



LEONI



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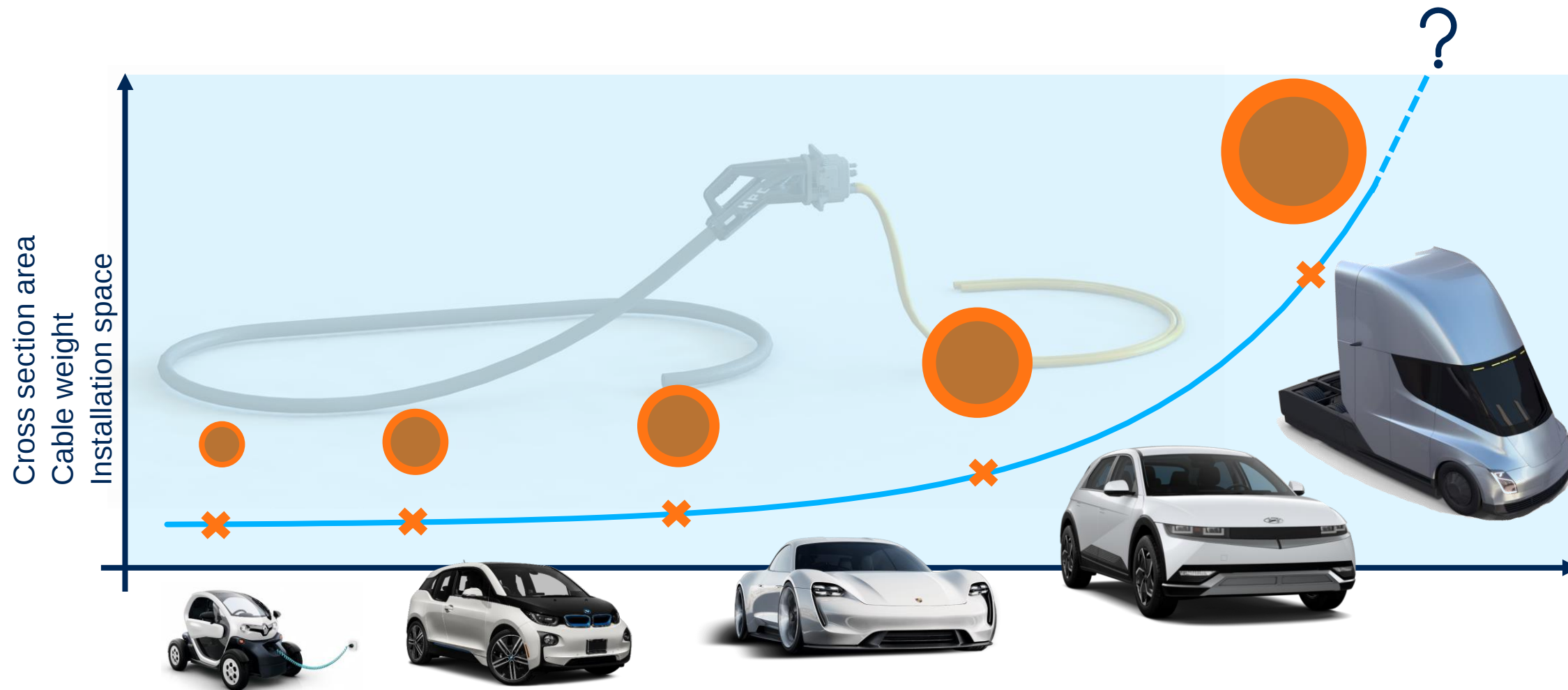


