

Amphenol

NAATBatt Meeting 2023

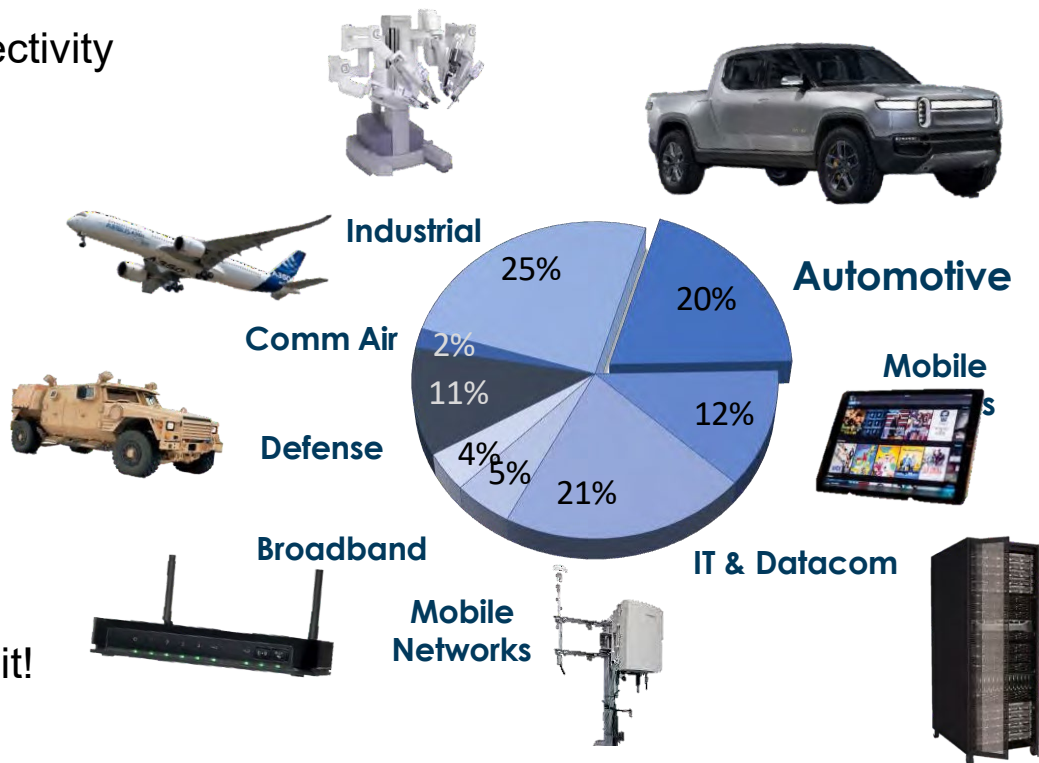
**Connecting
People and Technology**

February 2023



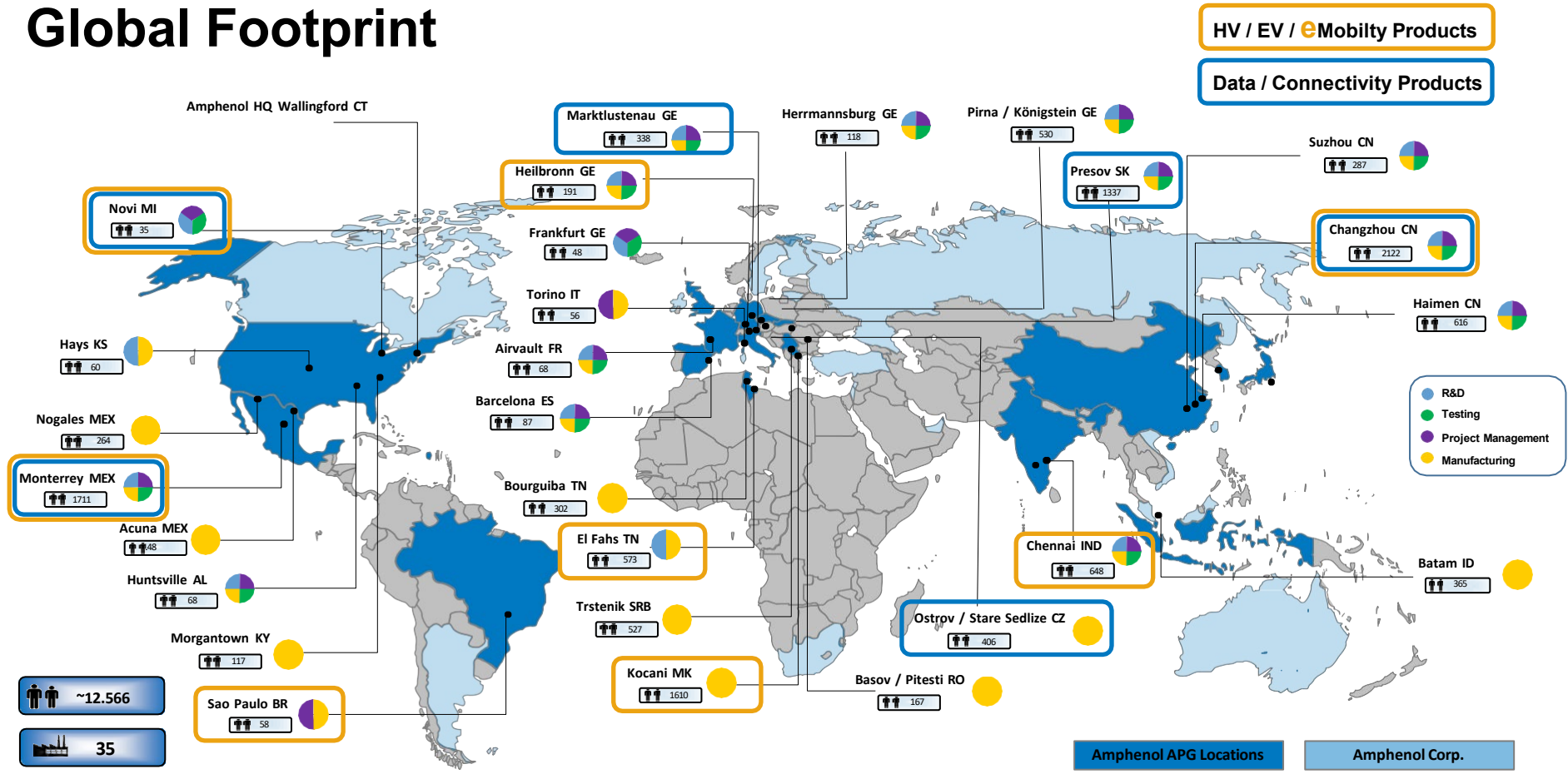
Amphenol Corporation - 2023

- High voltage / high current connectivity
- HV and signals harnesses
- Charge Plugs and Inlets
- Ethernet / high speed cx
