IMPACT DU COMPORTEMENT DES UTILISATEURS SUR LE POTENTIEL DE FLEXIBILITÉ DE FLOTTES DE VÉHICULES ÉLECTRIQUES

Journée Mobilité Electrique, SEE
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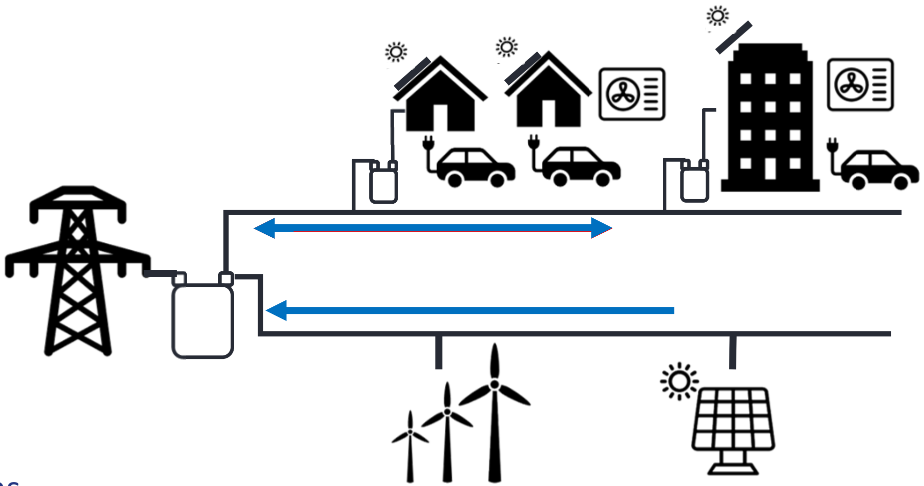
RESEARCH & DEVELOPMENT

AGENDA

- EV flexibility for distribution grids
- EV user plug-in behavior
- Impact on distribution systems & flexibility provision
- An EV case study

CHALLENGES FOR THE POWER SYSTEMS



Distribution systems are facing serious challenges:

- Electrification and new uses (mobility, heating, IT…)
- Integration of distributed generation

Significant investments to upgrade infrastructure

Using *flexibility* can help distribution grid operation and planning

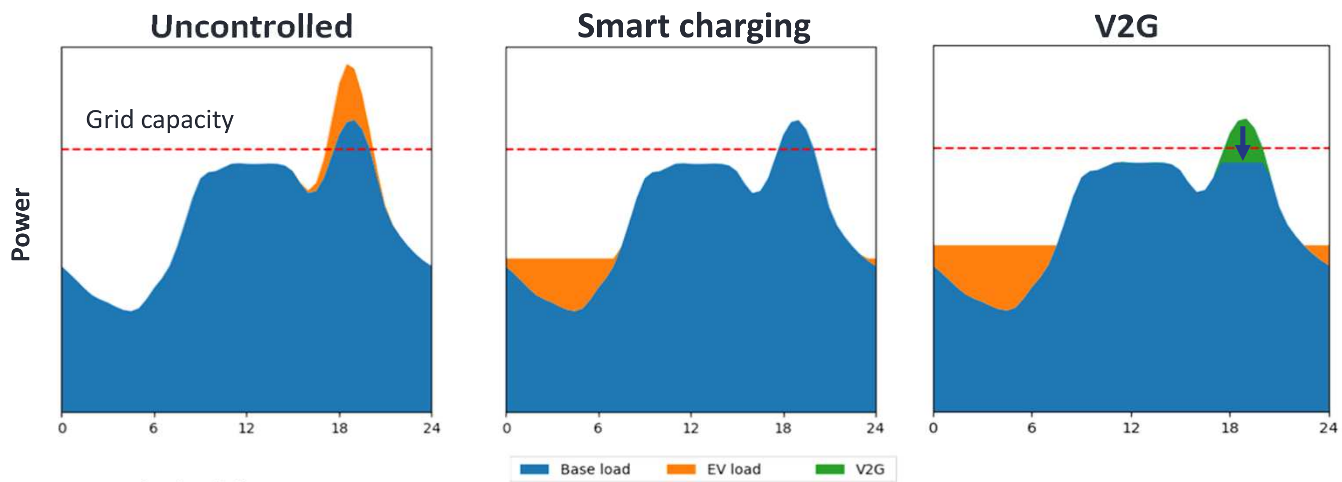
- Flexibility: The adaptation/control of consumption/production patterns

EVs can provide flexibility to the grid !

- Creating value for the electricity system and end-users
- Lowering total cost of ownership for end-users

WHAT IS FLEXIBILITY FROM EVS?

Ability to adapt the (dis)charging pattern of the EV



Many uses, for different stakeholders:

- For end-users: optimizing electricity bill, self-consumption
- For the whole system: frequency response, energy arbitrage
- **For distribution systems: congestion management, voltage regulation, fault-restoration, investment deferral**

How does EV user plug-in behavior affect EV integration?

RESEARCH QUESTIONS

What is the value of EV flexibility for distribution grids ?

