Internship opportunity

Development and implementation of an Energy Management System on two PV-battery-based microgrid platforms

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The internship is proposed by LMD and CERMICS laboratories of the E4C Interdisciplinary Center in collaboration with GeePs and LISN.

Duration: 6 months
Type of work : python programming / data analyses / experimental
Topics related to the subject: Integration of renewables (PV), smart-grids, micro(nano)grids, energy management of microgrids, DC power systems
Skills to be explored (and used): Python programming, Power and basic electronics (design, simulation & construction)

Specific Objectives:

- Code, test and validate an algorithm for the Energy Management System (EMS) of an existing laboratory scale nanogrid which is powered by PV, wind, battery and a secondary DC power source.
- Implement the algorithm online for a remote access to data and results.

Description of the project:

The development of smart grids is expected to come from the aggregation of basic low voltage power supply networks, known as microgrids, which associate local energy production with storage capacities and energy consumers. Microgrids restricted to a single building are often called "nanogrids" and are also getting attention as the building block of a microgrid. Such nanogrids are vulnerable to both sudden changes of power generation and load demand because of their small size, especially when operating in an island mode. Thus, managing uncertainty becomes essential when searching for an optimal nanogrid operation.

Figure 1: NRLAB views

In this context, two different scale platforms have been developed by the Energy4Climate (E4C) Interdisciplinary Centre at the Campus of IP Paris:

- a laboratory-scale nanogrid (hereafter referred to NRLAB for Nanogrid research lab, Figure 1) is being developed to serve as experimental test bench for research and pedagogical purposes.
- A building-scale microgrid demonstrator at the Drahi-X novation center building of Ecole Polytechnique (Figure 2).

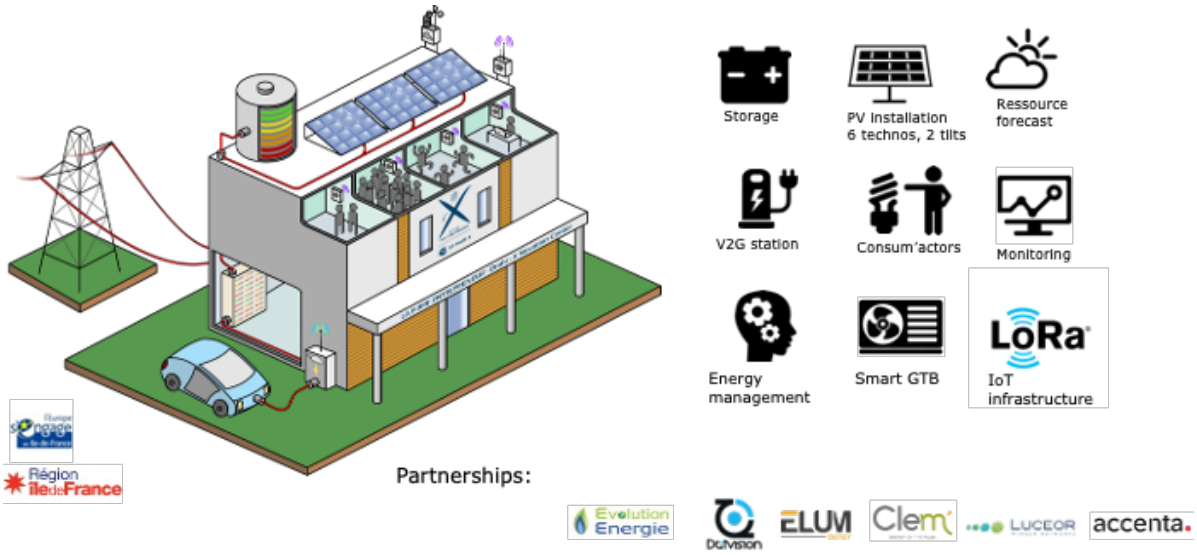

Figure 2. The Drahi-X building demonstrator scheme, with the main components and the industrial partners involved.

The NRLAB (see elements in Figure 1), is a 24 V DC system powered by a photovoltaic (PV) panel, a secondary power supplier (which makes the role of the utility) and two kinds of batteries. The consumption is set with a programmable load that reads and imposes in real time the actual electric consumption of the Drahi-X building at the scale around 1:100. All voltages and currents are measured and stored through a remotely accessible datalogger (CR1000X from Campbell Scientific). Figure 3 shows an example of the obtained measurements for a period of 5 consecutive days.

