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EV flexibility for the Electric System: The FCR case

Outline

1. Context & Objective
2. Mathematical formulation
3. Some results & perspectives



Context & Objectives



1. Context & Objectives

French Transportation Facts:

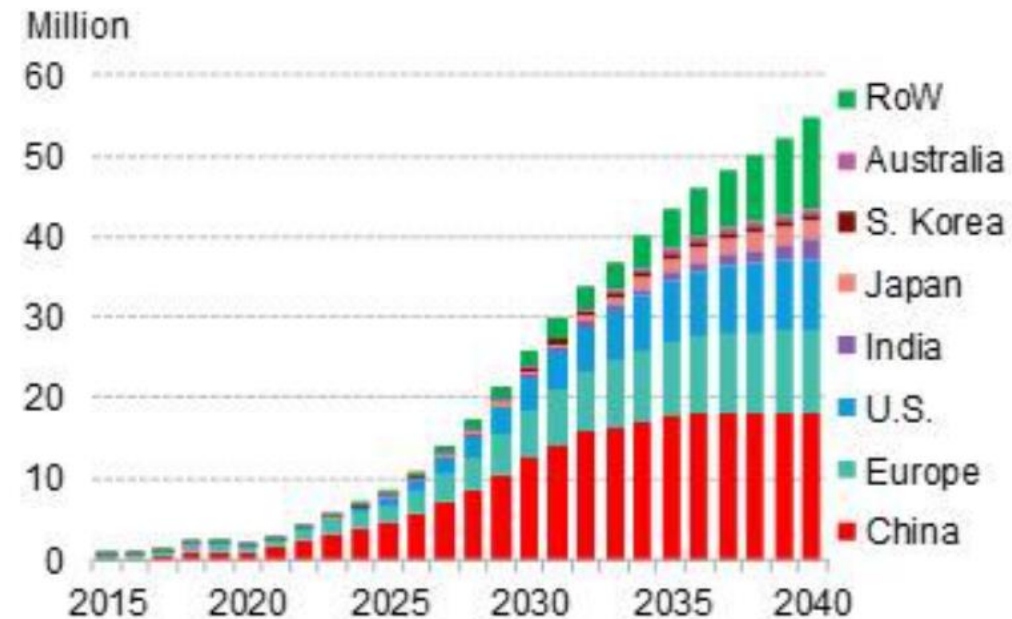
- Transportation represents 30% of the total final energy consumption
- Gas represents 98% of its energy source
- Road transportation represents 90% of it

Basic Transition to EV might :

- Stress the electricity production
- Stress the transportation network
- Stress the distribution network

Unless...

Figure 3: Annual passenger EV sales by region



Source: BNEF. Note: Europe includes EU, U.K. and EFTA.

