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SYNERGY Research Platform: LAAS Smart Building & Energy Microgrid

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LAAS CNRS

OUTLINE


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- Context & Motivations
- SYNERGY Research Platform
- Research activities
 - Smart reconfigurable PV energy management
 - Predictive dynamic thermal simulation of a building
 - DC microgrid management: OPA project
- Conclusion

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Climate Change Challenges

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- **Horizon 2020:**
 - 20% greenhouse gas reduction,
 - 20% energy efficiency improvement,
 - 20% increase of renewable energies.
- **Horizon 2030:**
 - 40% greenhouse gas reduction,
 - 30% energy efficiency improvement,
 - 27% increase of renewable energies.

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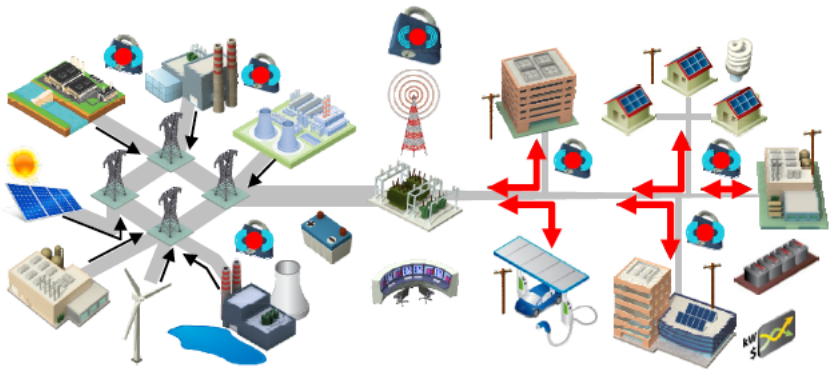
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From Today's Power System to Smart Grid

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Internet of Energy: merging Internet and Energy grid networks

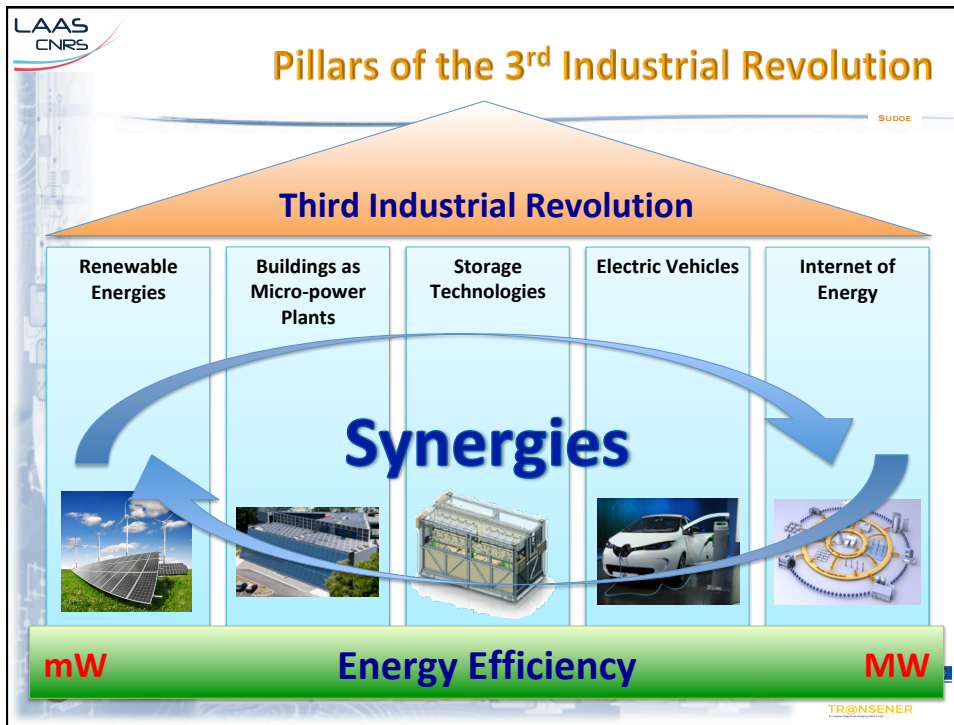
- Bi-directional communication of data and energy



Third Industrial Revolution

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ADREAM* Project

State-Region Contract Project 2007-2013
 Funding: 7.2 M€ (Building: 5.2M€, Equipment: 2 M€)

Ambiant Intelligence, Internet of Things, Autonomy

- Open & Pervasive Embedded Systems
- Human & Robot Interactions
- Resilience
- Security & Privacy
- Optimization
- Smart Grids
- Energy Conversion & Management

Cyber-Physical Systems:

- Investigate & Propose Theories, Methods & Tools for Architecting, Experimenting & Assessing
- Exploit & Develop Synergies & Interdisciplinary Studies

**Architectures Dynamiques Reconfigurables de systèmes Embarqués Autonomes Mobiles*

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Building Modularity

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SYNERGY Research Platform

- **100kWp photovoltaïcs**
- **Geothermics:**
 - Canadian well
 - Vertical Geothermics
 - Heat pumps (3)
- **Storage:**
 - Lead Batteries (59kWh)
 - Li-ion Batteries (56kWh)
 - Supercapacitors (286Wh)
- **Three supervision systems:**
 - Lighting, Ambient Temperature Control, Energy production/consumption

