# Smart Grid Thermique Electrique (SmartGTE) demonstrator

## Dataset before the system installation

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# 1. Introduction

In 2019, École Polytechnique committed to an ambitious carbon neutrality plan for its campus, which was formalized in the Climate Plan presented in January 2022. As its buildings are fifty years old, it is essential to renovate some of them and improve their energy efficiency, starting with the energy systems. In this context, the École Polytechnique is opening up to the implementation of a demonstrator in collaboration with the Energy4Climate center for thermal and electrical smart grids involving four residential buildings. The four residential buildings are located on a plot of approximately 2 hectares to the southeast of the Institut Polytechnique de Paris campus (Figure 6). These buildings are used to house married students and executives. There are two main outdoor parking areas with around 50 spaces available.


*Figure 1 Bâtiments du campus devant accueillir le smart GTE.*

Built in the mid-1970s, the apartment buildings were constructed according to 1960s standards prior to the first oil crisis. Apartment buildings 43-44-45 and 66 (Figure 2) had an insulation renovation, with the replacement of exterior joinery and the installation of external thermal insulation on the entire building.

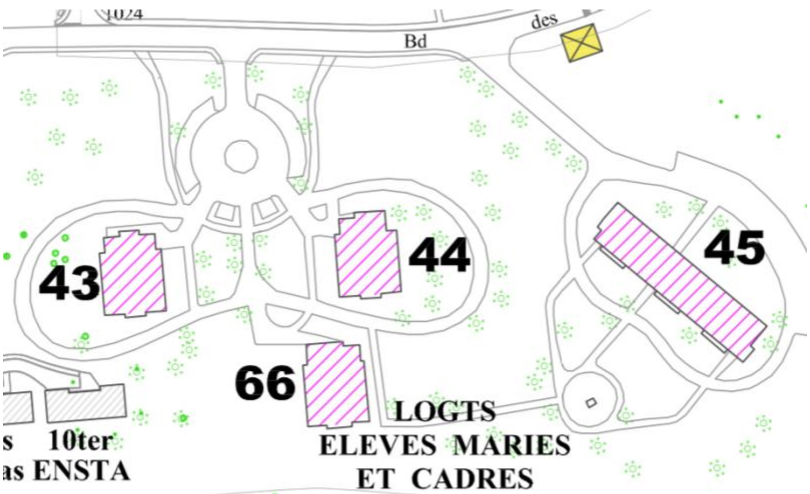


*Figure 2 Bâtiments du campus et leur numérotation devant accueillir le smart GTE*

# 2. SmartGTE demonstrator project

The objective of this demonstrator is to set up a geothermal heat production system and reinforce it with electricity and heat production using photovoltaic solar panels.

This system will operate on two different time scales: one in the short term for immediate consumption and one in the long term for inter-seasonality. The scientific objective is to optimise the management of the solar energy produced between these two time scales. Thanks to an intelligent energy management system, it will determine when to store heat and when to use it to maximise energy efficiency.

This demonstrator addresses a major challenge: how to store low-carbon energy produced in summer for use in winter, when demand is higher and the supply of carbon-free energy is more complex. Unlike conventional batteries, which quickly lose their charge, this system explores sustainable and efficient solutions.

The Thermal & Electrical Smart Grid demonstrator is an important lever for decarbonisation. By largely replacing gas supply with optimised electrical management, the buildings concerned will be able to reduce their $CO_2$ emissions by 78%, according to estimates from the selected system. This experiment will also make it possible to assess the impact of inter-seasonal storage on energy consumption and its integration into the overall network.

Beyond the environmental benefits, this project will have a direct social impact. Residents of the buildings concerned will benefit from lower energy bills. In addition, researchers will have a unique testing ground for analysing actual consumption at the building level and improving smart energy management systems.

In a spirit of knowledge sharing, the data collected by the demonstrator will be made available. The project also plans to focus on actual usage, user feedback and their adoption of the technologies implemented. The demonstrator is also open to the integration of electric vehicle charging stations and stationary battery storage.

This initiative will therefore benefit users as well as researchers and stakeholders in industry and urban planning, promoting the development of more efficient and sustainable energy solutions.

# 3. Electricity consumption measurements

In terms of data collection, the first step for SmartGTE was measuring the electricity consumption for each of the four buildings at 5-minute time steps. Figure 3 shows the meters that were installed in mid 2024 as well as 2 days of measurements.