The Drahi-X building has a 16,7 kWp PV installation, a 30-kWh battery and an energy management system capability that has developed in collaboration with Elum Energy.

At its current version, the nanogrid has a rule-based energy management system (EMS) which allow to open and close components relays depending on voltage threshold values. The Drahi-X microgrid uses also a rule-based nanogrid with power targets for the battery and the grid electricity.

The objective of the internship is to implement, test and validate an EMS algorithm that decides on different actions taking into account forecasts for PV and load profiles.

On the NRLAB side, the system should be able to : 1) connect or disconnect the elements of the grid 2) charge or discharge the battery 3) control the power supplier and 4) change the Load (in order to simulate Demand Side Management DMS actions from the real building). On the Drahi-X side, the system should dynamically manage the power of the battery depending on the desired optimisation and the given forecasts.

As part of the EMS implemantation, several cost functions will be tested corresponding to different services: 1) minimising the electricity costs 2) reducing the CO2 footprint of the real building or 3) maximizing the comfort of the occupants.

The algorithms of the EMS will be developed following the approach in
Adrien Le Franc, Pierre Carpentier, Jean-Philippe Chancelier, Michel De Lara. EMSx: A Numerical Benchmark for Energy Management Systems. In Energy Systems, accepted for publication.

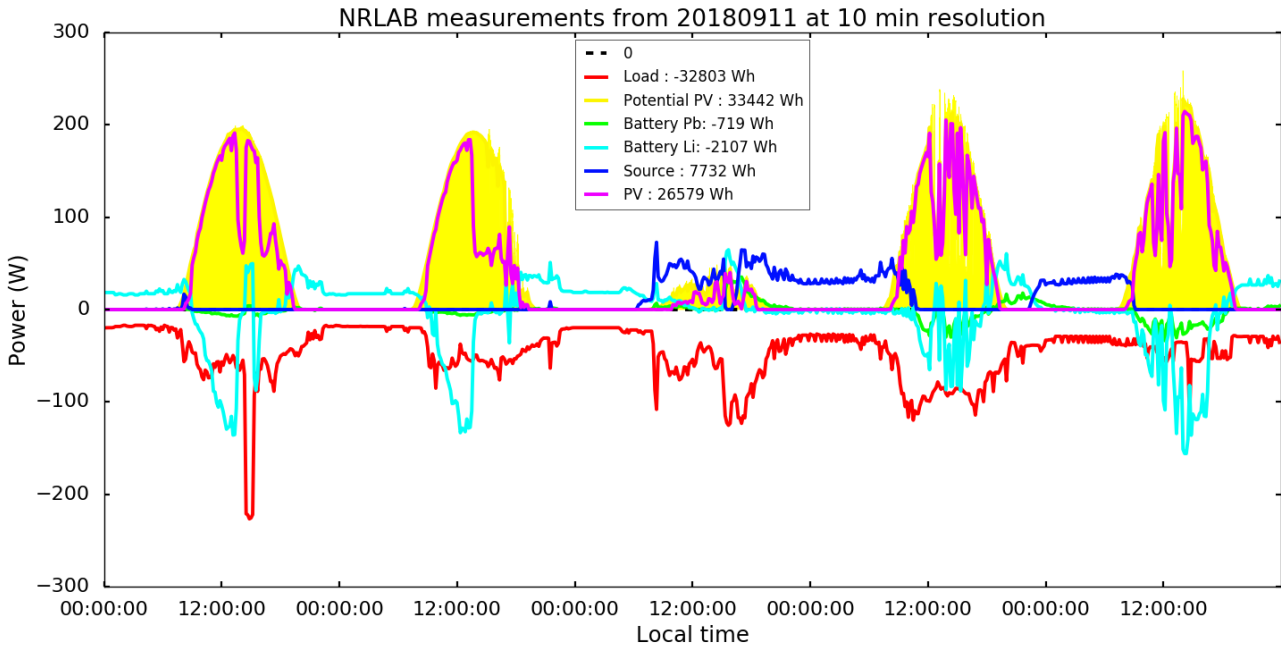

Figure 3: Measurements from the NRLAB nanogrid for 5 consecutive days. Negative values correspond to power that is consumed, either by the Load, which corresponds to 1% of the real consumption of a tertiary building, by the batteries (to store energy). The Potential PV is calculated from the measured irradiance received by the PV panel.