- Fiber Optic cx
- Bus bars
- Cell Connection Systems
- Antennae
- Inverters/converters
- Service Disconnects
- Sensors
- combined stamping/molding
- ...if it moves electrons, we make it!



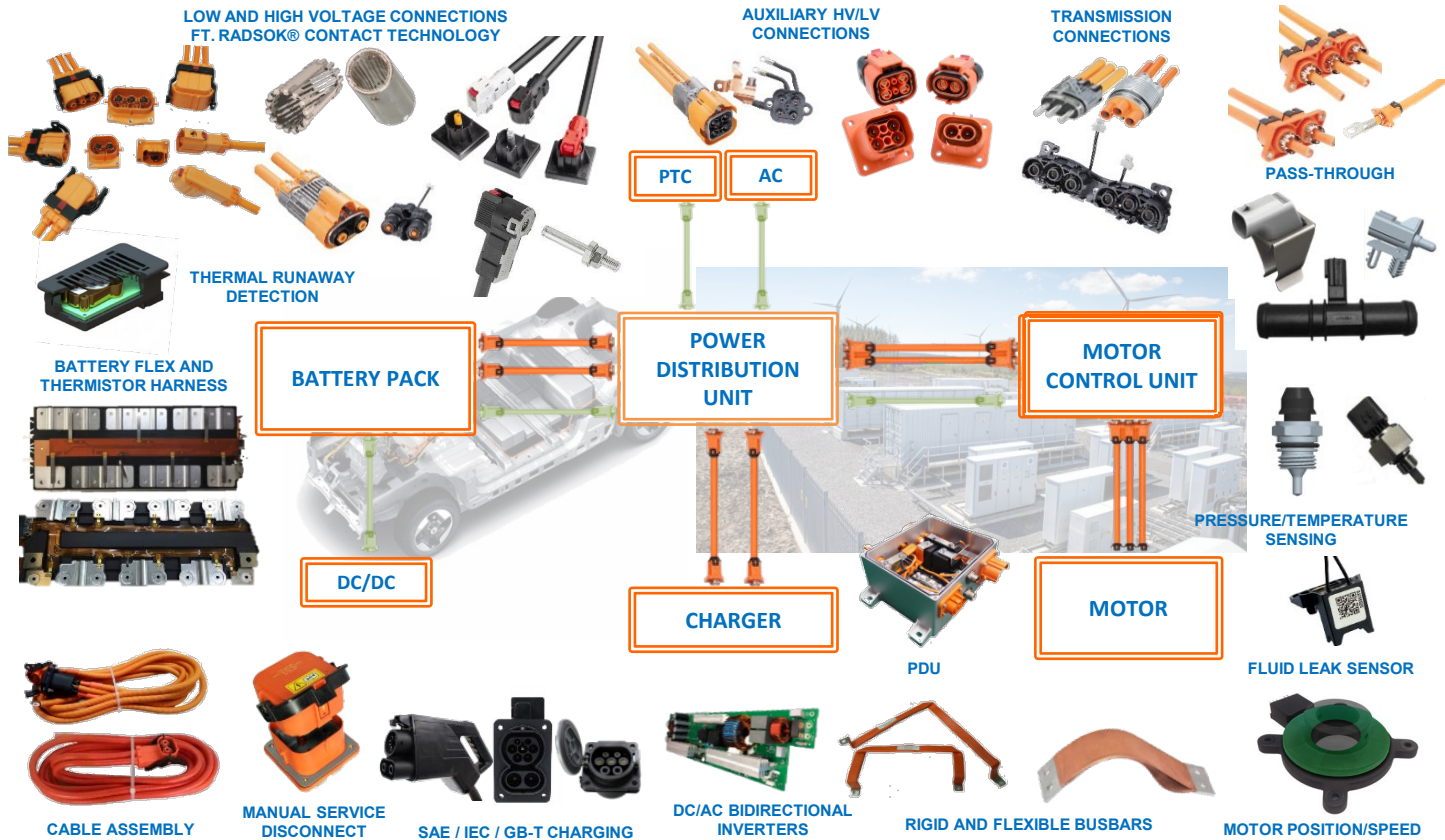
>135 Companies in 3 Divisions and 12 Groups • > 91.000 Employees • > 12.6 Billion US\$ Sales 2022