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Supervision System

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- **Heating, Ventilation, Air Conditioning**
 - 650 points of measurement and regulation
- **Lighting**: 3700 measurement points
 - Movement detection and illumination sensors
 - Power adjusted according to ambient light level
 - Setting of time slots / operation by zone
- **Electricity**: 500 data collected
 - Detailed power consumption (zone, usage...)
 - Energy production (photovoltaic, geothermics)
 - Correlation to environmental/ambient measurement

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Real-time monitoring of PV production/consumption

| Date | Événement | Libellé | Équipement |
|----------------------|---|---------------------------|--------------|
| 26/03/13 15:47:41 | Alarme: Arrêt de la production photovoltaïque | Arrêt de la communication | Module 200 W |
| 26/03/13 15:47:41 | Alarme: Arrêt de la production photovoltaïque | Arrêt de la communication | Module 200 W |

CONSIGNATIONS

ALARMES

CNRS ADMINISTRATEUR

SNEF

Station météo

0.0 °C

0.0 %Hr

986.4 mBar

594.6 W/m²

N 1.4 m/s

Synthèse production:

Puissance: 46436 W

Energie Totale: 101.76 MWh

CO₂ Evités : 9.04 Tonnes

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SYNERGY: SYstems for smart eNERGY management

Objectives:

Providing key original building blocks and a global approach for smart energy management – from microsystems to smart grid

Three main topics:

- Efficient energy generation and processing
- Integration of renewable energies
- Smart energy management
 - *Internet of energy*

Components & Systems
↓
Advanced Modeling

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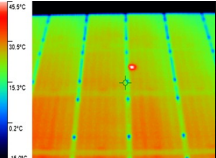


- **Research activities**
 - Smart reconfigurable PV energy management
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Impact of Defects on PV Performance






Gain power electronics in a PV installation (NREL LAB)

| Type of mismatch | Losses | Gain DC-DC |
|---------------------------------------|----------|------------------------|
| Shadow residential roof, one-string | 5-15% | +15-20% of the losses |
| Shadow residential roof, multi-string | 5-20% | +20-30% of the losses |
| Commercial system | 1-5% | + 30-40% of the losses |
| Orientation mismatch | 5-20% | +100% of the losses |
| I_{opt} mismatch | 0.2-1% | +100% of the losses |
| Soiling | 1.5-6.2% | +15-40% of the losses |


 LAAS- TOTAL SA Collaboration
 PhD of Youssef EL BASRI

Contact: Corinne Alonso


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Smart Reconfigurable PV Energy Management



Shading evolution over time

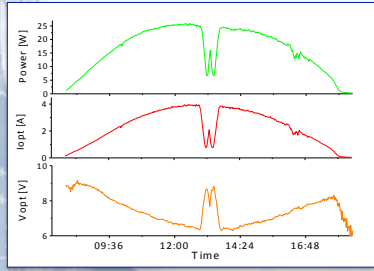
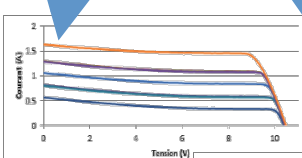
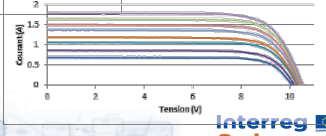
6 PV Modules


Speed of shadow 30 cm/h

Partial shading

Uniform shading

Photovoltaic system under shading condition


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Smart Reconfigurable PV Energy Management

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Mitigating the detrimental effects of partial shading

w/o Bypass

With Bypass

Distributed

| Type of architecture | Energy | Gain (%) |
|----------------------|--------|----------|
| Without Bypass | 374Wh | |
| With Bypass | 468Wh | |
| Distributed | 507Wh | 10.4% |

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Energy Transition & Buildings

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- 43% primary energy consumption
- 4/5 for thermal purposes (heating, cooling, sanitary water, cooking)
- **Very slow evolutions**: each year total of new buildings represents 1% of existing ones and demolitions 0,1%
- **Ambitious political actions** needed to speed up this evolution

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Predictive Dynamic Thermal Simulation of a Building


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Objectives: optimization of the power consumption of the building for better energy efficiency

PRODUCTION

- Photovoltaics
- Geothermics







CONSUMPTION

- HVAC
- Electronic equipment
- Lighting

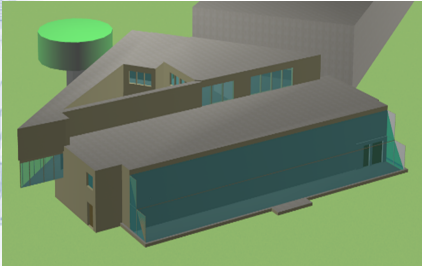
- Development of accurate and compact models
 - Model reduction
 - Identification of relevant input and output data for each model
 - Calibration of models against measured data
 - Prediction of electric power consumption of systems
 - Improvement of thermal regulation according to real-time electricity production

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Contact: Bruno Estibals

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LAAS CNRS **Predictive Dynamic Thermal Modeling of a Building** SUDOE



