

# Charging Voltages and Power Levels

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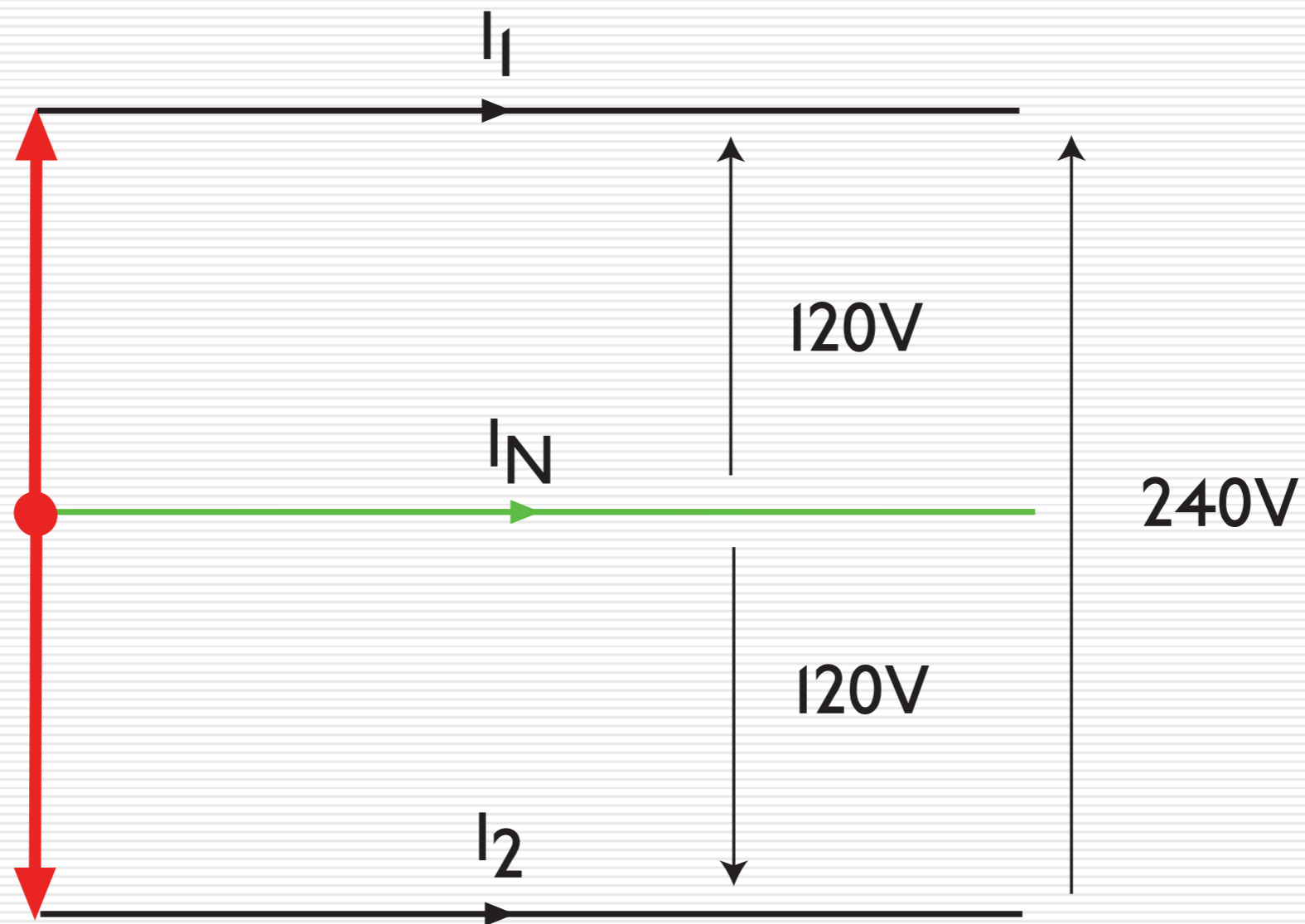
*Vrije Universiteit Brussel*