Global Footprint



Every Amphenol facility capable of locally producing any Amphenol product

Supporting Mobile and Stationary Sensing & Electrification Solutions



Grid to Wheels Safety, Sensors & High Voltage Electronics

Combining skills and expertise to solve critical issues

Sensing:

- Temperature
- Pressure
- Gas concentration
- Current
- Fluid Level
- Concentration
- Speed
- Rotary/Linear Position
- Accoustic /ultrasonics
- Vibration / Acceleration
- Force
- Air Quality
- Particulates / Dust
- Moisture / Humidity
- Process Controls
- Validation Instruments
- ...and more



From cell manufacturing to battery safety and precision control sensors

Amphenol sensors utilized throughout xEV, Fuel Cell and ESS Applications

Battery:

- 
- **Busbar, Cell Temperature – non contact**
 - **Cold plate temperature**
 - **Connector temperature – including non-contact**
 - **Water intrusion/coolant breach**
 - **Early Thermal Runaway Detection (REDTR)**
 - **Cell connection systems**
 - **Current**

HP/HX:

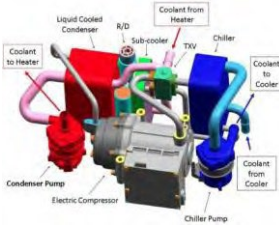
- 
- 
- **Coolant Temperature, Pressure**
 - **Refrigerant Temperture**
 - **Refrigerant Pressure/Temperature**
 - **Evaporator Temperature**
 - **Position sensors**
 - **Coolant level Sensors**
 - **Current**

Motor / Inverter:

- 
- 
- **Motor coil temperature**
 - **Motor position/speed**
 - **Inverter FET temperature – non-contact**
 - **Current**

Fuel Cell:

- 
- 
- **Hydrogen Pressure**
 - **Hydrogen Temperature**
 - **FC Stack Temperature**
 - **Hydrogen leak**
 - **Cathode hydrogen**
 - **Humidification / dielectric / level**
 - **Intake Relative humidity / Temperature / Pressure**



Delivering Value-Add  Sensors

THERMAL RUNAWAY DETECTION

Temperature Sensors
Measure and monitor battery temperature to detect Thermal Runaway conditions.
• Capable of single or multiple cell detection

Pressure Sensors
Detect pressure change inside the battery cell that indicates Thermal Runaway conditions.
• Surface mountable
• Simple 3-command PC interface
• Very low current consumption: <25µA

Gas Detection Sensors
Detect the out-gassing of Carbon Dioxide (CO₂) to indicate pre-combustion conditions.
• Single and dual channel configurations
• Self-calibration with patented ABC Logic™ Software

Gas Detection Sensors
Detect the presence of combustible gases that indicate Thermal Runaway conditions.
• Sensitive to multiple gases: H₂ / CH₄ / CO₂
• Fast response time: <10 seconds
• IP6K7 rating

BATTERY COOLANT

Temperature Sensors
Measure and monitor fluid temperature of inlet/outlet battery coolant to provide indication of battery cell temperature.
• No leak path - Sensor cavity and tube are one piece
• USCAR sealed connection system
• Many part geometries: inline tube, flying lead and integral sensor

Pressure Sensors
Measure the pressure in the cooling system to control pump capacity.
• Internal metal sealing for high media compatibility and no leakage
• Customized calibration for high accuracy

Combined Pressure & Temperature Sensors
Measure pressure in the cooling system, while, at the same time, measure temperature of the coolant for optimum thermal management.
• Available versions: R1234yf (up to 35bar) and R744 (up to 200bar)
• Tested LIN 2.1 conformity
• Automatic address assignment within LIN network (Slave Node Position Detection)

Ultrasonic Level & Temperature Sensors
Continuously monitor fluid level for early detection of coolant leakage.
• Level accuracy: ±2mm
• Temperature accuracy: ±2.5°C
• Output protocol offerings: Analog, PWM, SENT, CAN, LIN
• Input voltage options: 5V / 12V / 48V

