# e-mobility Infrastructure Standardization
# 2009 ZEV Technology Symposium
# Sacramento, CA

**September 22nd, 2009**

R. Oestreicher/W. Preuschoff, Daimler AG
R. Bogenberger, BMW AG

# Agenda

- **Need for standardization**
- **Vehicle 2 Grid Communication**
    - **Same Use-Cases – different implementation ?**
    - **Future-proof OSI-Layer - based standardization**
    - **One worldwide standard for Smart Charge Communication**
    - **What will happen if we fail to harmonize**
- **AC chargers and infrastructure**
    - **European targets and technical concepts**
    - **Status of international standardization**
    - **Comparison of European, US and Japanese concepts**
    - **Summary**

# Standardization beneficial for all stakeholders

## Everyone benefits from standardization

| For customers/society | For Utilities/OEMs |
| --- | --- |

**Customer acceptance**
- One single solution worldwide
- No adapters or different cables needed
- Faster electric vehicle run-up/market success
- No retrofit costs for adopting to new charging systems

**Cost**
- No sunk costs for proprietary interim solutions
- Shared development and standardization costs
- Economies of scale

**Societal Benefit**
- Intelligent usage of renewable energy
- Green lifestyle
- Intelligent usage of given power plant capacities

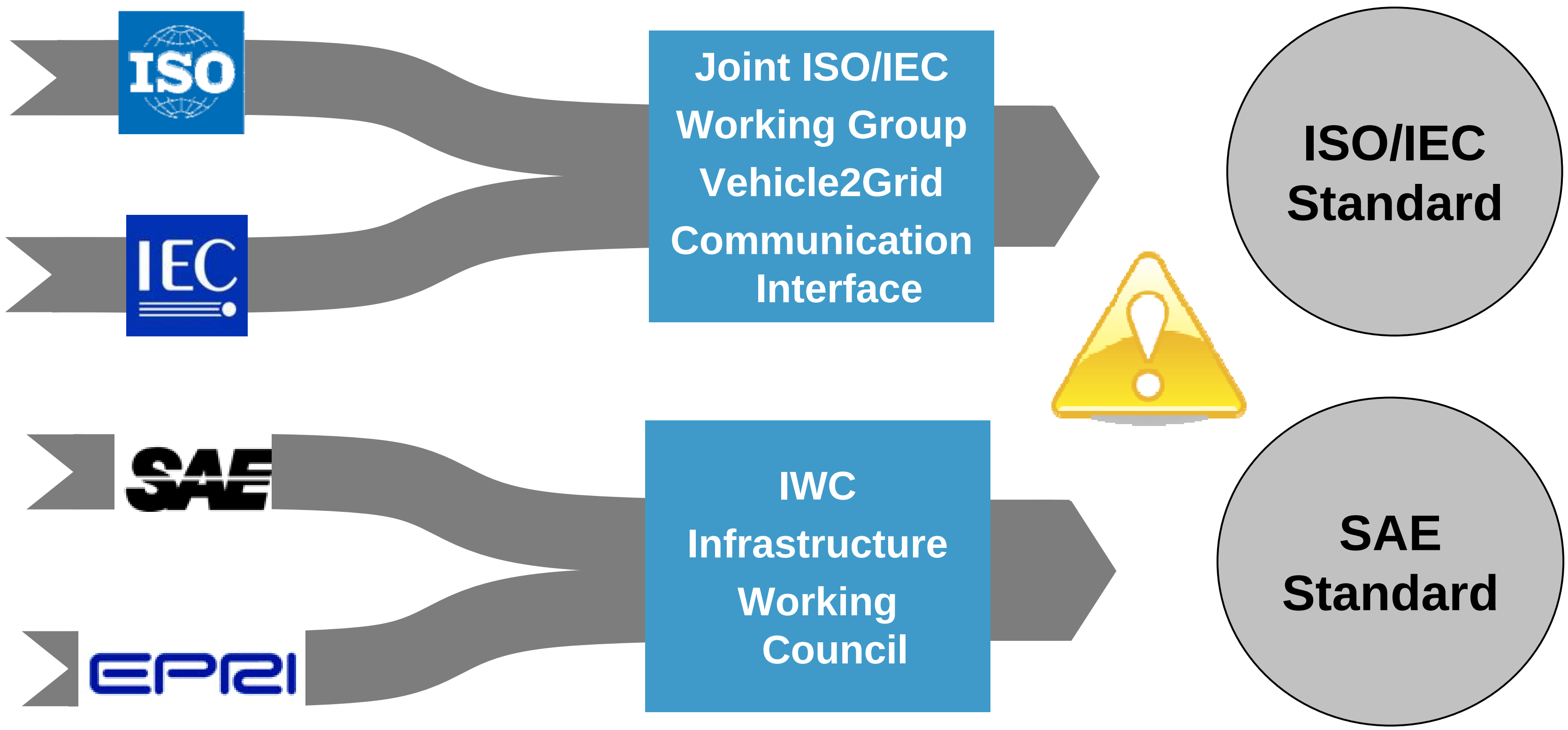
# Different stake holders working on different "Standards"

| Organizations / Standardization Aspects | Inter-national standardization | | National standardization | | | Additional Consortia & companies or standardization bodies | | | | Interest groups | | | | | Rule making | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ISO | IEC | SAE International | DIN | | ZigBee Alliance | HomePlug | ITU | Coulomb Technologies | | VDA | ACEA | AAM | … | UNECE | Air Resources Board | NIST |
| **Use cases** | | | | | | | | | | | | | | | | | |
| Optimized recharge (cost, renewables, load leveling, …) | | ⚠ | ⚠ | | | ? | ⚠ | ✓ | | | ✓ | ✓ | ? | | ✓ | ✓ | ? |
| Payment & billing | | | | | | | | | | | | | | | | | |
| Electric vehicle status (SOC) | | | | | | | | | | | | | | | | | |
| Remote services (pre-conditioning, EOC configuration, I&M) | | | | | | | | | | | | | | | | | |
| **Communication technology** | | | | | | | | | | | | | | | | | |
| Physical & data link layer | | ⚠ | ⚠ | | | ✓ | ✓ | | | ✓ | ✓ | | ? | | ? | ✓ | ? |
| Application layer protocols | | | | | | ✓ | | | | | | | | | | | |

**Ongoing standardization activities**

✓ Confirmed activity  ? Interest expressed, concrete activity not yet confirmed  ⚠ Action required

# Current parallel Vehicle2Grid Standardization



# As Use-Cases are the same, why not develop one common standard ?

**Optimized Charging**

- **Grid** and energy mix (**green**) optimized charging
- Improve battery life through intelligent charging
- **“Plug and charge”**
- **Customer defined** “End of Charge”, to maximize vehicle availability

**Automatic Payment and Billing**

- System oriented on well-known **mobile phone** functionality
- **Simple contract with electricity supplier**
- Automatic billing
- **“Roaming”**
- Safe and **private** payment through public/private Key security

**Value Added Services**

- Mobile access to important vehicle parameters (State-of-Charge, range, charging profile)
- Online tracking of contract/payment information

