



EV (SOLAR) CHARGING @CEA: EXPERIMENTAL RESULTS

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PV2E_MOBILITY
French Contribution to IEA PVPS T17 - PV
& Transport



- **EVCI & PV**
 - Cadarache
 - EVCI & PV
 - EV charging demand
 - Objectives
- **Experimental setup**
 - EvolVE EVCI
 - EVs and users
 - Control architecture
 - User journey
- **Experimental results**
 - Global figure
 - Lessons from examples



Associated R&D projects:
EvoLVE Project with RTE
G. Vignal



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

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

PV2e_Mobility
M. Sechilariu



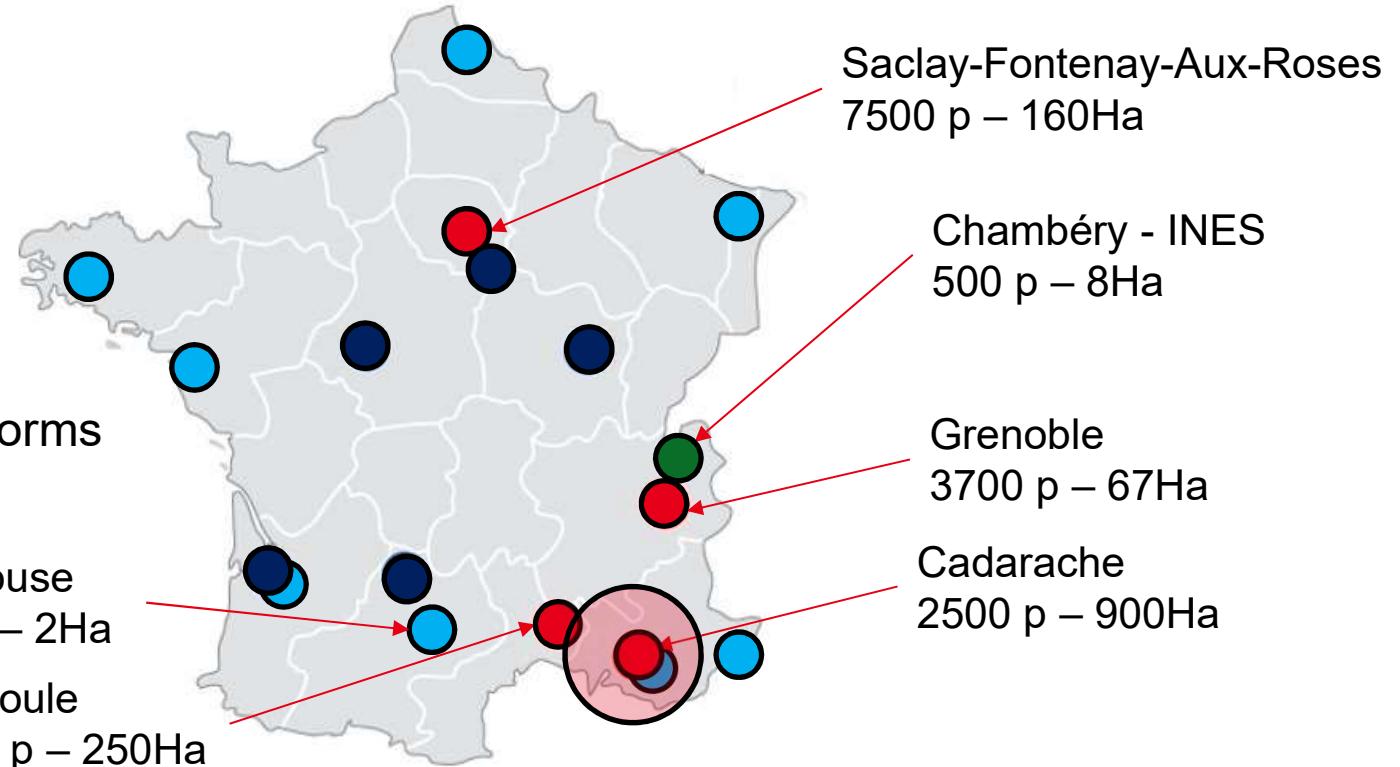
CEA CENTERS

● 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

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

5500 workers

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

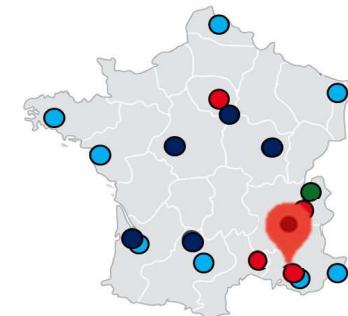
Heat network

Private medium voltage distribution power network

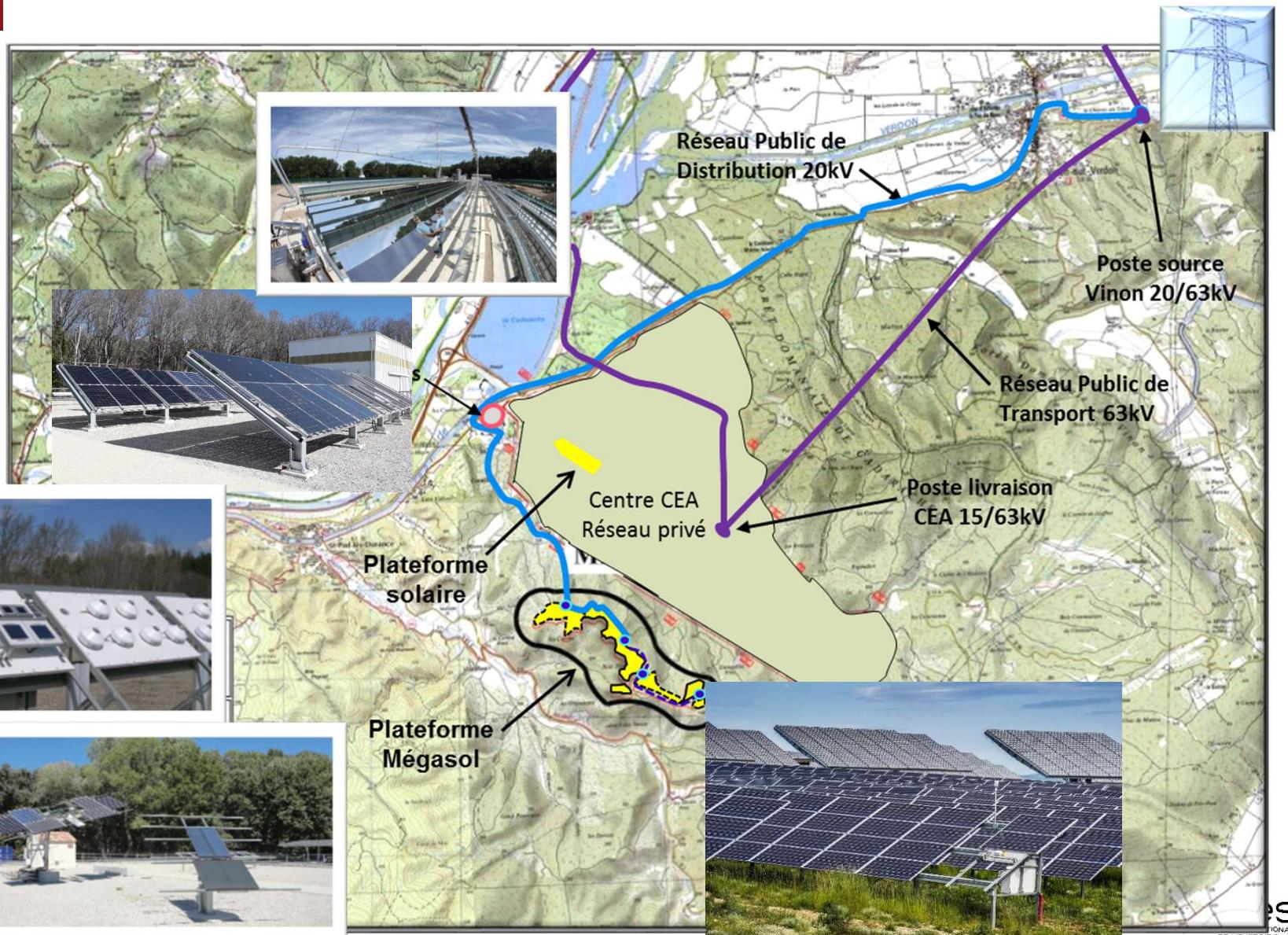
- 63kV / 15kV substation
- 18 MV loops (85km of 15kV underground lines)
- 3kV public lighting network
- EVCI : 80 charging points at 22kVA



