

## **The path to a global EV charging system – How to harmonize the customer interface**

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### **Summary**

As an international standard of a reliable, safe and powerful charging system to support basic charging as well as long range E-Mobility a significant number of companies support the Combined Charging System (CCS). To harmonize and further develop the holistic system approach of charging, the CharIN e.V. was initiated by various OEM and suppliers of the value chain. The association with over 80 international members is continuously growing and fostering CCS as the global charging standard.

*Keywords: AC-DC, EV, EVSE, fast charge, standardization*

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### **1 The Path to High Power Charging**

Due to the current design of EVs, which are typically used in urban areas and their surroundings with less than 10.000 km travelling range per year, the limitations of electrical range and charging power are almost acceptable. The extension of the electrical range with model year updates and new car models offers more range stability in all climate und traffic conditions and gives flexibility to the customers. EVs which will be launched during the next years will additionally support long distance travel.

In combination with a high power charging infrastructure the charging time at a certain charging spot can be reduced to a maximum of 4 minutes for 100 km electric range. These long range EVs open the opportunity of driving purely electric for new user groups like business travelers, driving up to 50.000 km per year.

Therefore, the CharIN e.V. focuses on the requirements specification of a reliable, safe and powerful high power charging system to support long range E-mobility – the Combined Charging System (CCS). The challenge in charging is to do it as fast as possible that means the charging power has to be increased without ignoring the AC aspect and the overall one system approach of charging.

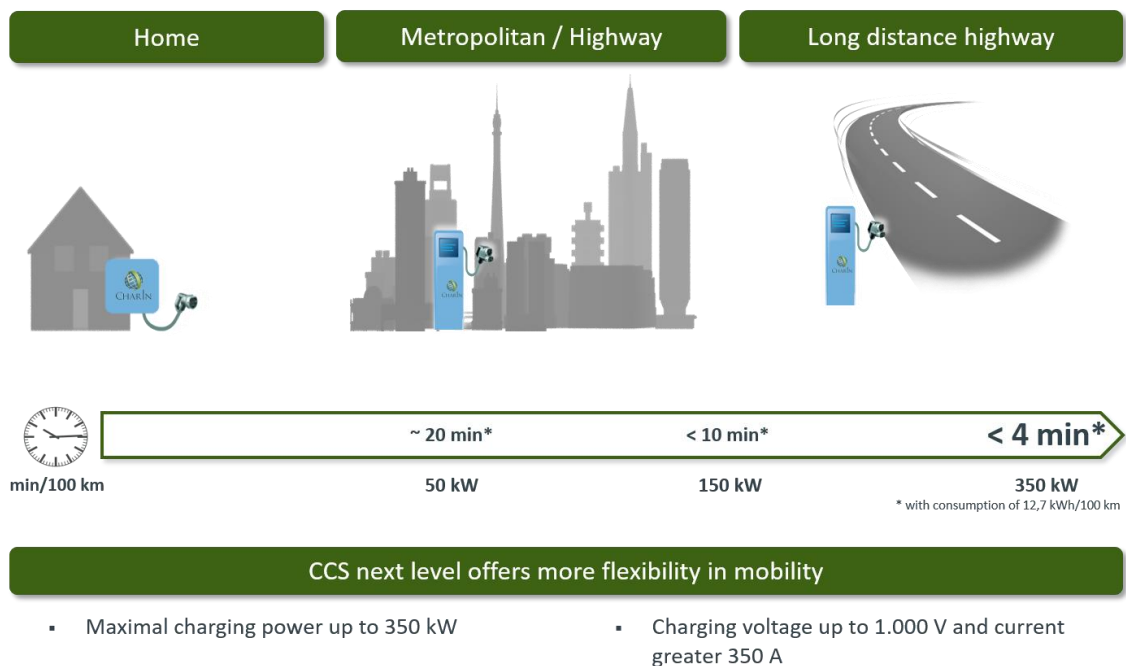


Figure 1: Overview CCS – Charging Performance

## 2 International Initiative

The Charging Interface Initiative e. V. - abbreviated to CharIN e. V. - is a registered association founded by Audi, BMW, Daimler, Mennekes, Opel, Phoenix Contact, Porsche, TÜV SÜD and Volkswagen in 2015 to promote CCS as a standard worldwide. By mid of 2017 the association has grown to over 80 international members along the whole value chain; this is an increase by over 50 members during 2016. The current members are from Australia, China, Denmark, Finland, France, Germany, India, Japan, Korea, Portugal, Spain, Sweden, Taiwan, the Netherlands, UK and the US. 15 out of the top 20 car brands are already represented within CharIN.

