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## EV Solar charging at CEA: experimental results

Bruno Robisson, Sylvain Guillemin, Alexandre Mignonac

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cea tech

## EV (SOLAR) CHARGING @CEA: EXPERIMENTAL RESULTS

BRUNO ROBISSON, SYLVAIN GUILLEMIN, ALEXANDRE MIGNONAC



International Energy Agency  
Photovoltaic Power Systems Programme

**PV2E\_MOBILITY**  
**French Contribution to IEA PVPS T17 - PV**  
**& Transport**



**ines**  
INSTITUT NATIONAL  
DE L'ENERGIE SOLAIRE



# AGENDA

- **CEA EVCI & PV**
  - CEA EVCI
  - EV charging & PV @Cadarache
  - Objectives
- **Smart charging**
  - Control architecture
  - User journey
  - Definitions
  - Control algorithm
- **Experimental results**

Associated R&D projects:  
**EvoIVE** Project with RTE  
 G. Signal



**Neemo** Project with MCAST  
<http://neemo-project.eu/>  
 B. Azzopardi & R. Mikalauskiene

**INES.2S**  
<https://www.ines-solaire.org/ines-2s/>

**PV2e\_Mobility**  
 M. Sechilariu





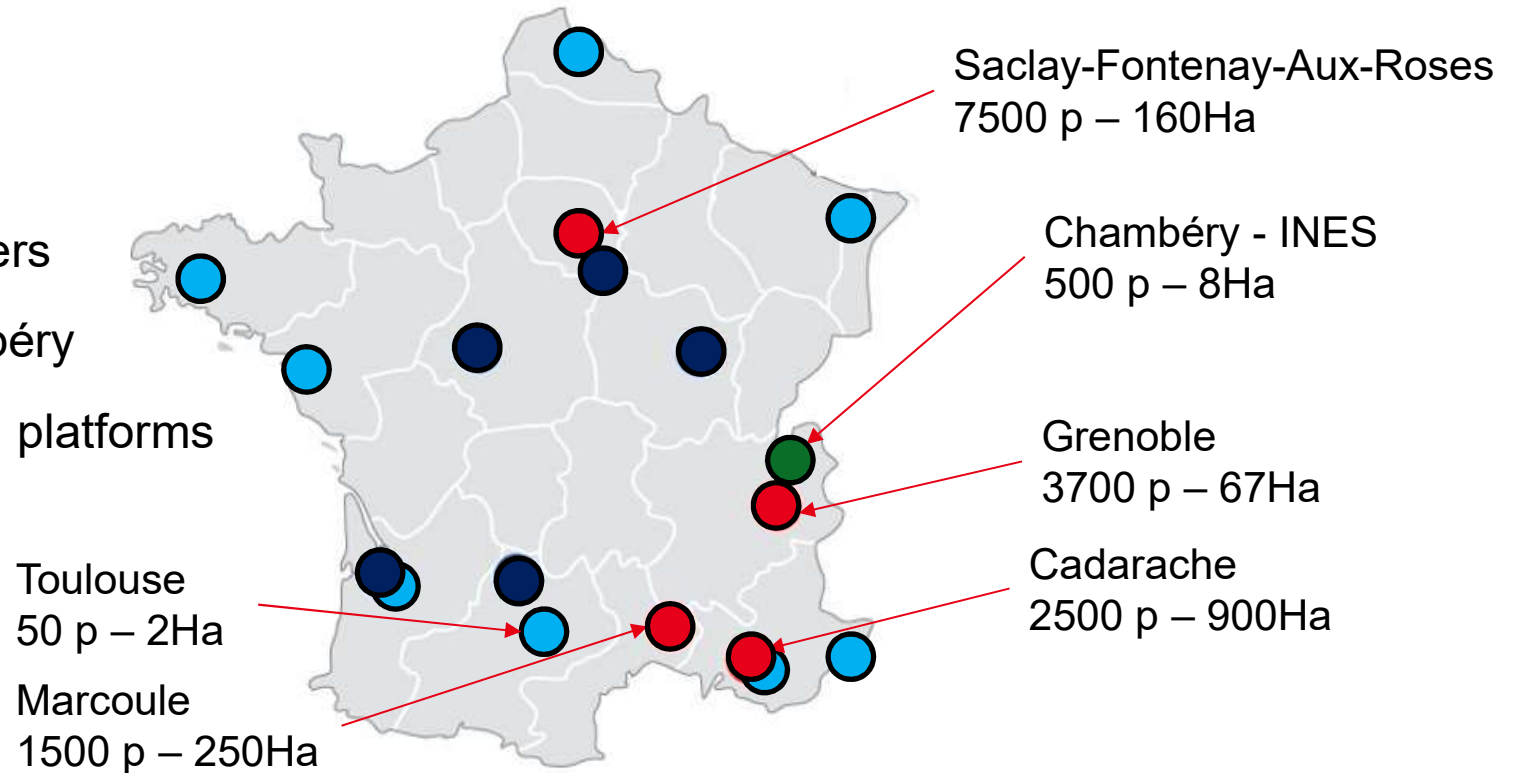
## CEA CENTERS

● Civil centers

● Military centers

● INES Chambéry

● Technological platforms



- **9** research centers (5 civil / 4 military)
- **8** technological platforms
- **20 181** employees (included 1 233 PhD students and 176 postdoctoral researchers)
- Budget of **5 billion** euros



# CEA CADARACHE – NEAR AIX-EN-PROVENCE

5500 workers

1600 Ha **900ha** fenced (22 km of fence)

480 buildings and **500 000** m2 of floor

70 Km of paved roads, 6 km of landscaped footpath, around 5500 people / day on site

29 Bus lines carrying a thousand employees

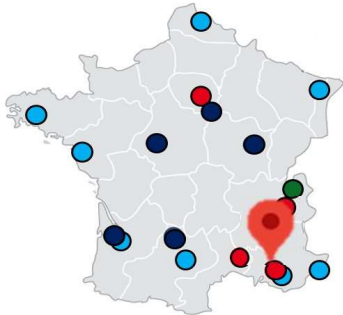
75 km of water distribution network (drinking water station, industrial water, purification station)

