SUSTAINABLE PLACES 2018
June 27-29,2018
Aix-les Bains, France

G2E lab
Grenoble Génie Electrique
Grenoble Electrical Engineering

Impact of heat pumps flexibility in a French residential eco-district

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Cross Disciplinary Program 2016

Eco-SESA
Univ. Grenoble Alpes
Smart energies in districts

16 laboratories, 100 researchers, Grant 1,7M€ for 4 years (2017-2020)

Systems

AAU ambiances architectures urbanités

LIG

G2ELab Grenoble Génie Electrique Grenoble Electrical Engineering

liten ceatech

LPSC Grenoble Laboratoire de Physique Subatomique et de Cosmologie

IMEP-LAHC

Pacte

Inria INVENTEURS DU MONDE NUMÉRIQUE

NÉEL institut

LMGP

GAEL Laboratoire d'Économie Appliquée de Grenoble

G-SCOP

LOCIE

LNCMI

LEPMI Grenoble - Chambéry

SIMaP

Uses and organisation

Components and materials

RESEARCH FRONTS

Eco-SESA
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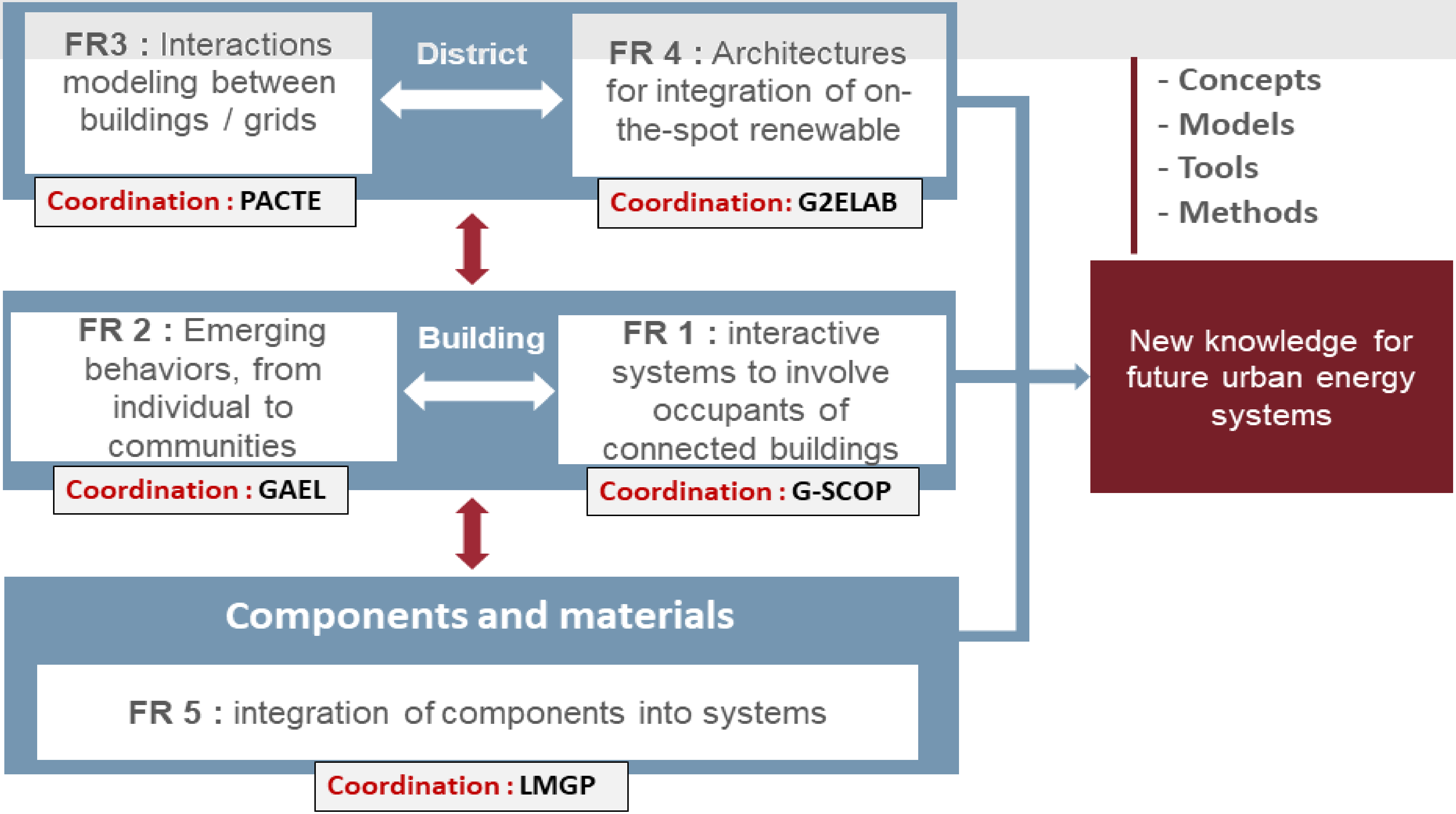
Smart energies in districts