### Core Members



### Regular Members



### Associated Members



Figure 2: CharIN members, June 2017

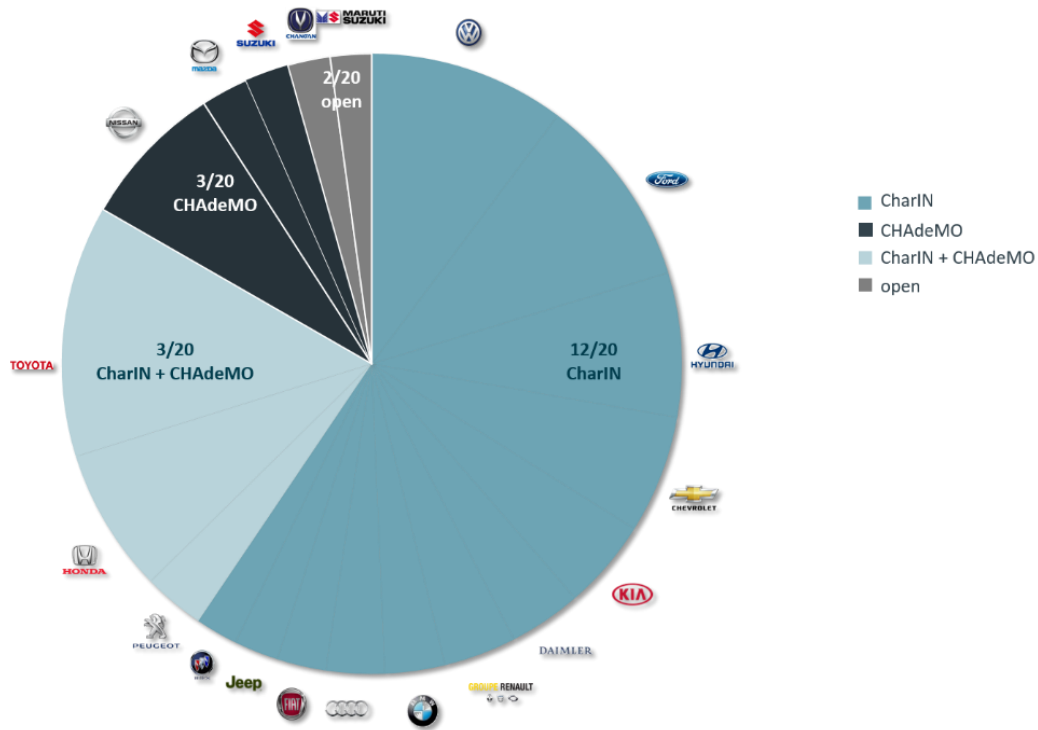


Figure 3: TOP 20 brands 2016 by volume

The positive membership development all over the world is related to an augmented international presence of the CharIN e.V. The association operates offices in Asia (Hong Kong, Korea, India) and North America and organizes regular calls, workshops and member meetings with respect to local requirements of the specific areas. Meetings so far have been done among others in Beijing, Seoul, Los Angeles, Detroit and Berlin. The first CharIN global Asia seminar is scheduled for September 26<sup>th</sup> -27<sup>th</sup> in Hong Kong.



Figure 4: CharIN offices worldwide, July 2017

### 3 The Customer Interface

To develop international requirements for charging and foster CCS as the global charging standard, regional activities lead by the offices in Asia, Europe and North America are realized with regional market leaders and regional member contact persons to show off regional developments and challenges.

In five different international working groups members compile and discuss current challenges and develop common requirements regarding different topics of Charging Communication, Charging Infrastructure, Charging Connection, Grid Integration and Conformance Test/Interoperability.