Private power network

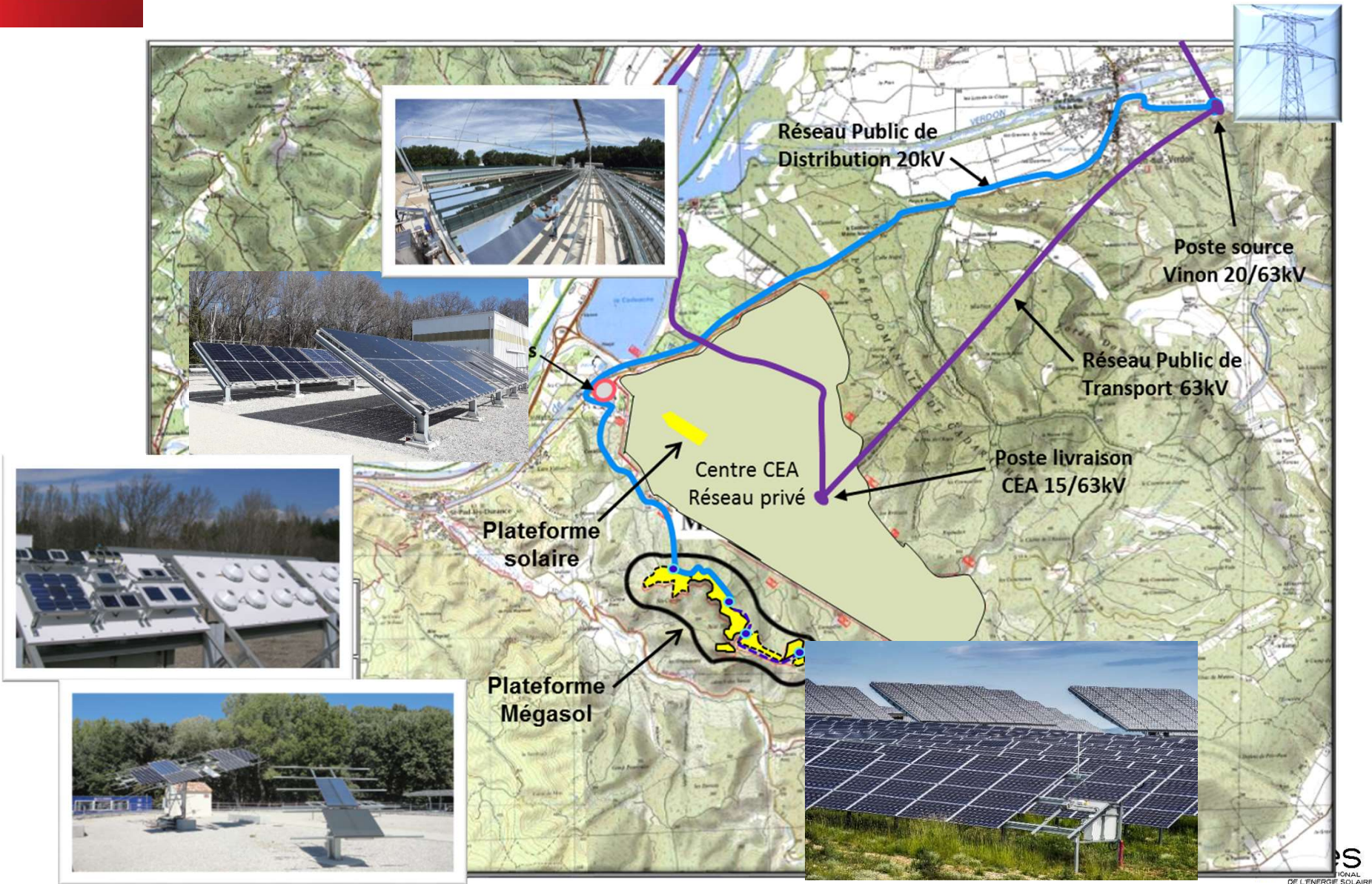
- 63kV / 15kV substation
- 18 MV loops (85km of 15kV underground lines)
- EVCI : 81 charging points at 22kVA
- 3kV public lighting network



63kV / 15kV substation



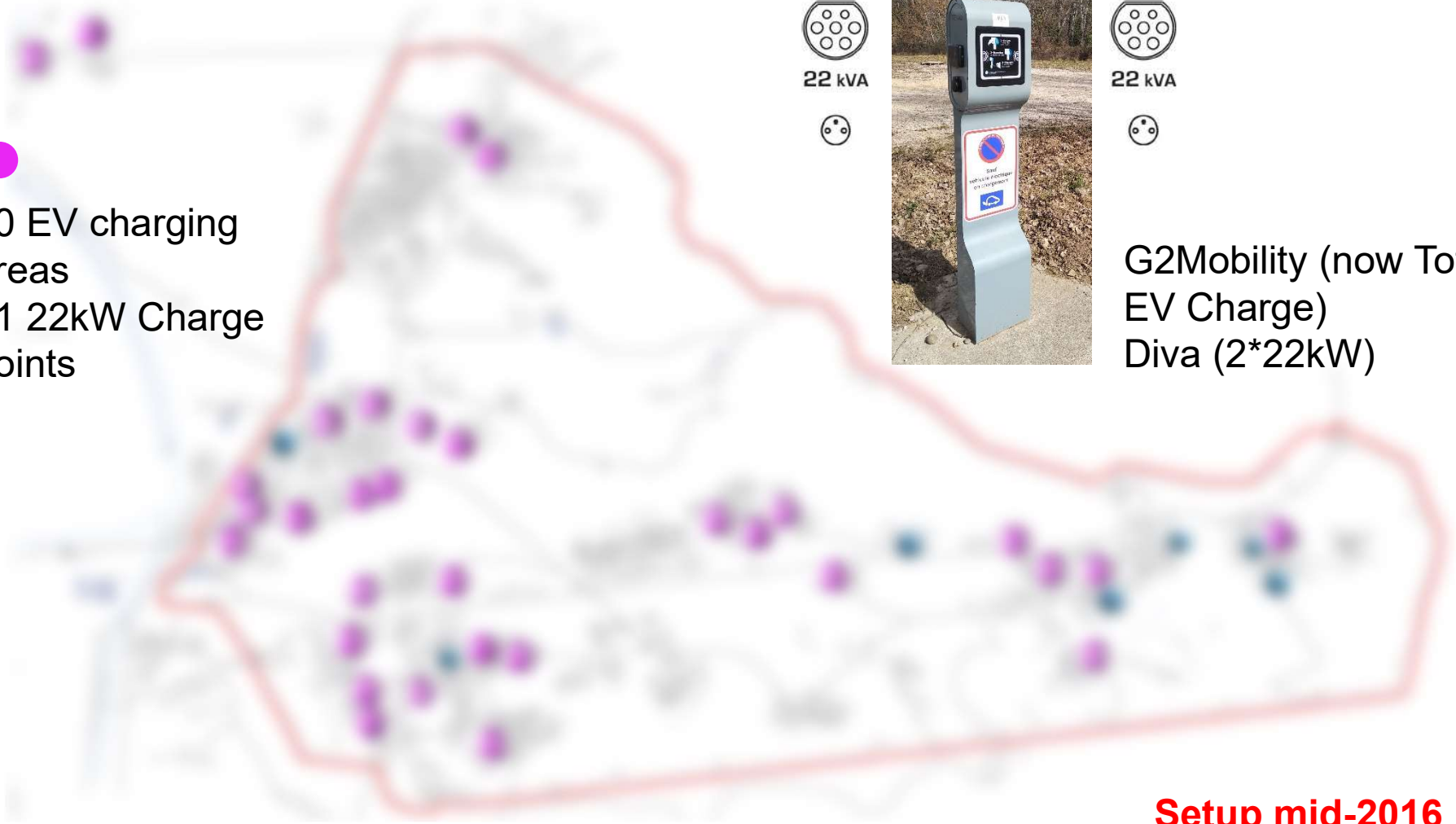
# CEA CADARACHE – SOLAR R&D





# EVCI CADARACHE – CHARGING STATION

30 EV charging areas  
81 22kW Charge points



22 kVA



22 kVA



G2Mobility (now Total EV Charge)  
Diva (2\*22kW)

