E4C INTERDISCIPLINARY CENTER

IPSL LMD

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PADOVA, ITALY
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Assessing the gains of a photovoltaic collective self-consumption from residential, industrial and tertiary buildings

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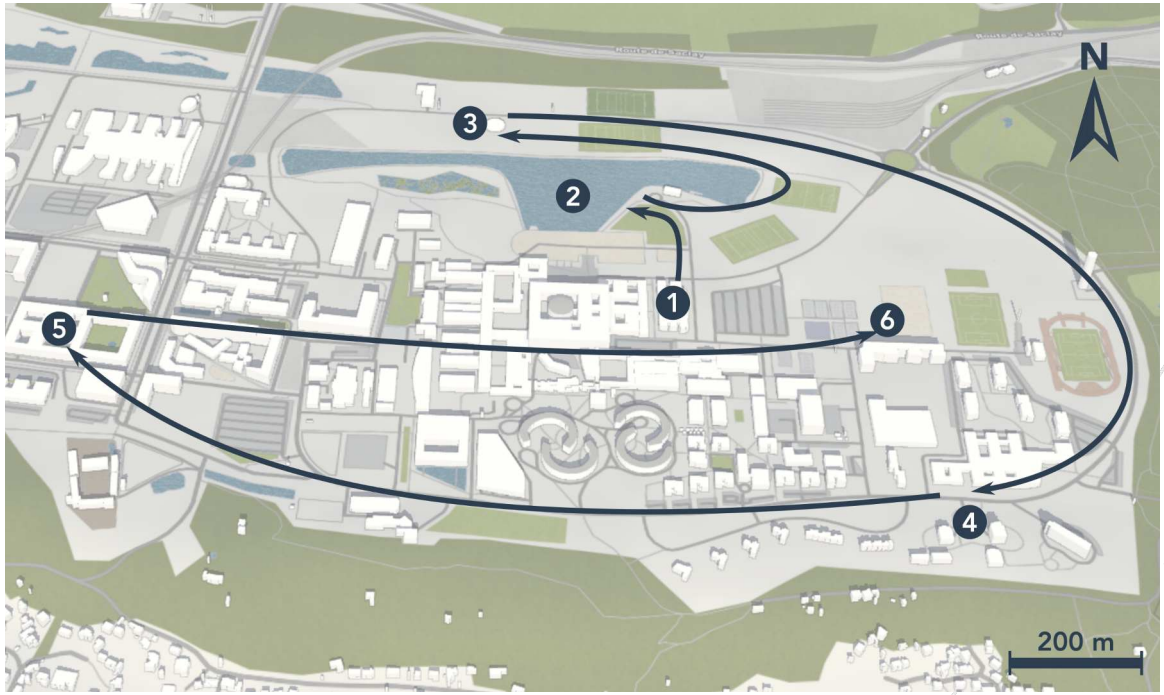
INVESTIR L'AVENIR

Energy4Climate living lab in Palaiseau



Drahi X-Novation Center
Electric smart-building

XSeaO$_2$
Carbon capture

SIRTA Observatory
AgriPV farm

Residential buildings
Electric/thermal smart-building

Télécom Paris
Smart gardens

103 residential building
Electric smart-building

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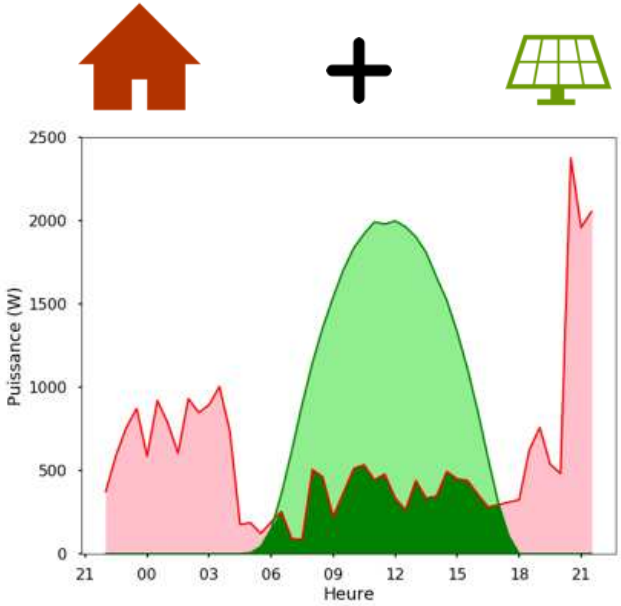
SIRTA Atmospheric observatory

- 150+ meteorological instruments
- 20 years of observations
- 3 Gb observations/day
- International observation network member (BSRN, AERONET, ACTRIS …)

- Commercial PV module testbench (2015-)
- Perovskite cells platform test
- 2 trackers PV 2-axes
- AgriPV (72 modules, 40 kWc, 1-axis tracker, salads are currently growing)

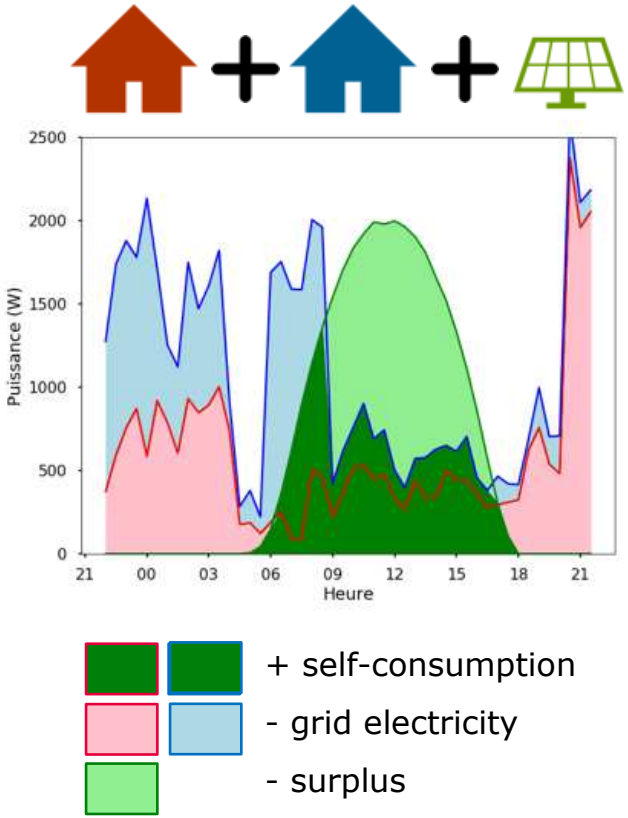
PV individual self-consumption (ISC)



- Avoid voltage rise during peaks PV production periods
- Helps to reach higher shares of installed PV in the electric mix
- Offers a cheaper, clean and local electricity to users

- However, PV production profile does not fulfill single user consumption habit
- Surplus can be valued through :
  - battery (inducing energy loss and extra-costs)
  - Network selling (less attractive price than self-consumed energy)

PV collective self-consumption (CSC)



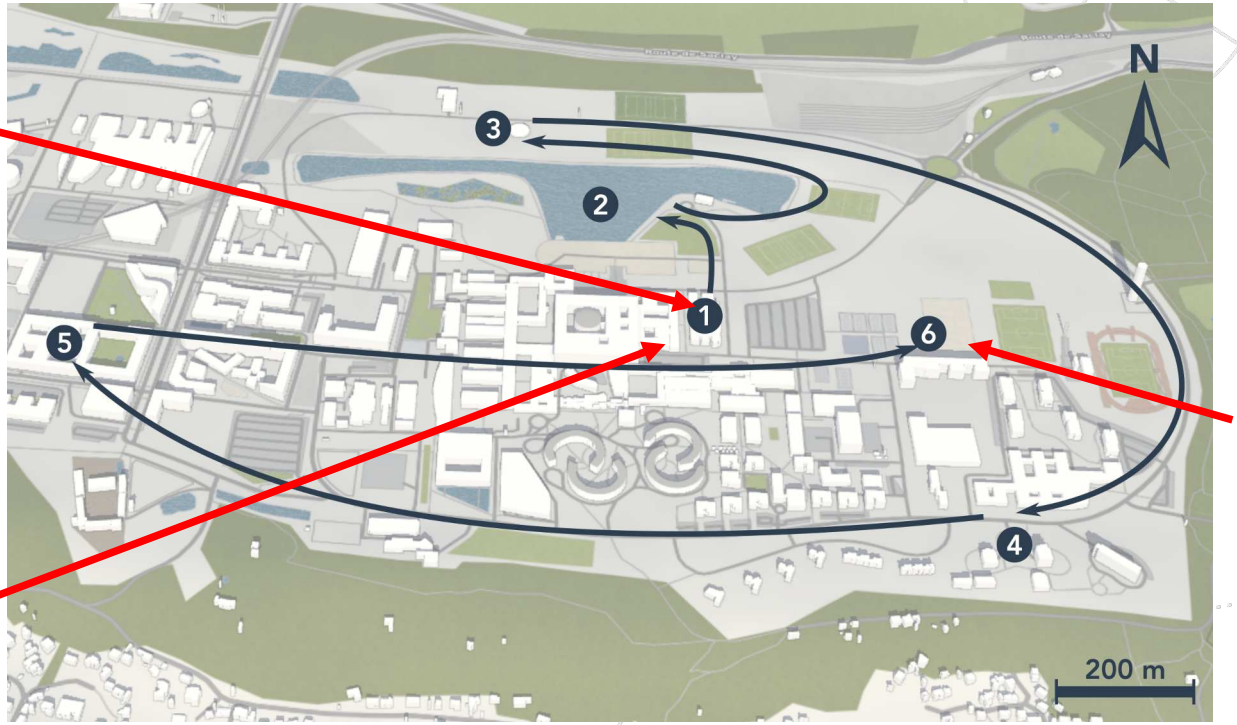
- Legally defined in France since 2018
- Enable to share PV production one or several plants to users located within a 2 km diameter circle (up to 10 km in rural areas)
- Key distributions of PV power production among users are defined by a community representative (PMO)
- Fair billing is computed and certified by ENEDIS (french DSO)

- Main metrics to assess CSC performance:
  - Self-consumption rate
  - Self-sufficient rate

Objective : assessing gain of a simulated CSC at Polytechnique

Drahi X-Novation Center
Electric smart-building
Tertiary

Magnan restaurant
Polytechnique main canteen
Industrial



103 residential building
Electric smart-building
Residential

PV production simulation

- Drahi-X PV farm is **an experimental PV power plant** with :
  - 53 panels
  - 17 kWp in capacity
  - 6 different PV technologies
  - 2 different inclinations
  - 2 reflectors (in front of some panels)
- Continue measurements available from **October 2020**)
- 1/3 of the building is in actual self-consumption

- We simulated 3 fictional PV farms by scaling Drahi-X PV production according to building average consumption
- We assumed the 3 buildings receive at each instant an equal GHI amount by m²
- PV measurements have been cleaned from incidental gaps and known biases (e.g. tree shadowing) using GHI observed by at SIRTA

Simulated CSC features for entire year 2022

	x3 	x10 	x15 	Total
PV simulated capacity (kW_p)	51	170	255	476
PV production (MWh)	244	813	1220	2277
Building consumption (MWh)	883	1999	694	3576

Drahi-X Novation Center

Polytechnique canteen

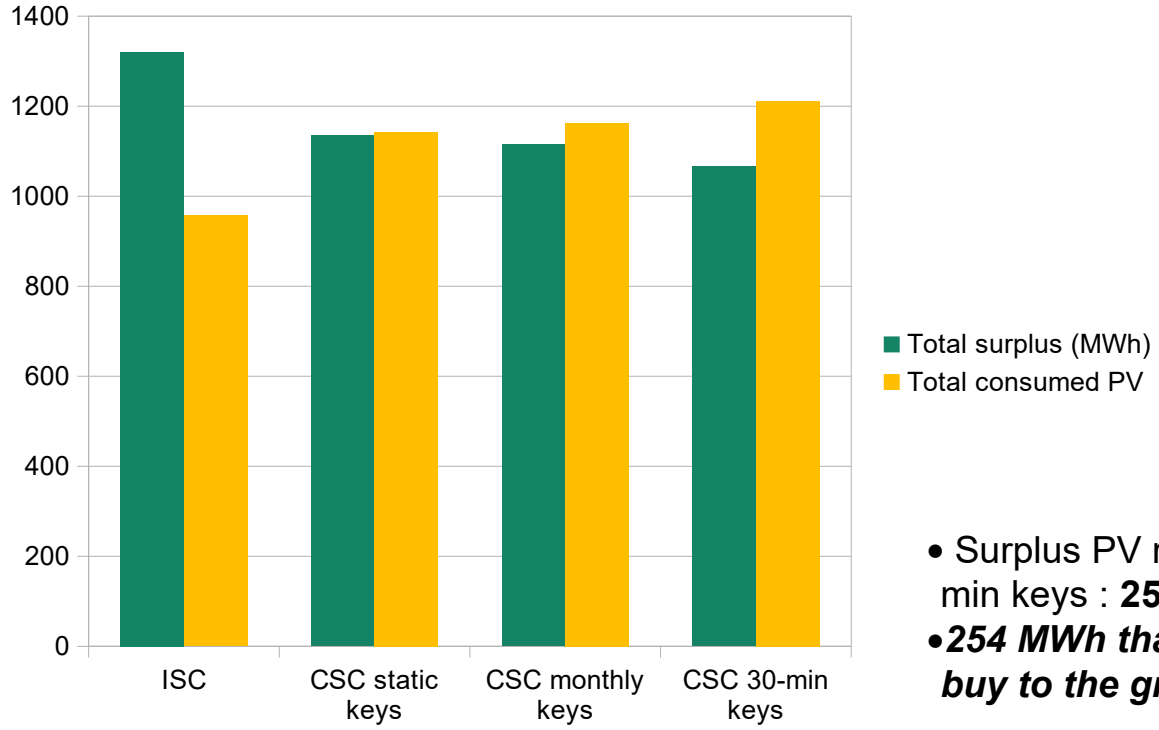
B103 student residence

Performance computation methodology

- The goal is to compute for each considered time-step :
  - **The self-consumption rate** (which part of total available PV production has been actually consumed ?)
  - **The self-production rate** (which part of total consumed electricity comes from the Sun ?)

