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# Harnessing Charging Power

## The Communication Issues of Electric Vehicle Charging Infrastructure from a Standardization Point of View

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# Overview

- Introduction: the EV standards landscape
- Charging standardization
- Standard accessories
- Charging performance and the grid
- Communication issues

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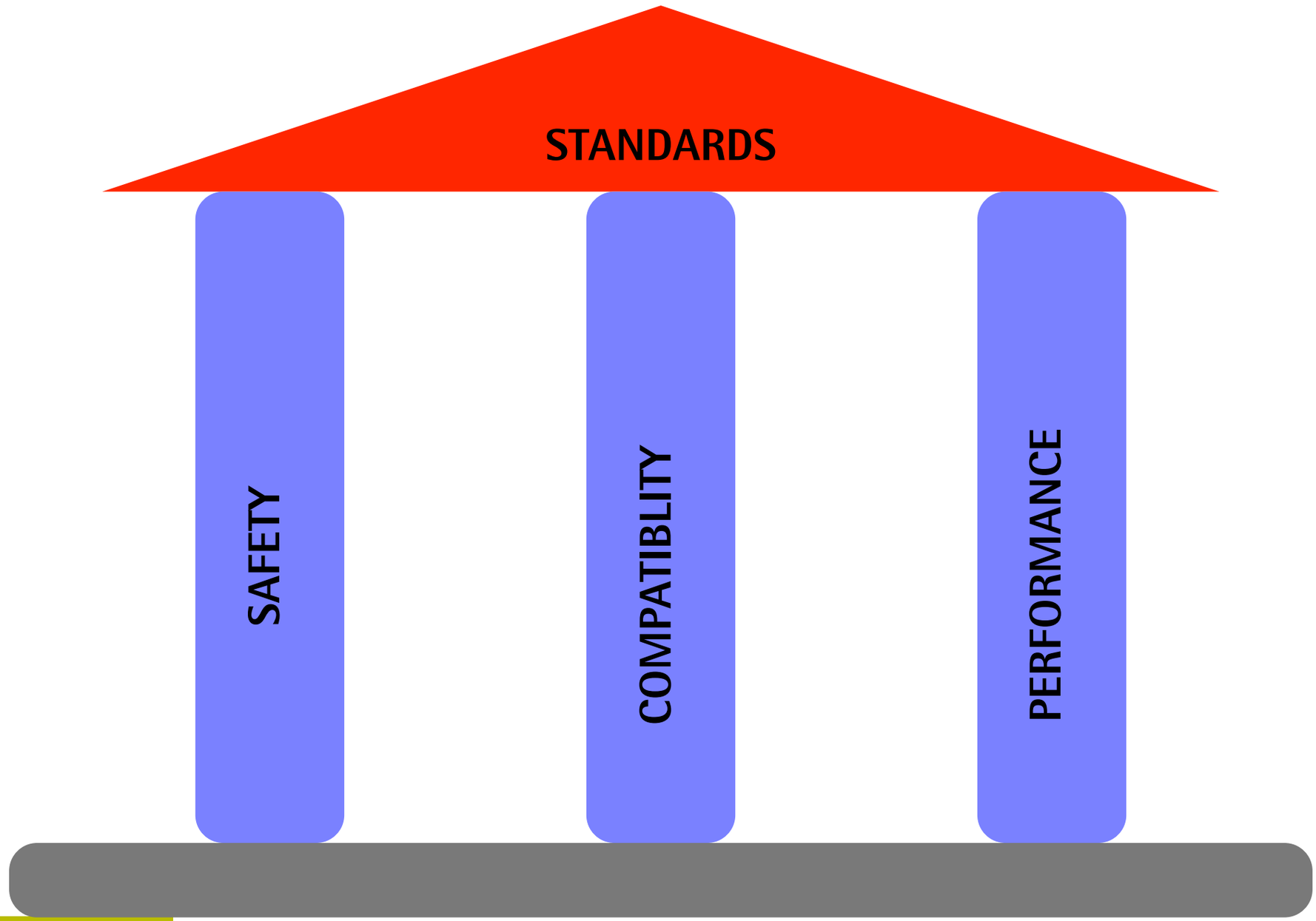
# Introduction: the EV standardization landscape

# The House of Standardization



# The electric vehicle

- Is it a Car

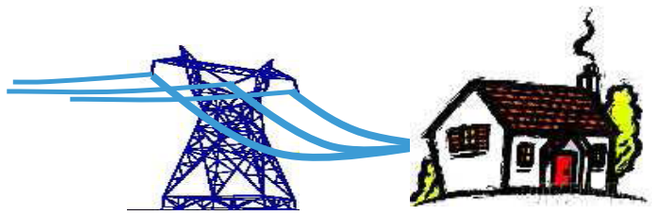
- or is it an Electrical Device?

# Committees in charge

Fixed installations
IEC 60364

Charging interface
IEC 61851
(TC69)

EV electrical aspects
(if not charging)
ISO TS22/SC21



Data transfer
JWG IEC/ISO V2G


Connective
Interfaces
IEC 62196
(SC23h)

Battery cells
IEC SC21A
Battery assembly
ISO TC22/SC21

SAE also has activities

# A Chequered Past

- Specific EV standardization work
  - Started around 1970 in the global committees
- Conflict of competence domains
  - Who should do the work
  - Background of committees
- Differences in standardization culture
  - Automotive
  - Electrotechnical

# Different viewpoints

| Car OEM | Electrotechnic |
|---|---|
| • Vehicles are products for world wide market<br>• Vehicle manufacturer has full product responsibility<br>• Consequently all automotive related standardization shall be concentrated on ISO TC22 “Road vehicles” including systems and components | • Vehicles charging are connected to electric supply and shall comply to all relevant standards for electric devices |

# Common viewpoints

- Minimize number of standards
- No conflicting standards
- No standards for where there is no demand

# Division of labour

| ISO TC22 SC21 | IEC TC69 |
| --- | --- |
| Aspects related to the electric vehicle as a whole | Aspects related to electrical components and electric supply infrastructure |

- ISO/IEC steering committee
- Outstanding issues

# Standards versus Regulations

- Standards
  - Voluntary documents obtained by consensus
  - Technical committees with engineers
- Regulations
  - Legally binding documents
  - Issued by government
  - Standards may find their way into the law

