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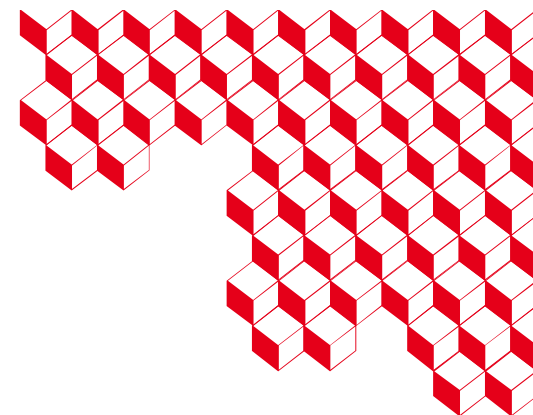
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Sizing PV plant for charging EVs : case study of an industrial site

Robisson Bruno, Ngo Van-Lap, Marchadier Laurie, Bouaziz Mohammed Farouk and Mignonac Alexandre

25/05/2023

T-IPV - French Contribution to IEA PVPS T17 - PV & Transport



International Energy Agency
Photovoltaic Power Systems Programme
T17 PV & Transport

Agenda

1. Context

2. Principle of the method

3. Method in details

Business Model

EV consumption

PV Production

EV charging

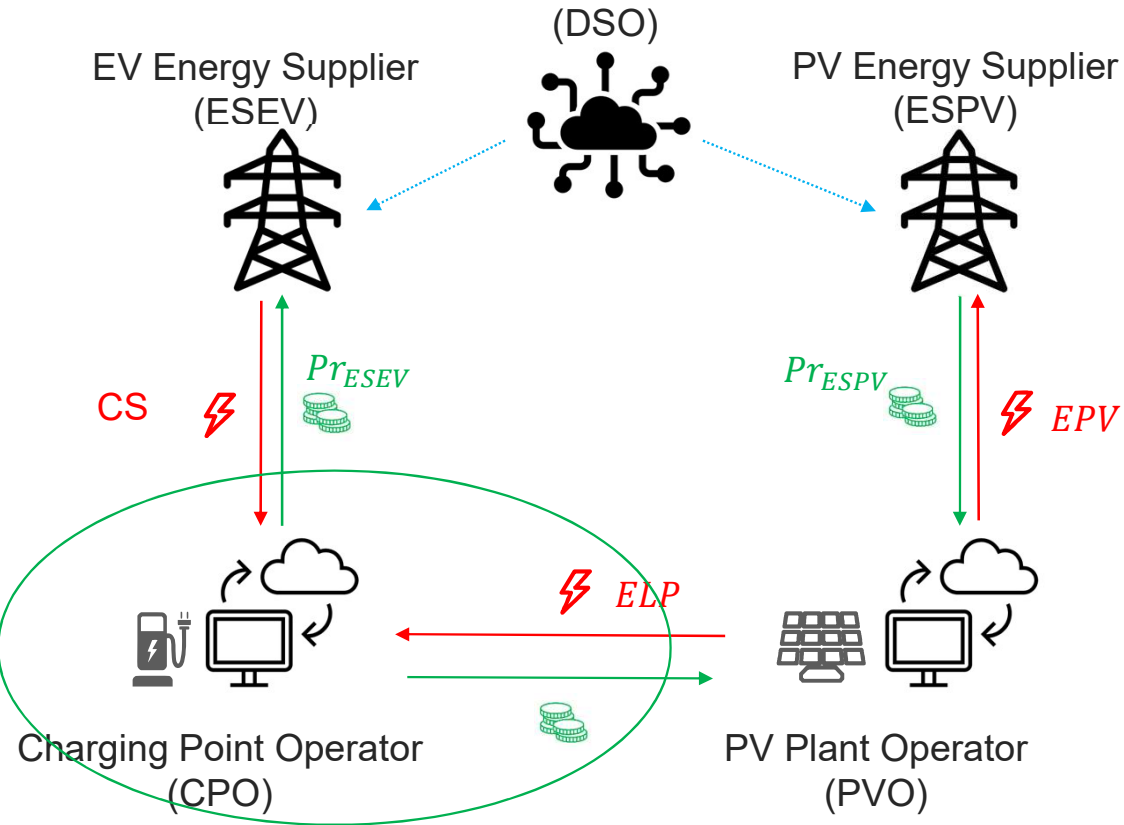
4. Examples

5. Conclusion and perspectives






1 ■ Context

Context



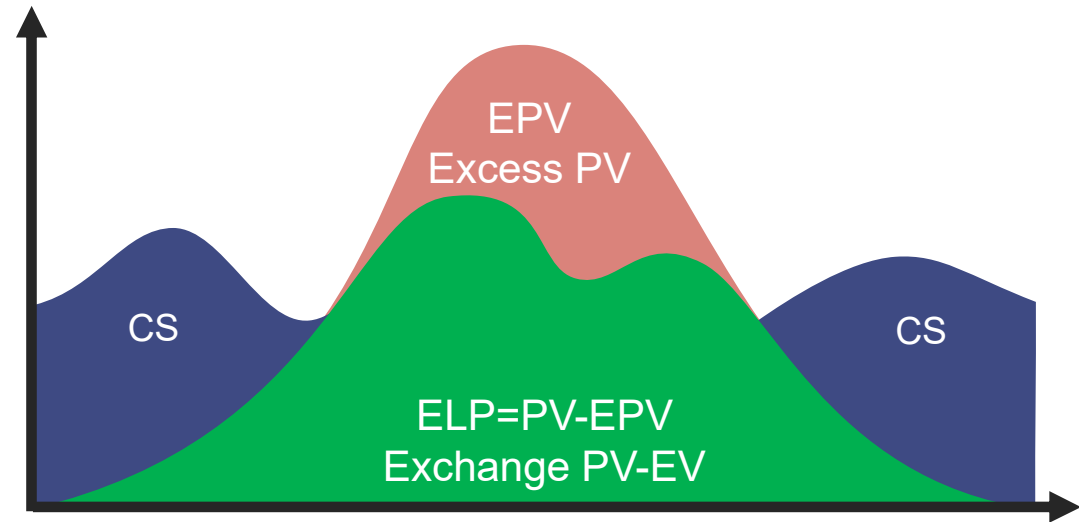
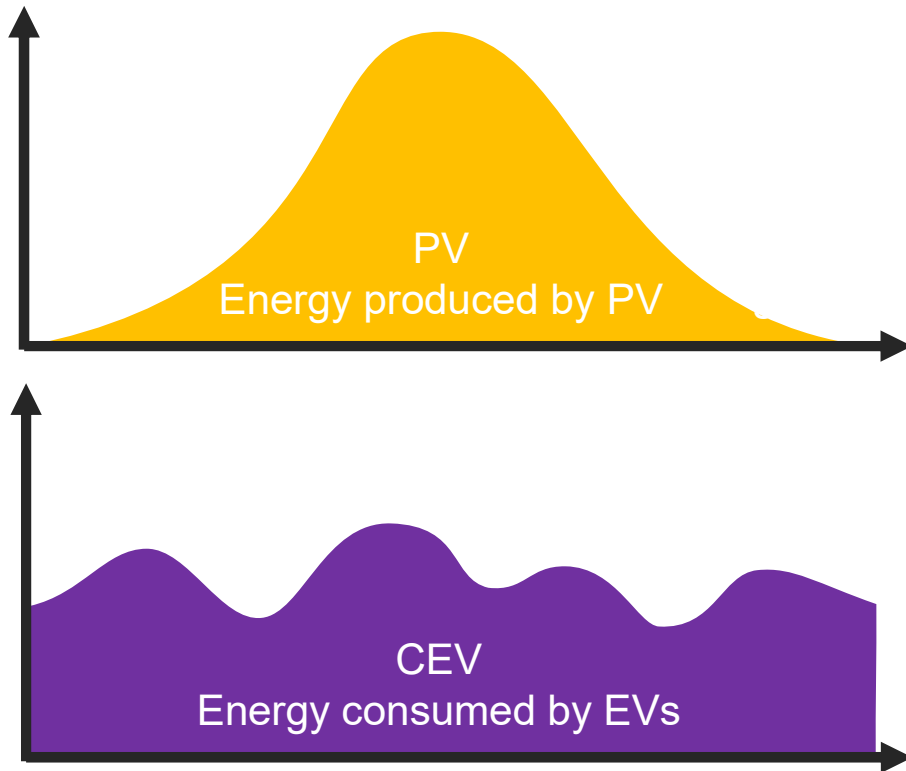
→ PV plants are solar carports or ground mounted PV plant near the EV charging stations } « Local » PV