Enlargement of Product Portfolio – LEONI[®] Hivocar Cool

Increase of current carrying capacity

Reduction of charging duration

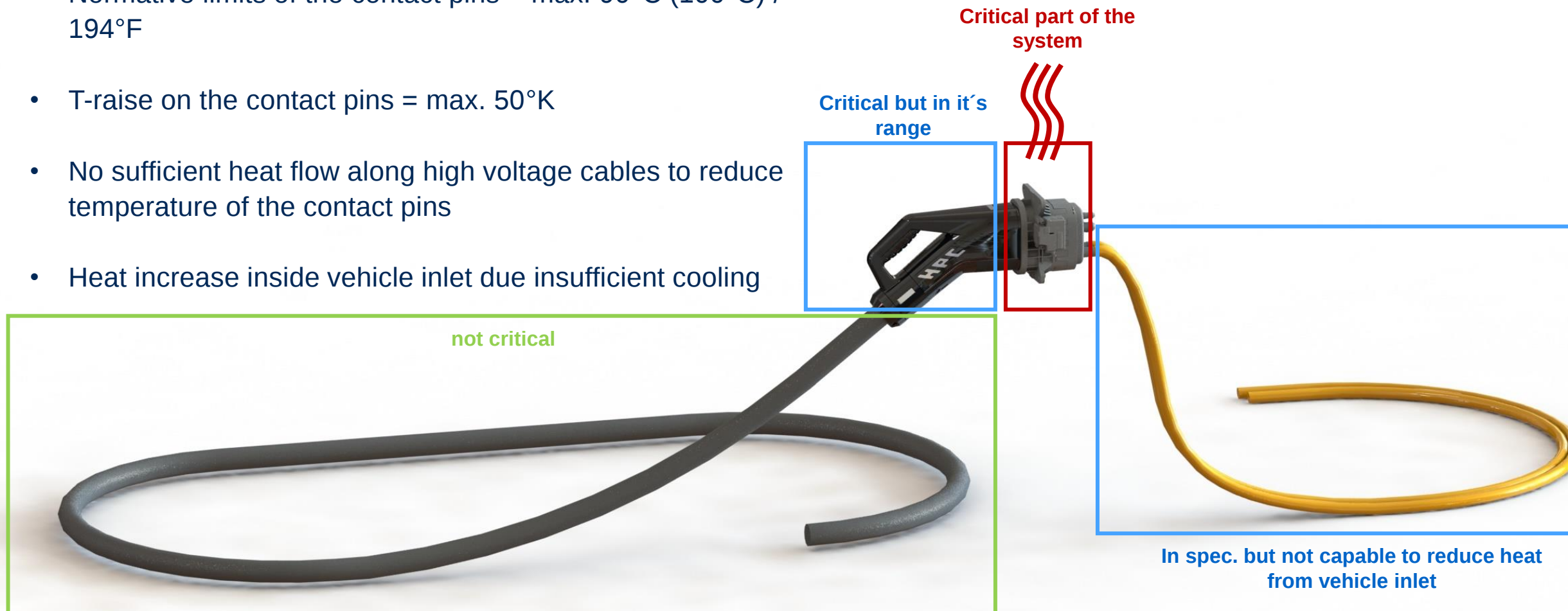
Permanent Increase of Cross Sections due to Increase of Charging Current



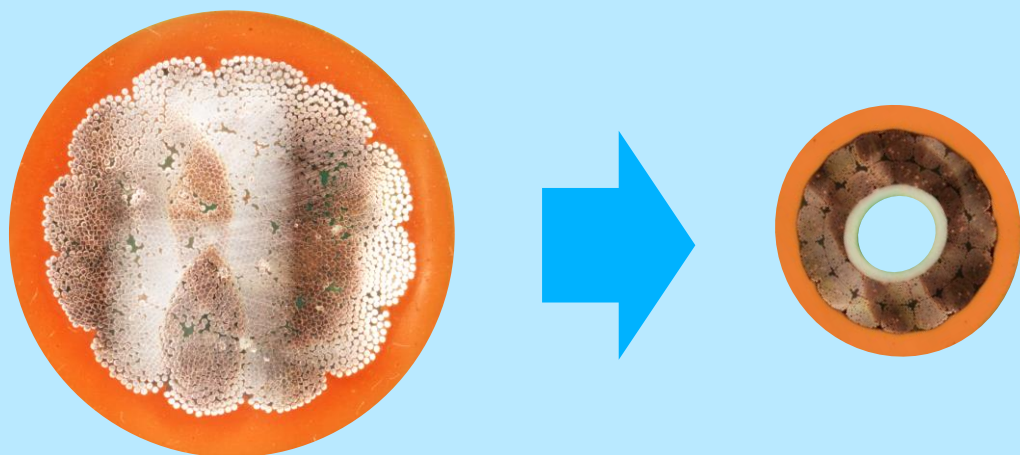
Temperature Limitation of the Charging Path

Contact pin temperature is the critical part of the system

- Normative limits of the contact pins = max. 90°C (100°C) / 194°F
- T-raise on the contact pins = max. 50°K
- No sufficient heat flow along high voltage cables to reduce temperature of the contact pins
- Heat increase inside vehicle inlet due insufficient cooling