1. How does user plug-in and driving behavior affect EV grid integration?
   1. On the impacts of EV charging into the grid
   2. On the flexibility these fleets can provide to the system

2. *Under which mechanisms can EVs provide flexibility to distribution system operators?*

IMPACT OF USER BEHAVIOR IN EV GRID INTEGRATION

Plug-in behavior

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ASSESSING EV-GRID INTEGRATION

Need to properly model driving and **charging behavior**

A common assumption in EV-grid integration studies: **EV users plugging-in every day**:

- High impacts of EV charging due to synchronization during low-price hours
- Used to estimate remuneration from flexibility provision

systematic plug-in behavior

But studies show that **EV users do not plug in every day**, even when having home charger access!

Non-systematic plug-in behavior

Biased estimations of grid impacts and flexibility availability

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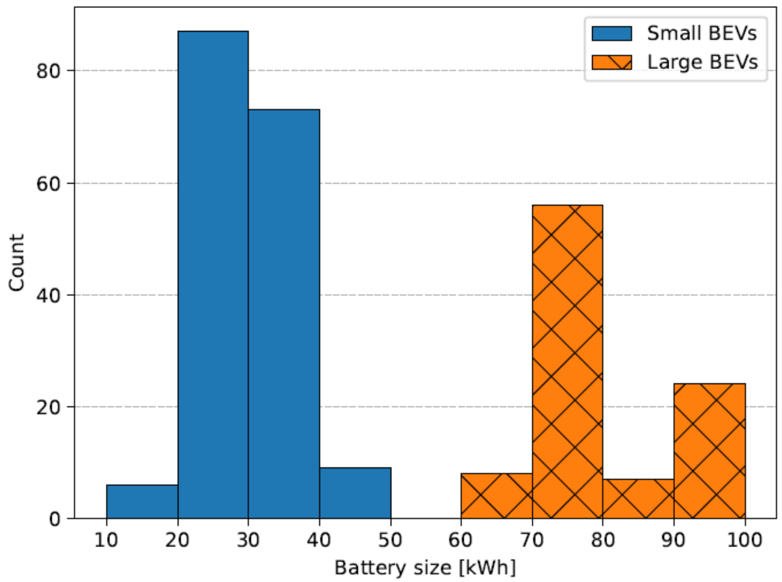
THE ELECTRIC NATION TRIAL