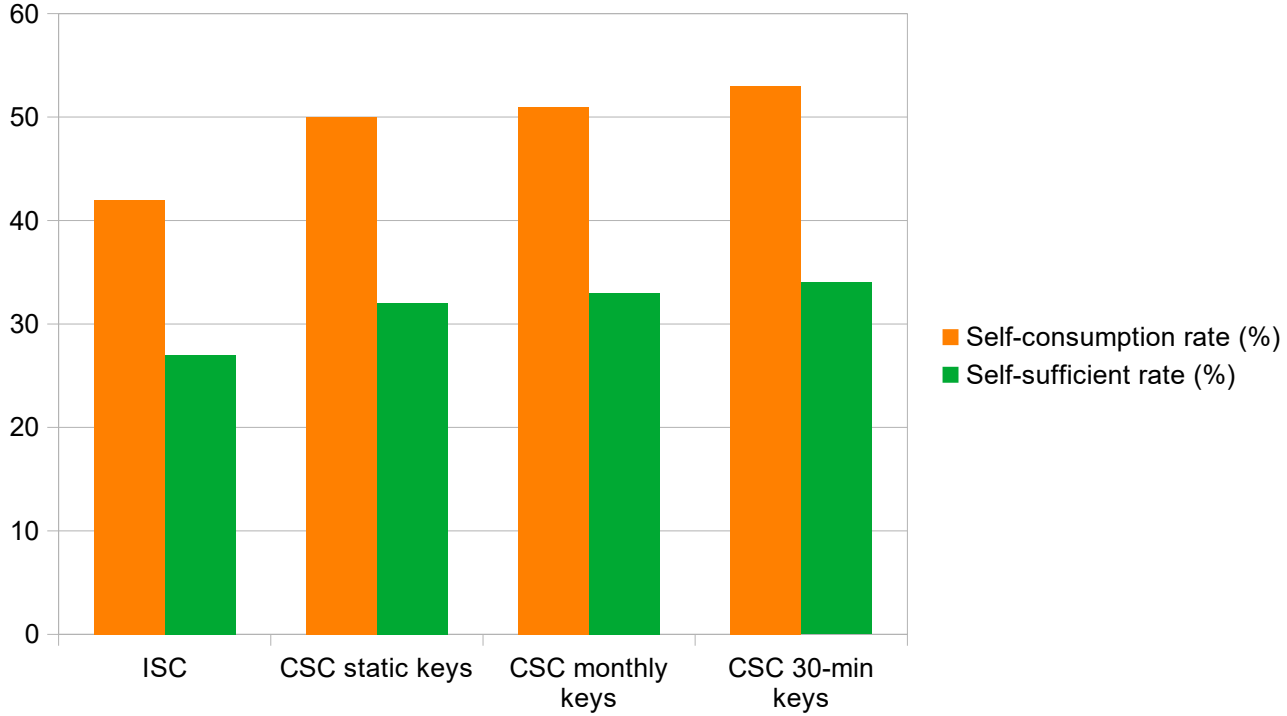
- 4 scenarios are considered
  - **Individual self-consumption** (no PV production shared between buildings)
  - **CSC with static repartition keys** (total PV production attributed with fixed rate, deduces from consumption share of 2022)
  - **CSC with dynamic keys monthly revised** using monthly consumption share (standard time step define by ENEDIS, French DSO for billing in CSC)
  - **CSC with dynamic half-hourly keys** (maximum authorized by ENEDIS).

Surplus and PV consumption for 2022

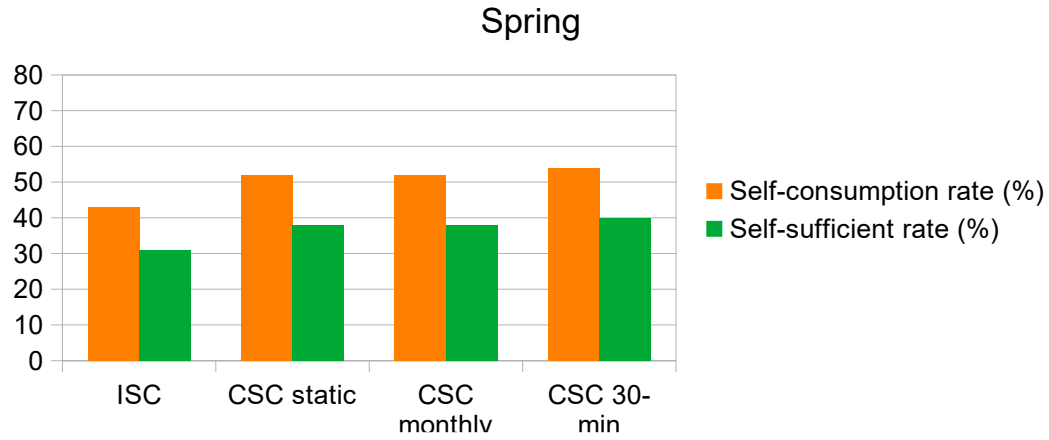


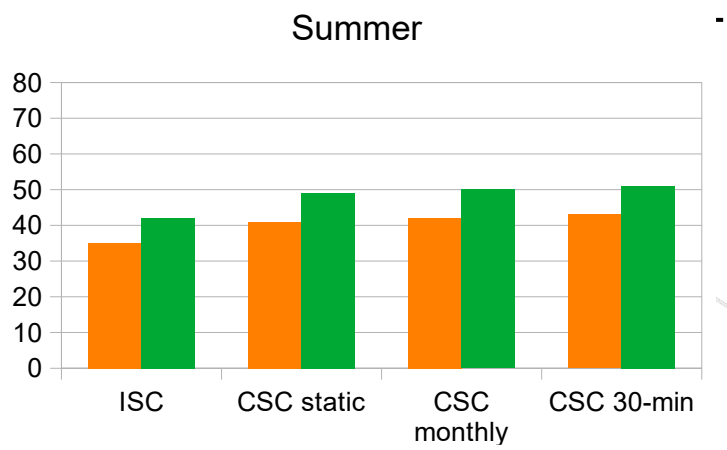
- Surplus PV reduction from ISC to CSC 30-min keys : **254 MWh (19.2%)**
- ***254 MWh that the community will not buy to the grid thanks to CSC !***

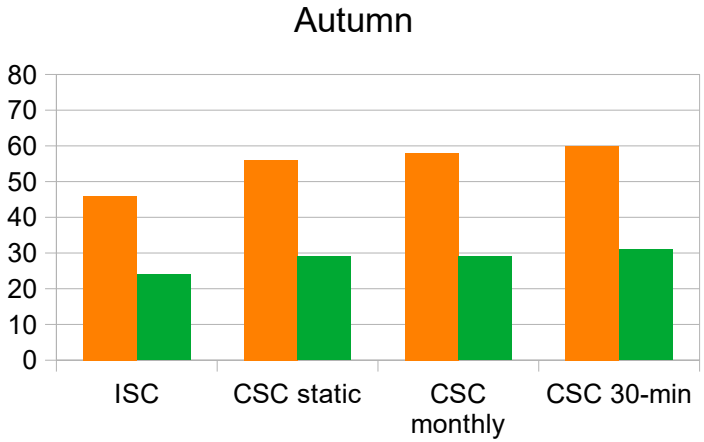
Self-consumption and self-sufficient rates for 2022