Setup mid-2016





## EVCI CADARACHE – EV & USERS

Model	Brand	#
Zoé	Renault	148
e208	Peugeot	38
Twingo	Renault	26
M3	Tesla	21
Leaf	Nissan	21
Kangoo	Renault	16
E-Niro	Kia	9
Berlingo	Citroën	5
Ioniq	Hyundai	5
Twizy	Renault	4
e2008	Peugeot	4
MS	Tesla	3
Golf-GTE	Volkswagen	3
ID3	Volkswagen	3
Fortwo	Smart	2
Outlander	Mitsubishi	2
I3	BMW	2
e3008	Peugeot	2
e-UP	Volkswagen	2

...

Type	#
External companies	27
Personal	212
Service	90
Taxi	3
	TOTAL= 332



### 3 involvement levels :

Control, information = 48 people

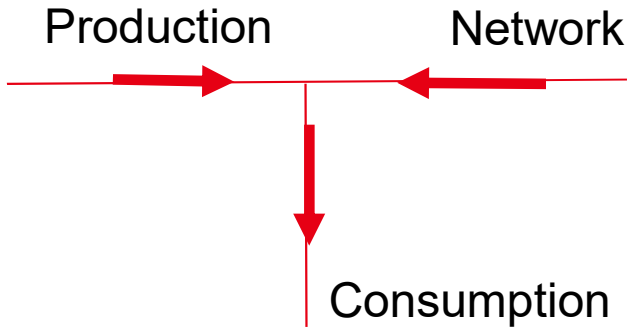
No control, information = 28 people

No control, no information = 256 people

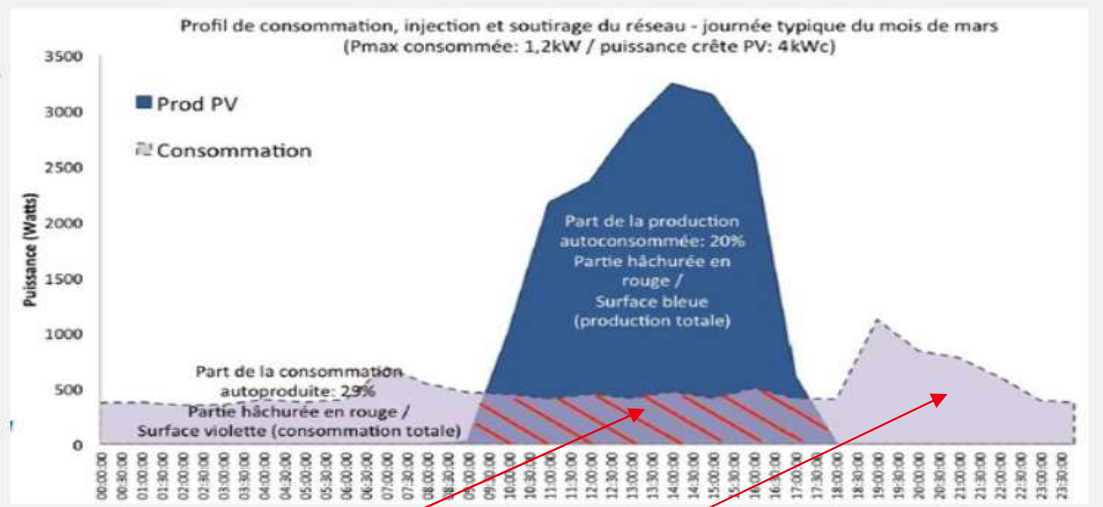




# OBJECTIVES



Network + Production = Consumption



Control algorithm : maximize

Selfproduction rate = (PV&consumption)/consumption

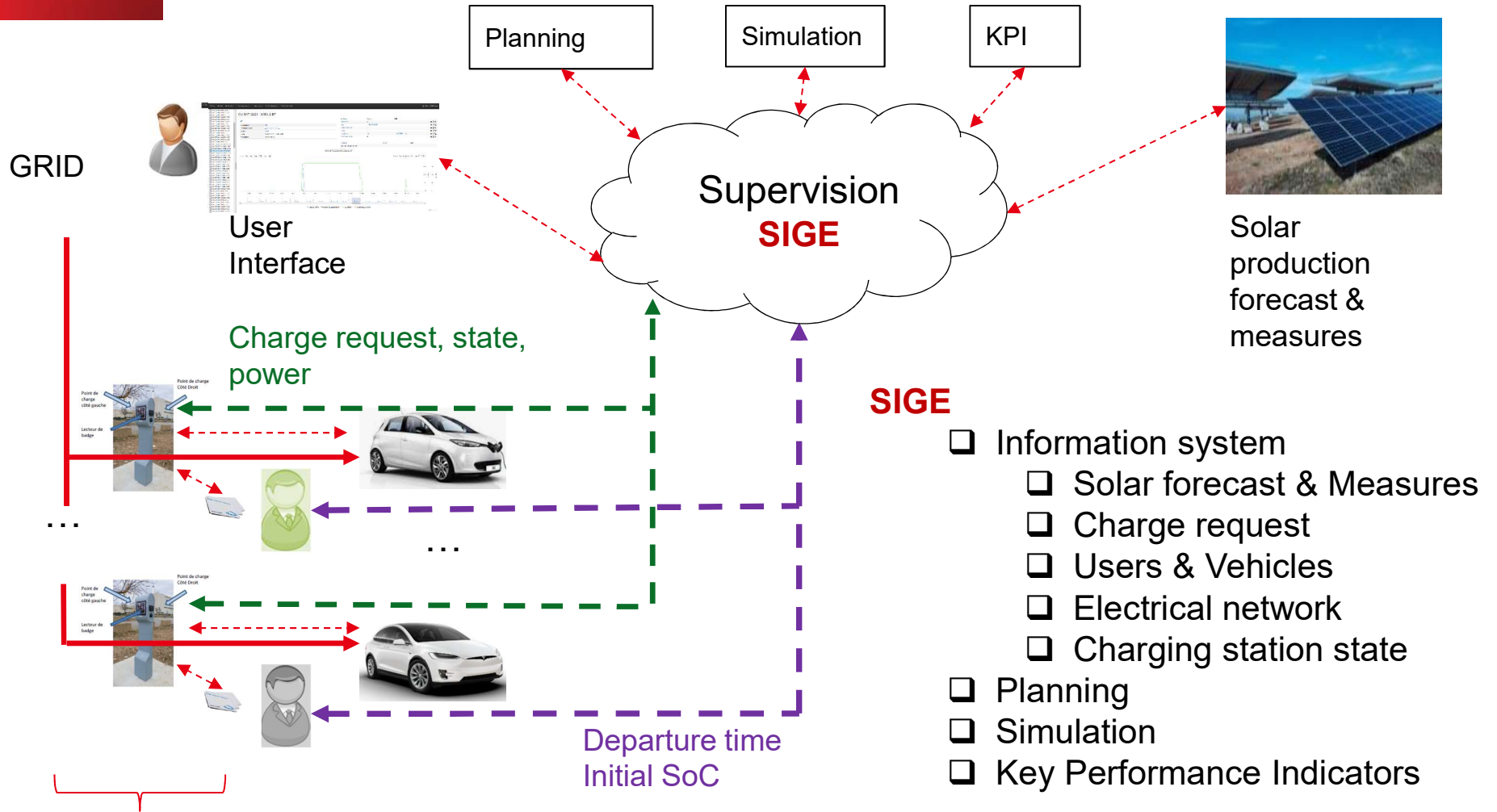