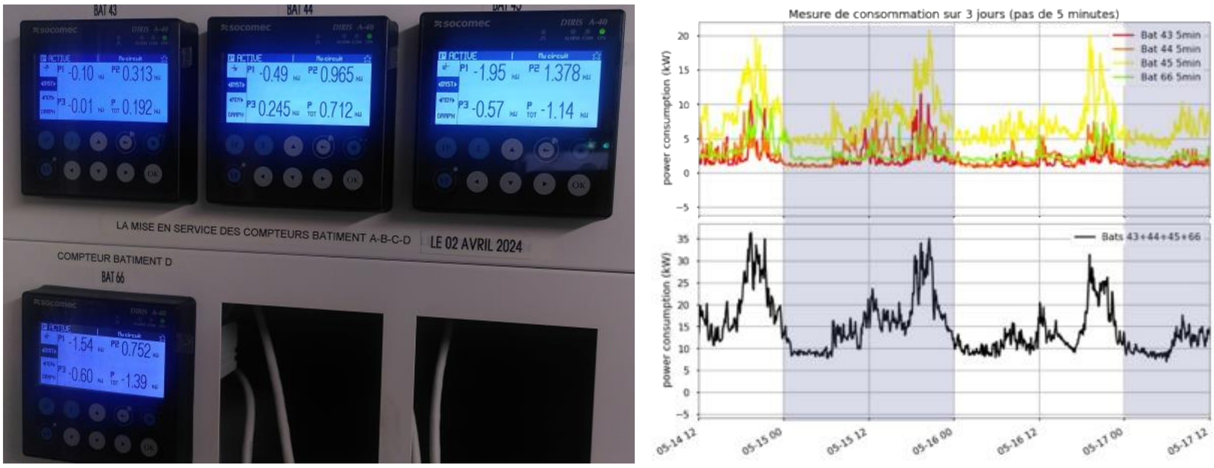

*Figure 3 (left) view of the 4 Socomec DIRIS A-40 meters measuring electricity consumption for each of the SmartGTE buildings. (right) Figure showing the measurements for 2 days*

# 4. PV production estimations

Since the PV rooftop installations were only built in Summer 2025, a first data set was created with simulated PV. That is PV was estimated from solar irradiance, air temperature and wind speed measurements. Two sources for these data were considered in order to enhance the possible study applications:

A. Nearby measurements: Located 1 km away, the SIRTA observatory (Figure 4, https://sirta.ipsl.fr/), measures global, diffuse and direct irradiance (Figure 5) as well as meteorological measurements (Figure 6) at 1-min steps.
B. Numerical Weather predictions: MeteoFrance's ARPEGE NWP outputs (with 7 km of resolution and 1h time steps) were available for the Campus grid point. Global solar irradiance, as well as air temperature and wind speed were the considered variables.

Data source A is used to estimate the real PV production that would have been produced by SmartGTE. Data source B is used to compute the dayahead PV forecasts.

PV is computed (whether from SIRTA measurements or ARPEGE forecasts) from solar irradiance, wind speed and air temperature, using python pvlib v0.13[1] functions, considering a PV installed capacity of 62 kWp with PV modules tilted 10º towards South (in order to stay close to the real PV installation in SmartGTE).

In particular, the methods used are :

- plane of array irradiance : pvlib.pvsystem.sapm_effective_irradiance
- PV cell temperature : pvlib.temperature.sapm_cell
- PV DC power : pvlib.pvsystem.pvwatts_dc
- PV AC power : pvlib.inverter.pvwatts

