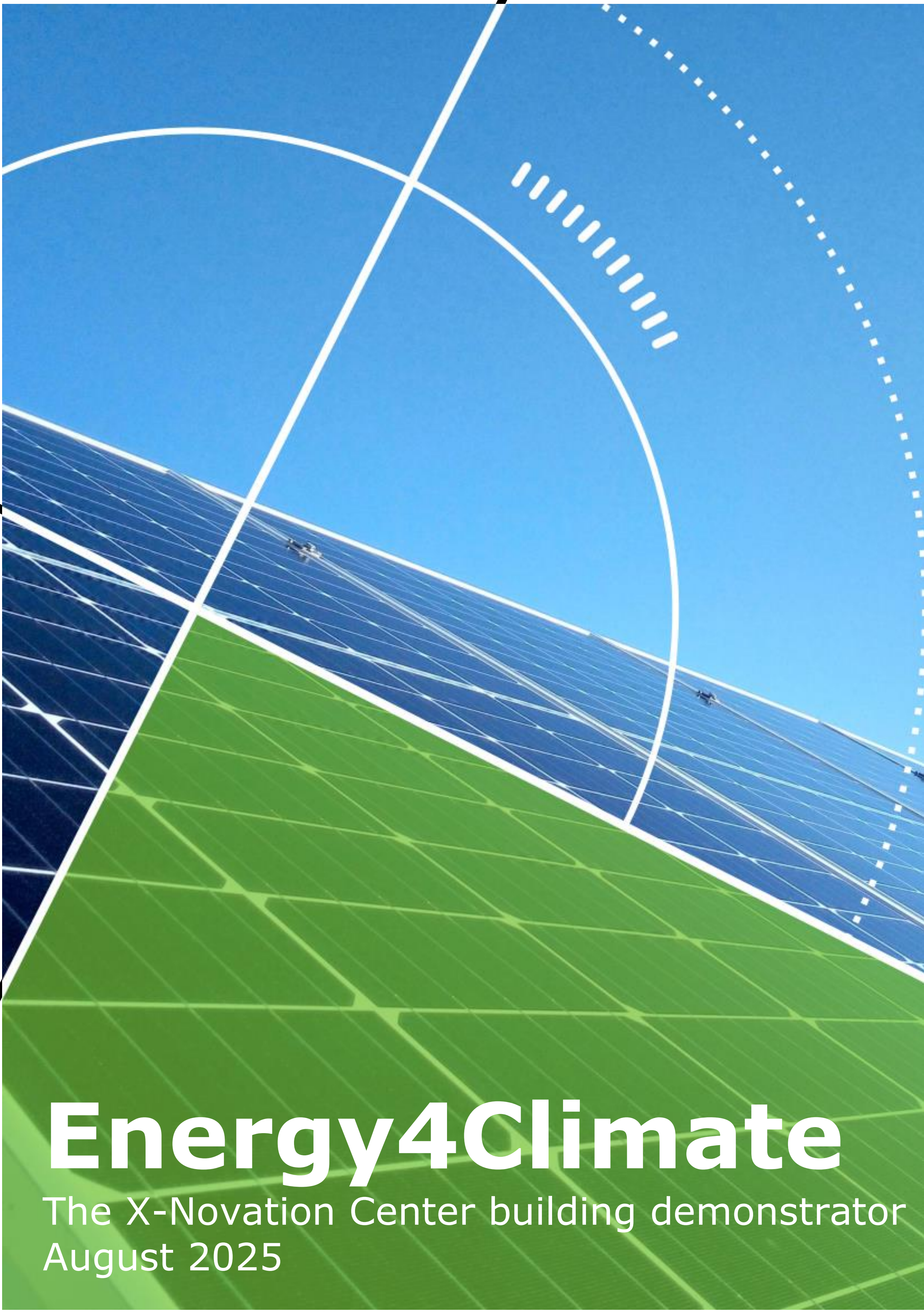

Energy4Climate

The X-Novation Center building demonstrator

August 2025

INSTITUT POLYTECHNIQUE DE PARIS

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1. Context and objectives

According to the International Energy Agency[1], the buildings and construction sector account for over one third of global energy consumption and emissions.
The current energy transition is shifting consumption towards electric, notably with heat pumps and electric vehicles. Both are directly linked to buildings, which are also becoming energy producers, particularly from renewable resources such as photovoltaics, which implies the development of sober, efficient and flexible energy management solutions.
The service improvement thanks to Smart Buildings should be evaluated by benefit/cost analyses through performance indicators. These indicators would be of different nature: economical (for instance through the electrical bill change), environmental (the carbon foot print of the used electricity), related to services to the grid (such as load shedding during peak periods) or well-being related (such as user satisfaction, comfort or new user services).
In this context, the demonstrator in the Drahi-X Novation Center at Ecole polytechnique was designed and up-stream studies were undertaken mainly to study the PV production, the consumption profiles, the self-consumption strategies and the energy flexibility potential of the building.
The Drahi-X Novation Center is a tertiary building with around 5000 m^2 of surface, and the main activity is start-up accelerator and incubator. Most of the space is filled with offices and meeting rooms, although there are also some labs, and in particular a Fablab.

Figure 1 View of the Drahi-X Novation Center building (source: Google Maps)

2. Main players

The demonstrator construction is led by the Energy4Climate (E4C) interdisciplinary Center of IP Paris and has counted with co-funding from the Chaire DTER (Défis technologiques pour une énergie responsable) supported by Total Energies through Fondation of Ecole polytechnique. AVNOR was in charge of the installation of the majority of the elements (in particular the PV installation, the battery, the electric vehicle charging point and all the associated components). Belenn Ingéniérie was the project builder (*Maître d'oeuvre*).
The demonstrator counted with the collaboration of 6 FEDER GPS (https://gridpower.eu/) partners:

- LMD/Ecole polytechnique/E4C, for the coordination of the installation of all elements and the definition of the photovoltaic (PV) plant + battery storage capacity,

[1] hthttps://www.iea.org/energy-system/buildings

- Dotvision, for about 15 Spoony smart meters and the creation of the data flow,
- Elum Energy, for the management and control system of the battery and photovoltaic inverters. Elum also provided essential help for the installation of egauge smart meters in several zones of the building (in particular zone 1 and zone 2, see below for details).
- Clem' for the control of electric vehicle charging terminal and the provision of the car-sharing system, including an API
- And Evolution Energie, responsible for the business model with blockchain and dahsboards.