## AGENDA

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# CONTROL ARCHITECTURE



## SIGE

- Information system
  - Solar forecast & Measures
  - Charge request
  - Users & Vehicles
  - Electrical network
  - Charging station state
- Planning
- Simulation
- Key Performance Indicators

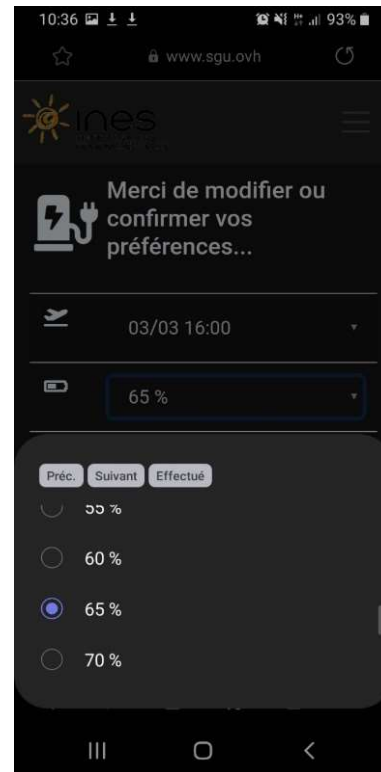
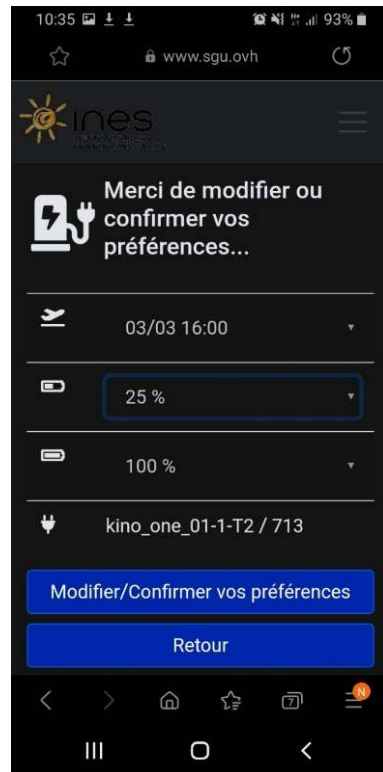
24 out of the the 81 22kW charge points @ Cadarache

→ Physical flows  
 - - - Information flows



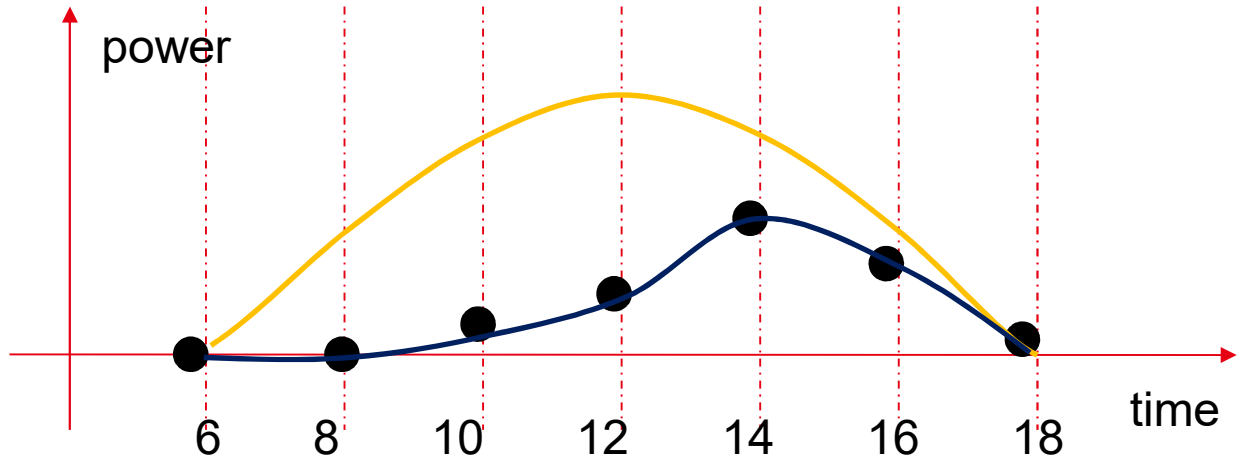
# USER JOURNEY

- The user connects his EV and passes his badge
- The supervision software sends an SMS inviting the user to confirm his departure time and the SOC of his car (default values are proposed).
- The EV is supplied with a test profile.
- Optimization and recharging are made on the basis of these data

