Impact of electromobility on electric power system

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Outline

- Some figures about EV → energy and power
- Impact of EV for electrical systems
- EV as flexible resources
- ICT for EV control
- Conclusion

Some basics

- Energy and power → two distinctive characteristics
- Power = flow of energy per time
- Electrical system delivers energy but its sizing must cope with power needs (peak power)
- Any increase in peak power → grid reinforcement

Some figures

- EV, energy needs:
  - 30 km/day and 250 d/y → 7500 km/y
  - 0.2 kWh/km → 6 kWh/d and 1500 kWh/y
  - One million EV → 1.5 TWh /y

    → 0.3% of the French or German demand

  - France → 3-6 millions EV in 2030 → 1-2% of energy

Some figures

- EV, power needs:
  - Charging power: 3.3 ; 7; 22; 43 kW and more than 50 kW
  - At home: 3.3 kW or 7 kW

6 kWh/d

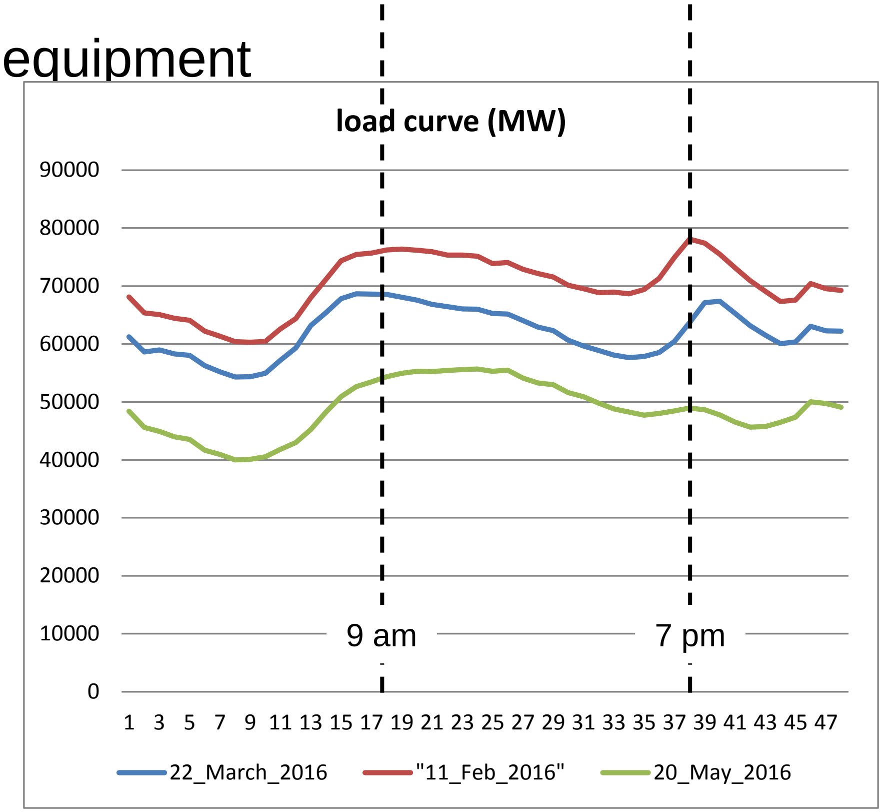
3.3 kW	7 kW
↓ 2h charging	↓ 1h charging
↓ Simultaneous charging of 1 million EV	↓
3300 MW around 7 pm 3 → 8%	7000 MW around 7 pm 7% → 15%

French peak at 7 pm :
40 GW → 100 GW

Simultaneous charging must be avoided

Impact of EV

- Some fundamentals about grid operation:
  - Instantaneous power balancing
  - Respect the voltage limits
  - Respect the thermal limits of equipment
- Typical daily load curve
  - Peak load at 7pm
  - Peak load at 8-10 am



Impact of EV

- EV
  - Additional energy need
  - Grid capability to deliver the power? ➡ The most critical
    - Global system → additional peak generation units ?
    - Local system → risk of overload (transformers, lines) or voltage drop in distribution grids, requirements for reinforcements ?

- Dumb charging of large EV fleets will be critical

Impact of EV

- Power impact depends on charging power
- Charging power is a trade-off between:
  - Energy to be delivered
  - Available time

  ➡ Low power charging is better for the grid

- Future evolutions:
  - Larger batteries for longer trips
  - More high power charging
  - More critical for the grid
  - Which adequation between charging point location and local grid capabilities?