→ PVO is not the CPO

-  Financial Transaction
-  Energy Flow
-  Information Flow

Exchange scheme € ↔ kWh

Exchange € ↔ kWh



CPO buys local PV energy (ELP) to the PVO
 CPO buys **Complementary Supply (CS)** to the supplier ESE
 PVO sells **excess PV (EPV)** to the supplier ESPV

$SPR \text{ SelfProductionRate} = ELP / CEV$
 $SCR \text{ SelfConsumptionRate} = ELP / PV$

$MeanPowerPrice = Cost_{CPO} / CEV =$
 $(Price_{PV} * ELP + Price_{Network} * CS) / CEV$



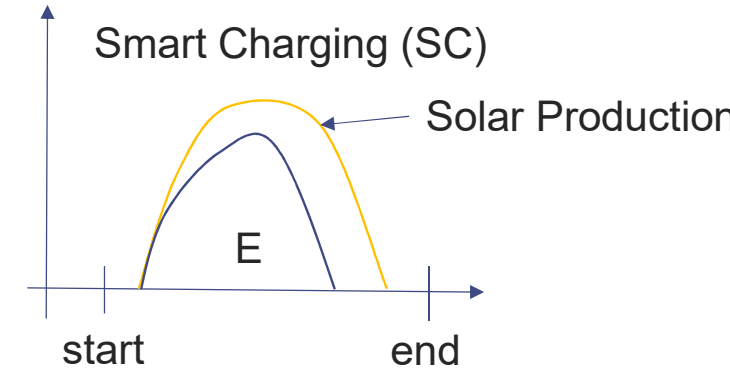
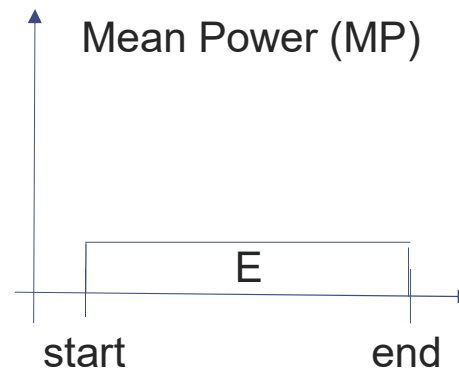
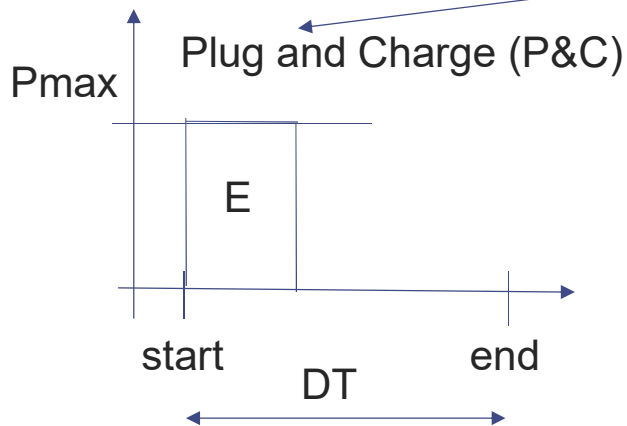


Problematic

Given an exchange scheme:
Given a certain target for CPO mean power price (€/kWh),
what will the PV peak power be (kWp)?
Or
Given certain PV peak power (kWh), what will be the CPO
mean power price (€/kWh)

For different charging strategies

Energy consumption E
Duration of Transaction (DT)



