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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





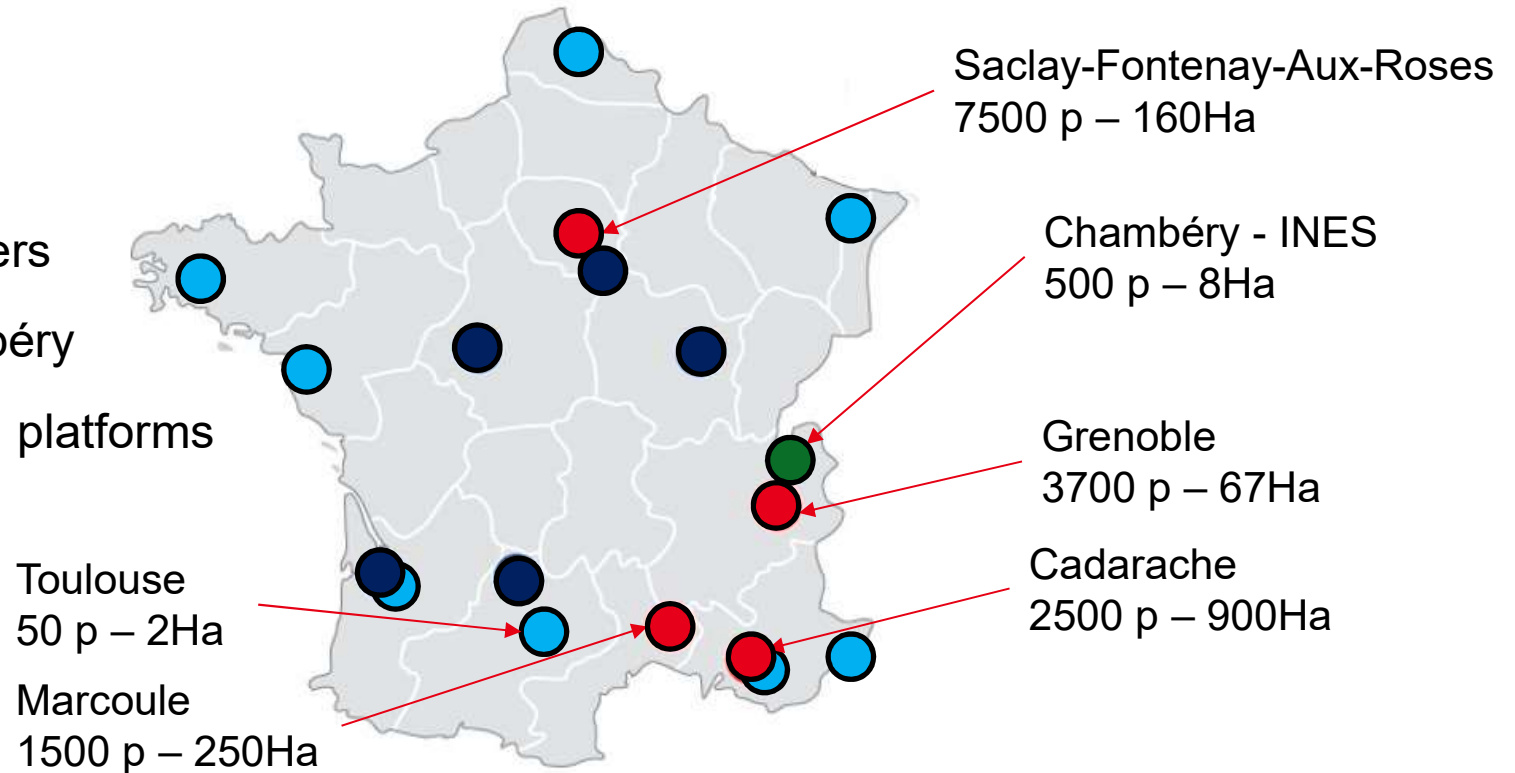
CEA CENTERS

● 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

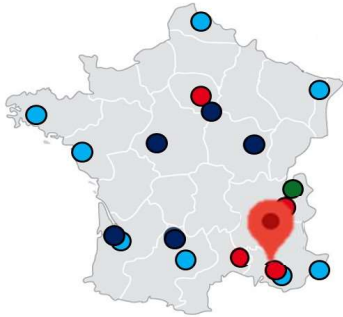
75 km of water distribution network (drinking water station, industrial water, purification station)

