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The Grenoble PREDIS – Building platform: A living lab and experimental lab for the study of energy and comfort in Smart-Buildings

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Abstract

We are presenting "PREDIS MHI" smart building platform for learning and research in the field of micro-grid. This platform is in GreEn-ER building, which is a new building in the centre of the eco-city in Grenoble, France.

Keywords: green building, smart building, smart micro-grid, energy efficiency, user centred building, living lab.

1. Introduction

1.1. Buildings energy figures

Based on 2014 energy key figures reports from IEA (International Energy Agency) and ADEME (French Agency for Environment and Energy Management), the building sector is still the main energy consumer worldwide. It is more especially the case in France with 40% of the total final energy consumption, which is divided into electricity (37%); gas (32%), oil (16%), renewable (15%) and coal (0.4%) as we can see it in Figure 1

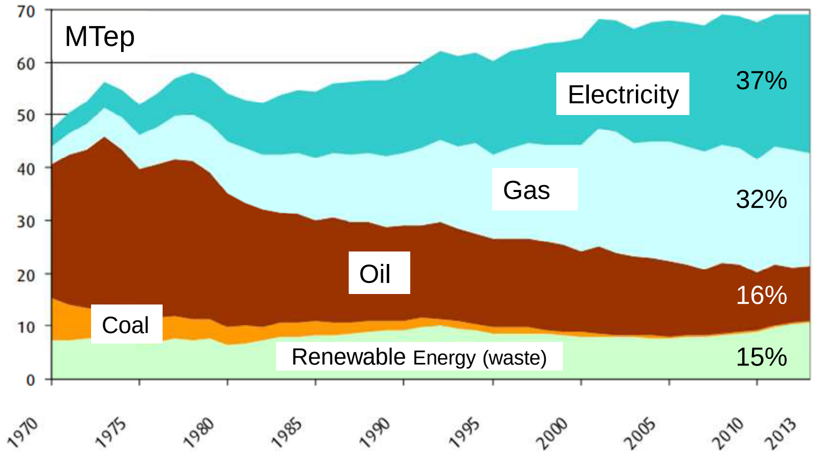

Figure 1: Final energy consumption in buildings in France

The impact of buildings consumption in the electricity sector is much more important since it represents 65% and it is still increasing since years (
Figure 2).
These figures are evidences that buildings are a main topic of interest regarding sustainability and energy.

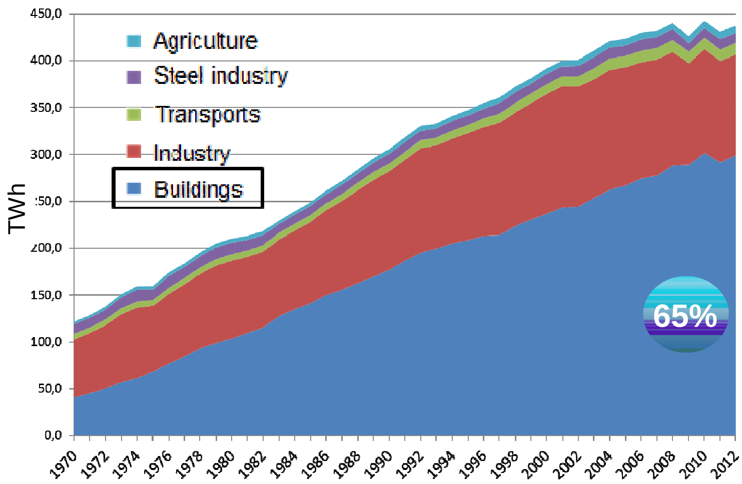

Figure 2: Building electricity consumption evolution in France since 1970

1.2. Smart building

Heating building correspond in France to the main consumption part as it can be seen with the strong correlation of consumption with temperature (Figure 3).

