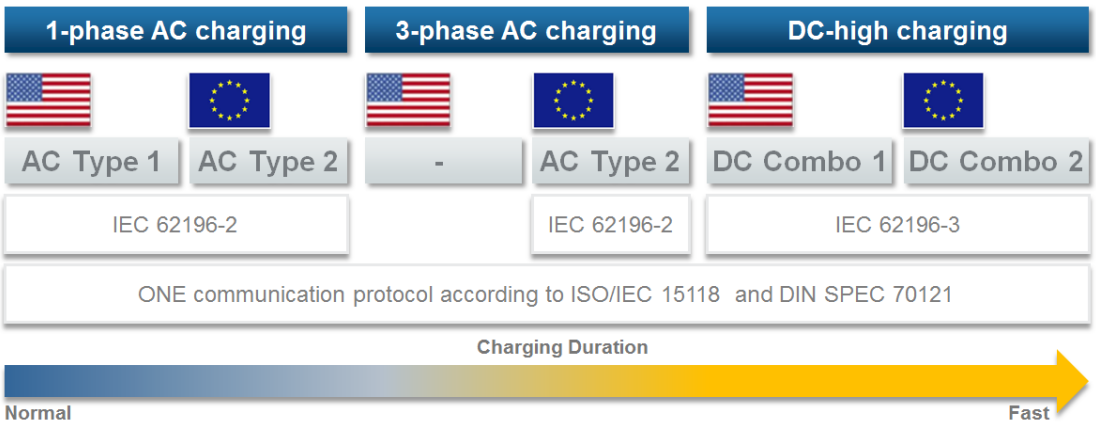

Figure 2 – Main standards for CCS

CCS is compelling and universal. It follows the ONE-Approach – ONE system for all.

The Core Features of the ONE-Approach of CCS are:

- One combined charging inlet per vehicle
  (depending on the charging scenario only the AC- or the DC part can be used)
- One charge control logic for all charging scenarios
- One charging communication interface
- One electric architecture for charging
  (2 connectors serve for all charging scenarios with one combined inlet)

The charge inlet features protective mechanisms for safe charging and is fitted with all the necessary pins for charging scenarios worldwide. A lock system prevents the connector from being accidentally pulled out of the inlet while charging. The charging process is controlled by special electrical signals from the moment the connector is connected to the inlet until the end of charging. The system also features fully automatic digital communication via PLC between vehicle and charging station. This allows charging control for complex charging scenarios, including compensating schemes and mechanisms for renewable energy-related power spikes.

The combined inlet of CCS is designed as a universal charging interface. The charge inlet for AC charging, as described in IEC 62196-2 has been extended by two pins for DC charging to allow high power charging in a very short period of time.

CCS is therefore an integrated solution for AC- and DC-charging. EVs are “CCS-capable” if they support either

- AC charging with Type 1 (US) or Type 2 (Europe) Connector according to IEC 62196-2 or
- DC charging with Combo 1 (US) or Combo 2 (Europe) Connector in IEC 62196-3

The following Clauses describe the set of features of CCS to be named:

- Charging Type, see 2.2
- Charging Inlet, see 2.3
- Charging Mode, see 2.4
- Load Balancing, see 2.5
- Charge Authorization Mode, see 2.6
- Charging Safety, see 2.7

2.2 Charging Type

The following charging types are supported by the CCS: AC and/or DC.

For AC two charging control methods can be differentiated:

- Basic signaling based on PWM
- High level communication based on PLC

For AC charging CCS supports one or both of the charging process control mechanisms.

For DC charging CCS supports only

- High Level Communication based on PLC

because it is needed to control the external DC charger.

The designation codes in Table 1 are used to name the features for Charging Type.

Table 1 – Designation Code for Charging Type

Description	Designation Code
AC Basic Signaling	AC BS
AC High Level Communication	AC HLC
DC High Level Communication	DC HLC

2.3 Charging Connector and Inlet

For AC charging in Europe the CCS uses the Type 2 Inlet or the Combo 2 Inlet mated with the Type 2 Connector. For DC charging in Europe the CCS uses the Combo 2 Inlet mated with the Combo 2 Connector.

The designation codes in Table 2 are used to name the features for the Charging Connector and Inlet.