Private power network

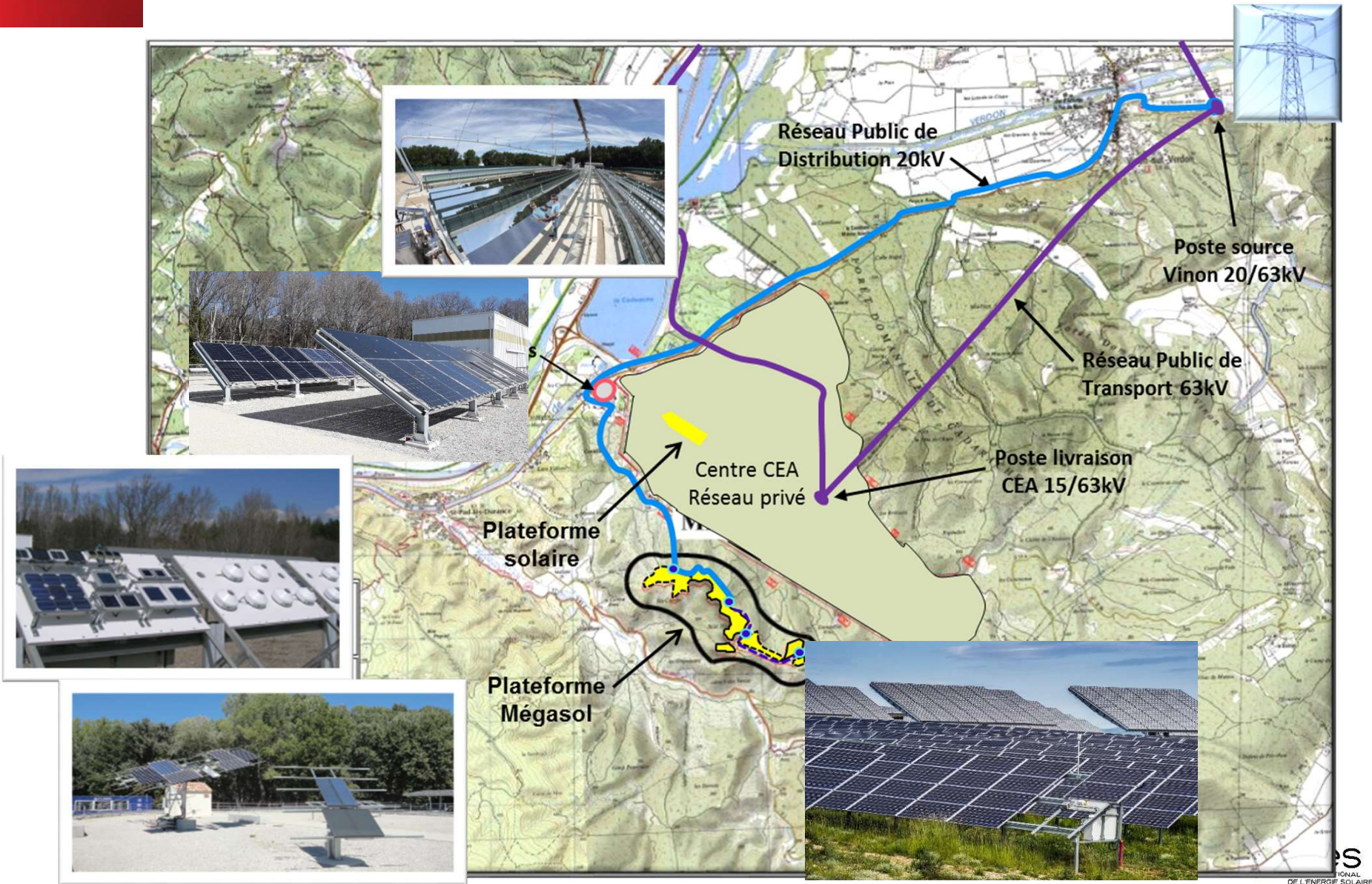
- 63kV / 15kV substation
- 18 MV loops (85km of 15kV underground lines)
- EVCI : 81 charging points at 22kVA