3D Model of ADREAM building

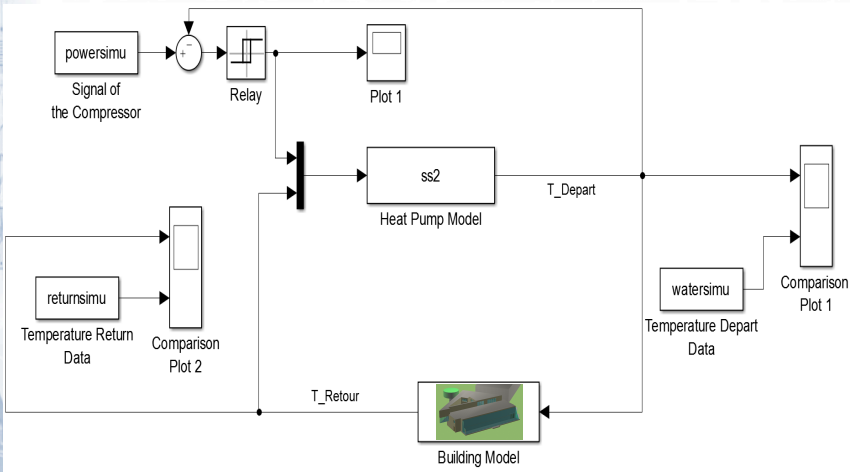
Power consumption: measured vs simulated

| Consumption Source | Real Consumptions [MWh/an] | Simulated Consumptions [MWh/an] | Relative Error [%] |
|---------------------------|----------------------------|---------------------------------|--------------------|
| Heat Pump 1 | 9,03 | 35,41 | 3,05 |
| Heat Pump 2 | 16,71 | | |
| Heat Pump 3 | 9,67 | | |
| Air Handling Unit | 17,79 | 17,55 | 1,35 |
| Distribution Pumps | 69,64 | 63,63 | 8,63 |
| Electronic Equipment | 65,77 | 63,43 | 3,56 |
| Lighting | 12,03 | 11,89 | 1,16 |
| TOTAL | 200,64 | 192,88 | 3,82 |

Objective Drastically reduce power consumption by at least 20%

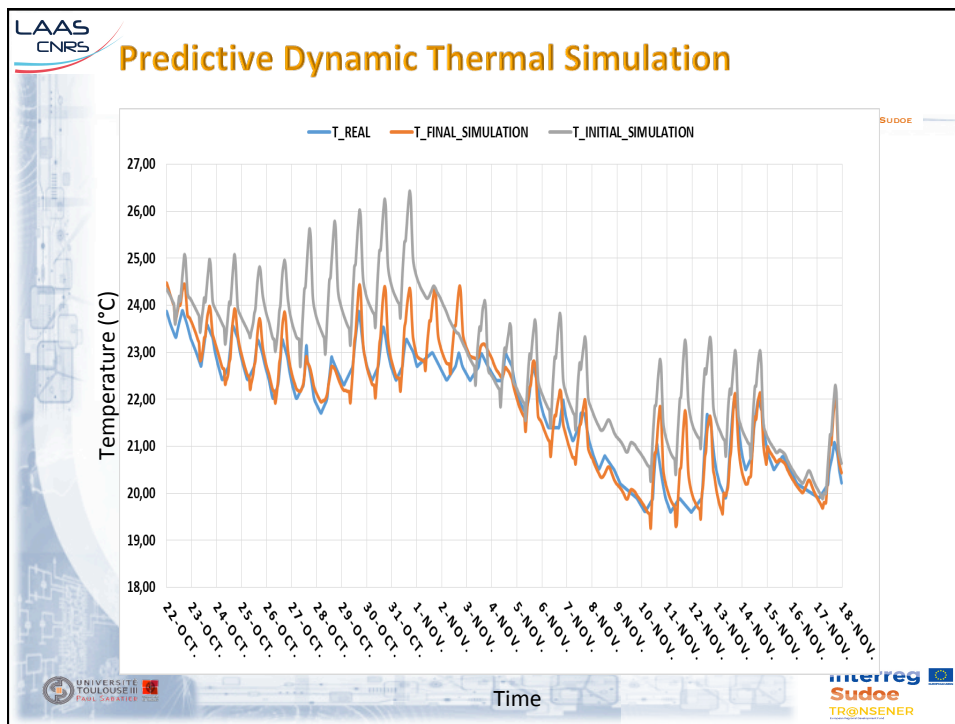
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LAAS CNRS **Predictive Dynamic Thermal Modeling of a Building** SUDOE



Simulation of the heat pump and control with Simulink

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DC Distribution Advantages

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- Most of *renewable energies* (PV, fuel cell, wind turbine) provide DC power
- Many *electronic equipment* (computers, LED lighting, smart phones, EV) operate under DC power supply
- Easier control compared to AC: *only voltage*
- *Connection of AC grids* with different frequencies
- *Reduced losses* over long-distance
- *Higher efficiency* than AC microgrid
- *Higher reliability*
- *Space and cost savings*



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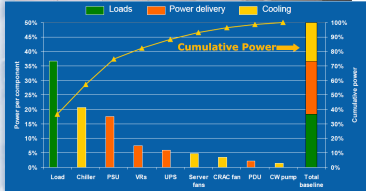
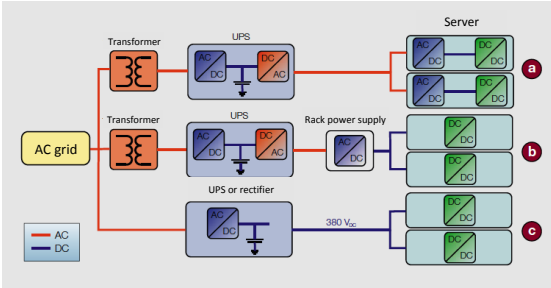
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DC Microgrid: application to data centers

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- In California, ~ **7.1 TWh/year*** are consumed by UPS (Uninterruptible Power Supply) that operate two conversions : AC/DC and DC/AC.