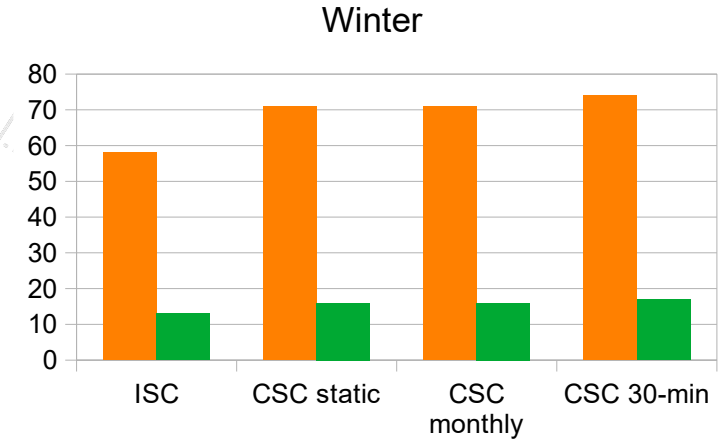


Seasonal self-consumption and self-sufficient rates



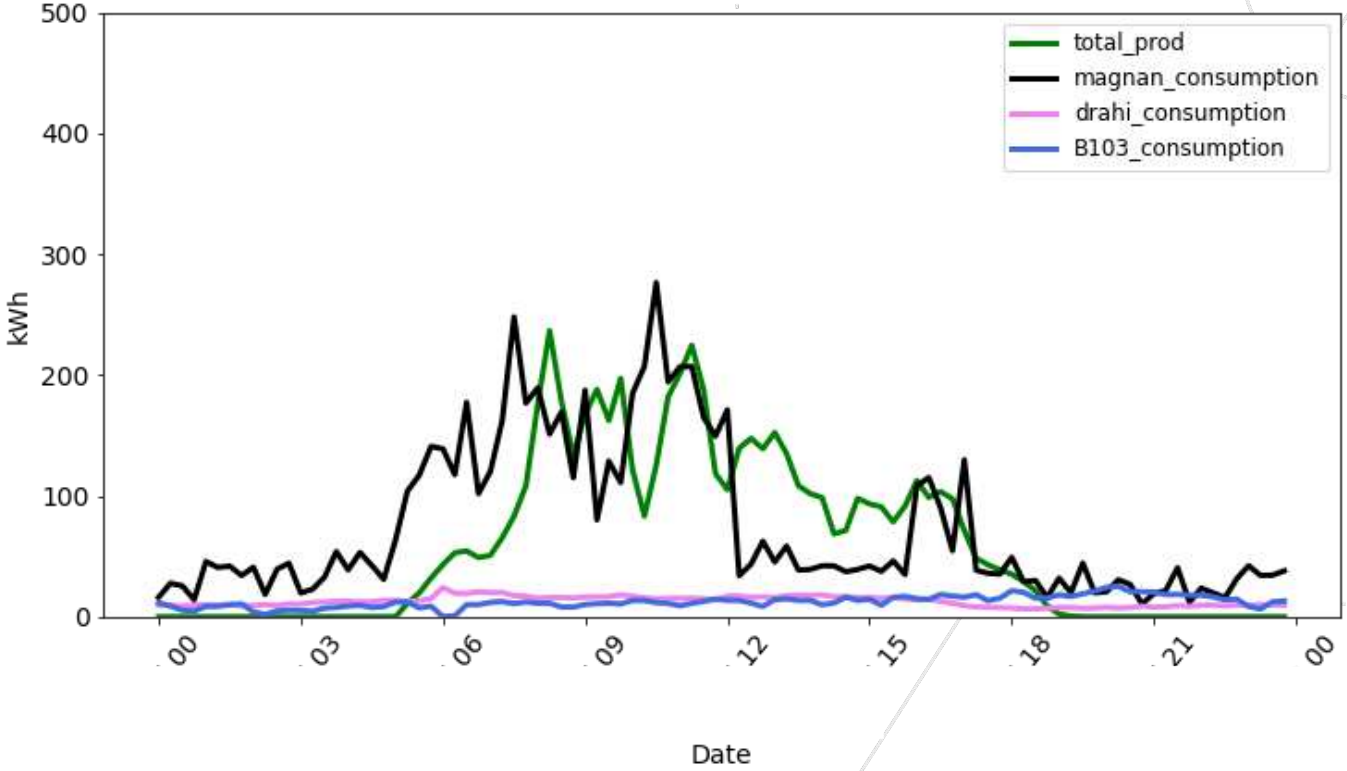






A day in summer – 7th July 2022

Seasonal Example



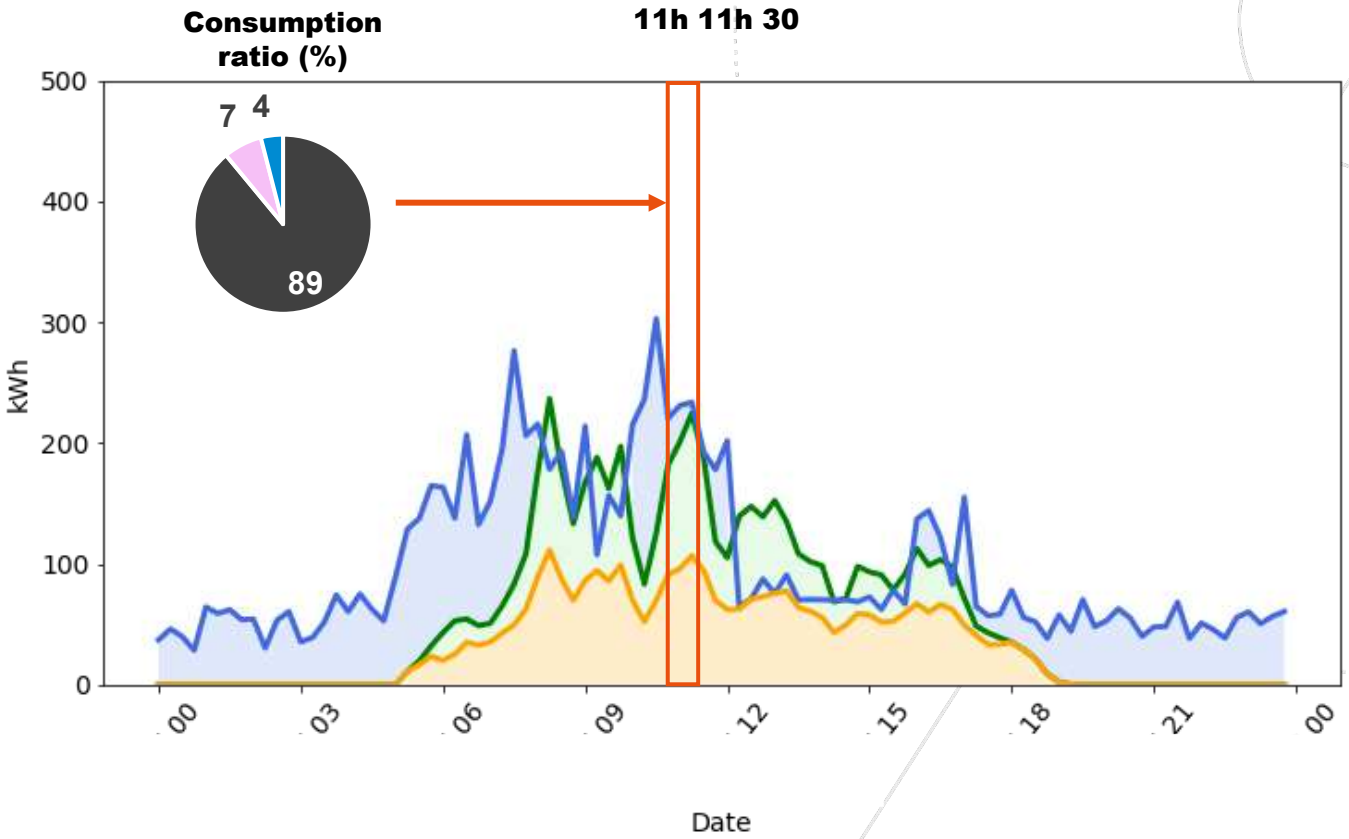
PV production

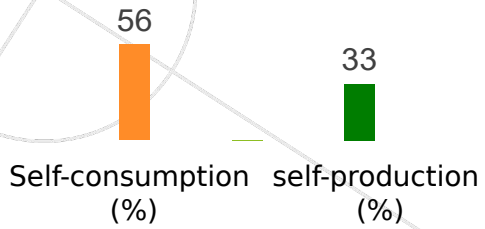
Drahi-X energy consumption

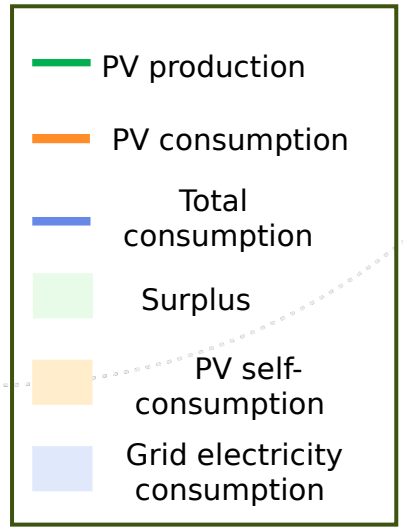
Canteen energy consumption

B103 energy consumption

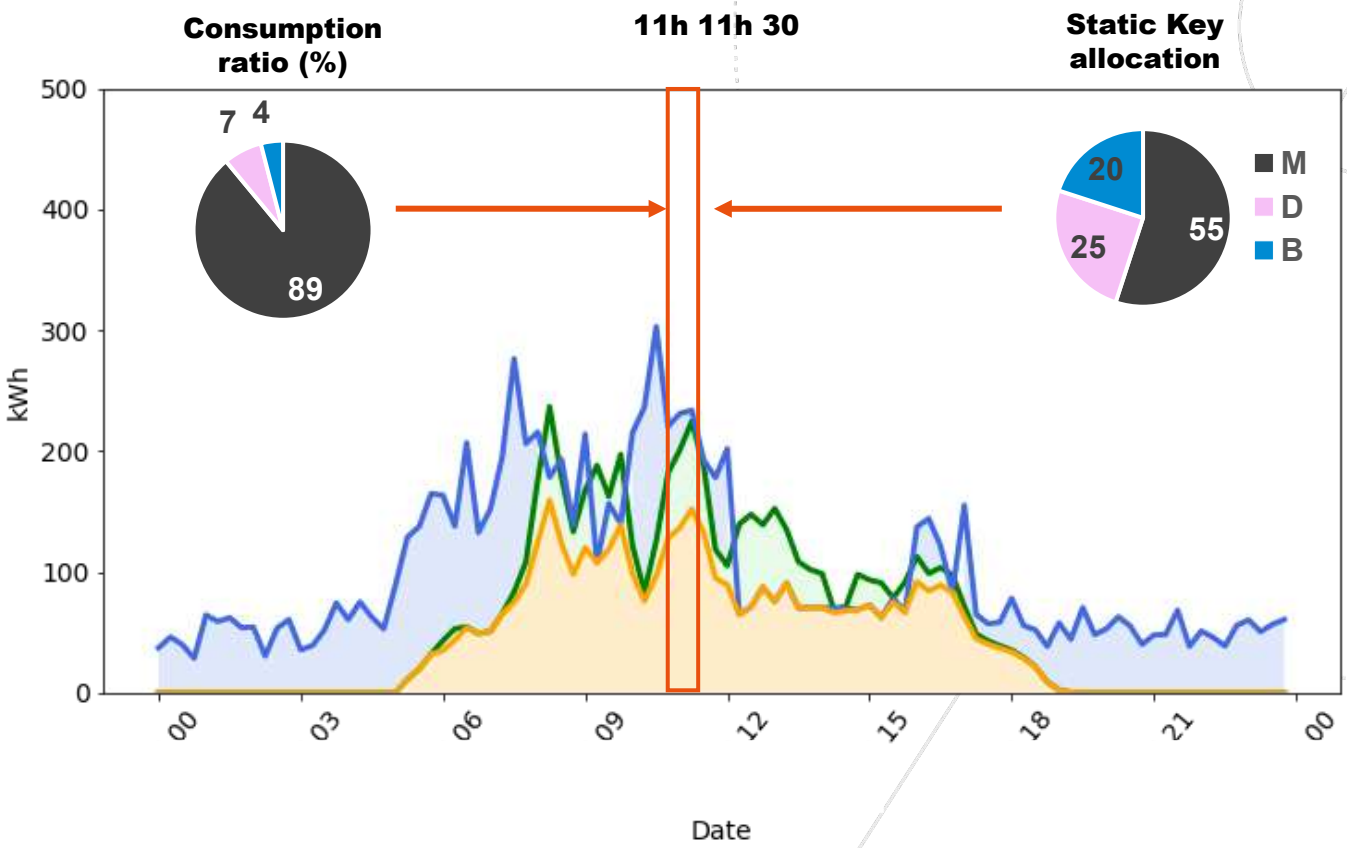
Individual self-consumption 7th July 2022