- 3kV public lighting network



63kV / 15kV substation



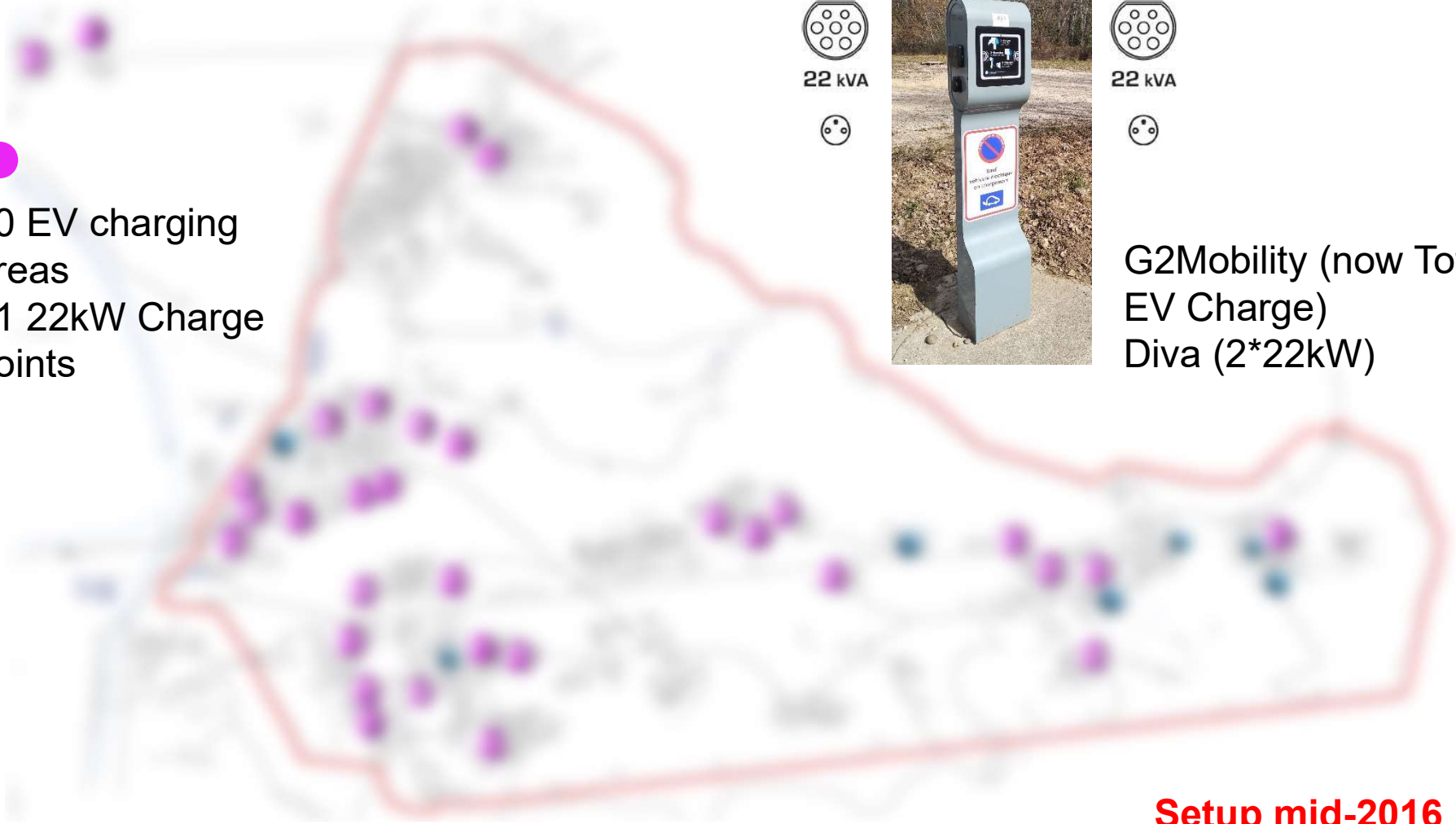
CEA CADARACHE – SOLAR R&D





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 :