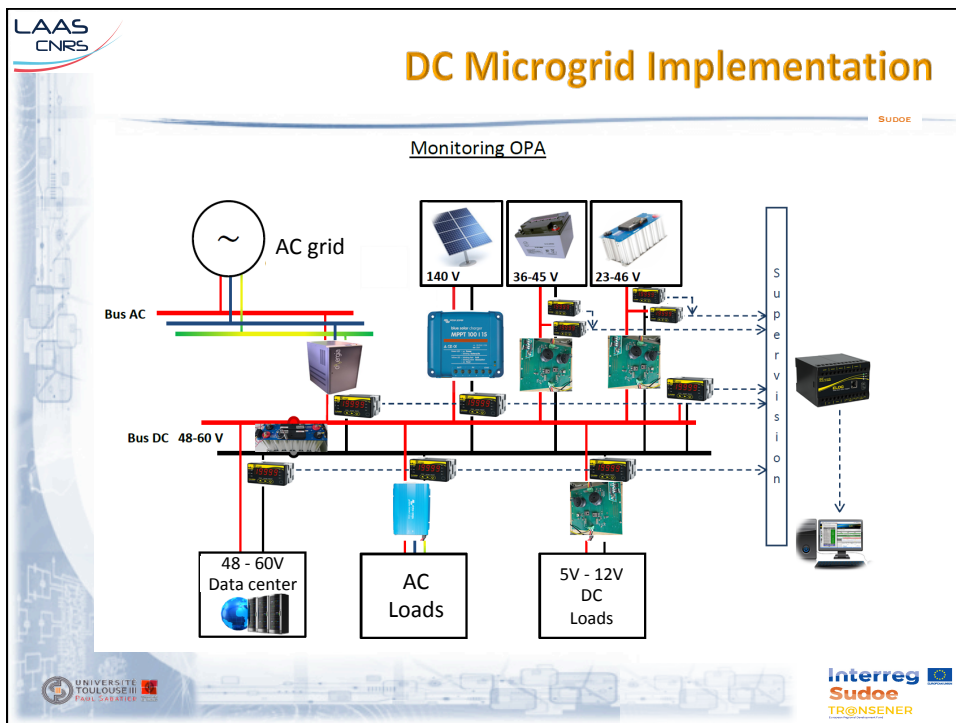
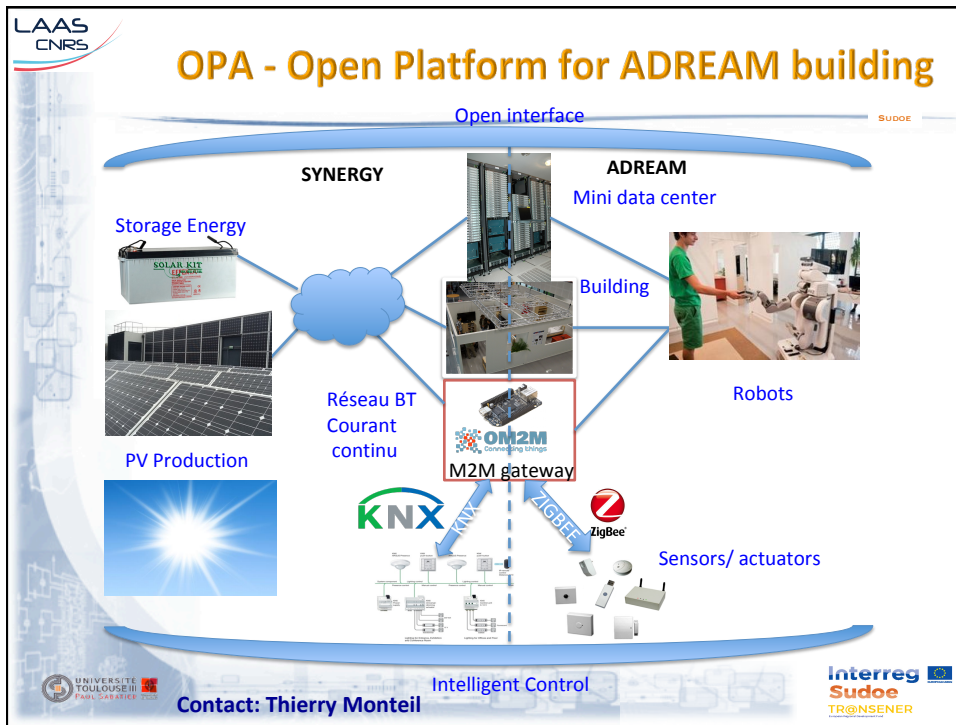




- DC microgrid: **7 to 28 %**** expected power consumption reduction

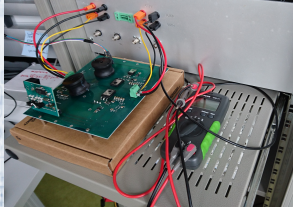
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* Fortenbery, Brian, Ecos Consulting EPRI, and William Tschudi. DC power for improved data center efficiency. (2008)
 ** Affolter, J. F., B. Chappuis, and L. Rigazzi. Réseaux de distribution basse tension en courant continu. Bulletin SEV/VSE (2014): 39-44.


