Charging EcoSystem future technology insights

from AC to Megawatt Charging System

Content

Pass Car Section

Trends / Xin1 Impact / Charging Efficiency / Charging Speed

CV/off-road Section

MegaWatt Charging System

Charging Validation

Status Quo / Methodology

AVL Testing Solutions

Will AC Charging be replaced by DC Charging in the near future?

AVL point of view and evaluation

Currently two trends within the industry

Relevant for
C to E Segment

DC Charging will be dominant in the future, especially for the use case V2G.
OBC will remain only for emergency charging,
max. 7 kW (1 phase) and uni-directional.

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Relevant for All Segment

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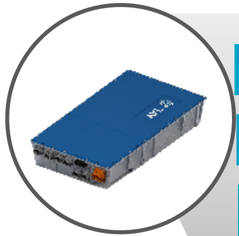
Additional trend for A/B Segment only:
Usage of high power AC Charging System only

Technology Trends Xin1 – Effects on Charging System Focus Europe/US

Today | Next vehicle Gen | Future



Standalone OBC

OBC +1 (e.g. HV/LV DCDC)

Features:
Bi-directional, “Split phase”

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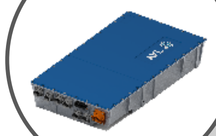

Standalone OBC

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Features:
Bi-directional, "Split phase"

2025+

Xin1 eDU

Up to 6in1

Physical & feature integration

*Image Source: Paper of PCIM Europe 2022, AC and DC Charging for Electric Vehicles with a Battery Modular Multilevel Managmeent (BM3) Converter System, Johannes Buberger

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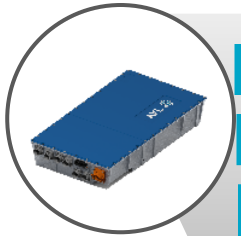

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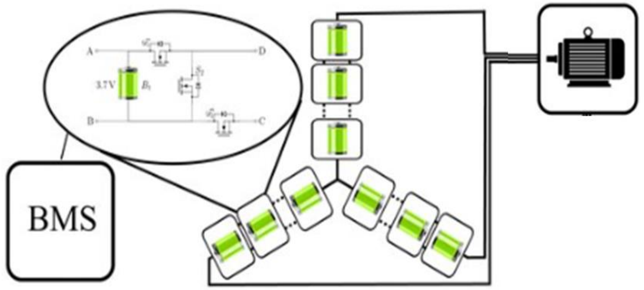


2030+

AC Battery / Smart battery converter*

New powertrain architecture

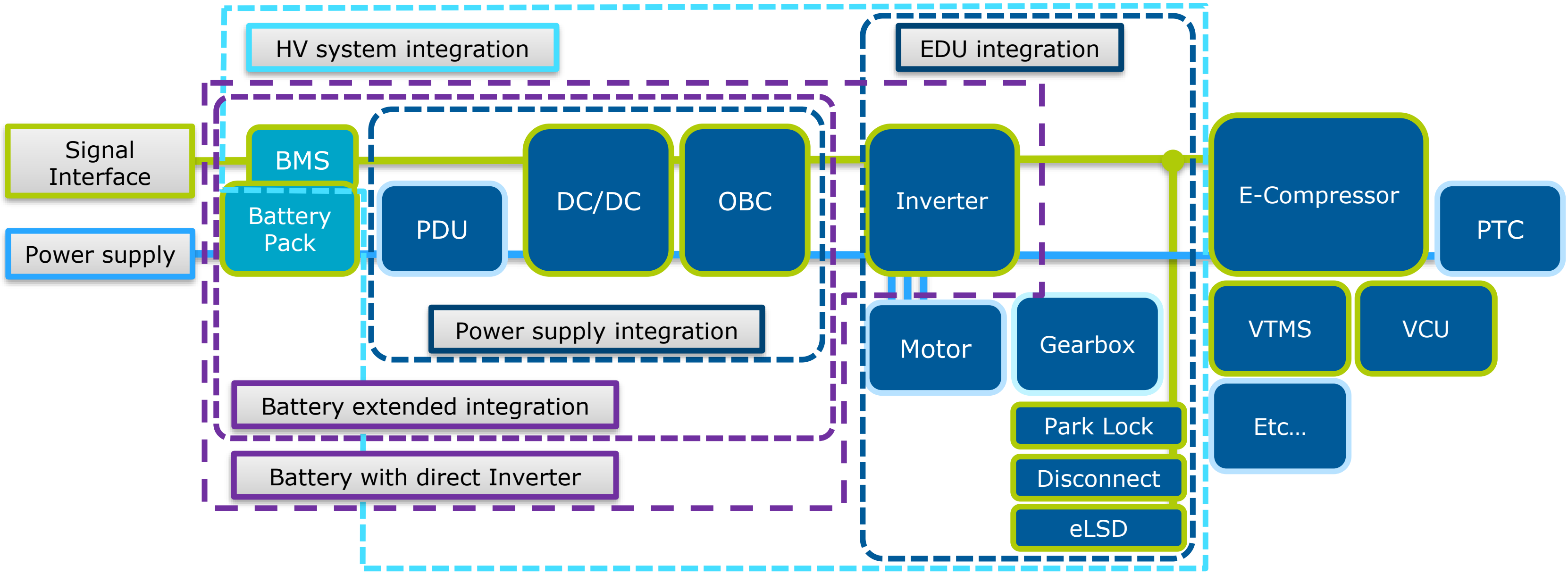
Inherent integration of OBC

Potential fast AC Charging

*Image Source: Paper of PCIM Europe 2022, AC and DC Charging for Electric Vehicles with a Battery Modular Multilevel Managmeent (BM3) Converter System, Johannes Buberger

X-in-1 Integration Strategies

Overview of current integration market trends & development strategies



Market Trends:

China
- X-in-1 EDU
- Integration level up to 12-in-1

EU
- X-in-1 EDU (moderate)
- Integration level up to 6-in-1

US
- Power supply & Battery extended integration

Integration Strategies:
- Component integration into one housing
- Control unit integration to reduce number of µCs
- Finding synergies

X-in-1 EDU
Multi System Integration – Improvement Potentials

Areas of improvement – reduction:
- Shared HV DC-Link Capacitor
- One Cooler Design
- Reduction of Connectors and Bus Bars
- One Housing Design – reduced interfaces
- Domain Controller for High Level Communication and Control Task
- Potential for reduced Validation Efforts