# Future-proof OSI-Layer - based standardization of Smart Charge Communication

| Layer | Data Communication Requirements | Technologies |
|---|---|---|
| 7 Application<br>6 Presentation<br>5 Session | **SmartCharge Communication**<br>• Payment & billing IDs and transactions<br>• Anti theft, tamper detection<br>• Pricing categories<br>• Energy demand & response info (local limits, optional grid load levels, …)<br>• Vehicle charge status & setup<br>• Additional provider info (location, etc.)<br>• SmartEnergy profile integration | • Smart Meter Language (SML)<br>• Common Information Model (CIM)<br>• Zigbee / HomePlug Smart Energy Profile 2.0<br>• New standard |
| 4 Transport<br>3 Network | • Reliable transmission<br>• Secure & protect customer data<br>• Directly send data to customer | • SML transport layer<br>• Internet Protocol Suite (TCP/IP & UDP) incl. security protocols<br>• New standard |
| 2 Data Link<br>1 Physical | • Use available industry standards<br>• Seamlessly integrate into public charge spots and SmartHome infrastructure<br>• Grounding circuit continuity monitoring and diagnostics | **Wired/Wireless**<br>Powerline Communications, HomePlug, ITU, PWM |

# Future-proof OSI-Layer - based standardization of Smart Charge Communication

**Layer**

**7 Application**

**6 Presentation**

**Additional use-cases**

- Vehicle2Vehicle
- Driver Assistance
- Mobility Services
- SmartCharge communication

**...**

**Diagnostic use-cases**

- World-wide harmonized OBD
- Remote Diagnostics & Software Updates
- Road- & Emissions Check
- …

**5 Session**

- **ISO 13400 – Diagnostics on TCP/IP**
- **ISO 27145 - World Wide Harmonized OBD**

**4 Transport**

**IETF RFC 768**
**User Datagram Protocol (UDP)**

**IETF RFC 793**
**Transmission Control Protocol (TCP)**

**3 Network**

**IETF RFC 792 / 2460 Internet Protocol (IPv4/IPv6)**

**Existing adaption layers**

**2 Data Link**

**1 Physical**

**IEEE 802.3**

**100BaseT Wired**

**IEEE 802.11 (g/n/p)**

**Wireless**

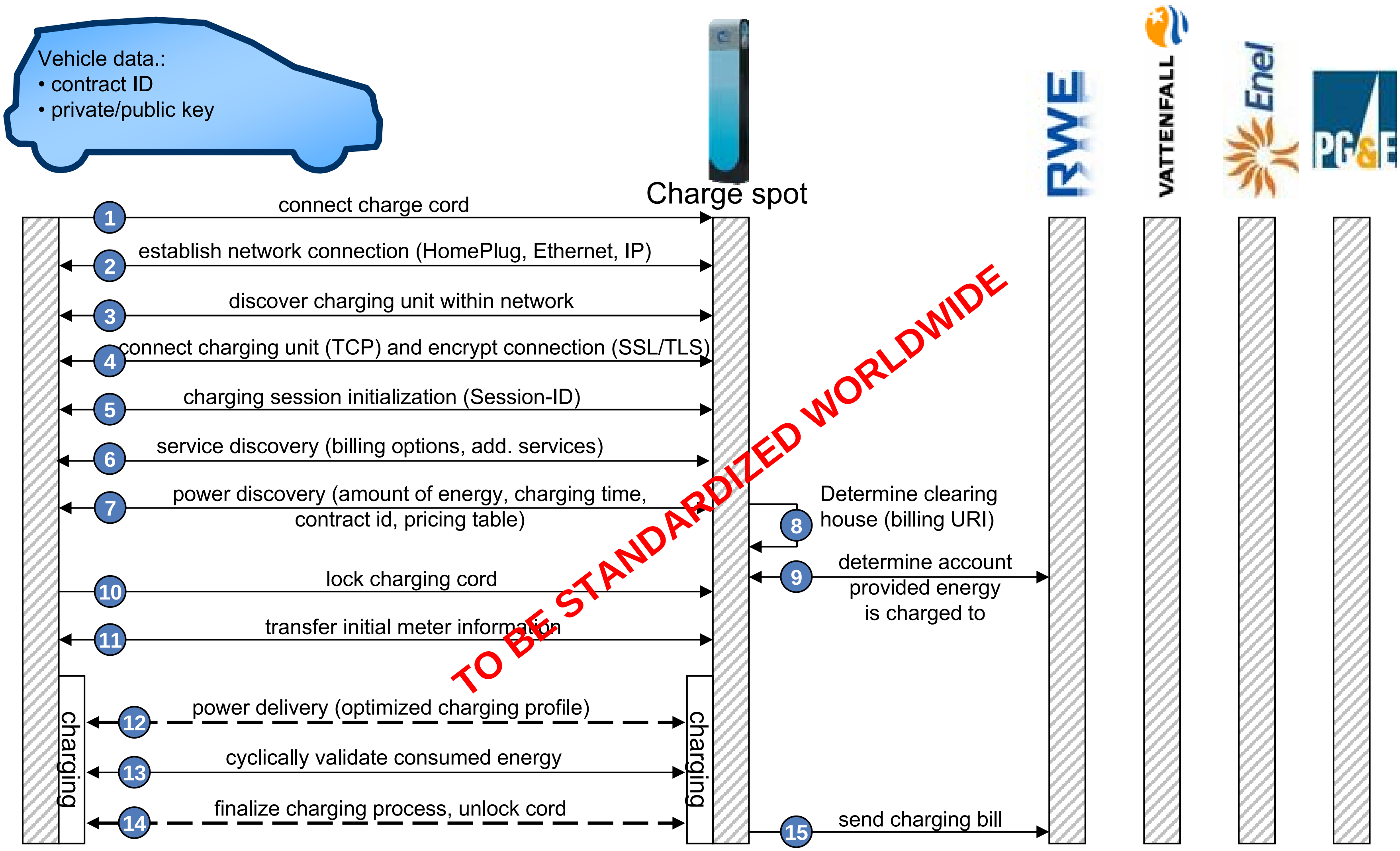
**GSM EDGE GPRS ...**

**Wireless**

**PLC**

**e.g. HPGP, ITU G.hn**

# Communication between vehicle and charge spot



# Consolidate ISO/IEC Vehicle2Grid Communication working group and SAE J2293 Task Force activities

**Layer**

| | Additional use-cases | Diagnostic use-cases |
|---|---|---|
| **7 Application** | • Vehicle2Vehicle<br>• Driver Assistance | • World-wide harmonized OBD<br>• Remote Diagnostics & |