The above elements were installed in 2020, except for the egauge smart meters, that are operational since 2016 (see section 3.c).

In 2022, a Building Management System for HVAC (Heating, Ventilation and Air Conditioning) control, was installed using Effipilot solution from Accenta (see section 3.e).

3. Demonstration elements

In the following sections we describe each of the key elements of the demonstrator and the links with the data available.

a. Photovoltaic installation

A rooftop PV platform have be installed filling the available space for the demonstrator, that is around 300 m^2. The PV capacity is 16.7 kWp with 53 PV modules.
In addition to its role to supply electricity for the demonstrator, this PV platform was designed to host research and training activities on PV performance. The scheme in Figure 2 shows the concept with the following characteristics:

- 6 PV module types are considered, including mono-Si (black and white backsheets), PERC, half-cell PERC, bifacial PERC and Qcells.
- 2 tilt configurations: 20º (panels #1 to #40) and 30º (panels #41 to #52)
- Two reflector planes in front of two rows of PV modules (panels #45 to #48 with polished steel reflectors and panels #49 to #52 with unpolished aluminum)
- DC/DC optimizers for each PV module of the installation.

The specifications for each PV module are shown in Figure 3

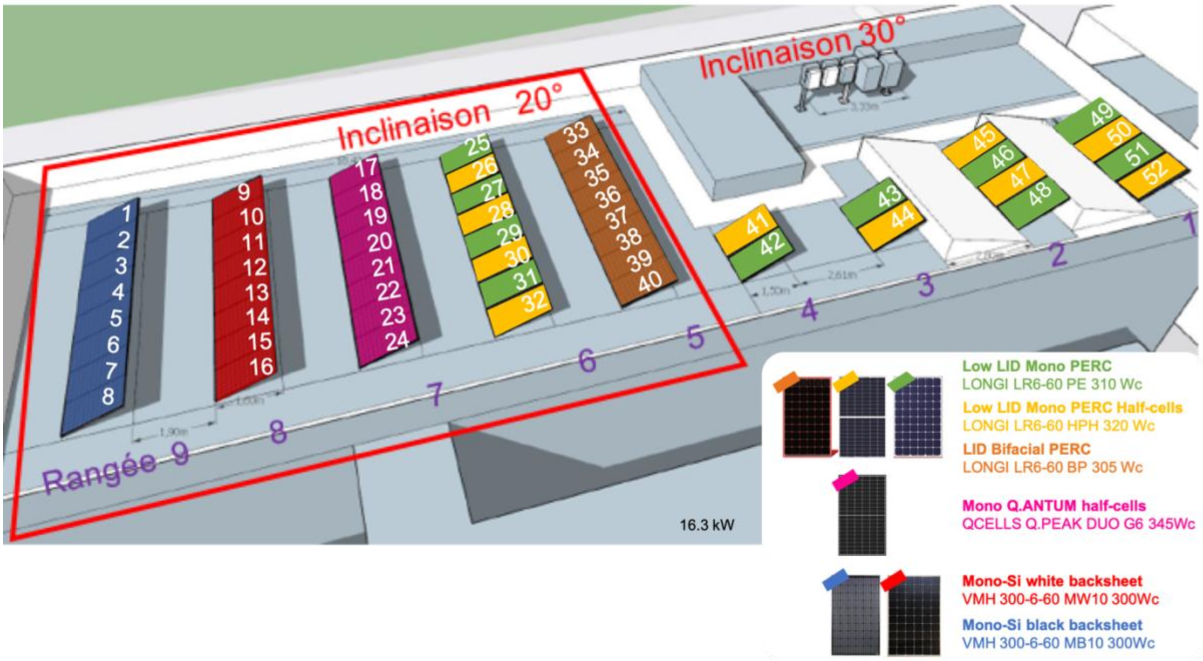

Figure 2 3D scheme of the roof-top PV installation for the Drahi-X Novation Center. Each color correspond to a different PV module that are shown in detail in the right bottom corner of the figure. PV module #53 (not shown in the figure) corresponds to a LG Neon bifacial 405Wp module installed un the roof of the inteverters shelter at 10º tilt towards the South (see Figure 9)

Parameter	Black Backsheet VMH 300-6-60-MB10	White Backsheet VMH 300-6-60-MW10	Q.ANTUM Half-cells QCELLS Q.PEAK DUO G6	PERC Half-cells LONGI LR6-60 HPH	PERC Full-cells LONGI LR6-60 PE	Bifacial PERC LONGI LR6-60 BP
P_{meas} (W)	300	300	345	320	310	305
V_{mpp} (V)	32.715	32.715	33.76	33.90	33.20	32.70
I_{mpp} (A)	9.17	9.17	10.22	9.43	9.35	9.33
V_{oc} (V)	39.84	39.84	40.49	40.90	40.30	40.10
I_{sc} (A)	9.83	9.83	10.73	10.02	9.98	9.92
α_{STC} (%/°C)	+0.06	+0.06	+0.04	+0.057	+0.057	+0.060
β_{STC} (%/°C)	-0.30	-0.30	-0.27	-0.286	-0.286	-0.30
γ_{STC} (%/°C)	-0.39	-0.39	-0.36	-0.37	-0.37	-0.37
η_{STC} (%)	18.37	18.37	19.30	19.10	19	18.40
Area (m²)	1.633	1.633	1.792	1.676	1.635	1.657

Figure 3 Specifications of PV modules at rooftop installation. αcorresponds to the short-circuit temperature coefficient, β to the open-circuit voltage temperature coefficient, γ to the power temperature coefficient, and ηto the module's efficiency.