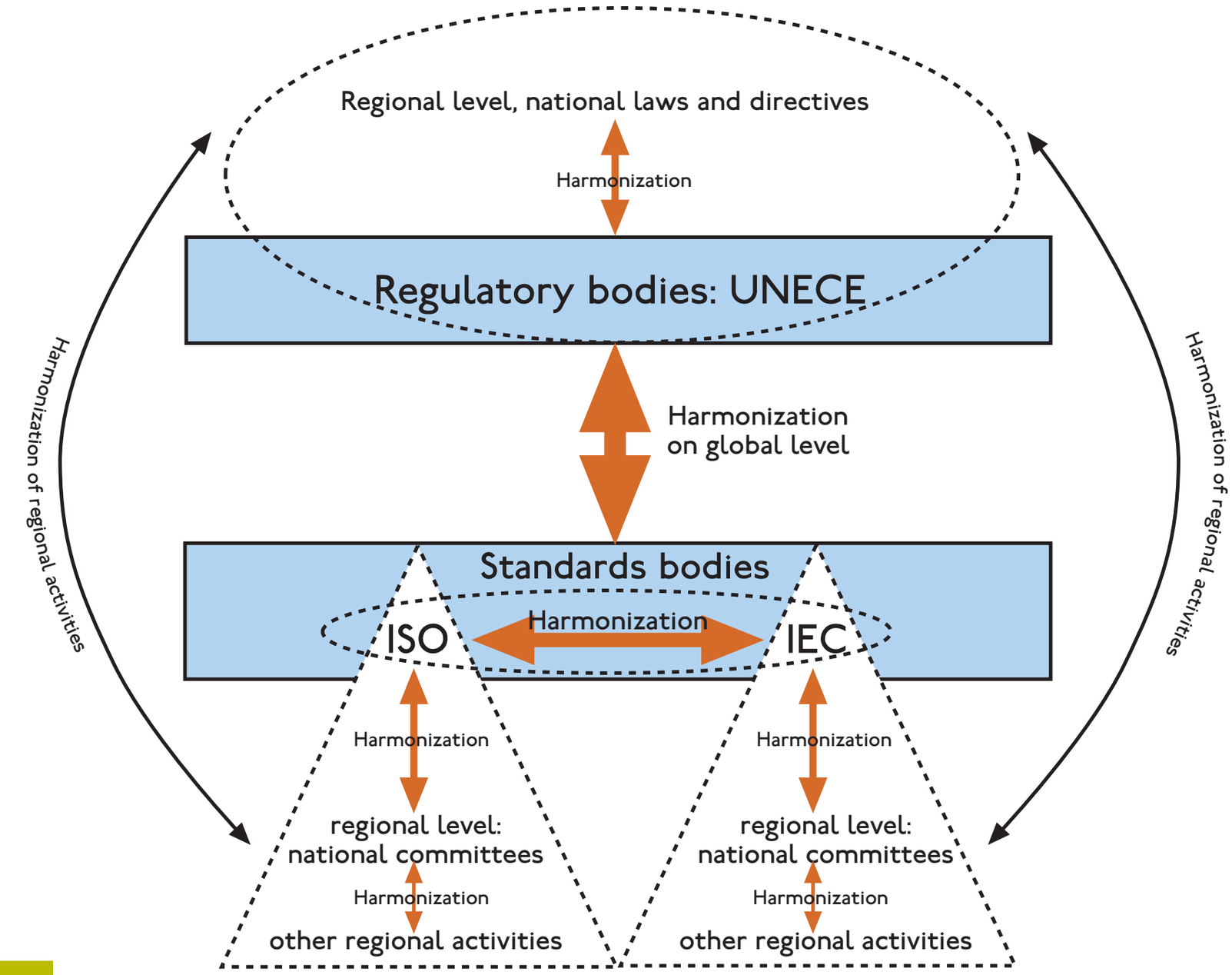
# Type Approval Regulations

- UNECE - United Nations Economic Commission for Europe
- Now adopted by most countries
- Regulation 100 - electric vehicles
  - Mandated by EU

# Interaction Standards and Regulations

- «New Approach» not yet adopted for road vehicles
  - UNECE regulations are UN matter, not EU
- Infrastructure standards such as 61851 are harmonized standards in Europe
  - Application of Low voltage directive on charging equipment
  - System boundary issues

# Standardization landscape



# Charging standards

# Safety standardization issues

- Protection of personnel
- Specific risks
  - Outdoor environment
  - Public spaces
  - Mechanical strain
  - Use by non-qualified personnel

# Charging infrastructure standards

- IEC 61851:2001 - Electric vehicle conductive charging system
  - Part 1: General requirements (FDIS level)
  - Part 21: Electric vehicle requirements (CD level)
  - Part 22: a.c. charging station requirements (CD level)
  - *Part 23: d.c. charging station requirements (NP level)*
  - *Part 24: d.c. charging station communication (NP level)*
- IEC TC69

# Definition of charging modes

- Mode 1 charging: non-dedicated outlet
- Mode 2 charging: non-dedicated outlet with in-cable protection device
- Mode 3 charging: dedicated outlet
- Mode 4 charging: d.c. connection

# Mode 1 charge

- Use of standard, non-dedicated socket-outlets
- No communication
- Earthing and GFCI/RCD are essential for safety
  - Compulsory in all new electric installations
  - Not guaranteed in legacy installations
- Not allowed in certain countries
  - May be allowed for private premises
- Most widely used system today
- Perfectly safe if used properly

# Mode 2 charge

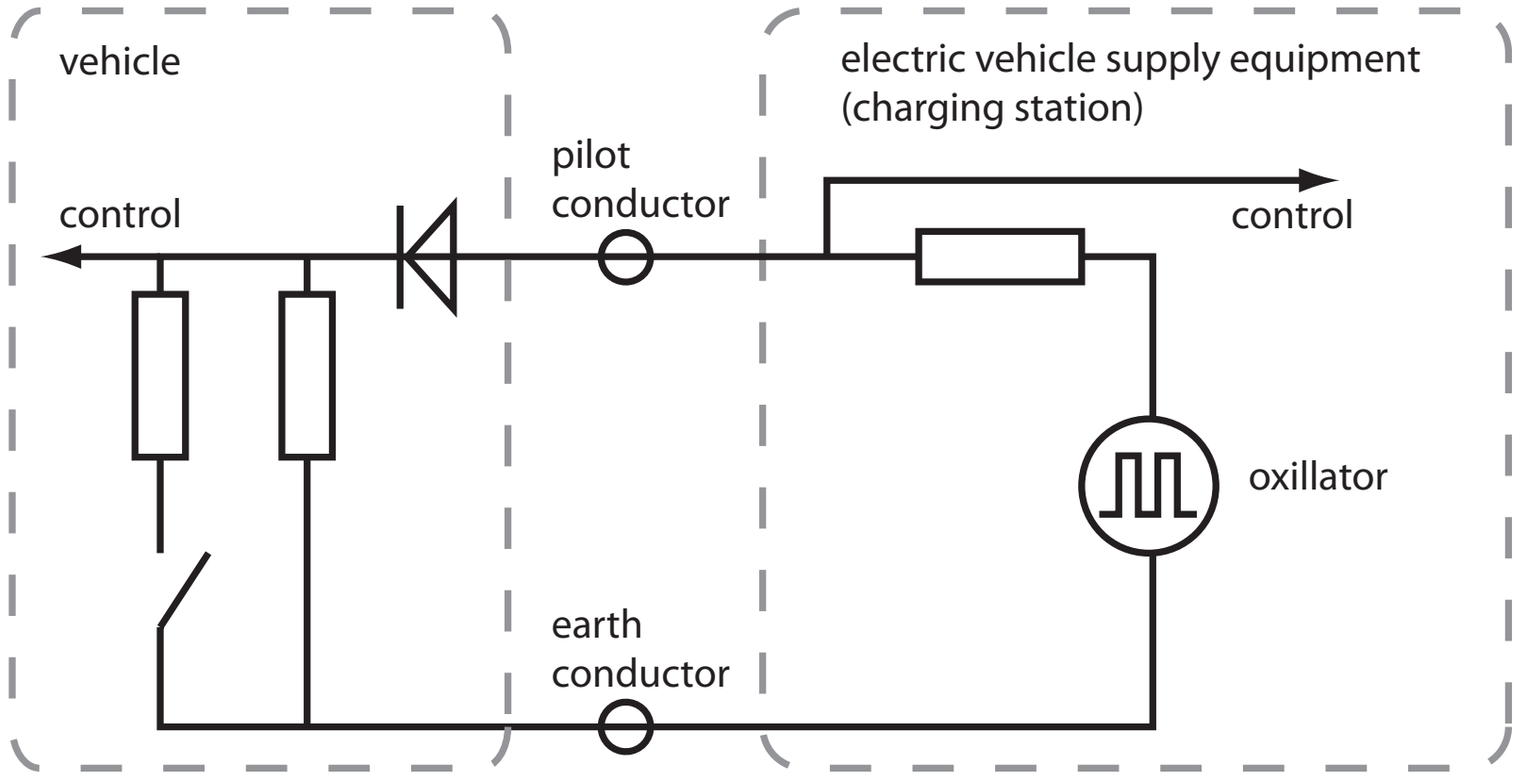
- Use of standard socket-outlets
- In-cable or in-plug protection box
- Initially a transitory solution in USA
- Now: renewed interest from OEM to replace Mode 1
- Plug is not protected!