A large-scale smart charging trial in the UK that run between 2017-2019

A wide range of BEVs, PHEVs & REX brands and models

ELECTRIC NATION

Battery sizes of BEV users

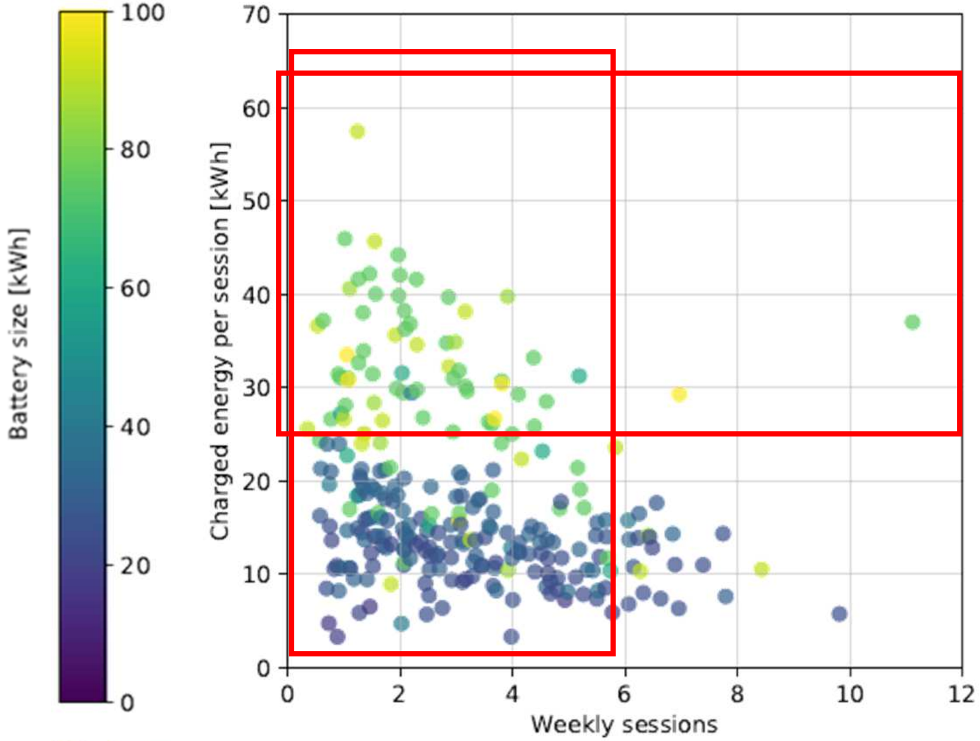


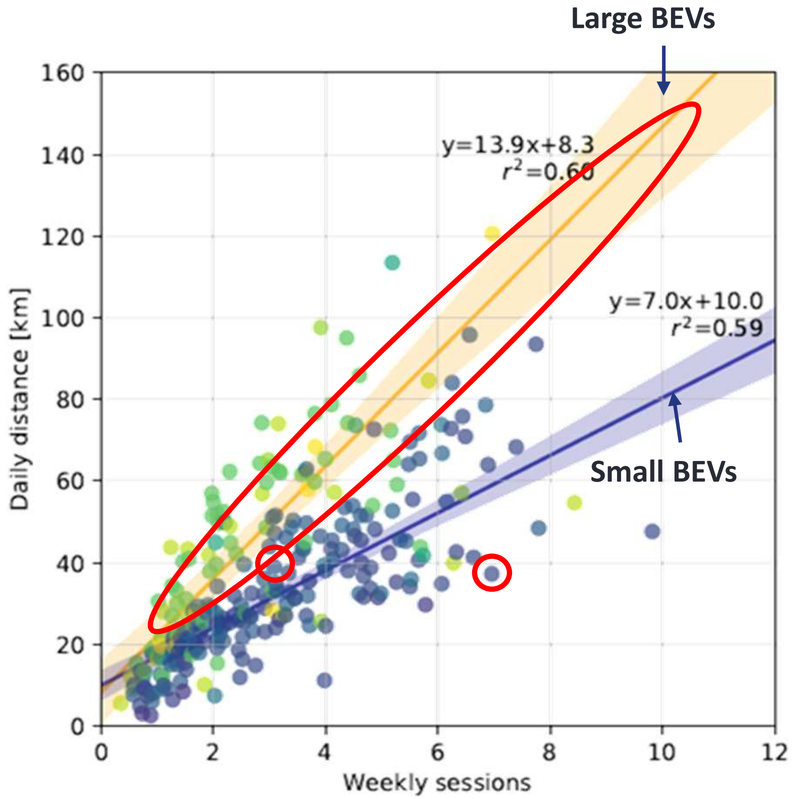
*265 unique users

PLUG IN BEHAVIOR TRENDS

Large EVs tend to charge less often, with higher energy per session, and driving longer distances

Large heterogeneity among users

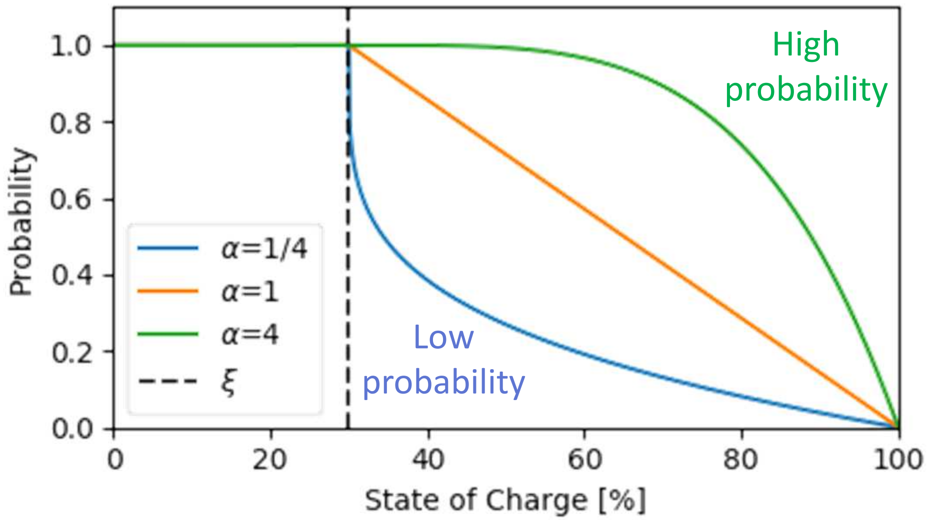




PLUG IN BEHAVIOR MODEL

Agent-based model of EV charging simulation

- Each EV simulated individually
- Stochastic parameters on:
  - Travelled distance
  - Arrival time
  - Departure time
- Plug-in decision module
  - Calibrated with data from Electric Nation
  - Capturing heterogeneity of users



Monte Carlo simulations to study the impacts of **non-systematic plug-in behavior**: **Systematic vs. non-systematic**

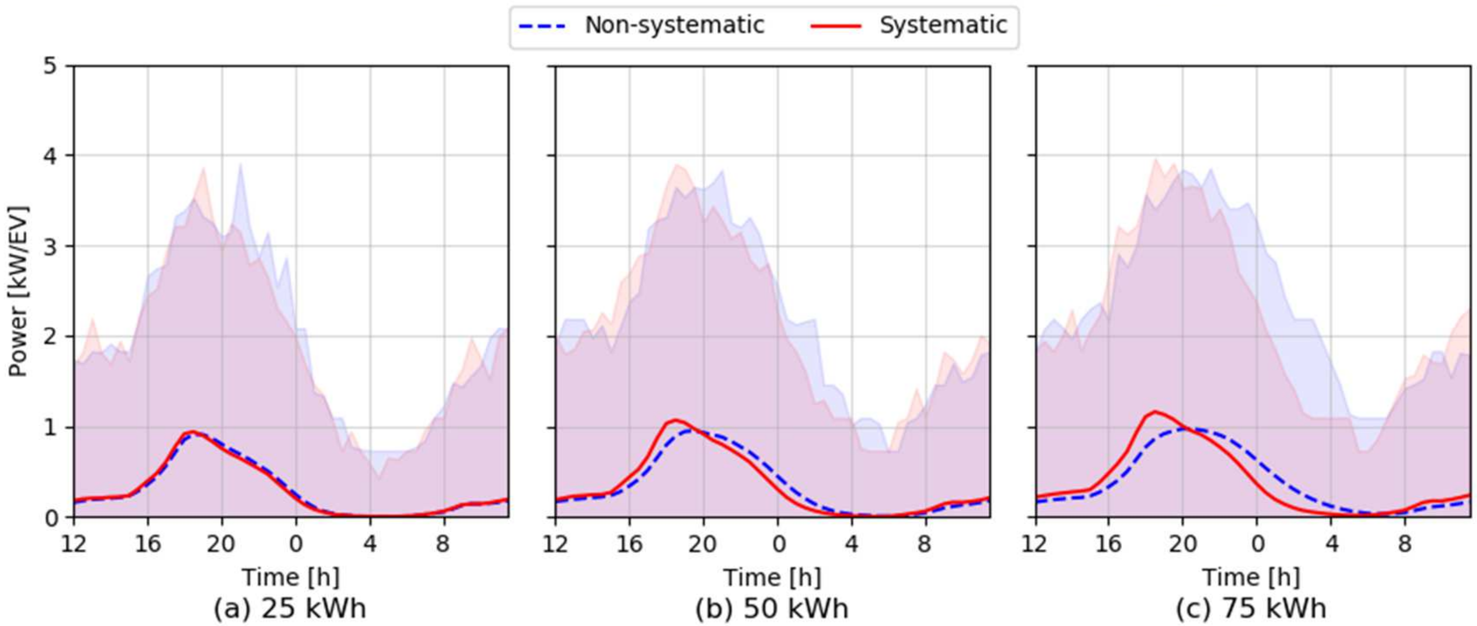
- On EV charging at different aggregation levels
- On flexibility of charging sessions