Figure 4 View of reflectors installed for panels #45 to #52. The installation of these reflectors were done between the 26 Oct 2021. This installation implied the shift of panels #43 and #44 about 30 cm to the South and it implied that, from then on, these two panels suffer a bit more from shading in winter (from the front row, that is panels #41 and #42).

These configurations allow multiple cross-comparisons for PV performance analyses in addition to PV modelling at the module and system levels.
The installation was commissioned on 17 July 2020 and, during the first year of operation, it produced 20.4 MWh for 16.7kWp, which is 1221 kWh/kWp. That is on the high range expected for the Paris region (rather sunny year).

Figure 5 View of the Drahi-X photovoltaic roof-top installation

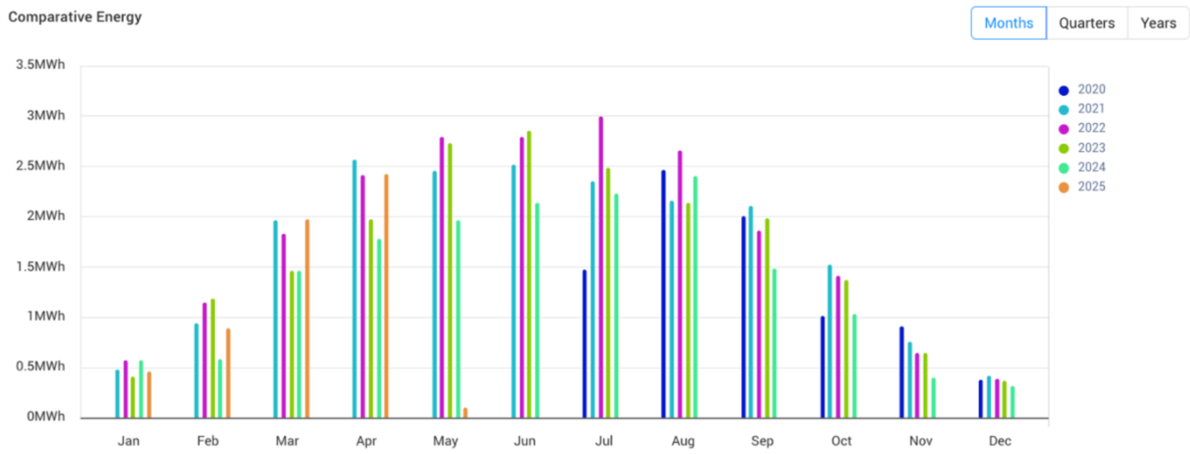

Figure 6 Monthly energy production of the Drahi-X photovoltaic installation.

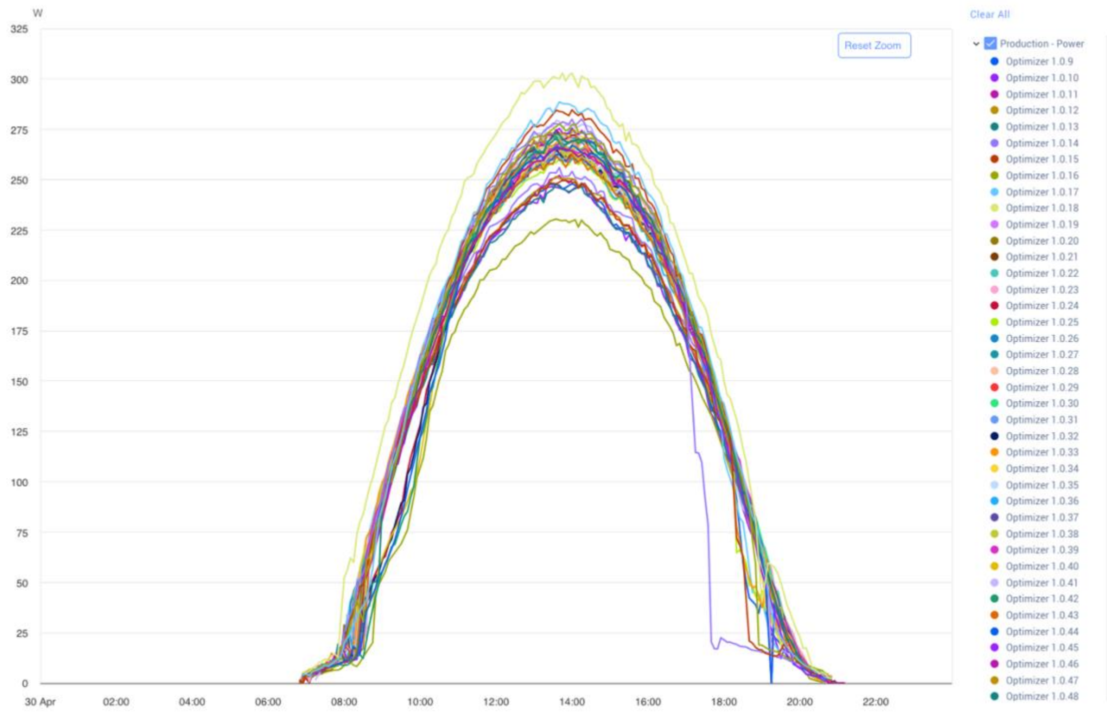

Figure 7 Power generation for a sunny day (29 April 2025) for each PV module

b. Electrochemical storage capacity

Two BYD batteries of 30kWh of storage capacity were installed on the roof next to the PV installation. Three Victron Multiplus 5000 inverters were installed, one per phase. The installation was done in a way that the PV and battery parts were only connected on the AC part, that is that separate battery and PV inverters were installed as shown in Figure 8. Figure 9 shows a view of the installation on the roof of the Drahi-X building.