Table 2 – Designation Code for Charging Connector and Inlet

Description	Designation Code
Type 2 AC Inlet	Type 2 Inlet
Combo 2 AC and DC Inlet	Combo 2 Inlet
Type 2 AC Connector	Type 2 Connector
Combo 2 DC Connector	Combo 2 Connector

2.4 Charging Mode

Four charging modes are defined. Modes 1 to 3 relates to charging with a charger unit installed in the vehicle (on-board charger), Mode 4 describes the use of an “off-board charger”.

Mode 1 is characterised as follows:

- AC charging at normal mains outlets
- no protection devices in the charging cable
- RCD in domestic installations an essential prerequisite
- no energy feedback, no communications

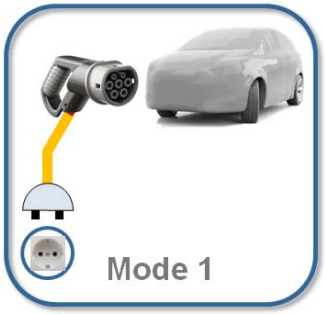

Figure 3a – Mode 1 Charging

Mode 2 is characterised as follows:

- AC charging at normal mains outlets
- charger cable with integrated safety devices in an in-cable control box comprising RCD, control pilot and proximity sensor
- without energy feedback, signaling between the in-cable control box and the electric vehicle is possible via the control pilot

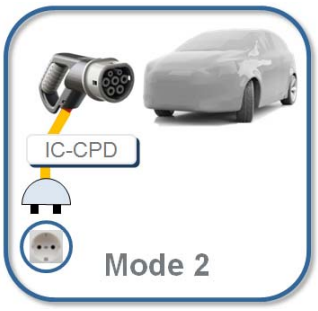

Figure 3b – Mode 2 Charging

Mode 3 is characterised as follows:

- AC charging at Type 1/2 charging stations
- safety equipment is a permanent part of the charging station, no in-cable control box required in the cable
- Type 2 plug interlock permits unsupervised operation, even in a public space
- as opposed to modes 1 and 2, energy feedback is possible via HLC, since communications are bidirectional throughout, control is possible and plugs can be locked

Figure 3c – Mode 3 Charging

Mode 4 is characterised as follows:

- DC charging at Combo 1 /2 charging stations
- Charging system can manage various charging currents and charging voltages to adopt various battery systems
- For charging control HLC is required

Figure 3d – Mode 4 Charging

The designation codes in Table 3 are used to name the features for the Charging Modes.

Table 3 – Designation Code for Charging Modes

Description	Designation Code
Mode 1 Charging	Mode 1
Mode 2 Charging	Mode 2
Mode 3 Charging	Mode 3
Mode 4 Charging	Mode 4

2.5 Load Balancing

CCS differentiates two methods for Load Balancing: Reactive and Scheduled.

Reactive is characterised as follows**:**

- The energy flow from the EVSE to the EV can be changed instantaneously to a specific limit
- The charging control can be used e.g. for adopting the consumed power to meet a defined power limit

Scheduled is characterised as follows**:**

- Supports Reactive Load Balancing
- Additionally, the energy flow from the EVSE to the EV can planned with different power limits and cost indicators over time
- Scheduled Load Balancing allows to predict the behavior of charging process and optimize the energy distribution in a Smart Grid

The designation codes in Table 4 are used to name the features for the load balancing.

Table 4 – Designation Code for load balancing

Description	Designation Code
Reactive load balancing	Reactive
Scheduled load balancing	Scheduled

2.6 Charge Authorization Mode

CCS differentiates two methods for authorizing the charging: External Payment and Plug and Charge.

Plug and Charge is characterised as follows:

- Standardized Authorization where the user just has to plug their vehicle into the EVSE and all aspects of authentication and authorization are automatically taken care of with no further intervention from the user
- Plug and Charge is based on security mechanisms and certificates for authentication and identification
- This authorization can include free charging but allows to limit the authorized user to a predefined user group

External Payment is characterised as follows:

- Any other mechanism that authorizes a user for charging
- Can be combined with External Identification Means
- This is e.g. a RFID or cash payment unit mounted to a EVSE
- External Payment can also include free charging, e.g. applicable for free charging stations or a wallbox in a garage.