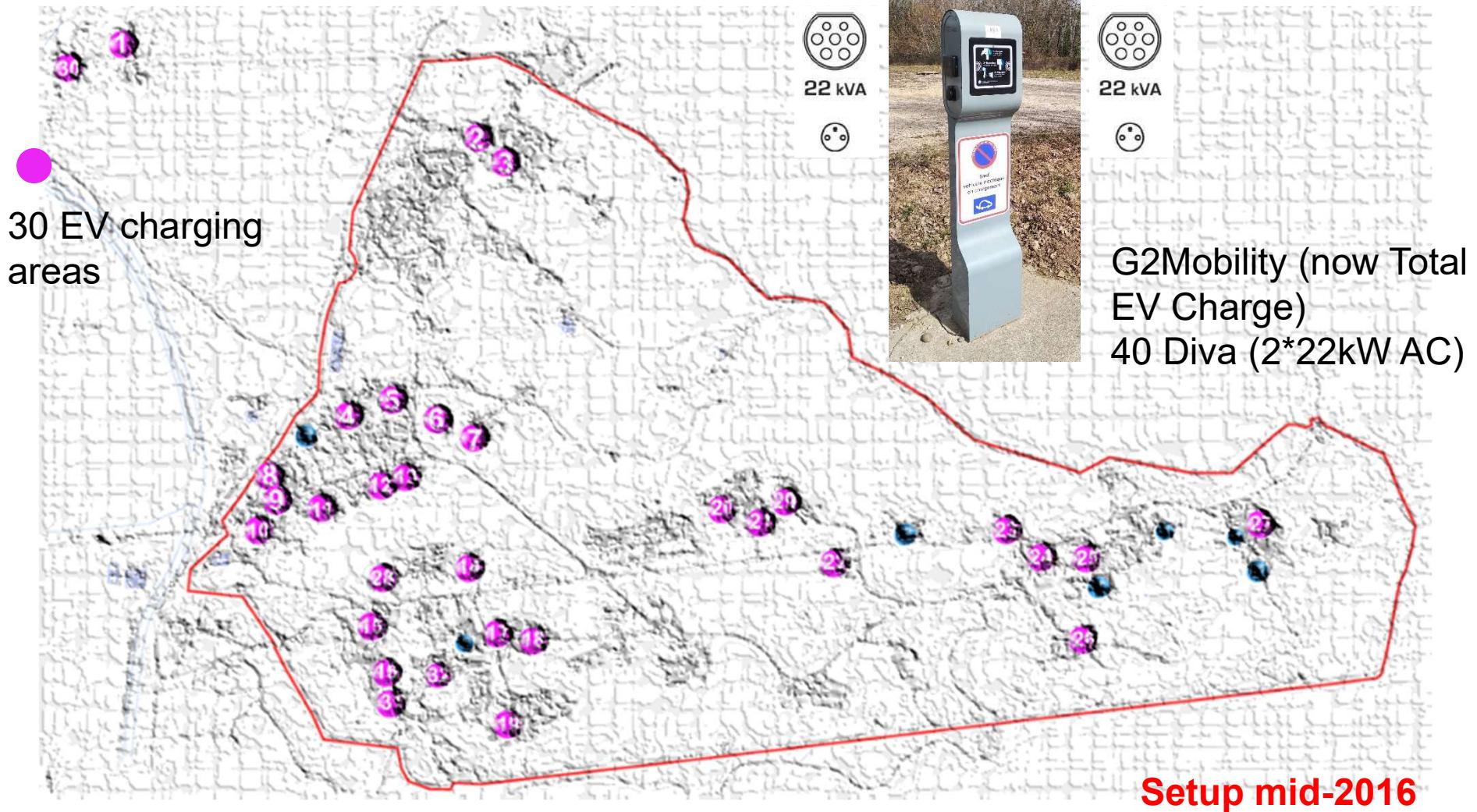
63kV / 15kV substation



CEA CADARACHE – SOLAR R&D



EVCI CADARACHE – CHARGING STATION



CEA = Charging Point Operator and e-Mobility Service Provider.

LOG OF CHARGING SESSIONS – JUNE 2016 / MAY 2020

HD: Date/Time at the beginning of the session (UTC)

Name of the charging station

ID: Value of the powermeter at the beginning of the session (Wh)

IF: Value of the powermeter at the end of the session (Wh)

HF: Date/Time at the beginning of the session (UTC)

of the user

DebutSessionUTC	FinSessionUTC	PointdeCharge	Badge	IndexDebut	IndexFin	TypedePrise
07/06/2016 11:38	07/06/2016 13:31	CU-BAT1011-13CEA-3	7490E56D	75873	80847	T2
08/06/2016 06:15	08/06/2016 11:43	CU-BAT1511-13CEA-3	CE14EB7E	74156	76878	T2
08/06/2016 11:47	08/06/2016 11:52	CU-BAT1011-13CEA-3	7490E56D	80906	81679	T2
08/06/2016 12:02	08/06/2016 13:46	CU-BAT1011-13CEA-3	7490E56D	81679	91062	T2
08/06/2016 12:22	08/06/2016 17:17	CU-BAT1011-13CEA-2	D527CEE3	29009	35782	T2
08/06/2016 12:34	08/06/2016 15:23	CU-BAT1511-13CEA-3	85F1D2E3	76878	81364	T2
08/06/2016 12:42	08/06/2016 12:57	CU-BAT8371-13CEA-2	6468EB6D	2686	3142	T2
08/06/2016 12:59	09/06/2016 08:38	CU-BAT8371-13CEA-2	6468EB6D	3145	66192	T2
08/06/2016 13:04	08/06/2016 13:08	CU-BAT8371-13CEA-6	6503DCE3	765	1566	T2