X-in-1 EDU

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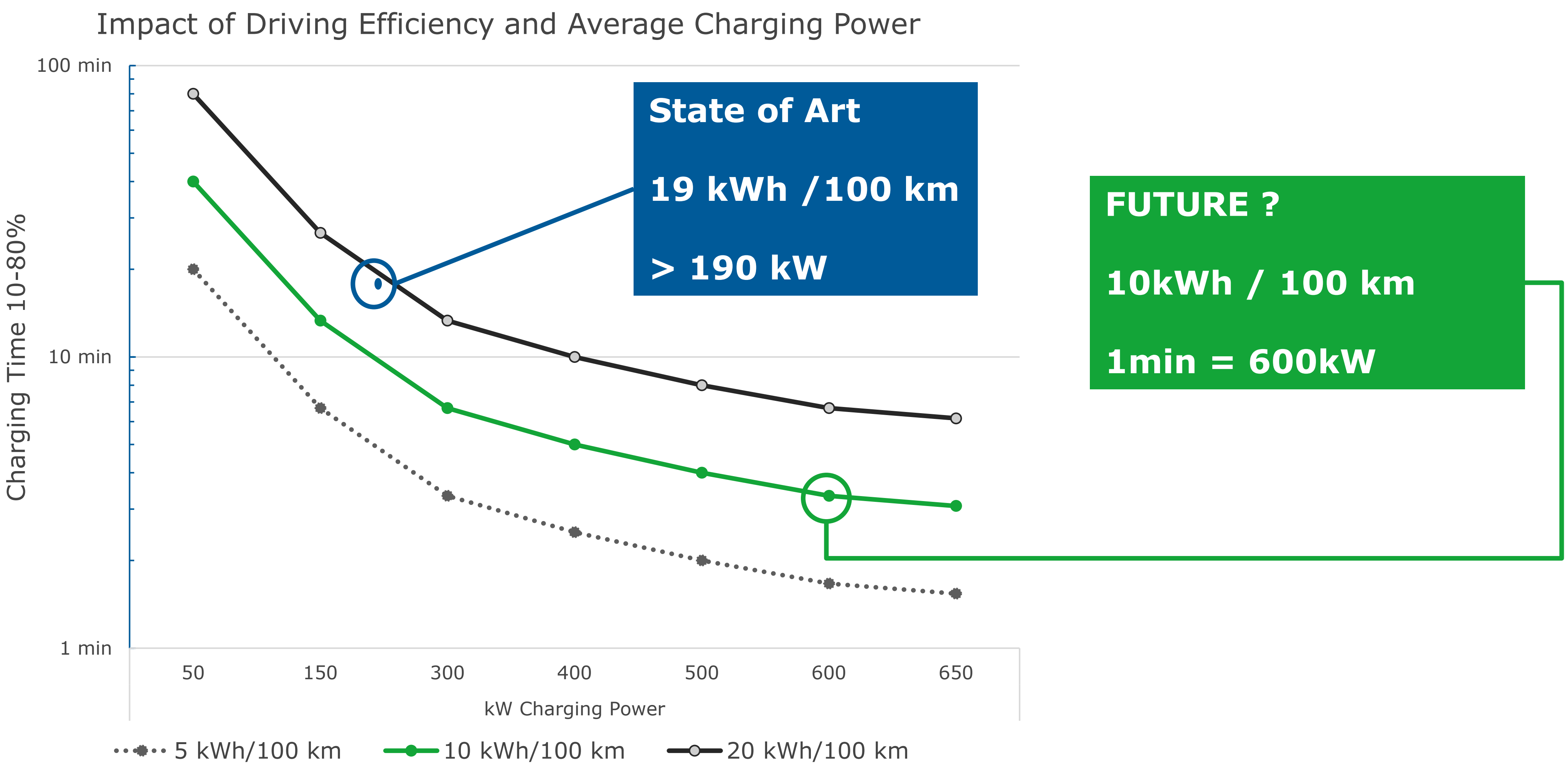
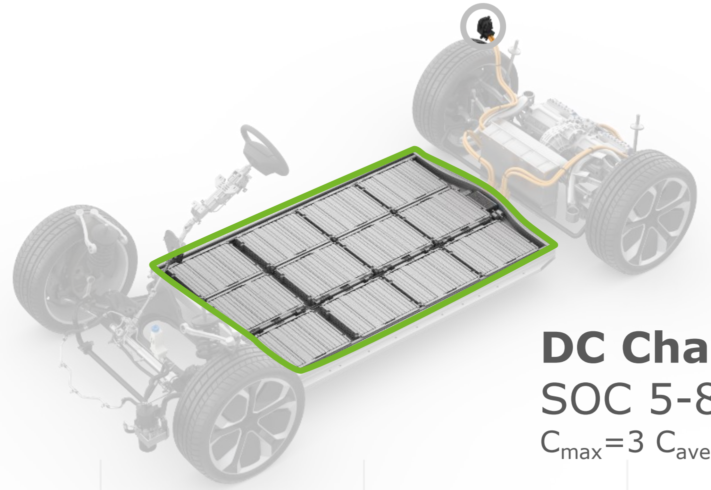
Cost	Weight	Package
Compared to 3-in-1 system up to	Compared to 3-in-1 system up to	Compared to 3-in-1 system up to
↓ 8% to 10%	↓ 5% to 8%	↓ 9% to 12%

Balance the Challenge
Driving Efficiency drives charging power requirement



Charging Losses – Analysis PassCar



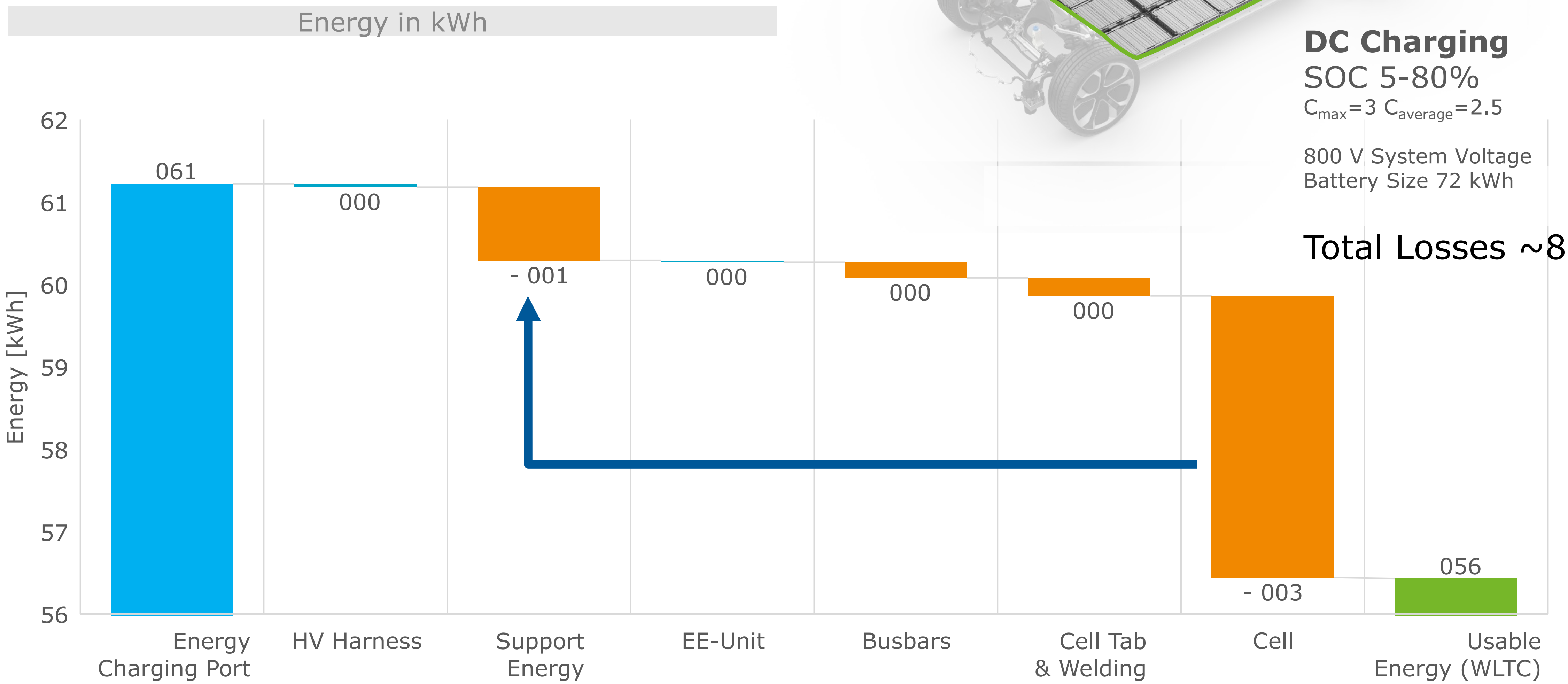
DC Charging

SOC 5-80%

C_{max}=3 $C_{average}$=2.5

800 V System Voltage
Battery Size 72 kWh

Total Losses ~8 %



MegaWatt Charging – A Critical Success Factor for Commercial Vehicle Electrification