Eco-SESA
Univ. Grenoble Alpes
Smart energies in districts

NEW RESIDENTIAL/COMMERCIAL DISTRICT

Cambridge

Projet urbain 2016/2034

Activités, recherche
En construction ou attribués / à attribuer

Logements
En construction ou attribués / à attribuer

Equipements publics
Livrés ou prévus / envisagés

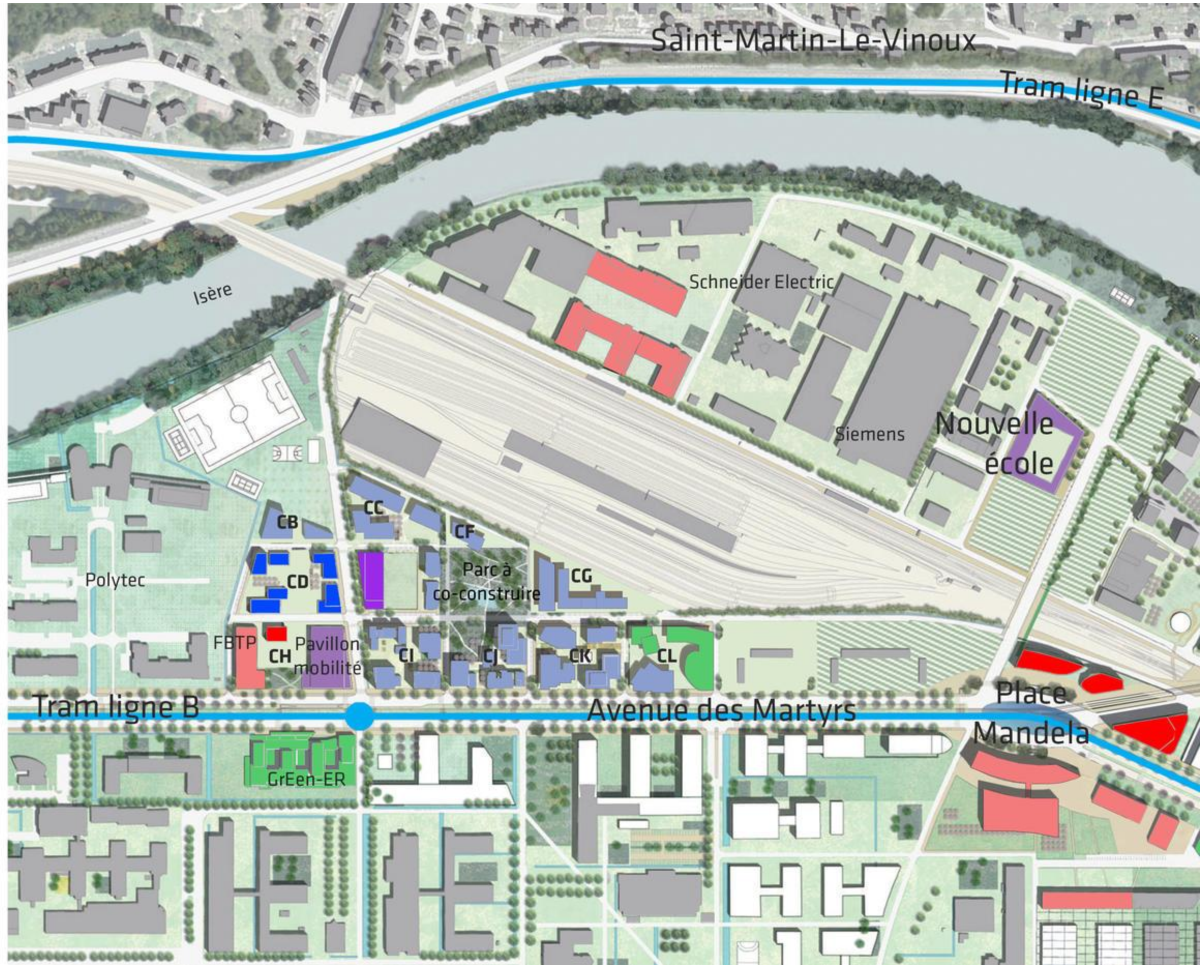
Universités, logements étudiants
En construction ou prévus / envisagés

Bâtiments existants

Secteurs constructibles à concerter

Potentiel constructible

Lignes de tramway
en fonctionnement



Outline

- CityZen project: Cambridge district
- Flexibility analysis using transfer rate profiles
    - Standard profile VS Simulated profile
- Different ways of modeling using available data
- Flexibility results and models comparison