1. Context & Objectives

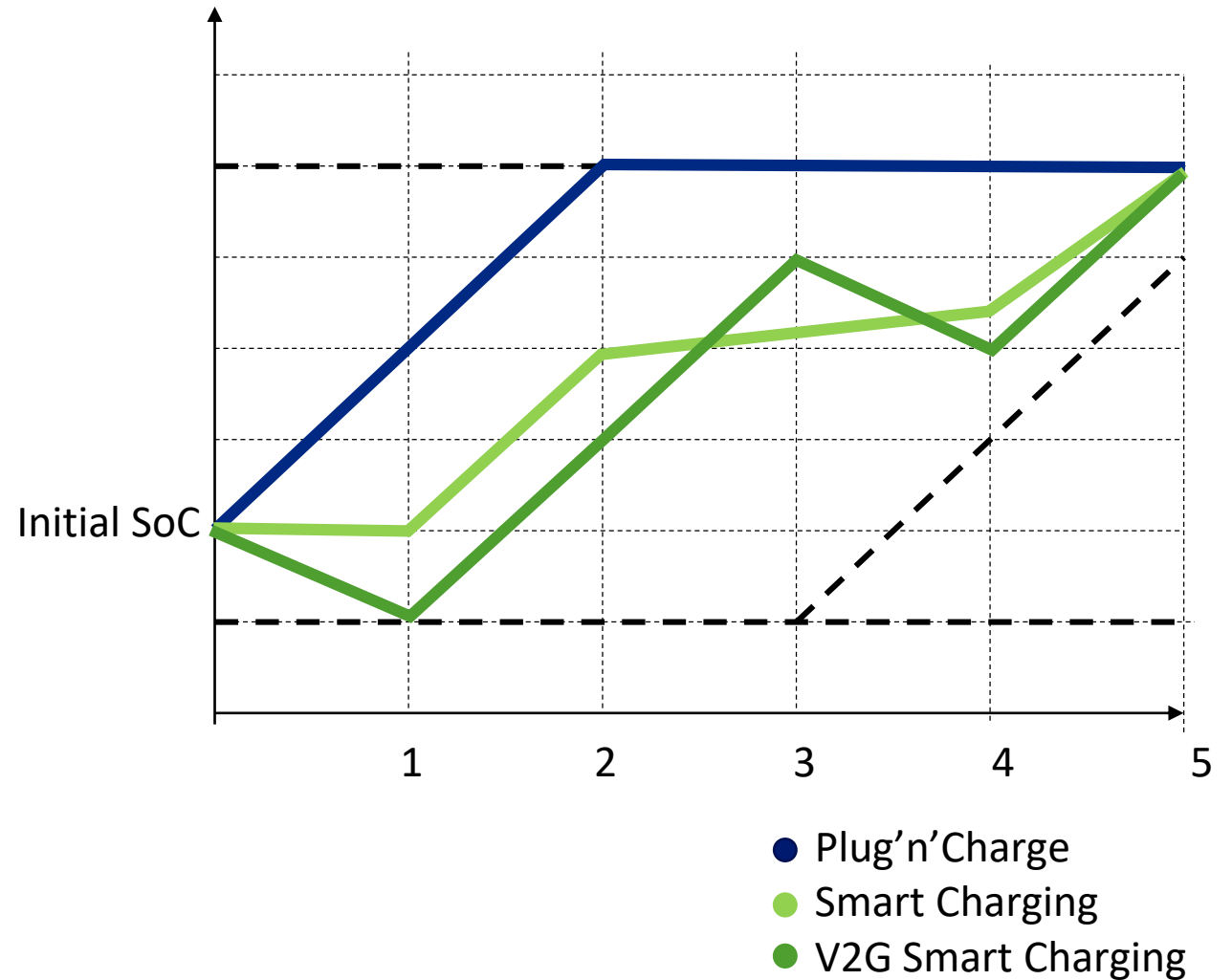
The charging schedule is integrated with the electric grid/production

Smart Charging is a first level integration of EV charging. It allows to reduce the stress by shifting the power usage in time and avoid consuming at the peak demand.

Vehicule to Grid (V2G) makes possible the EV to discharge the battery on the power grid. This allows to also reduce the global peak demand by reinjecting power to the grid.

V2G allows a seamless integration of the EV with the electric system.

In this work, we want to explore a tight integration of EV charging with the electric system