# Mode 3 charge

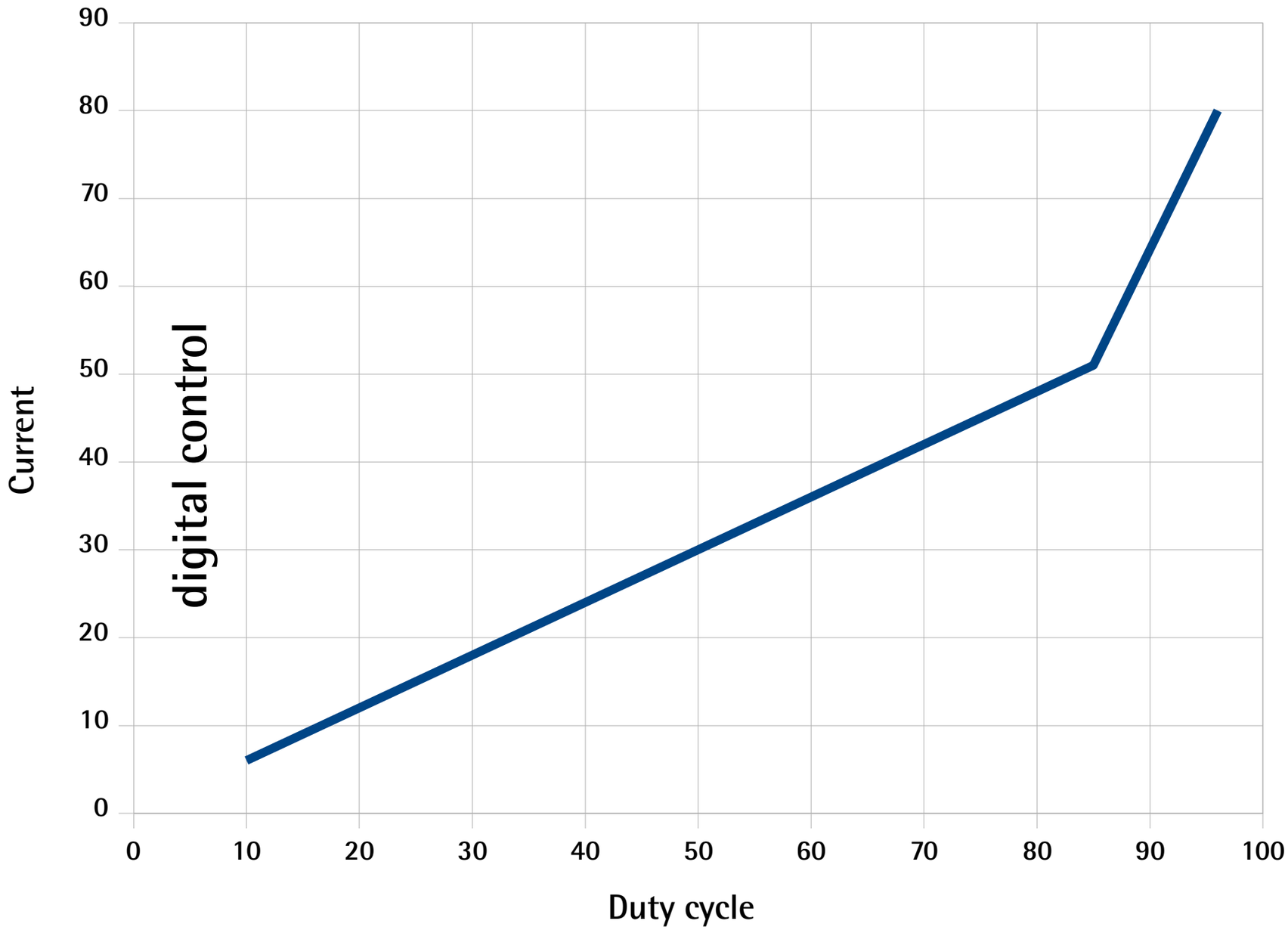
- Dedicated socket-outlet for EV use
- Protection with control pilot function
  - Verification of correct connection
  - Socket is dead if no vehicle is present
  - Integrity of earthing
  - Ampacity of charger
- Essential for public infrastructure