IMPACTS FOR DISTRIBUTION SYSTEM OPERATORS: UNCONTROLLED CHARGING

High variability of EV charging of small-size EV fleets (LV feeder level)

Larger battery sizes shift charging to later hours

Load curves for 20 EVs, 7 kVA. Uncontrolled charging

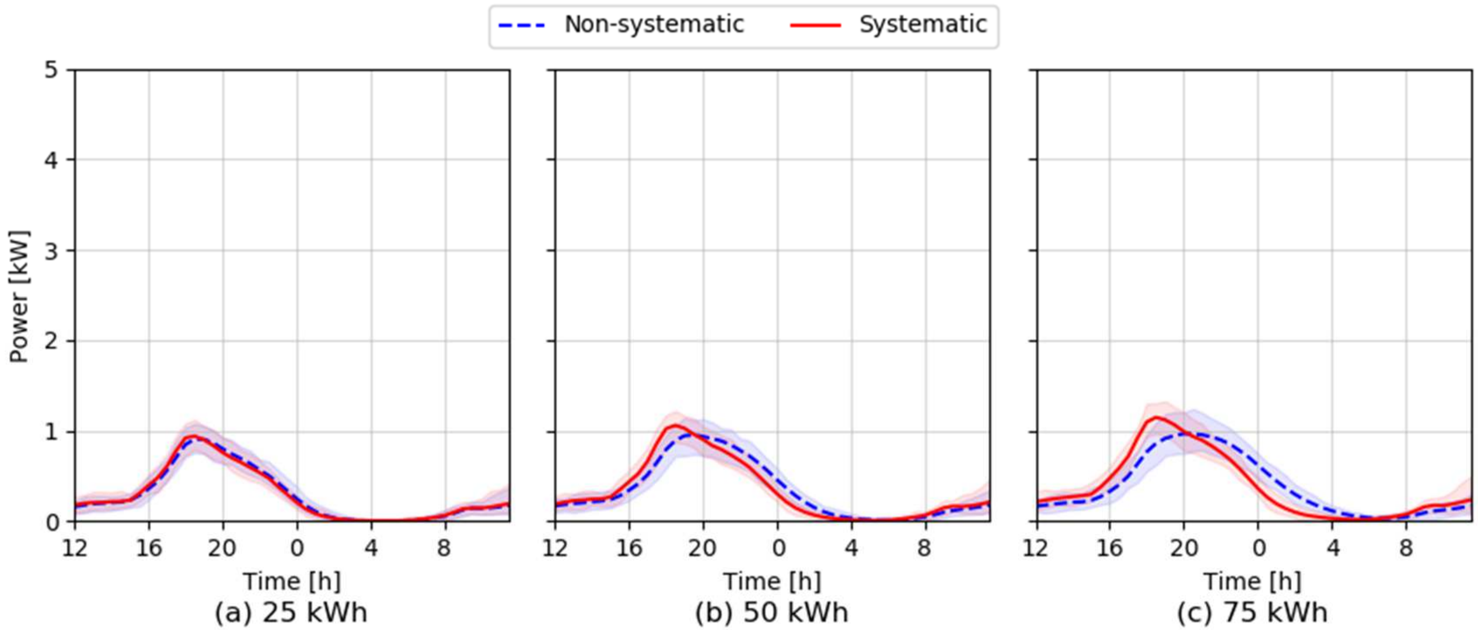


IMPACTS FOR DISTRIBUTION SYSTEM OPERATORS: UNCONTROLLED CHARGING

Low variability of EV charging of large-size EV fleets (HV/MV substation, MV feeder level)