Concept Change

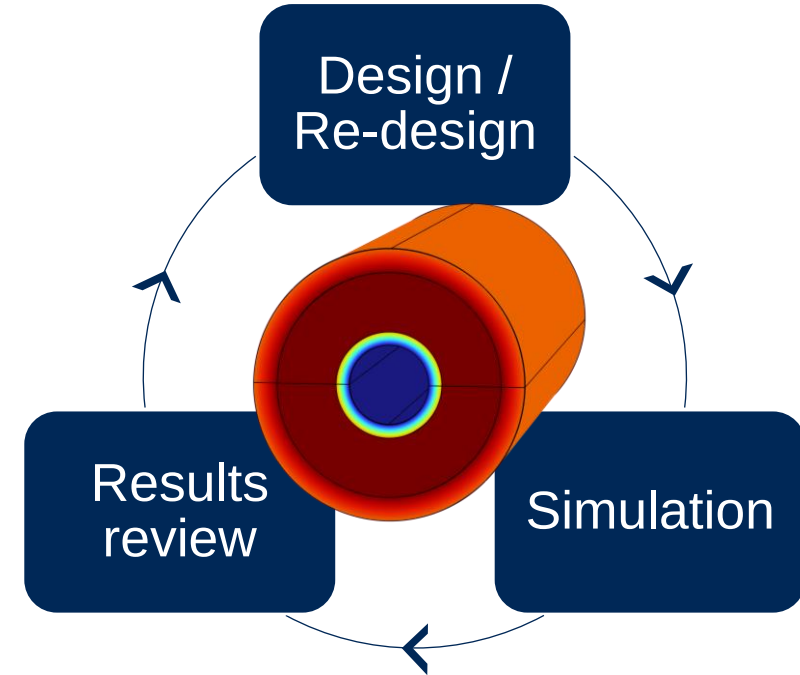


- Exponential increase of cross section and cable weight of existing high voltage cables due to steady increase of electrical current
- Development of cooled high voltage cables to increase transmission capacity while reduction of cable weight (CSA) and needed installation space in the vehicle
- Existing cooling systems in the vehicles can be used to cool the cables
- Same flexibility and easy routing as known from standard high voltage cables
- High resistance against vibration in comparison to busbar

Special Properties for LEONI® Hivocar Cool

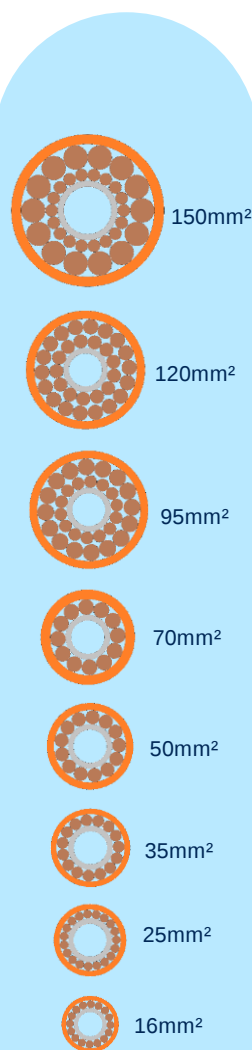
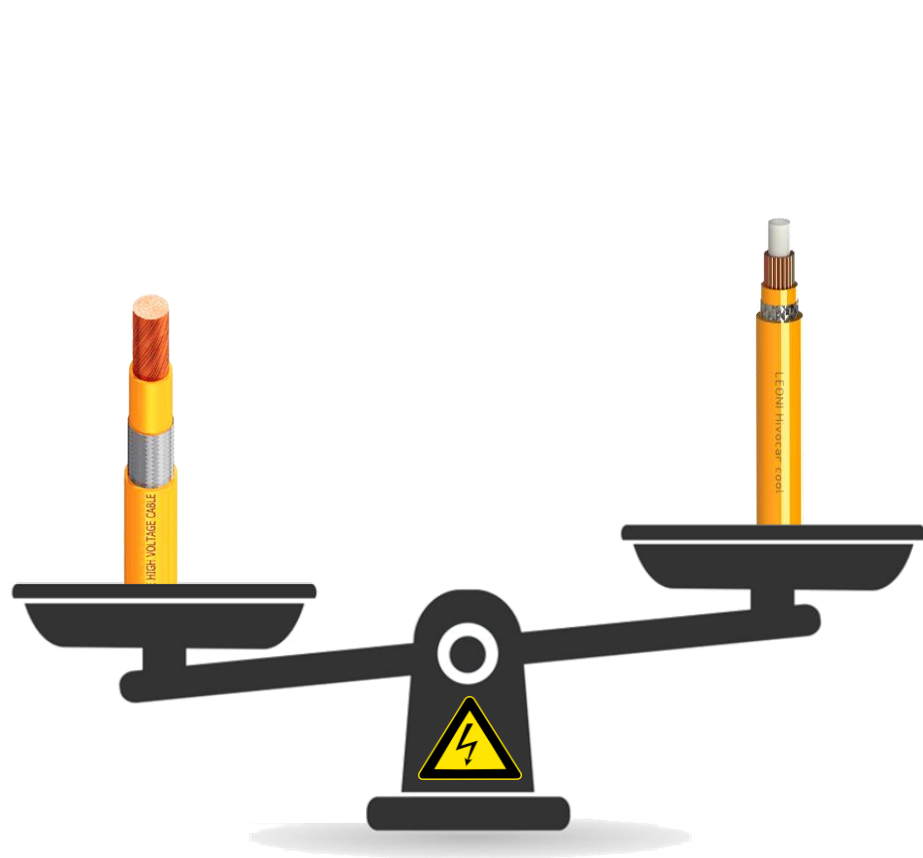
New product characteristics