**First joint Meeting between**

**ISO/TC 22/SC3/Joint Working Group V2G CI**
**&**
**SAEJ 2293/J2836 task force**

SAE International
**Meeting Notice**

ISO/TC 22/SC3/JWG V2G CI Meeting

Sponsor – Christoph Saalfeld & Rick Bleijs

Subject: J2293 Task Force Meeting's invitation to the ISO US meeting

Dates: September 25, 2009

Time: 9:00am – 4:30pm EDT

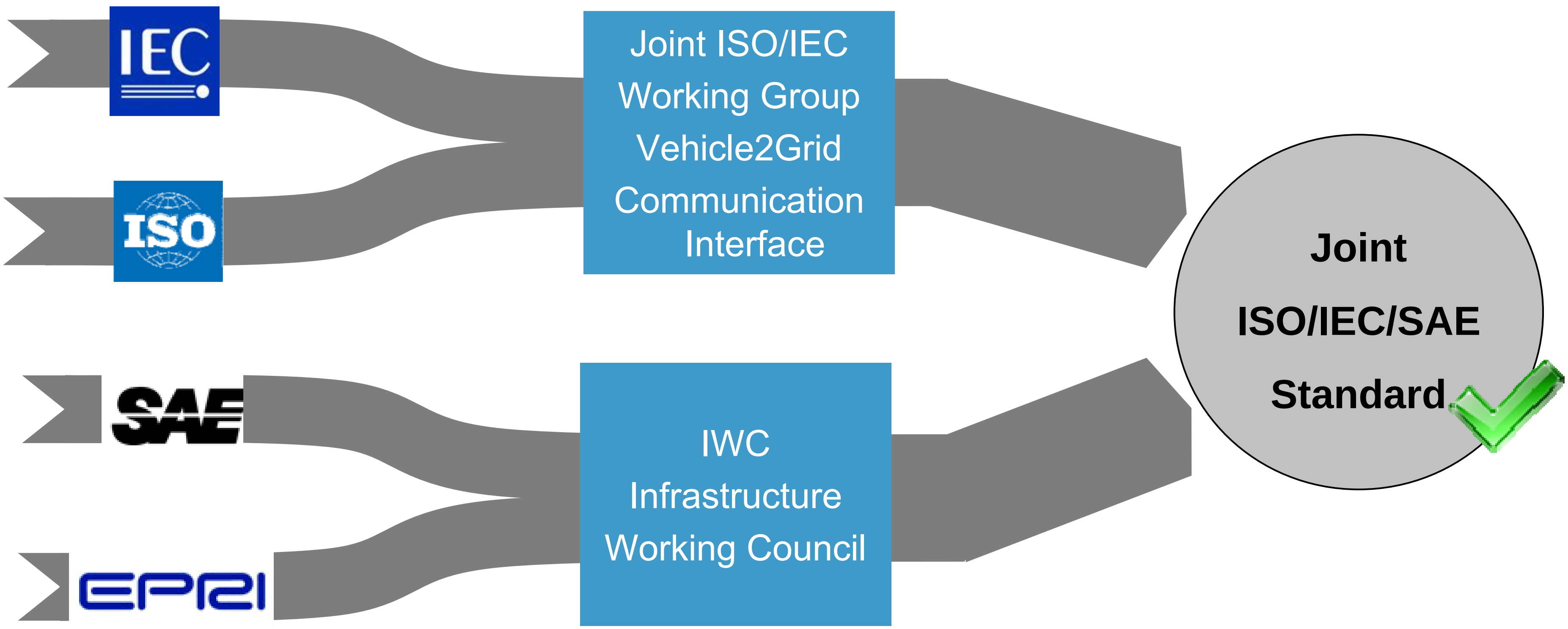
**SAEJ 2293/J2836 task force**
**PLC competition meeting with participation of**
**ISO/TC 22/SC3/Joint Working Group V2G CI**

SAE International

AGENDA

Hybrid J2293 Task Force
PLC Competition – Hosted by Jim Lawlis
Chairman - Rich Scholer
Date – September 29 & 30, 2009
Time - 9:00am – 4:30pm EST

# Target: One worldwide standard for Smart Charge Communication !



# If we fail to establish world wide standards electric mobility may never become mainstream

- Local legislative directives and local stimuli programs (EU, Chinese, Japanese, US, California) drive region/nation specific standards
- Different technologies need to be installed on vehicles to support regional standards
- Increase of cost for achieving similar goals with different solutions (no added value for customers or grid)
- Incompatible solutions highly limit available low cost recharging infrastructure and thereby impose high market introduction hurdles for electric vehicles (decreased customer acceptance)

# Agenda

- Need for standardization
- Vehicle 2 Grid Communication
  - Same Use-Cases – different implementation ?
  - Future-proof OSI-Layer - based standardization
  - One worldwide standard for Smart Charge Communication
  - What will happen if we fail to harmonize
- **AC chargers and infrastructure**
  - **European targets and technical concepts**
  - **Status of international standardization**
  - **Comparison of European, US and Japanese concepts**
  - **Summary**

# Technical concept driven by customer requirements

## Customer requirements

- **High density** infrastructure for consumer confidence and more daily range given battery size
- **High power** to allow faster charging in critical situations
- **High convenience** to improve consumer acceptance and battery lifetime (less deep cycling)
- **High reliability / safety** to improve consumer confidence
- **Long term viability** to avoid stranded investment

## Technical concept

- **On board chargers up to 43 kW** for high power and high density (total cost lower than DC)
- **3 phase power** beyond 7kW to reduce cost, volume and weight of charger and cable
- **Same connector geometry for 1 & 3 phase and all current levels** for compatibility and long term viability
- **Electromechanical interlock** to de-energize unused sockets and avoid tricking/hot disconnect
- Option for **plug connected mode 3 cables** to improve reliability/safety of public charging
- **Resistor coding of charge cable current rating** to allow smaller cables for low power applications without loosing compatibility

EV Infrastructure Strategic Guidelines
OEM / Utility Workshops

# On board chargers up to 43 kW to support most frequent use cases

| | | | | | |
|---|---|---|---|---|---|
| •1 Phase | 3kW (16A) | 7kW (32A) | 14kW (64A) | | Feasibility depending on battery technology |
| •3 Phase | | 11kw (16A) | 22kW (32A) | 43kW (63A) | |

| **Minimal** | **Standard** | **Opportunity** | **Emergency** | **"Range extension"** |
|---|---|---|---|---|
| • Grandma's house | • Own garage<br>• Curbside<br>• Employee parking | • Shopping mall<br>• Gym | • Curbside | • Highway filling stations |
| No better option available | Over night, at work<br>95% in 6h | While shopping<br>→ 50% in 30 min. | Wait at spot<br>→ 30 km in 10 min. | Wait at spot<br>→ 80% in 10 min. |