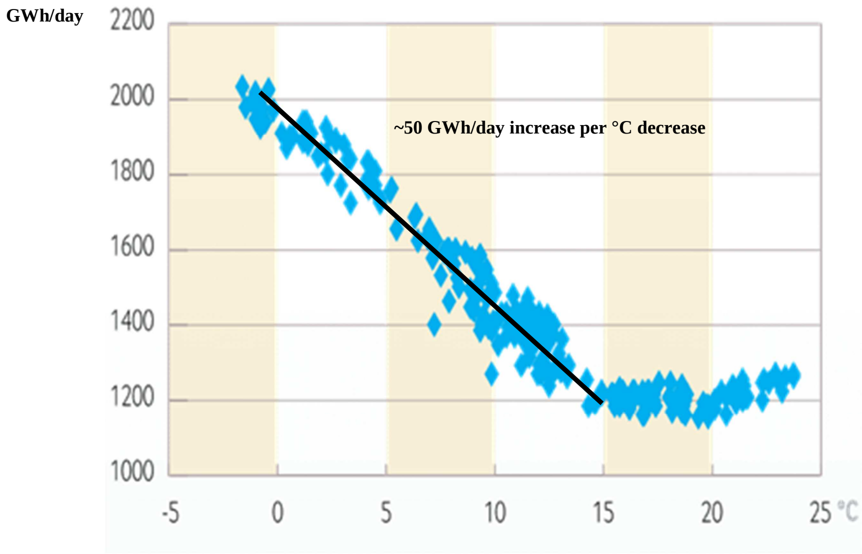

Figure 3: Correlation between temperature and electrical consumption in France – Gradient of daily consumption in France in GWh/day as a function of the average temperature in France (in °C)

