



# **Standardisation of e-bus charging: Overview & project activities**

**ASSURED Interoperability Workshop**

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# Agenda

- 1. Introduction**
- 2. Overview HVDC charging technologies**
- 3. Global overview Standardisation**
- 4. Activities and results in ASSURED**

# 1

## **Introduction**

**What is Standardisation and  
why it matters?**



# Standardisation: what is it and why it matters?

**Standardisation and interoperability of e-bus charging is key to enable the upscale of HD-EVs fleets.**

- It provides an indispensable basis for wider market penetration and enables the flexibility and optimisation of bus operations and higher rest value.
- It contributes to cost reduction of charge infrastructure by assuring functionality, compatibility, and interoperability.
- It does not bind the product choice to one solution or supplier.

**Agreed standards encourage innovation, boost confidence and create suitable market conditions for further technological development, reducing deployment barriers and facilitating competition.**

- Reliable, functioning interoperability between vehicles and chargers (of different vendors) is instrumental
- A standardized common test protocol Assured 1.1 secures compliance

**Standardisation of e-bus charging implies:**

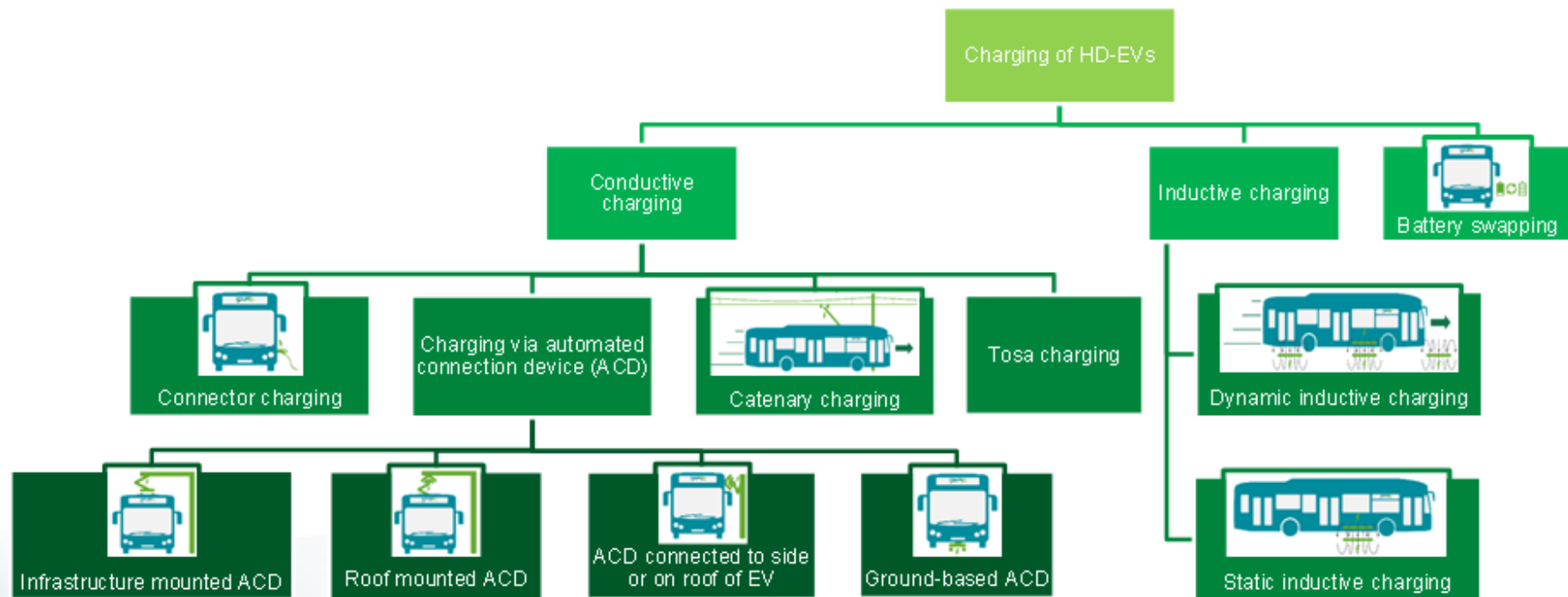
- Mechanical implementation and maximum parking tolerance
- Electric and functional safety
- Automated Connection Device interface (ACD)
- Communication securance