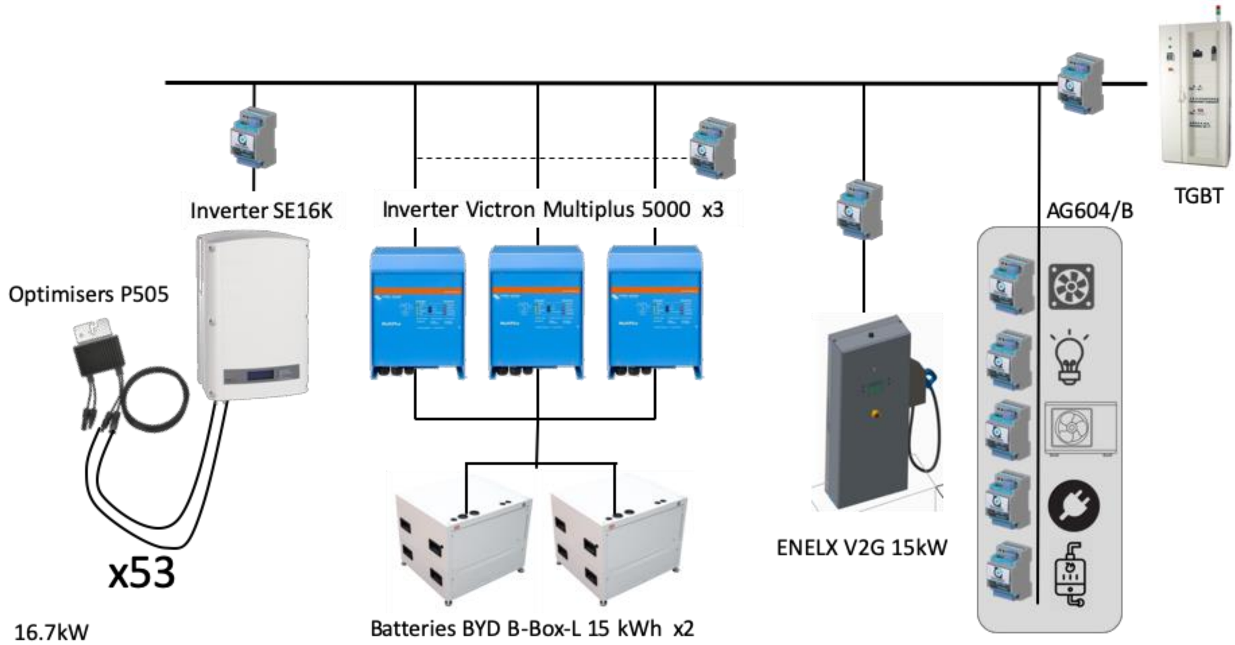

Figure 8 Wiring scheme for the PV - battery - EV charging - Load parts of the system. The ENELX V2G station was replaced in Summer 2024 by a V1G of 21 kW.

Figure 9 View of the battery (in blue) and PV (in blanc) inverters on the roof of the Drahi-X building

c. Egauge electricity meters

Electric consumption of the Drahi-X building is measured since July 2016. First measurements were for the total consumption of the 7 electric zones that existed by then as well as the global electric consumption (Figure 11 and Figure 12) using egauge meters (www.egauge.net). Measurements are stored at 1 second resolution since then.

Figure 10 (left) Location of the 7 electric Zones of the Drahi-X buildings for which consumption measurements exist since July 2016 (right) photo of the type of egauge devices installed (www.egauge.net)

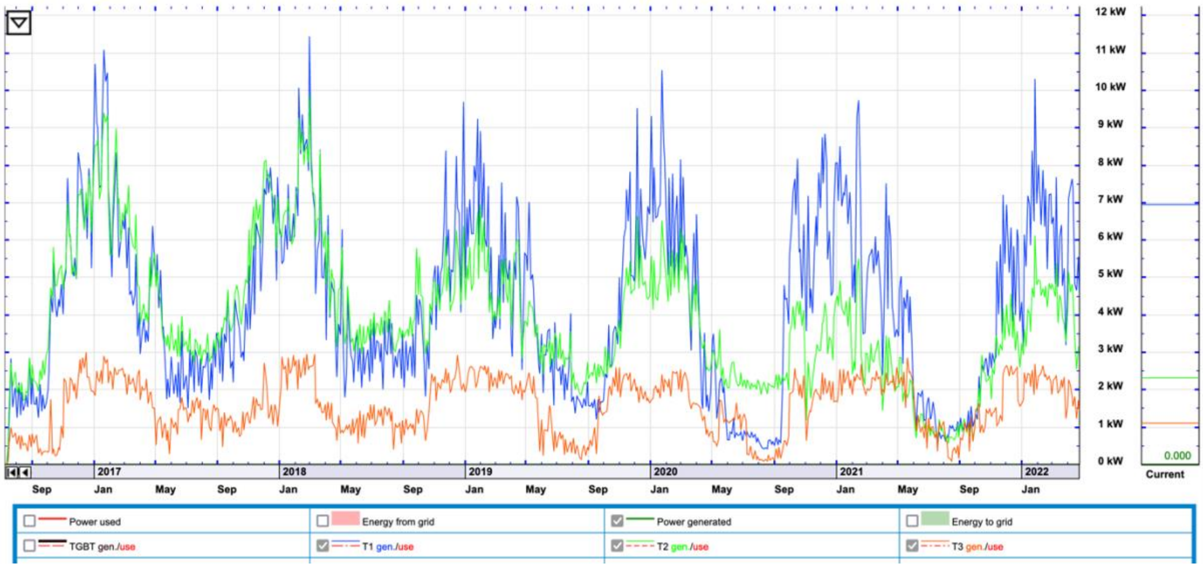

Figure 11 Screenshot of the electric consumption for Zones 1-3 of the Drahi-X building using egauge meters (since July 2016).