1. Frequency Containment Reserve

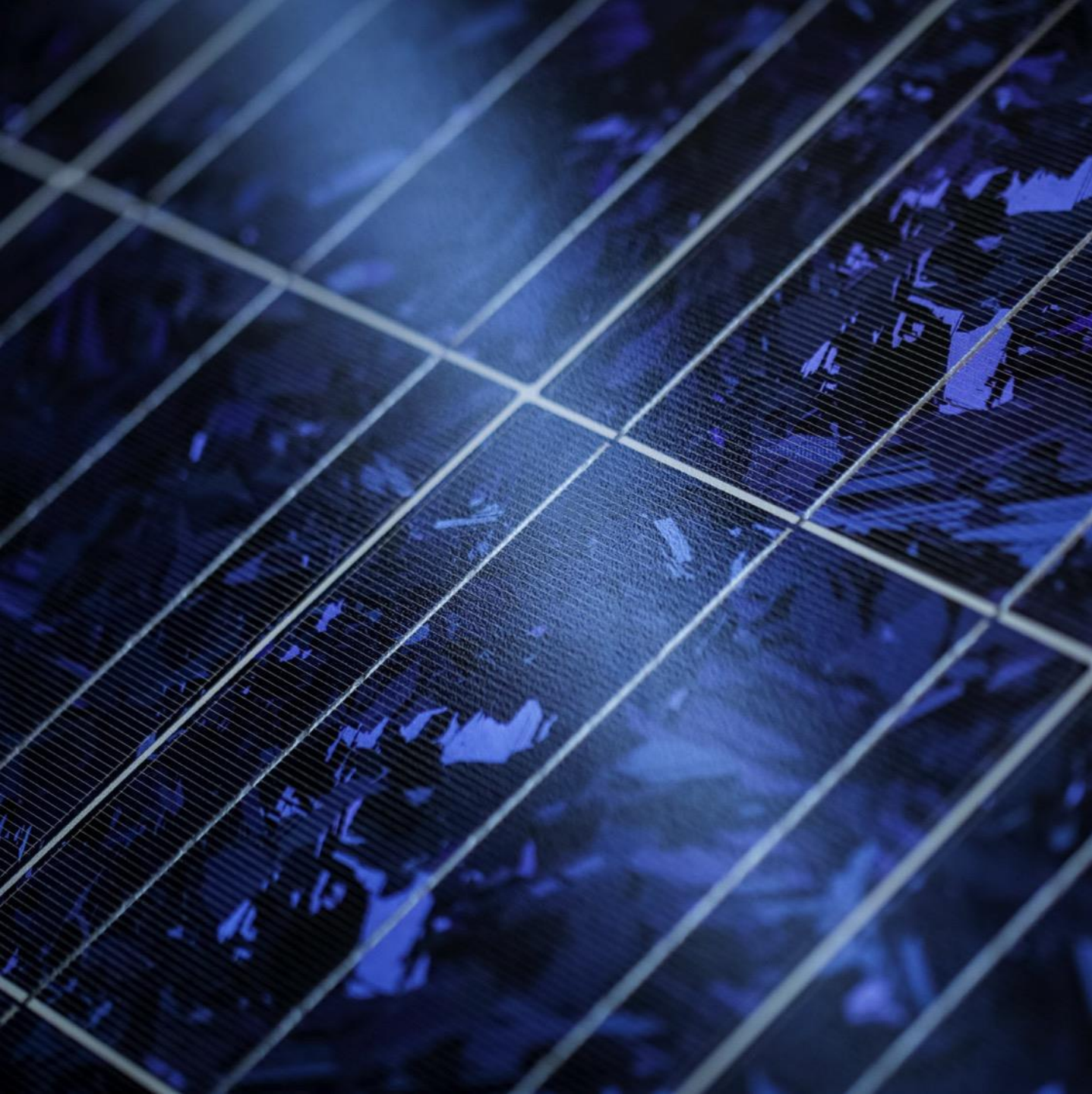
It is mandatory to keep the AC frequency really close to 50Hz (in Europe)

- Main electric production units (Thermal & Hydraulic) require that (for ☠️ reasons)
- The frequency reflects the balance between consumption and production
- Every day, we reserve some production capacities to dynamically adjust the production to maintain the frequency between acceptable values
- This is the Frequency Containment Reserve

In this work, we developed a method to optimize an EV fleet charging schedule while :

- Dynamically adjusting the charging power according the frequency
- Taking into account TSO requirements

This is the tightest integration with the electric system



Mathematical
model

2. Problem description

Hypothesis:

- Assuming the FCR capacity is already defined
- The time arrival and departure of each EV in the fleet is given
- The SoC at time of arrival is also given

The problem is to construct a charging schedule for each EV that minimizes the overall charging cost while

- fully charging the evs at the end of the charging session
- preserving enough power and energy capacity for the FCR