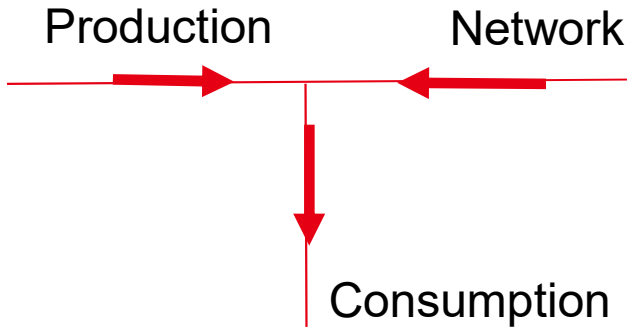
Control, information = 48 people

No control, information = 28 people

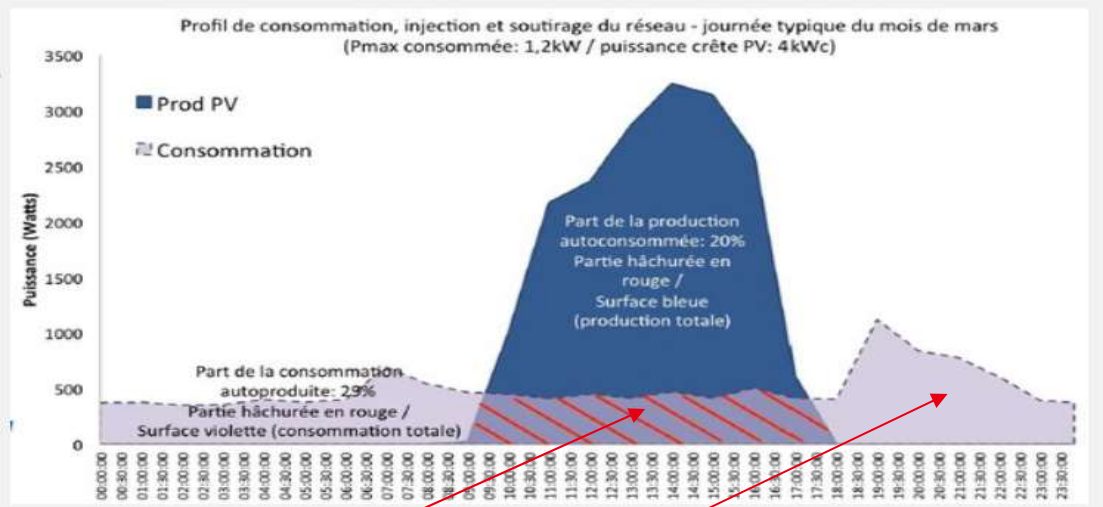
No control, no information = 256 people



OBJECTIVES



Network + Production = Consumption



Control algorithm : maximize

Selfproduction rate = (PV&consumption)/consumption

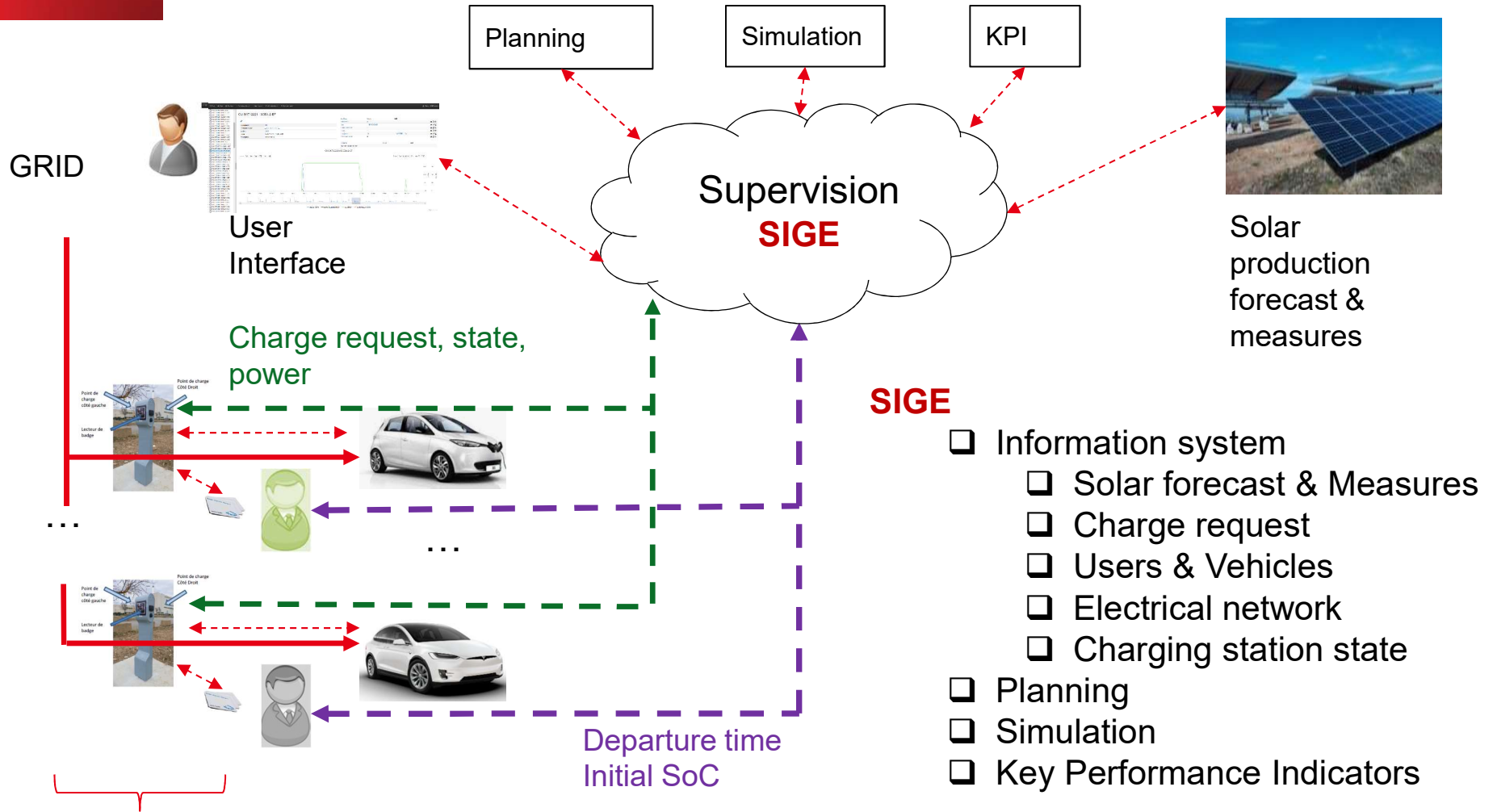




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CONTROL ARCHITECTURE



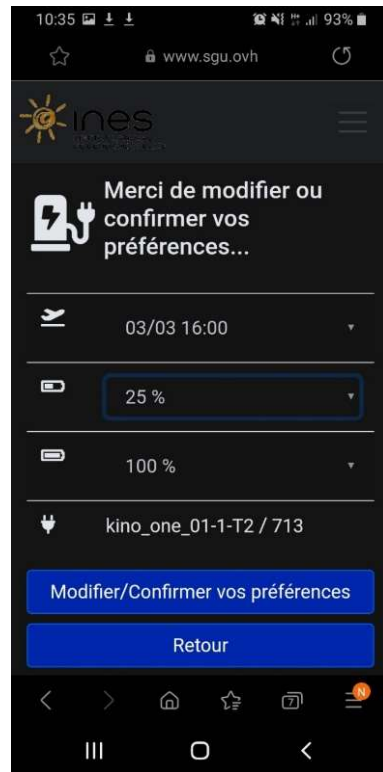
24 out of the the 81 22kW charge points @ Cadarache