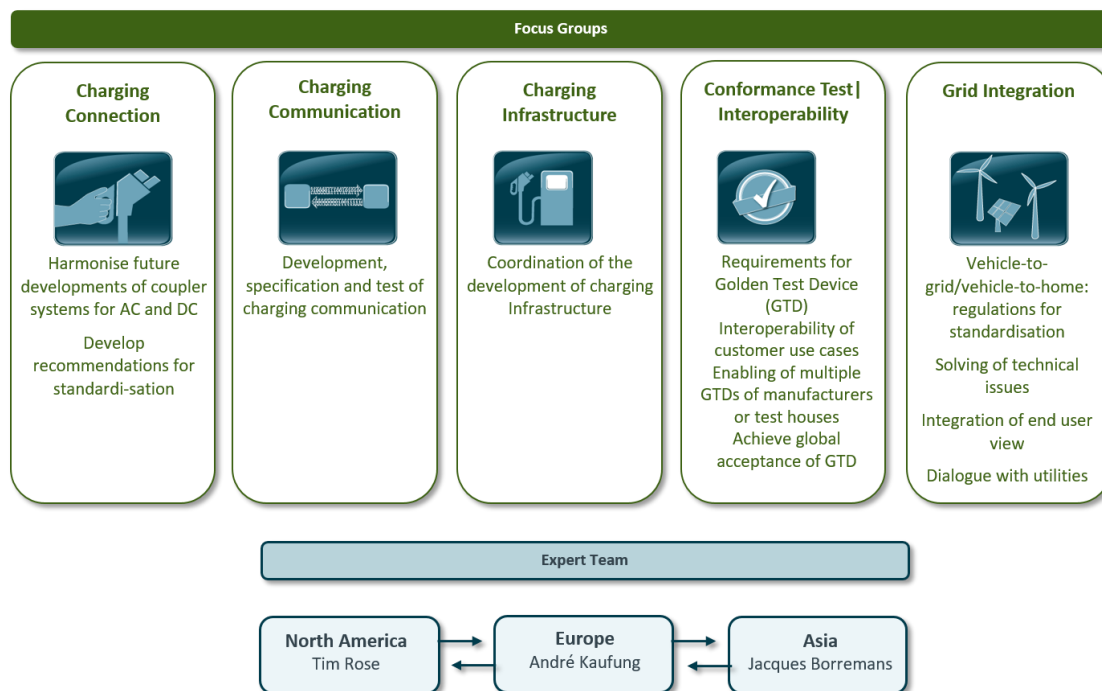


Figure 5: CharIN focus group set up

The path to EV fast charging includes an international standard of a reliable, safe and powerful charging system; a simple and consistent customer interface all over the world for all applications from bike to car and bus/truck, from low to high power charging. The worldwide alignment of requirements for EVs, EVSEs and its infrastructure is creating added value which will lead electro mobility to a success.

On that point, CharIN's three primary aims are to roll out and establish the Combined Charging System (CCS) as the global standard for charging battery-powered electric vehicles of all kind, to draw up requirements for the evolution of charging-related standards and set up a conformance verification system for use by manufacturers implementing the CCS in their products as well as to promote the CCS standard worldwide.

### 3.1 Vehicle to Grid Communication

By today's definition, the vehicle to grid communication optimally includes a unified AC/DC Charging Control system, an optimized load management system as well as a simple payment/billing method and additional PEV customer services. Currently, in definition is the seamless integration of a wireless charging control system, reverse power flow as well as extended smart grid functionalities which will make charging of electric vehicles even more comfortable and offer additional business opportunities.