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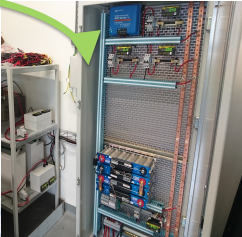
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Design and realization of DC/DC converters not commercially available




Energy source:
4 PV panels (1kWp)



Datalogger and sensors
→ DC grid Monitoring

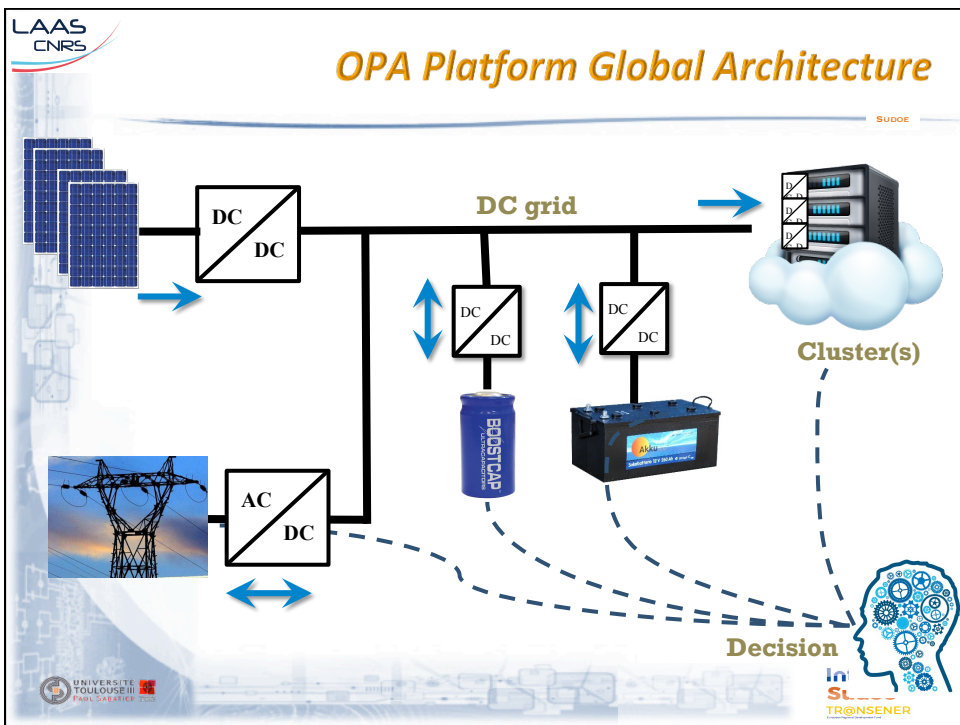


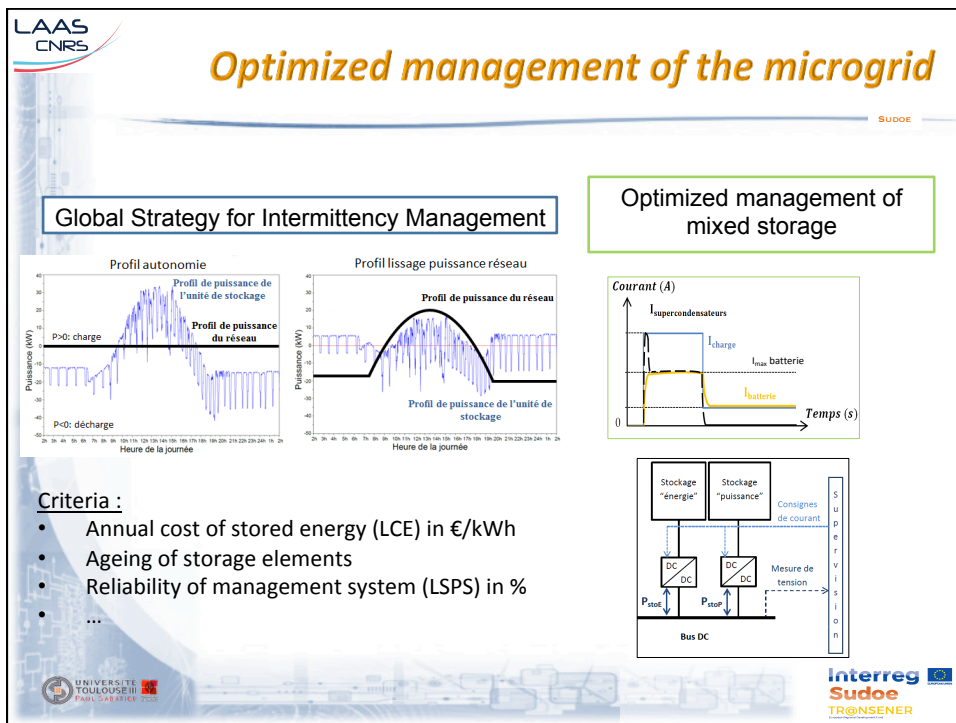
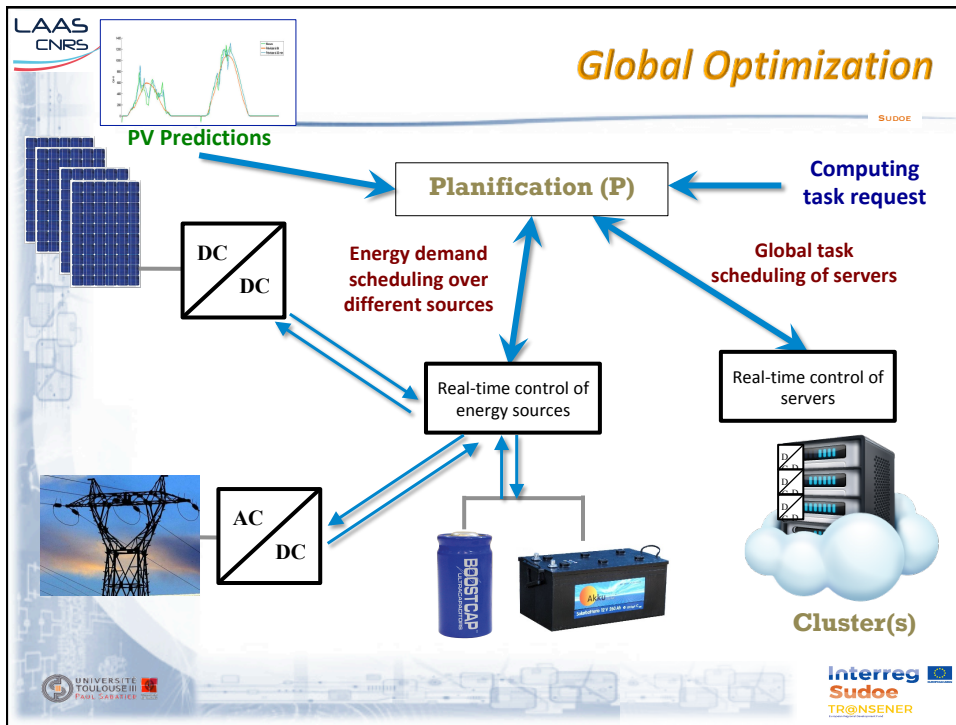
Hardware deployment:
batteries, supercapacitors,
DC grid

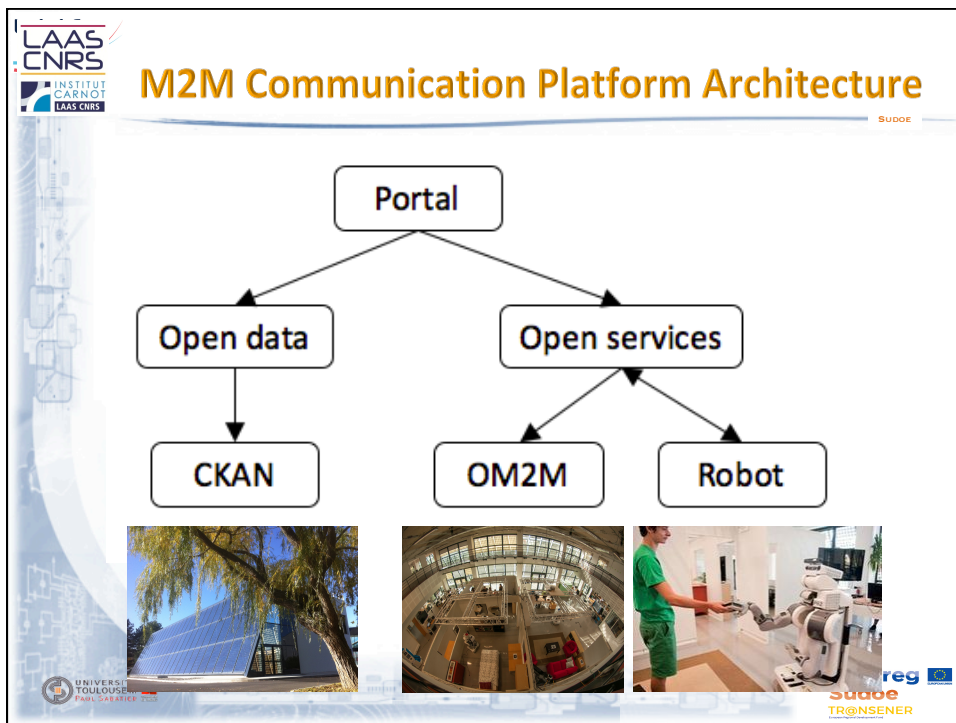
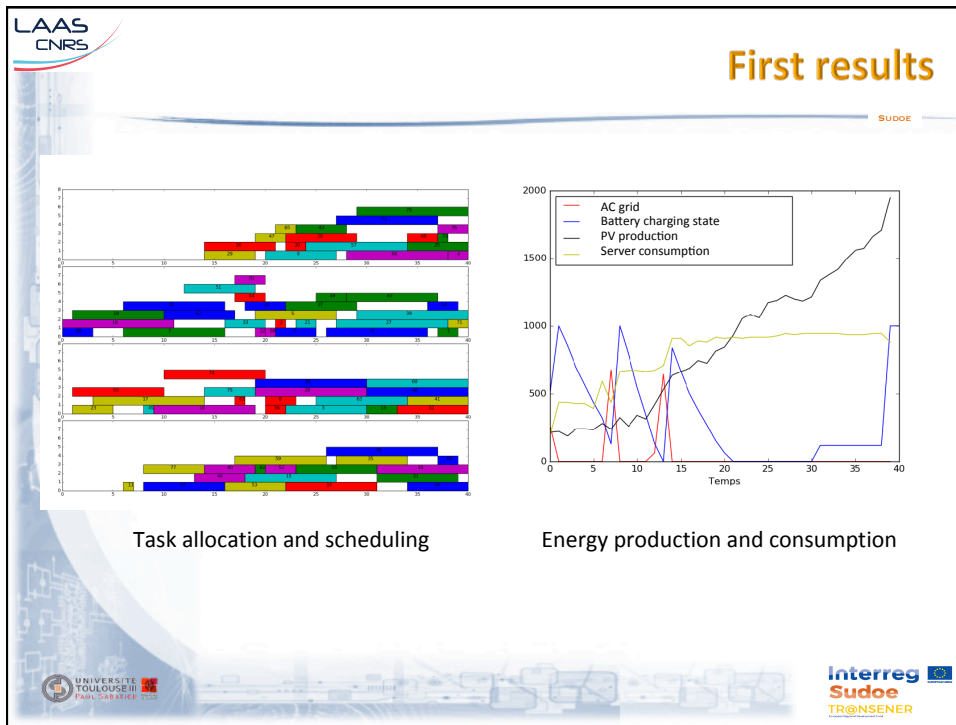