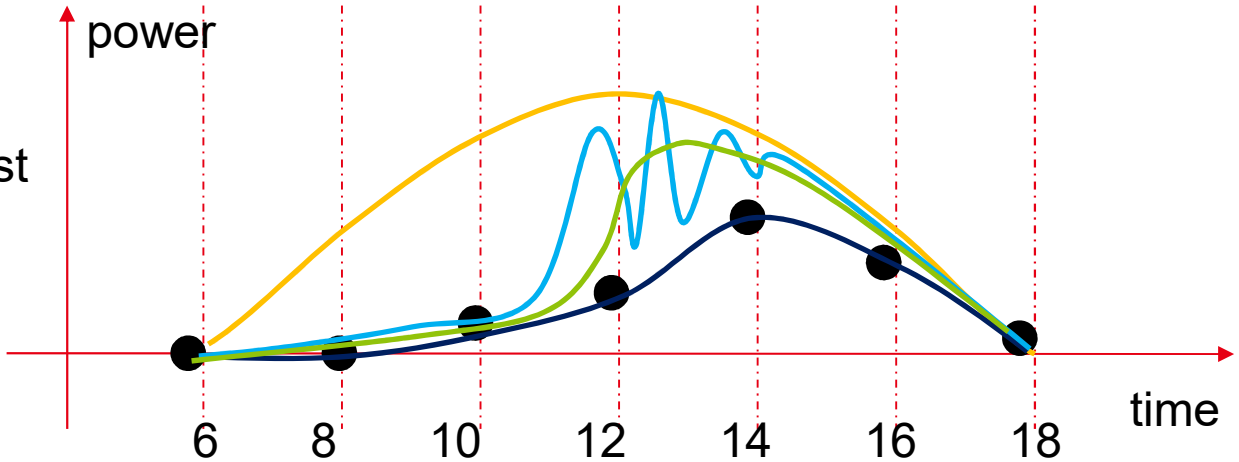


# DEFINITION : AVAILABLE POWER

- rawPowerForecast
- clearskyPower
- powerForecast



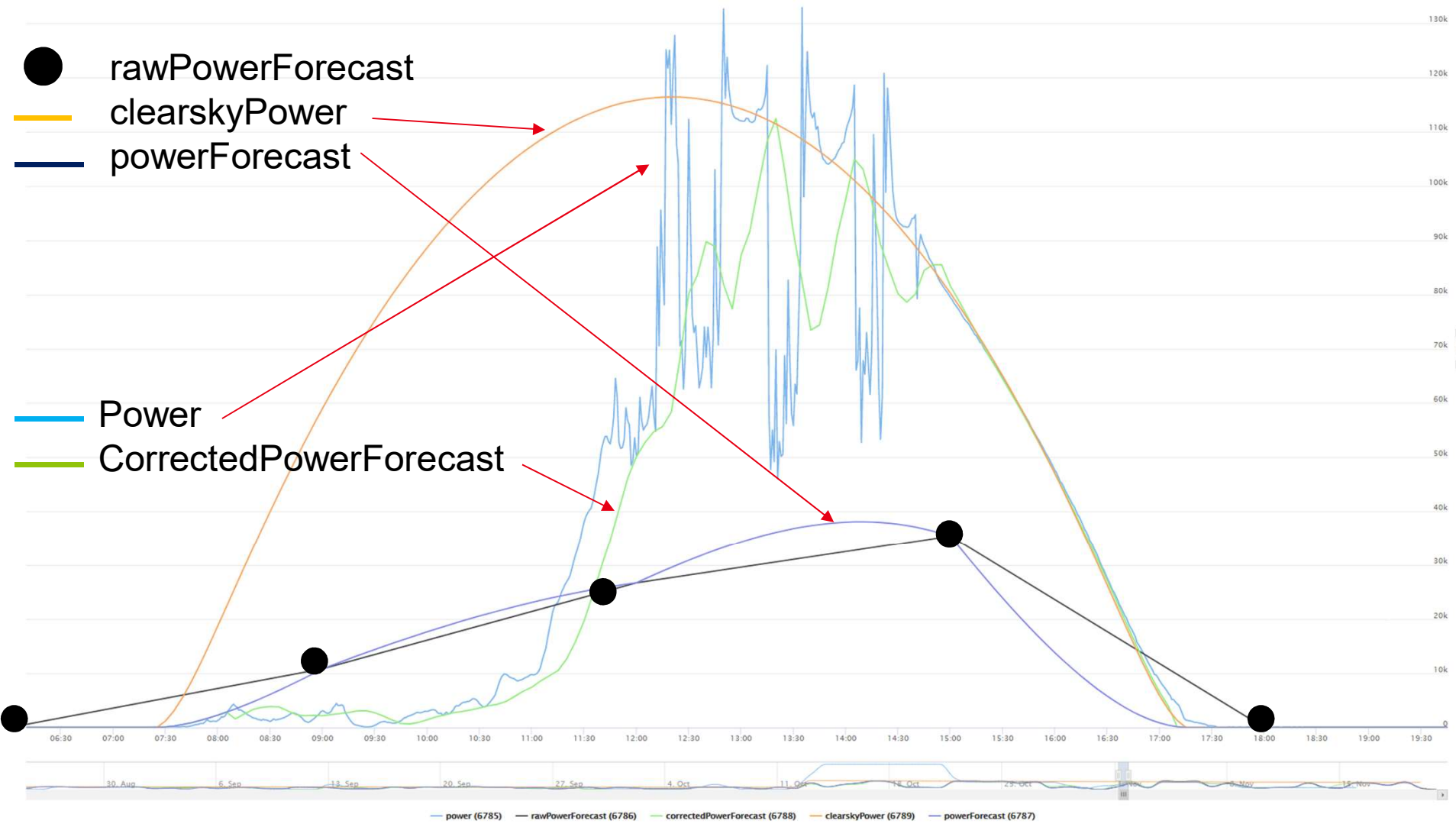
- Power
- CorrectedPowerForecast



➔ Available Power = CorrectedPowerForecast

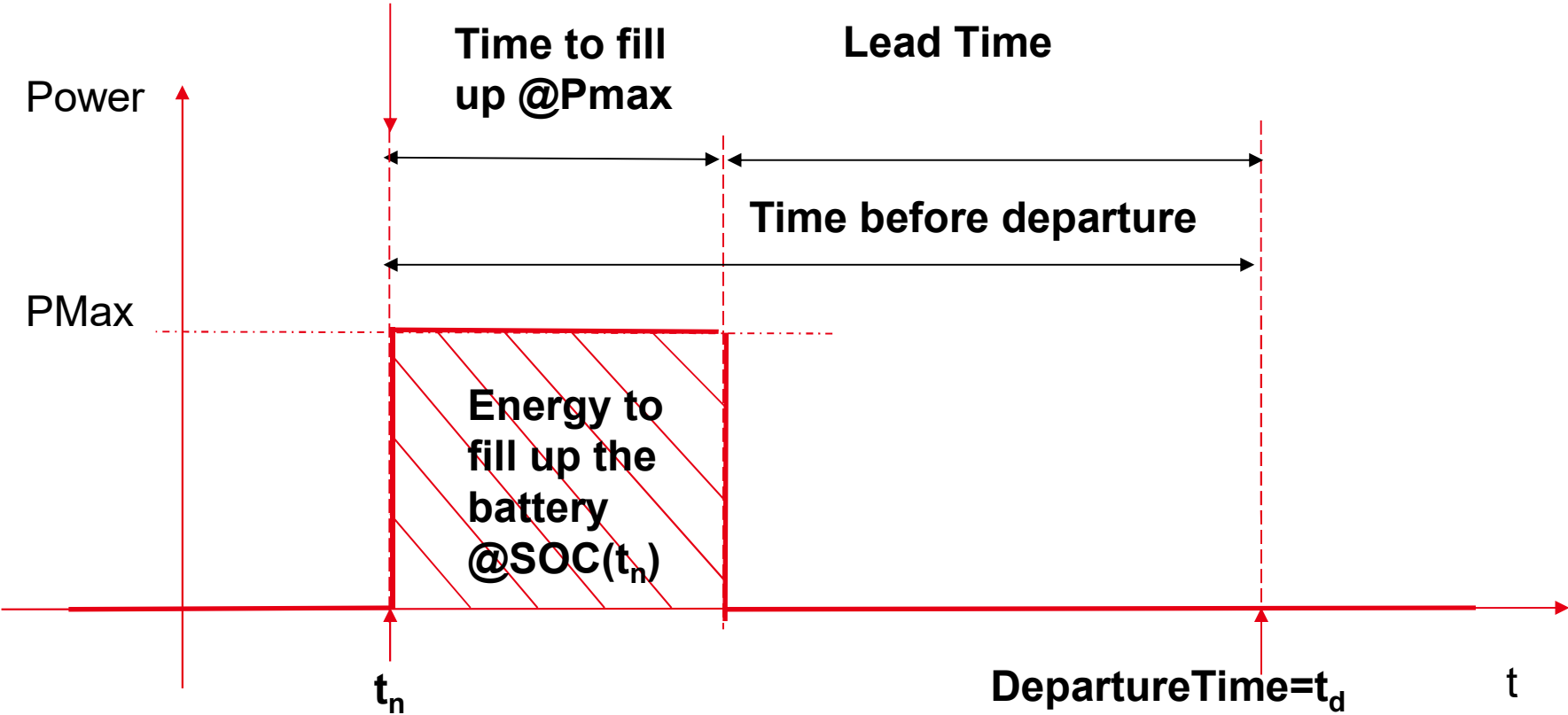


# DEFINITION: AVAILABLE POWER



# DEFINITION : LEAD TIME

Estimate the  $SOC(t_n)$  of the EV

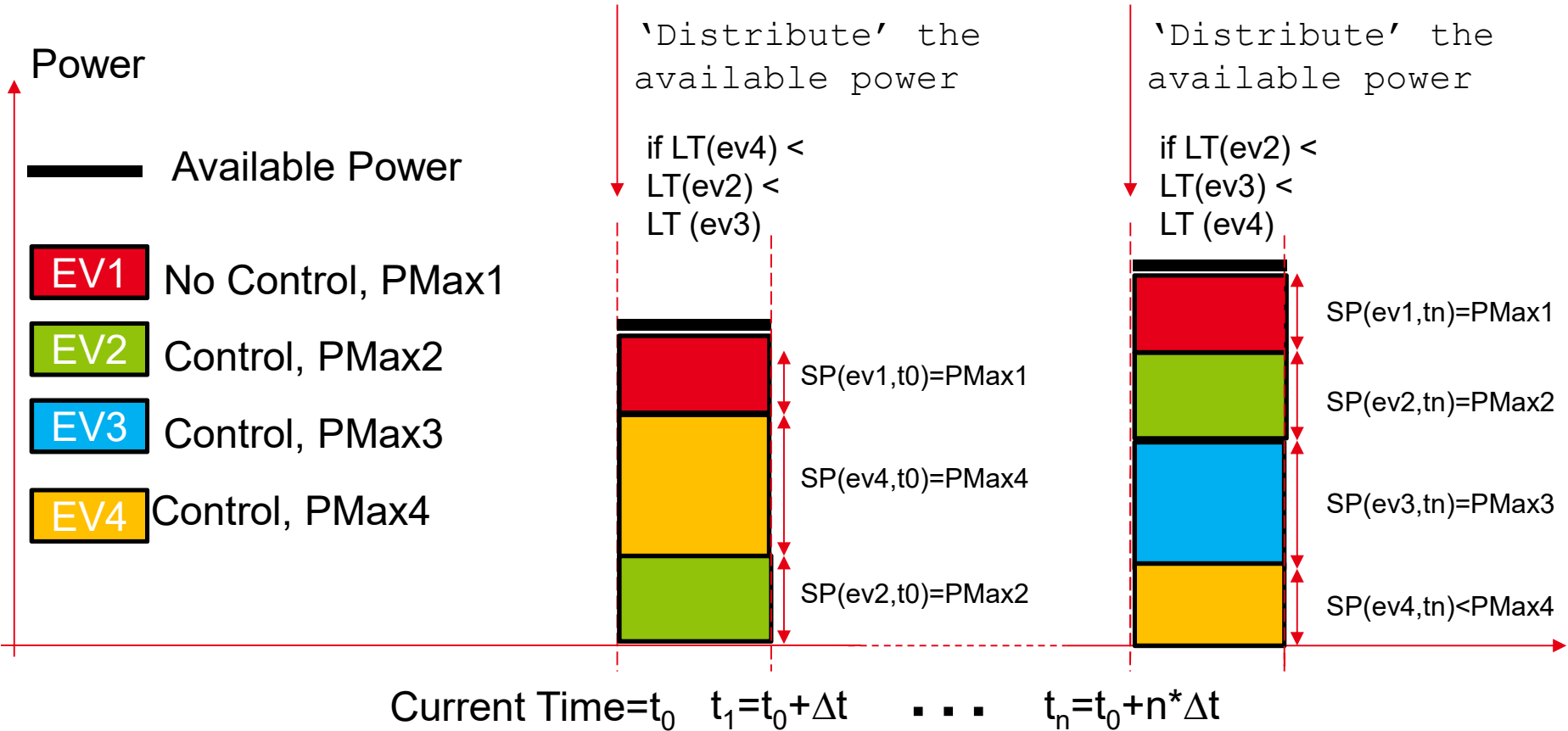


➔ The lead time is the difference between the amount of time before departure and the amount of time to fill up the battery at PMax.

# CONTROL ALGORITHM - PRINCIPLE

Estimate the SOC of all the EVs and the lead time of the controlled EV

Estimate the SOC of all the EVs and the lead time of the controlled EV



➔  $SP(ev, t)$  is the setpoint at time  $t$  of the charging point on which the ev is connected.