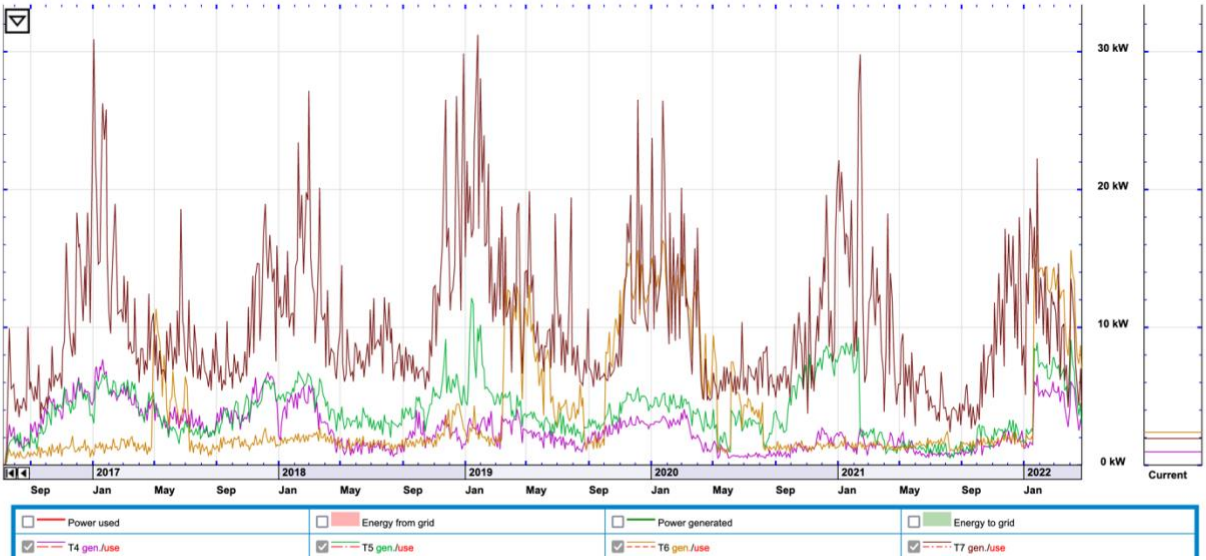

Figure 12 Screenshot of the electric consumption of Zones 4-7 of the Drahi-X building using egauge meters (since July 2016).

In April 2018, two new egauge devices were installed in Zones 1 and 2 in order to measure the consumption by type (heating/cooling, ventilation, plugs, lights and water heater). Data is also stored at 1s resolution since then. Figure 13 and Figure 14 show the evolution of these measurements since then. They show that main consumption is due to Heating during the cold months.

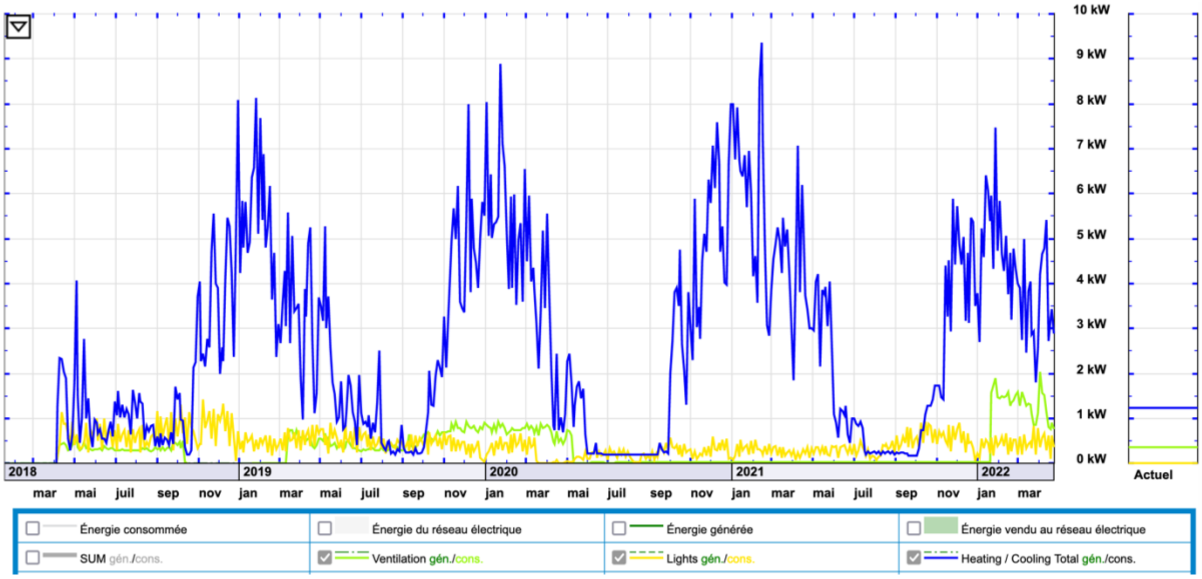

Figure 13 Screenshot of the electric consumption of different types in Zone 1 since April 2018