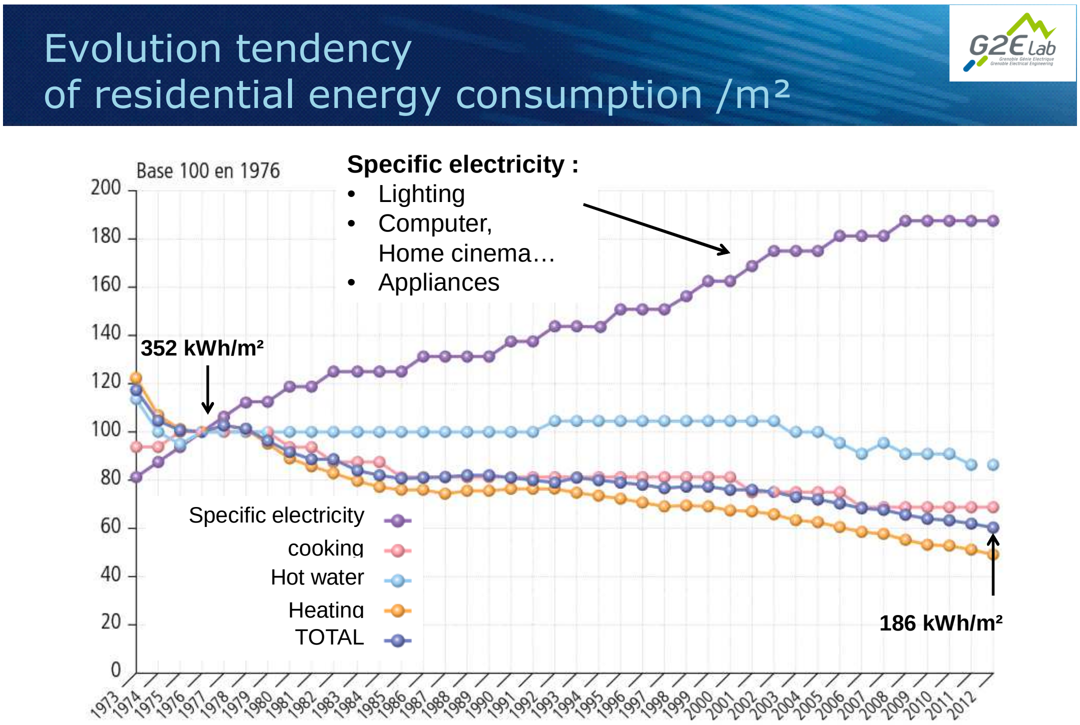

Figure 4: Evolution tendency of residential energy consumption /m² in France

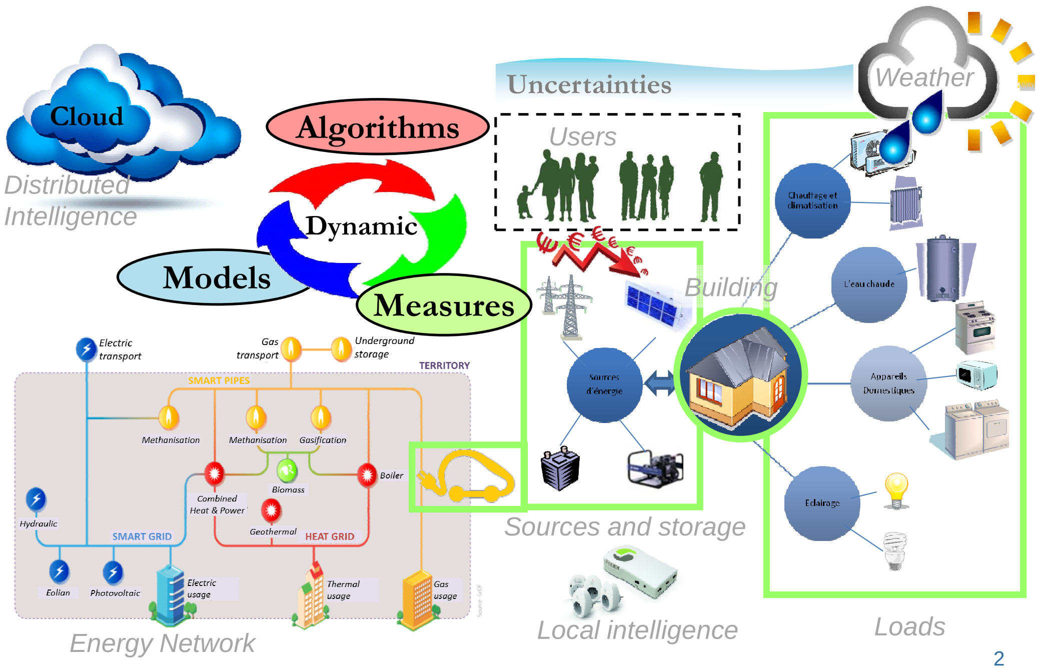

Figure 5: What a smart building has to manage

2. Energy efficiency in GreEn-ER

2.1. A new building for learning and research

GreEn-ER is a new building in Grenoble.

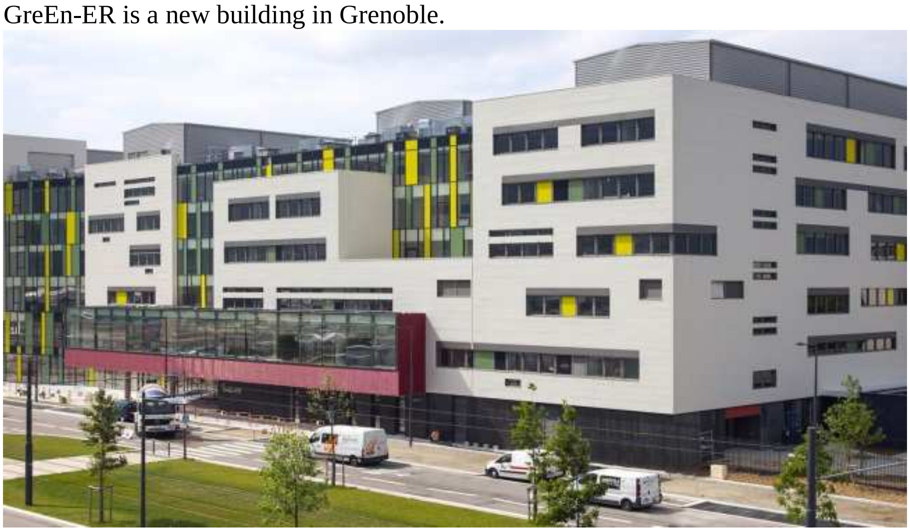

Figure 6: GreEn-ER building

Some figures:

- A 6 floors building with 4500 m² space per floor for platforms teaching / research
- 2000 people welcomed in the building, including 1,500 students.
- 1 research laboratory
- 2 restaurants (a brasserie and a university restaurant)
- 500m^2 of space at the Library

GreEn-ER is hosting master level training, for students of “Energy, Water and Environmental Engineering School” (Grenoble INP ENSE3), International master "Electrical Engineering for Smart Grids and Buildings" and open to other formations (industrial design, architecture school, ...).

GreEn-ER has a modern architecture as well as very good performances and high requirement in terms of management and sobriety in consumption of energy and water. Total primary energy consumption will be less than 2200 MWh / year which correspond to 110 kWh/m^2. In France, a multiplication factor of 2.58 is applied on electricity consumption to compute primary energy.

The energy to build GreEn-ER, including concrete structure, insulation, etc. has been approximated to 25 000 MWh

2.2. Building micro-grid

In GreEn-ER, PREDIS-MHI is 600 m² platform energy systems (Figure 7), has been specifically designed to reach zero energy building, and to study building or neighbourhood autonomy.

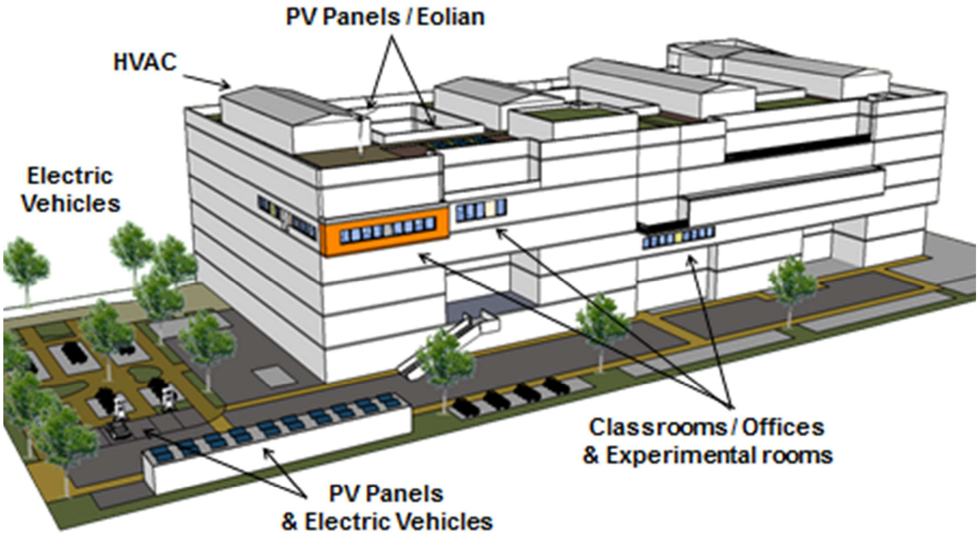

Figure 7: PREDIS MHI, production and storage

Energy systems are for instance dual flow ventilation with high efficiency recovery and with low temperature supply (Figure 8):

- heating: 30/25°C (occupation/inoccupation)
- cooling: 19/23°C (occupation/inoccupation)