- Tube dimensions and materials
 - Pressure loss
 - Heat conductivity
 - Media resistance of fluid - tube
 - Long term pressure resistance
 - Flexibility
 - Bend radius vs. flow rate
- Cable design
 - Mechanical stable tube – conductor design
 - Good heat transfer from coolant to copper
 - Economical manufacturability
- Coolant
 - Connection to existing cooling system in the vehicle



**Acceleration of development
phase supported by simulation**

Key Properties of LEONI® Hivocar Cool

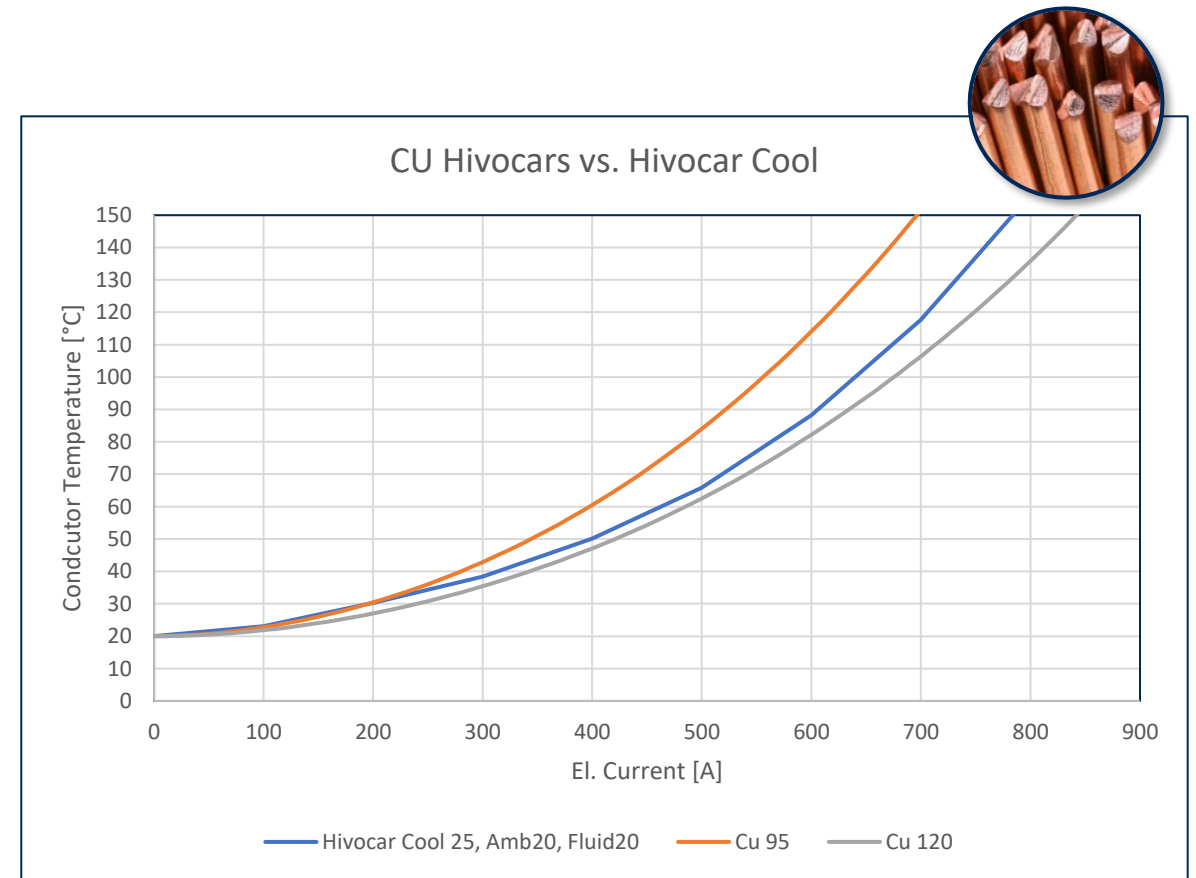
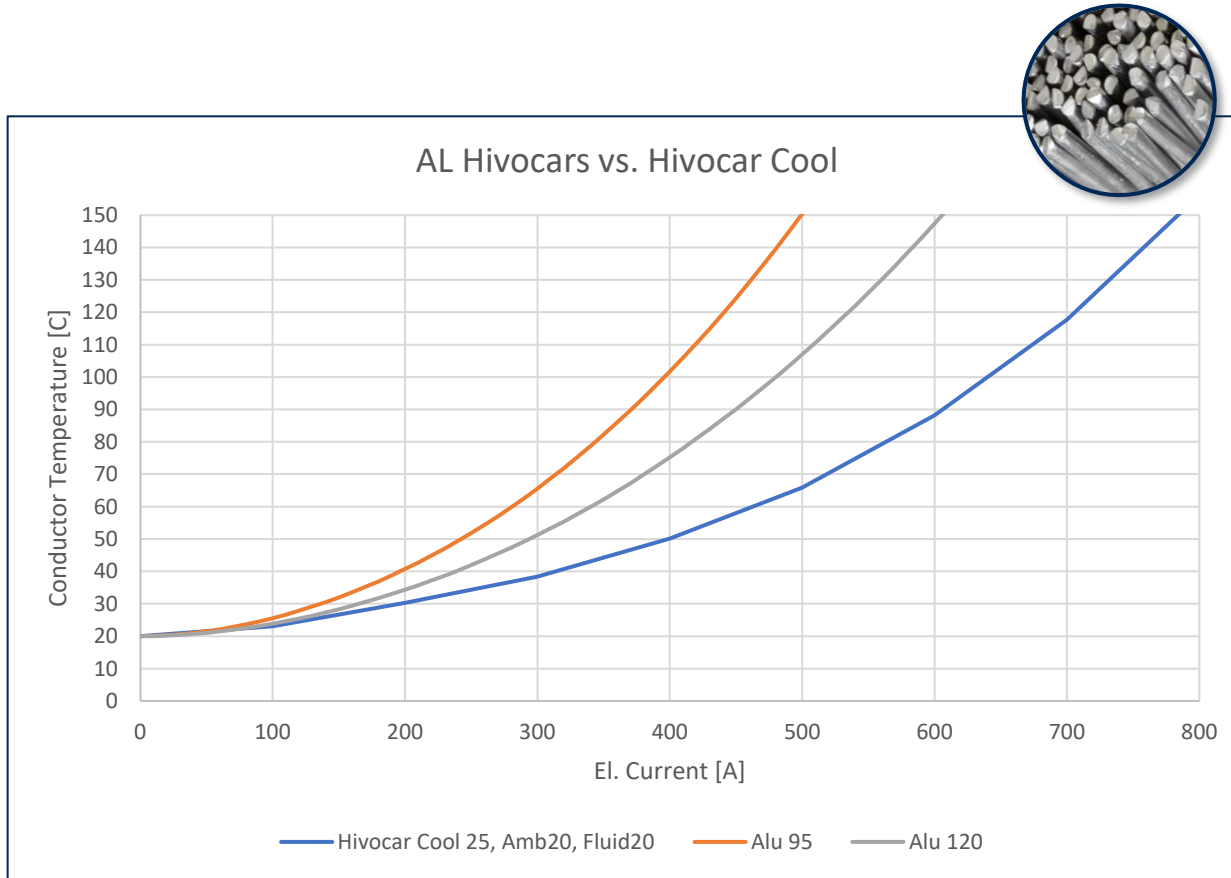