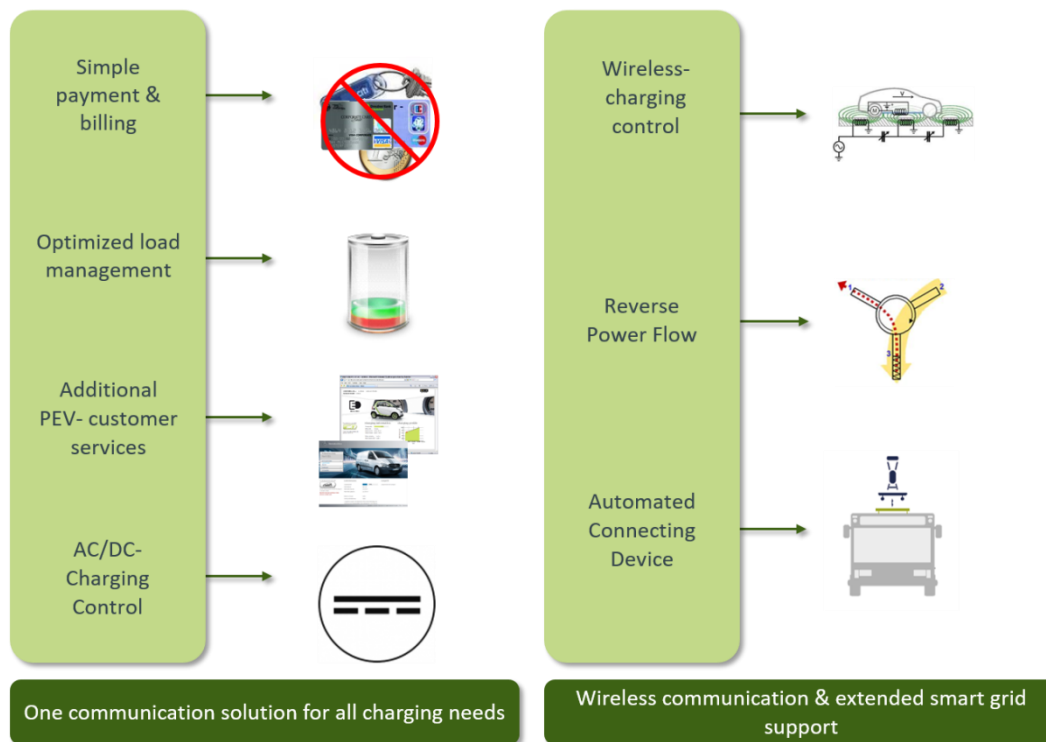


Figure 6: Vehicle to Grid Communication – Today’s and future use-cases

### 3.2 Harmonization of requirements

The harmonisation of requirements of the international charging industry with a clear recommendation on technology and customer interface is a major deliverable of CharIN. In the past, various position papers, recommendations and commitments were published and further will follow to promote the harmonization of requirements of the international charging industry.

#### 3.2.1 Information displayed on charging stations

Full customer satisfaction during the charging process is pivotal, and thus is key for the market uptake of EVs. Providing relevant and accurate information to the customer while charging is therefore of high importance. For this reason, CharIN published a guidance document with detailed recommendations on the charging parameters to be displayed to the customer.

#### AC charging stations

If the charging station has a display, the following values must be shown (mandatory information):

- Time charged
- Amount of energy delivered in kWh

The following values can be shown as optional information:

- Charging power in kW
- Cumulated costs in local currency

## **DC charging stations**

The following values must be shown (mandatory information):

- Time charged
- Amount of energy delivered in kWh

The following values can be shown as optional information:

- State of charge in %
- Charging power in kWh
- Cumulated costs in local currency

The following information should not be shown on the charging station display because it is either not relevant for the customer or cannot be calculated accurately by the charging station:

- DC voltage in Volt
- DC current in Ampere
- Remaining time until 80% SoC
- Remaining time until 100% SoC
- Remaining time until provider limit
- Time until charging is completed

### **3.2.2 Industry Statement on Future Charging Infrastructure**



Charging infrastructure plays an essential role for the market uptake of EVs, new technological developments need to be integrated quickly in order to shorten charging times. For that reason, CharIN envisions the following:

- The Combined Charging System is a worldwide standard with wide power range and functionality.
- In the coming years, multiple car makers will launch EVs, supporting higher battery capacities and faster charging, introducing an increased voltage level up to 1.000 V, but always supporting full downward compatibility.
- The infrastructure will have to be prepared for this and charger manufacturers will offer DC chargers for a rollout with flexible voltage (200 V – 1.000 V) accordingly, allowing higher charging power up to 350 kW and thus higher charging speeds.
- The flexibility of CCS charging voltage ensures forward and backward compatibility with new and existing EVs.
- The voltage range in the CCS standard supports the automotive OEMs in their choice of the on-board batteries and opens the range of potential battery performances for the different customer demands.
- The charging stations at the currently used voltage levels remain valuable and allow for a basic coverage to fulfil customer needs within their period of amortization.
- A uniform charging station technology for all vehicles offers the operators a better utilization of the locations.
- The preferred charging communication standard is ISO 15118, especially for high power charging. Chargers and EVs should nonetheless as much as possible be forward and backward compatible supporting both DIN SPEC 70121:2014 and ISO 15118 ED1.
- CharIN is working continuously on uniform certification devices and processes to assure safe and interoperable EVs and charging infrastructure, also at higher power levels and/or higher voltage levels.

### **3.2.3 DC Charging Power Classes**

The DC Charging Power Classes provide basic information on the performance of charging towards the customer. The system is based on three classes with significant differentiation in power output, a minimum

power is guaranteed in each class. They present a visibility of quality and performance identification for customers of fast and high power charging for electric vehicles.