→ Physical flows
 - - - - - Information flows



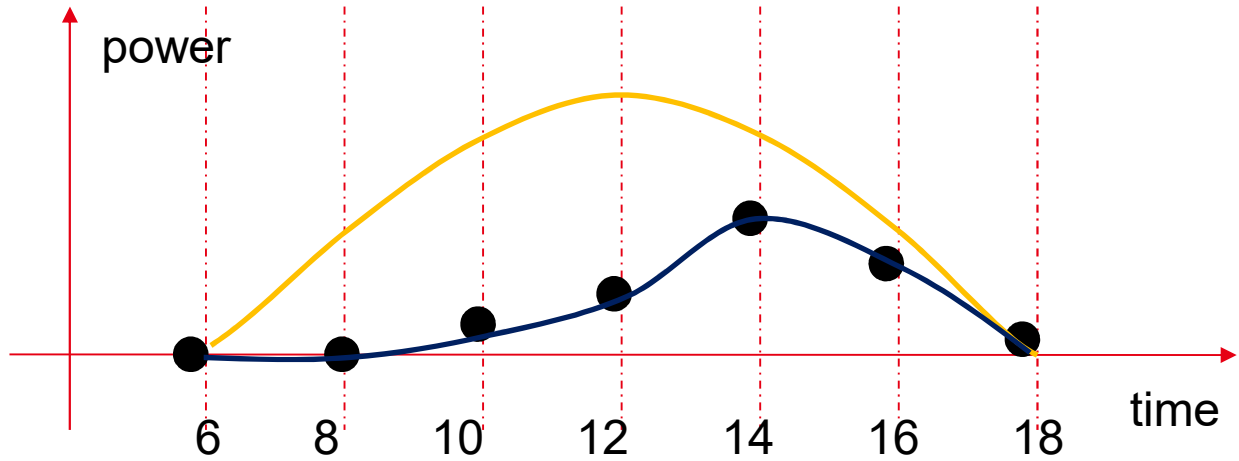
USER JOURNEY

- 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

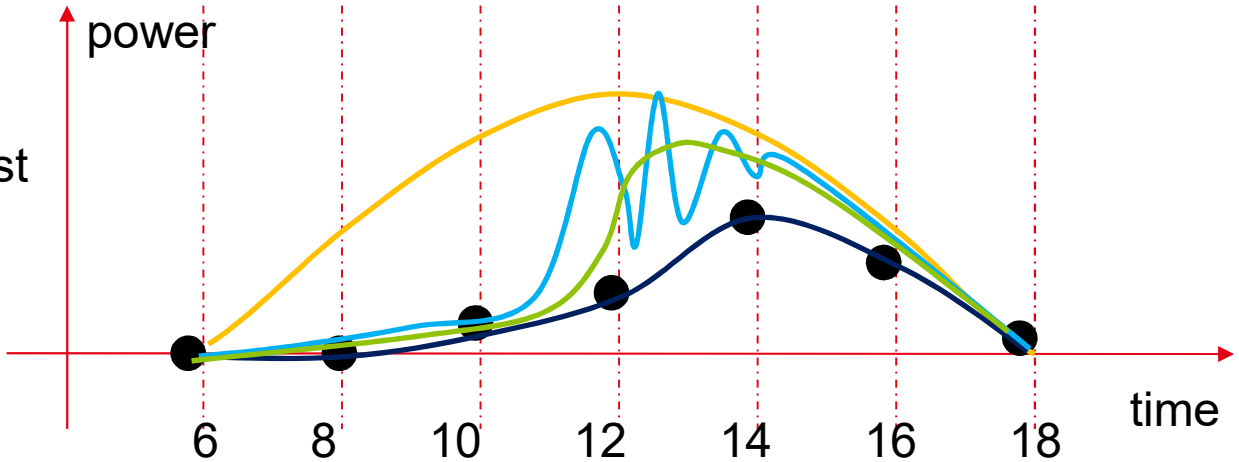


DEFINITION : AVAILABLE POWER

- rawPowerForecast
- clearskyPower
- powerForecast



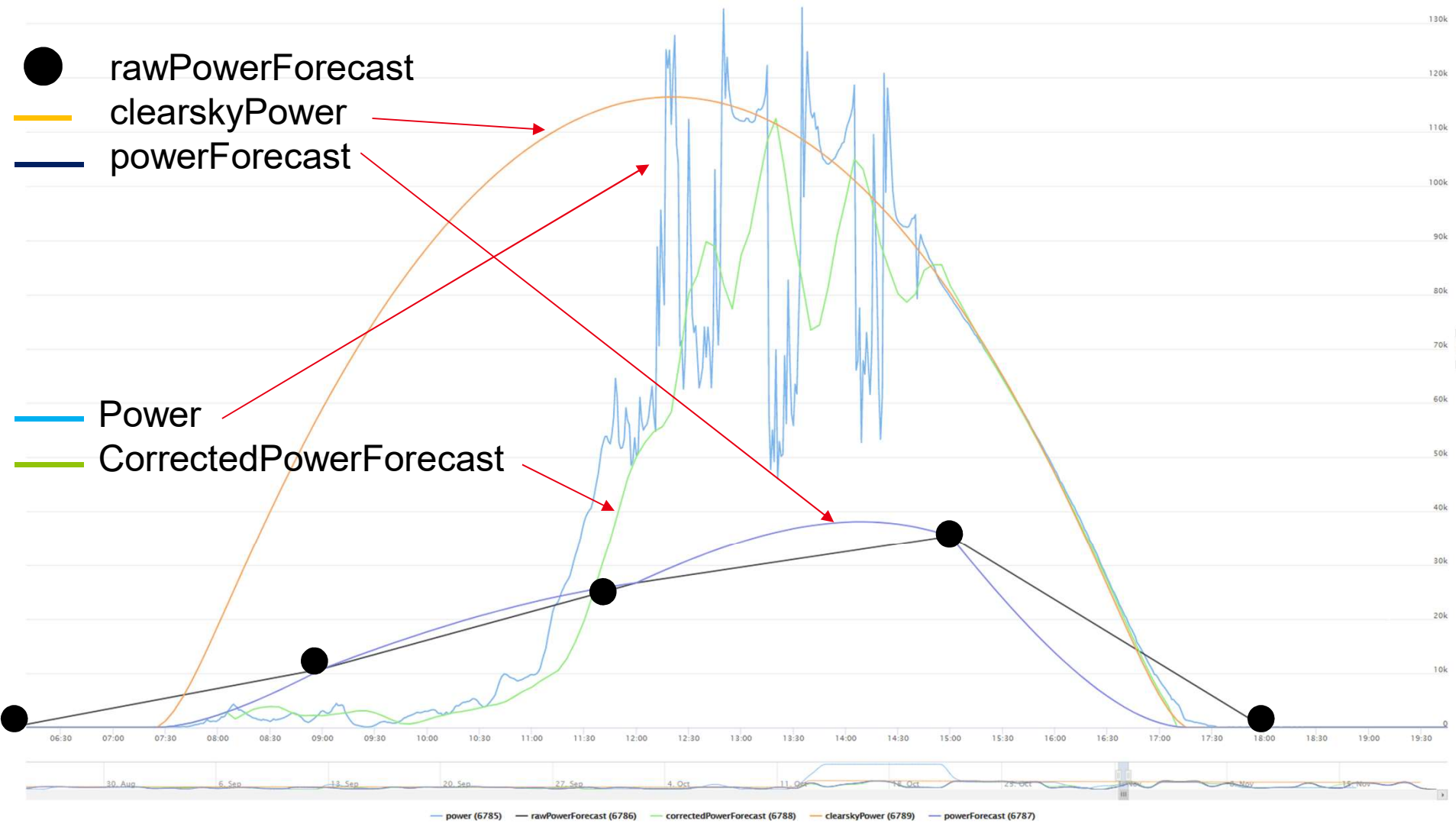
- Power