Introduction to MegaWatt Charging

Charging Infrastructure for BEV HD Vehicles
Motivation

Allowed non-stop driving time (EU)

4,5 h driving
45 min break
4,5 h driving

Consumption

110–200 kWh / 100 km
400–800 km / day
360–800 kWh Battery

Charging Power

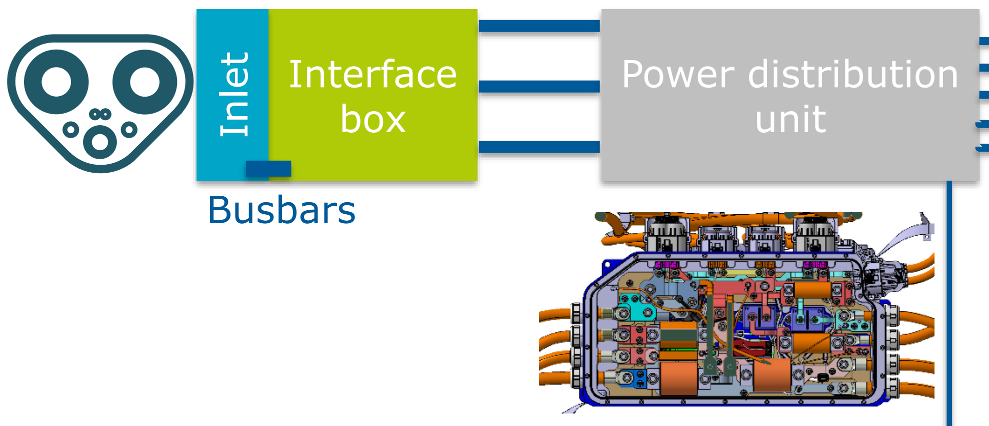
> 1000 kW
(during break stop)

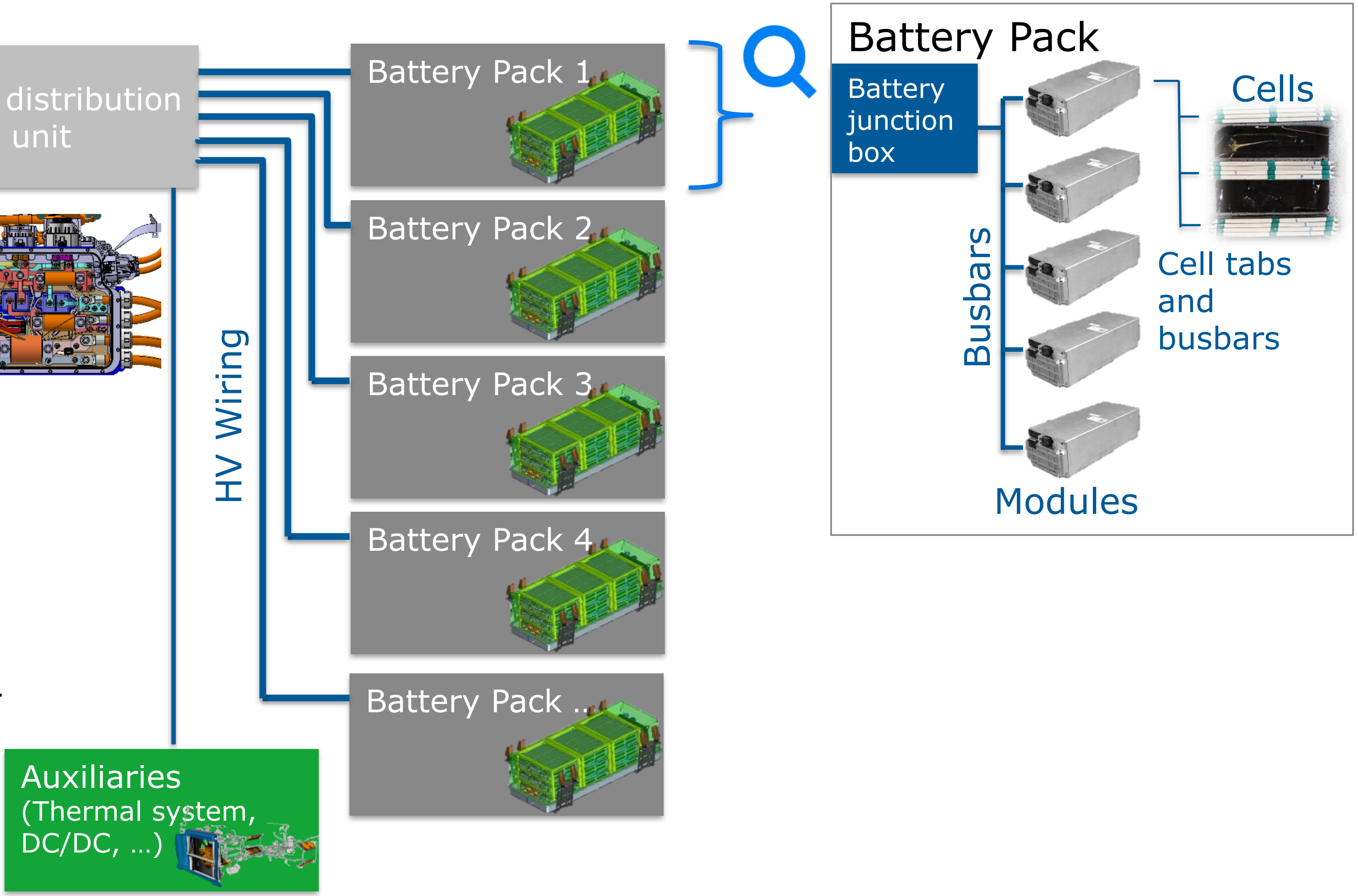
MegaWatt Charging – A Critical Success Factor for Commercial Vehicle Electrification

MCS System Architecture, Power Electronics & Control

Vehicle Architecture (AVL Proposal)