Range	Name	Short Name
50 kW < 149 kW	Fast Charging Schnellladen	FC 50
150 kW < 249 kW	High Power Charging Hochleistungsladen	HPC 150 
250 kW < 349kW	High Power Charging Hochleistungsladen	HPC 250 

The power classes always refer to the minimum charging power within the scope of a reasonable power range definition.

Figure 7: DC Charging Power Classes

**3.2.4 CharIN recommendation: A harmonized connector approach per geographical region facilitates EV market uptake**

Whereas in Europe the CCS Type 2 /Combo 2 connector is the agreed solution for AC and DC charging, in North America the CCS Type 1 / Combo 1 connector prevails. While some countries already integrated CCS Type 1 or Type 2 into their regulatory framework, other countries and regions did not finalize regulations supporting a specific CCS connector type yet. Therefore, different CCS connector types are used in different regions of the world.

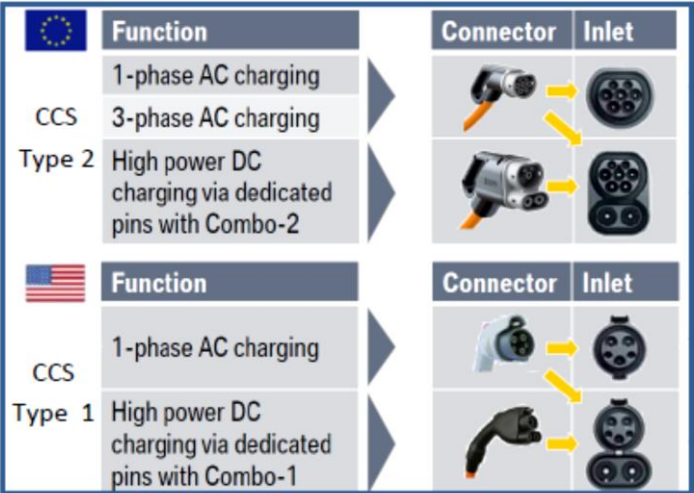


Figure 8: CCS Type 1 vs. Type 2

In order to speed up the market uptake, cross-border travel and charging for commuters, deliveries and tourists as well as interregional trade of (used) EVs must be possible. Adapters would cause high safety risks with potential quality issues and do not support a customer friendly charging interface. CharIN therefore recommends a harmonized CCS connector approach per geographical region as outlined in the below map:

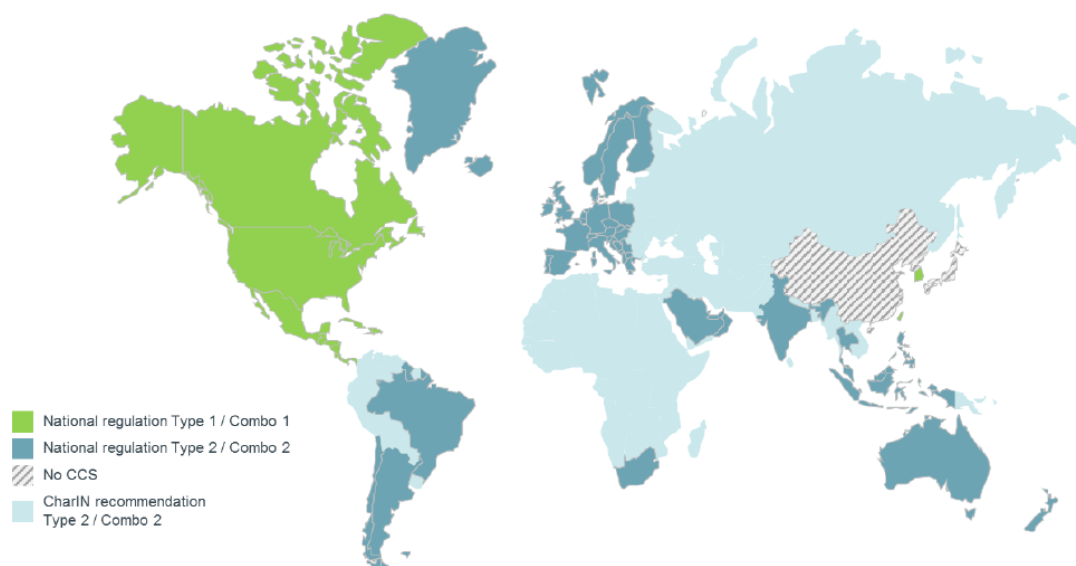


Figure 9: Map with usage of Type 1/Combo 1 vs. Type 2 / Combo 2

Characteristics of the Combined Charging System (CCS):