- CorrectedPowerForecast



➔ Available Power = CorrectedPowerForecast

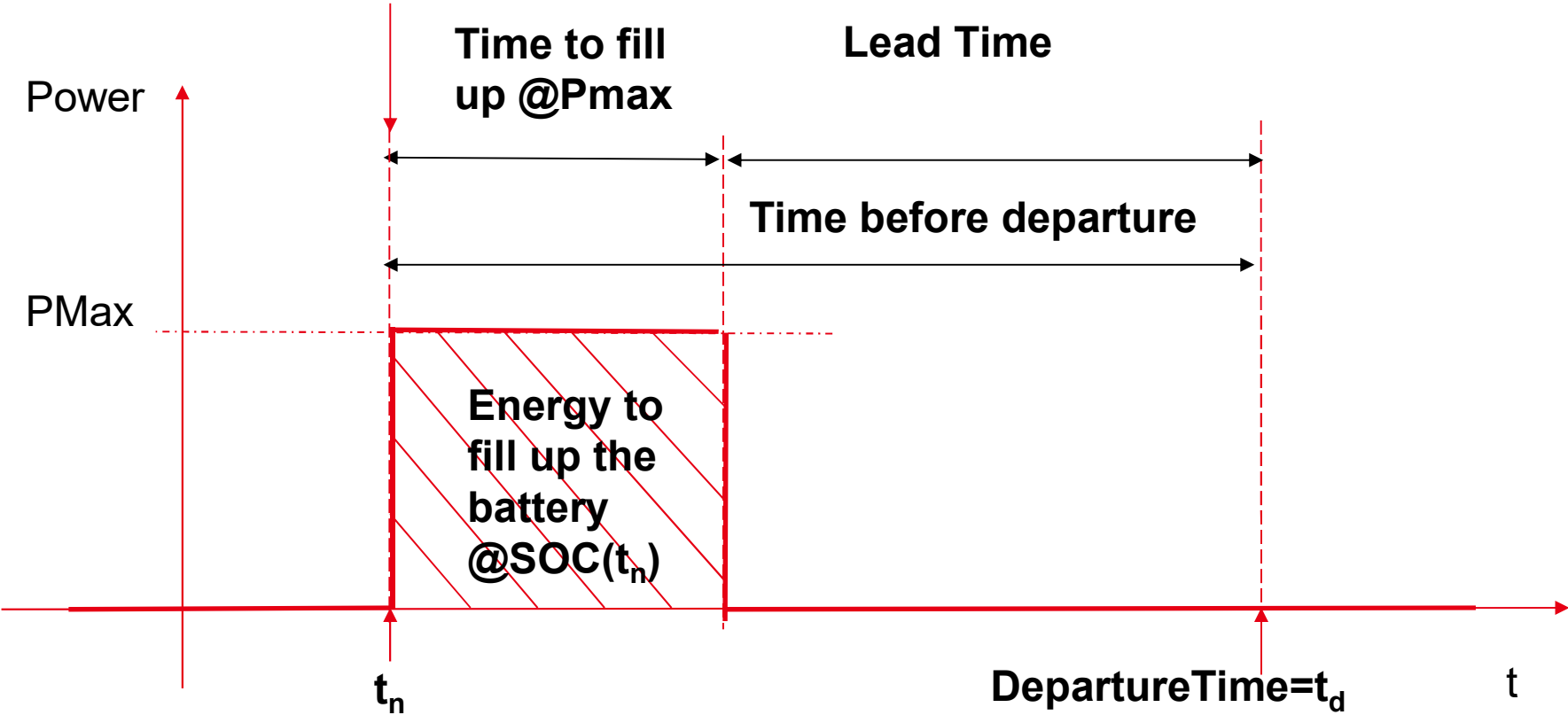


DEFINITION: AVAILABLE POWER



DEFINITION : LEAD TIME

Estimate the $SOC(t_n)$ of the EV

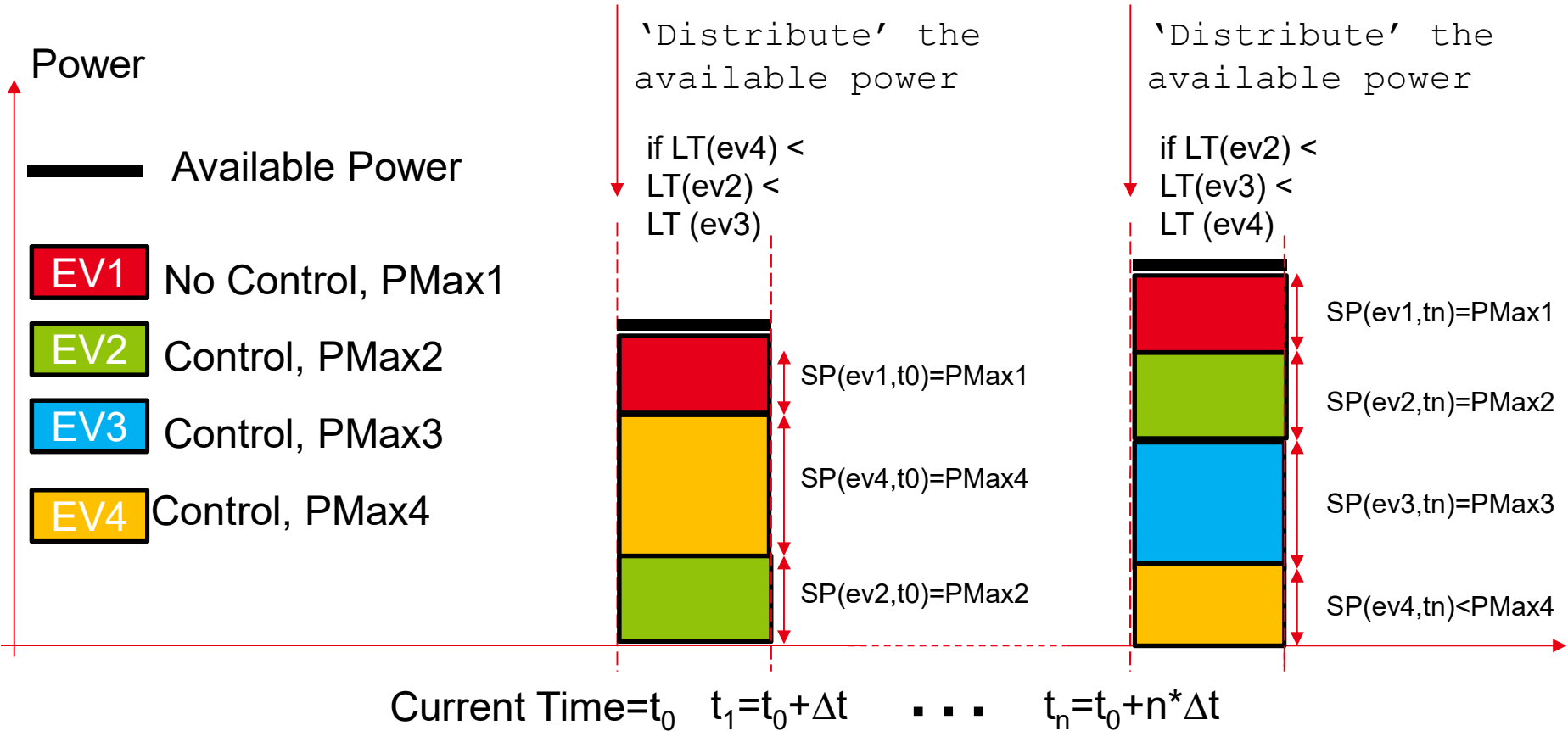


➔ The lead time is the difference between the amount of time before departure and