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OPA: Open Data Syndream Platform

- <https://syndream.laas.fr/>

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OPA Project
Open Platform for ADREAM

Please login to get privilege access

Latest news

OPA project website online Sept. 27, 2014
The Open data & Open services apps are now available. Create your account or authenticate using you... More

Project

Networking massive objects and intelligent agents.
Get privilege access to the Open Data and the Open Services.

OPA ADREAM CH2M

Open Data

Open data is the idea that some data should be freely available to everyone to use and republish as they wish, without restrictions from copyright, patents or other mechanisms of control. Get sensors data.

Note: Since you are not logged in, the list of datasets will be limited.

GET DATA

Open Services

Eclipse CH2M project provides a horizontal API service platform for developing services independently of the underlying network, to facilitate the deployment of vertical applications and heterogeneous devices.

Note: Please login to access to the Open Services app (only for Partners or LAAS employees).

SEARCH

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OPA: Open Data Syndream Platform

- <https://syndream.laas.fr/>

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OPA Project
Open Platform for ADREAM

Open Data

LAAS and CNRS have inaugurated the experimental building Adream in 2012. Unique in Europe, this building hosts research projects dedicated to ambient intelligence, that is to say communicating objects of tomorrow.

The building is equipped with a multitude of sensors to assess to the condition of the building and the connected devices inside. These range from energy efficiency to comfort requirements.

The data from most of these sensors are available.