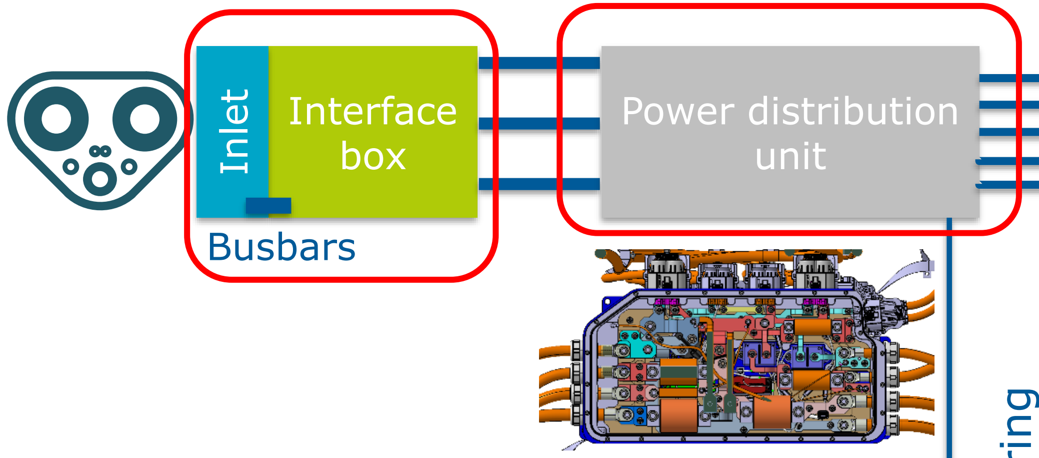
Power Distribution

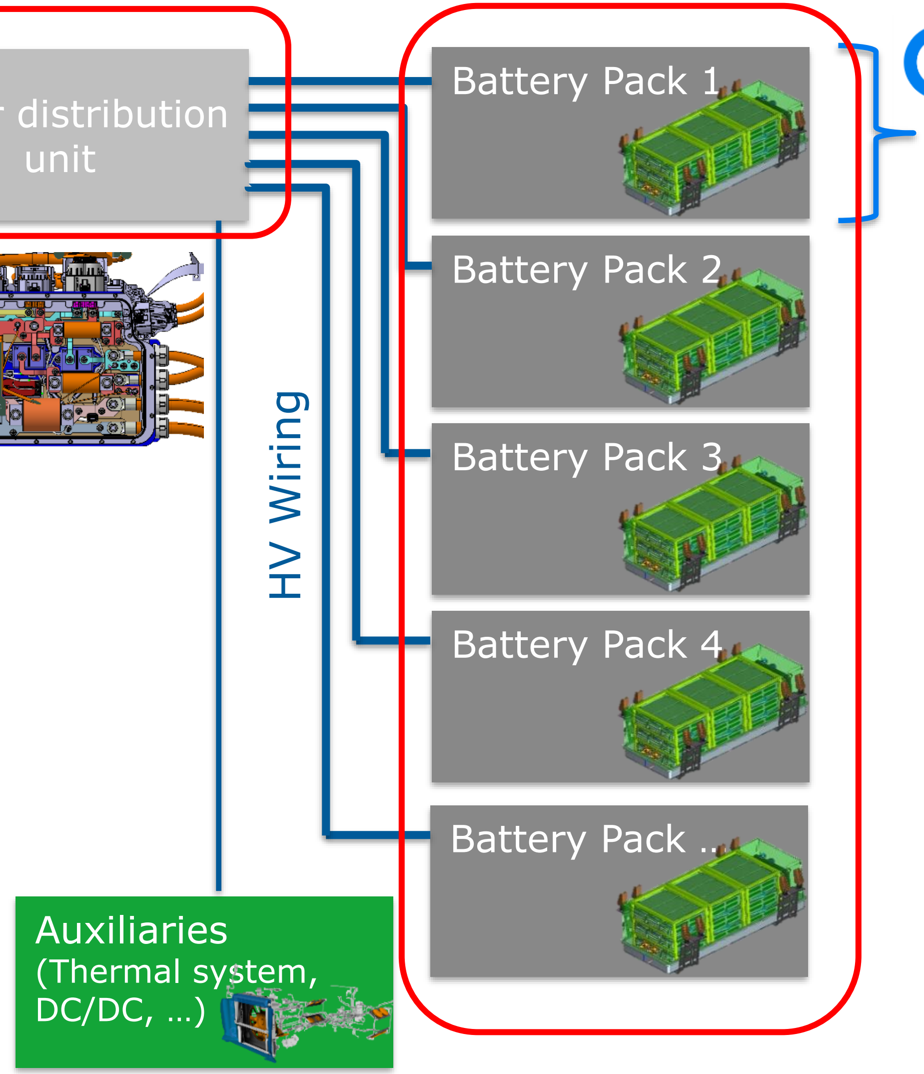


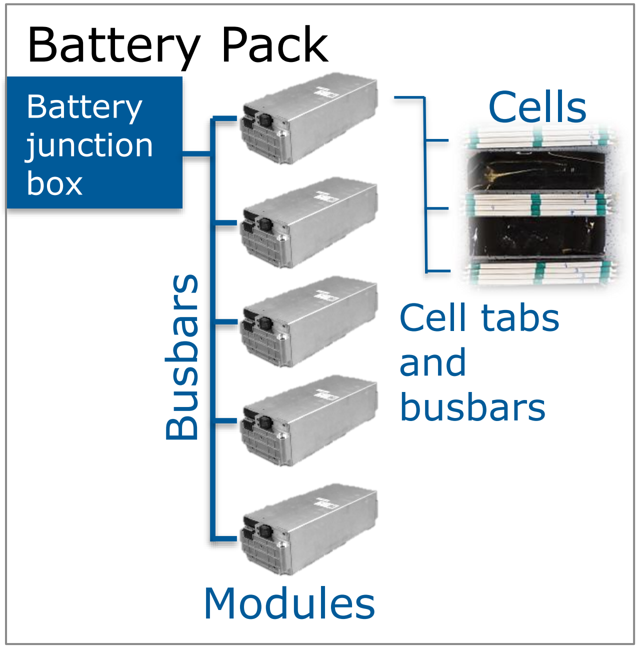


- High charging currents need to be handled and distributed accordingly
- Current paths divided as soon as possible to reach lower current levels on connectors, wires and sub-components

Vehicle Architecture (AVL Proposal)
Cooling





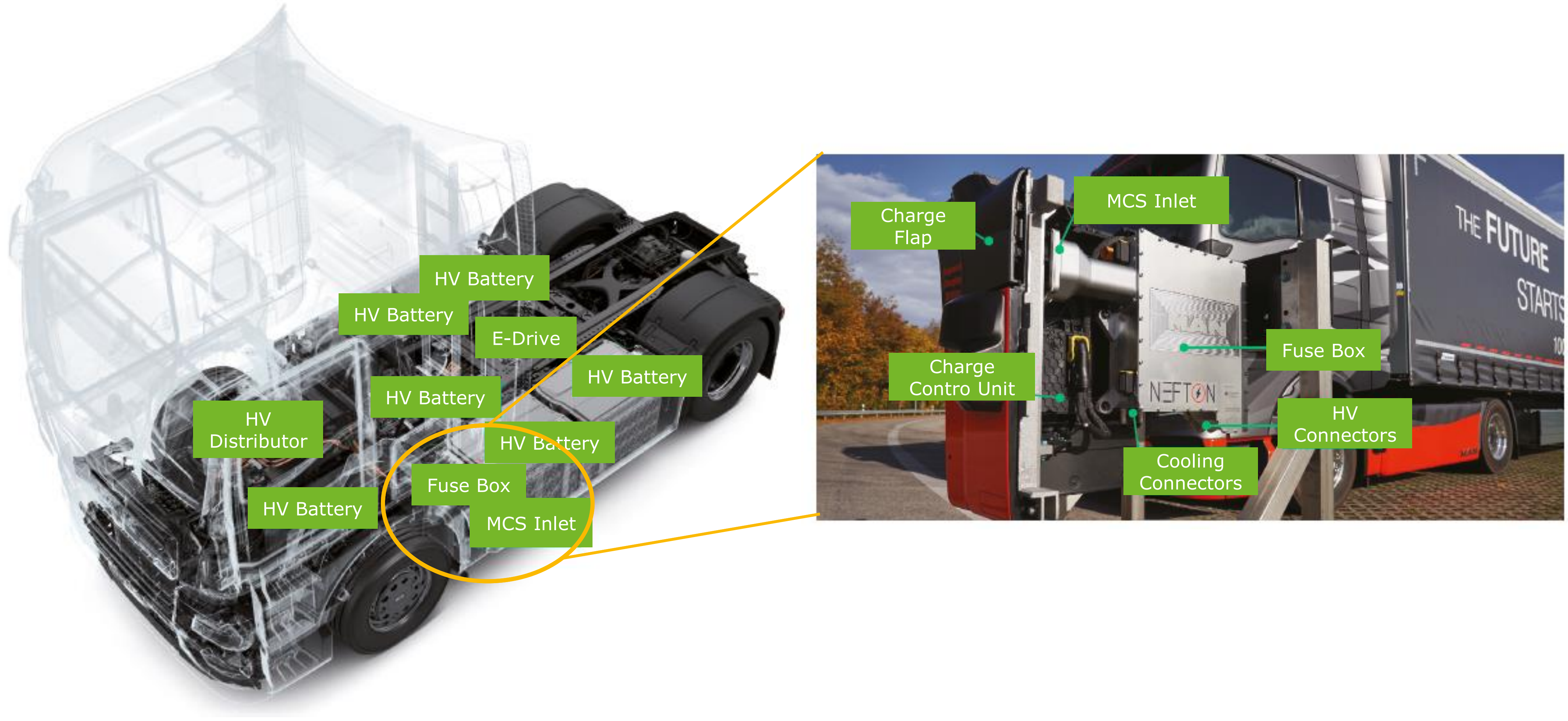


Heat losses to be cooled in:

- Interface Box
- PDU
- Battery
- Inlet

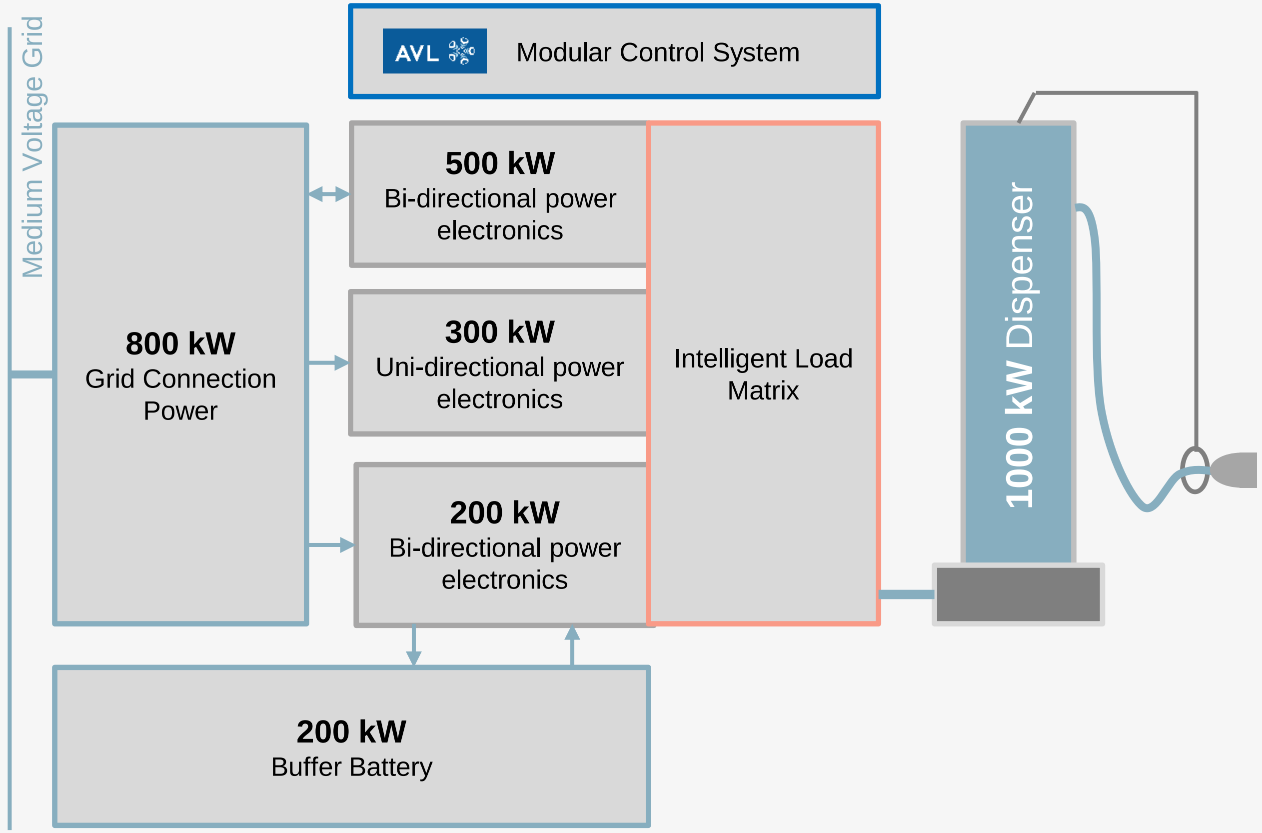
Vehicle Architecture

MAN Example from the NEFTON Project



Efficient Setup of a 1 MW Charging Station

Example from the NEFTON Project

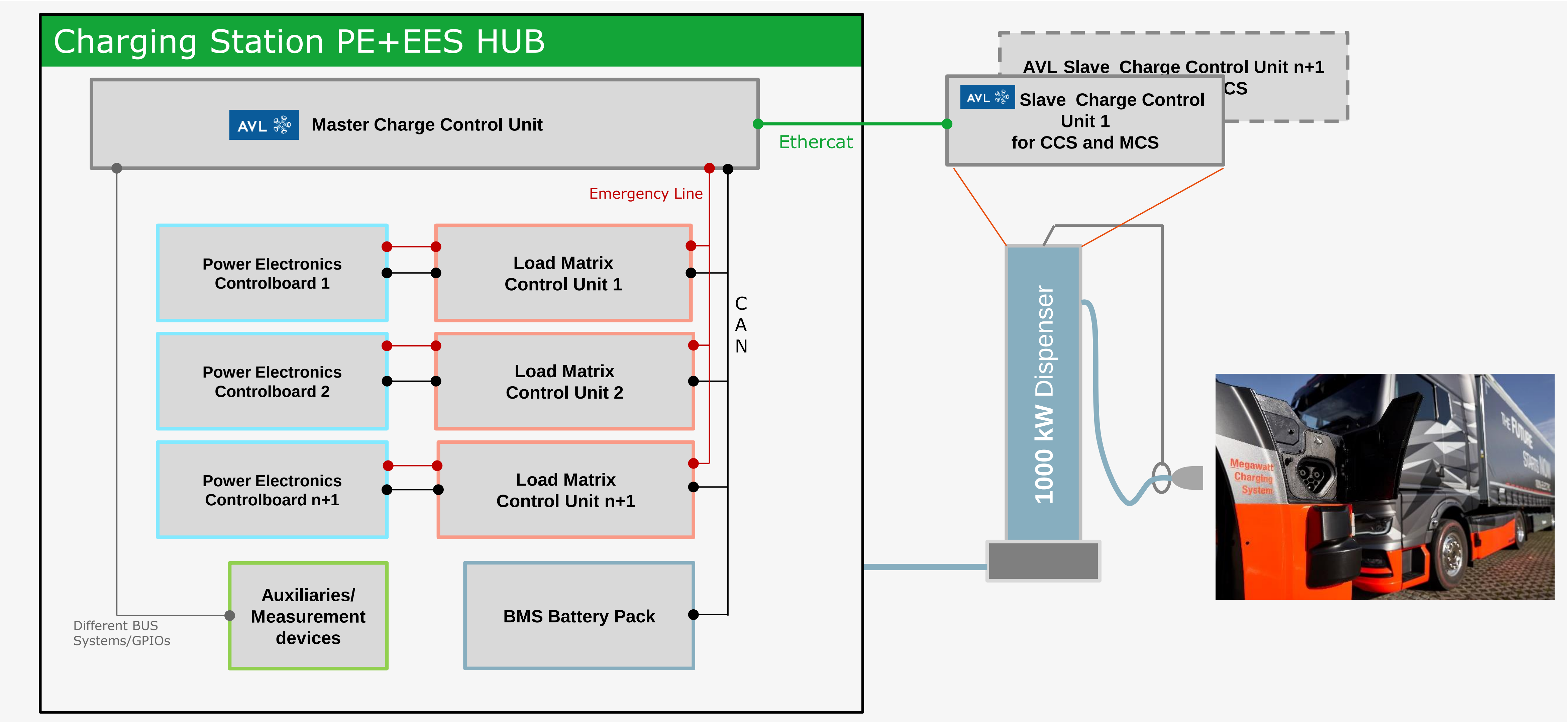


- Modular power electronics & control system
- Efficiencies above 98 % (PE only) reduce TCO and cooling requirements to a minimum
- Intelligent dynamic interconnection of unidirectional and bidirectional power electronics enables efficient overall energy management
- Reduced grid connected load lowers performance-based network charges