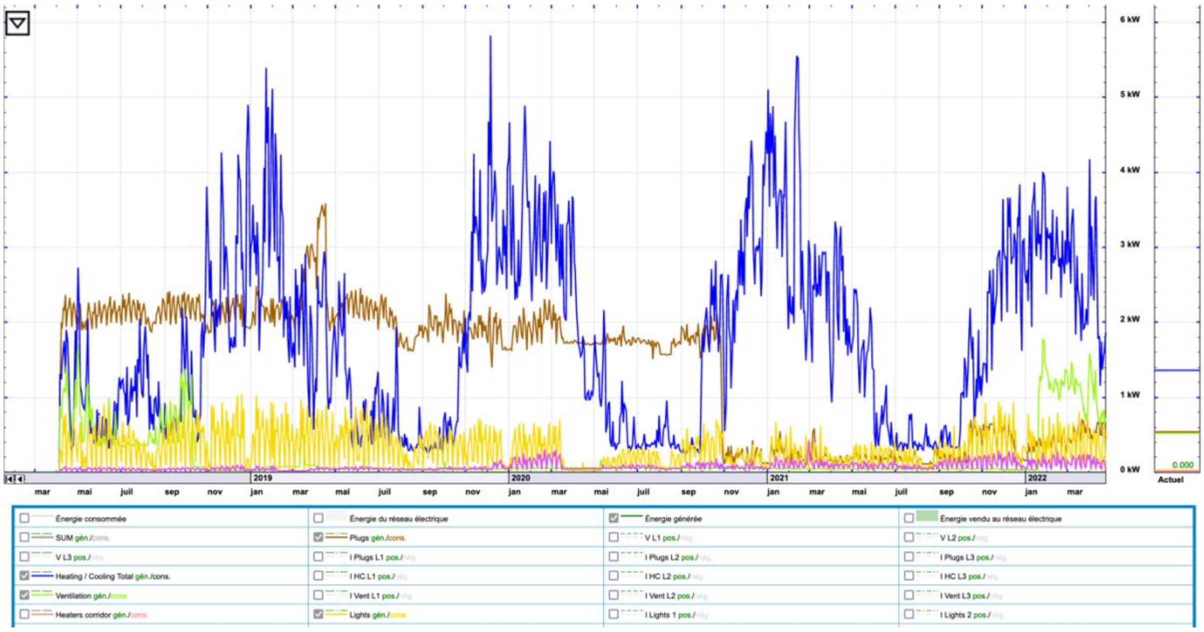

Figure 14 Screenshot of the electric consumption of different types in Zone 2 since April 2018

d. Spoony smart-meters from Dotvision

By the end of 2018 the new construction works started in the building in order to double the surface size. One of the consequences was the appearance of 4 new electric zones and a new general low voltage electric panel (TGBT). The measurement of the electric consumption for these new zones was done within the framework of the FEDER GPS project.

DotVision was in charge of installing smart energy meters (Spoony) to monitor the electricity consumption or production of these new zones in the Drahi-X building. The devices that were installed are:

- 5 Spoony in the TGBT cabinet for monitoring the general consumption of the building as well as the heavy machinery, Fujitsu, office and management circuits (Figure 15). Installation done on 6 Dec 2019.

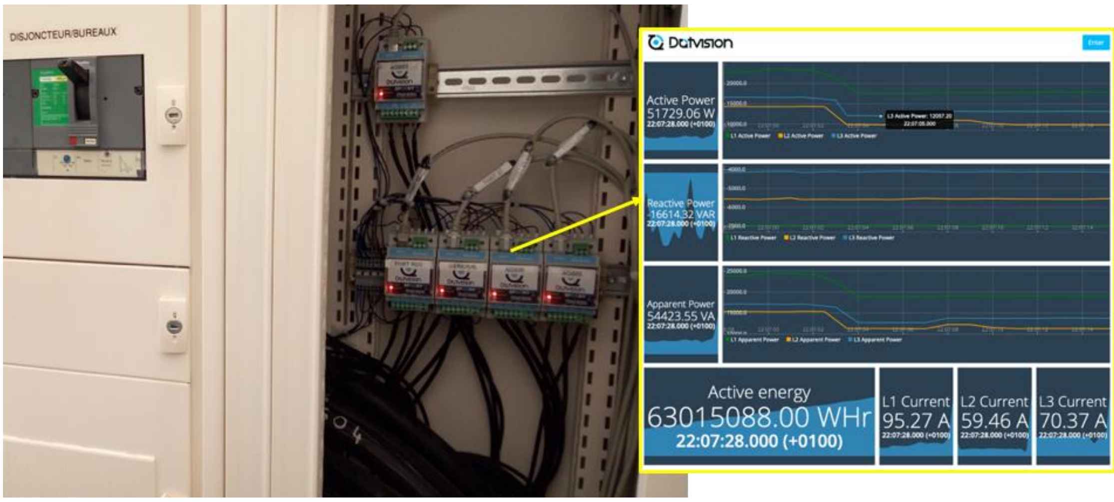

Figure 15 View of the 5 Spoony devices in the TGBT cabinet of the Drahi-X building.

- 7 Spoony in the 604 electrical cabinet (Figure 16) for consumption monitoring of the general electrical supply and lighting, heating, cooling, and outlet circuits and the EV terminal consumption. The installation were done on 7 Dec 2019.

Figure 16 View of the 604 electric panel after having installed 7 Spoony devices in two zones that are zoomed-in on the right. The orange zone contains a Spoony that allows to open/close the water heater circuit remotely.

- 2 Spoony where installed on 3 Sep 2020 on the roof of the building to monitor the photovoltaic panels and the batteries.

Figure 17 View of the electric panel on the roof of the Drahi-X building after having installed two spoony devices in order to count the photovoltaic and battery electricity.

- 1 Spoony was added in the 604 cabinet on Jan 13 2021 to measure the electricity exchange with Vehicle2Home charging point.