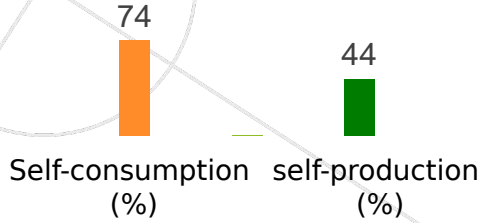






CSC static keys – 7th July 2022





PV production

PV consumption

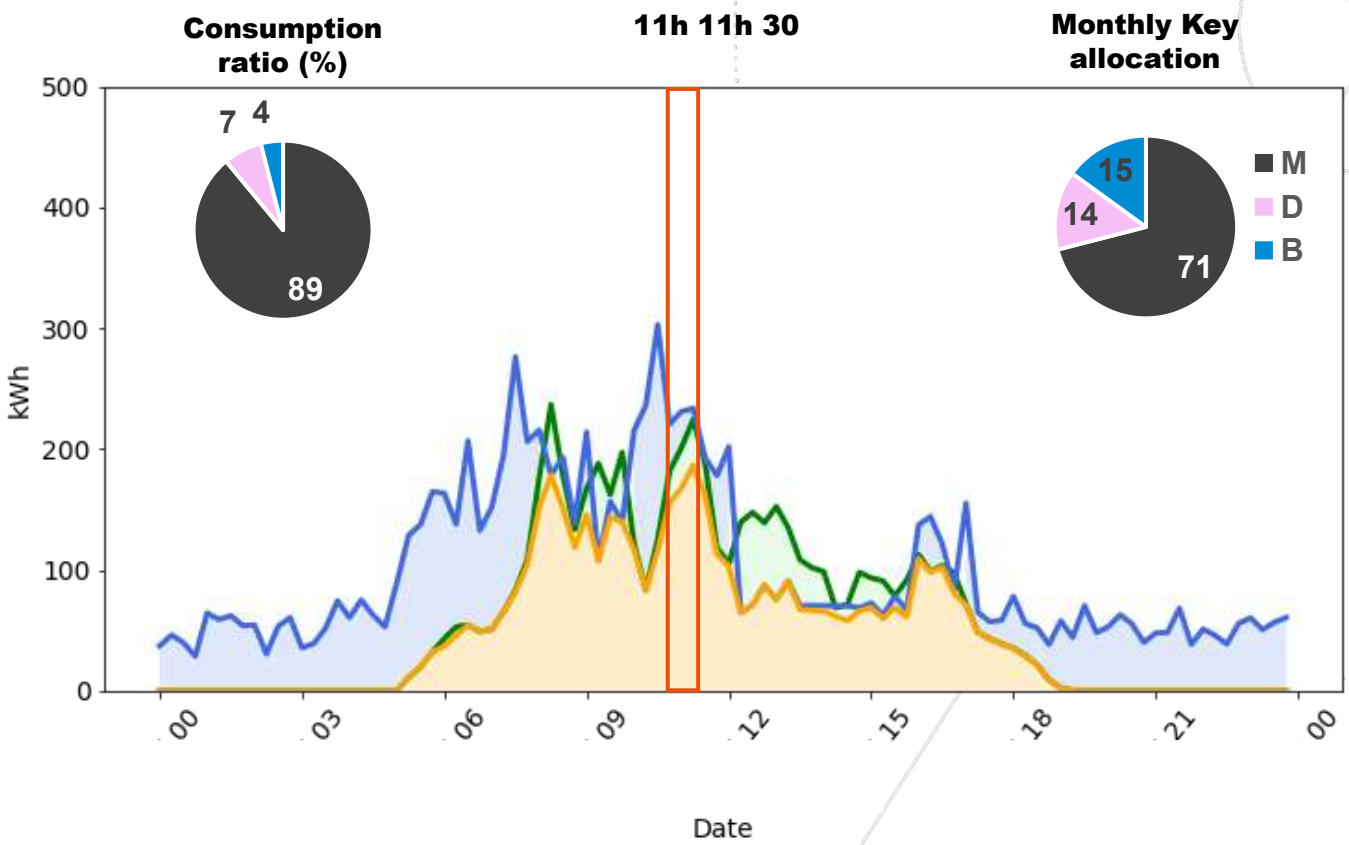
Total consumption

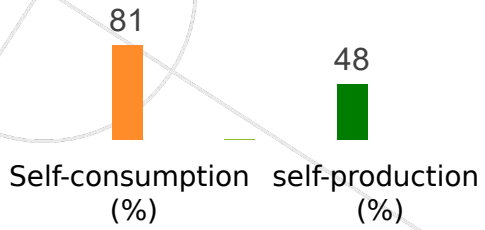
Surplus

PV self-consumption

Grid electricity consumption

CSC monthly keys – 7th July 2022





PV production

PV consumption

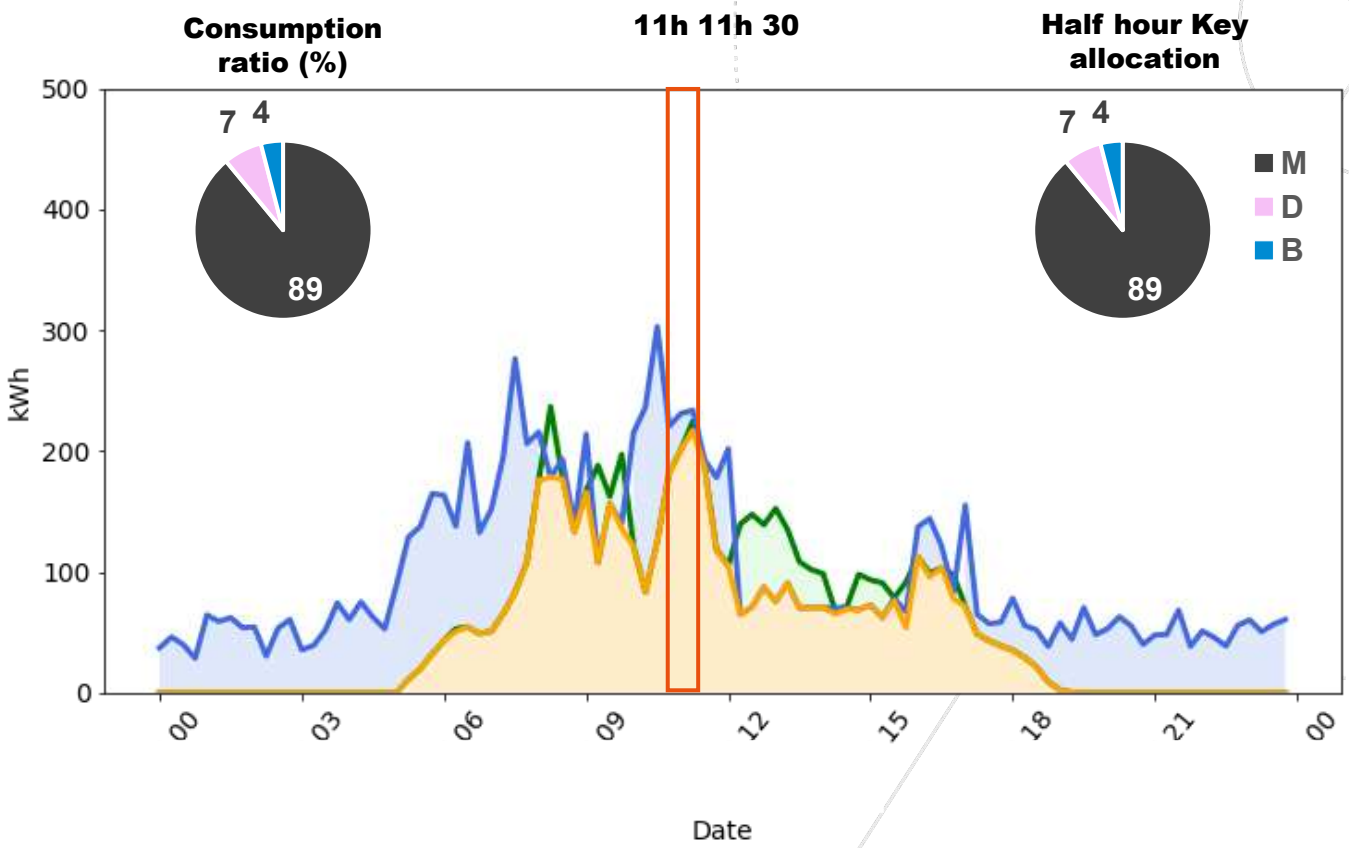
Total consumption

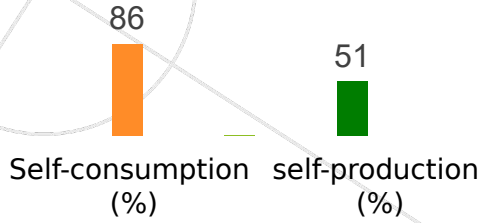
Surplus

PV self-consumption

Grid electricity consumption

CSC 30-min. keys – 7th July 2022





PV production

PV consumption

Total consumption

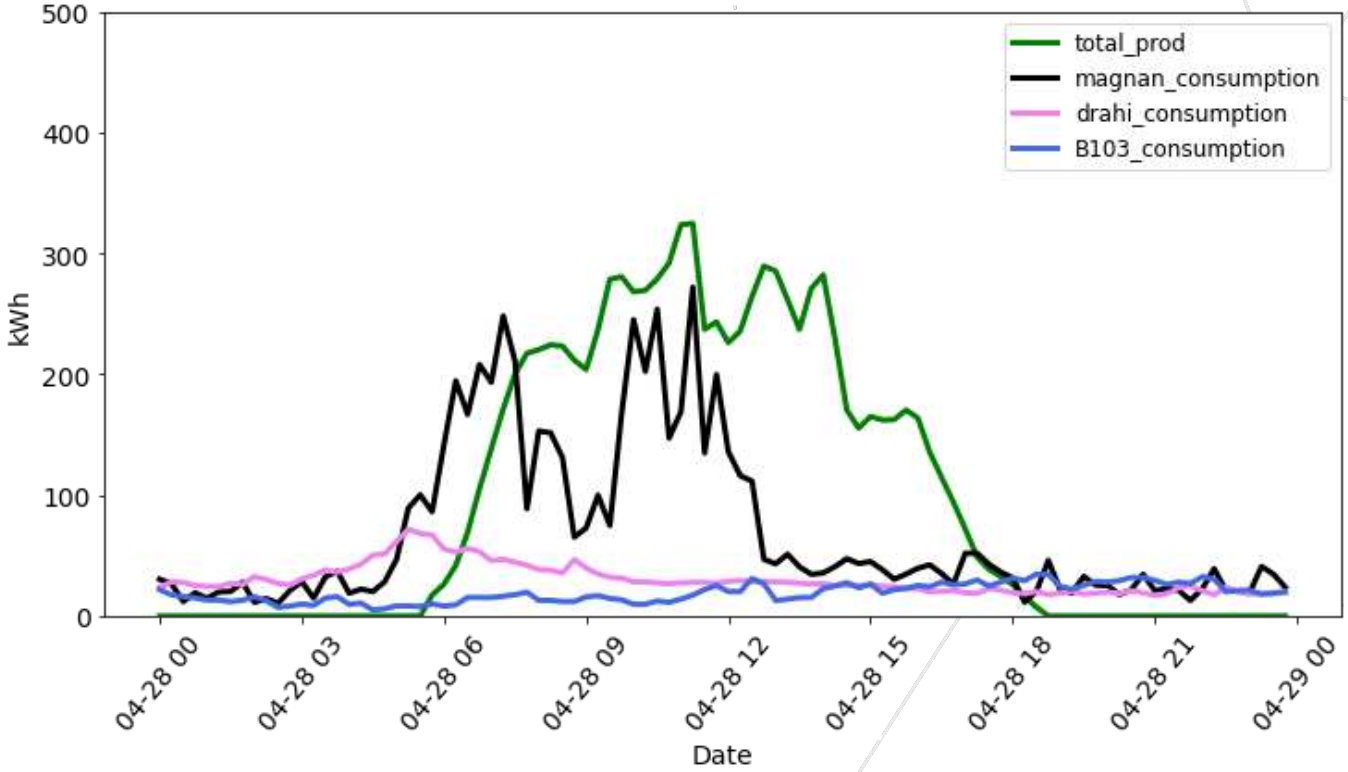
Surplus

PV self-consumption

Grid electricity consumption

A day in spring 4th April 2022

Seasonal Example



Date:
2022-04-28
(Spring)