Search data 253 datasets in total

E.g., photovoltaic, day, last

Advanced search Help page

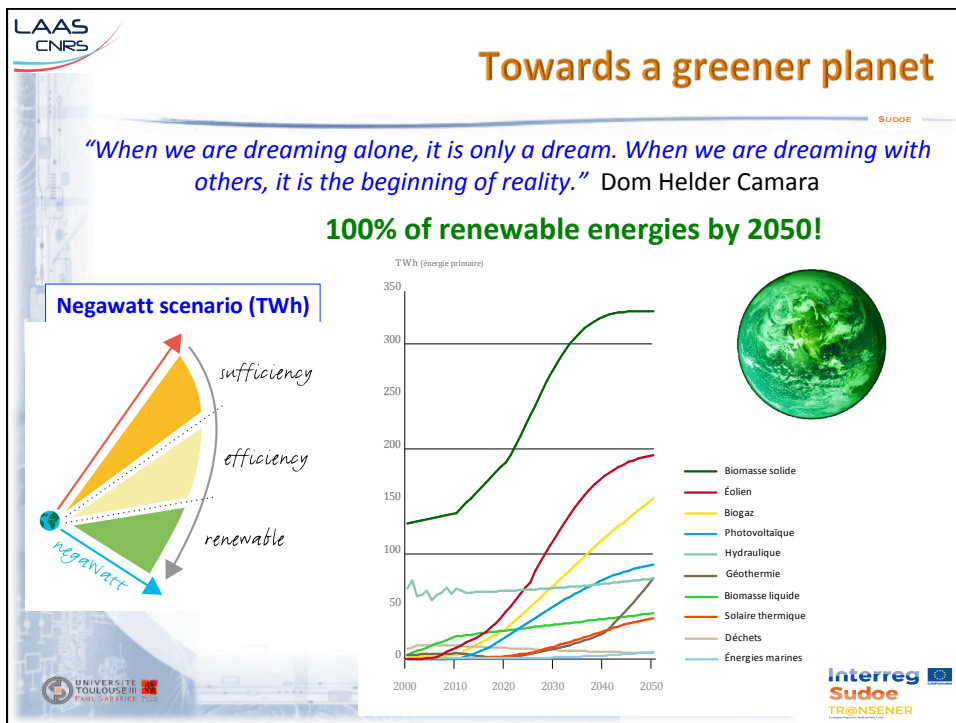
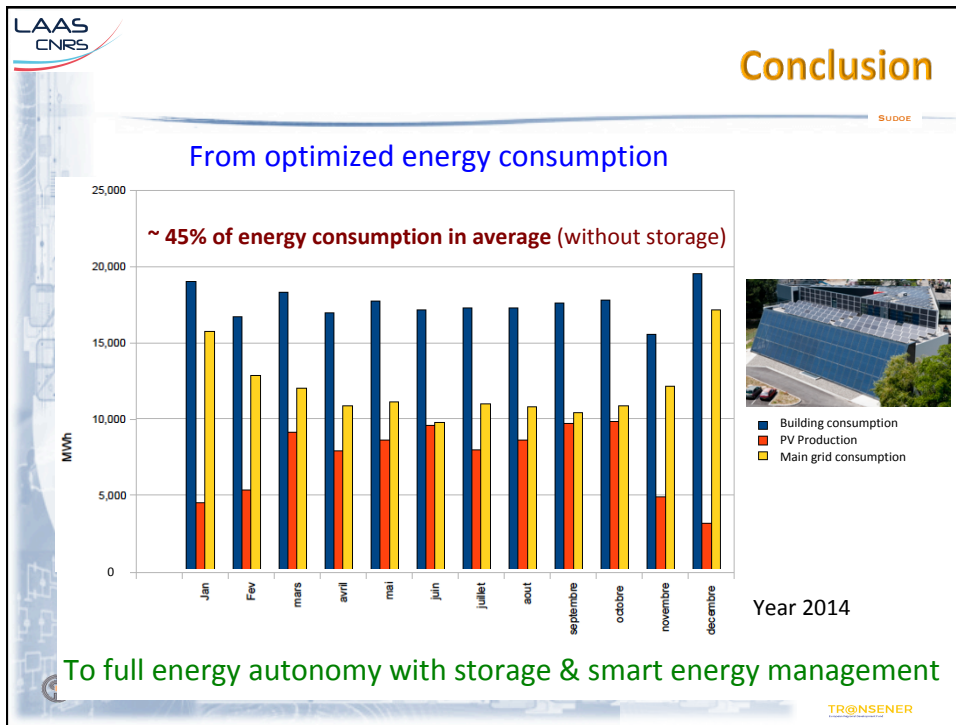
Popular Domains & tags:

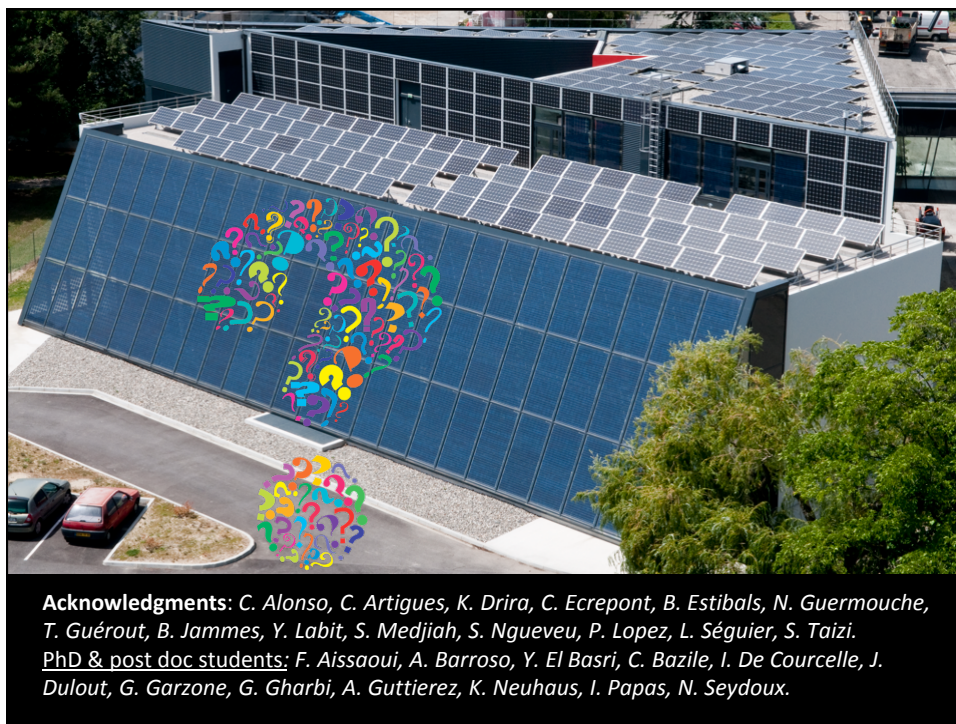
Electrical CVC Photovoltaic Meteorological

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