Transaction Duration (h)=(HD – HF)

Unreliable

Energy Consumption (kWh)=(IF – ID)/1000

GLOBAL STATISTICS

Period 01/06/2016 to 31/05/2020 :

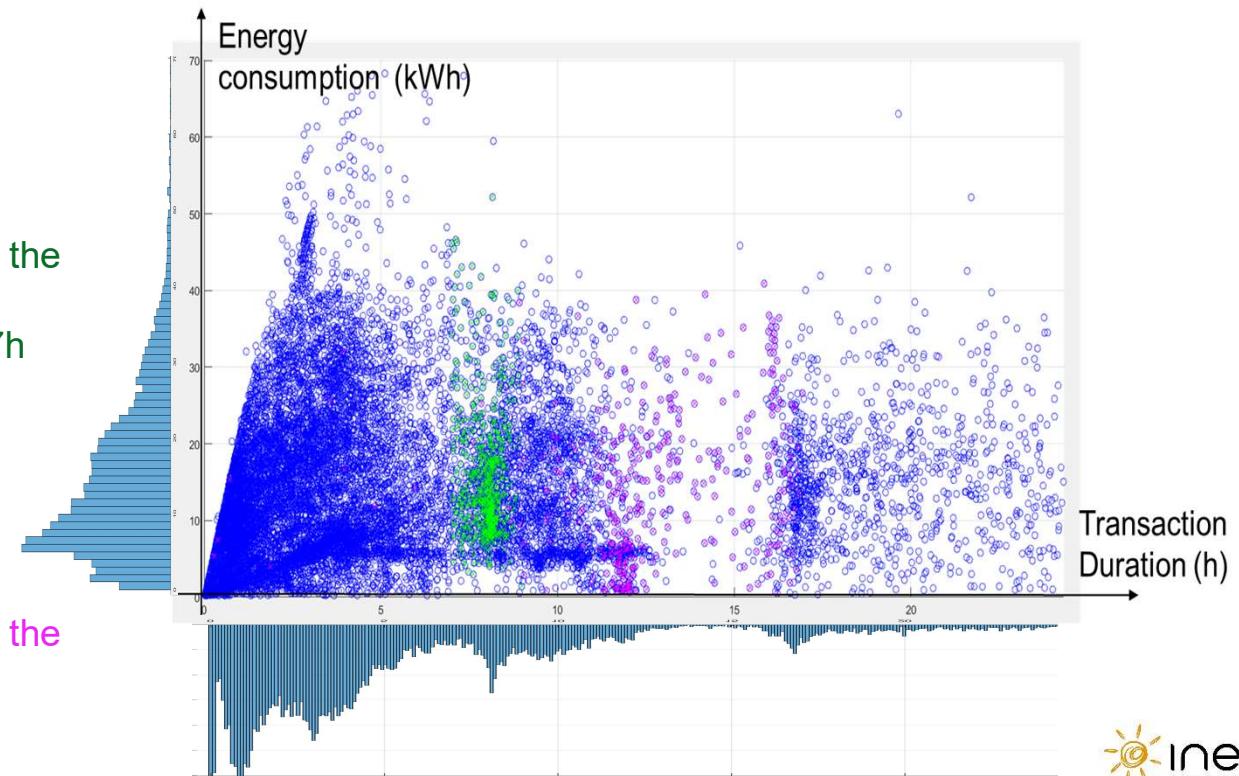
- 17045 transactions
- Mean of energy/transaction 14.8 kWh
- Mean of the transaction duration : 12.4h
- Total energy : 253.2 MWh
- ~1500000km @17kWh/100km

Full workday charging i.e

- start after 7h and finish before 17h the same day
- and charge duration greater than 7h (743 occurrences (4.7%))

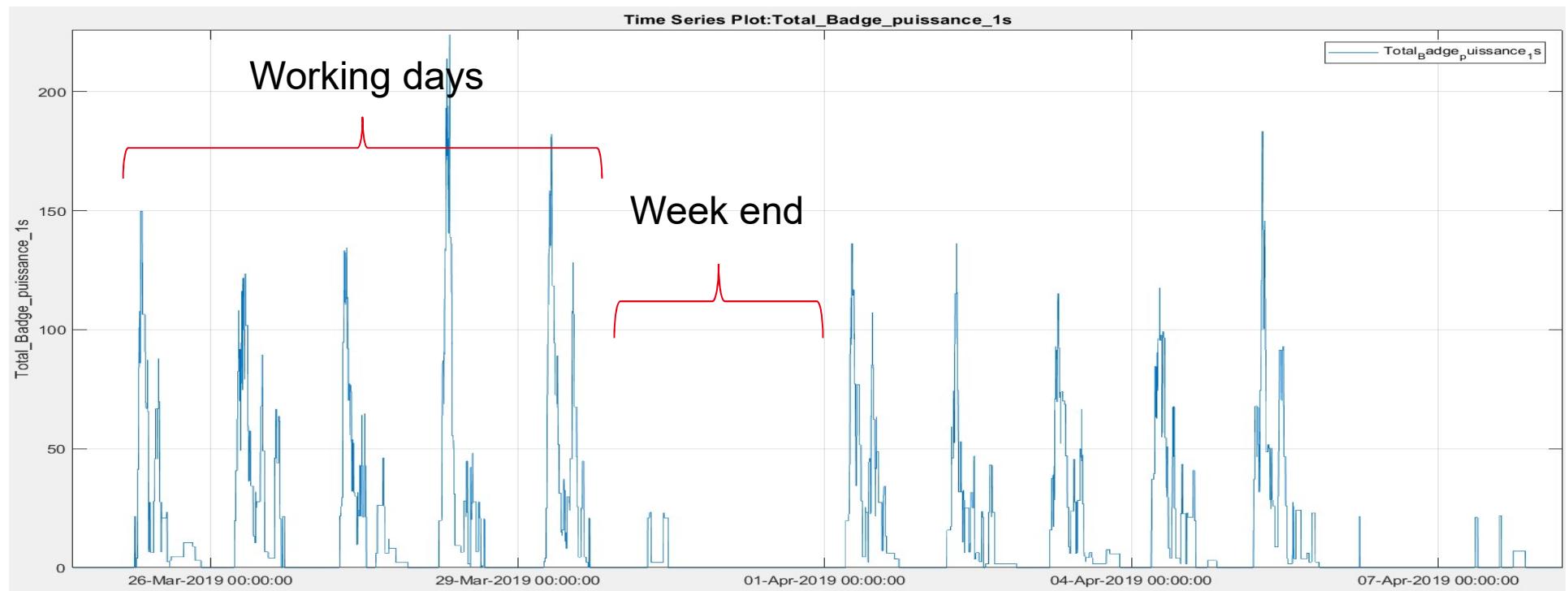
Full night charging i.e

- start after 15h and finish before 9h the following day (430 occurrences (2.7%))