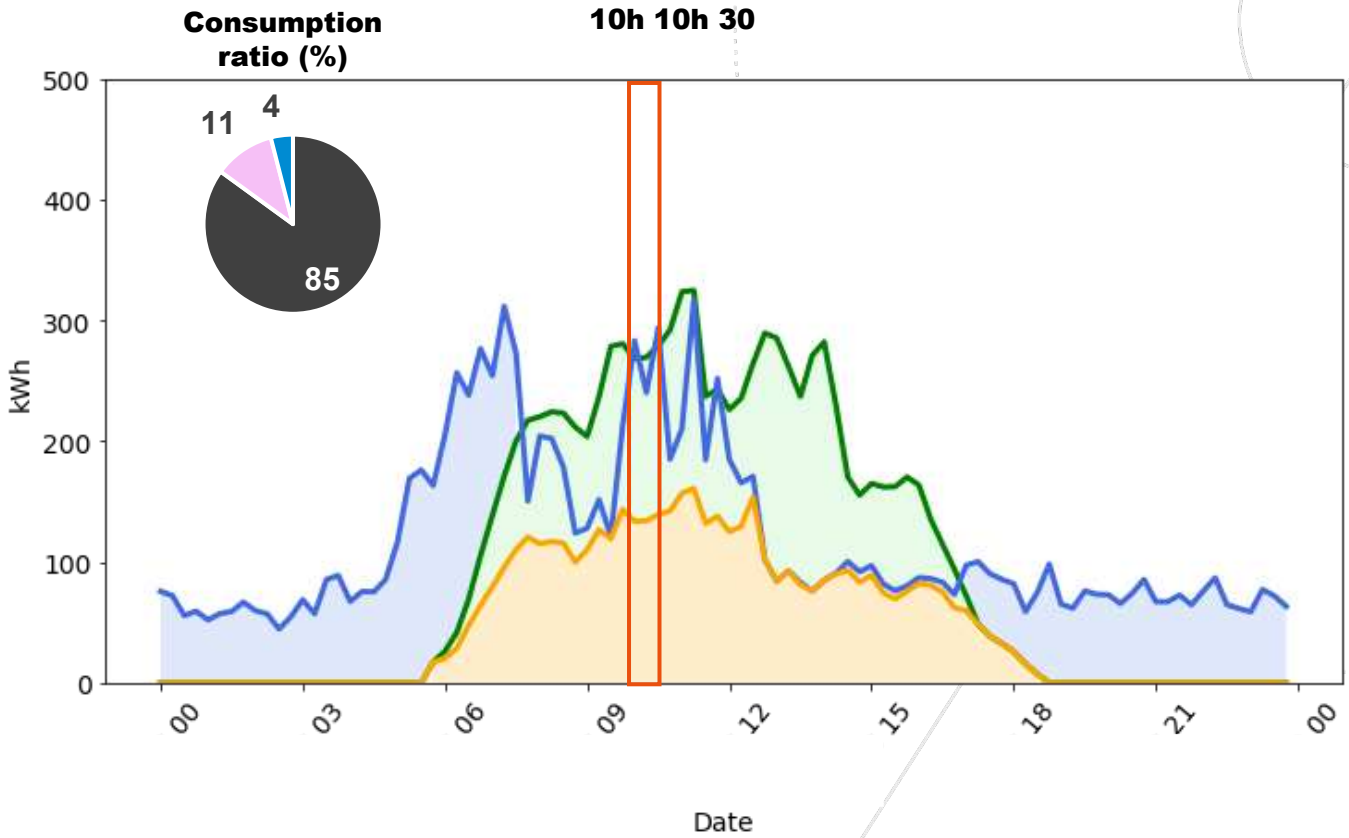
PV production

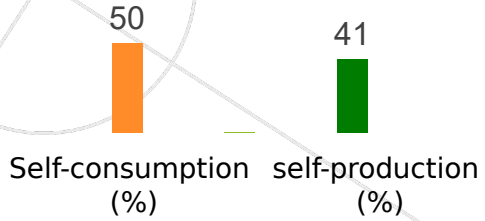
Drahi-X energy consumption

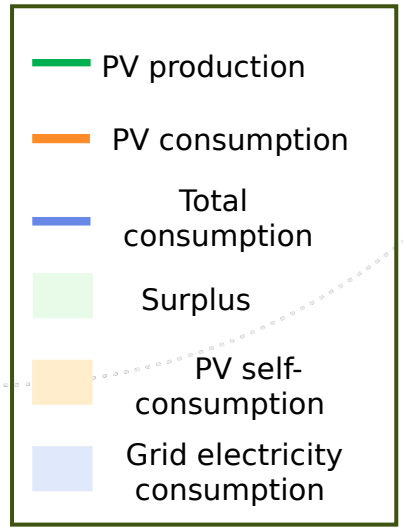
Canteen energy consumption

B103 energy consumption

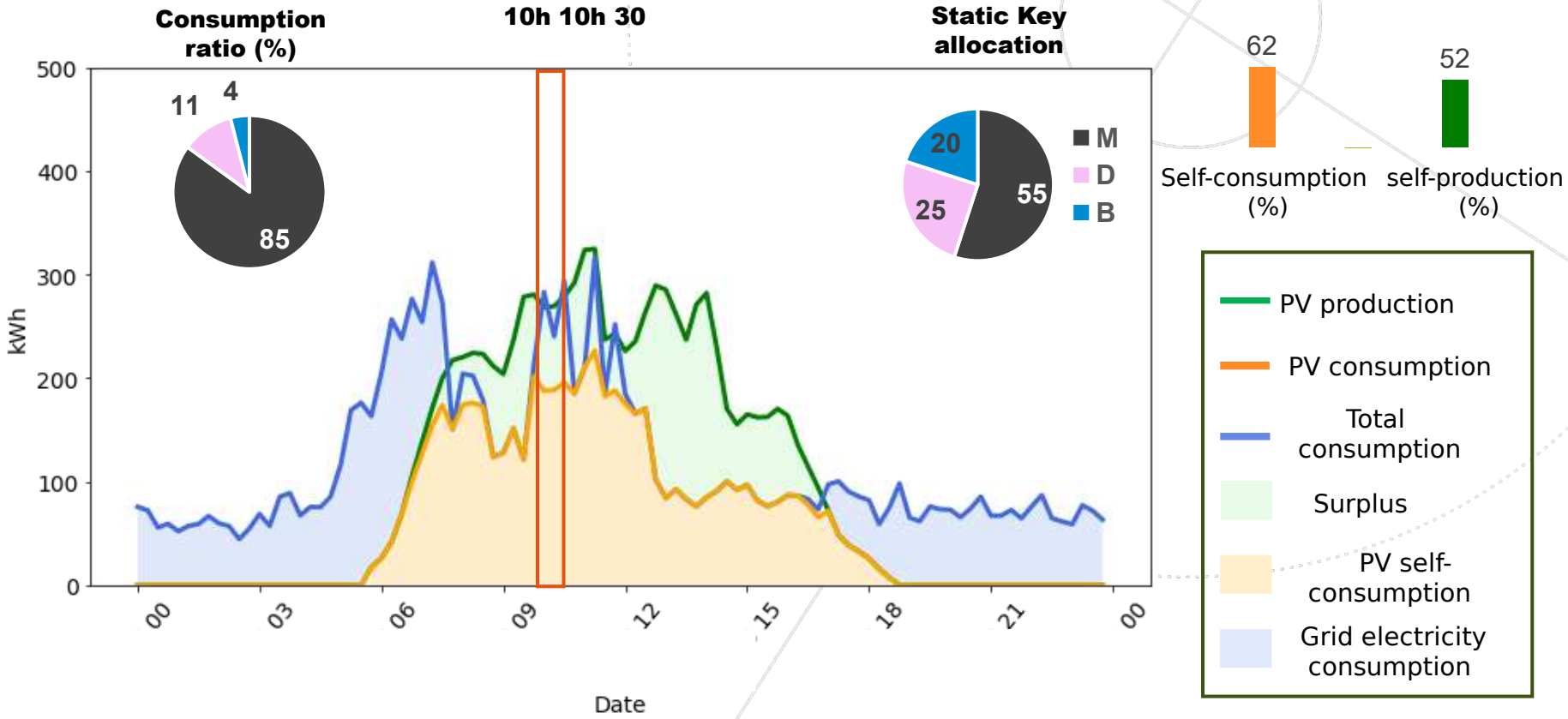
Individual self-consumption - 4th April 2022



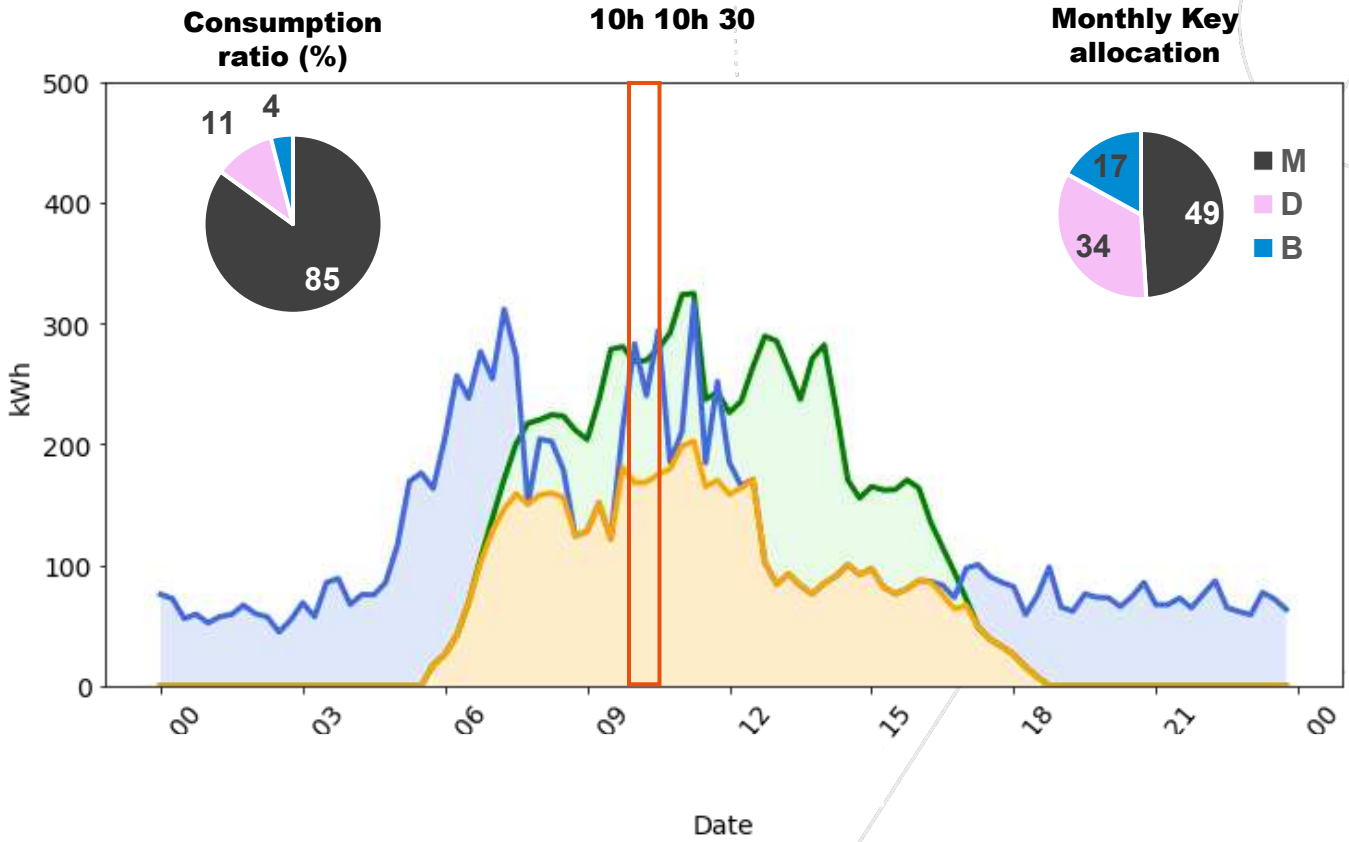


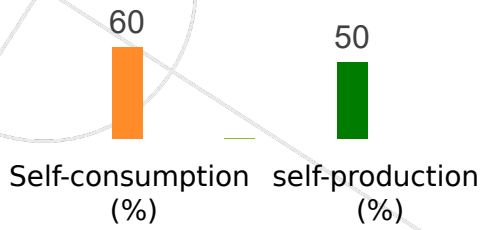


CSC static keys - 4th April 2022



CSC monthly keys - 4th April 2022





PV production

PV consumption

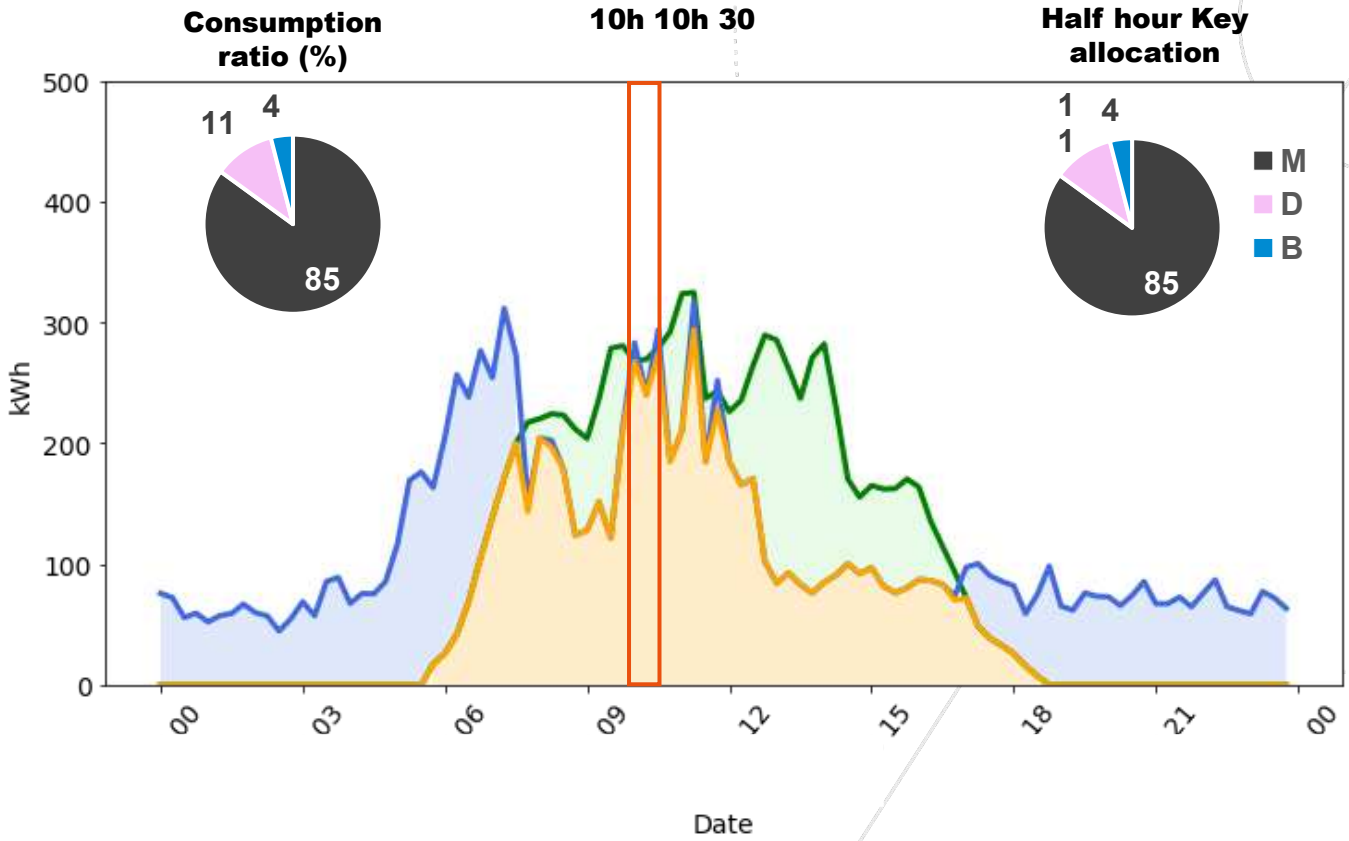
Total consumption

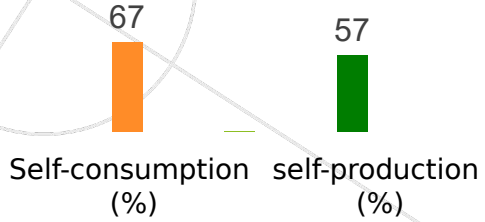
Surplus

PV self-consumption

Grid electricity consumption

CSC 30-min. keys - 4th April 2022





PV production

PV consumption

Total consumption

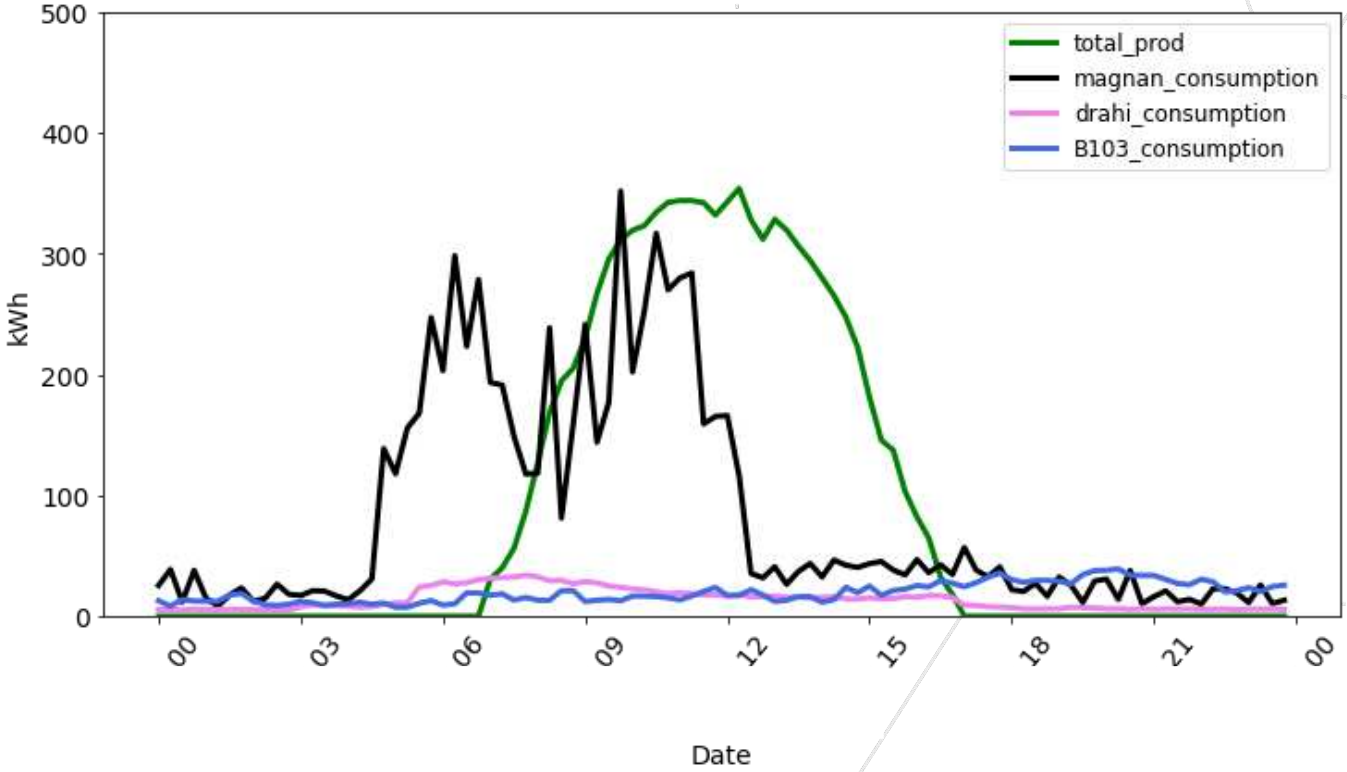
Surplus

PV self-consumption

Grid electricity consumption

A day in autumn - 4th October 2022

Seasonal Example



Date:
2022-10-04
(Autumn)