**Use of on-board chargers as charge spots must be low cost to allow high density**

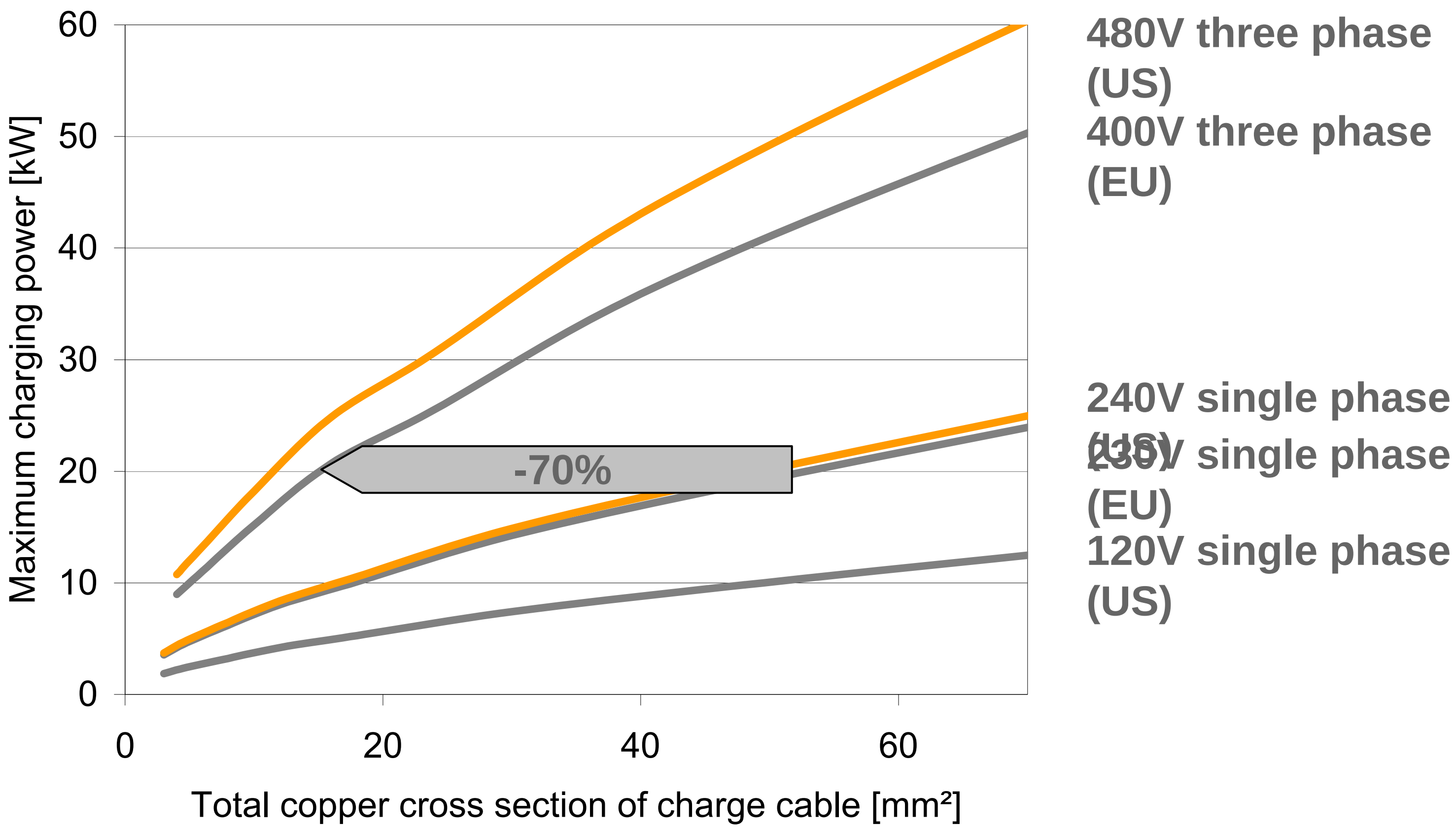
**DC supply required due to weight, size and cost**

# Three phase power beyond 7kW

| | Single Phase | | Three Phase |
|---|---|---|---|
| Power | 7 kW | +200% | 21 kW |
| Power modules | 3 | | 5 |
| Dimensions | 160x260x120 mm³ | | 300x300x80 mm³ |
| Weight | 6...7 kg | +70% | 10...12 kg |
| Volume | 5...6 liter | +40% | 7,2...8 liter |
| Cost | 100% | +50% | 150% |

Due to higher voltage and a constant power semiconductors can be used more efficiently and the size of capacitors can be reduced