EV: a flexible resource

- EV fleets have a flexibility potential
  - EV battery is a storage device
  - typically $\Delta t_{charge} << \Delta t_{parking}$ (at home or at work)
  - Control by the power converter
  - Fast response time

- Controlled charging when power grid capabilities are available

EV: a flexible resource

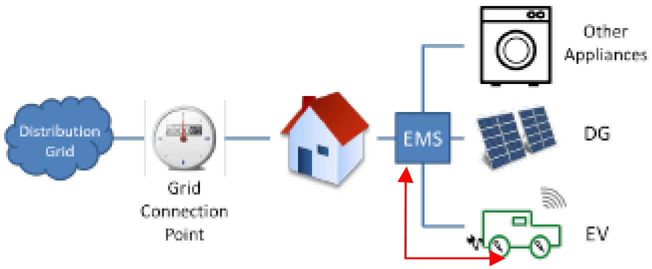
- Storage capacities available for the electrical system, in the respect of mobility needs
- Distributed storage
- Grid ➔ EV (smart charging)
  - Load shifting in off-peak hours
  - Controlled charging for delivering frequency regulation services
    - Response time of batteries can be very short (< 10 sec)
  - Charging in case of large amount of local RES
    - EV can help to solve RES constraints (congestions and voltage rise)

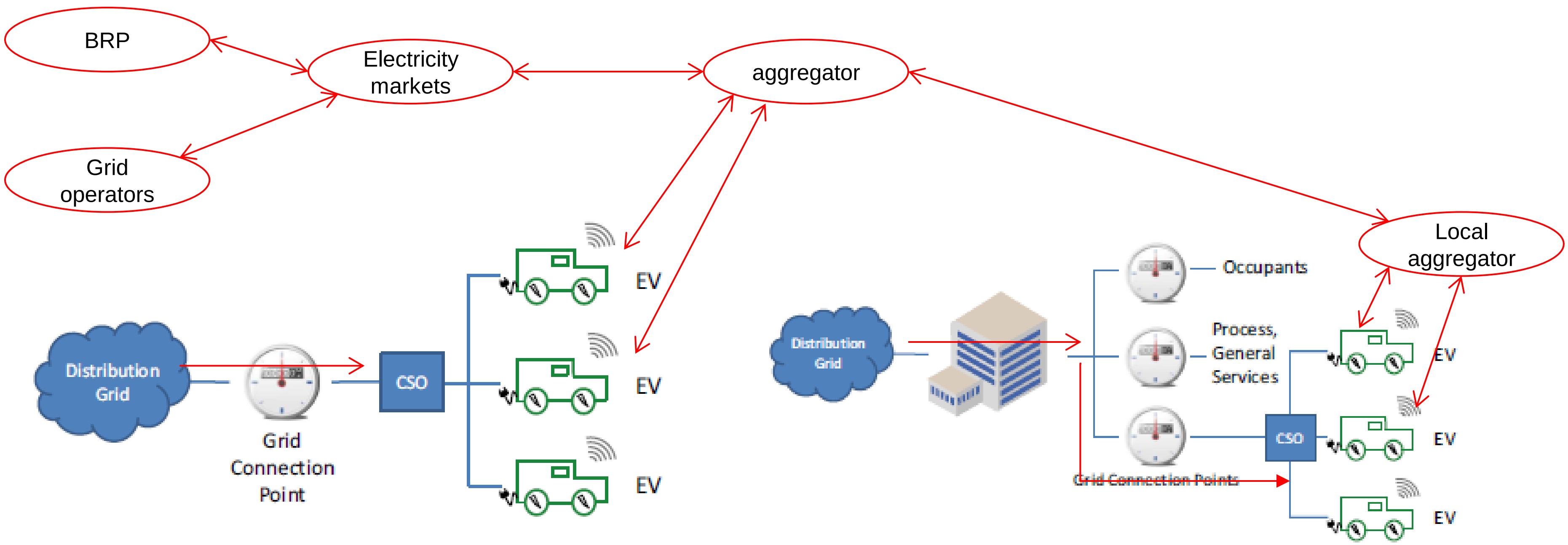
EV: a flexible resource

- Grid ←→ EV (*vehicle-to-grid)*
  - Batteries could deliver power/energy into the grid
  - Frequency regulation services → power capabilities of the batteries, fast response time
  - Services for distribution system operators
  - V2B, V2H (*vehicle to building, home*)
    - Peak saving
    - Self-consumption
  - Load smoothing with RES
    - Charging if much RES
    - Discharging if low RES

ICT for EV control

- Digitalization will help to control EV :
  - Local energy manager (building, home)
  - Remote aggregator for grid services