BATTERY PACK

Temperature Sensors
Measure and monitor surface temperature of the many batteries within the battery cell, which is critical to preserving the chemistry of the battery.
• Single point temperature sensors
• Rigid and flexible types
• Custom sensor packaging

CELL CONNECTION SYSTEM (CCS)

Temperature Sensors
Provide temperature and voltage sensing to monitor the state of charge of the battery cells.
• High current circuit for battery cell connectivity
• Available styles:
Wire Harness and Flexible Printed Circuit (FPC)

HIGH VOLTAGE CHARGER CONNECTOR

Temperature Sensors
Detect over-temperature conditions during charging.
• Installed within the connector

MOTOR COIL

Temperature Sensors
Measure and monitor temperature of the motor coil to provide feedback on the operating conditions of the electric motor.
• Field-proven design
• Variety of lead lengths, terminal and connector options

POWER INVERTER / E-MOTOR

Temperature Sensors
Measure and monitor operating temperature of the power inverter to provide feedback on unsafe conditions.
• Fast response time
• Pigtail connector

Inductive Position Sensors
Provide data on the angular position of the rotating motor shaft to optimize control of the motor inverter.
• Inductive eddy-current with weight and size reduction
• Stable output over extended temperature range (-40°C/+160°C) and radial/axial misalignment
• Robust against magnetic flux and external stray fields

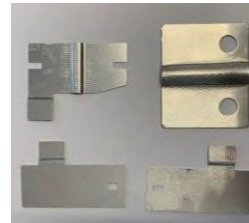


• **Highlighted indicates 2022 New Product Launches**

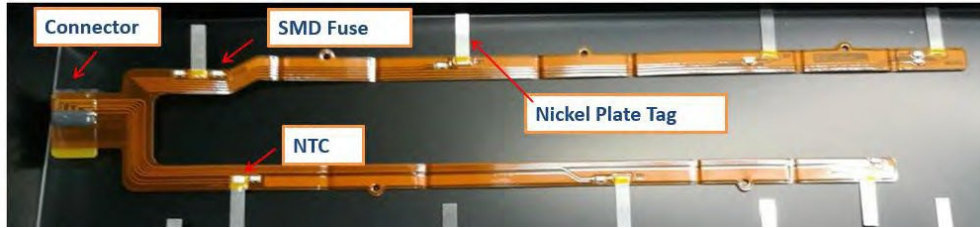
Busbars



- **Custom busbar design:** experts in modeling and simulating current flow, thermal response and induction mitigation
- **Applications:**
 - Inner Battery Connections
 - Pack To Pack
- **Experience:** copper and aluminum, all sizes
- **Supported in 3 major regions: NA, Europe, Asia**



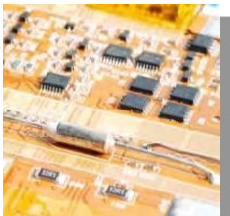
Flex Printed Circuit (FPC) Design



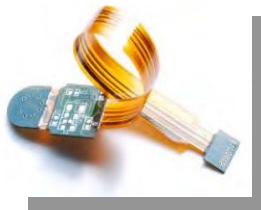
- Single layer, Multilayer, Rigid Flex Circuits
- Harsh Environment: Reliable in high vibration, great chemical resistance
- Excellent Signal Integrity: EMI Shielding, Impedance Controlled, Twisted Pair
- Dynamic Flexure: Over 200K Bending Cycles with Standard Materials
- Multiple Surface Treatments
- Provide Design Flexibility, Reduce Weight, Lower Assy Cost & Labor Time, Pack Size Reduction



Amphenol Flex Capabilities



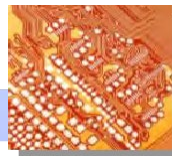
Component / Surface Mount / Hand Assembly and Other Value Added Assembly/ Services



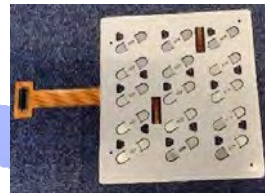
Rigid-Flex Double and Multi-layer $\leq 16L$



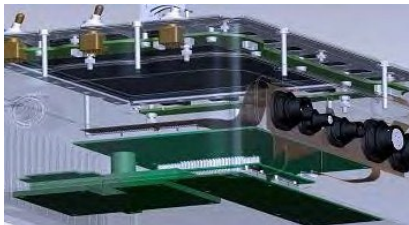
Multilayer FPC $\leq 12L$



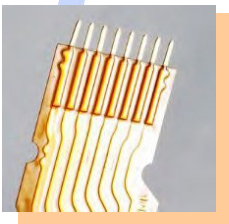
Single- and Double-layer Flex Circuits (FPC)