- Charging power up to 350 kW (today 200 kW)
- Charging voltage up to 1.000 V and current greater 350 A (today 200 A)
- Integrated electrical architecture for all relevant AC and DC charging scenarios
- One inlet and one charging architecture for AC and DC to enable low overall system costs
- Only one communication module for AC and DC charging, Powerline Communication (PLC) for DC Charging and advanced services
- State of the art communication via HomePlug GreenPHY enables integration V2H and V2G

### 3.2.5 CharIN’s perspective on Inductive Charging

To underline its “one system for all” target, CharIN has decided to incorporate inductive charging into its global approach.

Given that unified charging communication within CharIN already includes wireless communication for inductive charging and that CharIN has been already successful in establishing an industry guidance for conductive charging, it is essential for the association to attend to inductive charging.

Even so many activities and attempts to define a global standard for inductive charging have already been carried out, the final regulation is still open. Inductive charging offers customers great benefit to their charging experience. As interoperability and conformity between the electric vehicle and the infrastructure are key, CharIN will take on the task of having the basic requirements in place as soon as possible for introduction to all major markets within 3 years. Having the majority of leading companies in the field of charging with their unique expertise allows to exchange and define comprehensive best practices and to form a platform for sharing and generating information and harmonizing requirements. With its global membership base, CharIN can clearly contribute to the consolidation of concepts and requirements as a basis for a stable standardization status.

The inclusion of inductive charging within CharIN covers all charging scenarios and completes the charging portfolio.

## 4 Summary

CCS is currently the world's only charging system that covers all charging scenarios with a single product. Drivers of any type of electric vehicle can choose between normal and fast charging as well as AC (single-phase up to three-phase) and DC (up to high power of > 350 kW) – and they only need a single system for all these options. The CCS also has the advantage of being accepted and supported by a significant number of major companies from different industries.

The CharIN association is unique, as it is comprised of multiple experts across a variety of international industries who work together as a team to make this future oriented system design possible. The association itself is non-profit and open to all interested parties.

Rather than reinventing the wheel, the CCS team focused on an innovative approach: rethinking existing systems, while incorporating all the relevant international standards. The result is an ingenious and future-proof solution that is universal for all electric vehicles and charging scenarios while remaining safe and easy to use. That's what makes the CCS so unique!

CharIN's three primary aims are to roll out and establish the Combined Charging System (CCS) as the global standard for charging battery-powered electric vehicles of all kind, to draw up requirements for the evolution of charging-related standards and set up a conformance verification system for use by manufacturers implementing the CCS in their products as well as to promote the CCS standard worldwide.

New charging interfaces like inductive charging are enhancing the CharIN portfolio to a one stop shop for every charging scenario.

## 5 Acknowledgments

The worldwide distribution of the global CCS Standard is supported by the activities within the international standardization bodies as well as local governmental regulations. The engagement of universities and research institutes in the field of interoperability and conformance helps to develop it further.

Especially the international "CCS Festival" format, initiated and organized by the University of Dortmund brings major stakeholders together to improve the systems quality for a secure customer interoperability.

The Joint Research Centre (JRC) as the European Commission's science and knowledge service and the Argonne National Laboratory (ANL) as the American science and engineering research center are supporting the system evaluation and enhancement with their broad expertise.

## 6 References

- [1] *CharIN e.V.*, [www.charinev.org](http://www.charinev.org), accessed on 2017-06-30

## 7 Authors



Claas Bracklo is Senior Manager Electromobility at the VDA, Chairman of the Charging Interface Initiative (CharIN e.V.) and representing BMW within the National Platform Electromobility (NPE).

He joined BMW in March 2005 and held various senior management positions in research and development with focus on E/E-architectures, system design, hardware/software components and in car networking. Before his current position in the innovation field electromobility he was in charge of body electronics development.

He started his career with Mercedes Benz and Daimler in the development of bus systems technology and introduced the CAN and LIN in car networking. He led several teams in the area of system test, architecture and ECU-development. He was initiator and founding member of the LIN, Autosar and FlexRay consortium and acted as the FlexRay spokesperson in the initial phase.

Claas Bracklo holds a degree in Electrical Engineering from the University of Dortmund.