# 2

## **E-Bus HVDC Charging**

### **Main technologies**

# HVDC charging technologies for HD-EVs



# Conductive (contact) charging

- **Connector (manual) plug CCS, power 50-250 kW**
- **Automated Connection Device (ACD), pantograph, power range 150-600 kW:**
  - Infrastructure-mounted ACD
  - Roof-mounted ACD
  - ACD connected to side or on roof of vehicle
  - Ground-based ACD
- **TOSA charging, grid e-motion flash solution, short bus stop high-power boost, 600 kW**



# CCS Connector charging





# Infrastructure-mounted pantograph





# Roof-mounted pantograph



Source: TMB (Barcelona Demo) and VDL (Eindhoven Demo)



# Ground-based ACD

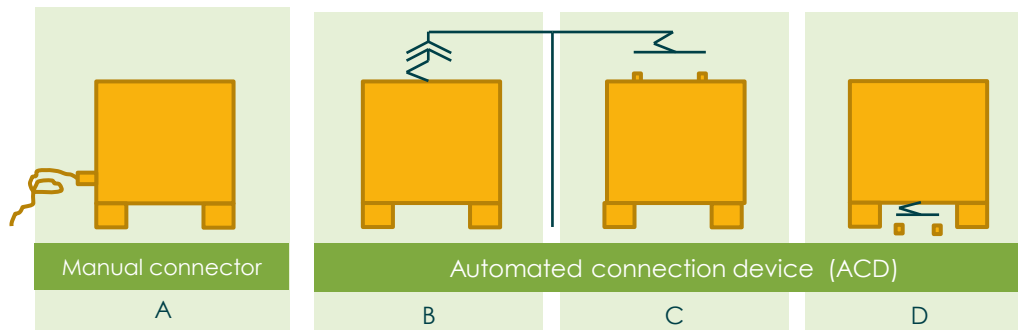


# State Standards Conductive Charging

- ASSURED has developed a Roadmap for standardisation
- Standard requested to be ready by end 2019 (EC M533)
- CEN-CENELEC process is delayed

## E-Bus Standards

Reminder: Operators need a suite of standards to ensure interoperability (Communicational, Electrical, Safety, Mechanical)



| Charging options | Manual connection                             | Automatic connection              |  |                                   |
|------------------|---|-----------------------------------|--|-----------------------------------|
|                  | A<br>(connector)                              | B<br>(roof mounted<br>pantograph) | C<br>(infrastructure<br>mounted<br>pantograph) | D<br>(under floor<br>mounted ACD) |
| Communication    | ISO 15118-2 Ed1                               |                                   | ISO 15118-20 Ed1                               |                                   |
|                  | ISO 15118-3                                   |                                   | ISO 15118-8                                    |                                   |
| Electrical       | IEC 61851-1<br>IEC 61851-21-2<br>IEC 61851-23 |                                   |  |                                   |
|                  | ISO 17409 Ed1                                 | IEC 61851-23-1                    | IEC 61851-23-Ed 2 (DC charging station)        |                                   |
|                  | ISO 17409 Ed2                                 |                                   |  |                                   |
| Mechanical       | IEC 62196-3<br>Configuration FF               | prEN50696<br>Configuration xx     | prEN50696<br>Configuration yy                  | prEN50696<br>Configuration zz     |



# TOSA flash-charging



Photo credit Patrick Garçon



Photo credit Antoine Monié

eBusway, Semitan, Nantes Métropole (FR)

Photo credit Antoine Monié (<https://tmc-innovation.fr/projets-metallerie-innovants/totem-e-busway-nantes-44/>)



# Catenary charging



Source: <https://www.ovpro.nl/>  
Arnhem, NL

# Inductive (wireless) charging

- **Wireless charging is performed using either capacitive (low power applications) or inductive (high power) charging technology.**
- **Static and dynamic inductive charging**



Source: EMT Madrid



Source: TfL, ZeUS Project

# Battery swapping

- **A robotic system swaps the discharged battery or battery pack of the vehicle for a fully charged pack.**
- **Not common for HD-EVs in Europe.**