Laminated Busbar including voltage measurement and Temp sensing



Electronic Integration Box Build



Power Flex, Sculptured Flex for up to 100/200A



High Speed Flex



Heater Flex 1W – 300W



High Operating Temp Flex $\leq 200^{\circ}C$



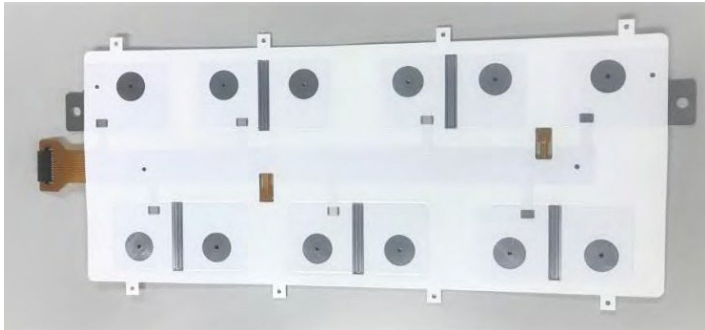
Battery Sensing Covers (CCS) /Wiring, busbar with temp and Cell voltage measurement



Battery Flex up to 750mm or 1.2m and now special lengths

New Products from Amphenol

- Laminated Busbar for battery solutions
 - New from Sincere
 - A complete one piece solution consisting of: Busbar (etched/stamped), voltage sensing, flex interconnect, other sensing
 - Suitable for: Prismatic, Cylinder or Pouch batteries
 - Resulting:
 - Lower weight, Lower profile, Lower NRE