NEFTON
DLR Projektträger
Gefördert durch:
Bundesministerium für Wirtschaft und Klimaschutz
aufgrund eines Beschlusses des Deutschen Bundestages

AVL's Modular Control System

Example from the NEFTON Project



MegaWatt Charging – A Critical Success Factor for Commercial Vehicle Electrification

Energy Flow & Losses from Grid to Vehicle

Simulation

Description of BEV Charging Use Case

- Cell Data

Parameter	Value
Chemistry	LFP (cost efficient cell)
Nominal Voltage	3.3 V
Capacity	27 Ah

- Battery Pack data

Parameter	Value
Config	242 series / 4 parallel
Nominal Voltage	800 V
Capacity	86.2 kWh
Charging energy (20–80 %)	51,7 kWh
Charging power limit (~ 2C)	174 kW

- BEV Battery System data

Parameter	Value
Number of Packs	6
Nominal Voltage	800 V
Overall Capacity	**517.2 kWh (long haul truck)**
Charging energy (20–80 %)	310.3 kWh
Overall charging power (2C)	**~ 1000 kW**

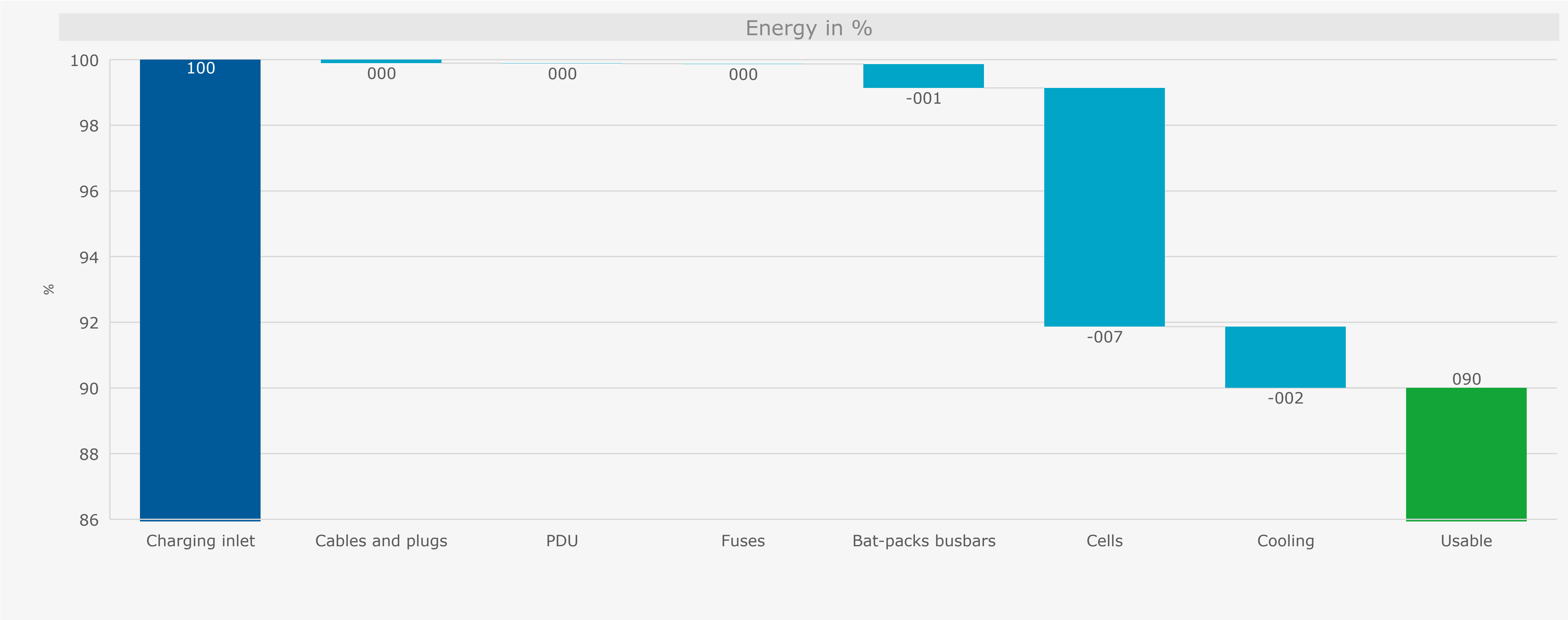
Charging Use Case
(Defined for 1 Bat-Pack)

Parameter	Value
Battery Charging Power (~2C)	174 kW const
Charging energy (20→80 % SOC)	51.7 kWh

- Battery Pack Charging Key Facts

Parameter	Value
Battery Charging Power (~2C)	174 kW const
Charging energy (20→80 % SOC)	51.7 kWh
Charging Time	**~ 20 min**
Mean Battery Terminal Voltage	865 V
Mean Battery Charging Current	**201 A**
Mean Cell Charging Power	161 kW
Mean Cell Charging losses	**13 kW**

Resulting Energy Split



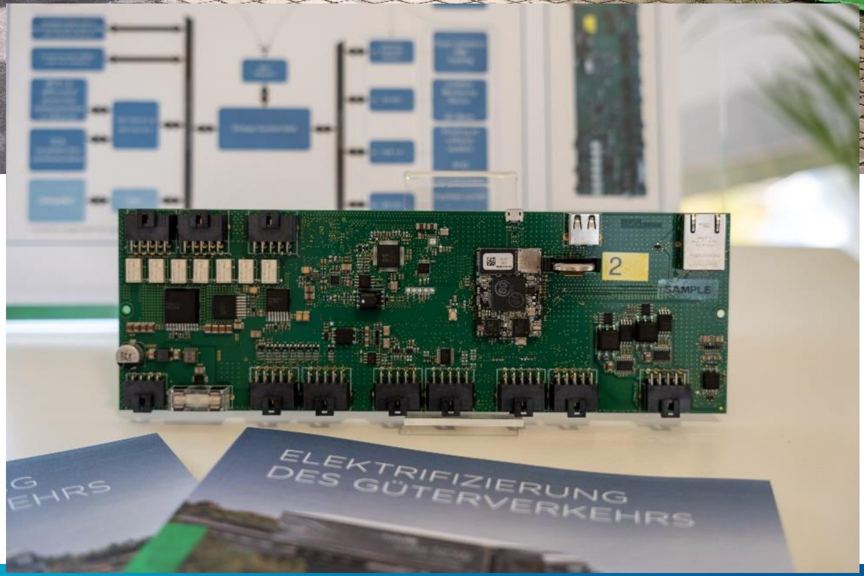
MegaWatt Charging – A Critical Success Factor for Commercial Vehicle Electrification

Status Funding Project NEFTON

NEFTON MCS System

Final Demonstration

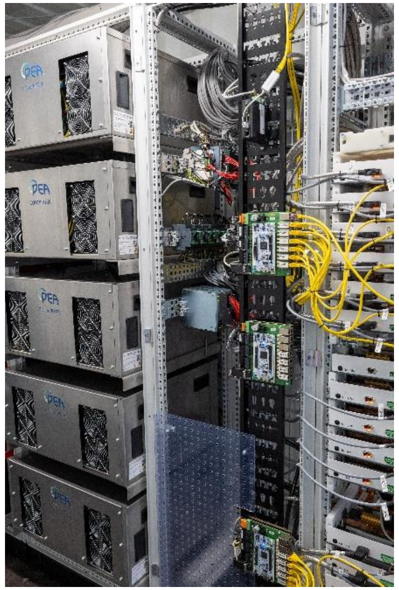
1 MW Charging successfully demonstrated to the public in 07/2024