2. Some notations

δt = timestep duration

$p_{ev,t}$ = charging power (> 0 means charging, < 0 means discharging)

$batt_{ev,t}$ = state of charge of the battery

$capacity_{ev}$ = battery max capacity

c_t = electricity cost

ρ = battery efficiency

$FCR_{ev,t}$ = power reserved for FCR service

δt_{FCR} = requested duration at full FCR activation

$demand_t$ = FCR demand

$t_{0,ev}, t_{F,ev}$ = beginning and ending of the charging session

2. Basic V2G Smart Charging

$$\min \sum_{ev,t} c_t p_{ev,t}$$

s.t.

$$flow : \quad batt_{ev,t} = batt_{ev,t-1} + (\rho p_{ev,t}^+ - p_{ev,t}^-) \delta t$$

$$capacity : \quad batt_{ev,t} \in [0, capacity_{ev}]$$

$$pmax : \quad p_{ev,t} \in [-pmax, pmax]$$

$$SoC_0 : \quad batt_{ev,t_{0,ev}} = SoC_{ev}$$

$$SoC_F : \quad batt_{ev,t_{F,ev}} = capacity_{ev}$$

$$transaction : \quad p_{ev,t} = 0 \forall t \notin [t_{0,ev}, t_{F,ev}]$$

2. FCR requirements

$$\min \sum_{ev,t} c_t p_{ev,t}$$

s.t.