## AGENDA

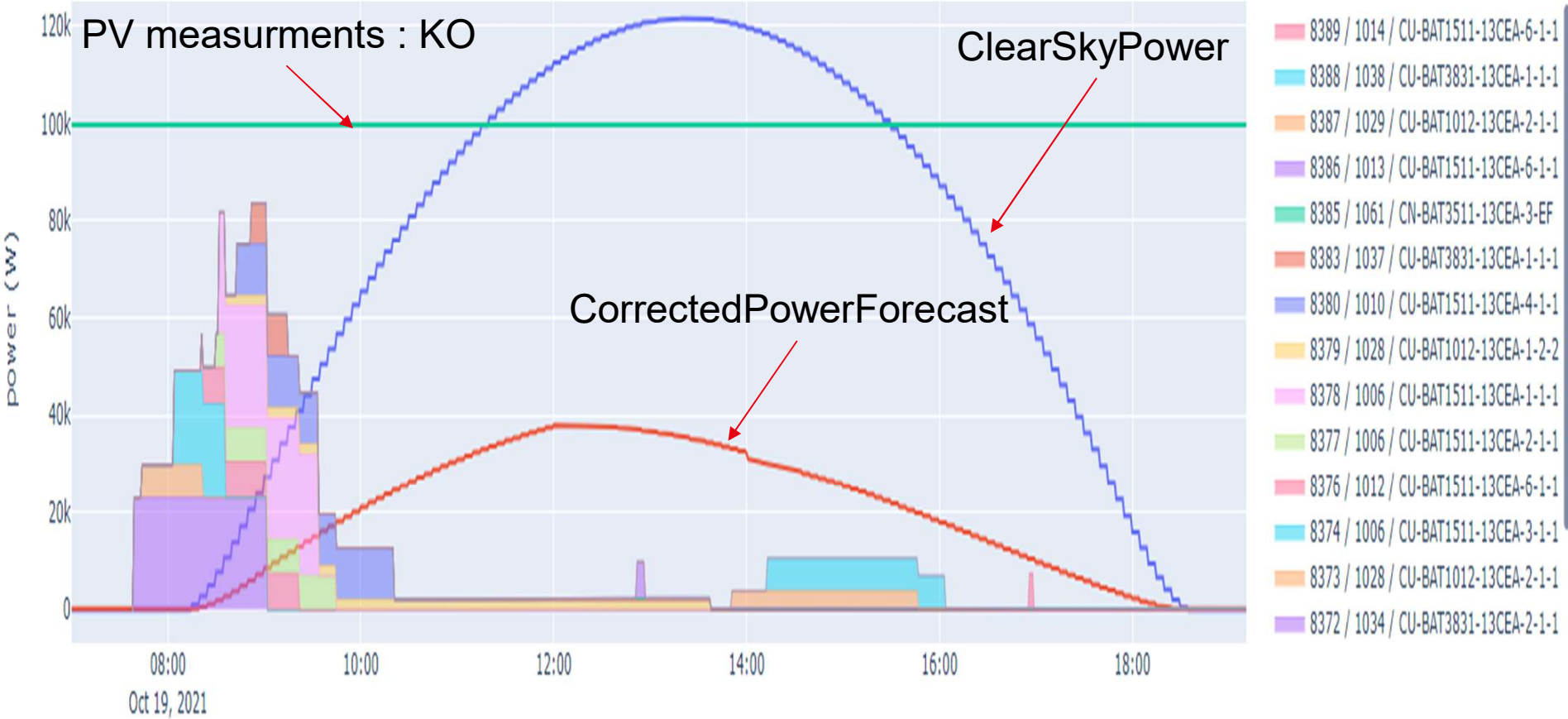
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# EXPERIMENTAL RESULTS

- 19/10/2021 : Cloudy day
- 16 charging sessions
- PV plant = 160kWp

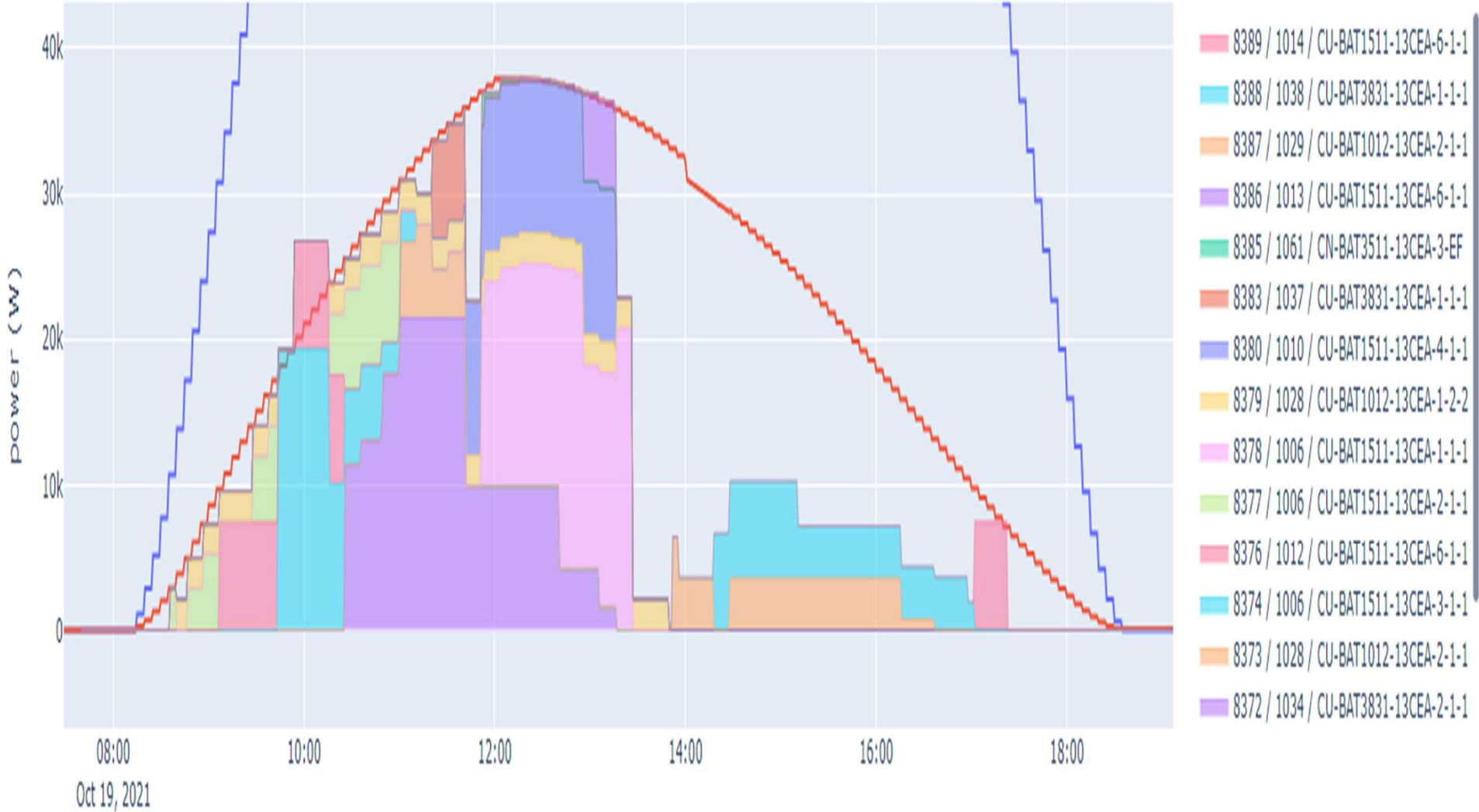
Cumulated simulated charging power without control :