Algorithm detailed in a future paper

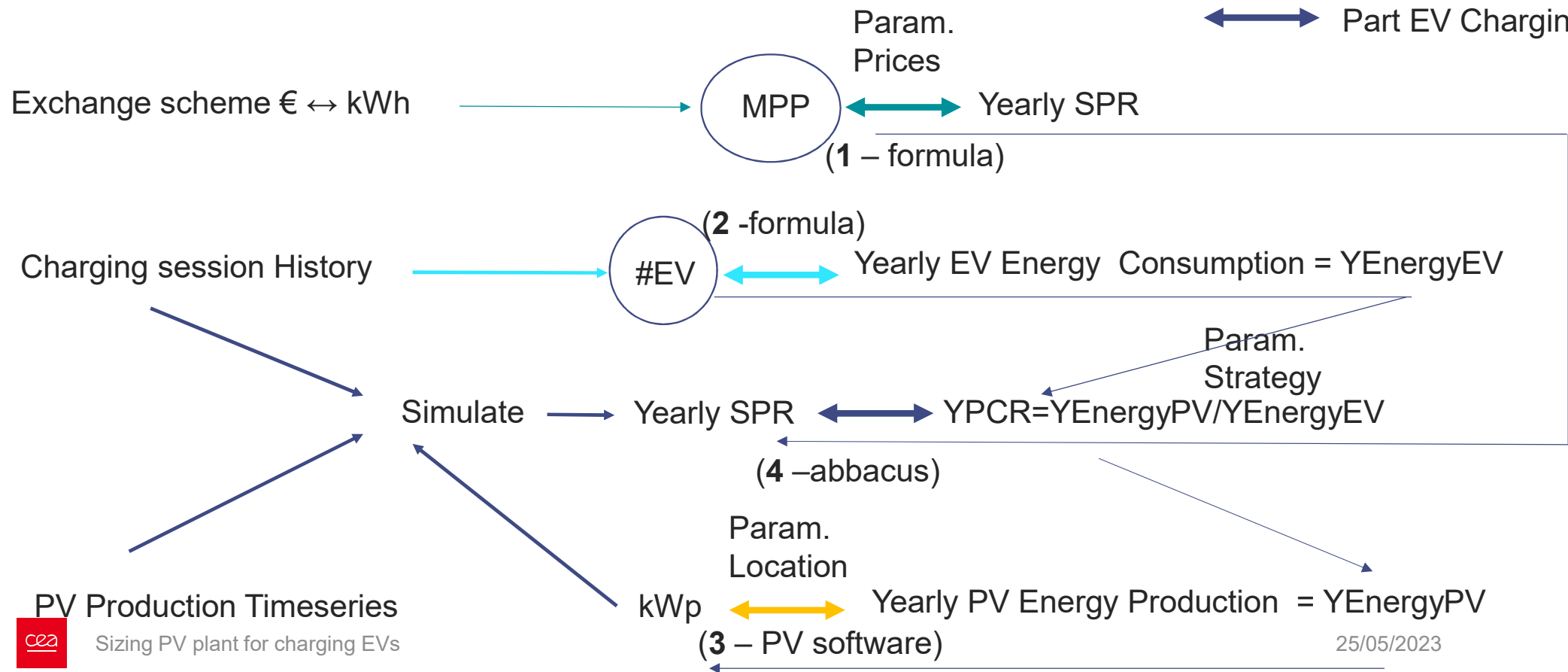


2. Principle of the method



Principle of the method

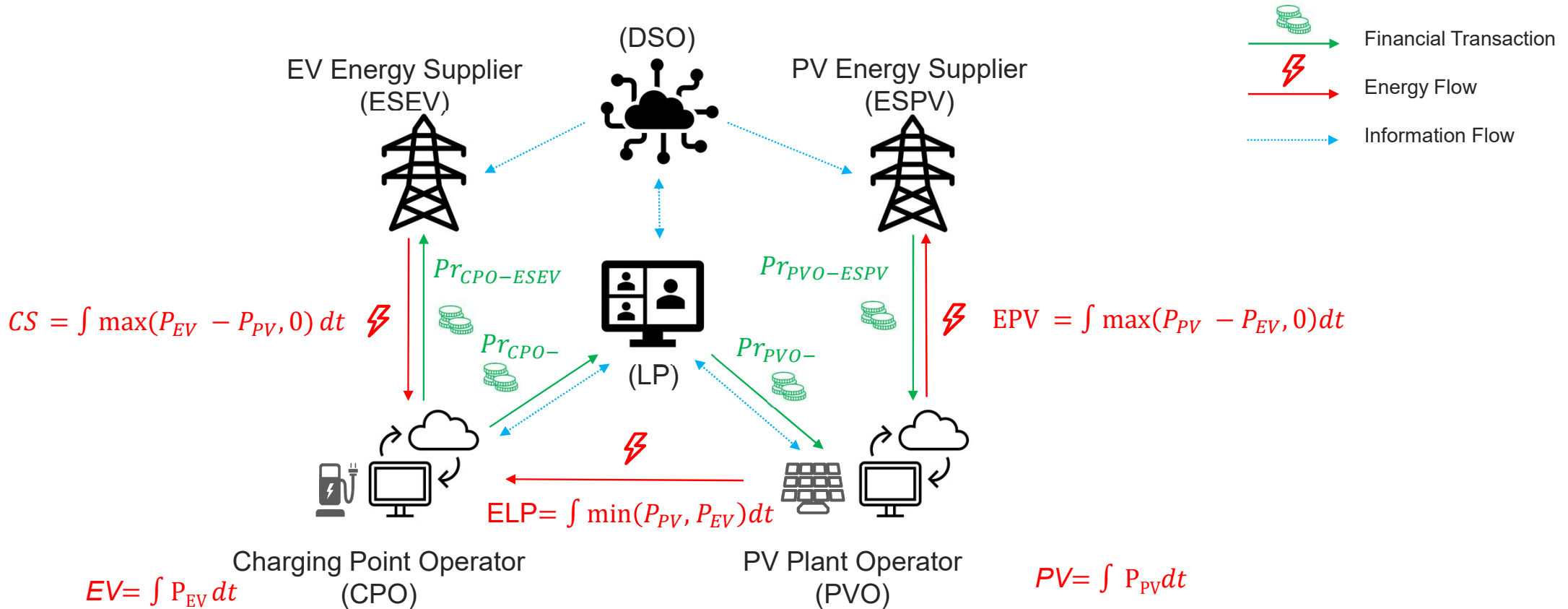
- ↔ Part Business Model
- ↔ Part EV Consumption
- ↔ Part PV Production
- ↔ Part EV Charging





3 ■ Method in details

Business models





Business models

With hypothesis

- Fixed prices
- $P_{PVO-LP} = P_{PVO-ESPV}$ → PVO sells energy at the same price whatever the customer
- $P_{PVO-LP} = P_{CPO-LP}$ → LP makes no financial margin

Then

$$MPP = \text{Cost-LT}_{CPO} / \text{CEV} = P_{CPO-ESEV} - \text{SPR} * (P_{CPO-ESEV} - P_{CPO-LP}) \quad [\text{Relationship 1 - formula}]$$



EV consumption : Charging sessions

From CEA Cadarache research center : EVCI of 81 charging points (30 stations) at 22kVA