Key facts

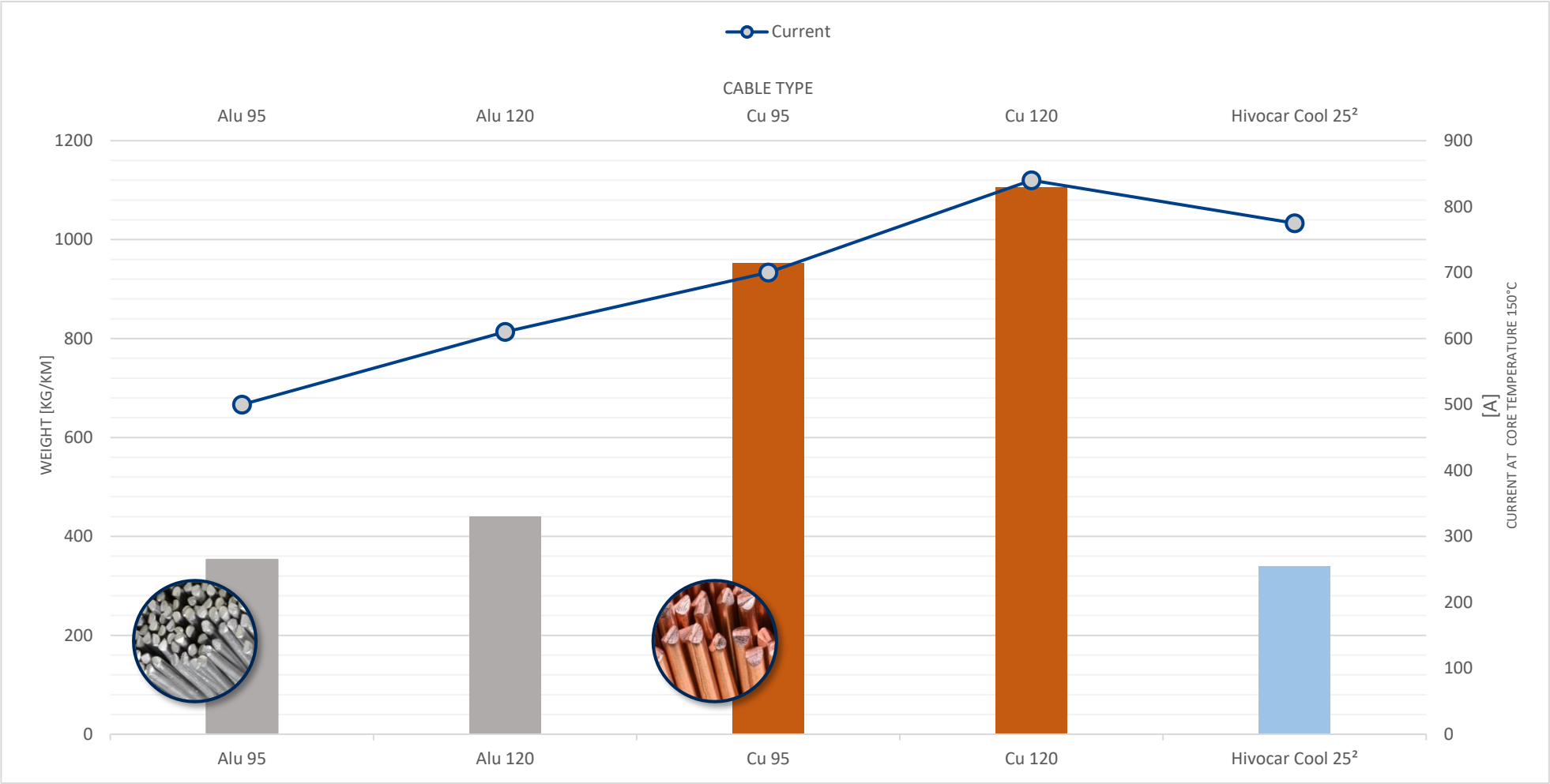
- much **higher current carrying capacity** in comparison to uncooled standard HV cables at same temperature rise
- Portfolio from 16 up to 150mm² cooled
- Lower CO₂ footprint in comparison to standard HV cables
- up to **30% lower diameter** in comparison to a HV cable with comparable ampacity
- up to **75% weight reduction** in comparison to a HV cable with comparable capacity