MAX CHARGING POWER HYP. : LOAD CURVES

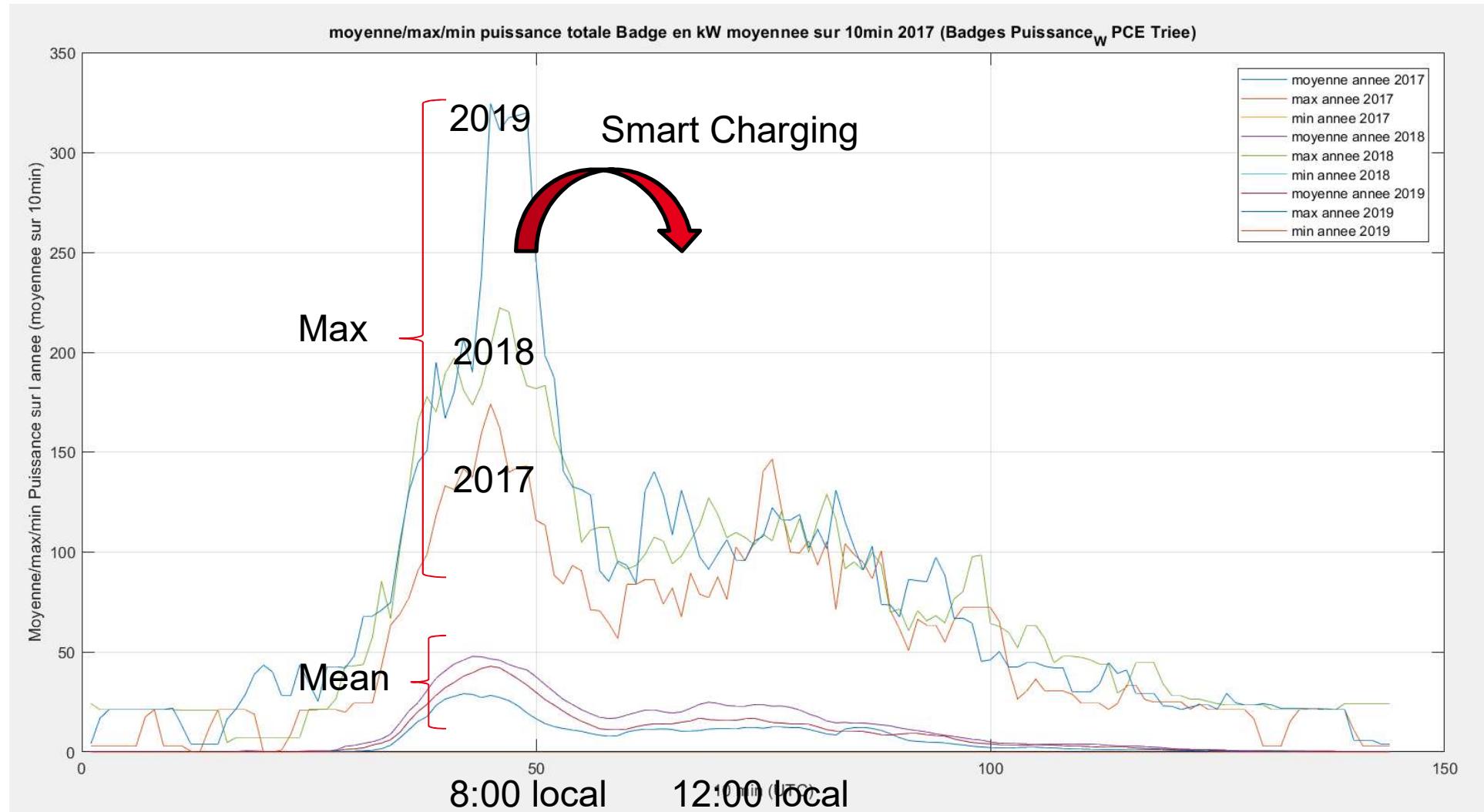
Total load curve (i.e. the sum of the power consumption of the EVs) during 2 weeks:



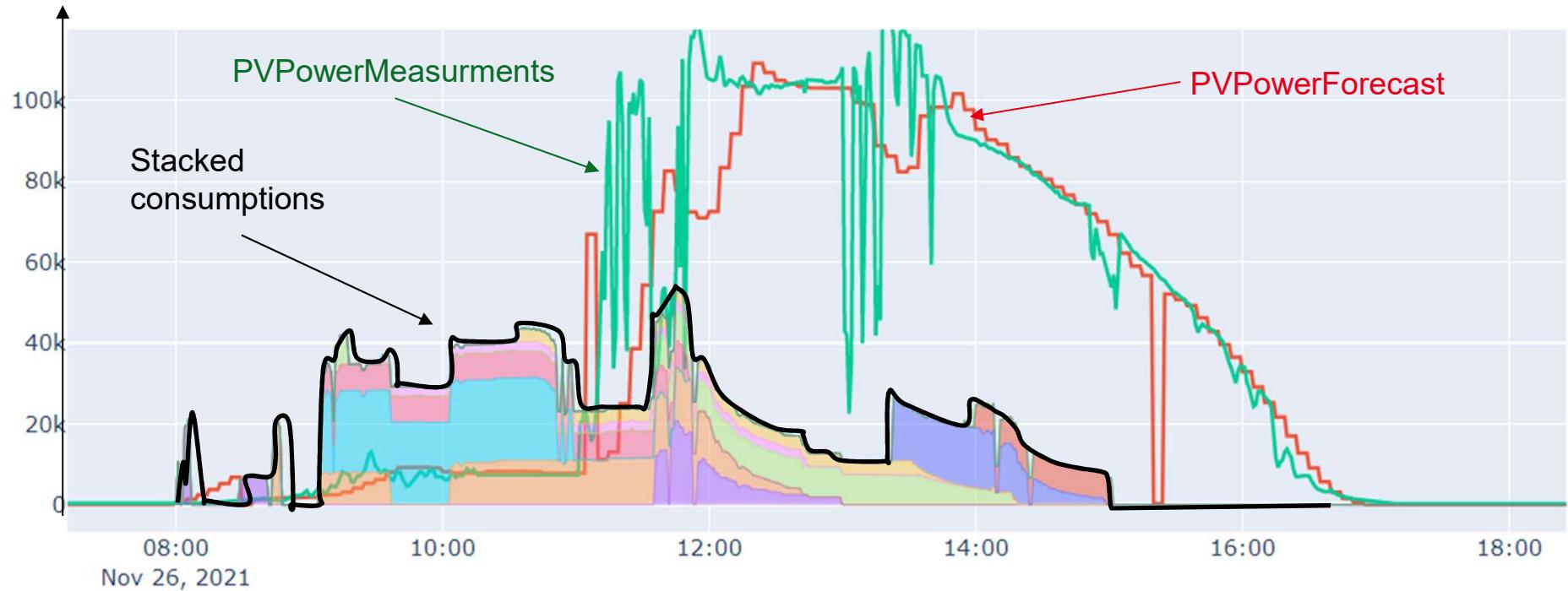
Hypothesis:

- the charge is carried out at constant power and this power is the maximum charging power of the car
- the charge begins as soon as the car is connected to the charging station