the amount of time to fill up the battery at PMax.

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

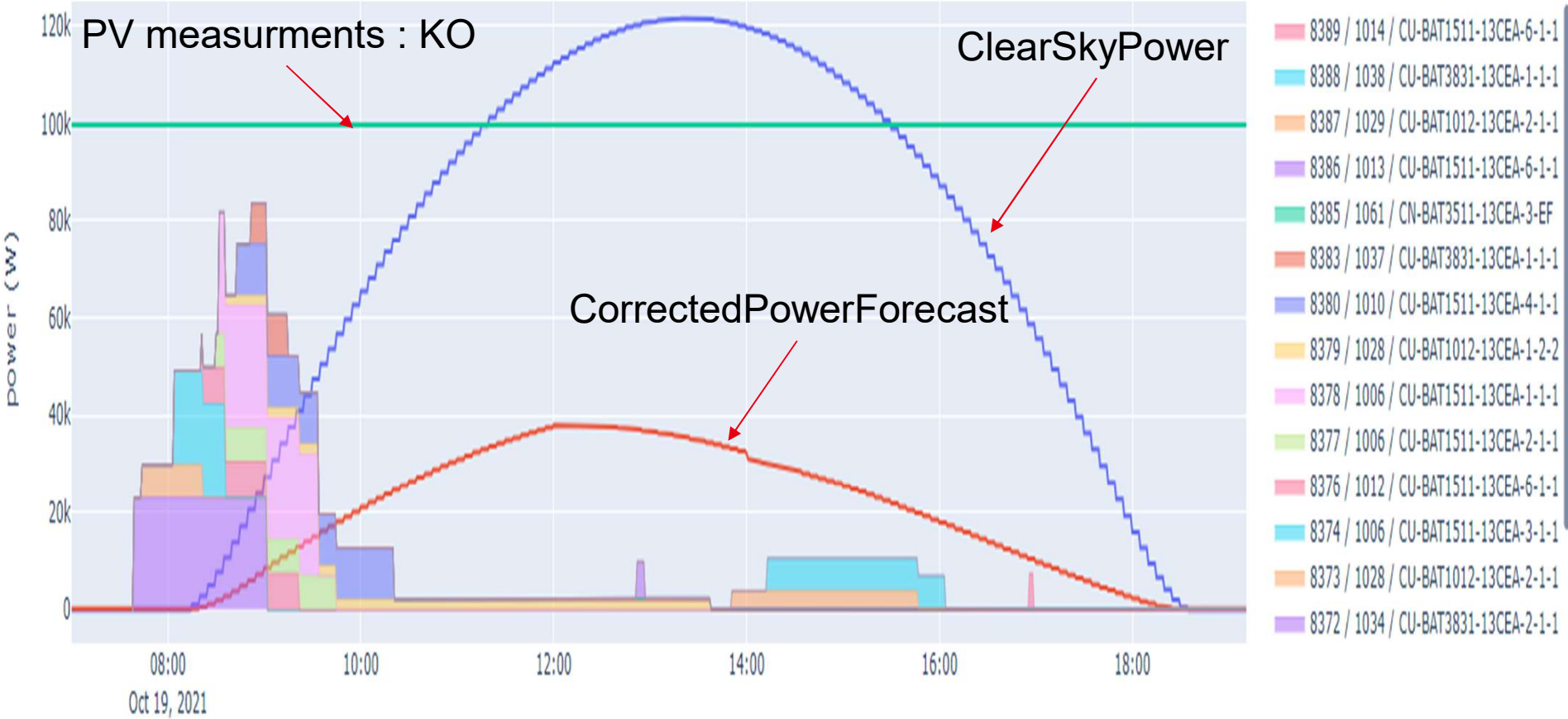
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EXPERIMENTAL RESULTS

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

Cumulated simulated charging power without control :