Key Properties of LEONI® Hivocar Cool

LEONI® Hivocar Cool 25mm² higher performance than 95mm² uncooled (Cu)



Comparison Cable Weight – max. Current Capacity



Current Load Capacity

Comparison LEONI® Hivocar cool vs. LEONI® Hivocar

max. current @ 150°C surface temperature

	LEONI® Hivocar Cool	LEONI® Hivocar	
CS	25mm ²	95mm ²	120mm ²
I _{max}	775	690	840
CS	35mm ²	~ 2 x 50mm ² = ~ 100mm ²	
I _{max}	950	870	
CS	50mm ²	~ 2 x 70mm ² = ~ 140mm ²	
I _{max}	1150	1120	
CS	70mm ²	~ 2 x 95mm ² = ~ 190mm ²	
I _{max}	1250	1380	
CS	95mm ²	~ 2 x 120mm ² = ~ 240mm ²	
I _{max}	1625	1680	

Extended Datasheet to Implement LEONI Hivocar® Cool in the Vehicles

All needed information to integrate *Hivocar Cool* into a wiring harness

- Power loss (W/m)
- Cooling performance vs. volume flow
- Current carrying capacity with different coolant temperatures
- T-raise curves
- Derating curves in dependency of:
 - Volume flow
 - Coolant temperature
 - Cable length
- Overload