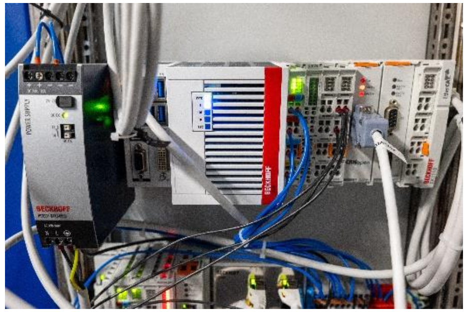
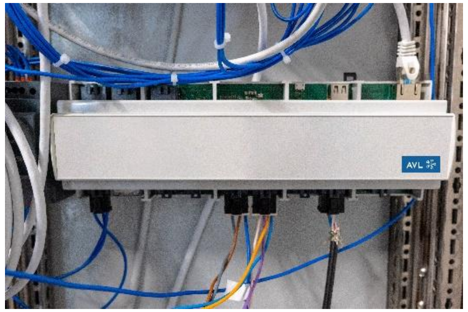
NEFTON Project Insights

Current Status, Site: Plattling, Germany

Load Matrix and Power Electronics




Modular Control System

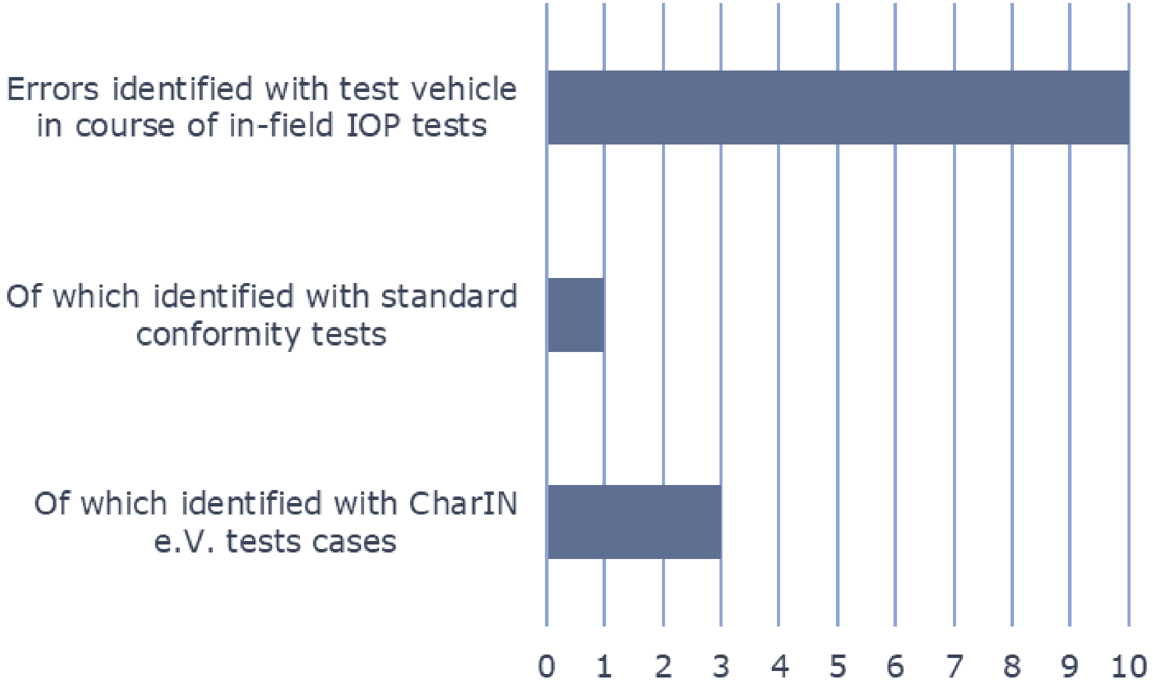



Dispenser & Energy Storage

Charging Validation

Charging Validation
Status Quo

Coverage of identified charge errors based on different test methods



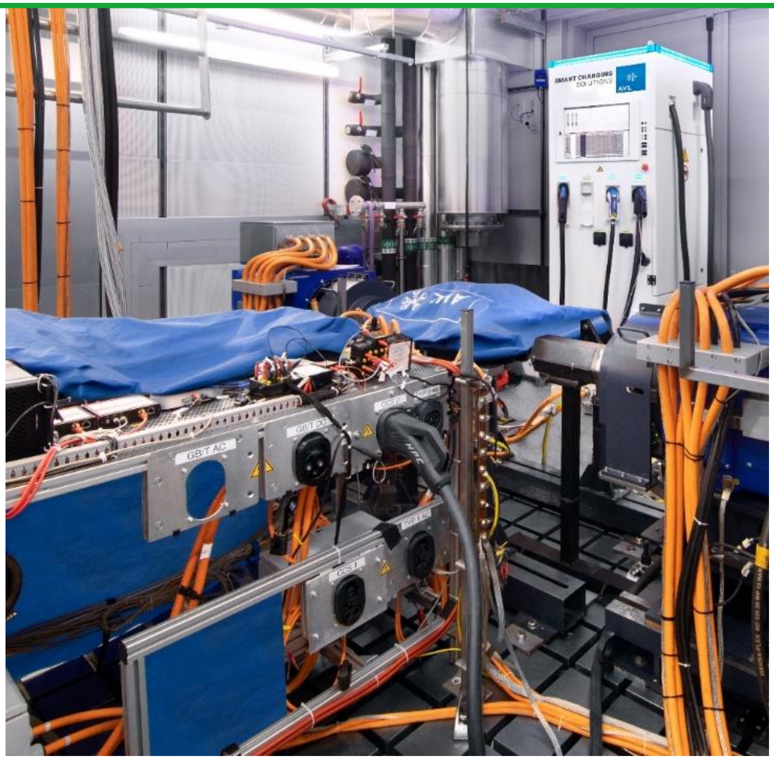
In-fiel IOP test are still needed to ensure convenience for the driver

Charging Validation
Methodology and test system as key elements

Charging System
Verification and Validation Roadmap

+

AVL test bed for
the validation of a charging system



Testing Roadmap

Charging component Tests → Charging function and component integration testing → In-Lab Standard conformity and IOP tests → Charging performance testing and function tests vehicle - level (charging and vehicle function interaction) → In-Lab Standard conformity and IOP tests → In- Field IOP testing

Test on sub system without battery

Test on sub system and vehicle with battery

Test on final vehicle setup (focus thermal management system

Test on final vehicle setup (geometrical application charging system)

Maturity of UUT

Test Bed Set Up (all charging components, no vehicle, no final geometrical topology) →
- Vehicle close set up (Vehicle, or Test bed),
- Nearly all powertrain components
- Close to final geometrical topology

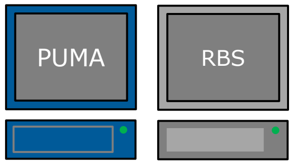
→ Vehicle set up close to SOP vehicle

Enabler: Testing of the **charging function components** relevant for interoperability as early as possible

AVL test bed: **Reproduce anomalies** from the field from component to vehicle level