Source: <http://www.sustainabilityoutlook.in/>



# 3

## **Global overview**

### **Standardisation**

# Safety standards vehicles/batteries

|                      |   |
|----------------------|---|
| <b>ISO 6469 1-3</b>  | Specifications for batteries and high-voltage systems on electric vehicles (ISO, 2019a; ISO, 2018a; ISO, 2018b)   |
| <b>ISO 6469 4</b>    | Specifications for batteries and high-voltage systems on electric vehicles following a collision (ISO, 2015a)   |
| <b>ISO/DIS 21498</b> | Specifications for high-voltage systems on electric vehicles (ISO, 2018c)   |
| <b>ISO 12405</b>     | Specifications for lithium-ion battery packs and systems (ISO, 2018d)   |
| <b>ISO 21782</b>     | Specifications for electric propulsion components (motor, inverter, DC-DC converter) and their combinations (motor system) for electric vehicles (ISO, 2019b; ISO, 2019c) |
| <b>SAE J1766</b>     | Recommended practice for electric and hybrid vehicle battery systems integrity in the event of a collision (SAE International, 2005)                                      |
| <b>SAE J2929</b>     | Safety standard for electric and hybrid vehicle propulsion battery systems using lithium-based rechargeable cells (SAE International, 2011)                               |
| <b>SAE J2344</b>     | Guidelines for electric vehicle safety (SAE International, 2010)  |
| <b>SAE J2464</b>     | Recommended practices on electric and hybrid electric vehicle rechargeable energy storage system (RESS) safety and abuse testing (SAE International, 2009a)               |
| <b>UL 2580</b>       | Specifications and stress tests for large electric vehicle batteries aiming to mitigate the risk of fire and electrical hazards (UL, 2020)                                |

|                  |  |
|------------------|--|
| <b>SAE J2910</b> | Recommended practice for design and testing hybrid electric or fully electric trucks and buses for electrical safety (SAE International, 2014) |
| <b>SAE J3004</b> | Standardisation of battery packs for fully electric and hybrid trucks and buses (SAE International, 2012b)                                     |
| <b>SAE J3125</b> | Integration of battery pack systems in bus electrification (SAE International, 2016)   |

# Charging standards

## Plug-based charging

|                  |   |
|------------------|---|
| <b>IEC 62196</b> | Series of standards for conductive charge connectors (plugs, socket-outlets, vehicle connectors and vehicle inlets) for electric vehicles (IEC, 2014a; IEC, 2016b; IEC, 2014b)  |
| <b>IEC 61851</b> | Series of standards covering safety-related specifications on the charging station, the electromagnetic compatibility and the communication between vehicle and charger (including vehicle to grid functionality) (IEC, 2017a; IEC, 2017b; IEC, 2018; IEC, 2014c; IEC, 2014d; IEC, 2020a) |
| <b>ISO 17409</b> | Specifications for the connection of electric vehicles with an external electric power supply (ISO, 2020a)  |
| <b>ISO 15118</b> | Series of standards for vehicle-to-grid communication interfaces, protocols and data requirements (ISO, 2019d; ISO, 2014; ISO, 2015b; ISO, 2018e; ISO, 2018f; ISO, 2020b; ISO, 2021)  |
| <b>SAE J1772</b> | Specifications for conductive charge connectors (plugs, socket-outlets, vehicle connectors and vehicle inlets) for electric vehicles (most relevant for North America and Japan) (SAE International, 2012a)   |
| <b>SAE J2953</b> | Requirements and specification by which a specific electric vehicle and charger can be considered interoperable (SAE International, 2013)   |
| <b>SAE J3068</b> | Electric vehicle power transfer system using an AC three-phase capable coupler (SAE International, 2018)  |

## Inductive charging

|                  |  |
|------------------|--|
| <b>IEC 61980</b> | Series of standards and specifications for the equipment needed for the wireless transfer of electric power from the supply network to electric road vehicles (IEC, 2020b; IEC, 2019b; IEC, 2019c) |
| <b>ISO 19363</b> | Safety and interoperability requirements for the on-board equipment that enables magnetic field wireless power transfer for electric vehicle charging (ISO, 2020c)                                 |
| <b>SAE J1773</b> | Recommended practices on electric vehicle inductively-coupled charging (SAE International, 2009b)  |
| <b>SAE J2954</b> | Specifications on safety, interoperability and electromagnetic compatibility of wireless power transfer for light plug-in electric vehicles (SAE International, 2020b)                             |

## Battery swapping

|                  |  |
|------------------|--|
| <b>IEC 62840</b> | Series of standards for electric vehicle battery swap systems (IEC, 2016a; IEC, 2019a) |
|------------------|--|