Larger battery sizes shift charging to later hours

Load curves for 1000 EVs, 7 kVA. Uncontrolled charging



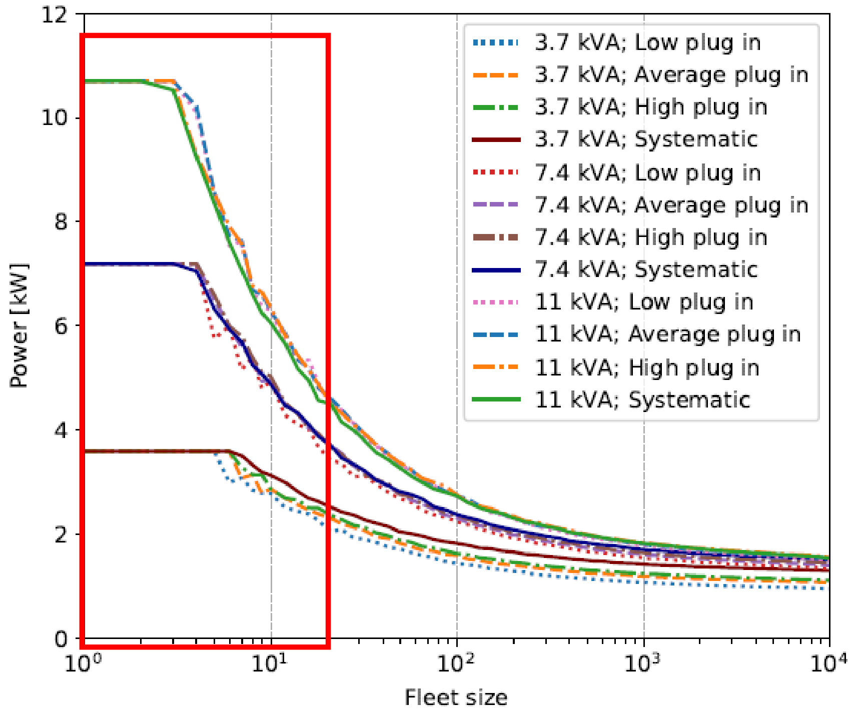
UNCONTROLLED CHARGING

Higher impacts on LV (feeder) level & increased risk with high power chargers

No significant impact of non-systematic plug-in behavior on peak load!

50 kWh battery

Peak load for different EV fleet sizes



PRICE-RESPONSIVE CHARGING

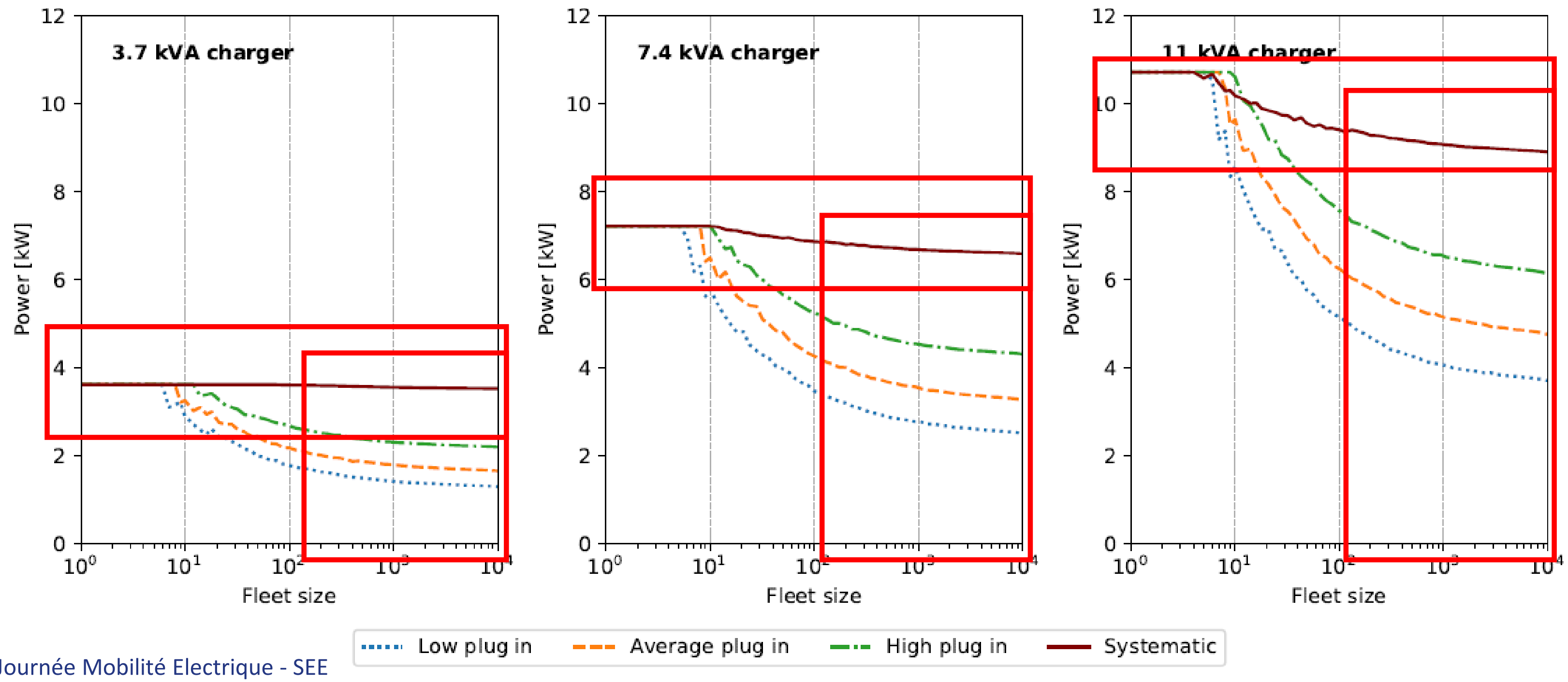
Synchronization of EV charging at low-price hours => **High impacts at MV level**