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

HF: 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)

of the user

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

$$\text{Transaction Duration (h)} = (\text{HD} - \text{HF})$$

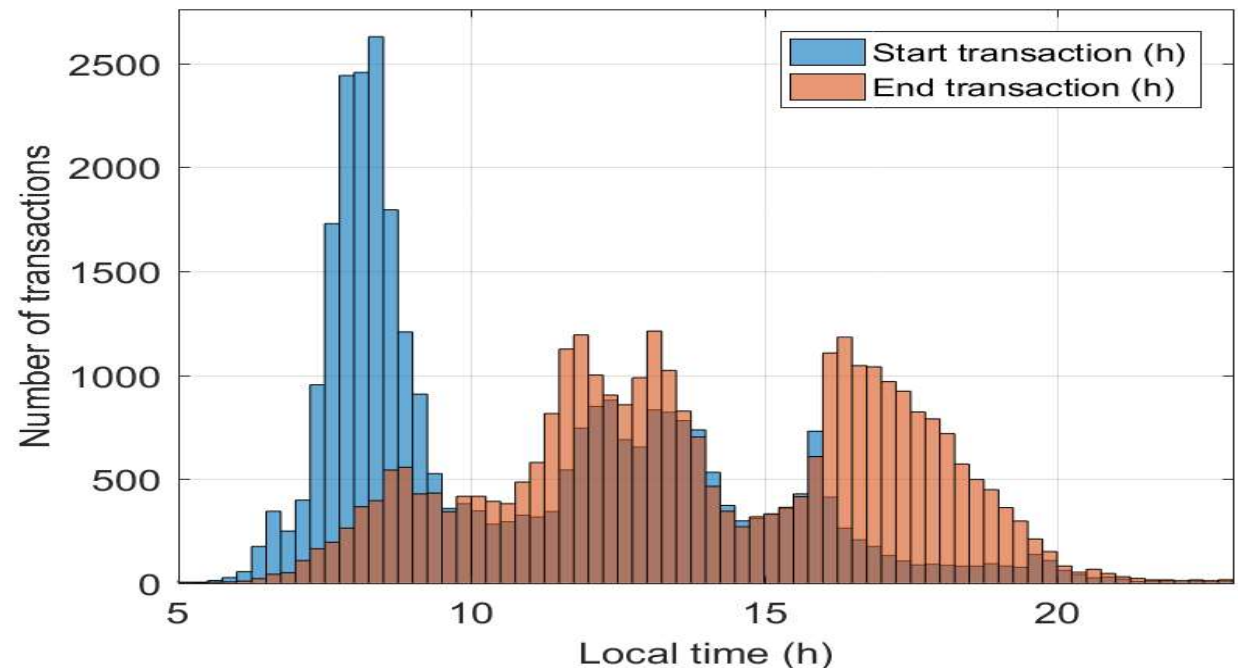
$$\text{Energy Consumption (kWh)} = (\text{IF} - \text{ID}) / 1000$$



EV consumption : Charging sessions

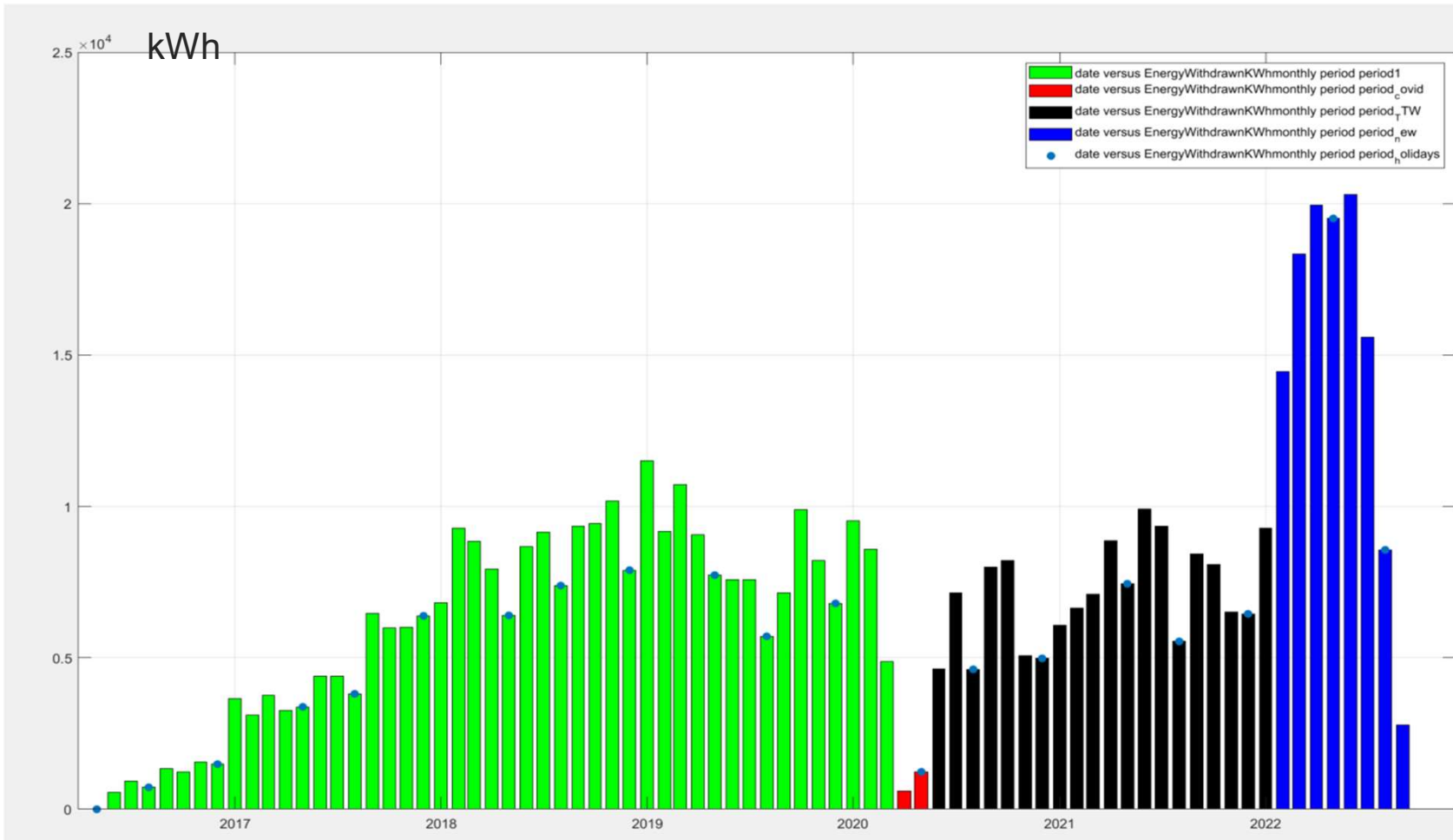
From 1st June 2016 to 31th August 2022

- 32014 transactions
- Mean of energy/transaction 17.22 kWh
- Mean of the transaction duration : 11.3h
- Total energy : 551 MWh