# Electricity distribution in America

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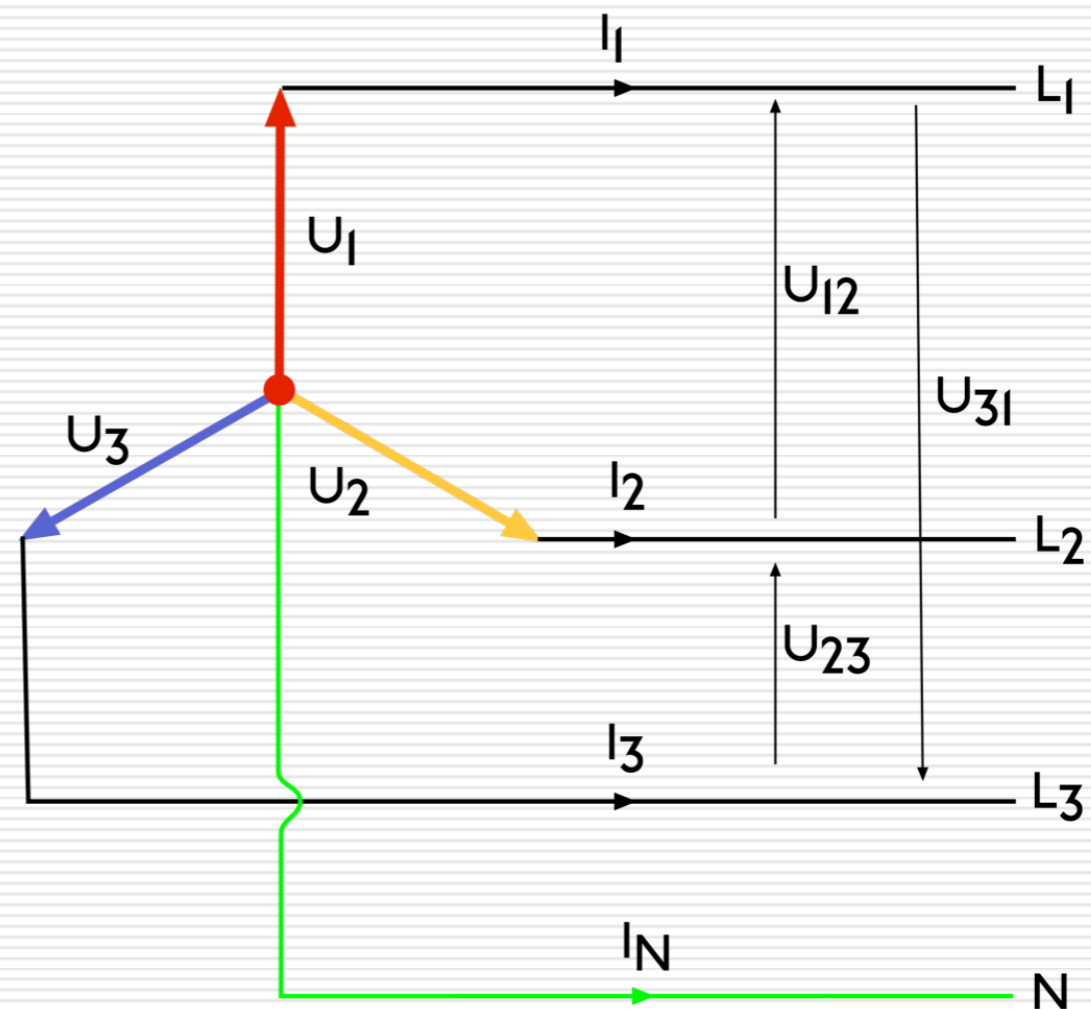
- ❖ Three-wire split phase system
- ❖ 120V between phase and neutral
  - ❖ standard domestic outlets
- ❖ 240V between phases
  - ❖ high-power consumers (e.g. electric range)
- ❖ Three phase used for motors (rarely found in domestic environment)