EXPERIMENTAL RESULTS

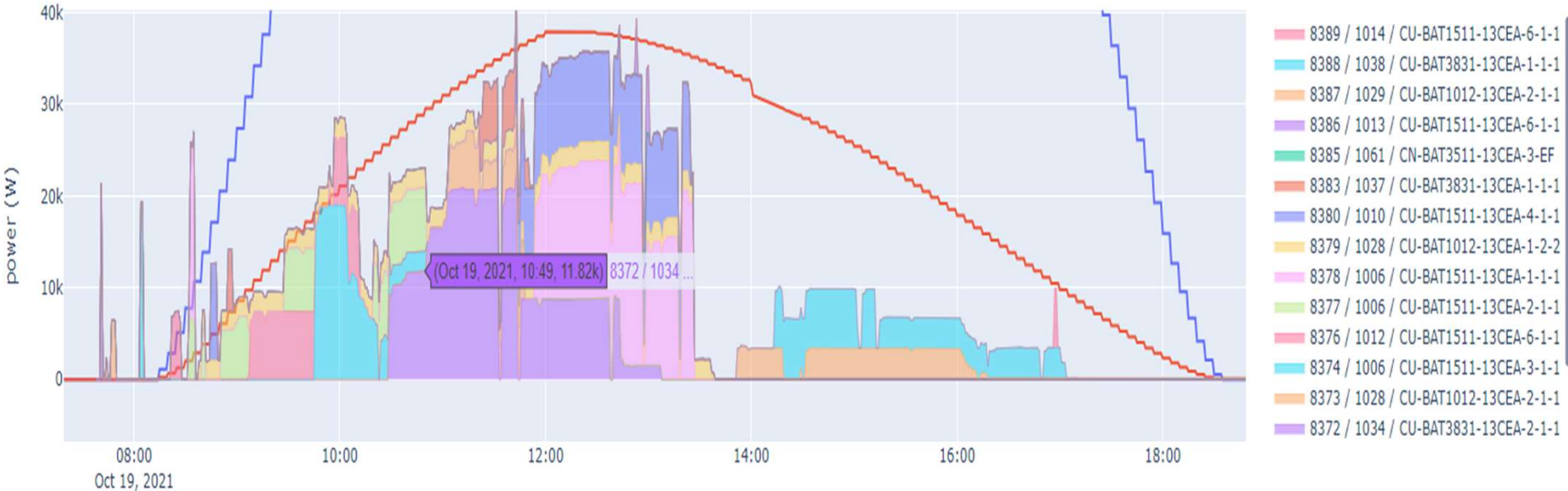
Cumulated power setpoints with control:





EXPERIMENTAL RESULTS

Cumulated measured charging power with control:



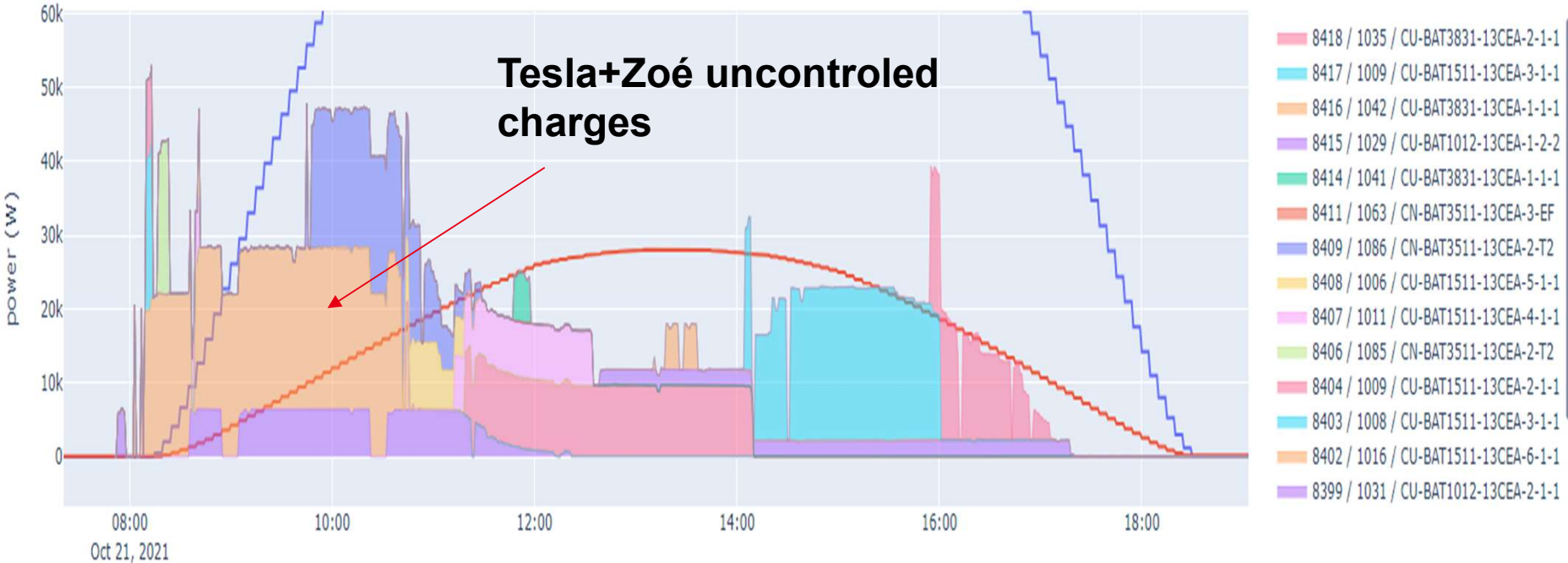
17 Charging sessions	141.3 kWh EV energy transferred to the vehicles (~941.85 km)	221.4 kWh PV energy	127.5 kWh Self-consumption	90 % Self-production ratio	13.7 kWh Grid energy taken from the grid	48.5 kWh Uncontrolled self-consumption	34 % Uncontrolled self-production ratio	92.8 kWh Uncontrolled grid energy taken from the grid	100 % 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:



19 Charging sessions	214.5 kWh EV energy Energy transferred to the vehicles (~1430.28 km)	174.0 kWh PV energy	128.8 kWh Self-consumption	60 % Self-production ratio	85.8 kWh Grid energy Energy taken from the grid	84.0 kWh Uncontrolled self-consumption	39 % Uncontrolled self-production ratio	130.6 kWh Uncontrolled grid energy Energy taken from the grid	81 % 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

Contact : bruno.robisson@cea.fr

Commissariat à l'énergie atomique et aux énergies alternatives
17 rue des Martyrs | 38054 Grenoble Cedex
www-liten.cea.fr

Établissement public à caractère industriel et commercial | RCS Paris B 775 685 019

INES Site
Institut National de l'Énergie Solaire
50 avenue du lac Léman
73375 Le Bourget-du-Lac France
04 79 79 20 00