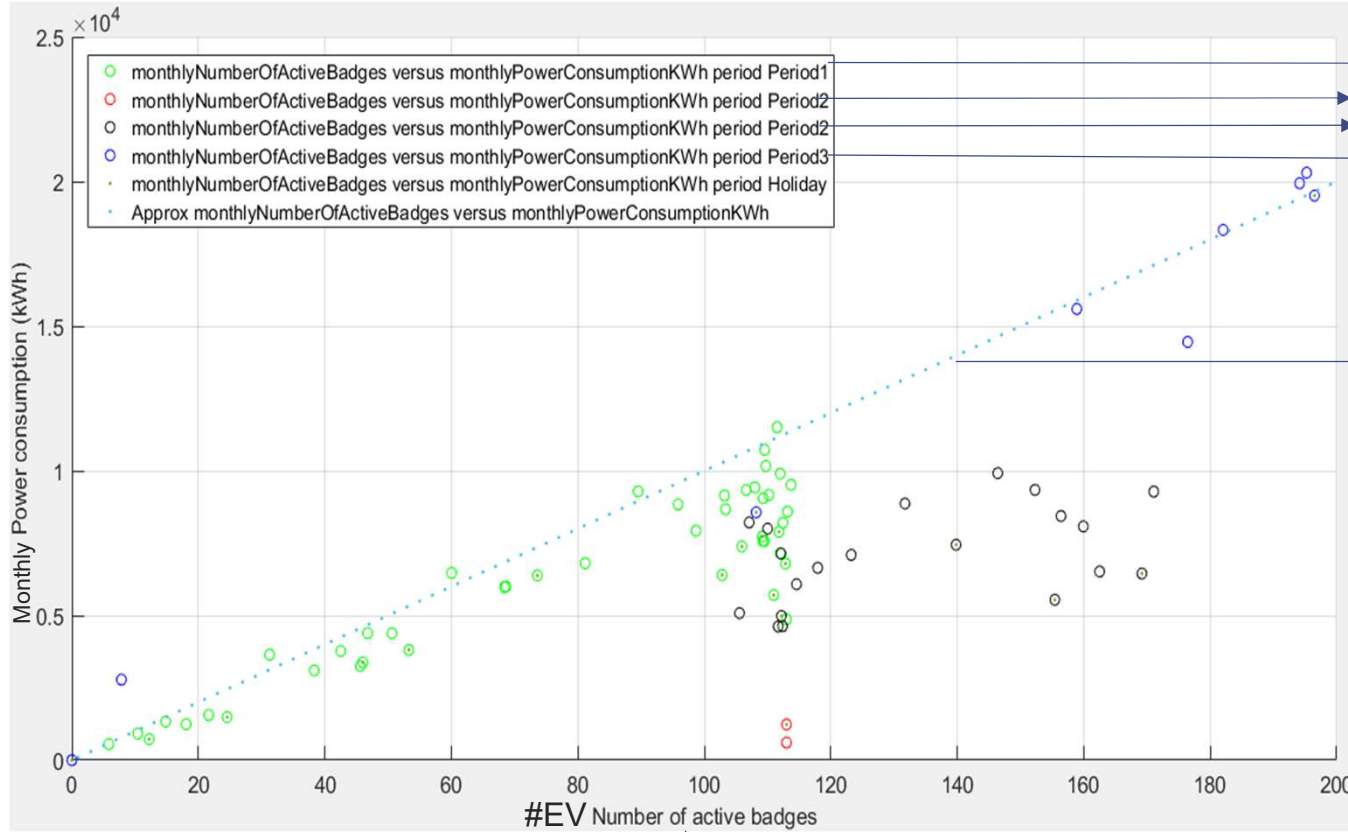
EV consumption : Charging sessions



- Pre-covid
- First lock-down
- Hybrid working
- Post-covid



EV consumption : Charging sessions



Pre-covid
First lock-down
Hybrid working
Post-covid

Monthly Power Consumption
 $= 100 * \#EV$ (in kWh)

Yearly EV Energy Consumption
 $= Y_{EnergyEV}$
 $= 12 * 100 * \#EV$ (in kWh)

[Relationship 2 - Formula]

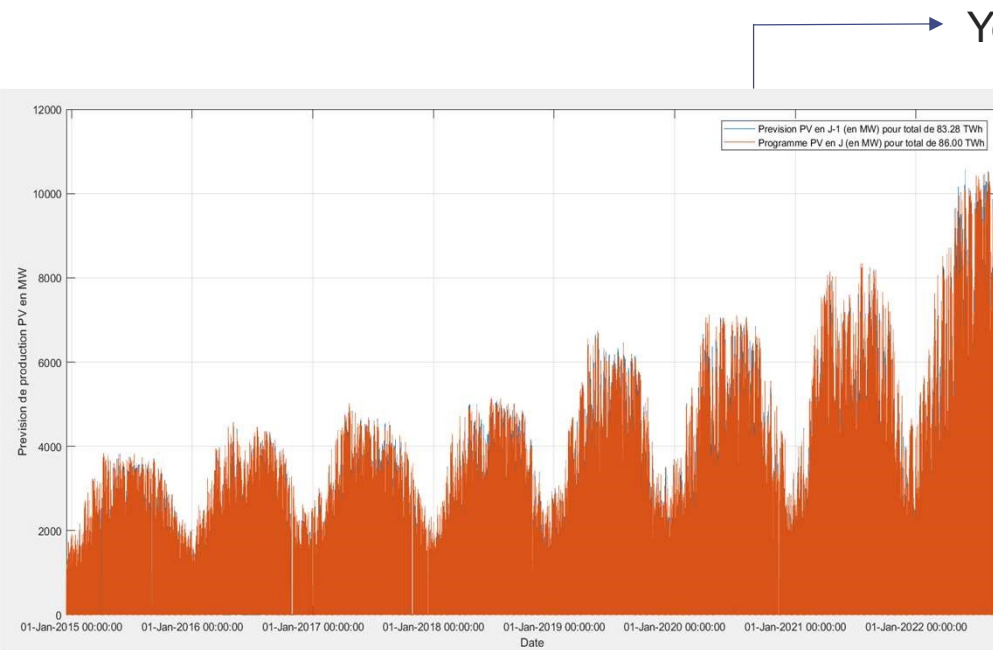
A badge is said to be “active” from its first connexion to the EVSE to its last connexion.
The number of active badge is computed for charging session history.