# American three-wire system



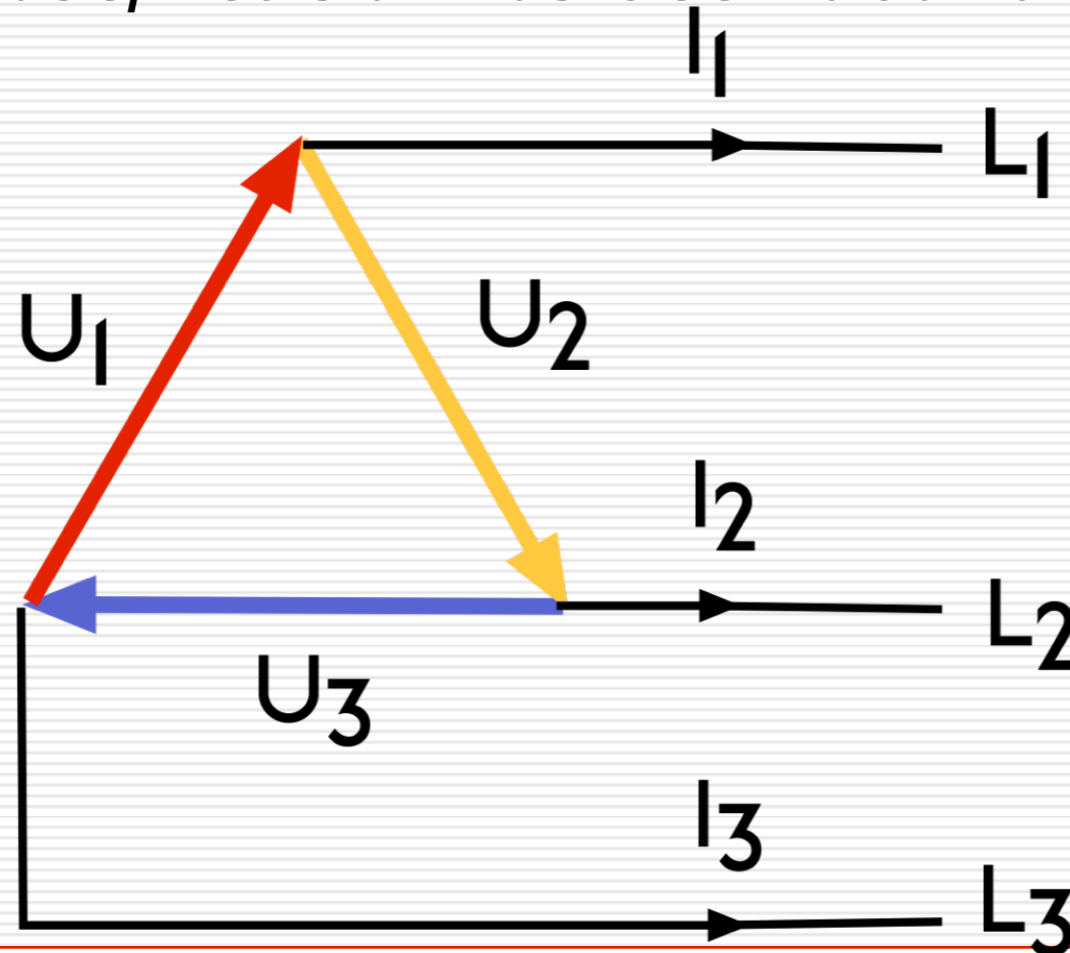
# Electricity distribution in Europe

- ❖ Universal three phase distribution
- ❖ 4-wire: 3 x 400 V + N
  - ❖ 400V between phases
  - ❖ 230V phase to neutral