# 4

## **Activities & results in ASSURED**

**Horizon 2020 Project of 39 private and public leading partners of  
the entire value chain of electric urban vehicles.**

# Overview Standardisation activities

**activities and results of ASSURED core team members involved in standardisation committees and working groups**



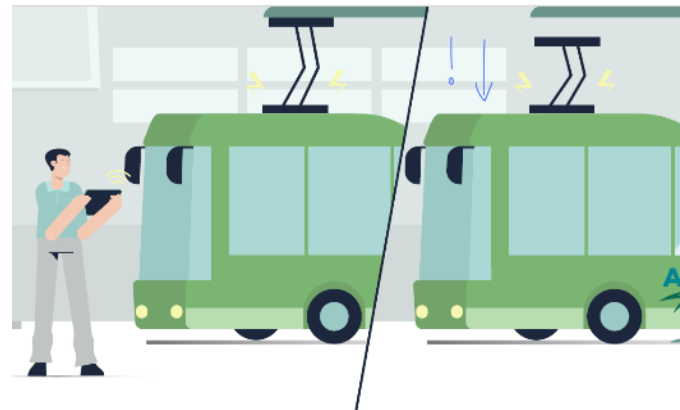
# ASSURED activities on STD and INT

## Standardisation

- ASR 1.0 Interoperability Reference
- Report: Pre-normative roadmap on ASSURED key technological solutions on work
- Continuous support and monitoring to the CEN/CENELEC Standardisation Committee

## Interoperability

- Definition of test requirements, methodology & set-up for conformance & interoperability tests
- Review of the “Conformance & Interoperability Test Protocols”



# Standards charging process

| Charging Process  | Type A                                  | Type B   | Type C                                  |
|---|---|--|---|
| General   | ISO15118-20                             | IEC 61851-23 Ed 2.0 CD chapter C.3.  | ISO15118-20                             |
| IT requirement  | 411 of IEC 60364-4-41:2005 or ISO 17409 | ISO 15118-2 (2016)<br>IEC 61851-24 (Pre-charge specification and contact sequence defined in ASSURED 1.0 interoperability reference) | 411 of IEC 60364-4-41:2005 or ISO 17409 |
| Insulation monitoring   | IEC 61557-8                             |  | IEC 61557-8                             |
| Pre-charging  | 101.2.1.6                               |  | 101.2.1.6                               |
| Specific requirement:<br>Turn on inrush current (DC side)<br>Load dump<br>Short circuit | This clause of Part 23 is applicable    |  |   |
| Contact sequence  | IEC 62196-3 clause 6.7 not required     |  | IEC 62196-3 clause 6.7 not required     |
| Initialization  | ISO 15118-2:2014                        |  | ISO 15118-2:2014                        |
| Connecting  |   |  |   |
| Insulation Check & Pre-charge   |   |  |   |
| Energy transfer   |   |  |   |
| Battery charging  |   |  |   |
| Auxiliary, HVAC energization  |   |  |   |
| Disconnection   |   |  |   |
| Vehicle free to move  |   |  |   |



# **ASSURED 1.0 Interoperability Reference**

**It describes standards and definitions used in ASSURED for conformance and interoperability testing of vehicles and chargers.**

- Used as a common test framework for charging infrastructure suppliers and e-bus manufacturers within and outside of the ASSURED project, until the ongoing standardisation of e-bus charging infrastructure is finalised.
- Released Jun 2019
- <https://assured-project.eu/news-and-events/news/assured-1-0-interoperability-reference>

**2019-2020, ASSURED performed successfully interoperability tests between different vehicles and charging stations.**



# ASSURED 1.1 Interoperability Reference

**ASSURED performed an extensive, independent test using the ASR 1.0 standards and conformance test protocols**

- The deviations and identified issues were summarised in the ASR 1.0 use case test protocols
- Points of improvement were be discussed in a dedicated workshop with ASSURED standardisation core team (technical specialists) and invited external experts.

**ASR 1.1 was updated according to the conformance and interoperability tests that were performed in the ASSURED project during late 2020 and early 2021.**

- Outcomes of the ASSURED Demonstrations (test in real operation) have been updated in ASR 1.1 and related conformance test protocols

**Overview of deviations covered by the new updated standards, and which standards stay open, will be described in the ASR 1.1 as advice.**

- Expected release Dec 2021.

# Thank You!

**More info:**

**[www.assured-project.eu](http://www.assured-project.eu)**