Prismatic Cells



Cylinder Cells

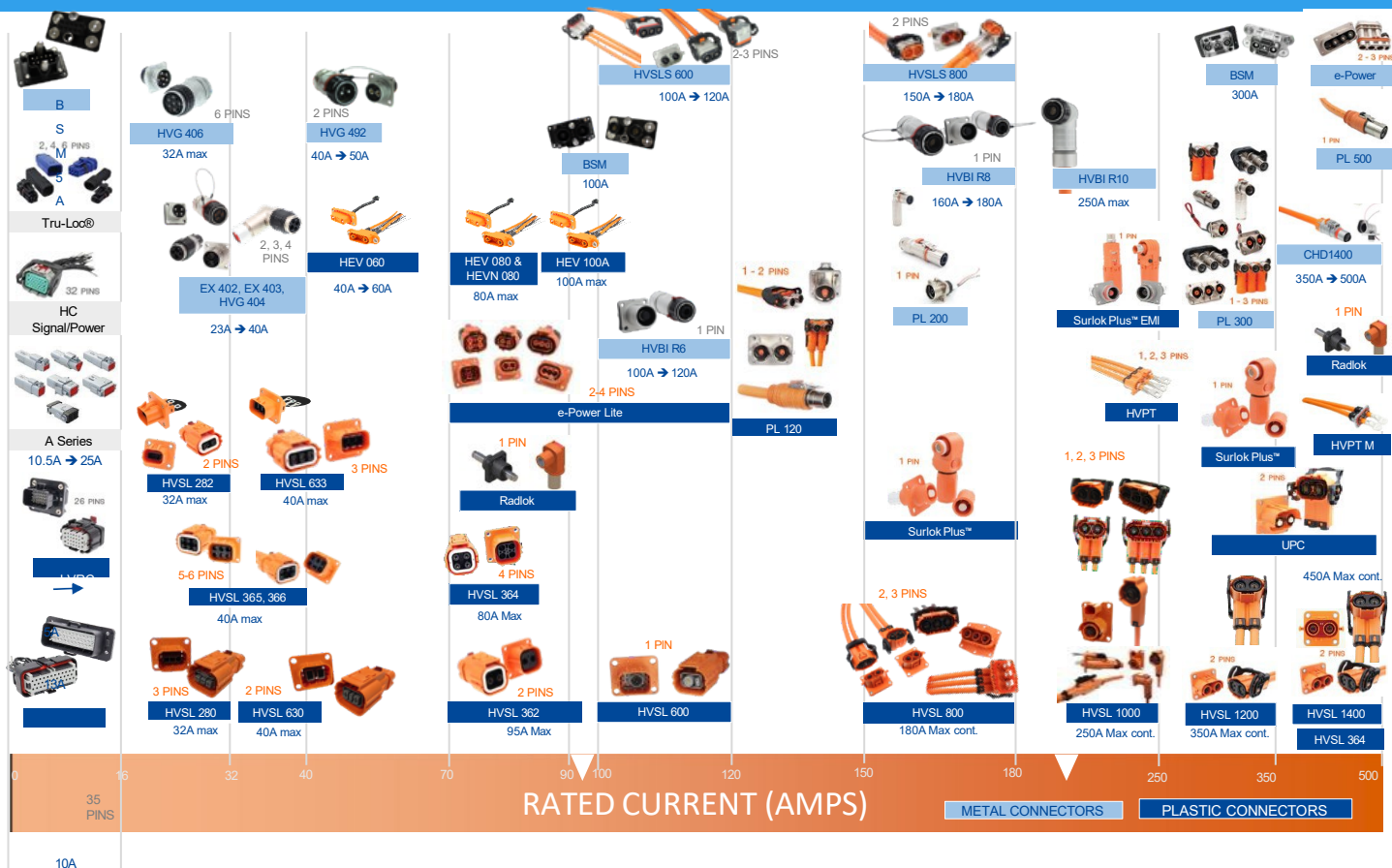


EV Charging : Plugs & Inlets

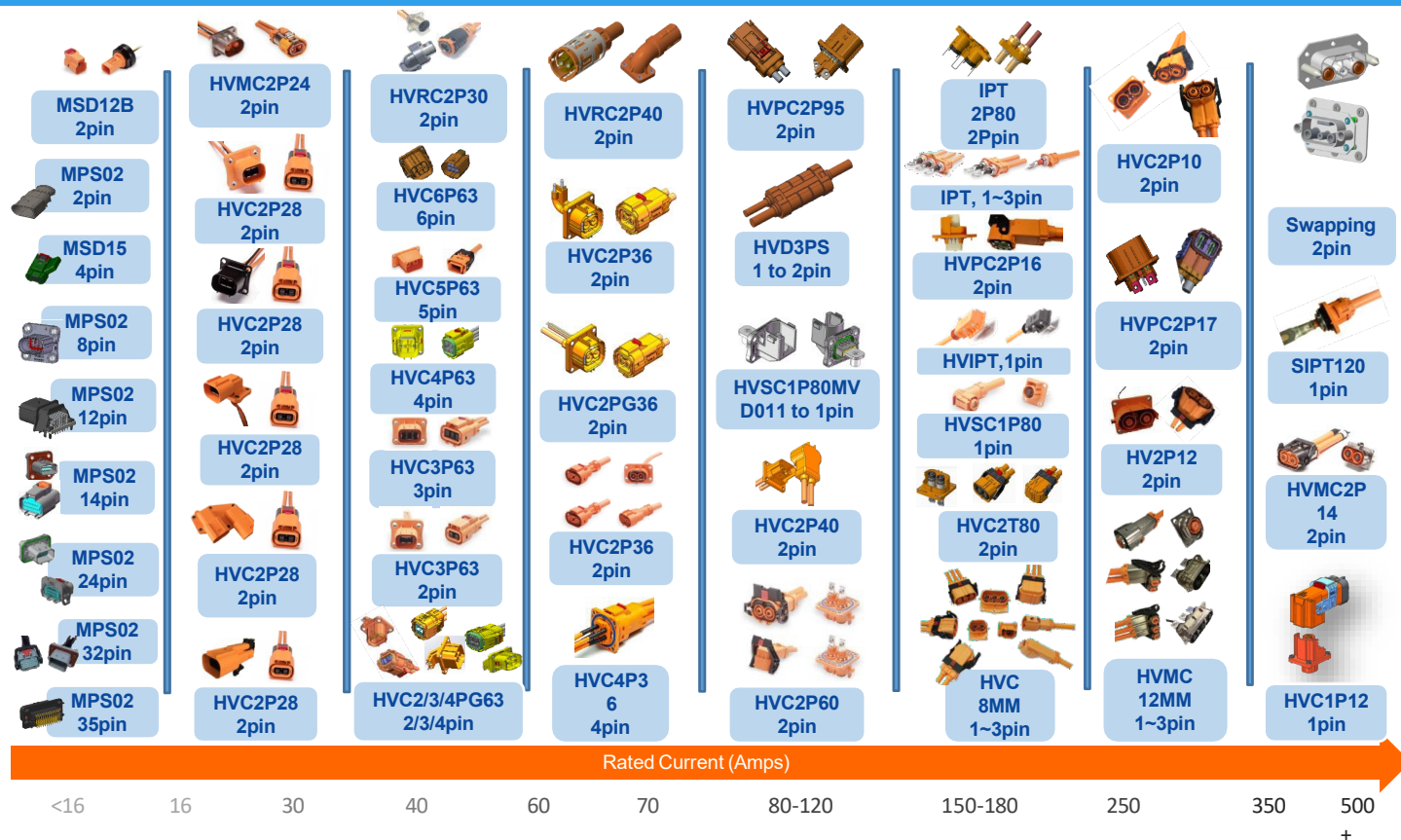
MCS		CCS1 UL		AC SAE J1772		CCS2 IEC		IEC AC		GB/T	
										 AC  DC	
 *	MCS LVL 1 Passive +350A	 *	CCS1 Plug HPC LCC 500A		AC SAE Plug 16A to 80A	 *	CCS2 Plug HPC LCC 500A		IEC Plug 16A to 80A	 *	GBT HPC LCC 600A
 *	MCS LCC Liquid Cooled LVL 2 1000A LVL 3 3000A		CCS1 Copper 125A -350A		AC SAE - CAC 32A		CCS2 Copper 125A -400A		IEC Jumper 16A to 80A		GBT DC 80A to 250A
 *	MCS Inlet Passive LVL 2 1000A	 *	CCS1 light 40A-65A-80A		AC SAE Portable Mode 1 16A to 32A	 *	CCS2 light 40A-65A-80A	 *	IEC Jumper 16A to 80A		GB/T Combo Inlet
 *	MCS Inlet Liquid Cooled LVL 3 3000A		CCS1 Inlet 65A - 500A	 *	AC SAE Inlet 16A to 80A	 *	CCS2 Inlet 65A - 500A	 *	IEC AC Portable Mode 1 16A to 32A		GB/T Inlet AC or DC