# Electricity distribution in Europe

- ❖ 3 wire: 3 x 230V
  - ❖ 230V between phases
  - ❖ 130V phase/neutral has been abandoned long time ago



# Electricity distribution in Europe

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- ❖ National differences based on historical developments and cultural tradition
  - ❖ France: domestic connections are single-phase, up to 90A!
  - ❖ Switzerland: generalized three-phase connection, all consumers  $\geq 16A$  are three phase
- ❖ Other countries are somewhere in between

# EV Charging Levels

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## ❖ Normal charging

- ❖ Use of standard socket-outlet

## ❖ Semi-fast charging

- ❖ Higher power available in domestic environment

## ❖ Fast charging

- ❖ Dedicated high power connections

# "Normal" charging

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

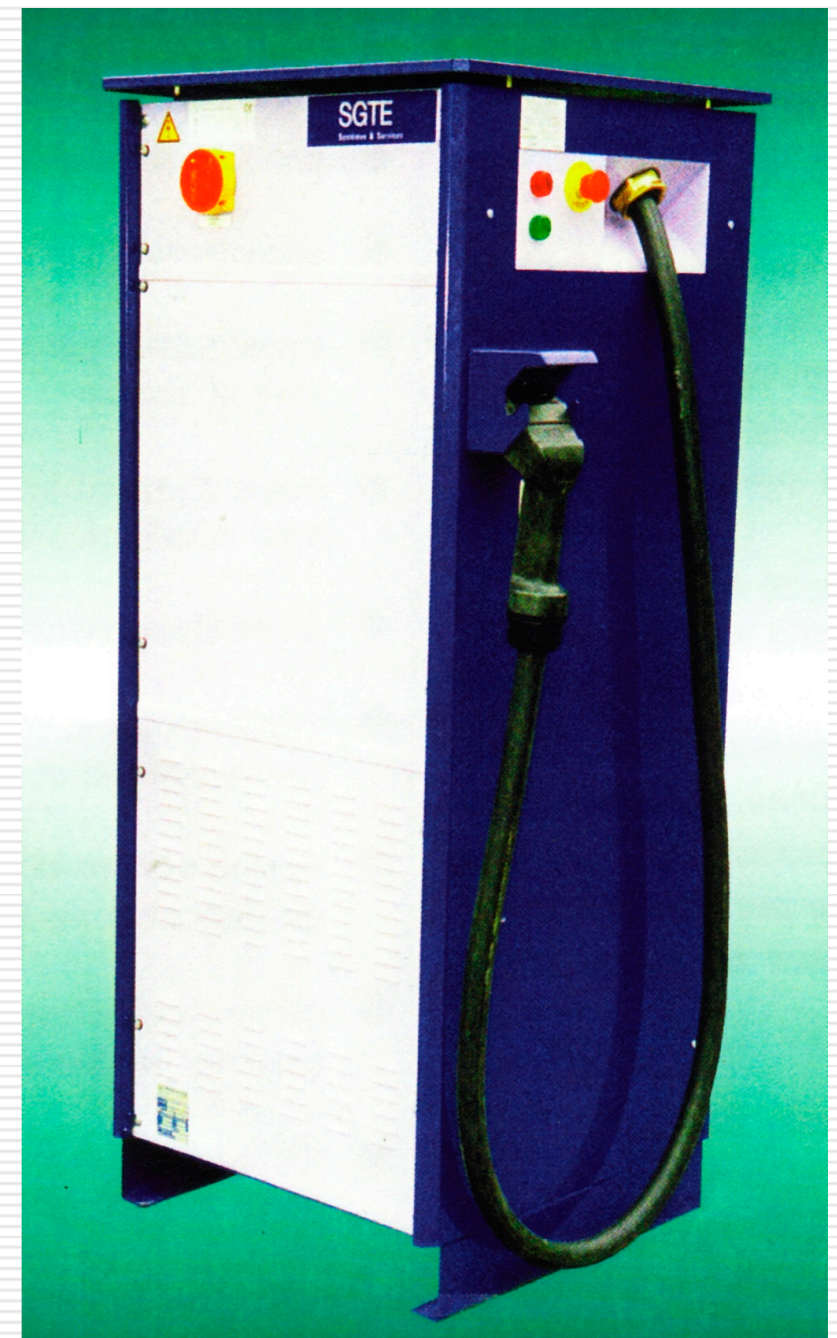
# "Semi-fast" charging

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- ❖ 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 some countries