- Need for ***smarter*** price signals

Non-systematic charging reduced risks for grid operator

Peak load for different EV fleet sizes

50 kWh battery



IMPACTS FOR FLEXIBILITY AGGREGATORS

EV flexibility depending on three factors:

- *Idle time*
- *Power (kW)*
- **Accessible storage capacity (kWh)**

We compute these factors for an aggregated EV fleet

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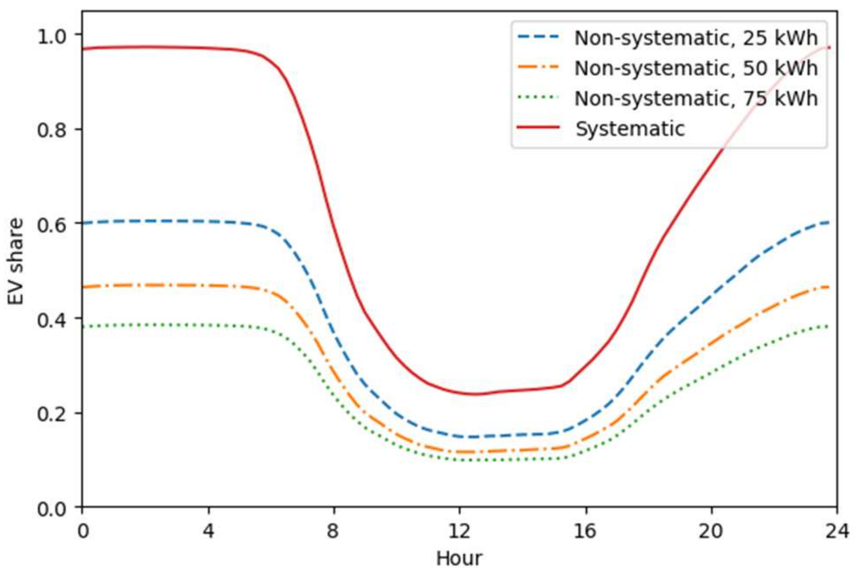
IMPACTS FOR FLEXIBILITY AGGREGATORS

Non-systematic plug-in means less EVs connected for flexibility

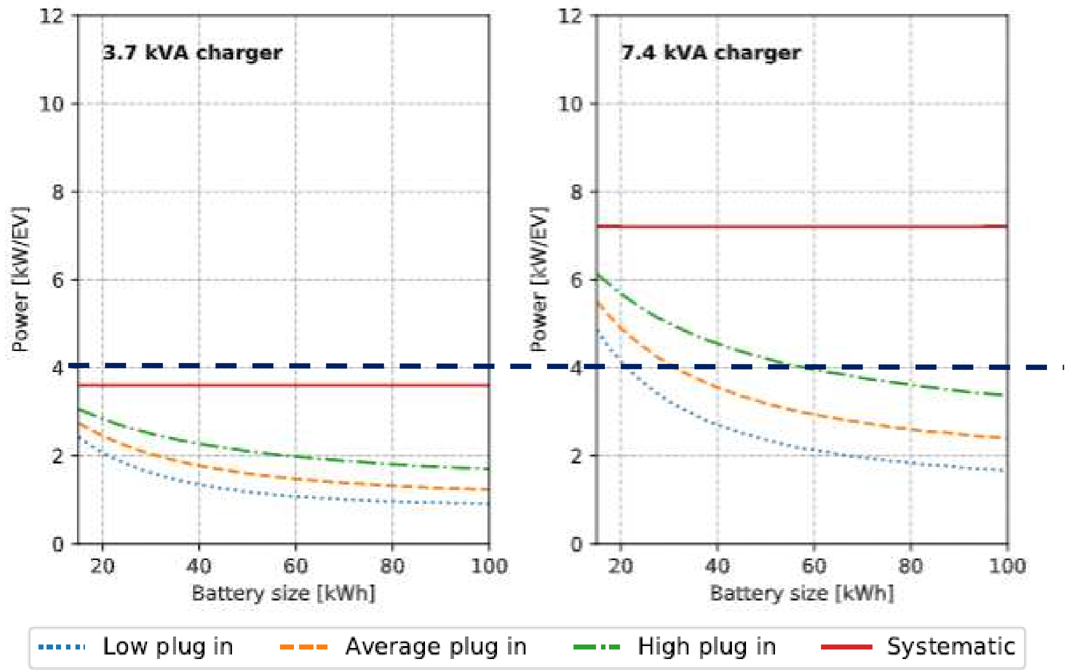
- Large EVs will connect less often

Reduced "kW to control"

Average connected EVs



Average connected power between 10pm-6am [kW/EV]