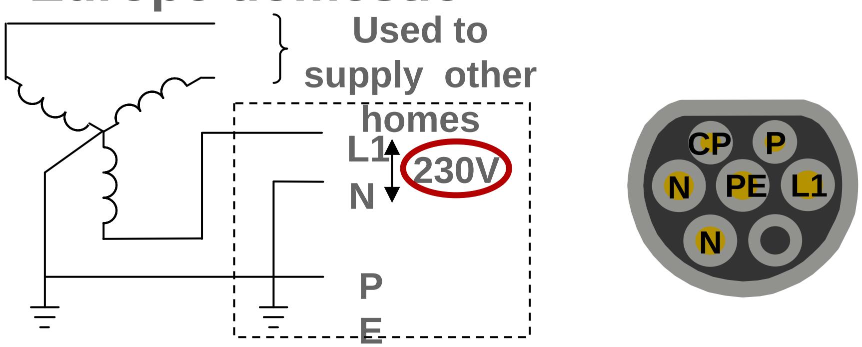
# Three phase power beyond 7kW



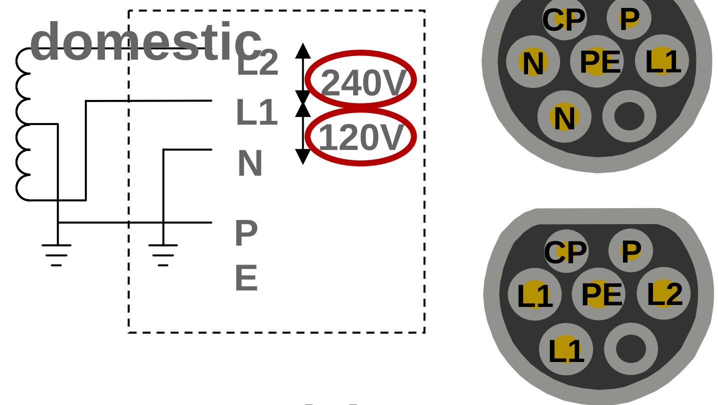

In the US the benefit of three phase power is even bigger than in Europe

# Same connector geometry for 1 and 3 phase

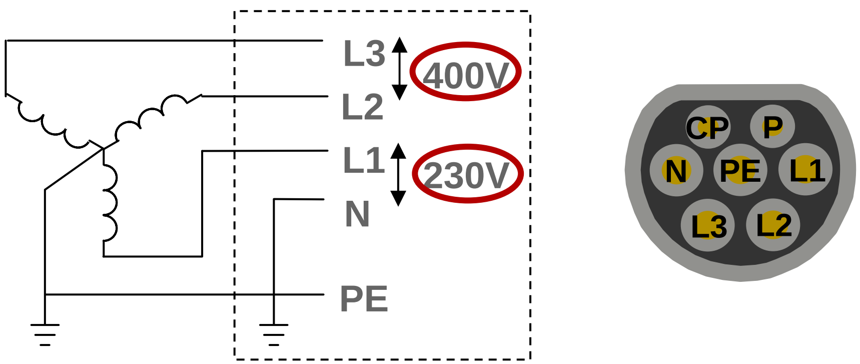
## Europe domestic



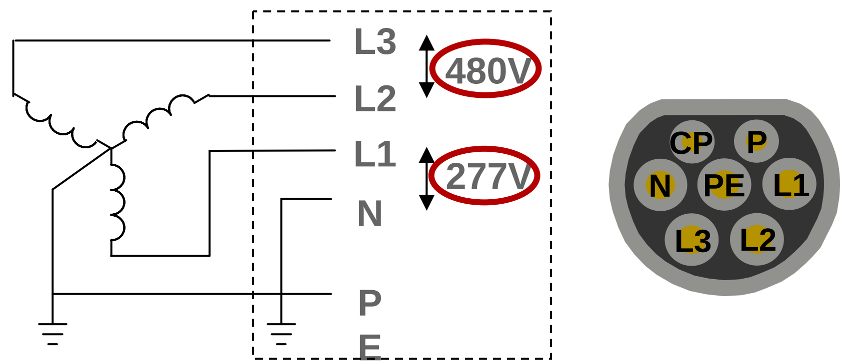

## USA domestic




## Europe commercial*



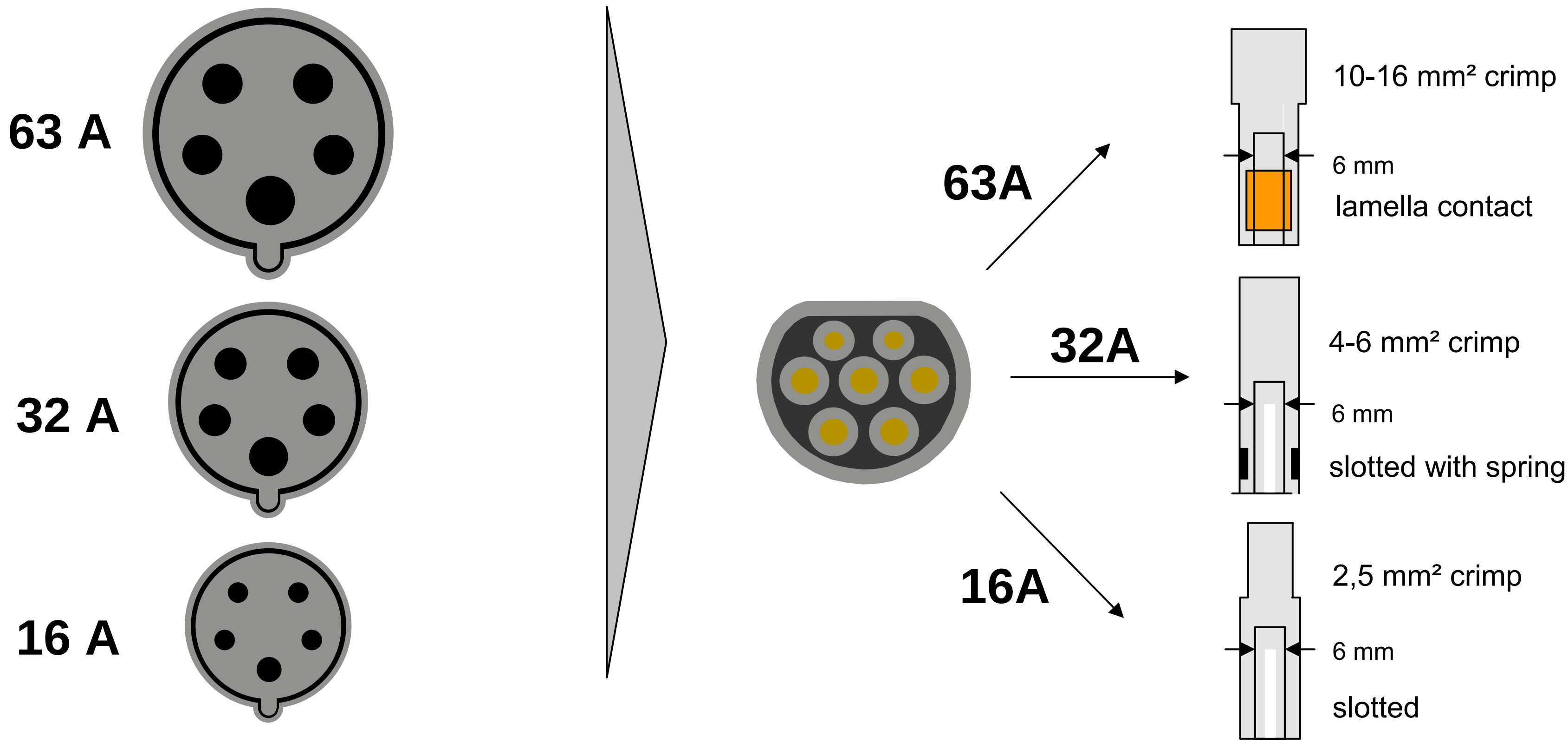

## USA commercial




*in northern Europe also domestic

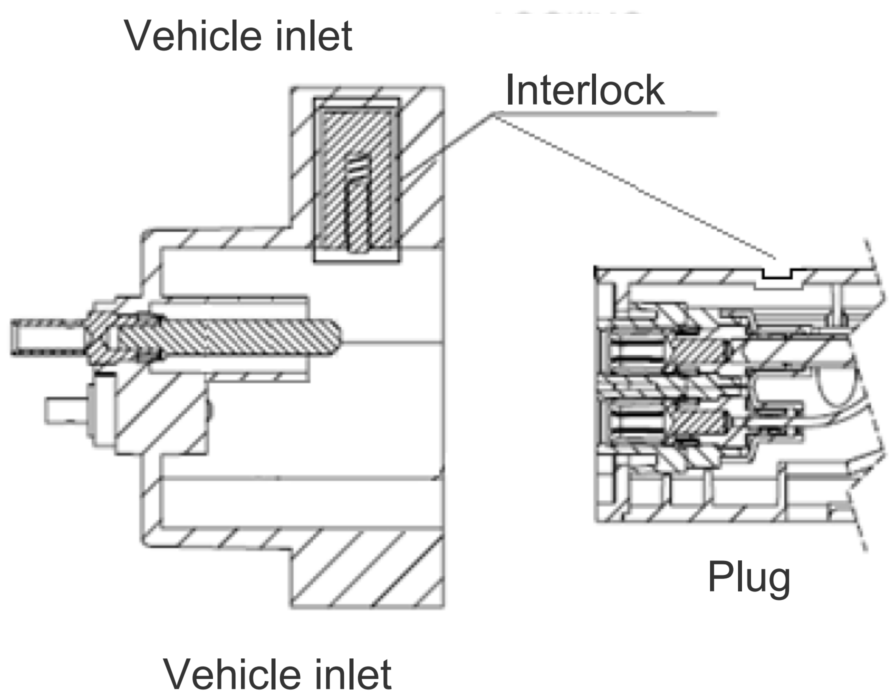
# Same connector geometry for all current levels

**Typical industrial connector concept** | **EV connector concept**




All contacts with same diameter (6mm) but option to use different technologies to reduce cost and insertion force for lower power levels

# Multi-purpose electromechanical interlock




Example:

① Insert connector

② Lock connector automatically

③ Switch on power automatically

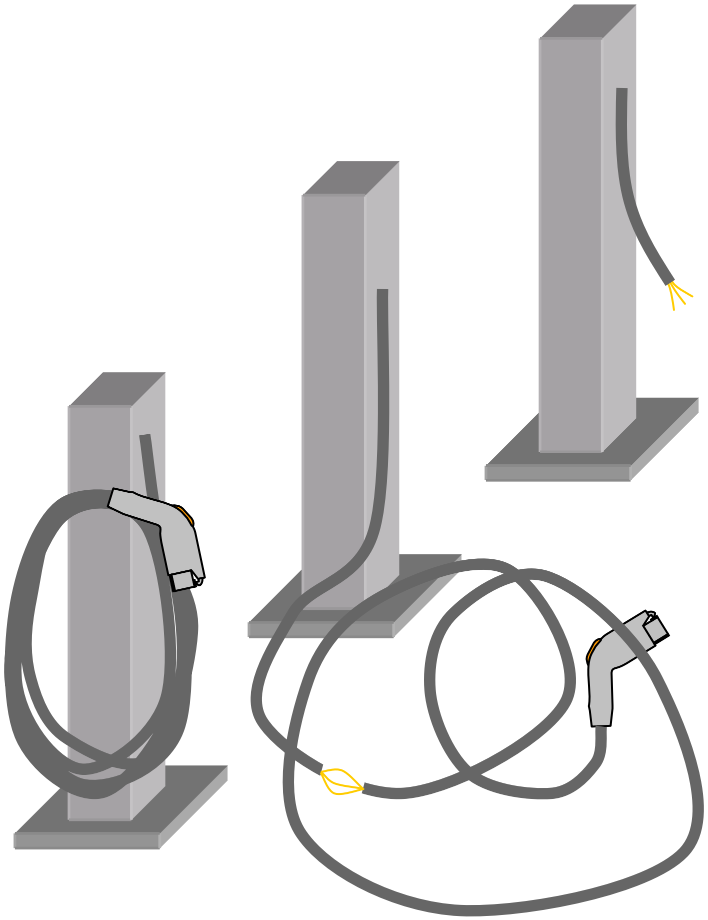
④ Open central locking (=authentication)

⑤ Switch off power automatically

⑥ Unlock connector automatically

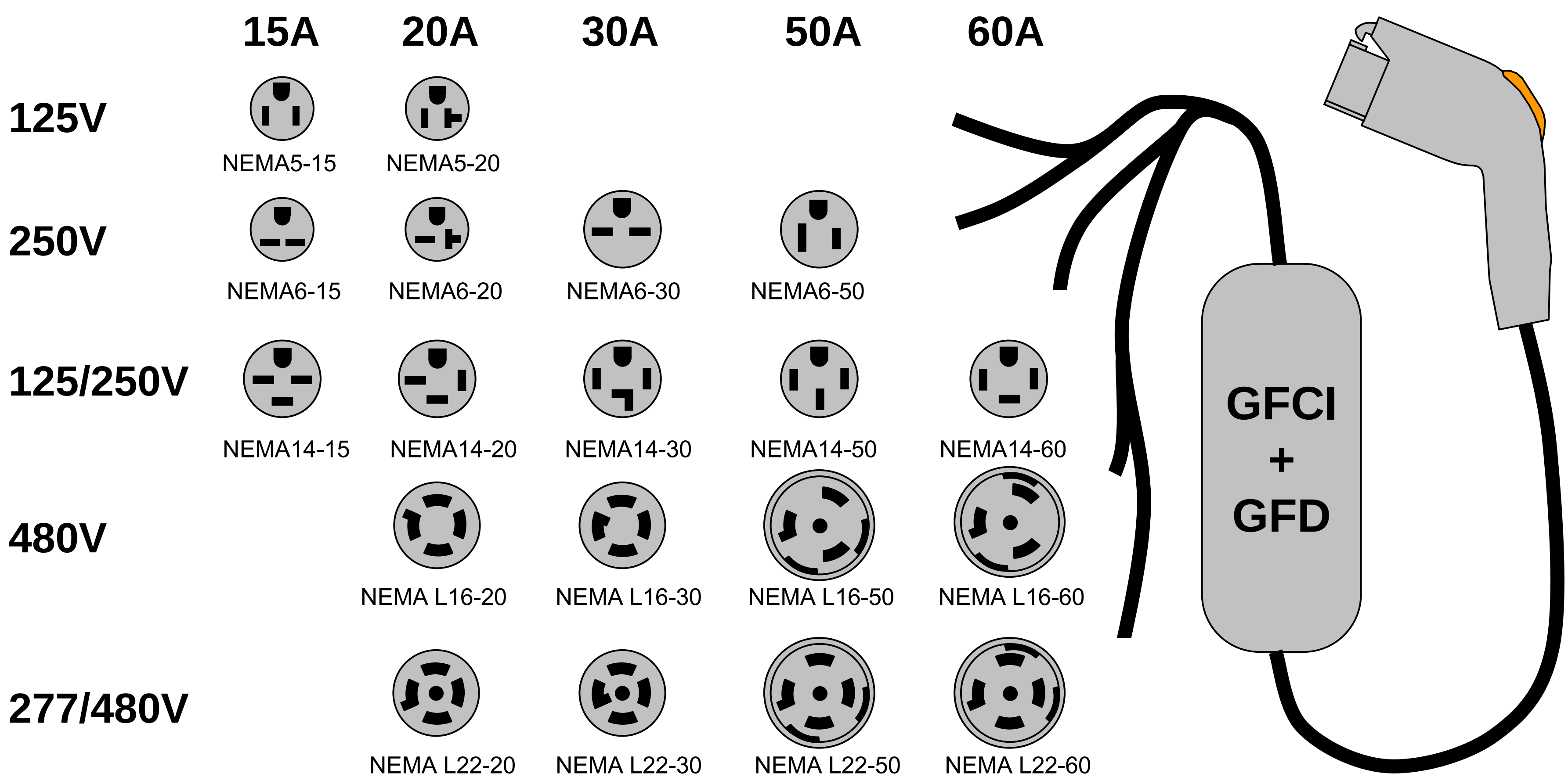
⑦ Take out connector within 2 minutes or automatically go back to ②

# Attached cables will probably not be suitable for public charging in all locations



- Very short inspection intervals needed as cables can be easily damaged in daily use
  (European utilities refuse to bear the risk)
- Vandalism and theft of cables highly likely, especially as cables are expensive and de-energized when not in use
- A connector standard established once can never be changed, as all vehicles sold and still in service would have to be updated