# Hard-wired control pilot

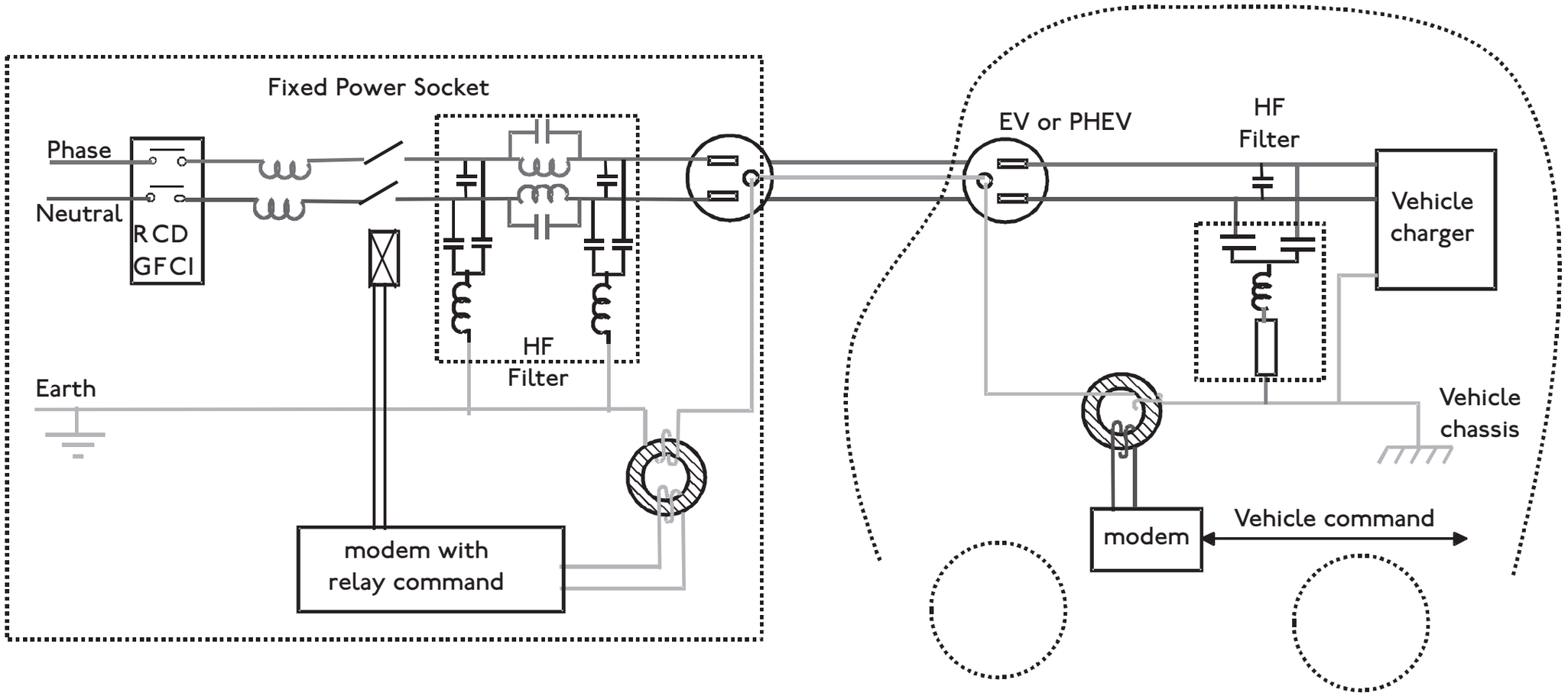
- First degree of communication
- Switch on vehicle to enable charging
- Ampacity control



# Control pilot duty cycle and ampacity



# PLC control pilot



# Battle of the Modes

- French-German car OEM in favour of Mode 3 only charging, with Mode 2 transitory solution for home charging
- User support for Mode 1 which is safe enough if used correctly
  - Northern countries - car heaters

# Mode 4 charge

- Stationary charger
- d.c. connection
- Heavy and expensive infrastructure
- Communication needed between battery and charger

# Accessories: plugs and sockets

# Standard accessories

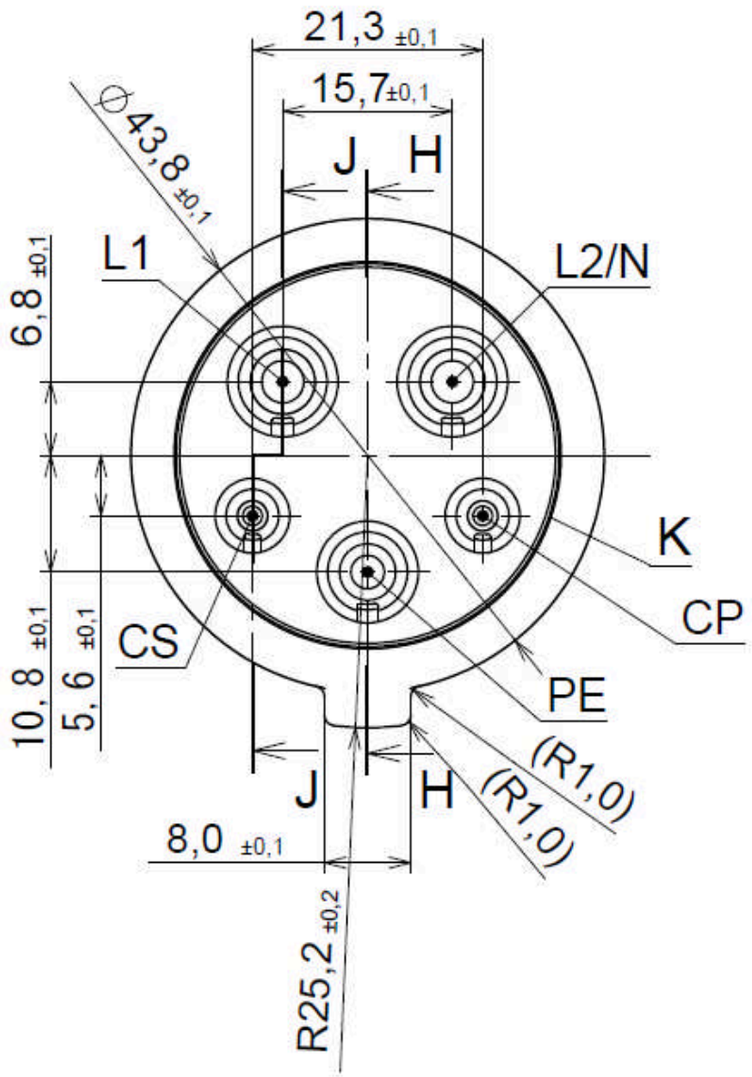
- Domestic accessories not well suited for heavy EV duty
- Industrial accessories (IEC 60309-2) preferable