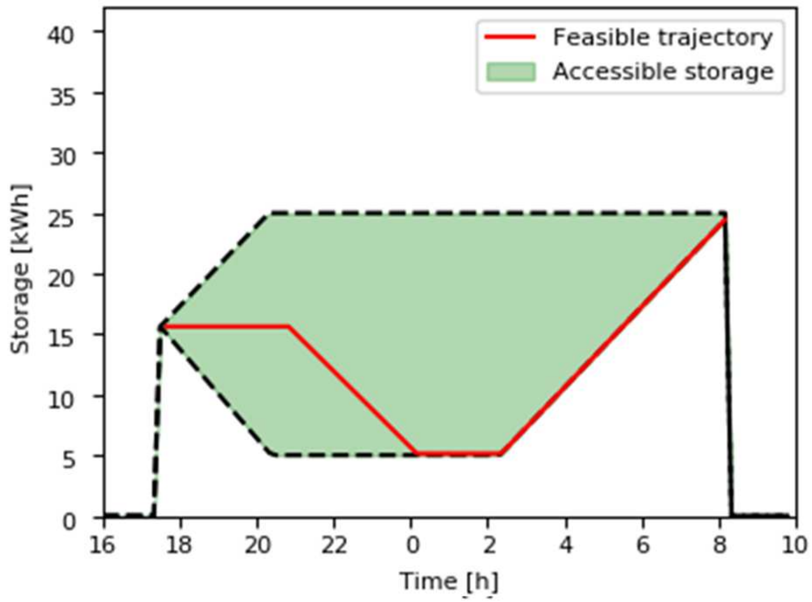


ACCESSIBLE STORAGE

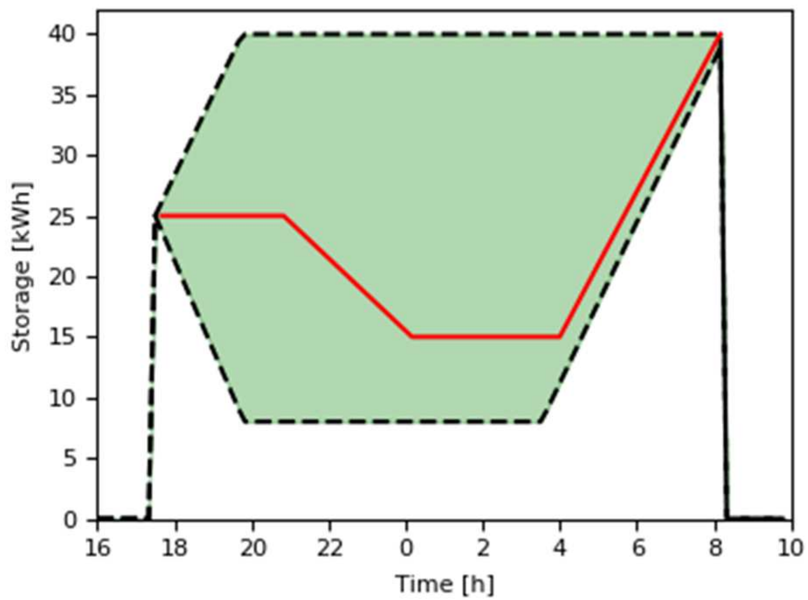
Accessible storage defined as the feasible charging trajectories of stored energy for a fleet of EVs

- Dependent on battery size, charger power and connected time

(A) 25 kWh, 3.6 kVA



(B) 40 kWh, 7.4 kVA



AS(A) << AS(B)