$$FCR : FCR_{ev,t} \geq 0$$

$$powercapacity : p_{ev,t} + FCR_{ev,t} \leq pmax$$

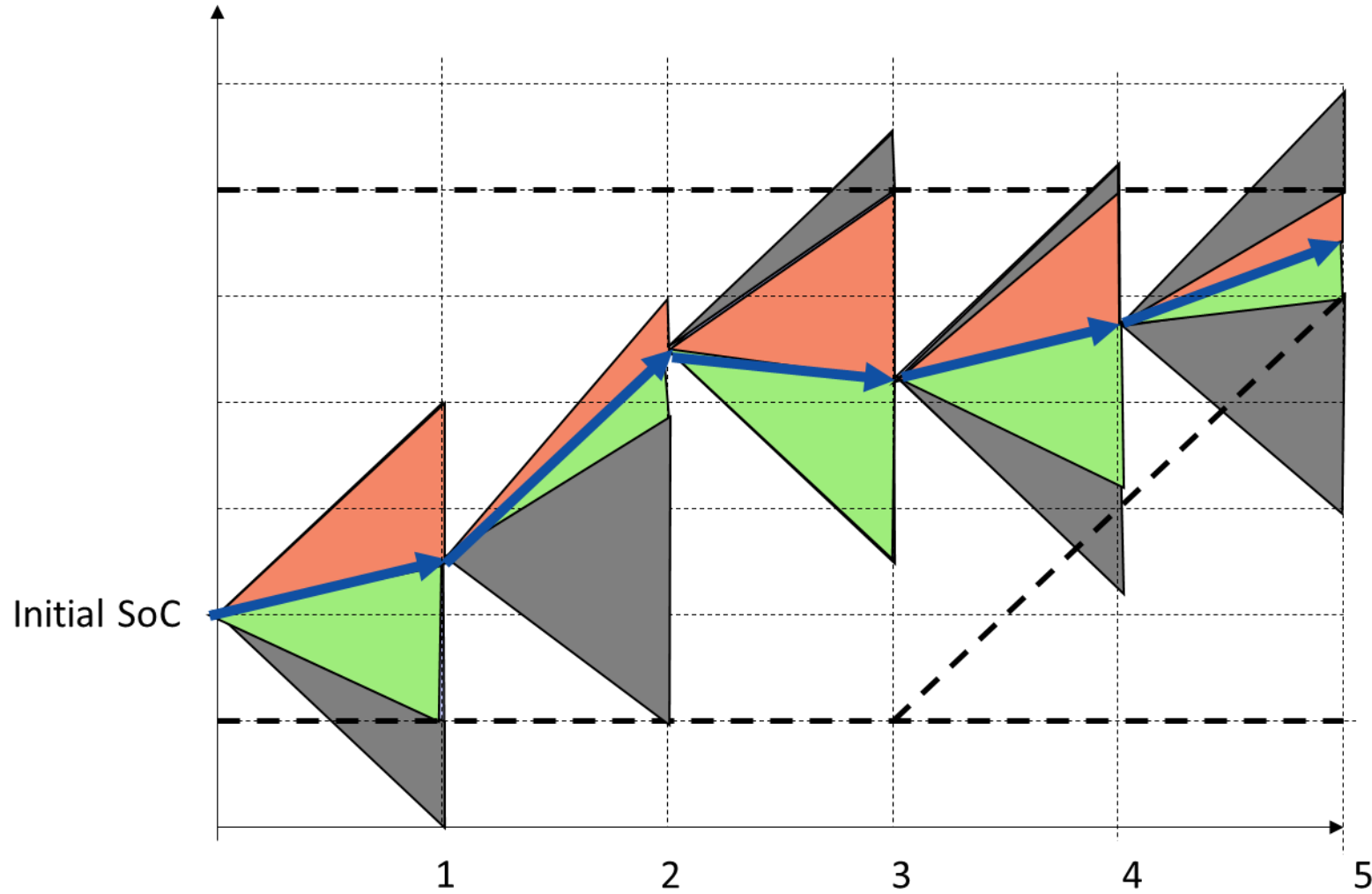
$$p_{ev,t} - FCR_{ev,t} \geq -pmax$$