The designation codes in Table 5 are used to name the charge authorization modes.

Table 5 – Designation Code for Charge Authorization Mode

Description	Designation Code
External Payment	EIM
Plug and Charge	PnC

2.7 Charging Safety

The Combined Charging System uses various safety measures to avoid

- Electric Shock,
- Fire and
- Electric Arc

under normal use including operation and non-operation mode. Table 6 gives an overview of some of the major safety measures. It does not claim completeness. For completeness and full description of requirements the relevant national and international standards shall be taken into account.

Table 6 – Overview on Safety Features

Description	Relevant Standard
Protection against direct contact and De-energization of unmated connector	ISO 17409 IEC 61851-1 IEC 62196-3
Basic insulation	IEC 61851-1
Locking of Connector by vehicle in dc supply mode	ISO 17409 IEC 62196-3 IEC 61851-23
Grounding, PE connection	IEC 60364-5-54
Continuity of connection between station and vehicle	IEC 61851-1 IEC 61851-23
Touch current limitation	IEC 61851-23 ISO 17409
Aging /environmental conditions to apply for the Combined Charging System	IEC 61851-1 IEC 62196-1
Adoption of measures from IT-systems	IEC 61851-23
Voltage measurement at vehicle inlet in combination with disconnecting device (unintended connection of AC/DC)	ISO 17409
DC Input resistance against damage due to AC voltage	ISO 17409
Temperature monitoring of connector	IEC 61851-23
De-energisation function of mated connector	ISO 17409
Exit strategies based on specified control (Charge sequence, communication)	IEC 61851-23
Prevention of unintended power supply from vehicle	IEC 61851-23
Overvoltage Category at Vehicle Connector	IEC 61851-23
NOTE: The overview on the Safety Features in Table 6 does not claim completeness.	

3 CCS 1.0

3.1 Set of features for CCS 1.0

Figure 4 defines the features for the three main charging types AC BS, AC HLC and DC HLC which shall be used for the implementation of CCS 1.0 in EV and EVSE's. Safety Features described in 2.7 are implemented in CCS 1.0.

Combinations between the three Charging Types are possible. The following (combinations) shall be supported for CCS 1.0:

1. AC BS
2. AC BS + AC HLC
3. AC BS + DC HLC

Optional all three Charging Types for CCS 1.0 are possible: AC BS + AC HLC + DC HLC.

	CCS 1.0 Features		
Charging Type	**AC BS**	**AC HLC**	**DC HLC**
Charging Connector	Type 2 Connector	Type 2 Connector	Combo 2 Connector
Charging Inlet	Type 2 Inlet or Combo 2 Inlet*	Type 2 Inlet or Combo 2 Inlet*	Combo 2 Inlet
Charging Mode	Mode 2 or 3	Mode 2 or 3	Mode 4
Load Balancing	Reactive	Reactive and/or Scheduled	Reactive
Charge Authorization Mode	EIM	EIM and/or PnC	EIM

* if DC HLC is supported

Figure 4 – Set of Features for the Combined Charging System 1.0

3.2 Set of standards for CCS 1.0

Figure 5 defines the relevant standards and specifications for the three main charging types AC BS, AC HLC and DC HLC for Charge Authorization Mode which shall be used for CCS 1.0. Further standards and specification for CCS 1.0 see Annex A.

	Specific standards for Charge Authorization Mode
CCS 1.0 AC BS	IEC 61851-1:2010 Ed 2.0
CCS 1.0 AC HLC	IEC/TS 62763:2013-12 ISO/IEC 15118-2:2014 Ed. 1.0 ISO/IEC FDIS 15118-3:2014
CCS 1.0 DC HLC	DIN SPEC 70121:2014-12

Figure 5 – Set of Standards for the three main charging types for CCS 1.0

4 Outlook on CCS 2.0

4.1 Expected set of features for CCS 2.0

Figure 6 gives an outlook on the expected features for AC BS, AC HLC and DC HLC in CCS 2.0 in comparison to CCS 1.0. The features for Load Balancing and Charge Authorization Mode for DC HLC have been extended for CCS 2.0. Changes are underlined.