Benefit: Reduction of cost-intensive field tests & **expensive late bug fixing**

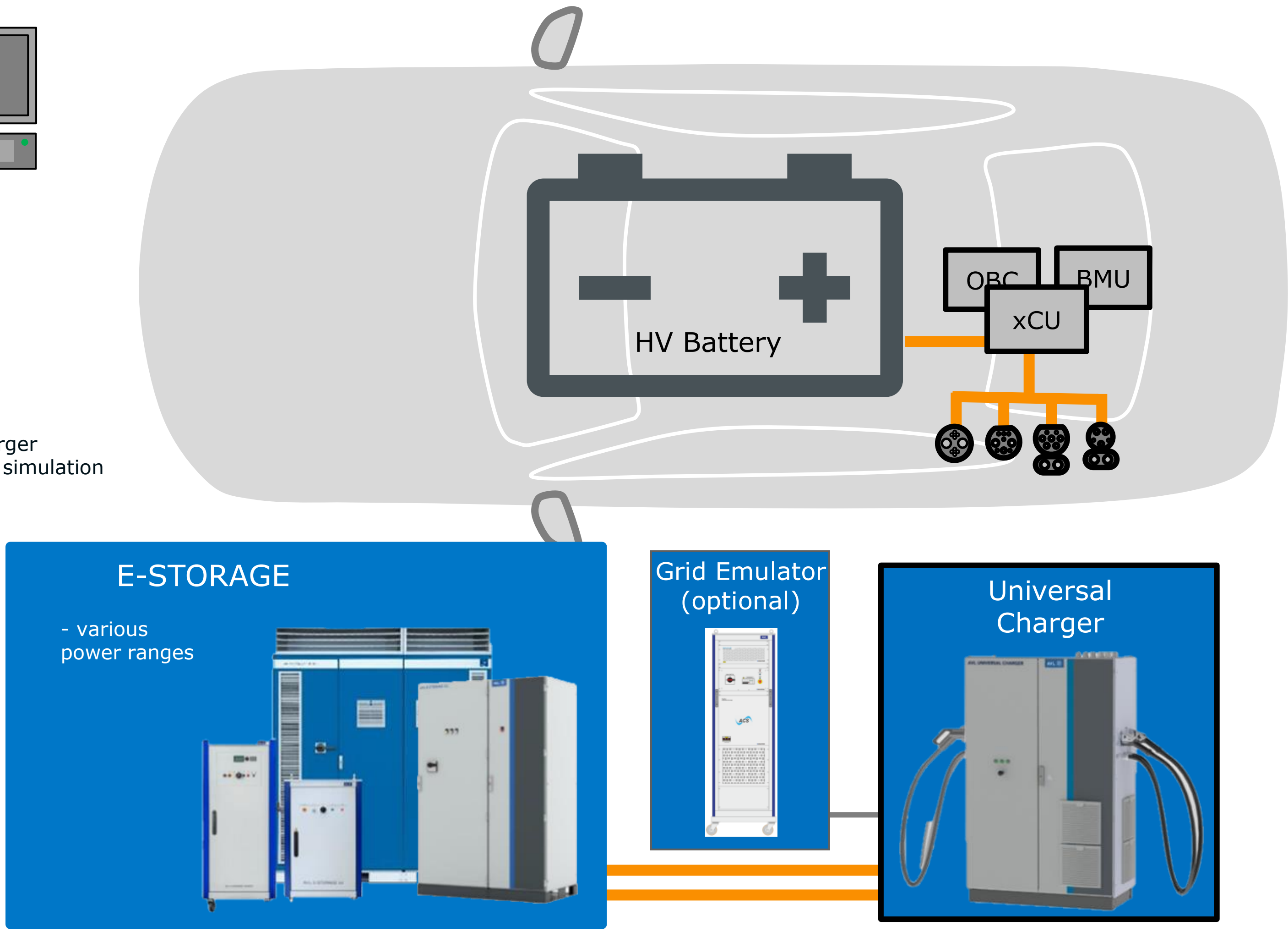
AVL Vehicle Charging TS™ - schematic

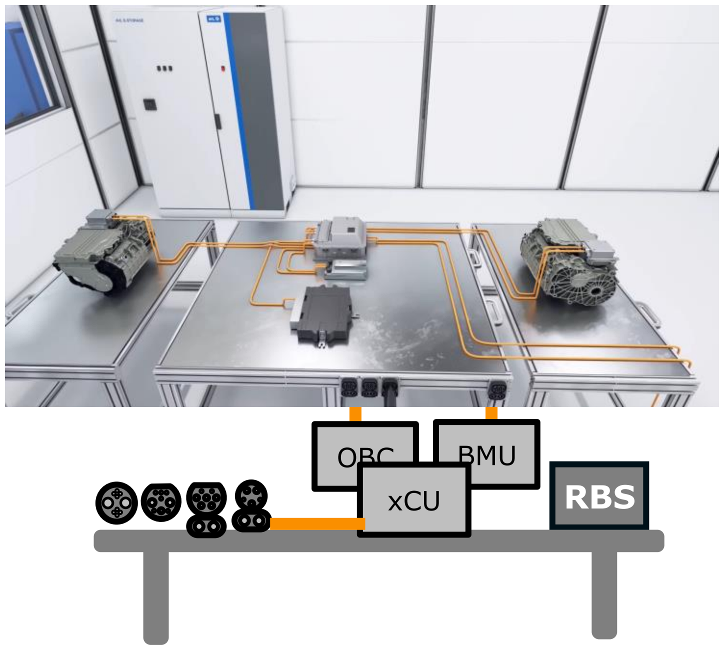


Testbed Safety System

HV: High voltage
OBC: Onboard charger
RBS: Residual bus simulation

High precision measuring device (optional)





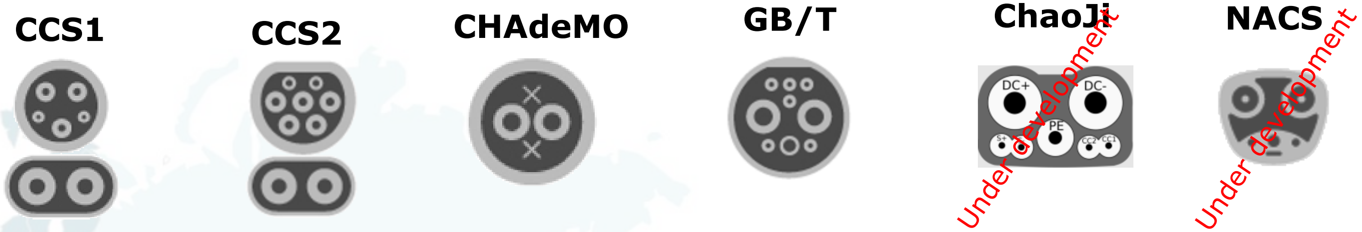
AVL Vehicle Charging TS™ - Charging standards; use case

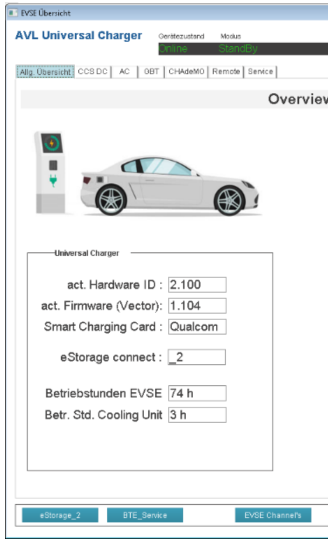
AC

Type 1 | Type 2 | GB/T | NACS

DC

CCS1 | CCS2 | CHAdeMO | GB/T | ChaoJi | NACS





- Test Automation → influenceable CP, PP
- Conformance / Interoperability tests
- Performance tests
- Failure Emulation

DC charging cable	
CCS 1	Max. 1000 VDC, max. 800 A, active liquid cooled, 5 meters optional 8 meters at 500A
CCS 2	Max. 1000 VDC, max. 800 A, active liquid cooled, 5 meters optional 8 meters at 500A
CHAdeMO	Max. 1000 VDC, max. 200 A, passively cooled, 8 meters
GB/T	Max. 1000 VDC, max. 250 A, passively cooled, 8 meters

AVL Vehicle Charging TS™ – providing the right testbed for the right work

- according to your software development

Thank you

www.avl.com