* Work in Progress 2022 * Work in Progress 2023 Q1/Q2

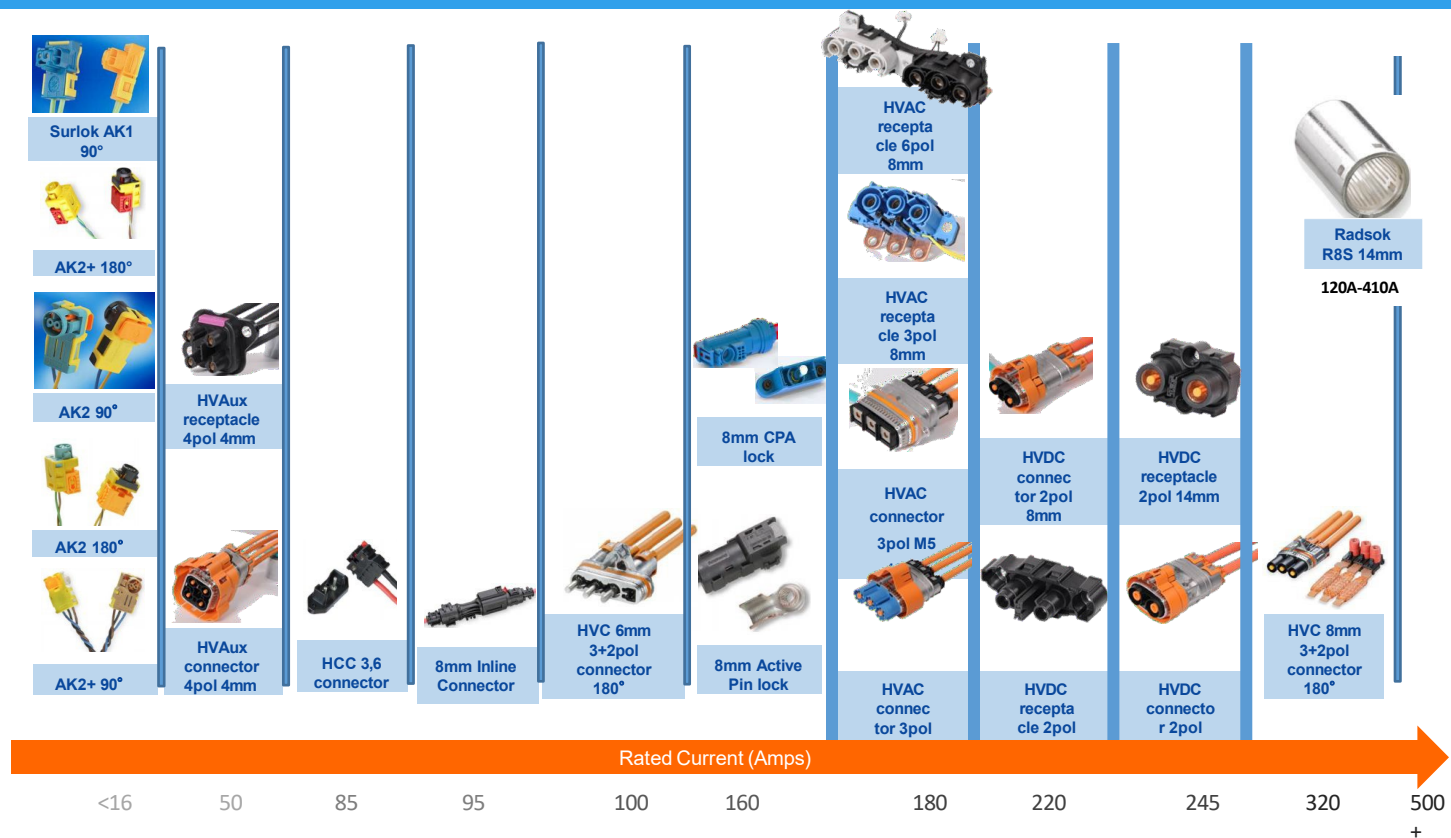
Amphenol Industrial Connectors by Current



Amphenol Automotive Connectors by Current (China)



Amphenol Automotive Connectors by Current (Europe)



Amphenol & Sustainability

2023 SDG Goals



6.4 Clean Water and Sanitation

By the end of 2030, Amphenol will reduce total water withdrawal of top 20 sites by 15% vs. 2021 levels.



7.2 Affordable and Clean Energy

By the end of 2030, Amphenol will increase our use of renewable energy to 50% for energy used at our facilities.



8.7 Decent Work and Economic Growth

By the end of 2025, Amphenol will enhance ESG elements in existing supplier auditing programs and conduct audits for suppliers in the highest ESG risk category.