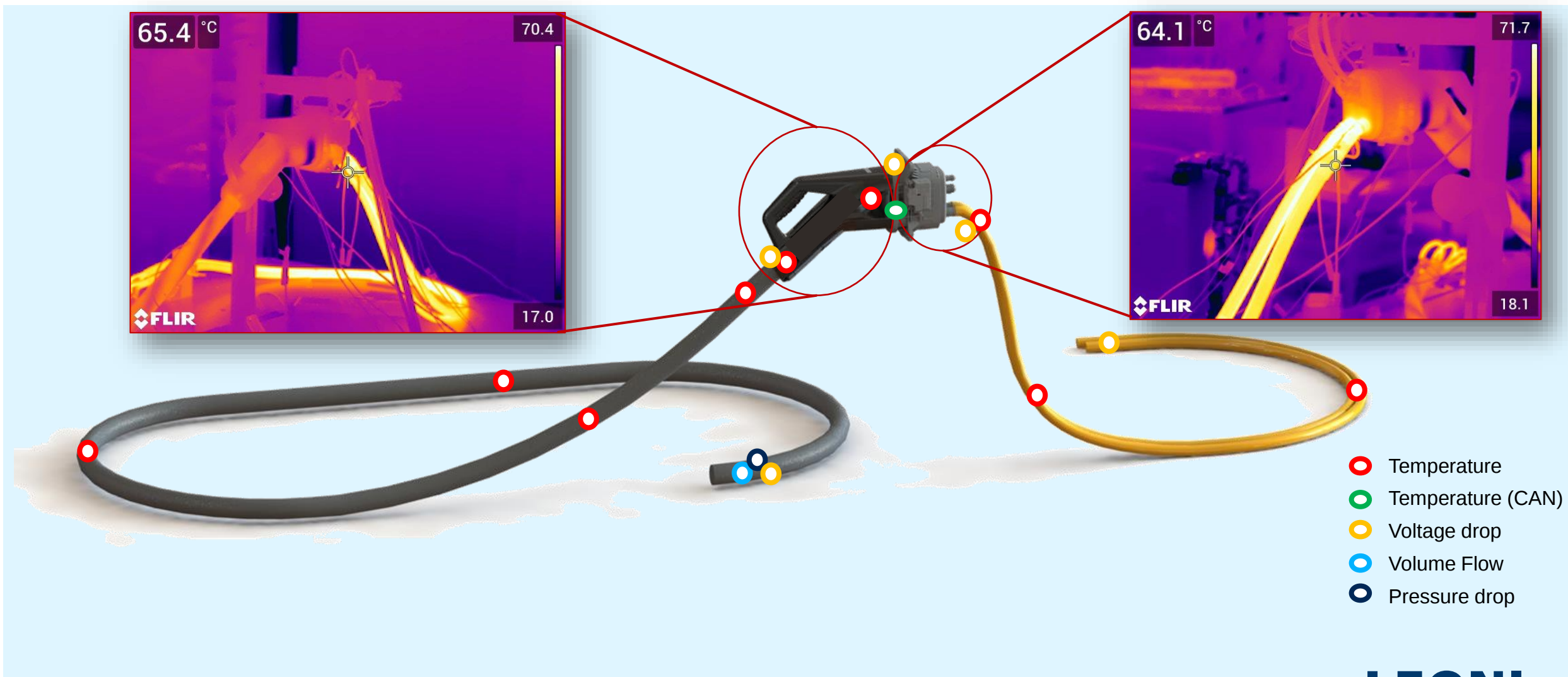


Qualification Status of LEONI Hivocar® Cool Cables

- ✓ First tests based on ISO 19642-5 in lab successful (25 + 50 + 70 mm² - 1st generation)
- ✓ First optimization loop successful (improvement bending behavior and heat flow to coolant)
- ✓ Definition / Construction of optimized prototypes (16, 25, 35, 50, 70, 95, 120, 150 mm² - 2nd generation – high flex and standard types)
- ✓ Enhanced datasheets available
- ✓ Lab test of complete portfolio based on ISO 19642-5
 - ✓ Long term aging performance for 3000/150°C
 - Long term pressure test performance for 3000h
 - ✓ Long term media resistance test 1000h / 90°C
- ✓ Determination of min. Bending radius for constant volume flow
- ✓ Creation of thermal simulation models and verification in own test lab
- Prototypes in tests at customers for harness tests

CCS charging path

System test with CCS – inlet – measuring set up



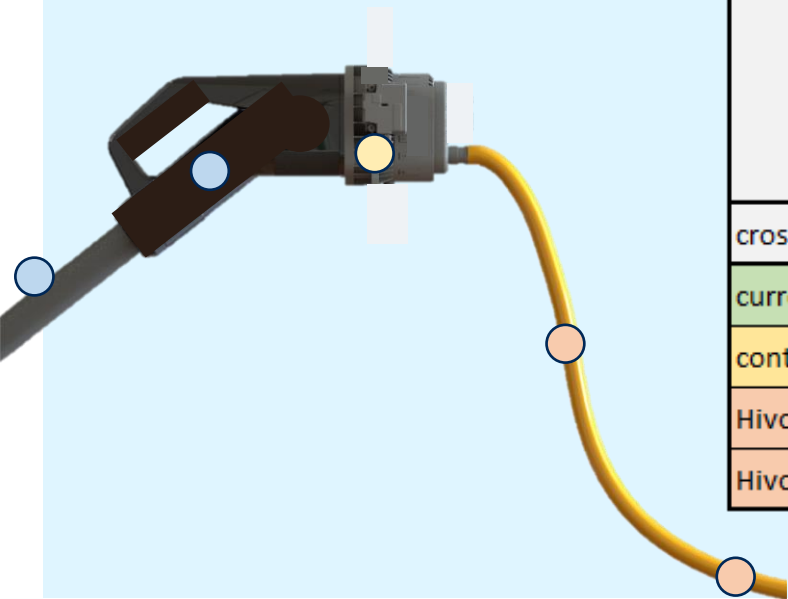
CCS charging path

System test with CCS – inlet - results

Potential solution for CCS+ (800A)

Comparison of serial CCS-Typ 2 Inlets with standard HV cables and LEONI *Hivocar*® Cool