[1] https://pvlib-python.readthedocs.io/en/v0.13.0/

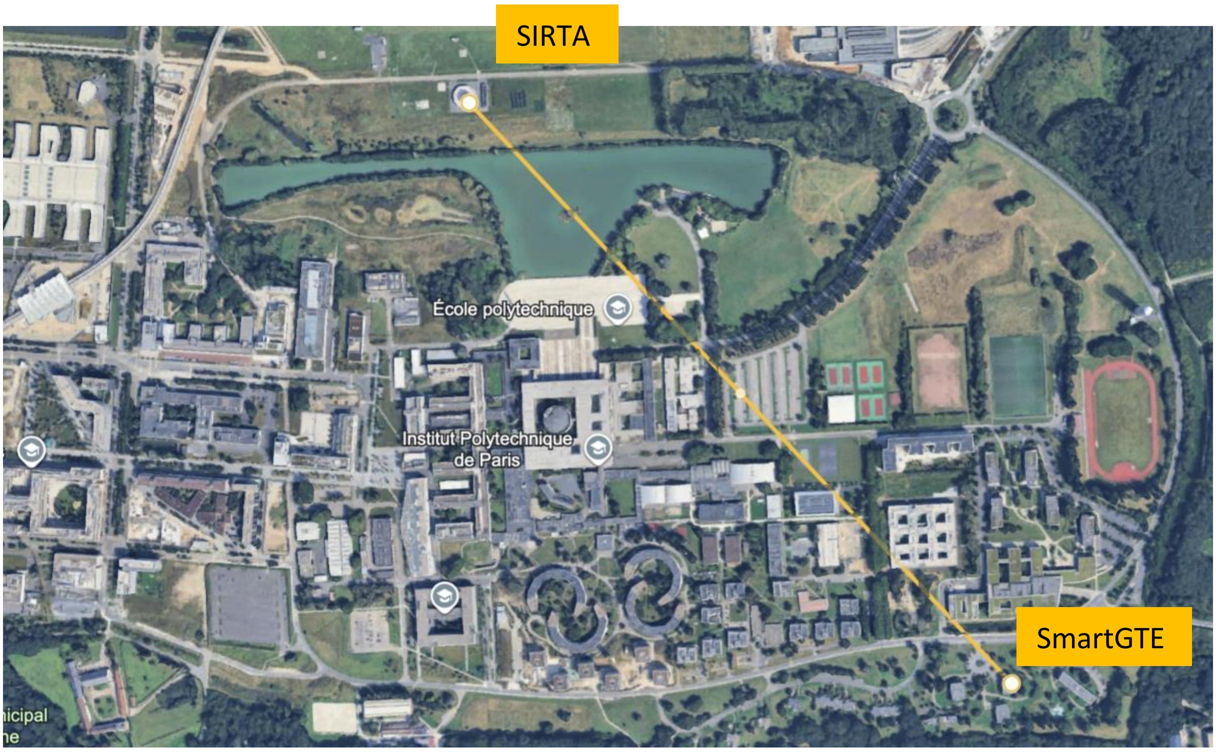


*Figure 4 Campus View with the location of SIRTA observatory (from which solar irradiance and meteorological measurements are taken), 1 km North-West from SmartGTE location*

*Figure 5 SIRTA's roof-top radiative installation measuring solar global, direct and diffuse irradiance*

*Figure 6 SIRTA's state-of-the-art meteorological station measuring several variables, such as air temperature and wind speed*

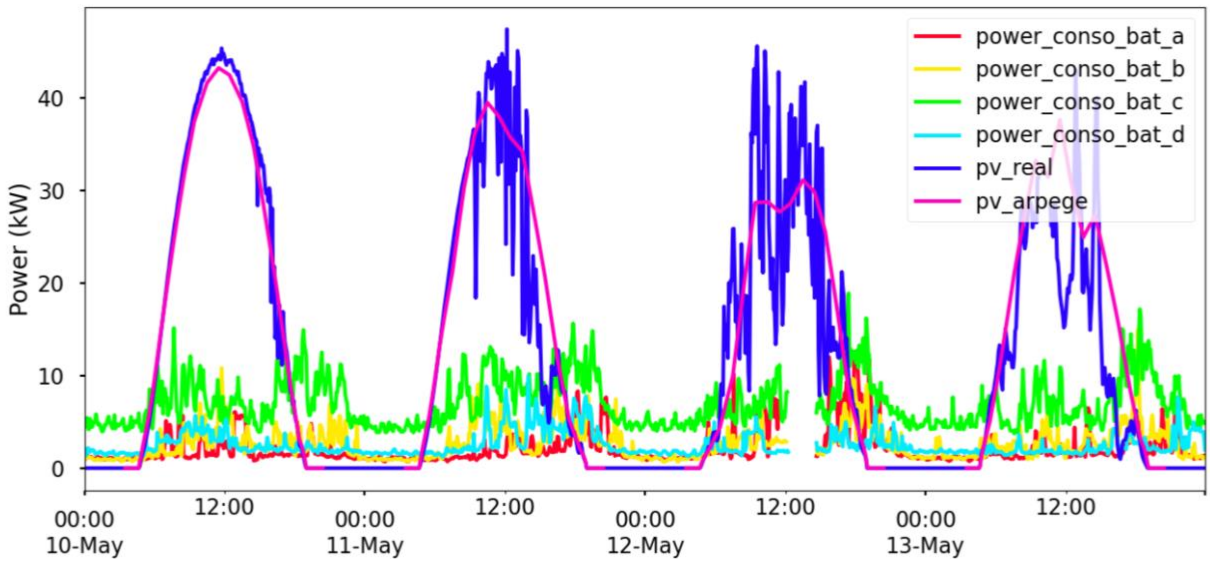


*Figure 7 Plot of 4 days of all data : PV estimation (pv_real), PV forecast (pv_arpege) and PV consumption (power_conso_bat_x)*