11.5 Sustainable Cities and Communities

By the end of 2025, Amphenol will ensure our business continuity plans address issues related to physical risks as per TCFD for the top 20 manufacturing locations.



12.2 Responsible Consumption and Production

By the end of 2025, Amphenol will conduct a detailed analysis of its cardboard and plastic packaging use to support future packaging optimization efforts.



12.4 Responsible Consumption and Production

By the end of 2025, Amphenol will assess the use of PFAS in products and processes across its manufacturing locations.



13.1 Climate Action

By the end of 2025, Amphenol will reduce revenue-normalized Scope 1 and 2 emissions by 15% compared to our 2021 levels.



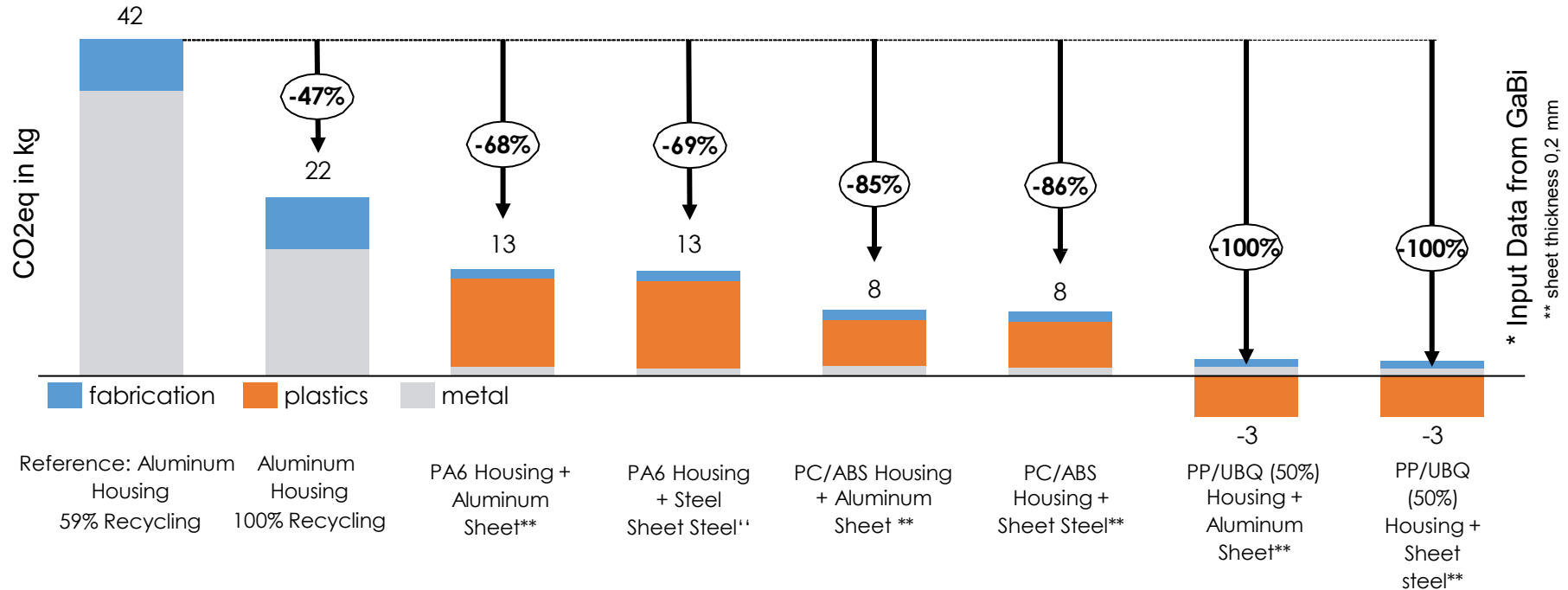
16.2 Peace, Justice and Strong Institutions

By the end of 2025, Amphenol will deliver enhanced training on its health and safety requirements to all Amphenol businesses worldwide.

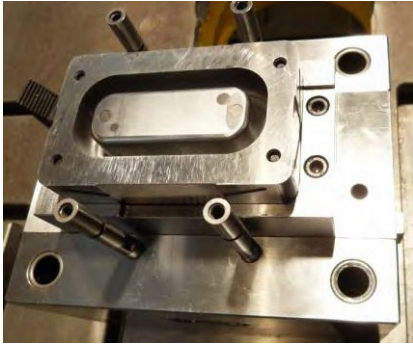


EAC+: Sustainable Electric Architecture Casings – LCA

Pre-estimation of the life cycle assessment - CO₂eq of comparable housings*



EAC+ Current status and first samples



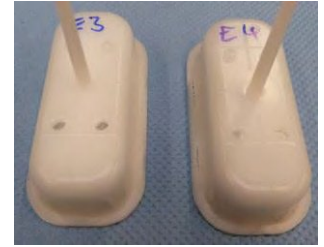
pre-sample
molding tool



First metal sheet
forming tests
(aluminium & steel)



Integrated metal
sheet forming &
injection molding



first pre-samples
(Januar 2023)