	CCS 2.0 Features		
Charging Type	**AC BS**	**AC HLC**	**DC HLC**
Charging Connector	Type 2 Connector	Type 2 Connector	Combo 2 Connector
Charging Inlet	Type 2 Inlet or Combo 2 Inlet*	Type 2 Inlet or Combo 2 Inlet*	Combo 2 Inlet
Charging Mode	Mode 2 or 3	Mode 2 or 3	Mode 4
Load Balancing	Reactive	Reactive and/or Scheduled	Reactive and/or Scheduled
Charge Authorization Mode	EIM	EIM and/or PnC	EIM and/or PnC

* if DC HLC is supported

Figure 6 – Expected set of Standards for the three main charging types for CCS 2.0

4.2 Expected set of standards for the CCS 2.0

Figure 7 gives an outlook on the expected standards for AC BS, AC HLC and DC HLC for Charge Authorization Mode in CCS 2.0. Further standards and specification for CCS 2.0 see Annex B.

Expected changes for the set of standards for AC BS, AC HLC and DC HLC in comparison to CCS 1.0 are underlined.

	Specific standards for Charge Authorization Mode
CCS 2.0 AC BS	IEC 61851-1 Ed 3.0
CCS 2.0 AC HLC	IEC 61851-1 Ed 3.0, ISO/IEC IS 15118-2:2014 Ed 1.0 ISO/IEC IS 15118-3 Ed 1.0
CCS 2.0 DC HLC	DIN SPEC 70121:2014-12 ISO/IEC IS 15118-2:2014 Ed 1.0 ISO/IEC IS 15118-3 Ed 1.0

Figure 7 – Expected set of Standards for the three main charging types for CCS 2.0

4.3 CCS 2.0 in relation to CCS 1.0

The automotive manufacturers mentioned in Subclause 1.1 have committed themselves to the use of CCS 1.0 in today's EVs and plan to support CCS 2.0 in EVs from 2015 onwards, see Figure 8.

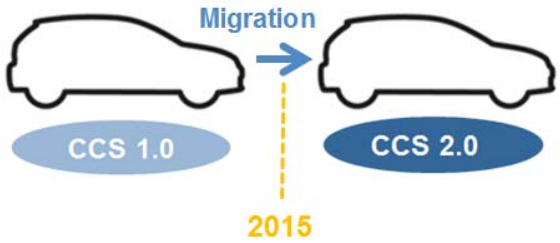

Figure 8 – CCS 1.0 and CCS 2.0 in EVs - Commitment

The automotive manufacturers in Subclause 1.1 therefore recommend the use of CCS 1.0 in today's EVSEs and CCS 2.0 in EVSEs beginning in 2015, see Figure 9.

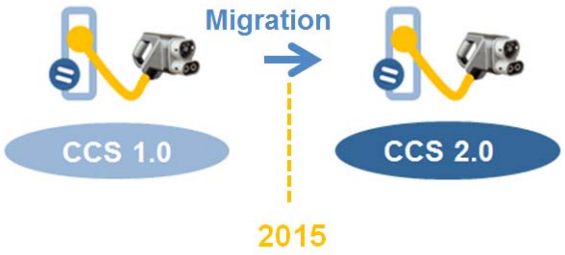

Figure 9 – CCS 1.0 and CCS 2.0 in EVSEs - Recommendation

Appendix A **Documents for the CCS 1.0**

The following documents shall be used for the implementation of CCS 1.0.

ISO/IEC 15118-1:2013, *Road vehicles – Vehicle to grid communication interface - Part 1 – General information and use-case definition*

ISO/IEC 15118-2:2014, *Road vehicles – Vehicle to grid communication interface – Part 2 Technical protocol description and Open Systems Interconnections (OSI) layer requirements*

ISO/IEC FDIS 15118-3:2014*, *Road vehicles – Vehicle to grid communication interface - Part 3 Physical layer and Data Link layer requirements*

ISO DIS 17409:2013-09, *Electrically propelled road vehicles – Connection to an external electric power supply – Safety requirements*

IEC 61851-1:2010, *Electric vehicle conduction system - Part 1 General requirements*

IEC CDV 61851-21-1:2014*, *Electric vehicle conduction system - Part 21-1 – Electric vehicle onboard charger EMC requirements for conductive connection to a.c./d.c. supply*