PV production : Timeseries

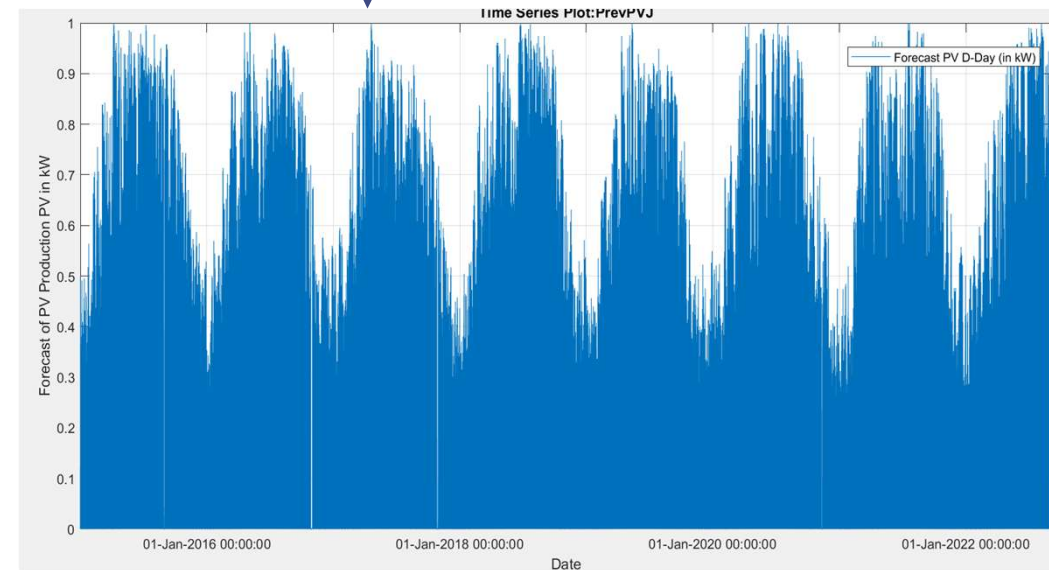


French PV production forecast (D-day at 8 o'clock, step 1 hour) from

<https://www.services-rte.com/fr/telechargez-les-donnees-publiees-par-rte.html?category=generation&type=forecasts&subType=SOLAR>



Yearly normalization



4GWp → 10GWp

1kWp

Hypothesis : PV forecast = PV production





PV production: Yearly production

Case 1 (with timeseries):

Integrate the power over a year : Location Cadarache



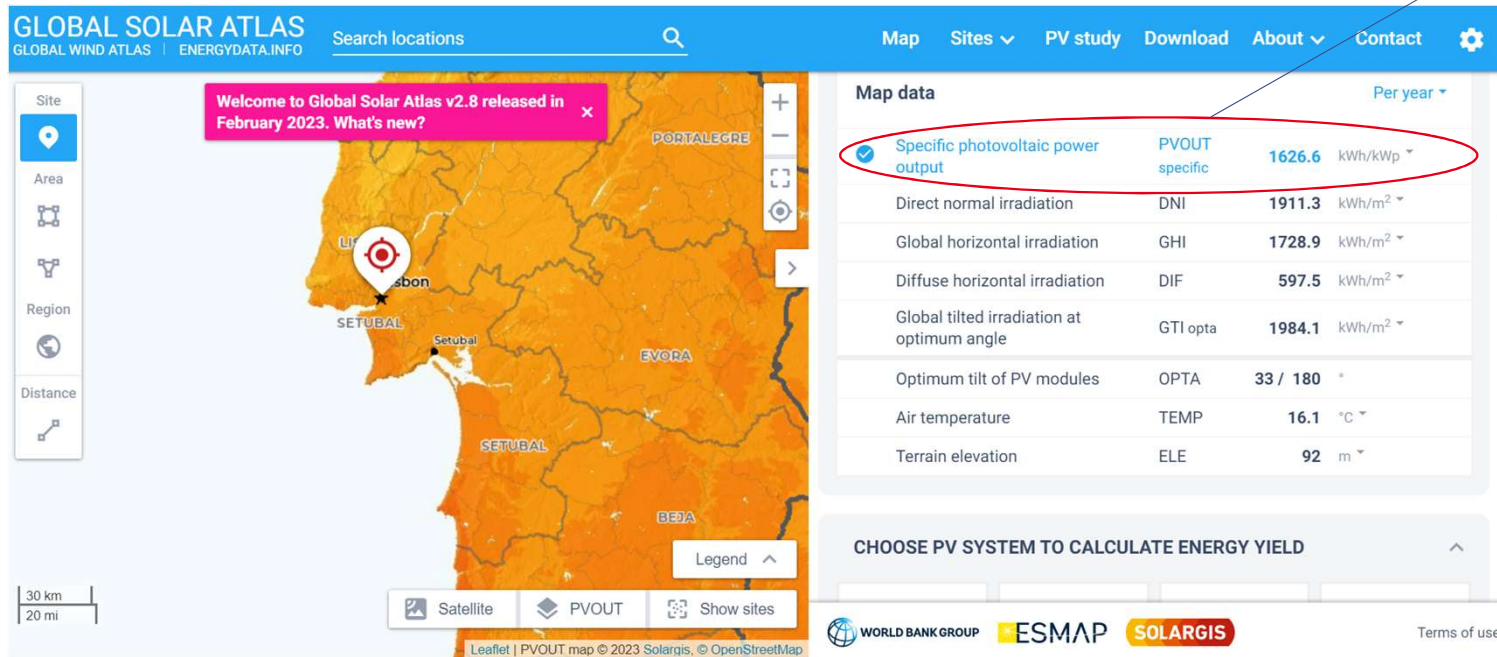
Yearly PV Energy Production
= YEnergyPV ~ 1700*kWp (in kWh)

Case 2 (without timeseries) :

Use a « solar atlas » (or PVGIS) : Location Lisbon



YEnergyPV ~ 1600*kWp (in kWh)



[Relationship 3 - Software]