# Dedicated EV accessories

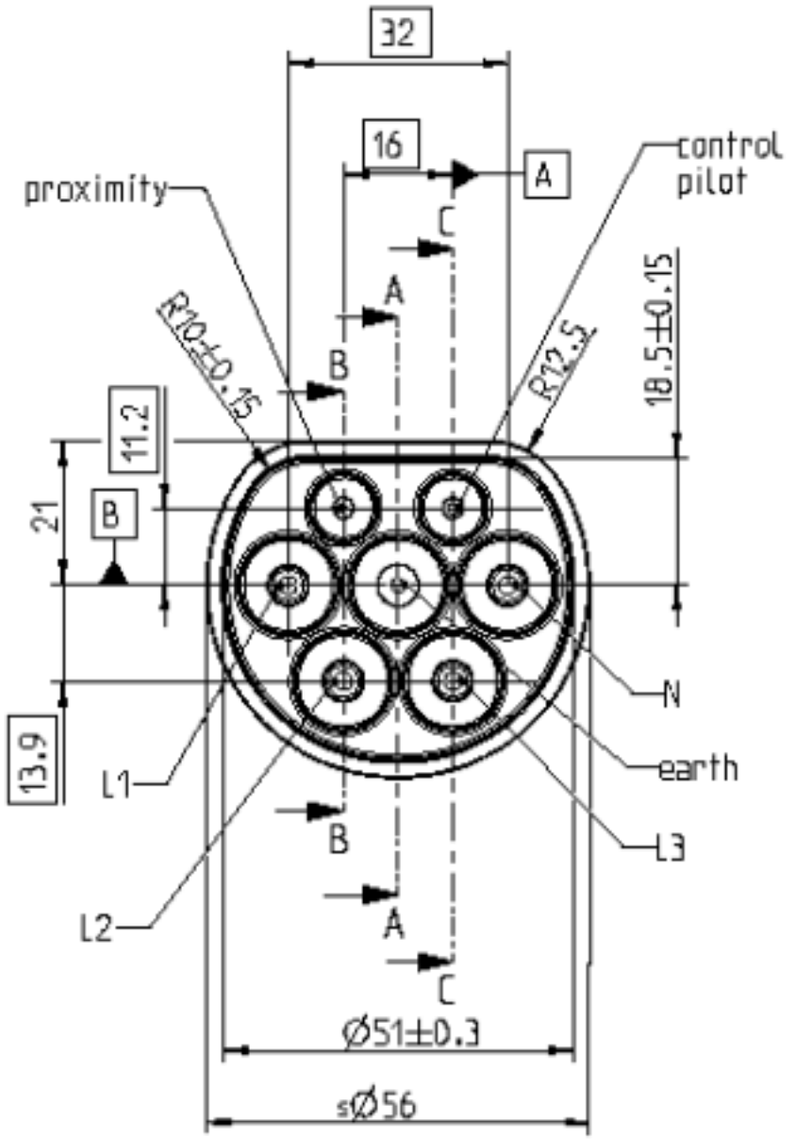
- Ongoing standardization work IEC SC23H
  - IEC 62196 - 2: Dimensional interchangeability requirements for pin and contact-tube vehicle couplers
    - Three designs for a.c. plugs and connectors
    - Discussion on single solution, facing national regulations on items such as shutters
  - New NP for d.c. couplers

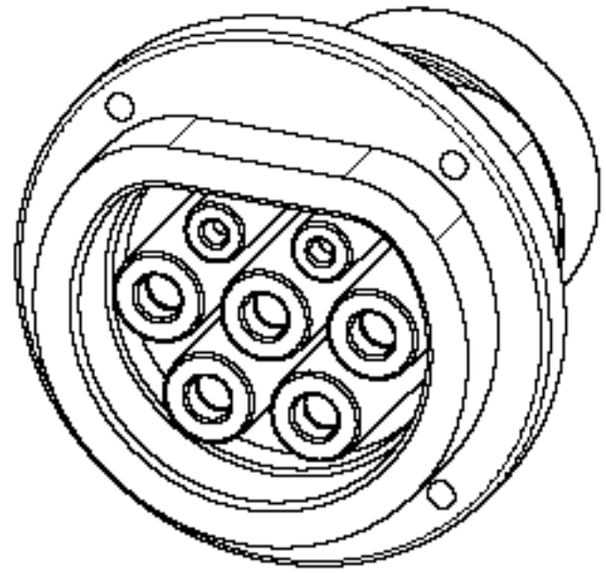
# Single phase 30A plug

- USA-Japan
- SAE J1772

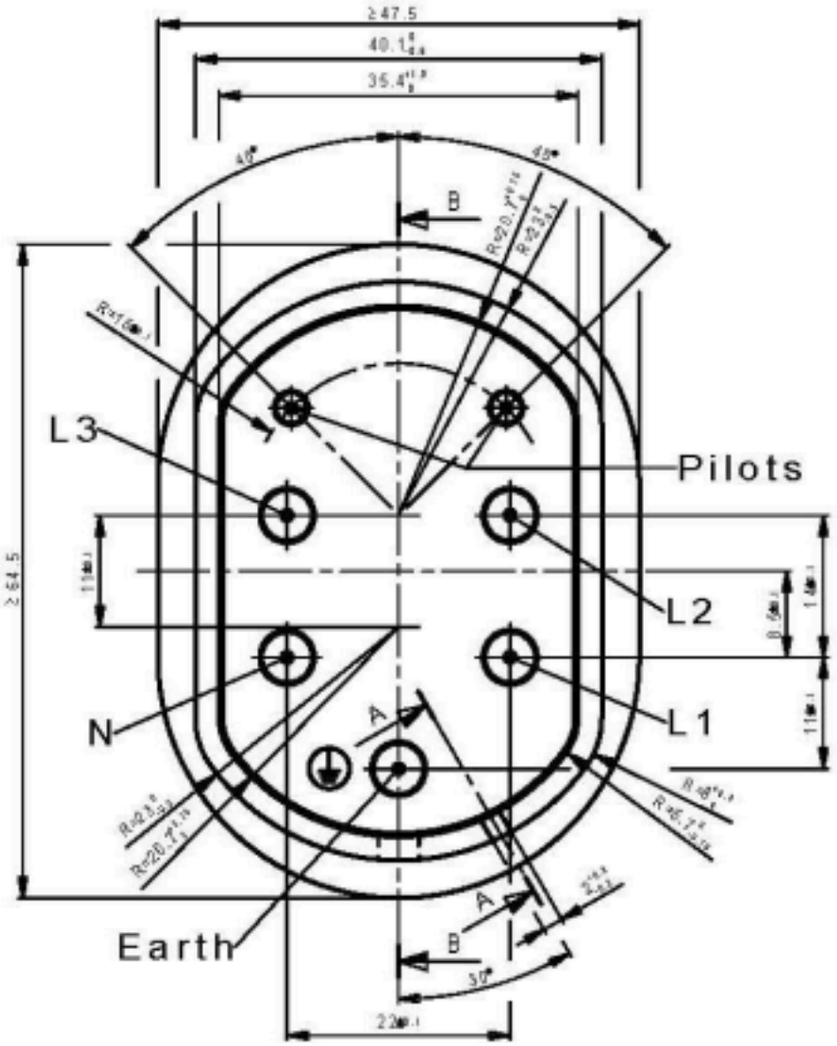


# Three phase plug (up to 63A)



# Three phase plug (32A)



# Charging performance and the impact of EV on the grid

# EV Charging Levels

- Normal charging
  - Use of standard socket-outlet
- Semi-fast charging
  - Higher power available in domestic environment
- Fast charging
  - Dedicated high power connections

# "Normal" charging ("Level 1")

- Standard power outlet
  - USA: 120V, 15A
    - 1,8 kW (with power factor 1)
    - *"Charge speed": 5 mph*
  - 230V, 16A
    - 3,7 kW (with power factor 1)
    - *"Charge speed": 10 mph*
- Universally available

# "Semi-fast" charging ("Level 2")

- Heavy single-phase outlet
  - 230V, 32A - 7,4 kW
    - *"Charge speed": 20 mph*
  - Generally available in domestic environment (32A = electric range)
- Three-phase outlet
  - 3x400V, 16A - 11 kW
  - Readily available in many countries