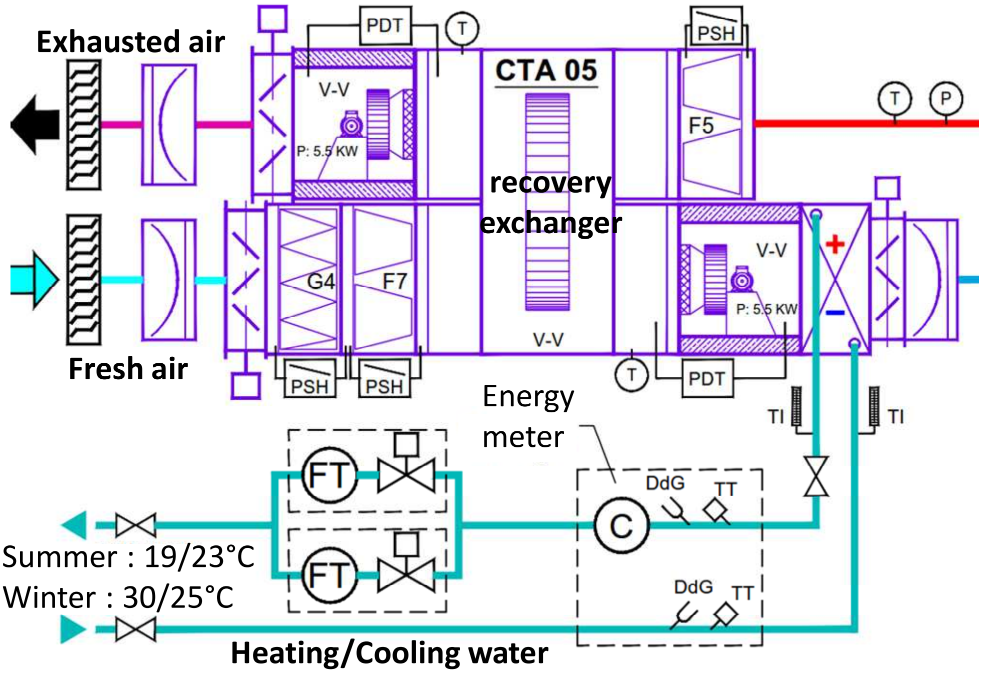

Figure 8: HVAC system

20kW of photovoltaic panels installed on vehicles roof, and other are planned to be installed on the building roof. Other electrical productions are available in PREDIS platform such as a fuel cell and combined heat & power (CHP) which is also able to heat our platform. Storage capabilities have also been installed with electrical vehicles, and laptop rooms. A 50kWh stationary battery will be added.

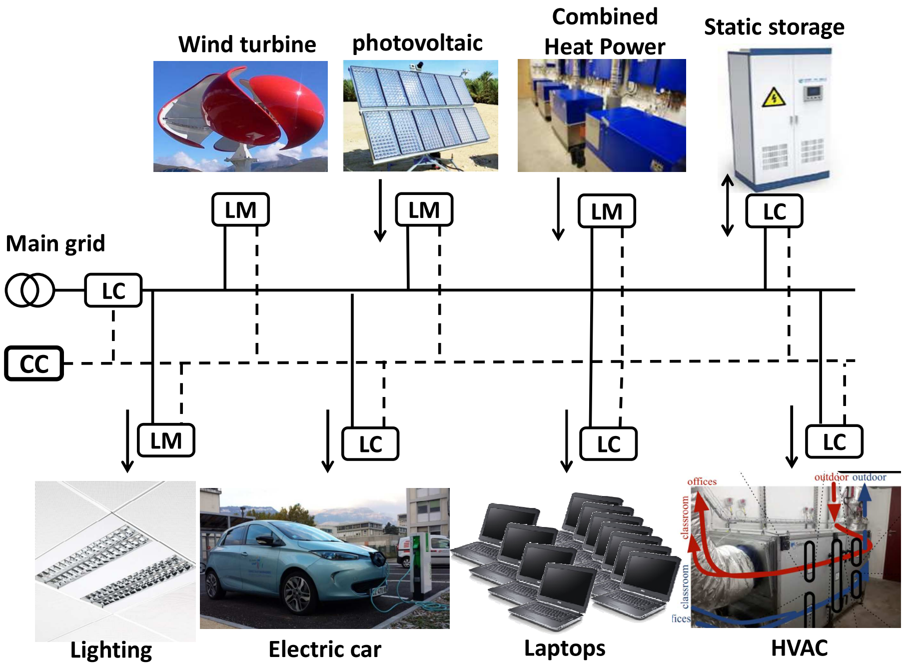

Figure 9: PREDIS MHI micro grid structure. (LC: Local Controller, CC : Central Controller, LM : Local Monitor)

Optimal control solutions based on predictive models will be tested in this platform. Solving the problem of demand response requires determining a generation and a controllable load demand policy that minimizes, over a planning horizon, an objective function subject to economic and technical constraints. This policy is used as reference for the voltage and frequency control in microgrid real-time operation.