- Real measurement in lab scale
- Highest temperature raise with bundled HV-cables.
- Temperature of contact pin via CAN-Readout of the HPC system
- Cooling effect to contact pins by the HV-cable



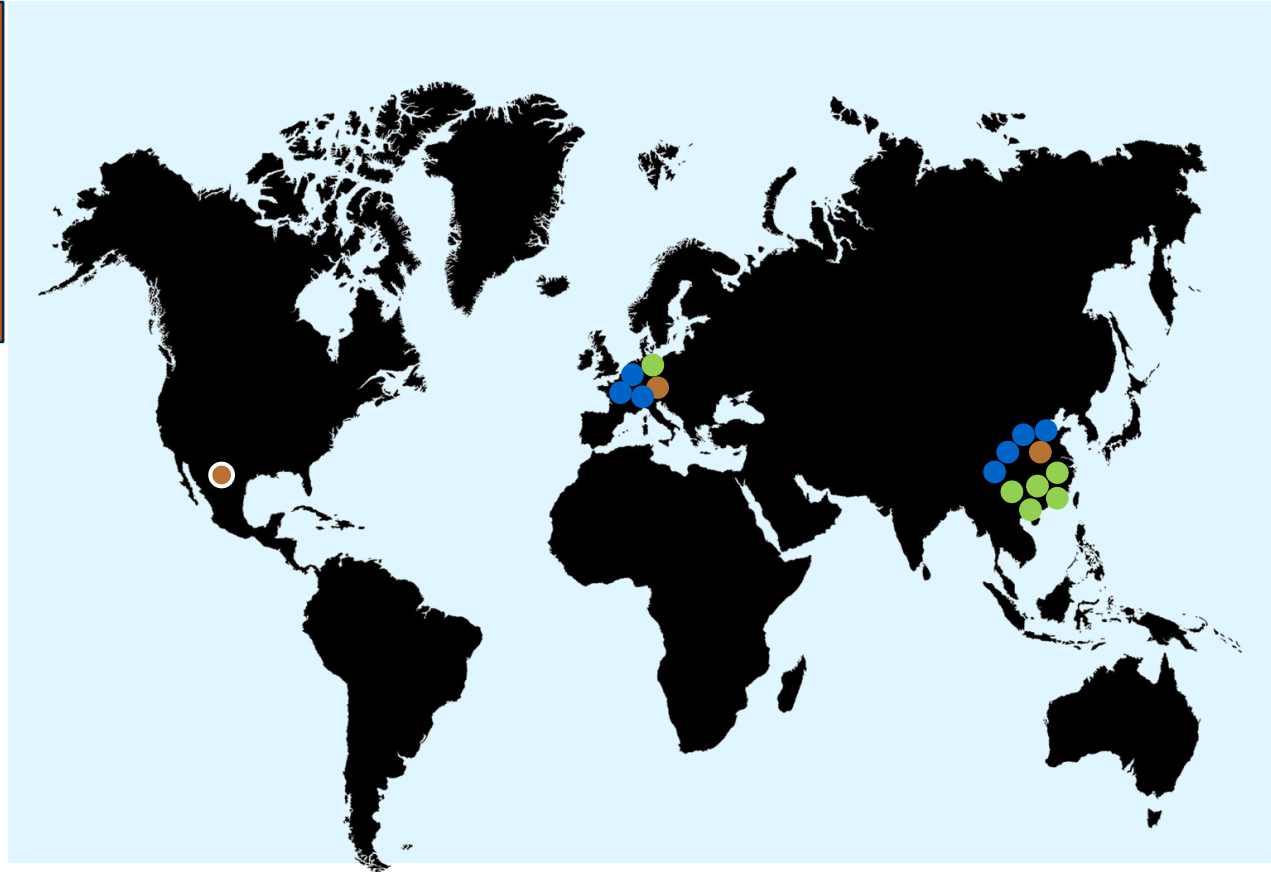
HPC charging cable: active cooled, 2l/min, 15°C LEONI <i>Hivocar cool</i> : active cooled, 4l/min, 20°C	—		LEONI	
	standard vehicle Inlet		<i>Hivocar cool</i> at CCS Vehicle-Inlet	
cross section	70mm ²	95mm ²	35mm ² cooled	70mm ² cooled
current	340A	440A	480A	575A
contact pin temperature (CAN)	90	90	90	90
Hivocar surface	78°C	80°C	39°C	36°C
Hivocar (bundled)	95°C	103°C	48°C	43°C

*HPC: 15°C; 2l/min, Inlet: 20°C; 4-7l/min

Global Status of LEONI Hivocar® Cool

LEONI Production sites (for Hivocar cool):

- › Germany
- › China
- › USA / México (planned)



OEM Projects:

- › China
- › Germany

HV-connector development:

- › Germany
- › China

Thank you for your attention.

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