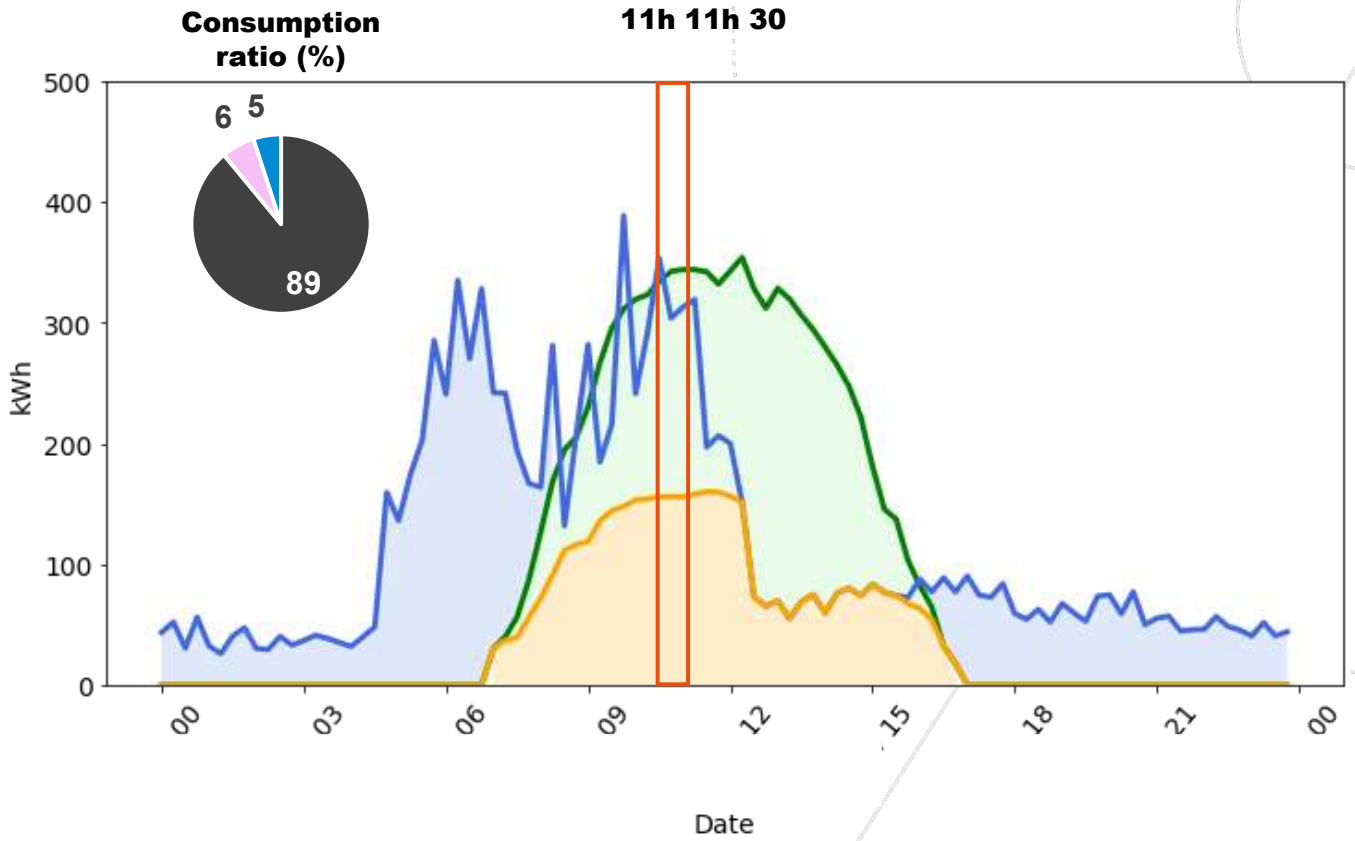
PV production

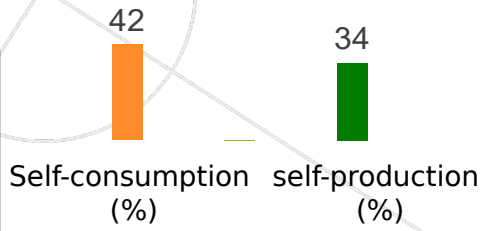
Drahi-X energy consumption

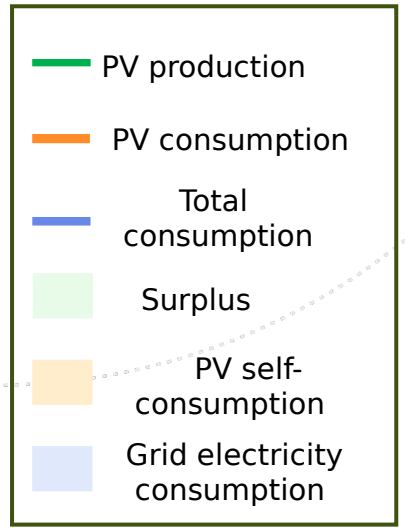
Canteen energy consumption

B103 energy consumption

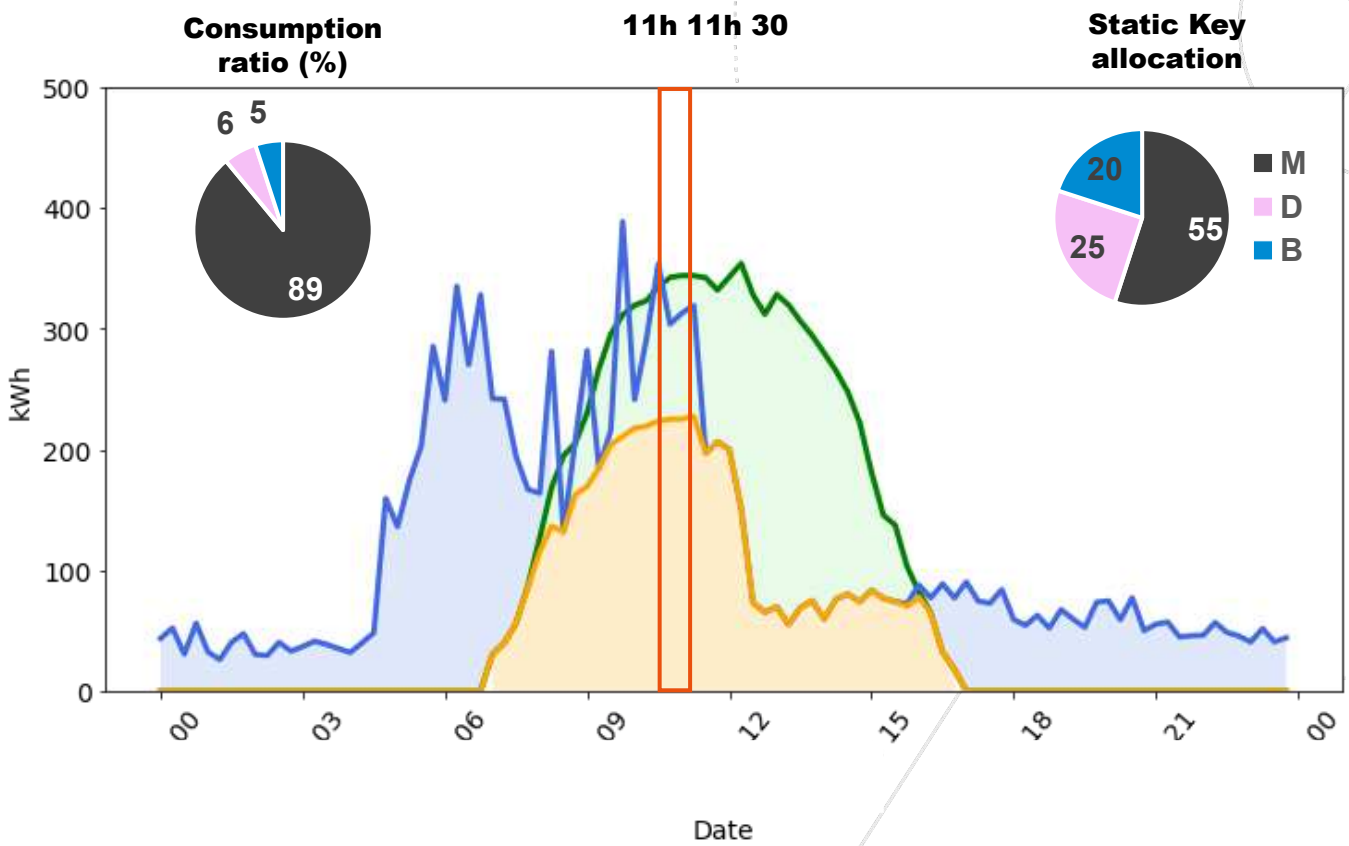
Individual self-consumption - 4th October 2022