IEC CDV 61851-21-2:2014*, *Electric vehicle conduction system - Part 21-2 – EMC requirements for OFF board electric vehicle charging systems*

IEC 61851-23:2014, *Electric vehicle conduction system - Part 23 – D.C. electric vehicle charging station*

IEC FDIS 62196-1:2014, *Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles - Part 1 – General Requirements*

IEC 62196-2:2011, *Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles - Part 2 – Dimensional compatibility and interchangeability requirements for a.c. pin and contact-tube accessories*

IEC FDIS 62196-3:2014*, *Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles - Part 3 – Dimensional compatibility and interchangeability requirem. for d.c. and a.c./d.c. pin and tube-type contact vehicle connectors*

IEC CDV 62752:2013, *In-Cable Control and Protective Device for mode 2 charging of electric road vehicles (IC-CPD)*

IEC/TS 62763:2013-12, *Pilot function through a control pilot circuit using PWM modulation and a control pilot wire*

DIN SPEC 70121:2014-12, Electromobility - Digital communication between a d.c. EV charging station and an electric vehicle for control of d.c. charging in the Combined Charging System

Appendix B **Expected documents for the CCS 2.0**

The following documents are expected for the implementation of the CCS 2.0. Please note that some International Standards are not finally issued having an IS-Status by ISO and IEC.

ISO/IEC 15118-1:2013-04, *Road vehicles – Vehicle to grid communication interface - Part 1 – General information and use-case definition*

ISO/IEC 15118-2:2014-02 Ed 1.0, *Road vehicles – Vehicle to grid communication interface – Part 2 Technical protocol description and Open Systems Interconnections (OSI) layer requirements*

ISO/IEC 15118-3 Ed 1.0, *Road vehicles – Vehicle to grid communication interface - Part 3 Physical layer and Data Link layer requirements (at the time of publication of this document Ed 1.0 not published by IEC as International Standard)*

ISO 17409 Ed 1.0, *Electrically propelled road vehicles – Connection to an external electric power supply – Safety requirements (at the time of publication of this document Ed 1.0 not published by IEC as International Standard)*

IEC 61851-1 Ed 3.0, *Electric vehicle conduction system - Part 1 General requirements*

IEC 61851-21-1 Ed 1.0, *Electric vehicle conduction system - Part 21-1 – Electric vehicle onboard charger EMC requirements for conductive connection to a.c./d.c. supply (at the time of publication of this document Ed 1.0 not published by IEC as International Standard)*

IEC 61851-21-2 Ed 1.0, *Electric vehicle conduction system - Part 21-2 – EMC requirements for OFF board electric vehicle charging systems (at the time of publication of this document Ed 1.0 not published by IEC as International Standard)*

IEC 61851-23:2014, *Electric vehicle conduction system - Part 23 – D.C. electric vehicle charging station*

IEC 62196-1 Ed 3.0, *Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles - Part 1 – General Requirements (at the time of publication of this document Ed 3.0 not published by IEC as International Standard)*

IEC 62196-2:2011-10, *Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles - Part 2 – Dimensional compatibility and interchangeability requirements for a.c. pin and contact-tube accessories*

IEC 62196-3 Ed 1.0, *Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles - Part 3 – Dimensional compatibility and interchangeability requirem. for d.c. and a.c./d.c. pin and tube-type contact vehicle connectors (at the time of publication of this document Ed 1.0 not published by IEC as International Standard)*

IEC 62752 Ed 1.0, *In-Cable Control and Protective Device for mode 2 charging of electric road vehicles (IC-CPD) (at the time of publication of this document Ed 1.0 not published by IEC as International Standard)*

IEC/TS 62763:2013, *Pilot function through a control pilot circuit using PWM modulation and a control pilot wire*

DIN SPEC 70121:2014-12, Electromobility - Digital communication between a d.c. EV charging station and an electric vehicle for control of d.c. charging in the Combined Charging System

Appendix C **Bibliography**

The following documents are only for information purposes and are dispensable for the application of the Implementation Baseline.

ISO/IEC CD 15118-4:2014, *Road vehicles – Vehicle to grid communication interface - Part 4 Network and application protocol conformance test*

ISO/IEC AWI 15118-5:2012-06, *Road vehicles – Vehicle to grid communication interface - Part 5 Physical layer and data link layer conformance test*