Figure 18 View of the 604 electric panel after having added the Spoony to count the exchanges with the Vehicle2Home charging statoin

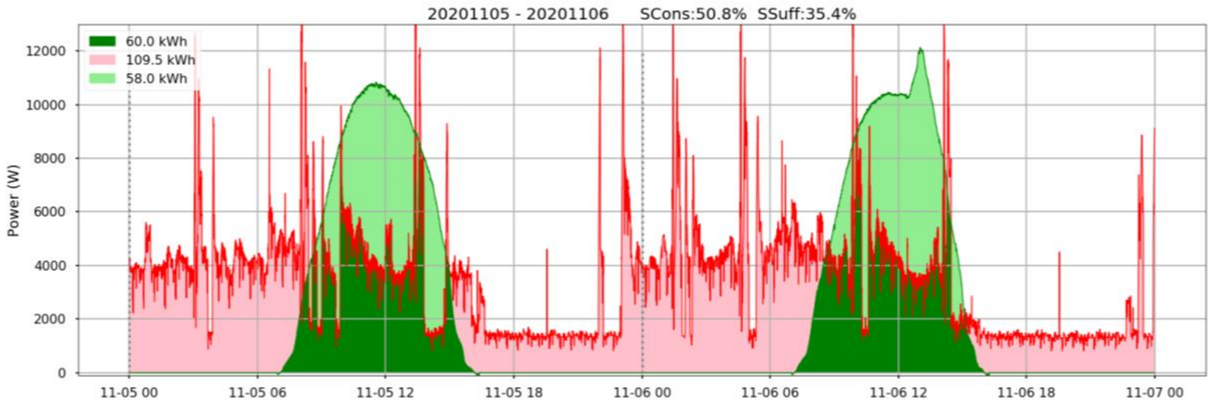

Figure 19 Spoony power visualisations for PV and consumption in zone 604 of the Drahi-X building for a 2-day period

e. Smart Building management System

From the beginning of 2022 a new building management system (BMS) will be commissioned at the Drahi-X Building, which will allows controlling and having access to all the measurements from the heat pump and ventilation systems. The BMS will be proposed by ACCENTA, and the heating-cooling-ventilation systems will be automatically controlled using predictive control based on artificial intelligence. The system allows remote control from research algorithms.

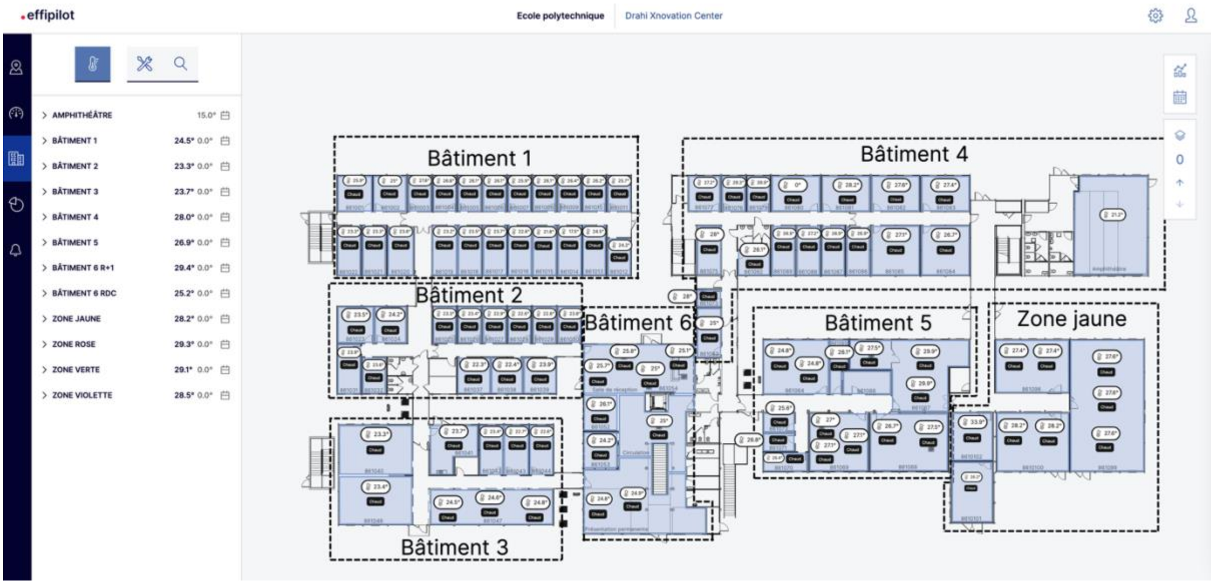

Figure 20 Screenshot of the Smart building management system platform (Effipilot, from Accenta).

4. SIRTA measurements

To complete the dataset and allow studies including meteorological and radiative data, the measurements from the SIRTA atmospheric observatory (https://sirta.ipsl.fr/) were made available too. These measurements (see Figure 21 and Figure 22) are about 350 m West from the X-Novation Center building.

Figure 21 BSRN (baseline surface radiation network) installation at SIRTA with Global, direct, diffuse solar irradiance as well as infrared irradiance measurements