Load demand can be classified by priority and type as critical:

- Critical load demand: has to be full supplied all the time, otherwise, it will cause deficit in the system.
- Reschedulable load demand: has a particular characteristic of being able to be allocated across a range of time.
- Curtailable (shedable) load demand: may have the power supply cut, as a non-priority load, if necessary.
- Diffuse load demand: is a new concept made to deal with a thermic load demand, having the diffuse effect or the pre-diffuse behavior. It could be turned off while the price is high and turned on, recovering the heat while the price is lower, or to cut the load peak.

In Tenfen 2014 [1], we have solved the energy management using a deterministic mixed-integer linear programming problem, where the planning horizon is 24 hours with one-minute time steps.

3. Real time energy management

In our platform, several hundred measuring points and control have been set up such as HVAC, dimmable lighting, blind, electrical plug consumption measure and switch…

These measures and commands are accessible through the building network infrastructure and the internet. Its communication protocol is web service based enabling interoperability. History is accessible by SQL request.

Many devices are added from the delivered building such as wireless sensors (433MHz, ZigBee, EnOcean, DeltaDore). In SmartGreen 2014, Abras [2] has presented the interoperability framework that we have developed in order to manage this interoperability through web-services (Figure 10)

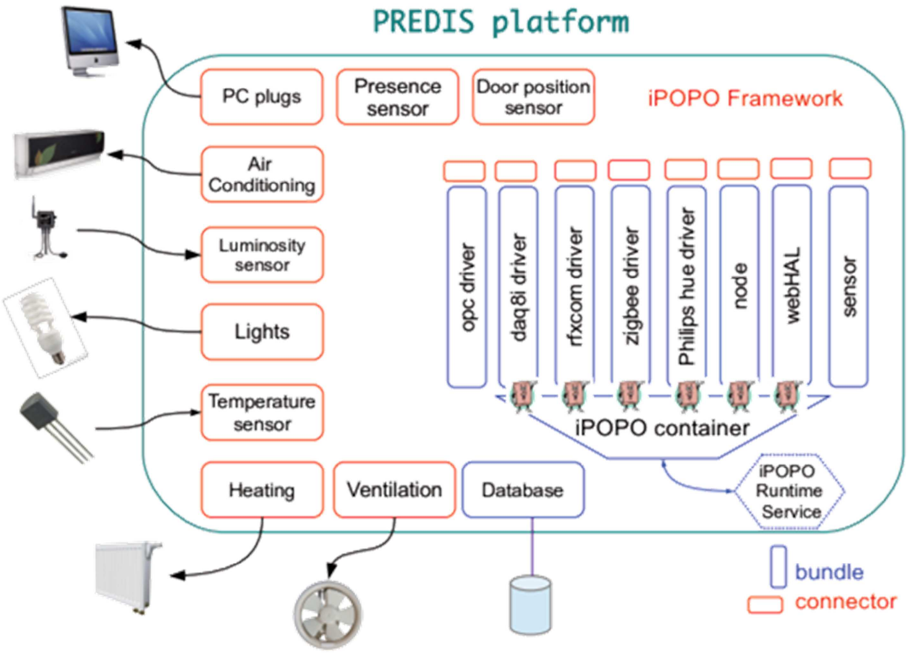

Figure 10: Sensor/actuators interoperability framework

The BMS (building management system) is able to present information to users and energy operator such as zoning with temperature (Figure 11), electrical distribution and photovoltaic

production (Figure 12).