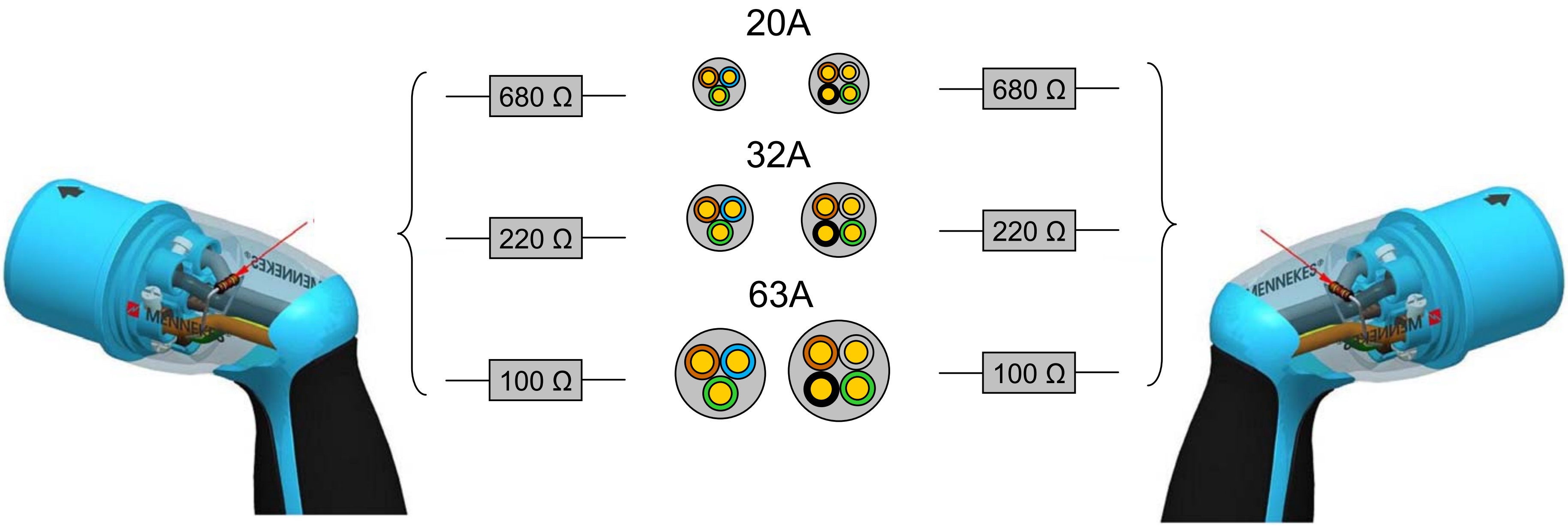
# Adapter solutions not viable for every day use



# Loose Mode 3 cable for improve reliability and safety

- Vandalism and theft can be reduced as cable is not hanging on the spot when not in use
- Cables can be easily inspected and replaced by the vehicle owner
- Inconvenient and expensive in-cable control boxes and adaptors can be eliminated

## Application specific cable size




**Redundant resistor coding:**

- Resistor values are detected independently by the vehicle and the charge spot
- Results are exchanged and compared
- Charge spot and vehicle are limiting the maximum current to the lowest value detected

# Joint position statement

**Commitment to Electric Vehicle Infrastructure Standards**

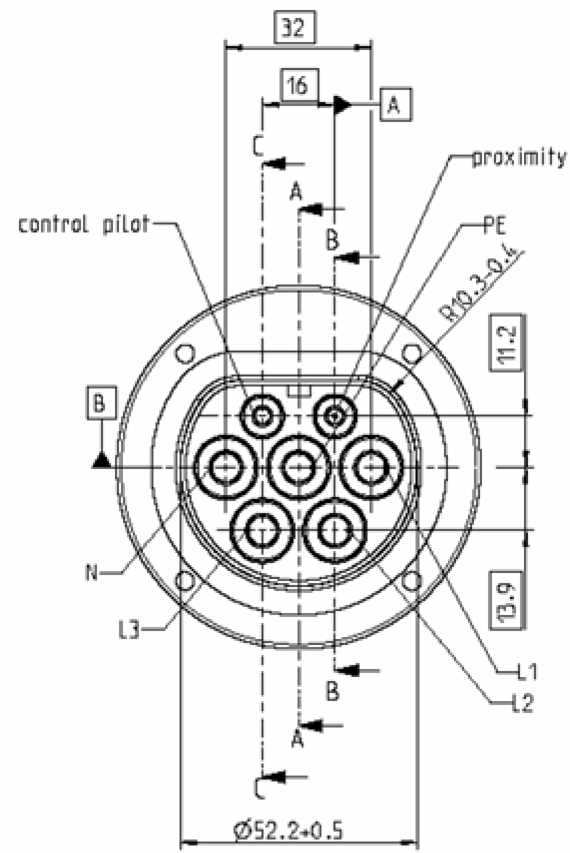
- **Globally Compatible**
- **Low Cost, Robust, Reliable**
- **Long Term Viability**
- **Safe and Customer friendly**

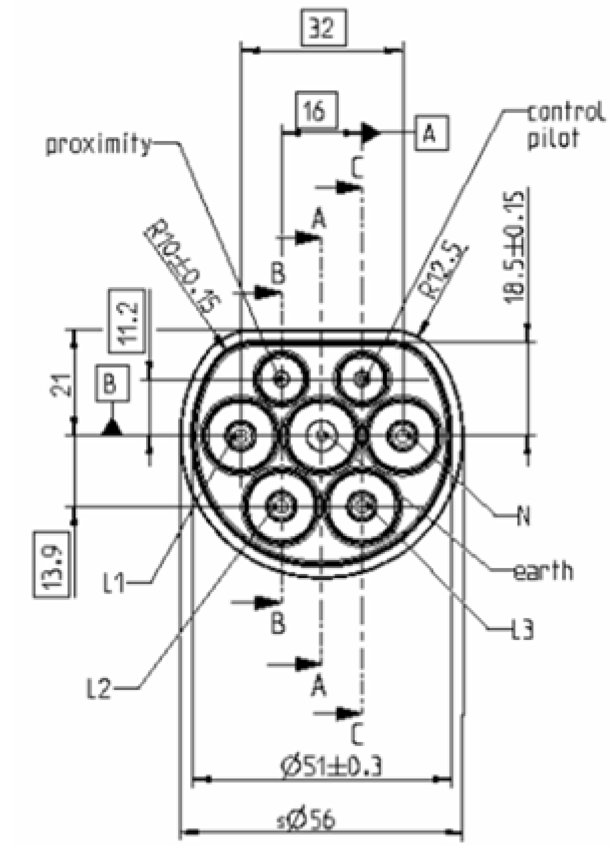
As infrastructure investments are costly, this physical interface or “Global Electric Vehicle Plug” must be viable not only for electric vehicles entering the market now, but for those vehicles with next generation battery and electric technologies.