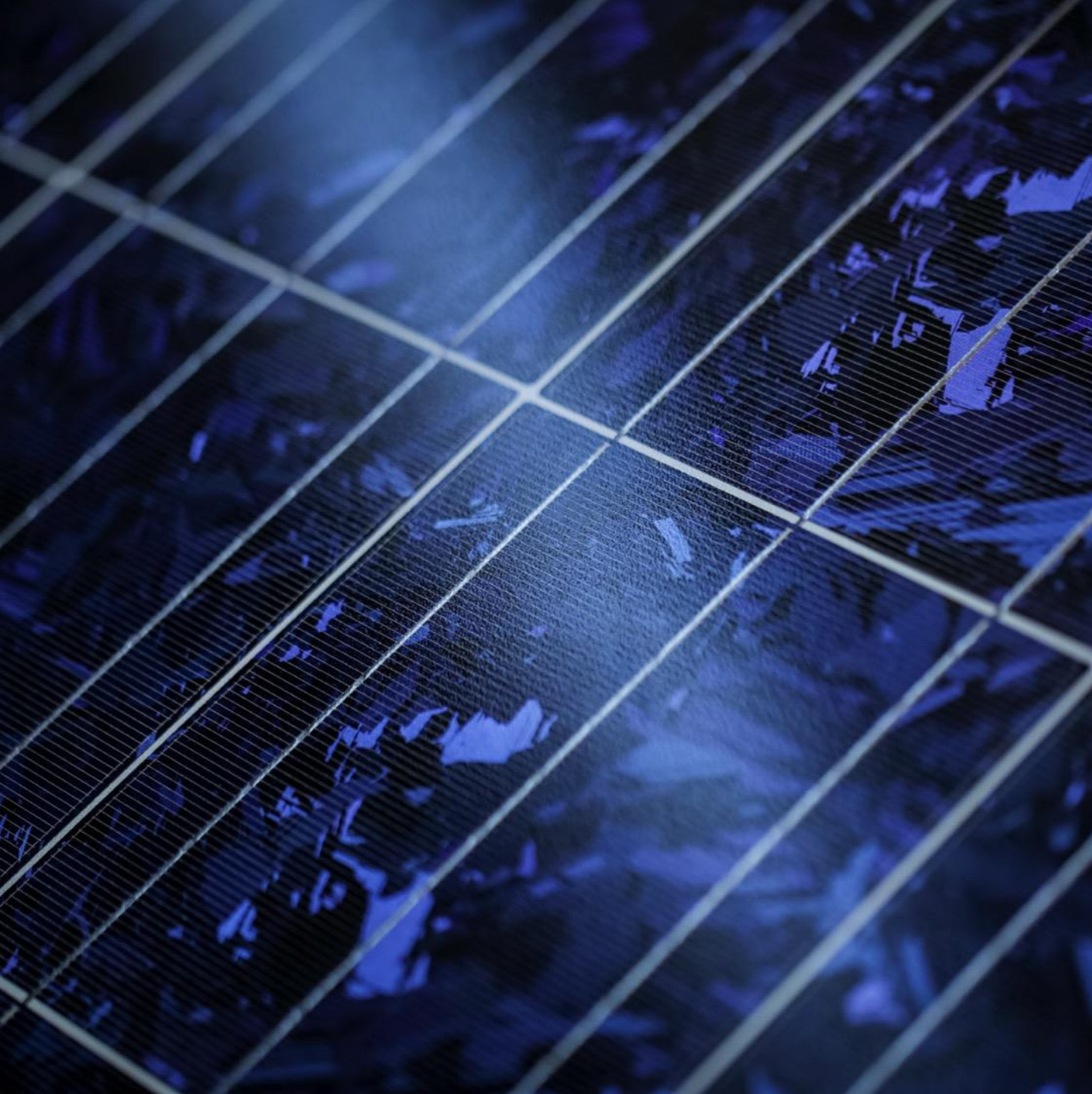
$$batterycapacity : batt_{ev,t} + \rho(p_{ev,t} + FCR_{ev,t})\delta t_{FCR} \leq capacity_{ev}$$