# EXPERIMENTAL RESULTS

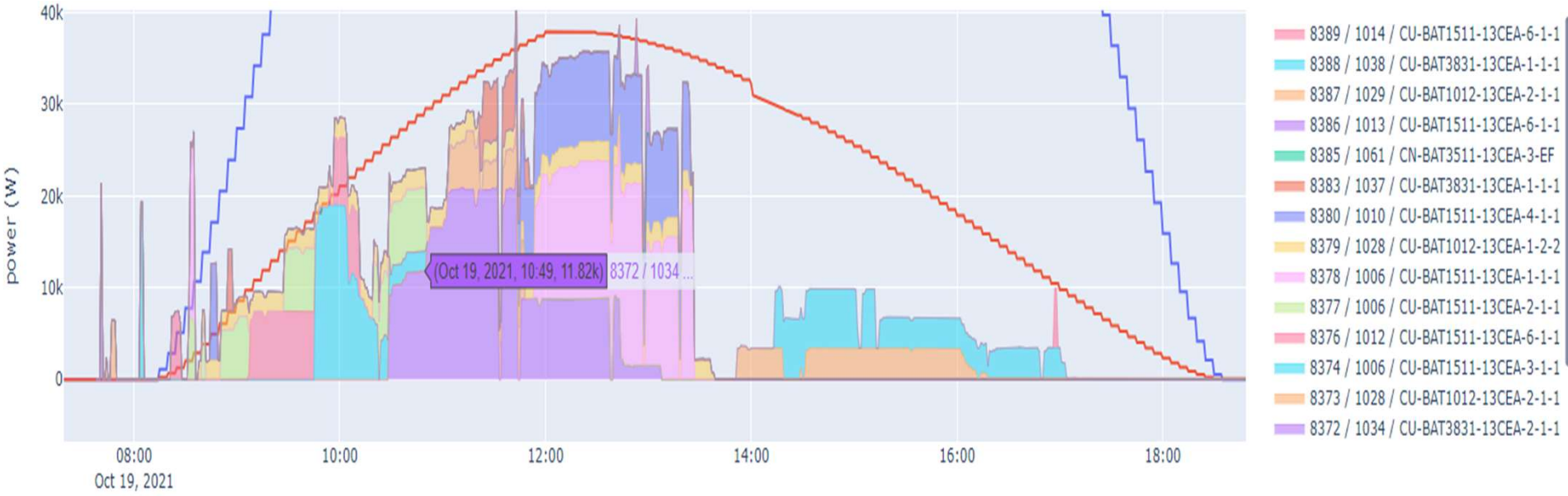
Cumulated power setpoints with control:





# EXPERIMENTAL RESULTS

Cumulated measured charging power with control:



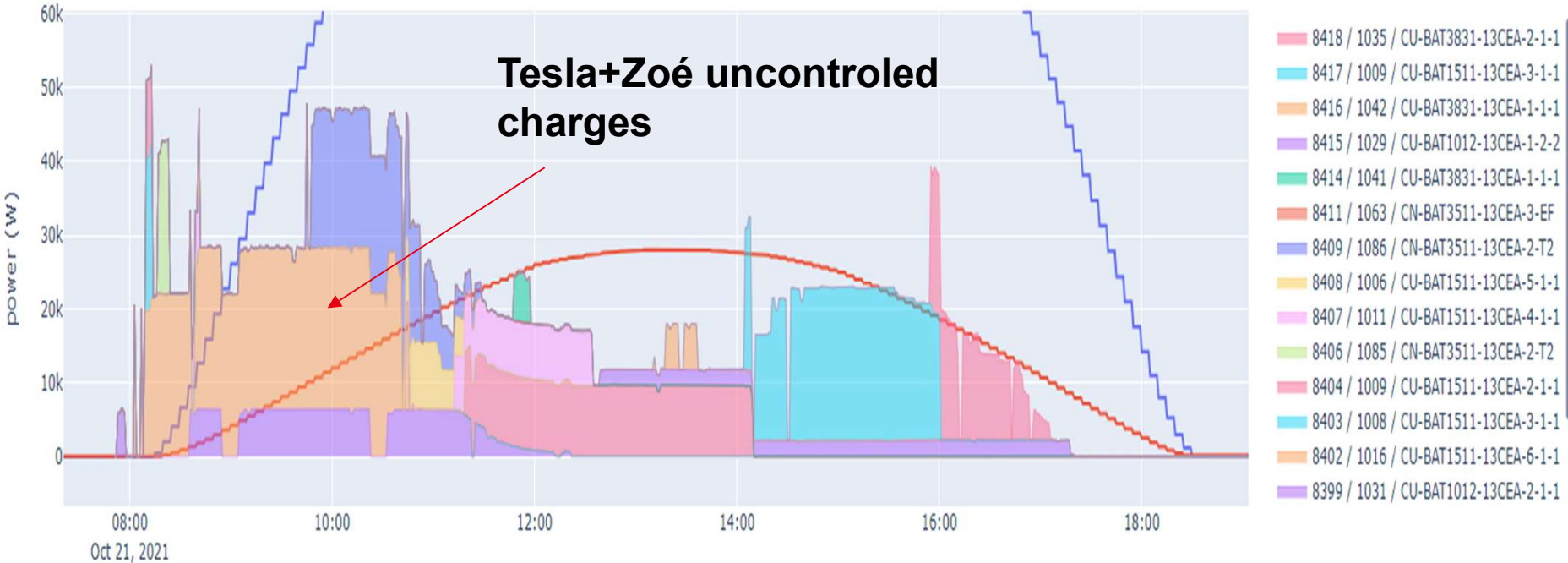
<b>17</b> Charging sessions	<b>141.3 kWh</b> EV energy transferred to the vehicles (~941.85 km)	<b>221.4 kWh</b> PV energy	<b>127.5 kWh</b> Self-consumption	<b>90 %</b> Self-production ratio	<b>13.7 kWh</b> Grid energy taken from the grid	<b>48.5 kWh</b> Uncontrolled self-consumption	<b>34 %</b> Uncontrolled self-production ratio	<b>92.8 kWh</b> Uncontrolled grid energy taken from the grid	<b>100 %</b> Theoretical maximum self-production ratio PV energy / EV energy
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➔ Large increase of the self-production ratio thanks to control



# EXPERIMENTAL RESULTS

Cumulated measured charging power with control:



<b>19</b> Charging sessions	<b>214.5 kWh</b> EV energy Energy transferred to the vehicles (~1430.28 km)	<b>174.0 kWh</b> PV energy	<b>128.8 kWh</b> Self-consumption	<b>60 %</b> Self-production ratio	<b>85.8 kWh</b> Grid energy Energy taken from the grid	<b>84.0 kWh</b> Uncontrolled self-consumption	<b>39 %</b> Uncontrolled self-production ratio	<b>130.6 kWh</b> Uncontrolled grid energy Energy taken from the grid	<b>81 %</b> Theoretical maximum self-production ratio PV energy / EV energy
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➔ **Users' behaviour strongly influences the results**



## PERSPECTIVES

- Follow the experiments during at least 9 months
- Increase the participants number
- Integrate the participants feedback in the control algorithm
- Improve the EV charging models and parameters estimation
- Improve the planning algorithm
- Add KPI, for example, that estimate the state of health of the batteries with and without control
- Improve the human-machine interfaces

**Thank you for your attention**

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