Based upon these constraints, this workgroup has developed a consensus on the functional requirements :

- **One Plug** for worldwide typical AC voltage and current levels
- Compatibility with **Single- and 3-Phase** electricity grids
- Charging at up to **500 Volts**, 63 Ampere 3-Phase or 70 Ampere Single-Phase
- **Low cost**, robust plug design for outdoor environments
- Redundant **safety** levels
- Plug **locking** functionality for security, user safety and theft

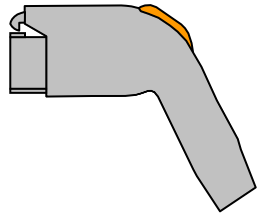
# Proposal submitted to IEC

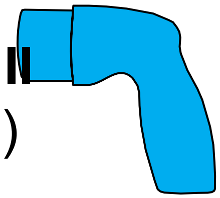



The universal single and three phase connector proposal was submitted to the IEC 62196-2 working group for international standardization

# One standard - two connectors



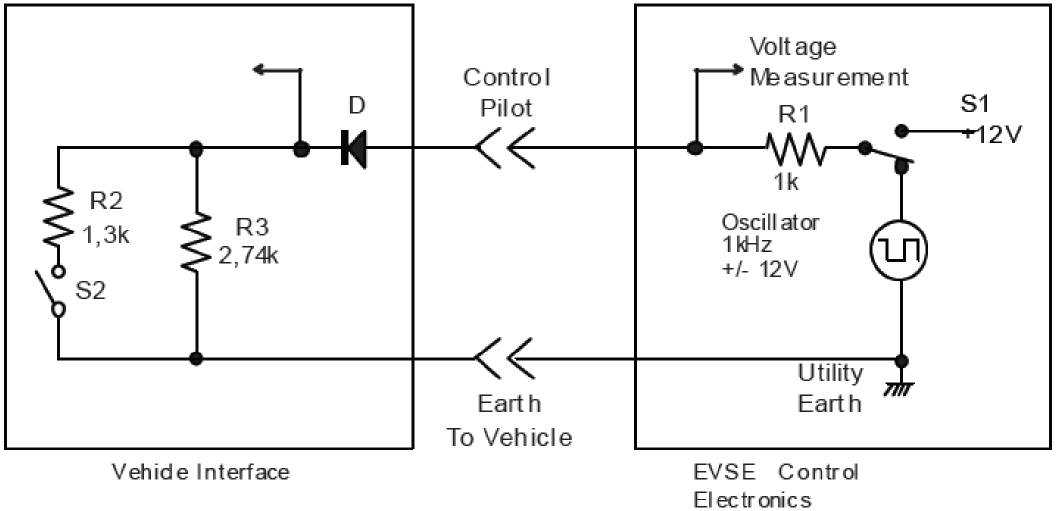


| | IEC 62-196-2 **Type I** (Japanese proposal*) | IEC 62-196-2 **Type II** (European proposal) |
|---|---|---|
| Maximum voltage | 240V | 480V |
| Maximum current | 32A (80A US) | 63A (70A single phase) |
| Phases | 1 | 1 to 3 |
| Maximum power | 7.2kW (19.2kW US) | 49.9 kW |
| Interlock | mechanical latch on connector | electromechanical latch on socket |
| Control Pilot | PWM signal | PWM signal |
| Proximity | Resistor in connector (also used to detect latch status) | Resistor (also used to detect current limit) |
| Digital communication | PLC | PLC |
| Intended use | vehicle | vehicle / infrastructure |

*also supported by SAE

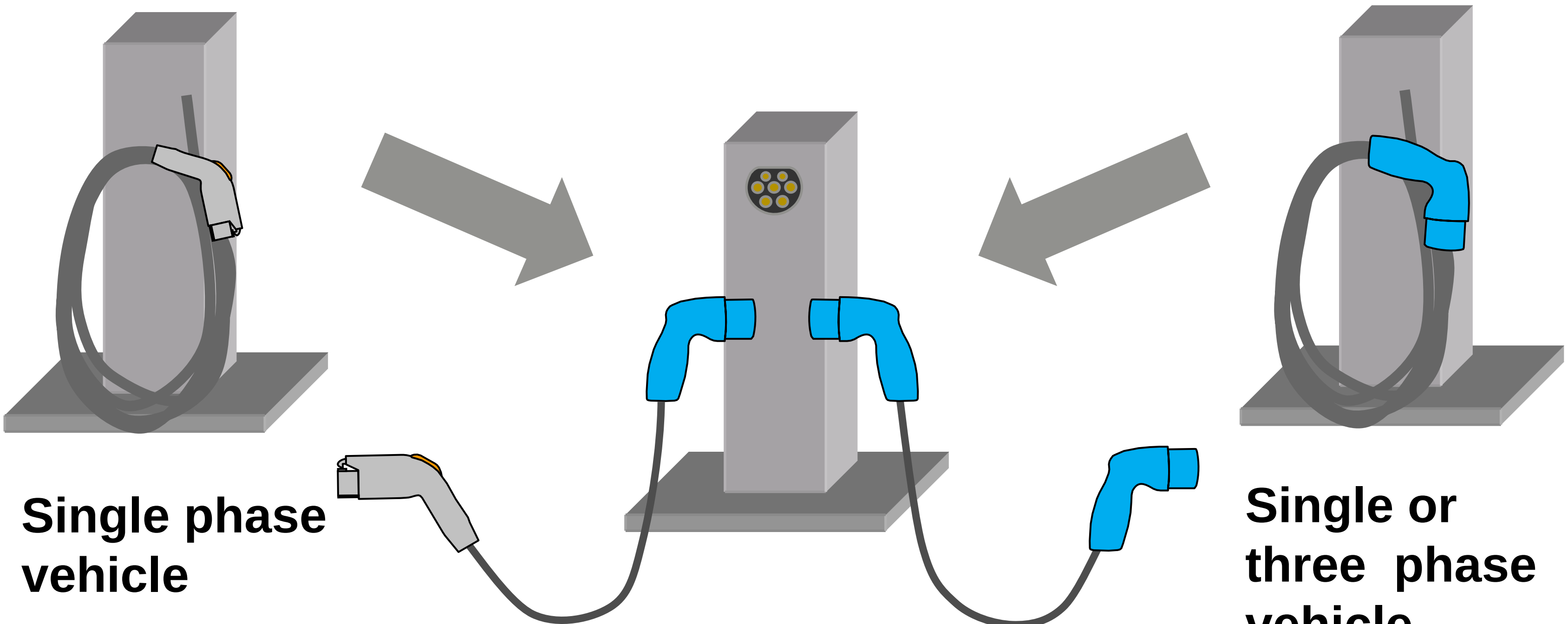
# Options to harmonize still exist

IEC 62196-2 Appendix A: Typical control pilot circuit




Despite different geometries both connectors can be used in the same system,
as the signals to control the charging process have been harmonized

# Possible path for harmonization




By using Type II sockets instead of fixed cables on the spot, loose mode 3 cables could be used to connect Type I and Type II vehicles

- Vehicles developed for the Type I connectors would not have to be modified
- Public charging infrastructure could become more viable (safety, vandalism, theft)
- The option to use three phases for future applications could be maintained

# Summary

- Two different charging connectors have been developed and will be standardized by IEC
- The Japanese proposal, which is also supported by SAE, is optimized for single phase charging with cables permanently attached to the spot
- The European proposal also includes provisions for three phase charging and the use of loose mode 3 cables
- As there will probably be a future need to use three phase power for public charging also in the US action should be taken now, to avoid stranded investments and costly retrofits:
  - Use of three 3 phase compatible Mode 3 sockets on public charge spots
  - Design all new single phase chargers to be compatible with 277V phase to neutral
  - Use three phase cables to connect new charge spots even if only one phase is used for the near future