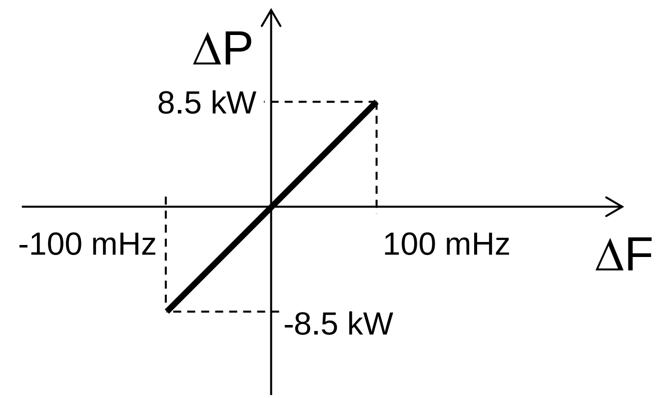


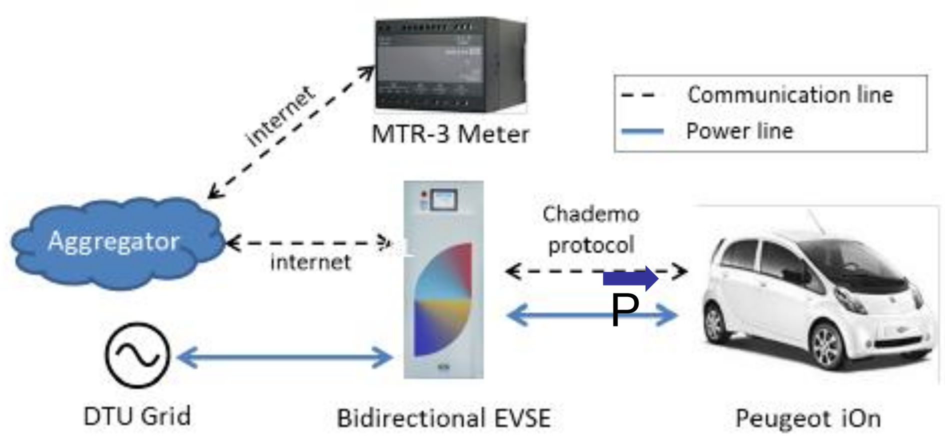
ICT for EV control

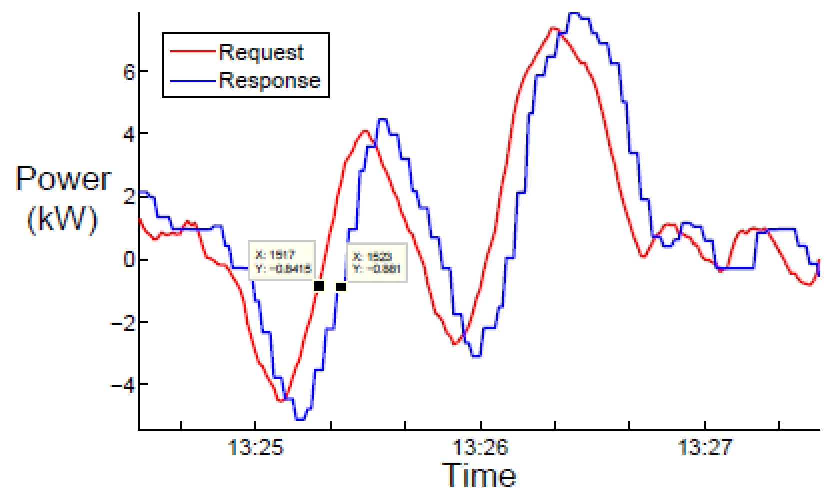
- Standards and protocols
  - IEC 15118, chademo, OCPP, …
- Technologies
  - PLC G3, Zigbee, internet
- Requirements
  - Reliability and response time for grid services
- Projects
  - Nikola(Dk) → grid services and market integration
  - BienVEnu (France) → smart charging in residential buildings

ICT for EV control

- Nikola(Dk) → grid services and market integration
  - Participation of PSA Groupe
  - Primary frequency reserve







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Conclusion

- Dumb charging → possible large constraints
- In case of large EV roll-out:
  - Grid constraints can be strong
  - Smart charging will be mandatory
- EV flexibility
  - Grid services (smart charging, ancillary services)
  - A real financial value for the users
- Reliable ICT are required to control EV

https://sites.google.com/a/essec.edu/chaire-armand-peugeot/