$$batt_{ev,t} - (p_{ev,t} - FCR_{ev,t})\delta t_{FCR} \geq capacity_{ev}$$

$$demandsatisfaction : \sum_{ev} FCR_{ev,t} = demand_t$$

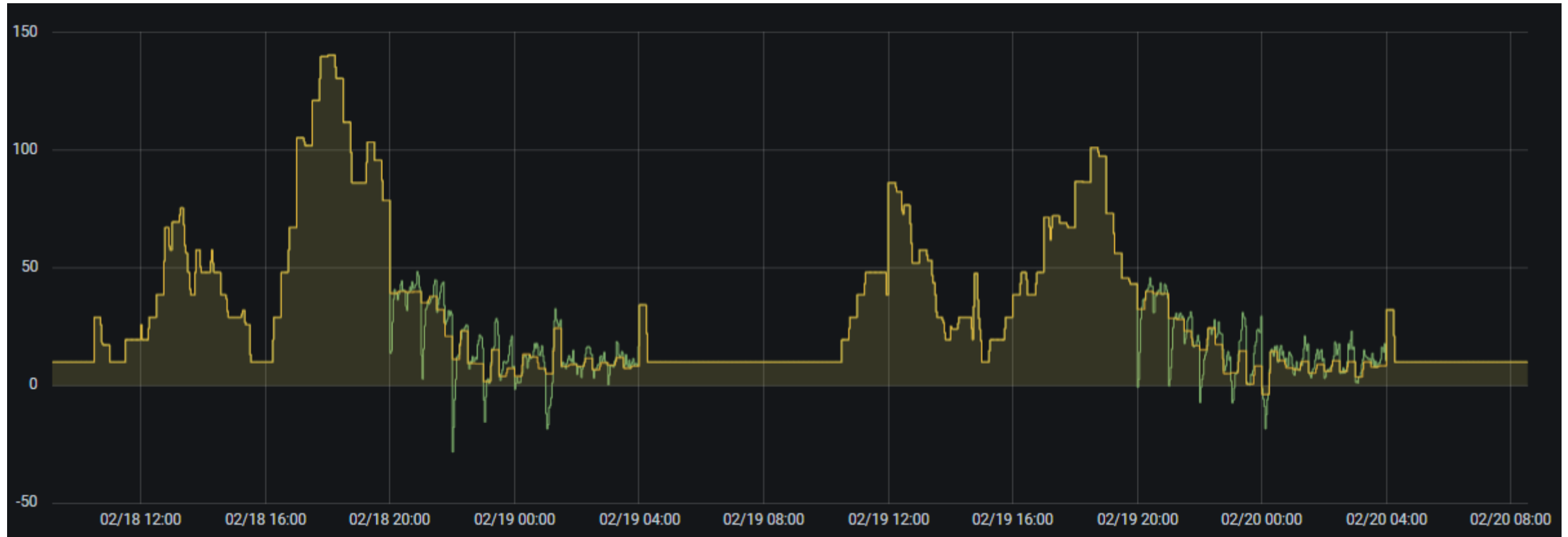
2. Basic Idea





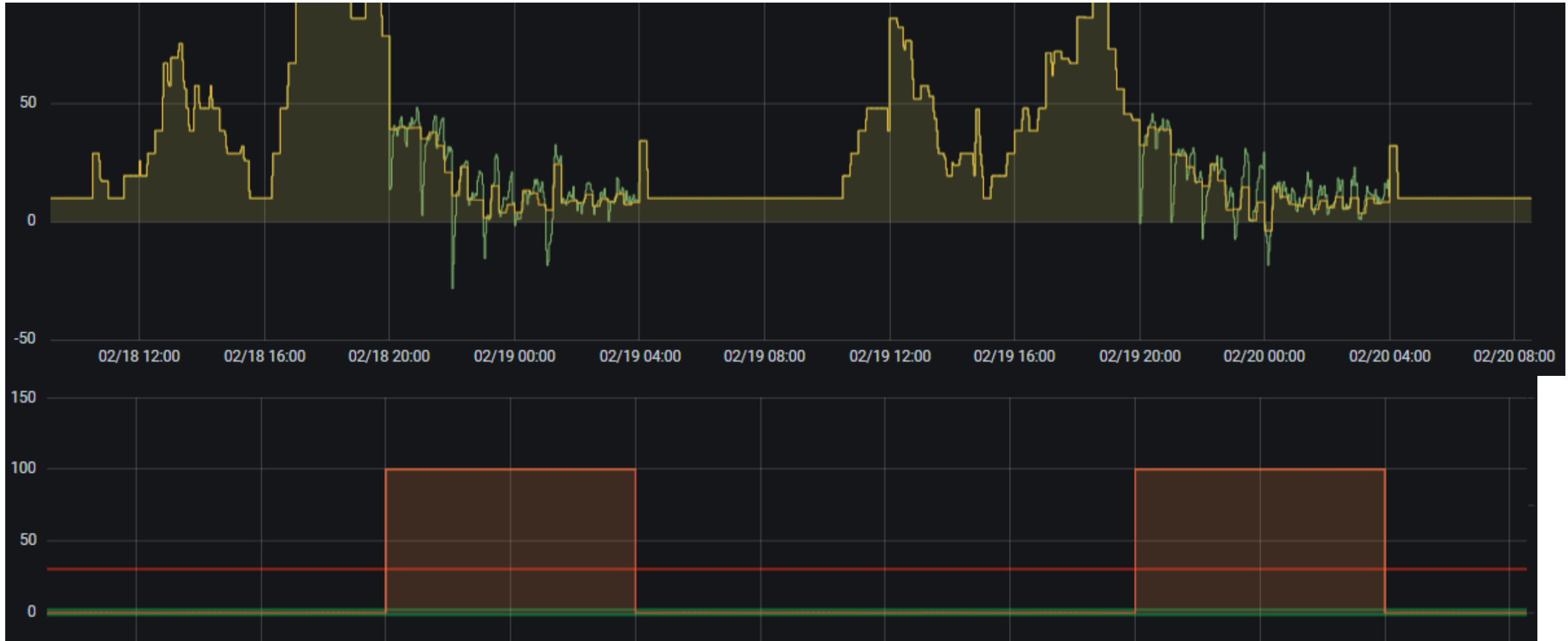
Some results & perspectives

3. Simulations :



- Overall fleet power
- Fleet power with FCR activation

3. Simulations



● FCR demand
● FCR capacity

● Overall fleet power
● Fleet power with FCR activation



3. Conclusions

We were able to integrate smart charging and FCR service
While guarantying the quality of service for the user AND the TSO

Next: ...