MAX CHARGING POWER HYP. : MEAN LOAD CURVES PER HOUR



OBJECTIVES



→ Selfproduction rate (classical definition)
= (energy consumption under green curve) / total energy consumption

However, in order to make the results independant from the PV forecast algorithm, we prefer to maximize the following rate :

→ Selfproduction rate (our experiments)
= (energy consumption under red curve) / total energy consumption

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EVCI CADARACHE – EV & USERS

Model	Brand	Number of EV on site
Zoé	Renault	163
e-208	Peugeot	43
Twingo	Renault	30
Model 3	Tesla	28
Leaf	Nissan	21
Kangoo	Renault	16
E-Niro	Kia	9
e-2008	Peugeot	6
ID3	Volkswagen	6
Berlingo	Citroën	5
Ioniq	Hyundai	5
Golf-GTE	Volkswagen	4
Twizy	Renault	4
Kona	Hyundai	4

Type	#
External companies	29
Personal	260
Service	84
Taxi	3
TOTAL = 376	



3 involvement levels :

Control, information (SOC and forecast departure time) = 75 people

No control, information = 21 people

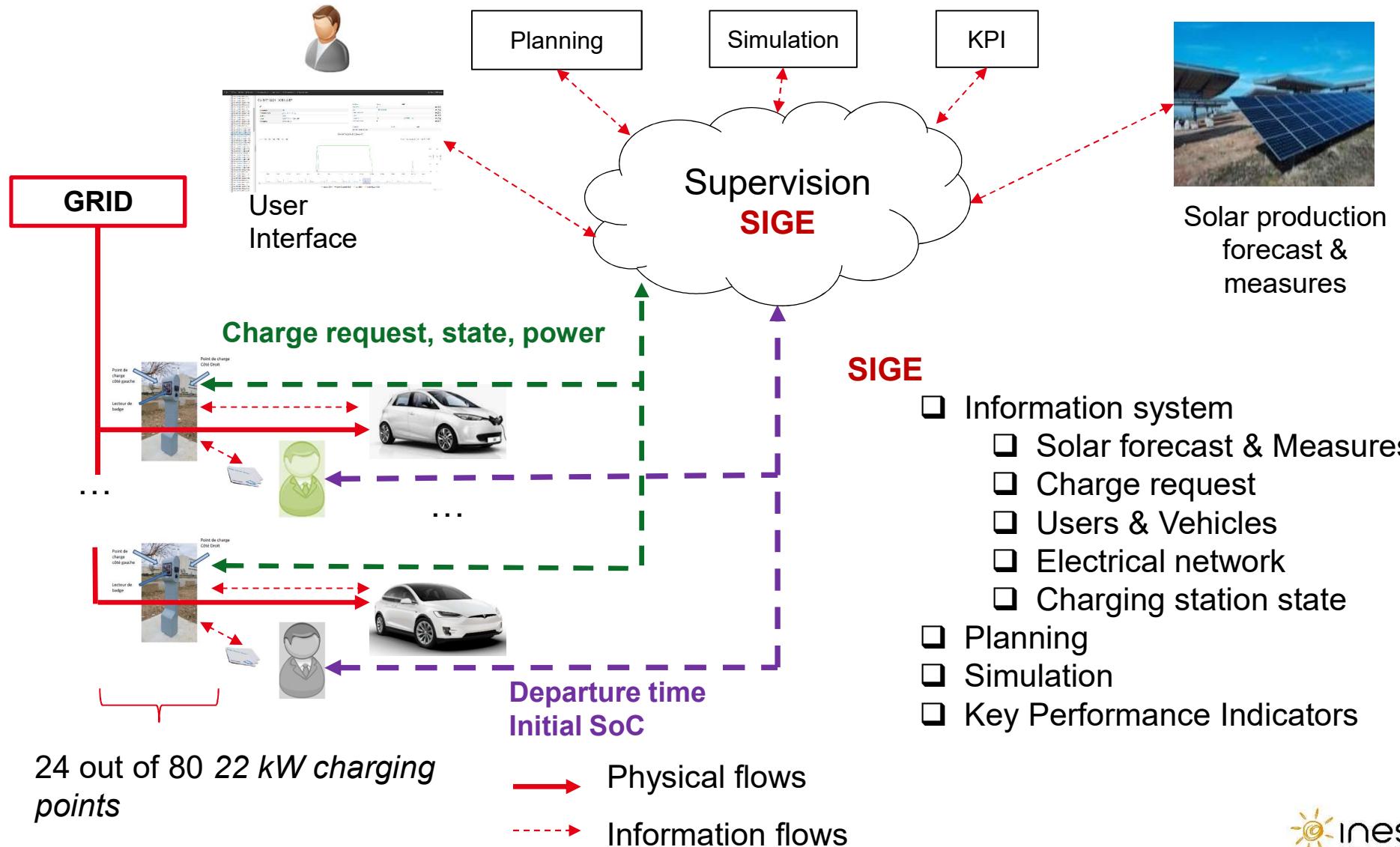
No control, no information = 280 people

...

...

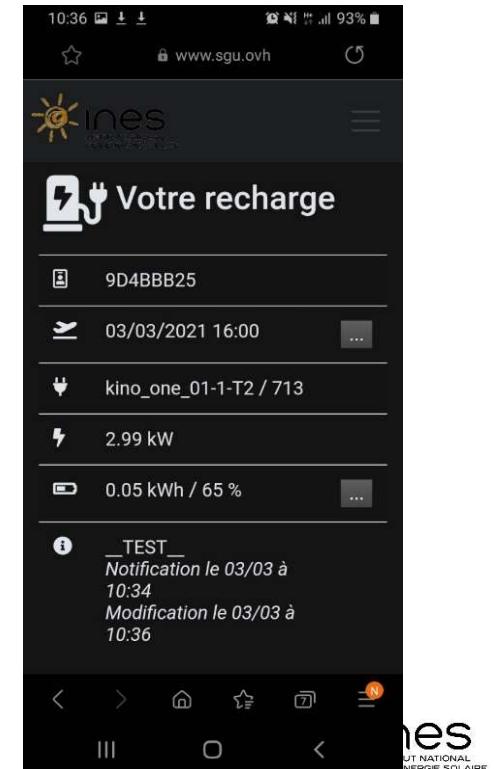
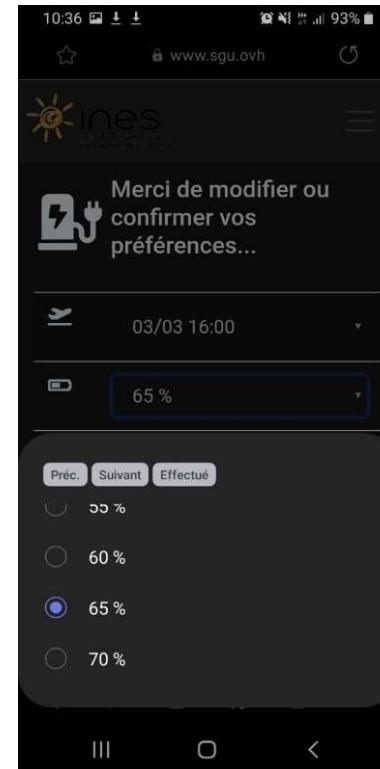
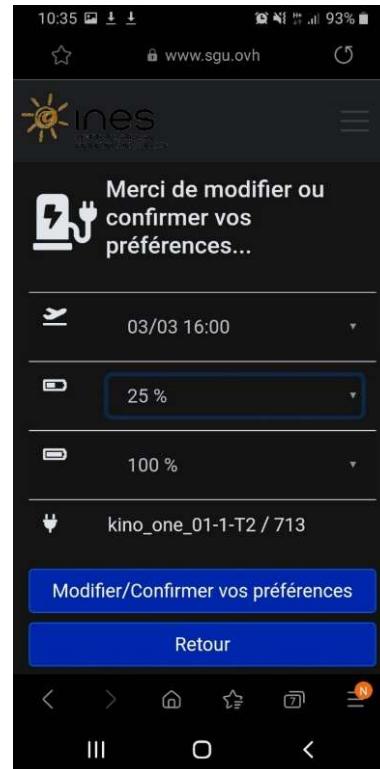
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CONTROL ARCHITECTURE