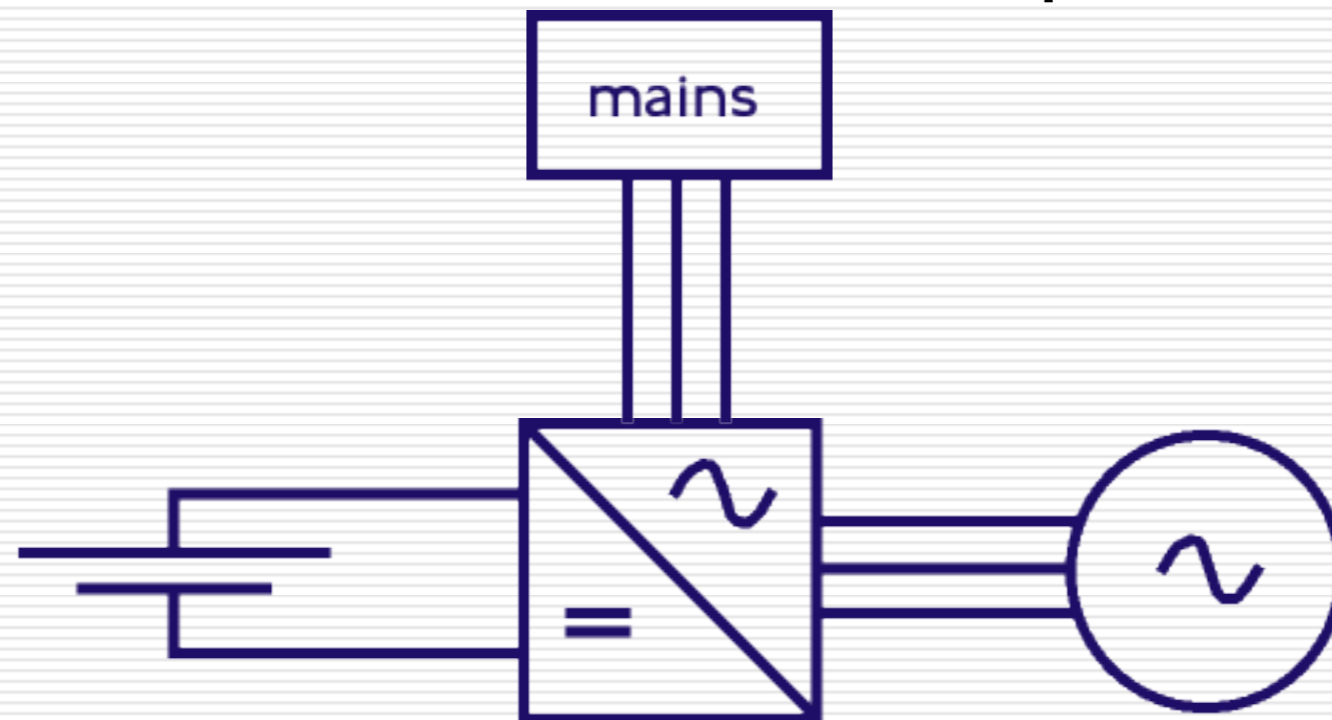
# "Fast" charging with d.c.