# "Fast" charging («Level 3»)

- Power ≥ 20 kW, up to 80% charge in ½ hour
- More expensive infrastructure
- Heavy cables: fixed to charging post
- Strain on batteries
- Strain on grid
- d.c. charging: external charger
- a.c. charging: via traction inverter

# Do we need fast charging?

- Availability of fast charging infrastructures provides a psychological advantage
- Fast charging does not allow for final charge
- Semi-fast (and even normal) charging provide good enough occasions for opportunity charging
- Nighttime charging creates an ample time window with cheap power

# Slow charge will be predominant

Fast Charge

charge < 6 kW

5%

95%

Fast – Expensive
Few

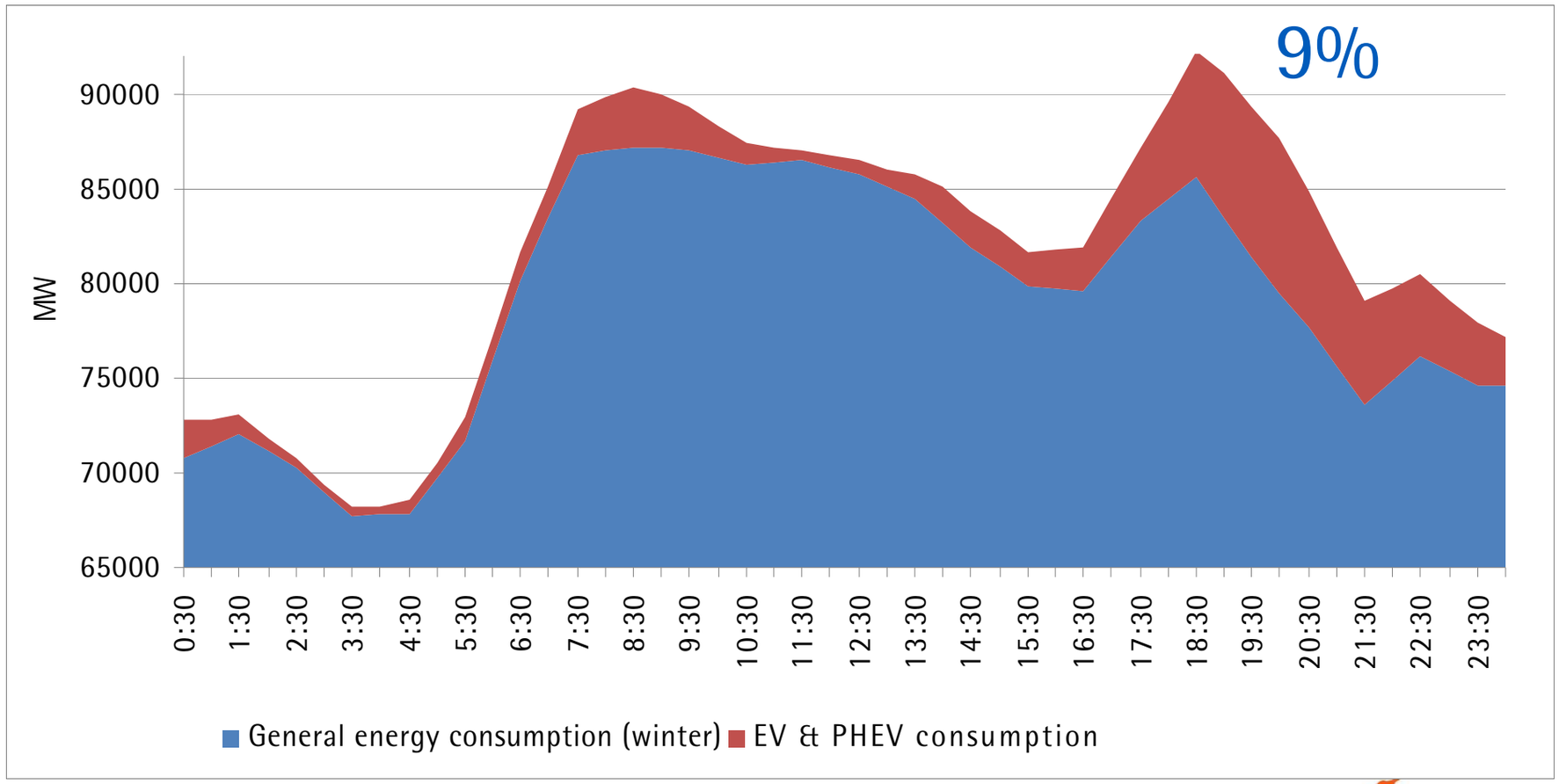
Overnight – cheap – efficient
available everywhere

# Smart grid issues

- Influence on the grid
  - No major problems on macro level taking into account evolution of generic energy consumption
  - Problems may occur with local distribution networks

# Influence on the grid

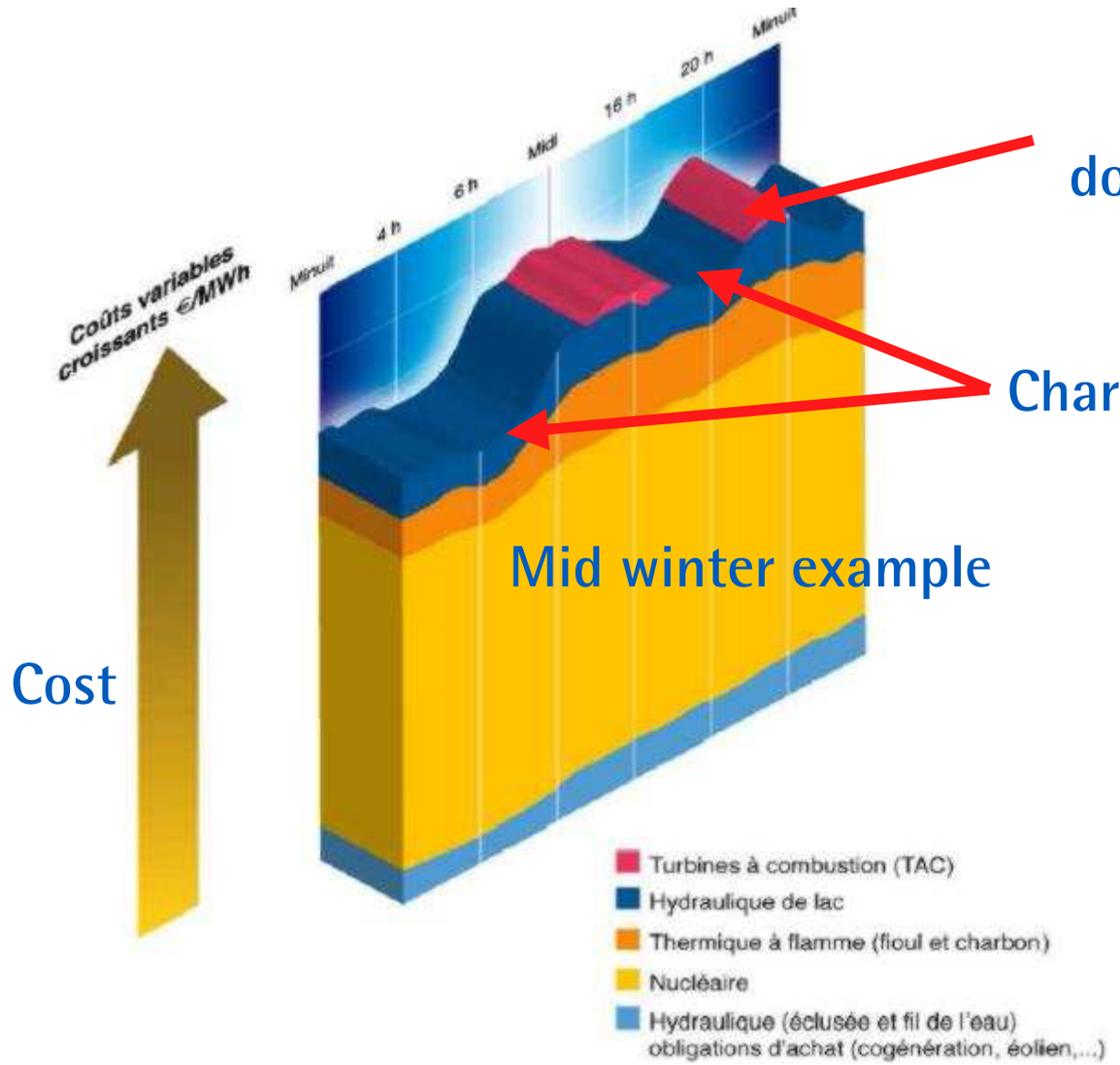
- 2025 forecast (EDF)