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.
- Scheduling and recharge are made on the basis of these data



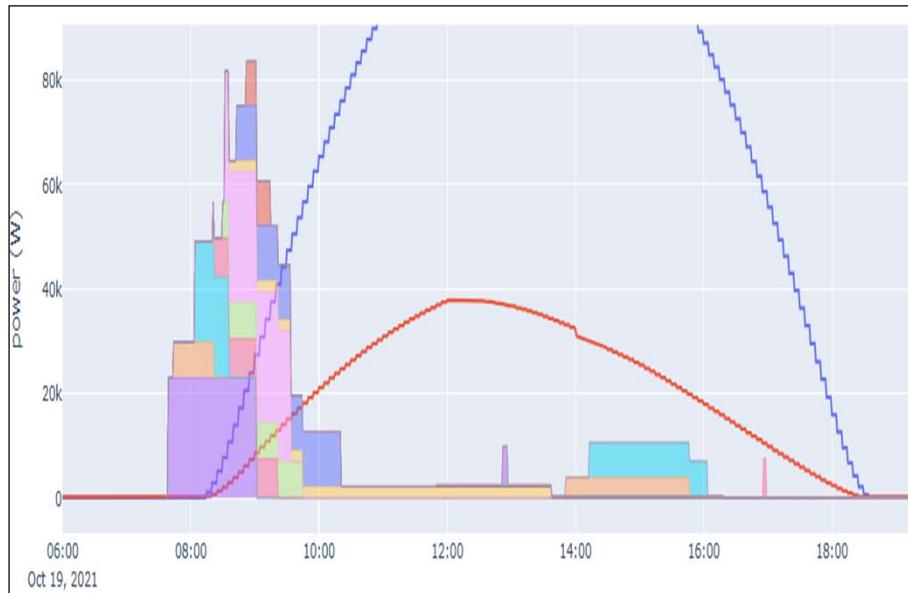
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FIELD TESTS SUMMARY

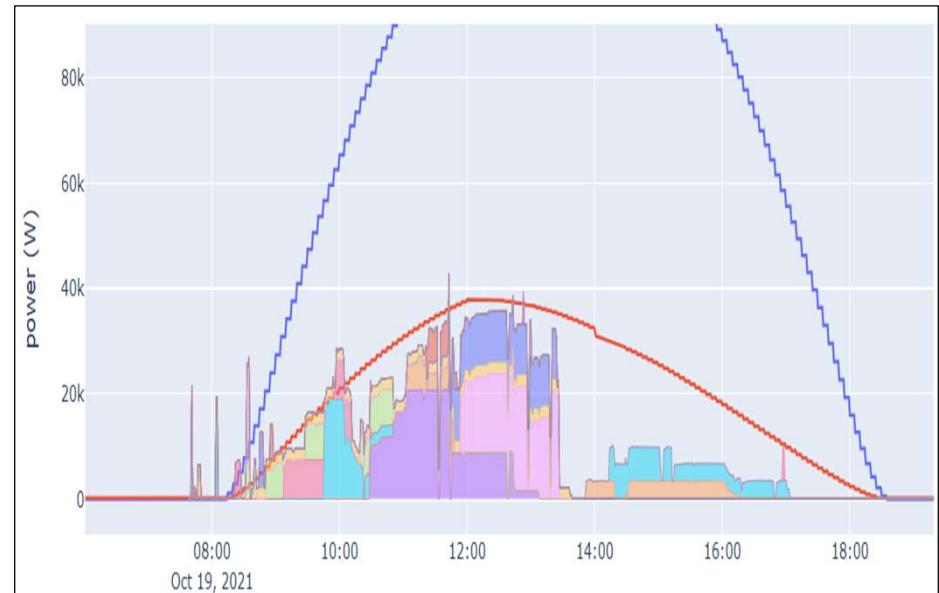
- **124 days between October, 1st 2021 and February, 1st 2022**
 - 73 days with exploitable results
 - 34 days without any EV charging stations
 - 17 days with measurements/control errors
- **887 charging sessions**
- **12.4 MWh (~14kWh/charging session)**

LESSON 1 : SELF-PRODUCTION INCREASE

- 19 Oct. 21 : Cloudy day
- 17 charging sessions (141kWh)
- PV plant = 160kWc (221kWh)
- Self-production rate **34%** (without control) and **90%** (with control)



Without control (simulation)

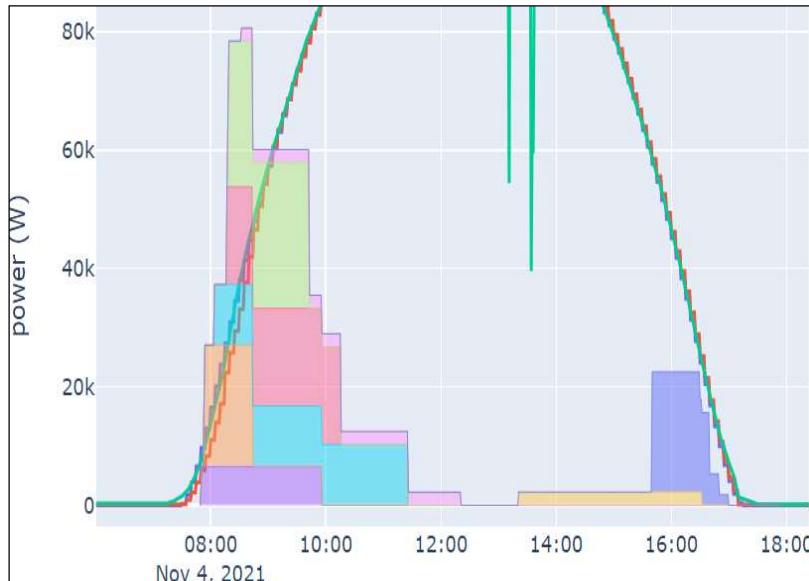


With control (measures)