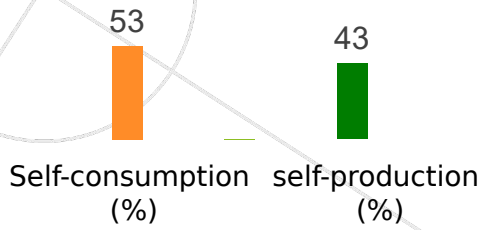






CSC static keys - 4th October 2022





PV production

PV consumption

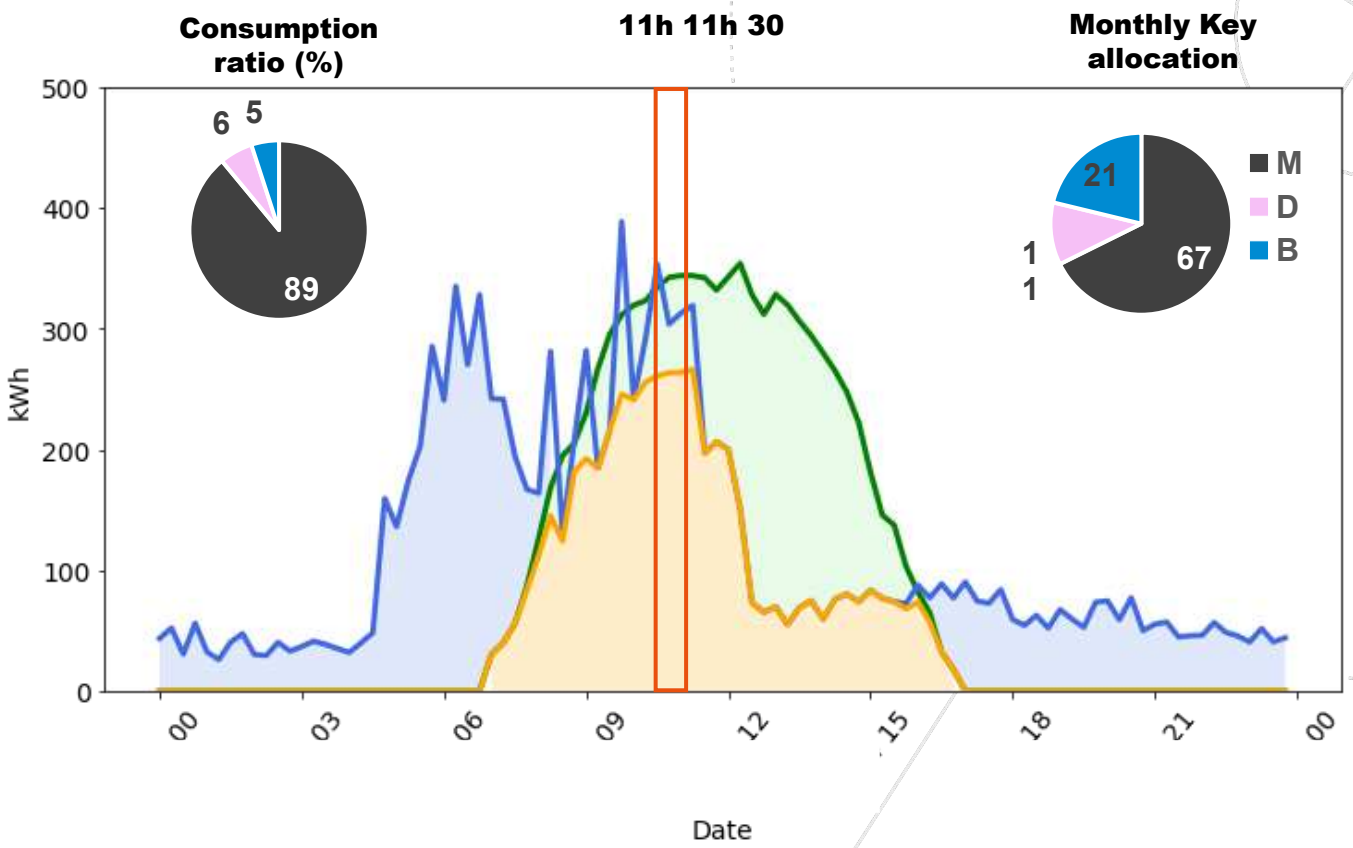
Total consumption

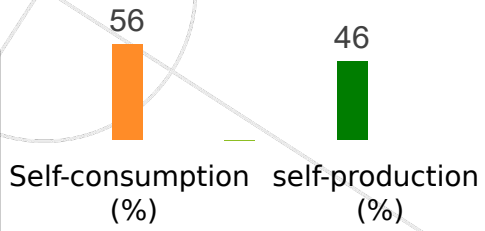
Surplus

PV self-consumption

Grid electricity consumption

CSC monthly keys - 4th October 2022





PV production

PV consumption

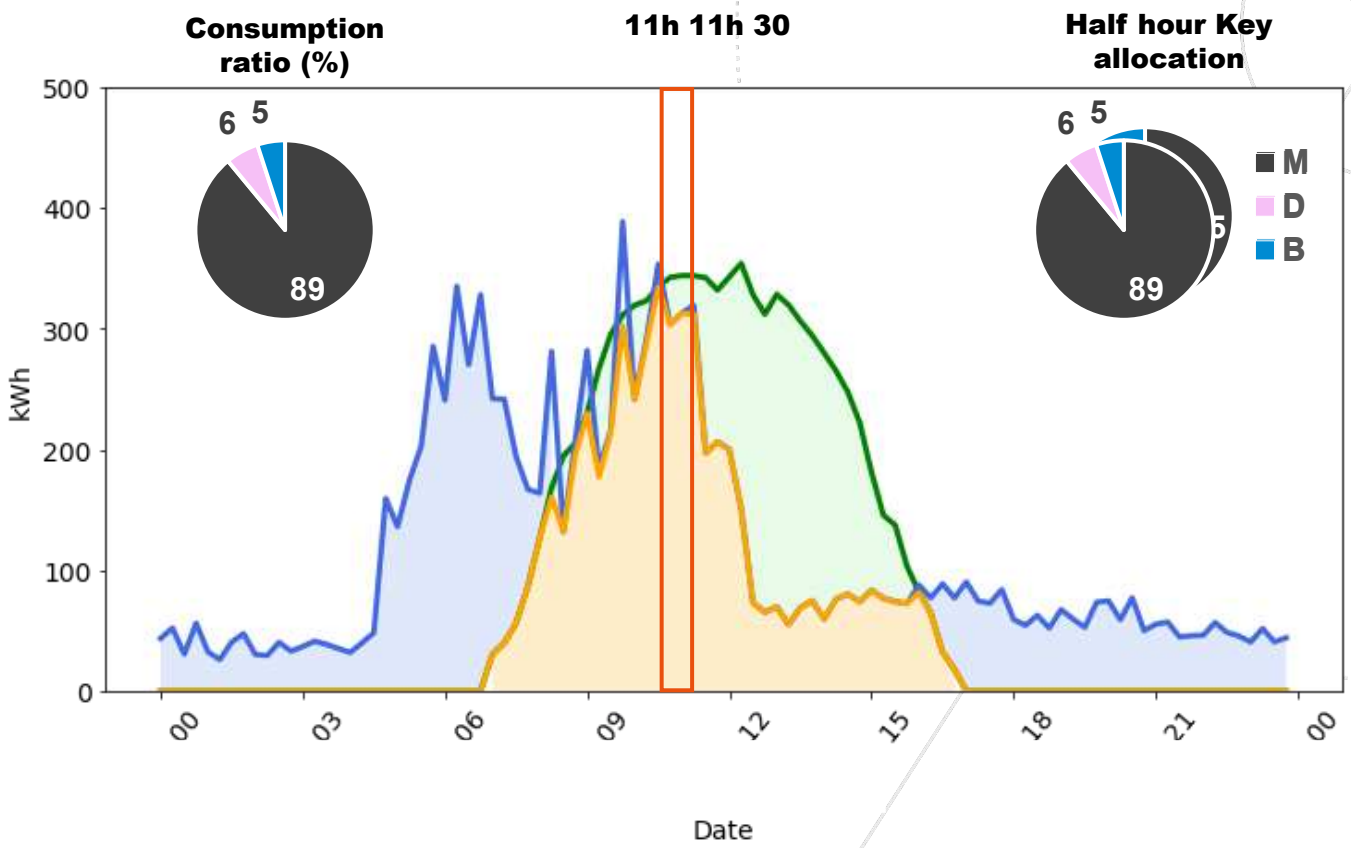
Total consumption

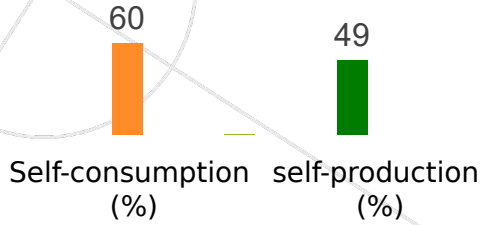
Surplus

PV self-consumption

Grid electricity consumption

CSC 30-min. keys - 4th October 2022





PV production

PV consumption

Total consumption

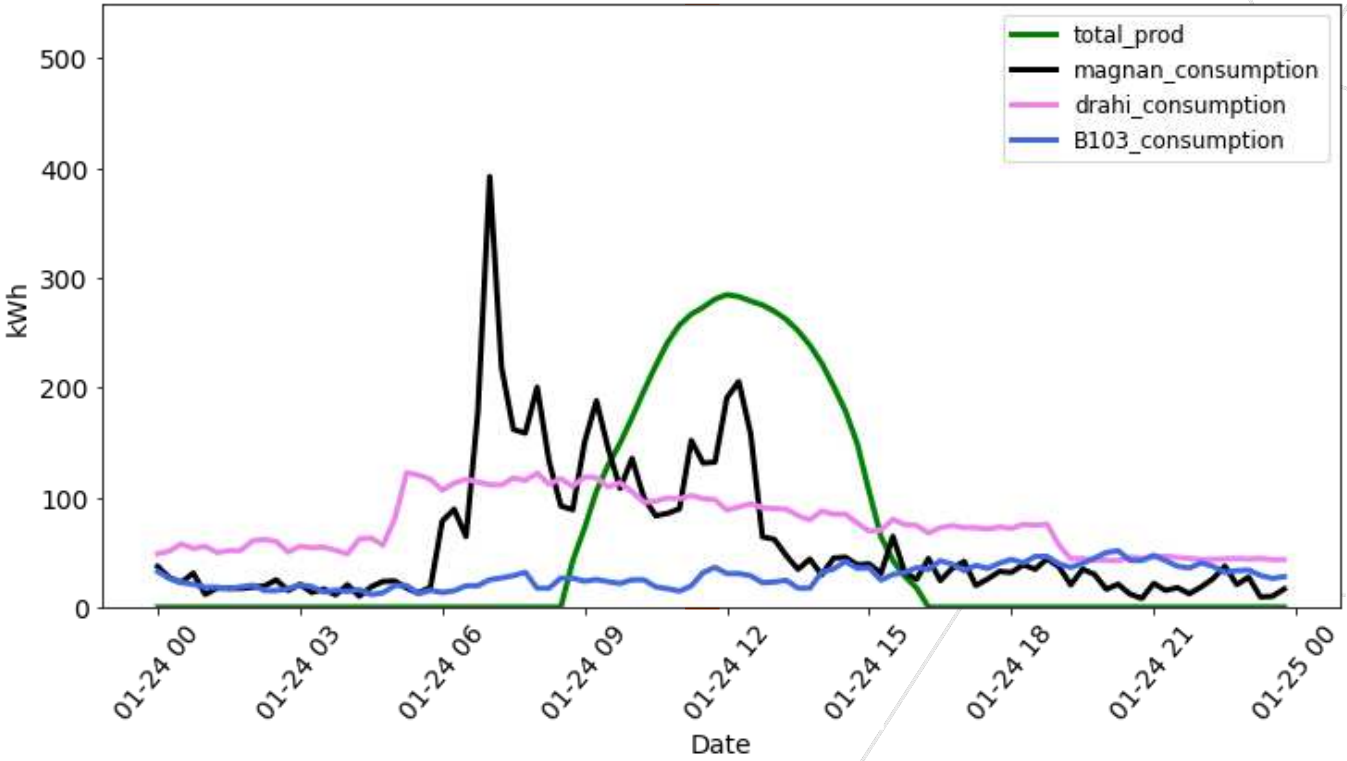
Surplus

PV self-consumption

Grid electricity consumption

A day in winter – 24th January 2022

Seasonal Example



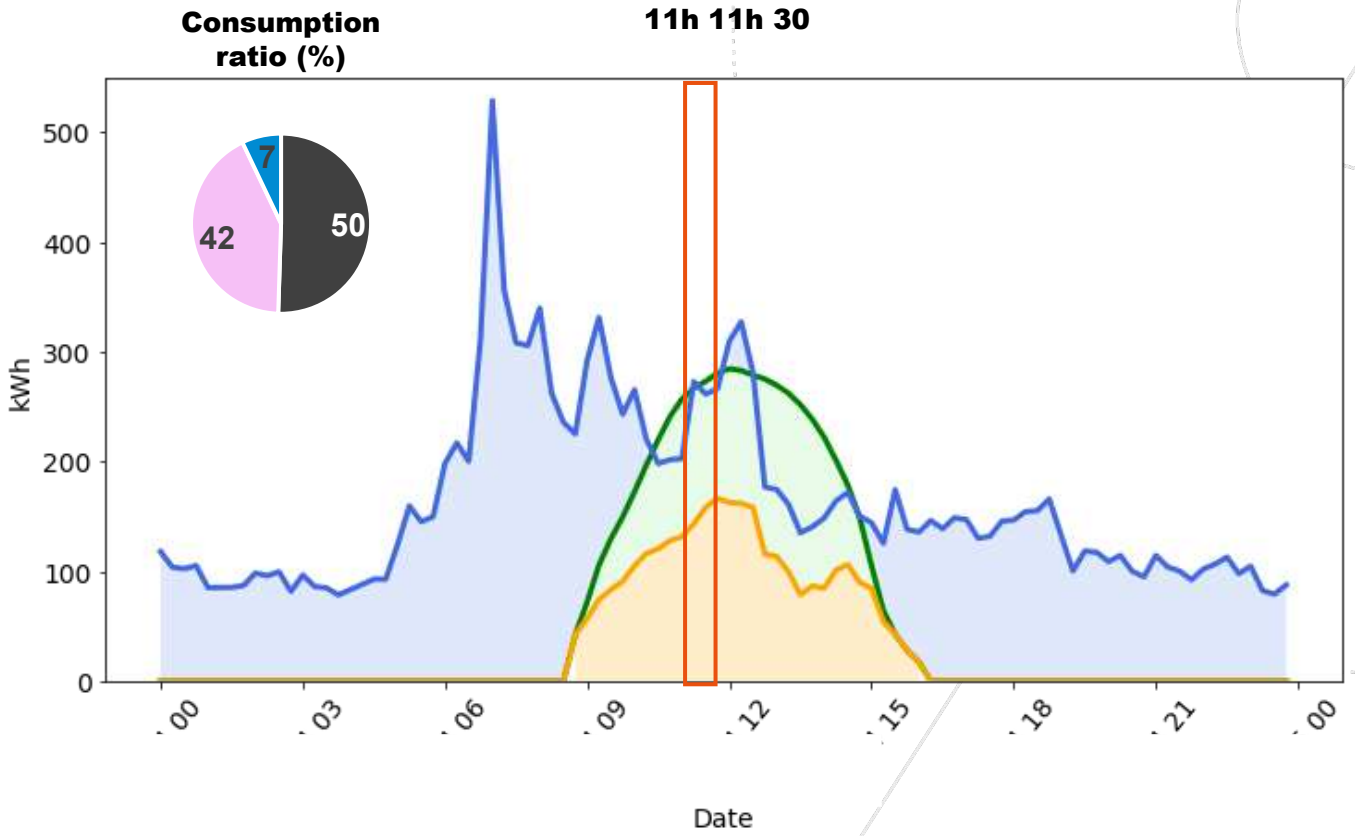
PV production

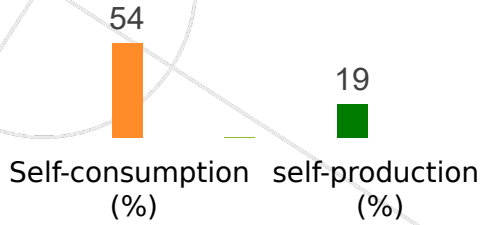
Drahi-X energy consumption

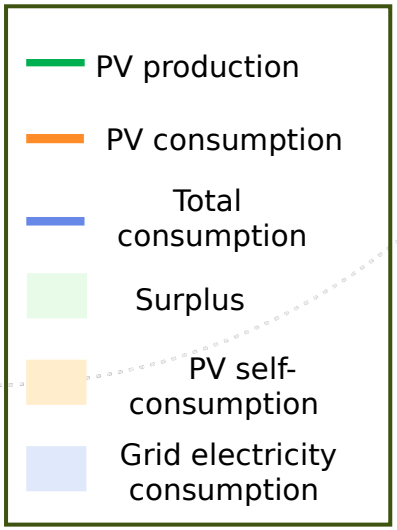
Canteen energy consumption

B103 energy consumption

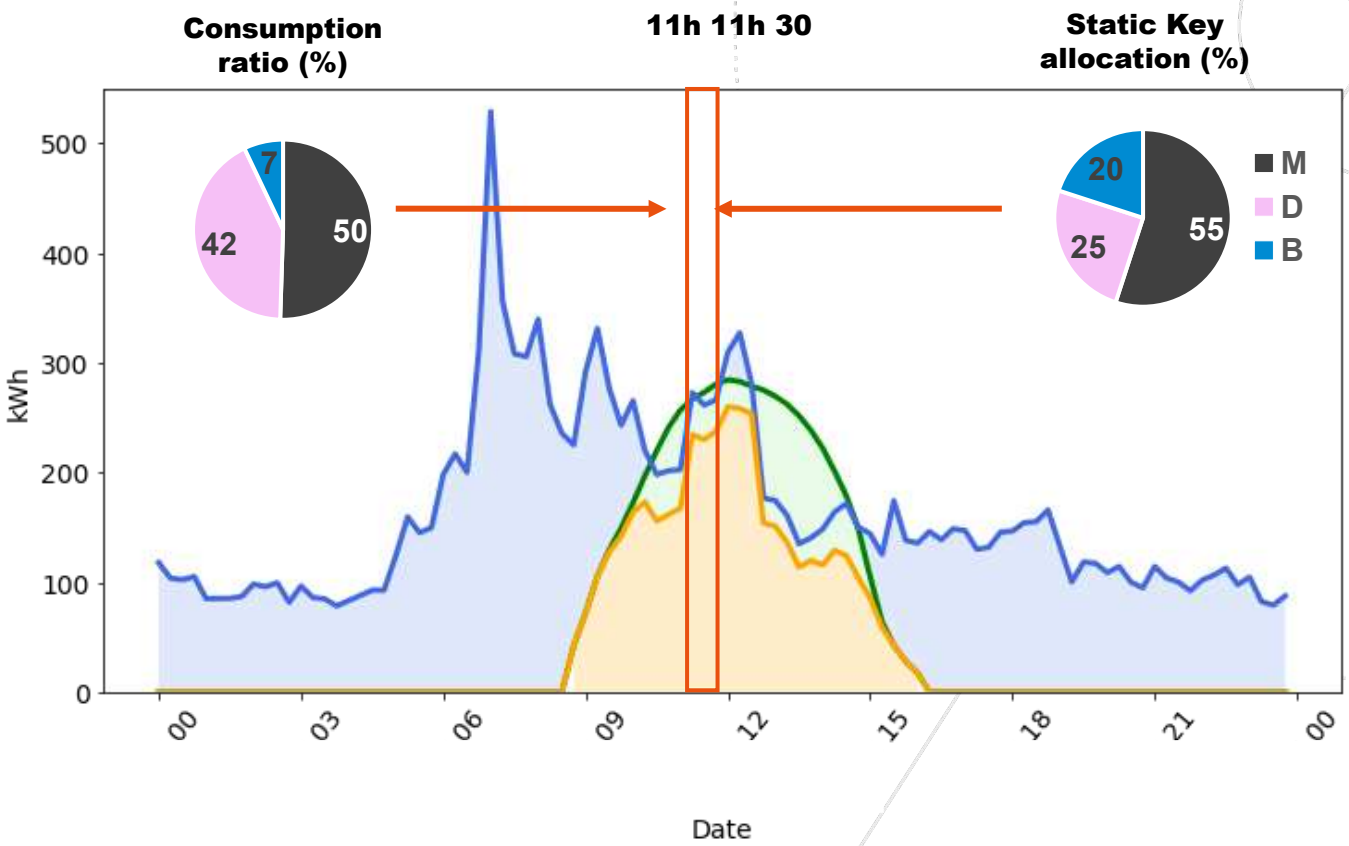
Individual self-consumption – 24th January 2022

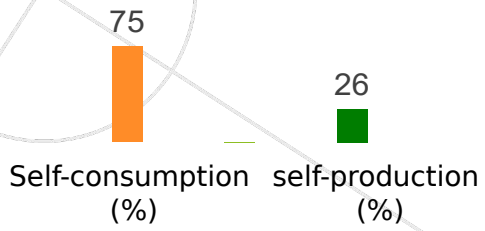