2025

# Smart grid

- Optimization of charging times



# Vehicle to grid

- Bidirectional energy flow
- Payment for energy charged
- Compensation for energy delivered
- Intelligent communication needed
  - energy metering
  - user readiness for charge

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# Communication issues

# Levels of communication

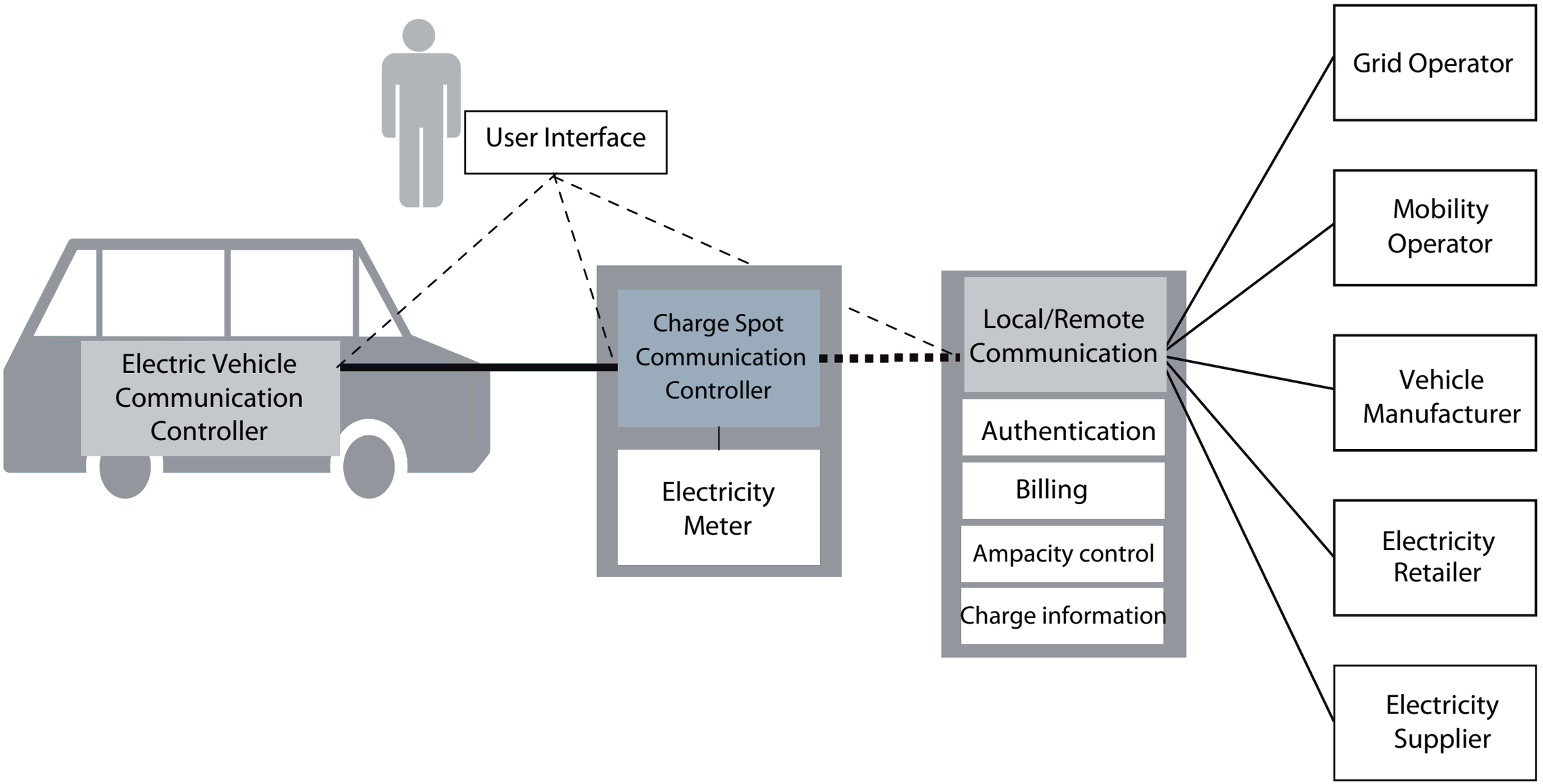
- Tariff information
- Charging process info
- Value added services
- Capability information
- User authentication
- Grid information
- Dynamic ampacity control
- Local ampacity limit
- Safety monitoring