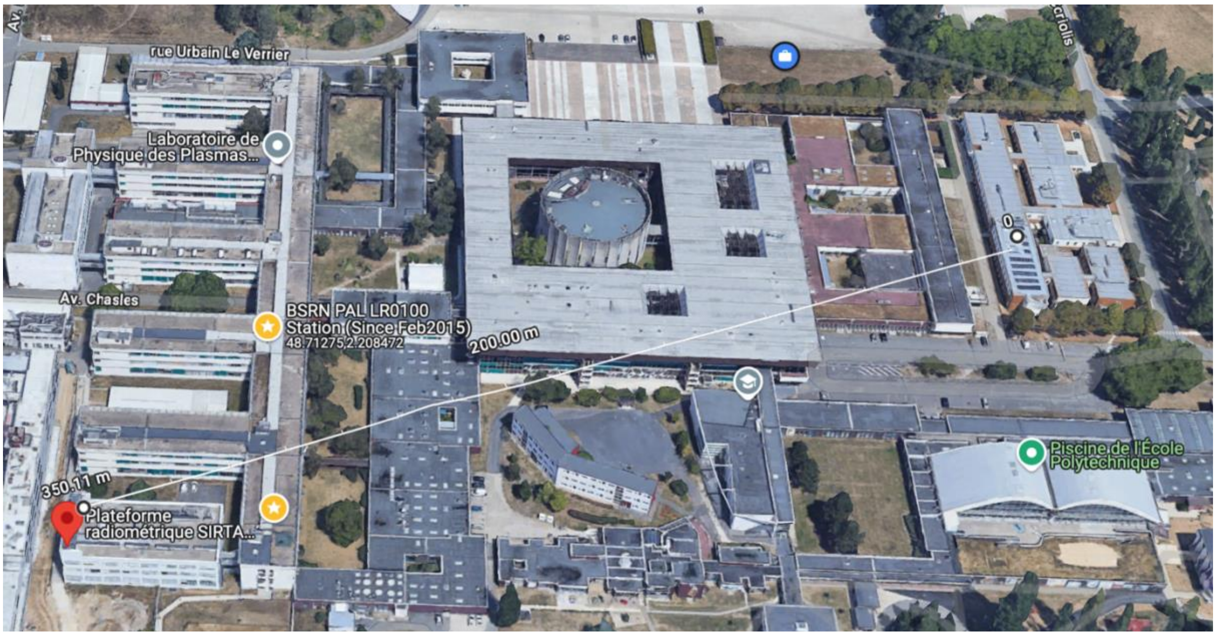

Figure 22 View of the distance between the X-Novation Center building (on the right) and the SIRTA rooftop platform (on the left). They are about 350 m appart.

5. Some remarkable events

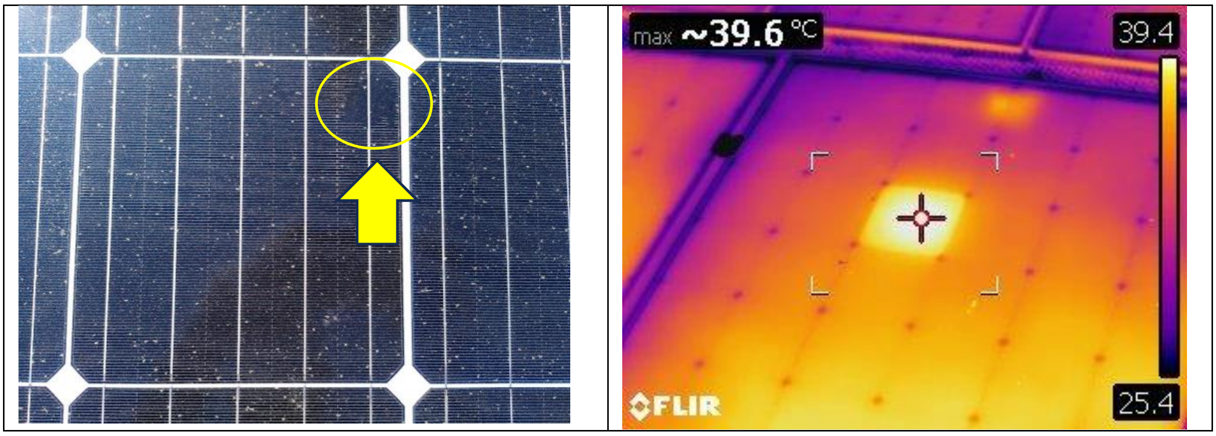

Figure 23 Panel #16 suffers from degradation from the beginning of the installation which makes it underproduce by about 10% compared to the others in the same row. The photo on the left shows the manufacturing default in the electric buses and the infrared image on the right shows how this corresponding cell is a hot spot (absorbs part of the power).

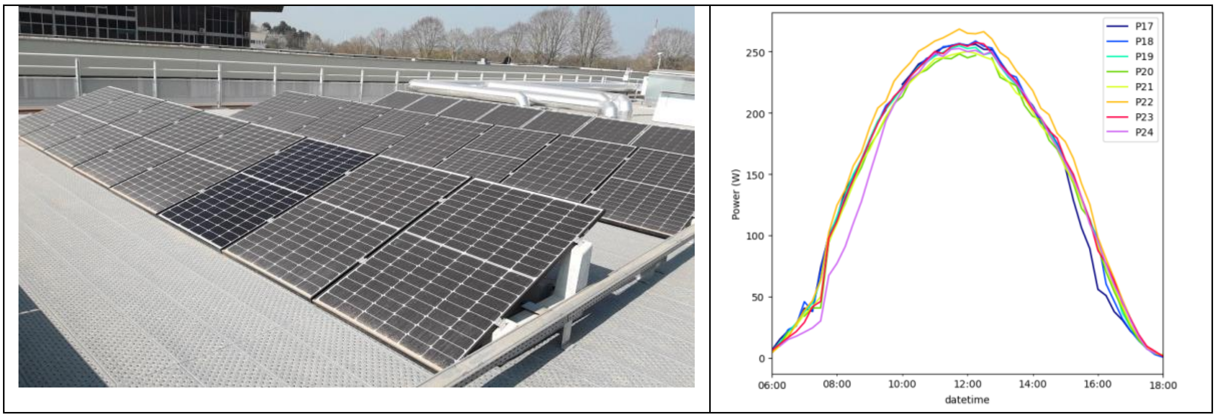

Figure 24 (left) Photo of the third row of PV modules (#17 to #24) for a sunny day (25 March 2022) showing soiling for all panels except for one (panel #22) that was cleaned. (right) Power curves for the eight panels of this row showing the increase of power for panel #22

Figure 25 Panels #36 (left) and #38 (right) were covered with a black plastic on the rear side for one year (4 Feb 2021 to 18 Mar 2022) as an experiment to estimate the bifacial gain of the panels (by comparison).

Figure 26 Snow on the installation on 10 Feb 2021 (left) and the state of the panels with still some snow for the ones 20º-tilted on 12 Feb (right).