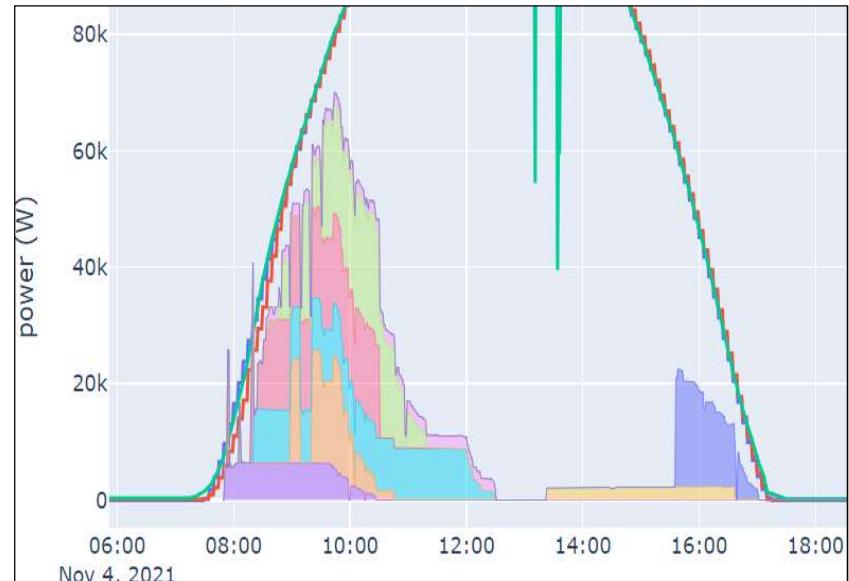
→ Large increase of the self-production ratio thanks to control

LESSON 2 : « NATURAL » SELF-PRODUCTION

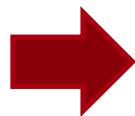
- 4 Nov. 21 : Sunny day
- 9 charging sessions (165kWh)
- PV plant = 160kWc (715kWh)
- Self-production rate **83%** (without control) and **97%** (with control)



Without control (simulation)



With control (measures)



Some days, the self-production rate is high, even without control

LESSON 3 : USERS' BEHAVIOUR

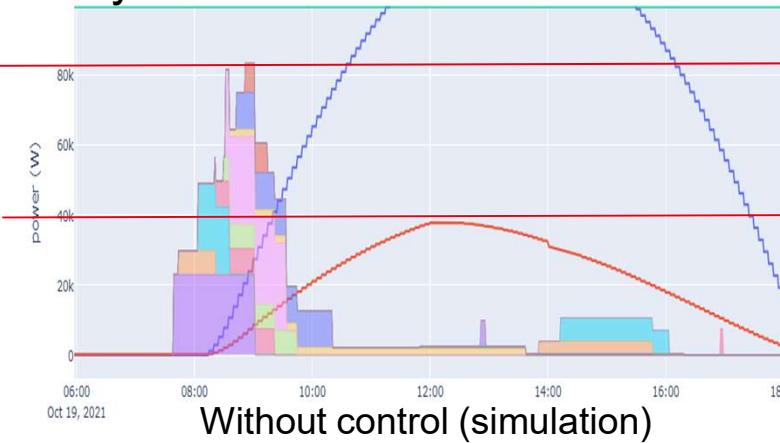
- 21 Oct. 21: Cloudy day
- 19 charging sessions (215kWh)
- PV plant = 160kWc (174kWh)
- Self-production rate **39%** (without control) and **60%** (with control)