- ❖ Mode 4 charging
- ❖ Heavy, expensive infrastructure
- ❖ Power typically 36 kW
- ❖ 80% charge in 1/2 hour



# “Fast” charging with a.c.

- ❖ Charging through traction inverter
- ❖ Connection to three-phase mains
- ❖ No expensive stationary charger needed
- ❖ Opportunities for bidirectional power



# Do we need fast charging?

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- ❖ 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

# The advantages of 240V

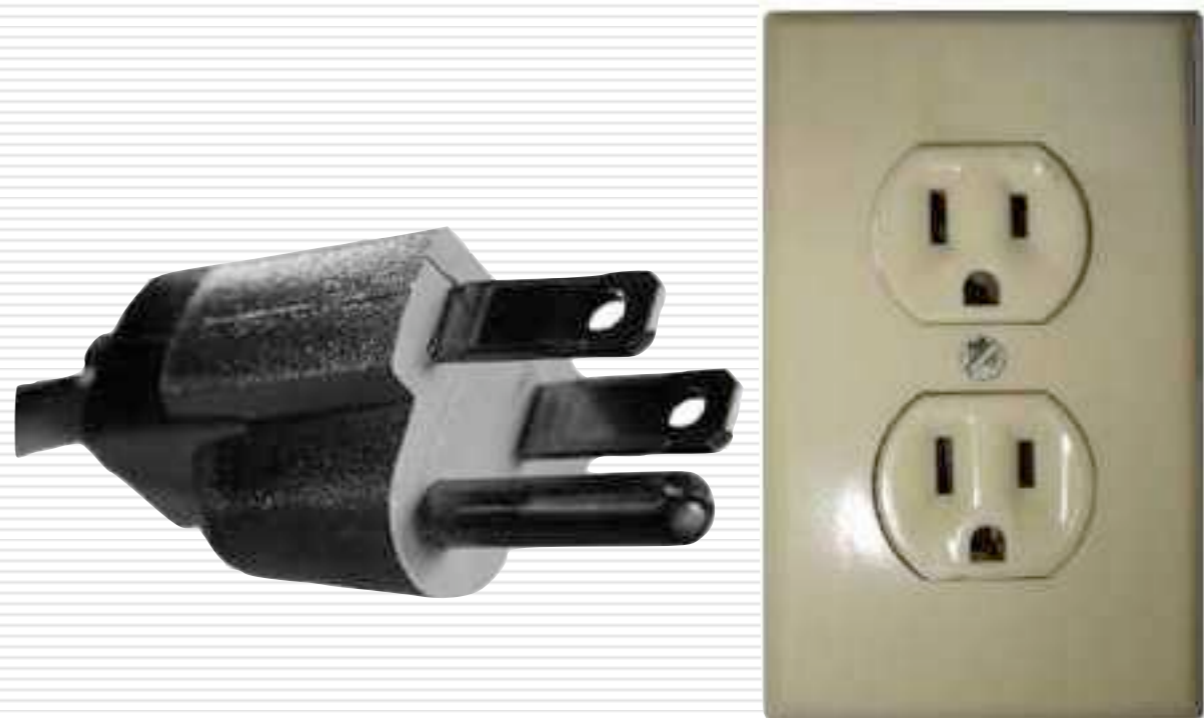
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- ❖ Double power available for same current
- ❖ Half the charging time
- ❖ 240V class voltages are used for domestic applications in full safety around the world
- ❖ Safety assured by GFCI and overcurrent protection
- ❖ Use of appropriate accessories (plugs and sockets)

# Appropriate Accessories

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- ❖ Domestic plugs and sockets are not optimal for EV duties



# Appropriate Accessories

- ❖ Industrial-type plugs (IEC 60309)
- ❖ Strong, safe and reliable
- ❖ Cheap standard plugs



# Conclusions

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- ❖ 240V charging is the way to go
- ❖ 120V option for low-power charging where no 240V outlet is available, as transitional solution
- ❖ Future developments should focus on 240V
- ❖ Semi-fast (30/32A) charging provides ample power and can be implemented in most environments