Minimal communication with pilot function

Communication required for remote billing and dynamic grid load control

User Convenience

# Actors involved



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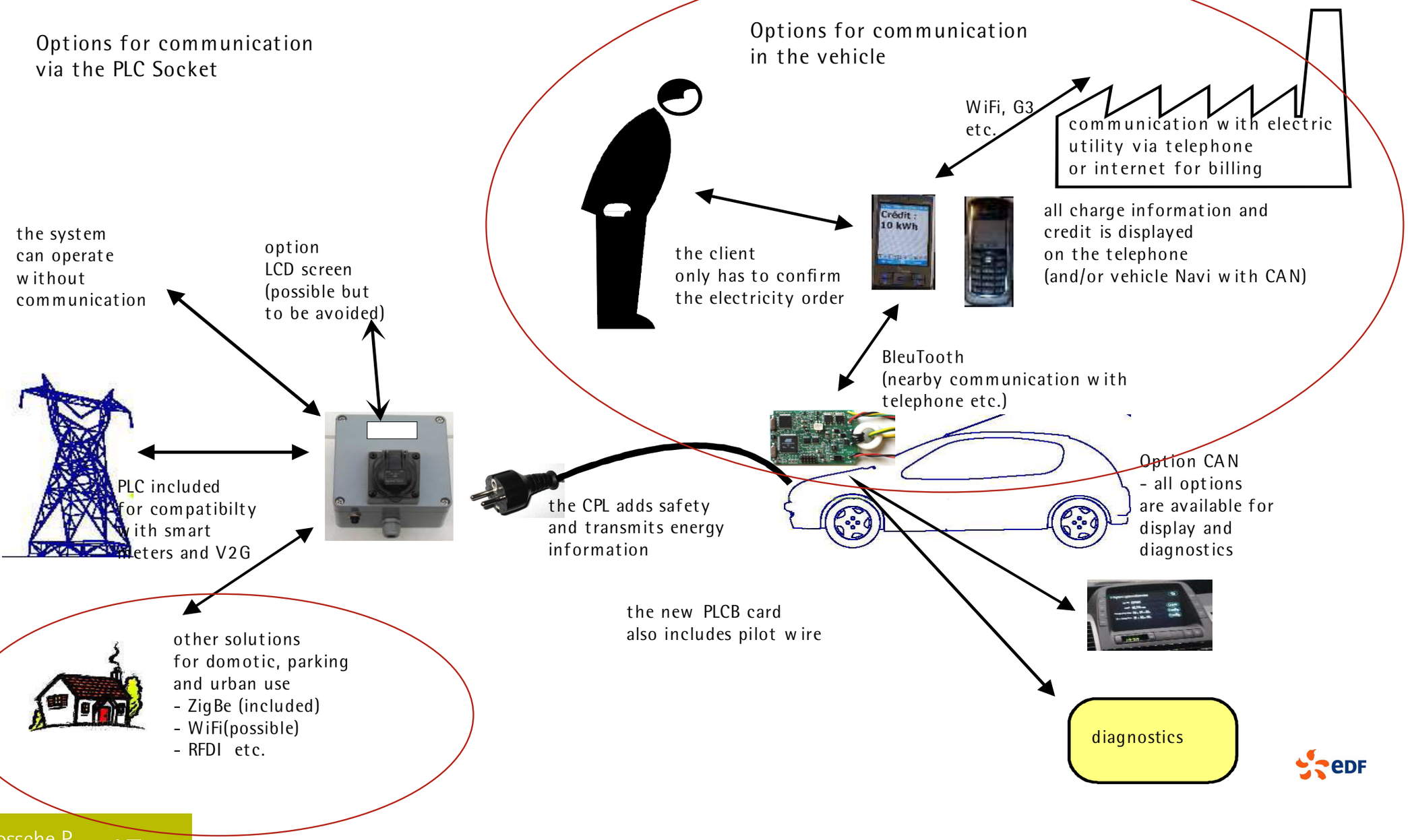
# Communication scenarios

Options for communication
via the PLC Socket

Options for communication
in the vehicle




EDF

# Use cases

- Definition of potential use scenarios
- Example: “Plug & Charge”
  - User plugs vehicle into the charge spot
  - Vehicle sends its ID to the charge spot to get authenticated by the clearinghouse through GSM
  - Authentication is successfully processed
  - Grid and tariff parameters are negotiated
  - Charging process starts automatically.

# Communication channels

- Interaction with utilities
  - Dynamic ampacity control for smart grid
- Interaction with vehicle OEM
  - Vehicle diagnostics
- Interaction with service providers
  - Billing and roaming

# Problems

- Complex business models
- Energy cost for a charge versus communication cost or parking cost
- Danger of overspecification and overstandardization, incurring excessive costs
- K.I.S.S. principle !

# Communication Standardization

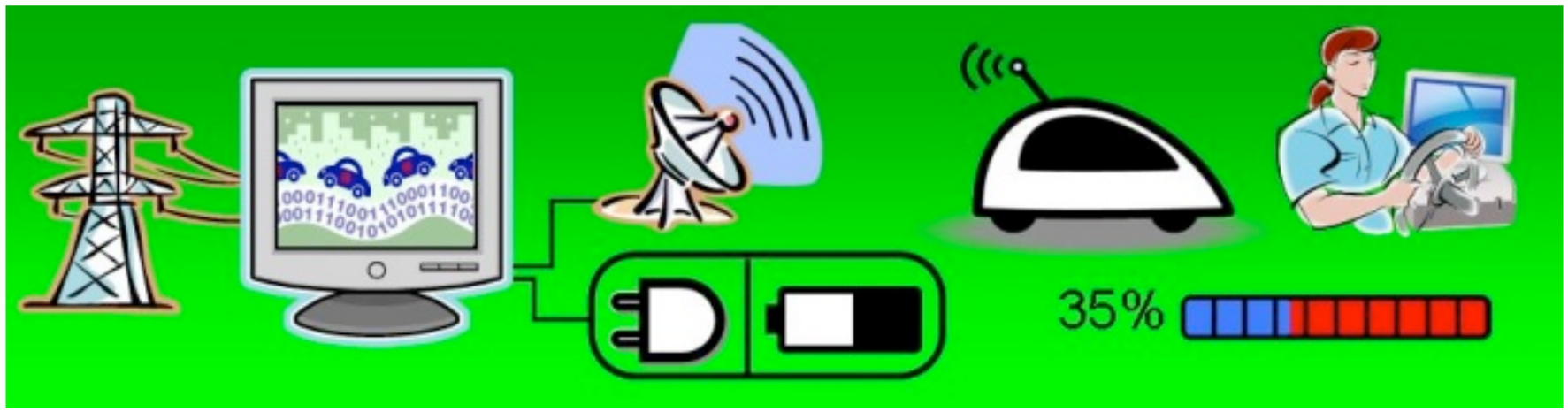
- Communication protocol vehicle - charging post
- Treated by JWG IEC TC69 - ISO TC22 SC21 - ISO TC22 SC3
- ISO 15118: Road vehicles -- Communication protocol between electric vehicle and grid
  - Part 1: Definitions and use-case
  - Part 2: Sequence diagrams and communication layers
- Liaison with ITU and ETSI
- USA: SAE J2836

# Communication Research

- FP7 project “ELVIRE”


- **EL**ectric **V**ehicle communication to **I**nfrastructure, **R**oad services and **E**lectricity supply

# ELVIRE




- Identifying business models and typical scenarios
- Bringing together automakers, suppliers, service experts, research and utilities
- Demonstrating the approach used to mitigate EV drivers' "range anxiety" through validation test.

# Conclusions

# Where do we go from here

- Standardization is essential for safety and compatibility
- Communication standards should address actual needs

- The ideal of infrastructure standards
  - **Any vehicle should be able to safely charge, anywhere.**