→ Users' behaviour strongly influences the results

LESSON 4 : MAX POWER CONSUMPTION

Day 19 Oct. 21

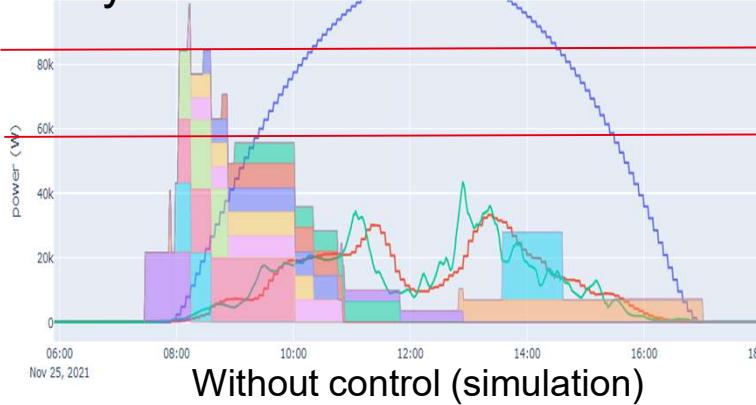


85kW

40kW

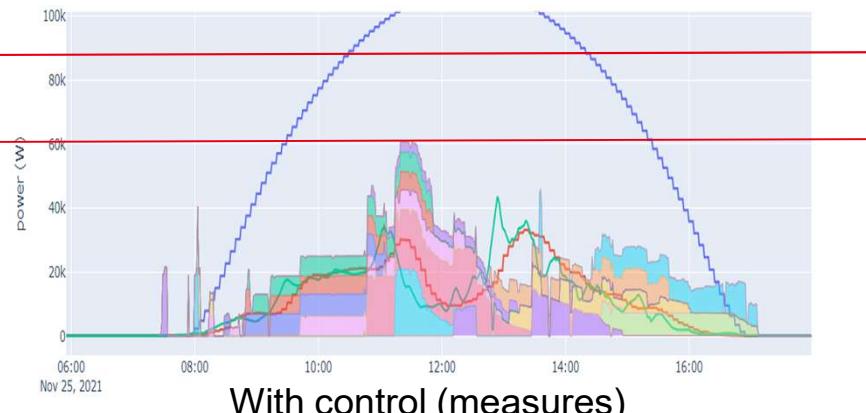


Day 25 Nov. 21



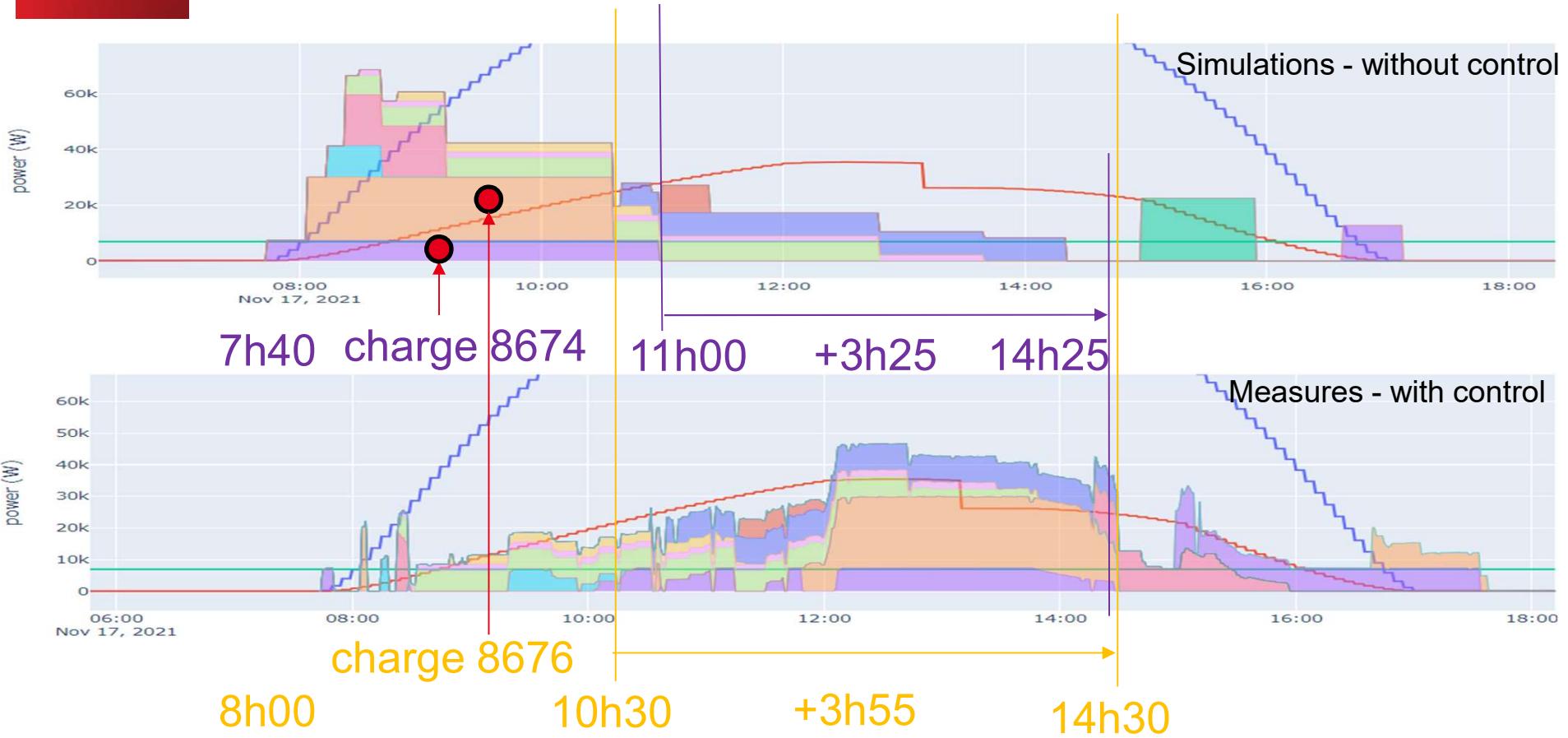
85kW

60kW



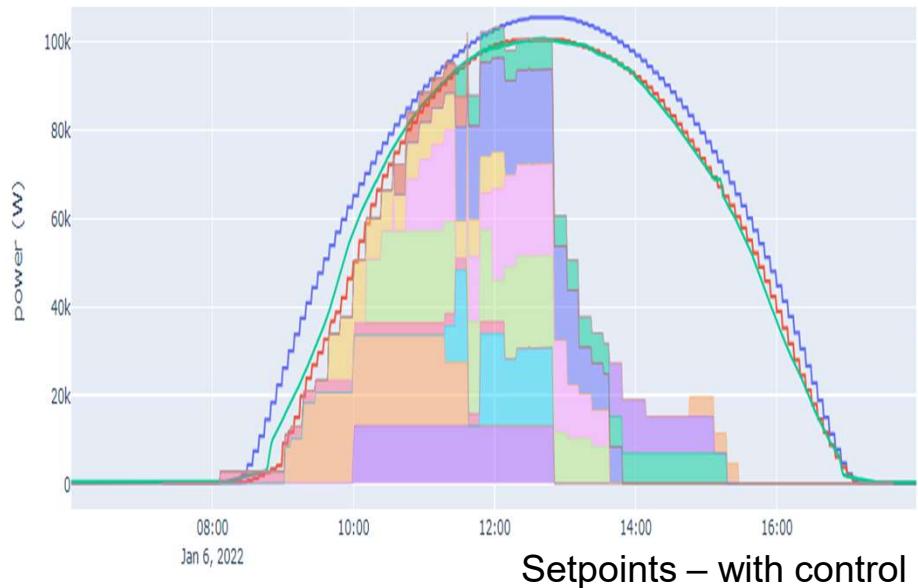
Increasing self-production rate may decrease the maximum value of the power consumption of the EVs

LESSON 5 : DELAYS

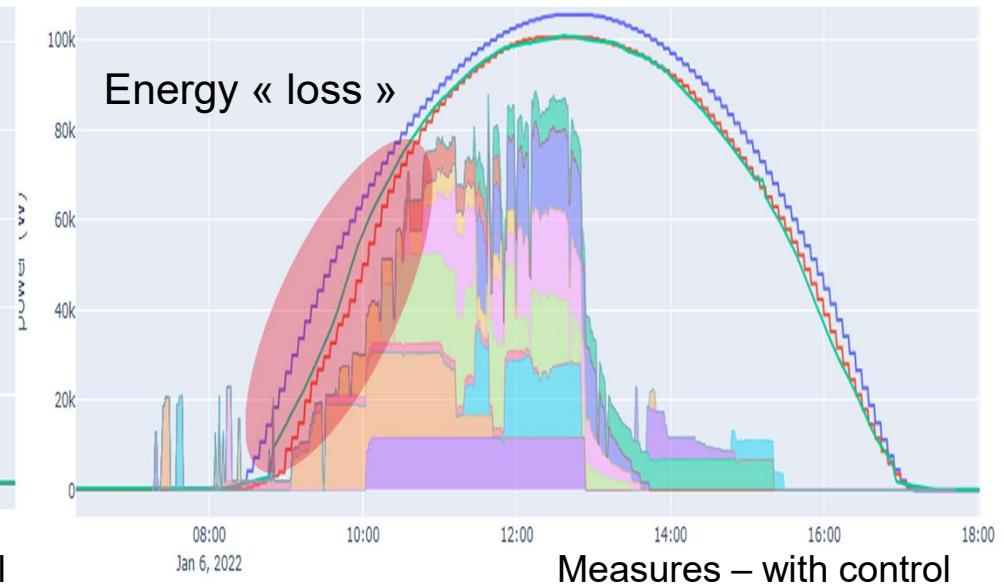


→ Increasing self-production rate may increase drastically the charging time (and so charging station occupancy rate), in particular when the weather is cloudy.

LESSON 6 : IMPORTANCE OF MODELS



Setpoints – with control



Measures – with control

Gap between setpoints and charging power :

- Car model
- Onboard charger size
- Type of connection, cable
- Battery : Temperature, age, SOC
- User setpoints
- Etc.



Accurate charging models are essential to improve charging control

PERSPECTIVES

- Follow the experiments during at least 3 months
- Increase the number of controled charging stations
- Increase the participants number
- Integrate the participants feedback in the control algorithm
- Improve the EV charging models and parameters estimation
- Add Key Performance Indicator , for example, that estimate the state of healf of the batteries with and without control
- Improve the planning algorithm

Details on algorithm and experimental setup available at:

<https://www.mdpi.com/2076-3417/12/9/4523>

Thank you for your attention

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