EV charging

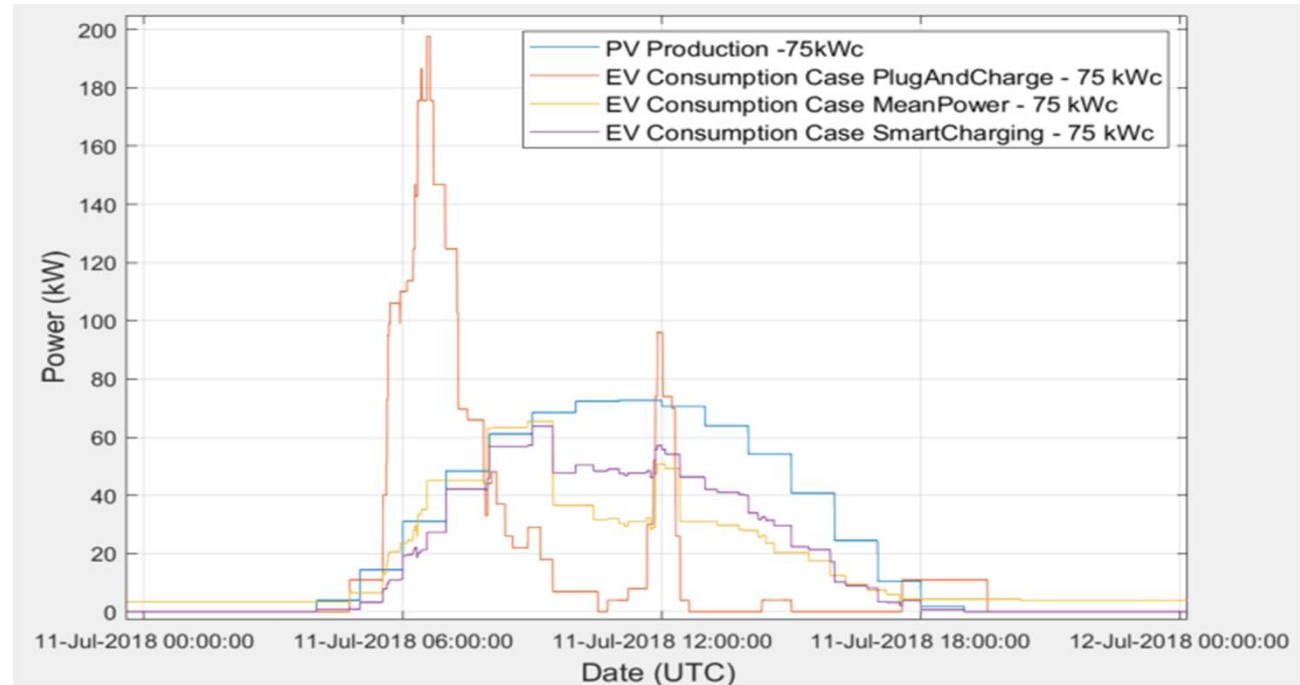


Charging session History
6 years period

Simulate for [PlugAndCharge;
MeanPower ; SmartCharging]

Compute a X kWp PV plant timeserie with
X in
[0,1,25,50,75,100,125,150,175,200,300,700,
1000,5000, 12000] (kWp)

PV Production Timeseries



Simulation results for a 75kWp PV production

KPI

KPI	PC	MP	SC
Self-Consumption Rate (%)	31	62	69
Self-Production rate (%)	49	89	100
Cost-LTC _{PO} (€)	55	47 (-15%)	44 (-16%)

KPI calculated on 11/07/2018

25/05/2023



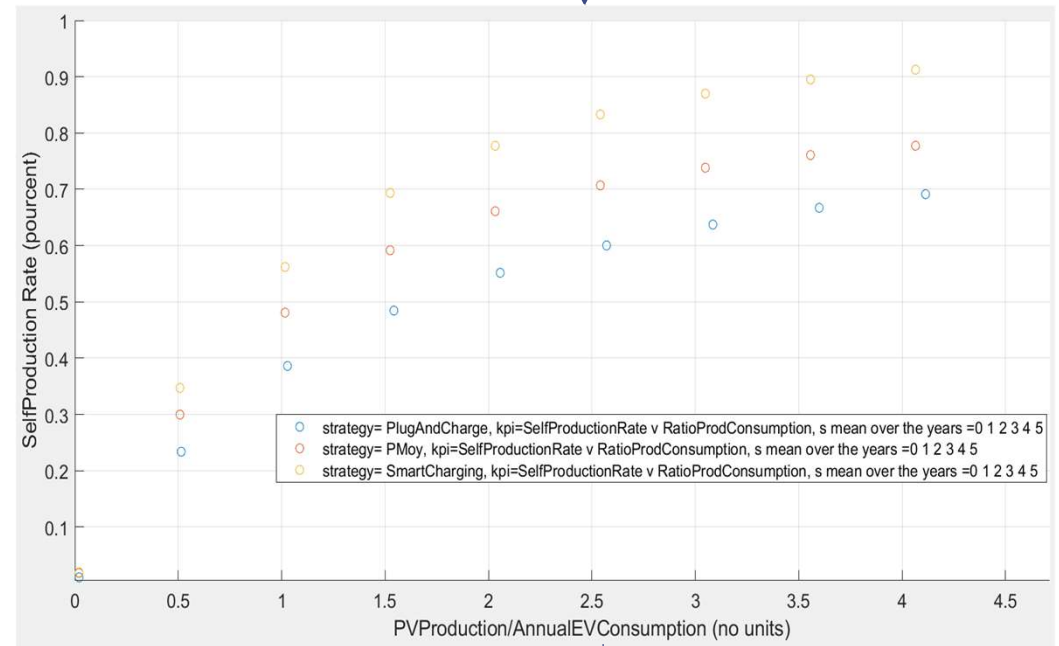


EV charging

From PV Production and EVConsumption, compute PCR= $\frac{\text{EnergyPV}}{\text{EnergyEV}}$

Compute SPR (SelfProductionRatio) for all Strategies and for all the kWp over the 6-years period

[relationship 4 - Abbacus]



Consider this relationship SPR/ ratio as the yearly reference:

$$Y_{\text{EnergyRatio}} = Y_{\text{EnergyPV}} / Y_{\text{EnergyEV}} \longleftrightarrow \text{Yearly SPR}$$



4. Examples



Application the method for sizing PV

Example of (fixed) prices 2023:

Interaction	Nomenclature	Value (€/MWh)	Composition
PVO – LP	Pr_{PVO-LP}	100	80 for Energy, 20 for Tax
PVO – ESPV	Pr_{ESPV}	100	100 Energy
CPO – LP	Pr_{CPO-LP}	100	100 Energy
CPO – ESEV (Long-term Fixed Price)	Pr_{ESEV}	170	85 Energy, 35 Tax, 50 Transportation

Hypothesis 2030 :

- Self-Consumption business model
- Energy prices 2022 = Energy prices 2030.
- CPO Target MPP = 120€/MWh
- CPO estimates an increase of 100 new active badges / year → #EV = 1000
- Charging session statistics will be similar :
 - Unchanged EVCI and EV characteristics
 - No change in working time and user behaviour (same start and end of transaction statistics)
 - No congestion in charging stations



Application the method for sizing PV

$$PLT_{CPO-ESEV}=170$$

$$P_{CPO-LP}=100$$

MPP=120

$$SPR = (PLT_{CPO-ESEV} - MPP) / (PLT_{CPO-ESEV} - P_{CPO-LP}) = 70\%$$

(1 - formula)

(2 - formula)

#EV=1000

$$Y_{EnergyEV} = 12 * 100 * 1000 = 1200000 \text{ kWh}$$

YPCRatio=4 if PlugAndCharge
 YPCRatio=2.5 if MeanPower
 YPCRatio=1.5 if SmartCharging

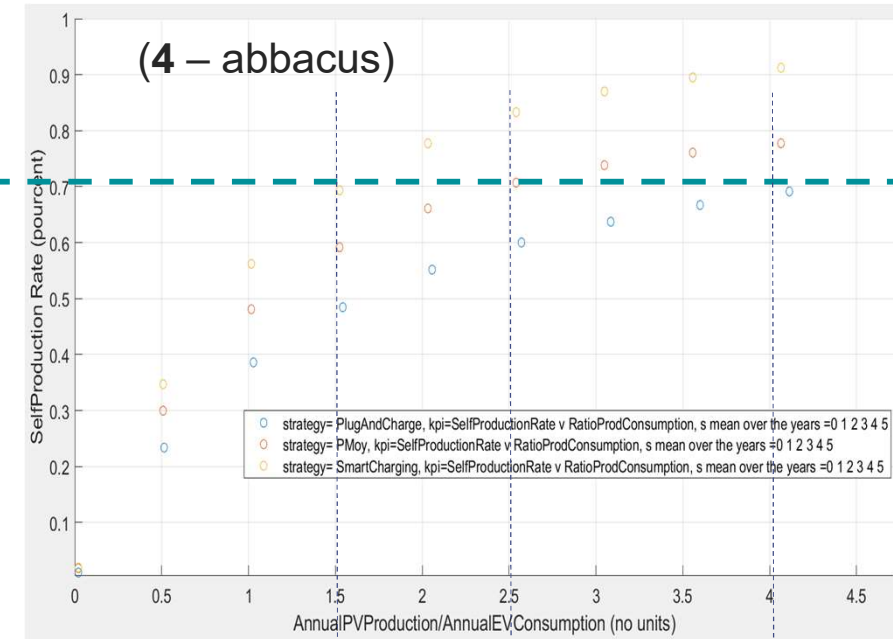
PlugAndCharge
 MeanPower
 SmartCharging

MWp=3 if PlugAndCharge
 MWp=1.8 if MeanPower
 MWp=0.9 if SmartCharging

Location
 Cadarache

YEnergyPV=4.8GWh if PlugAndCharge
 YEnergyPV=3.0GWh if MeanPower
 YEnergyPV=1.5GWh if SmartCharging

(3 - PV software)



~ 1.5
 SmartCharging

~ 2.5
 MeanPower

~ 4
 PlugAndCharge





5. Conclusion and perspectives



Conclusion and perspectives

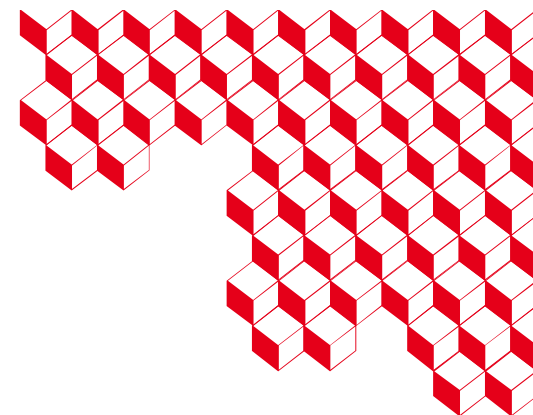
We propose a method either to size a PV plant or to estimate Mean Power Price in the case of self consumption scheme. This method is modular :

- Relationship 1 : Yearly Self Production Ratio \leftrightarrow Mean Power Price
 - Depends on the business model
- Relationship 2 : #EV \leftrightarrow Yearly EV Energy Consumption
 - Could be estimated from own charging session history
- Relationship 3 : Peak Power \leftrightarrow Yearly PV Energy Production
 - Could easily obtained from the internet
- Relationship 4 : Yearly Self Production Ratio \leftrightarrow Yearly PV Energy Production / Yearly EV Energy Consumption
 - Either Use abacus is similar charging demand statistics
 - Or simulations can be performed with rather simple tools (such as Matlab or Python). need
 - Charging session history
 - Timeseries of PV production (could easily obtained from the internet)

In our simple sizing example, smart charging reduces by a factor 3 the size of the PV plant necessary to reach a given Mean Power Price.

Perspectives:

- Compute other KPI to compare the different strategies
- Impact on PV forecast : distinction between forecast and production



Thanks for your attention

PV2E_MOBILITY / T-IPV
*French contribution
to IEA PVPS-T17*



International Energy Agency
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CEA/DRT/DTS/SMSP/LSA

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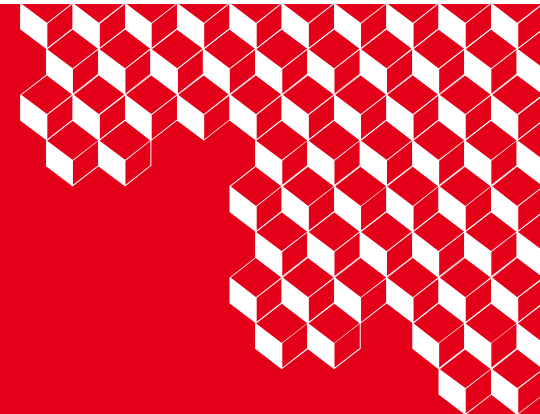
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