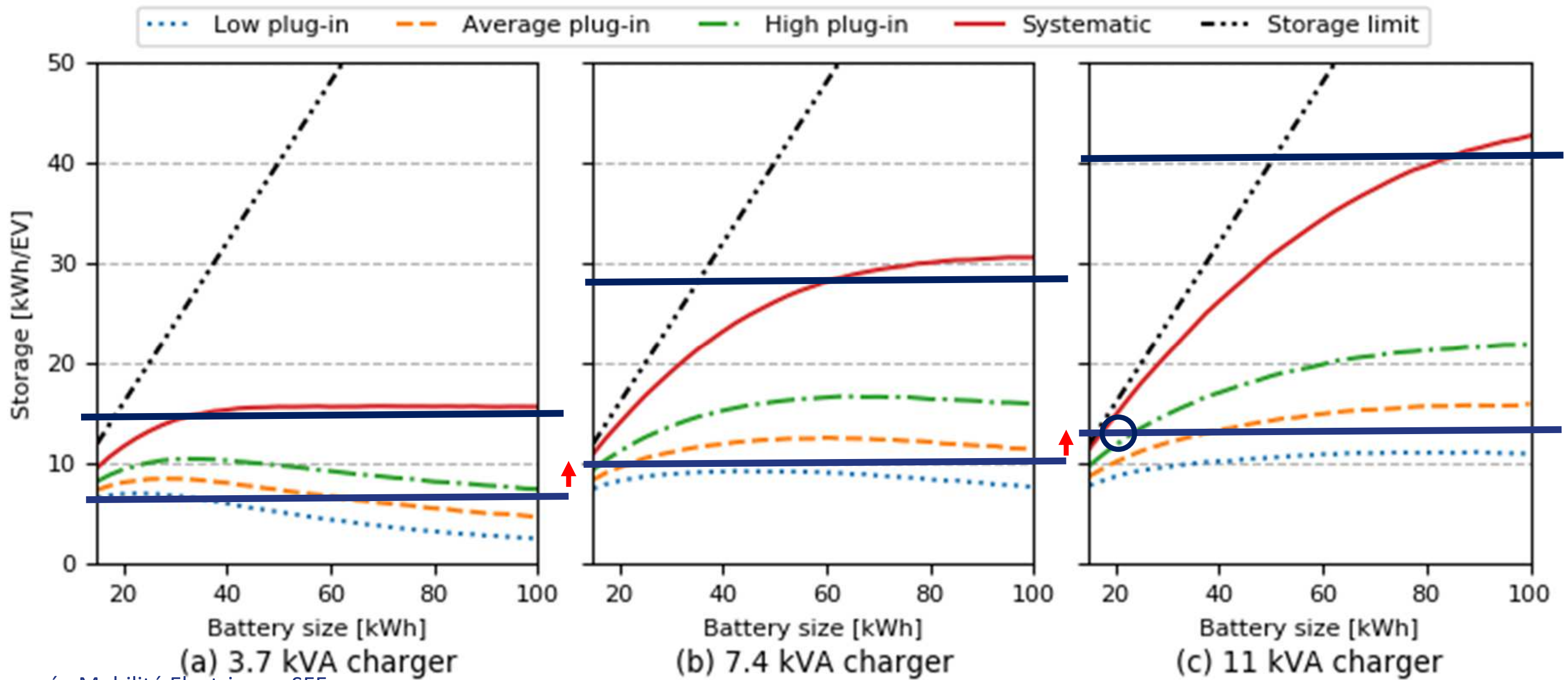
ACCESSIBLE STORAGE FOR AN EV FLEET

A maximum value for accessible storage depending on charger power, even for SPIB

With NSPIB, larger battery sizes reduce accessible storage

- And impact of increasing charger power is limited

Small EVs with high plug in can provide more storage than large 'average' ones



FLEXIBILITY PROVISION FROM EV FLEETS

EV fleets to provide flexibility (peak shaving) during an evening window (5-8pm)

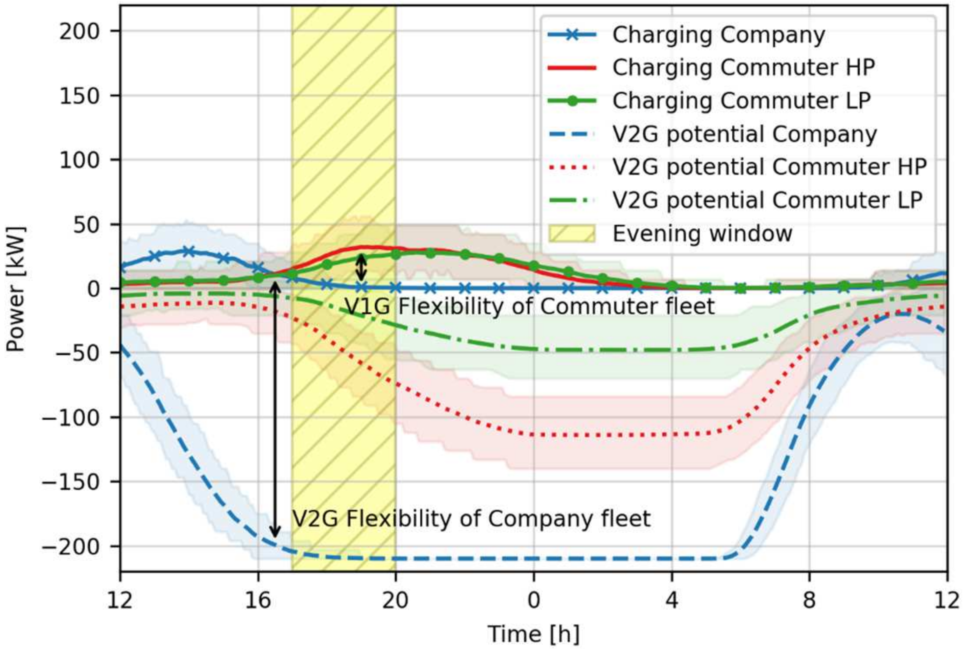
- **Company fleet** (Parker project, Denmark)
- **Commuter fleet** (average plug-in and higher plug-in frequency)
- 7kVA, 50 kWh batteries

Flexibility availability dependent on time of day and fleet reliabilit

V1G flexibility is limited, but V2G can greatly increase flexibility.

Usage patterns for company fleet make it a great flexibility resource

Charging and flexibility profiles, 30-EV fleet



(SOME) CONCLUSIONS

Regular EV users do not plug-in their vehicles everyday, even if they have easy access to a charger

Insights for distribution operators:

- Plug-in behavior and battery size have low impact on **uncontrolled** charging coincidence factors
- **Price-responsive** EV charging can create higher peaks if price signals are not adapted (synchronization of charging)
- Non-systematic charging can reduce the risks of EV charging synchronization (price-responsive charging)

Insights for flexibility aggregators:

- Systematic charging greatly overestimates regular EV users' flexibility potential
- Increasing plug-in ratios is more effective than increasing battery sizes/charger power
- Need to provide the **incentives to plug-in**
- Reliable fleets (ex. company fleets) can be great assets

THANKS!
QUESTIONS??