CSC static keys – 24th January 2022





PV production

PV consumption

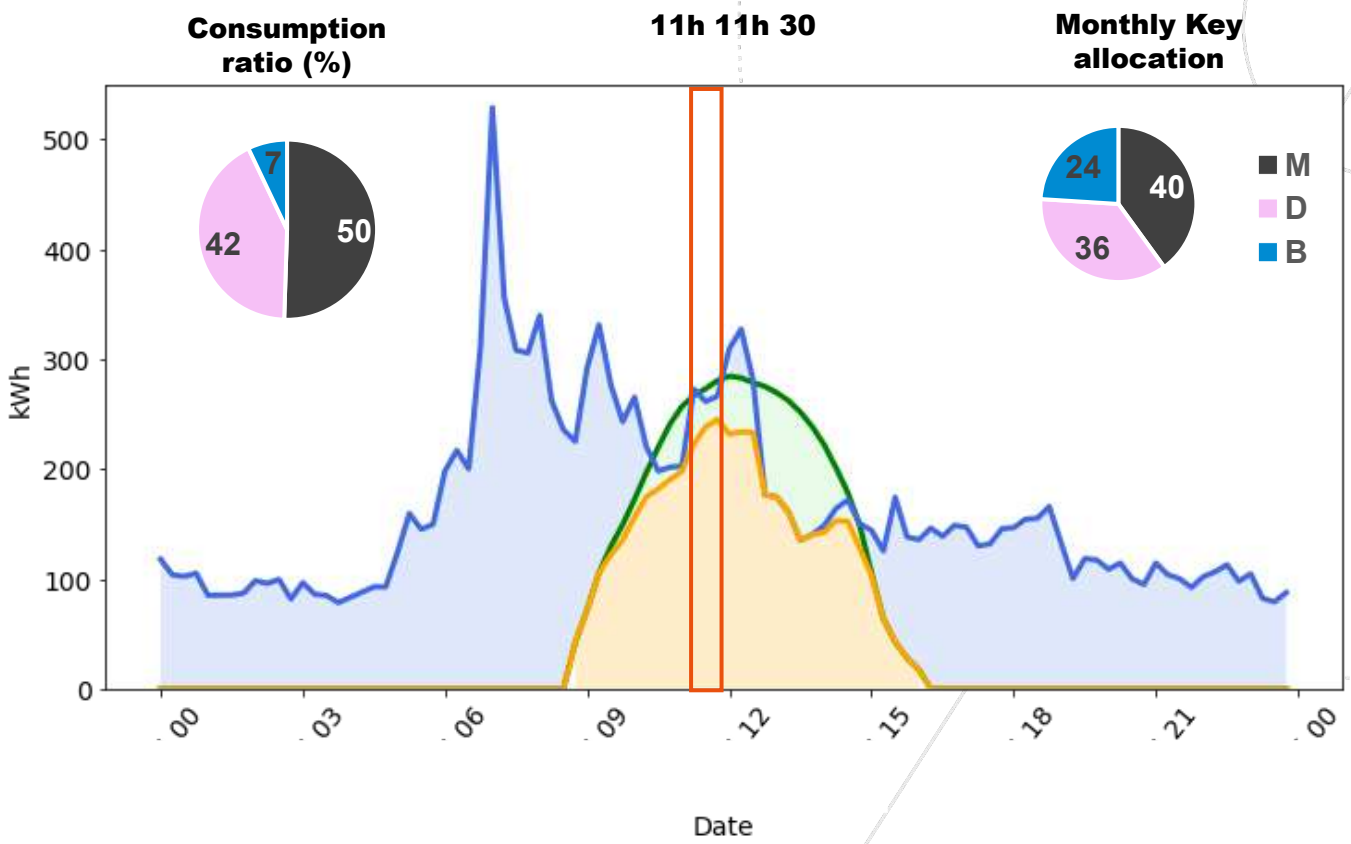
Total consumption

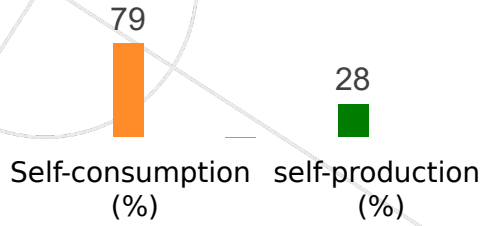
Surplus

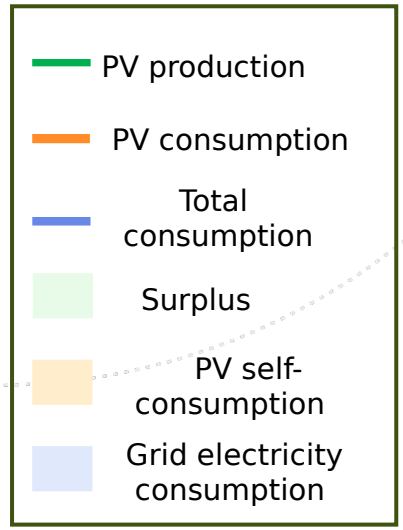
PV self-consumption

Grid electricity consumption

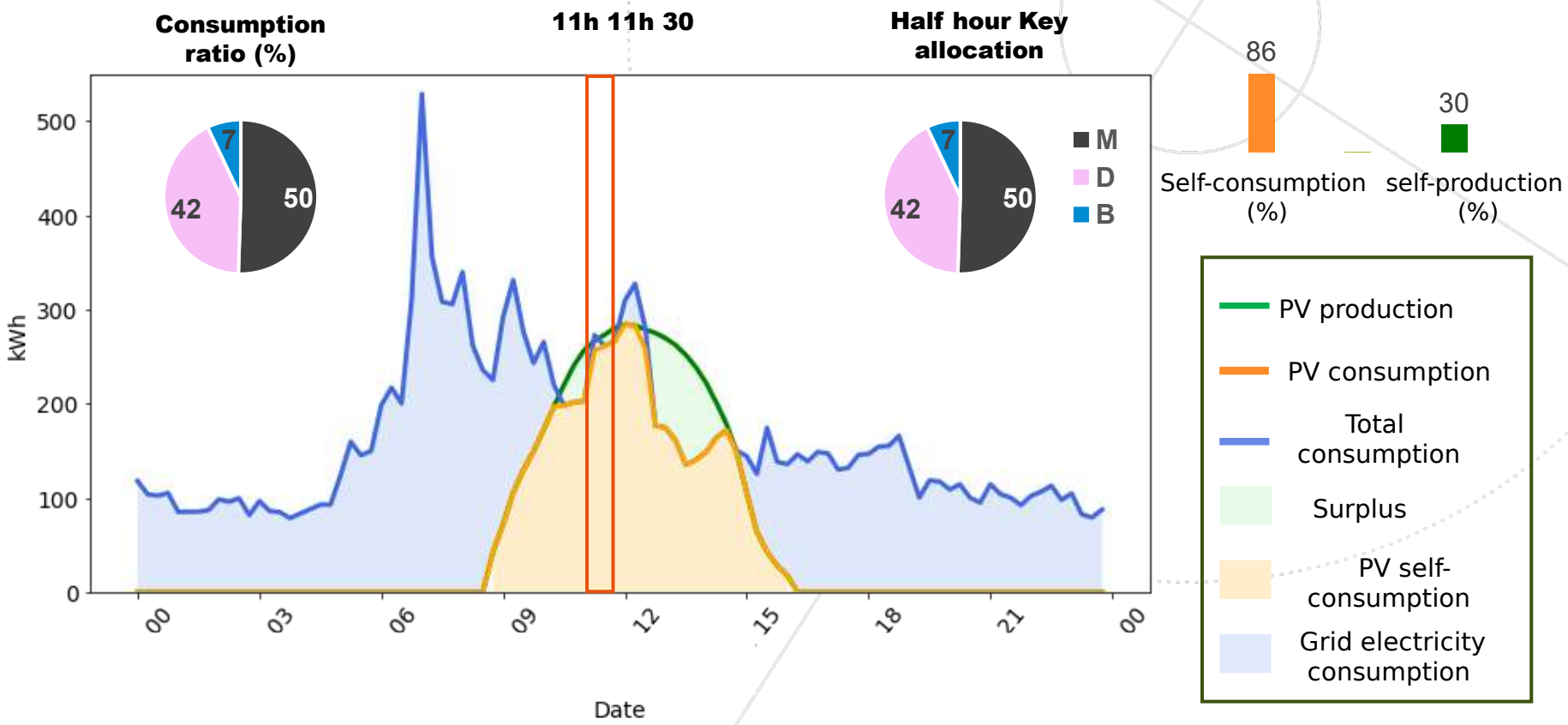
CSC monthly keys – 24th January 2022







CSC 30-min. keys – 24th January 2022



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Conclusion & perspectives

- By simulating an **energy community** we assessed the gains of collective self-consumption compared to individual self-consumption
- **PV surplus reduction of ~20 %** without any costly or complex technological solution, only a **short circuit energy distribution** management, less dependent on market fluctuations
- Further solutions will be explored to reduce surplus : accurate **PV production and consumption forecast** can help consumption flexibility, then increase self-consumption rate.
- Interested by this topic ? Want to **share energy community data ?** please contact us!

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