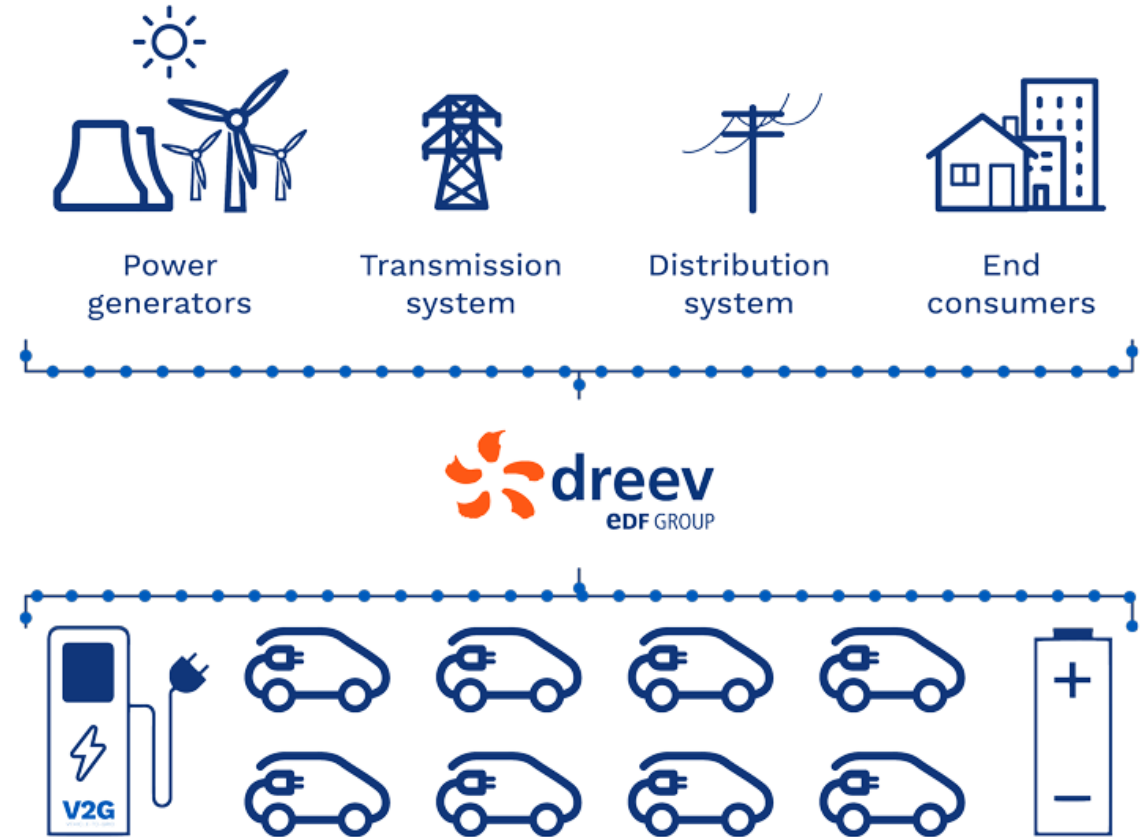
New services for the electric system to fully integrate V2G and electric system
In order to reach the same level of services as a regular power plant

This (and much more)
already exists...



4. Dreev : Smart Charging for Flexibility Markets

- EV flexibility aggregator for services to the electric system
- V2G and V1G
- Development in France, UK, Italy, Belgium, Germany



4. Dreev : Smart Charging for Flexibility Markets



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