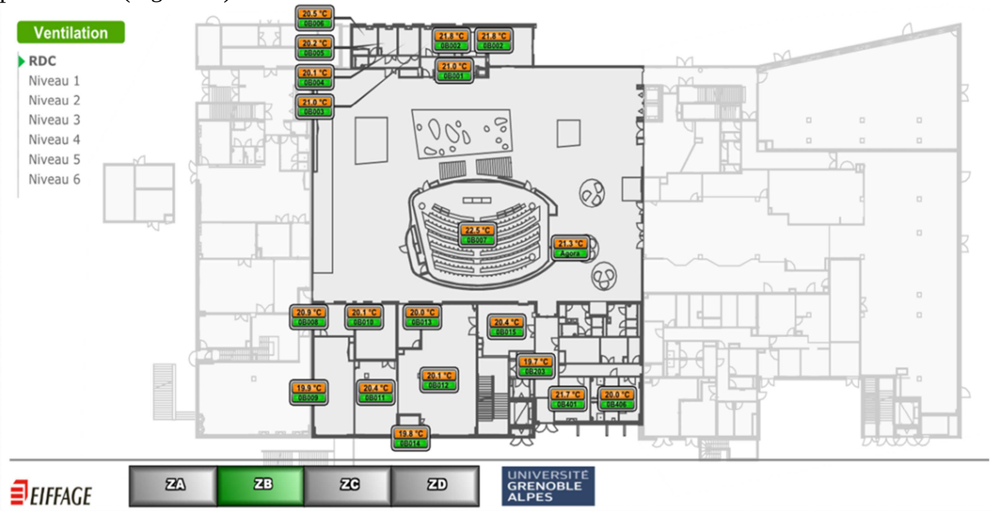

Figure 11: GreEn-ER SCADA: Zoning

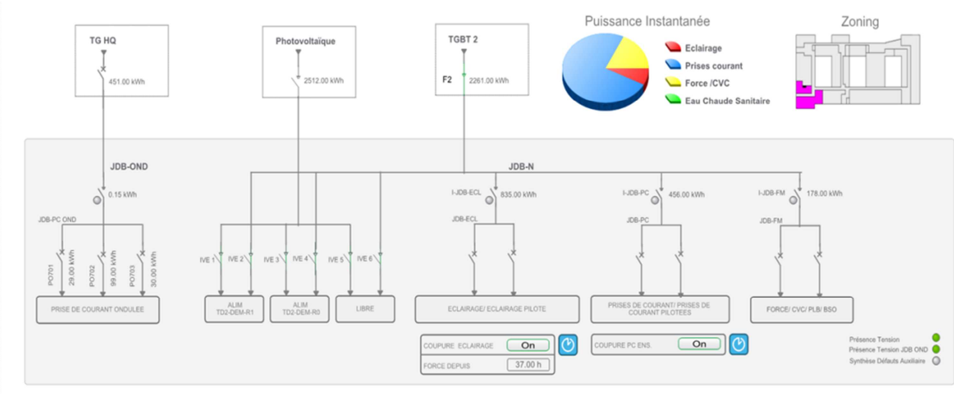

Figure 12: GreEn-ER SCADA: electrical distribution

4. Conclusions

This platform can be used in the ELECON project in order to produce data in "Intelligent Data Mining and Analysis" (IDMA) IEEE subcommittee (http://sites.ieee.org/psace-idma)

Acknowledgements

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References

[1] Daniel Tenfen; Benoit Delinchant; Frédéric Wurtz; Erlon C. Finardi; Jaqueline Rolim; Rubipiara C. Fernandes, “Load Demand, Batteries, and Electric Vehicles Modelling to the Energy Management of Microgrids”, Workshop ELECON, Magdeburg, October 2014

[2] S. Abras T. Calmant S. Ploix D. Donsez F. Wurtz, O. Gattaz B. Delinchant « Developing Dynamic Heterogeneous Environments in Smart Building Using iPOPO » SmartGreen’14, International Conference on Smart Grids and green IT Systems, Barcelona, Spain, 3:4 April 2014