City-zen project

- UE Project : FP7/ENERGY/SMART-CITIES-2013 / 8.8.1
- 2014 - 2019
- 27 partners from 5 countries (NL, FR, BE, UK, IT)
- 2 cities : **Grenoble** & Amsterdam
- Total budget : 41 M€, 25 M € as City-zen grant

Objectives

\+ 59 000 tonnes CO_2 saved per year

\+ 76 000 m² renovated residential buildings

\+ **10 000 dwellings connected to a Smart Grid**

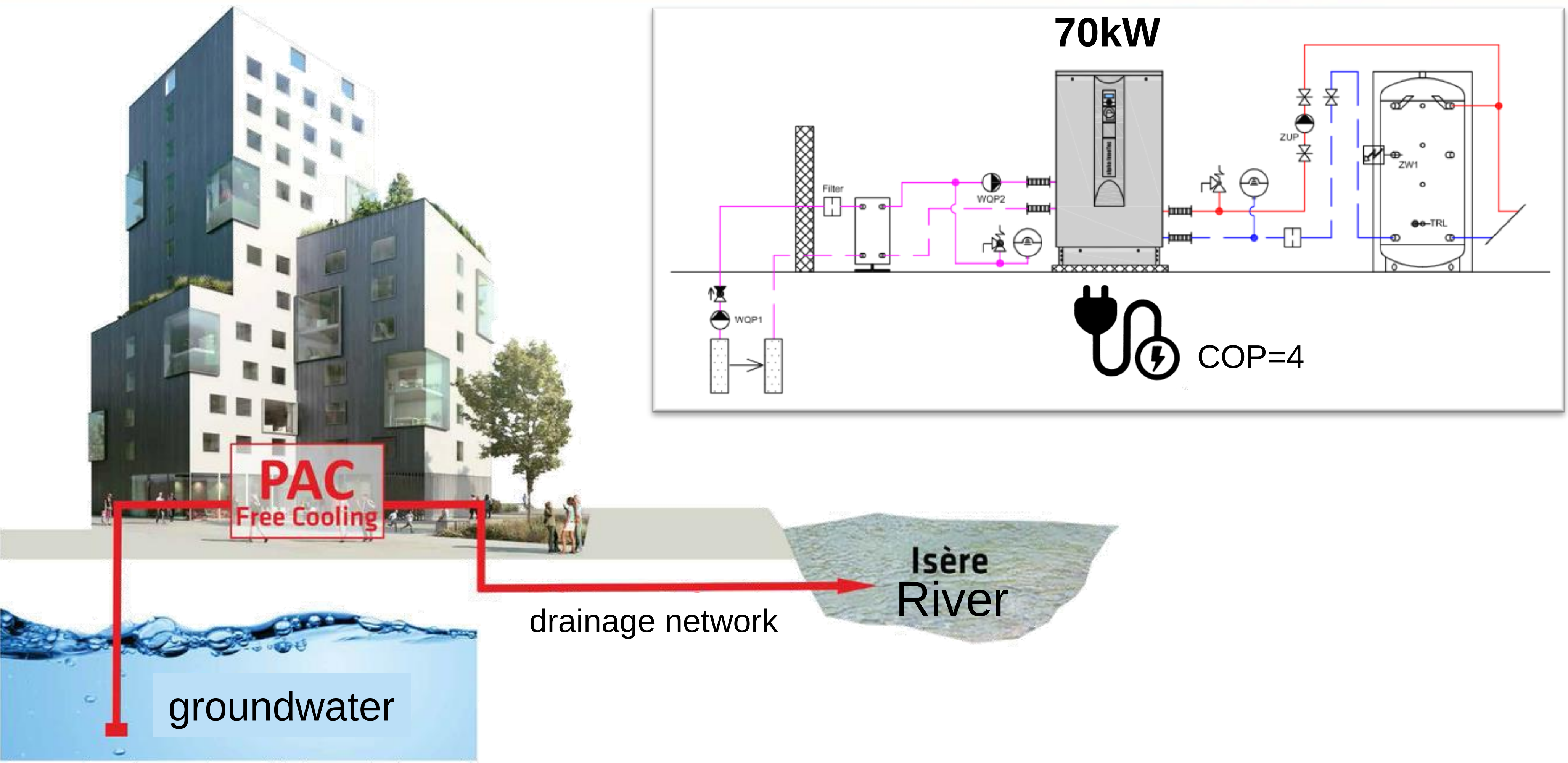
GRENOBLE PARTNERS INNOVATIVE ACTIONS

Technological innovation themes

- Residential Retrofit
- Heating and cooling
- Smart Grid

+ **Metropolitan energy roadmap**
+ **Users Empowerment**
+ **Technical & social monitoring**
+ **Communication & dissemination**

Heat pump on groundwater



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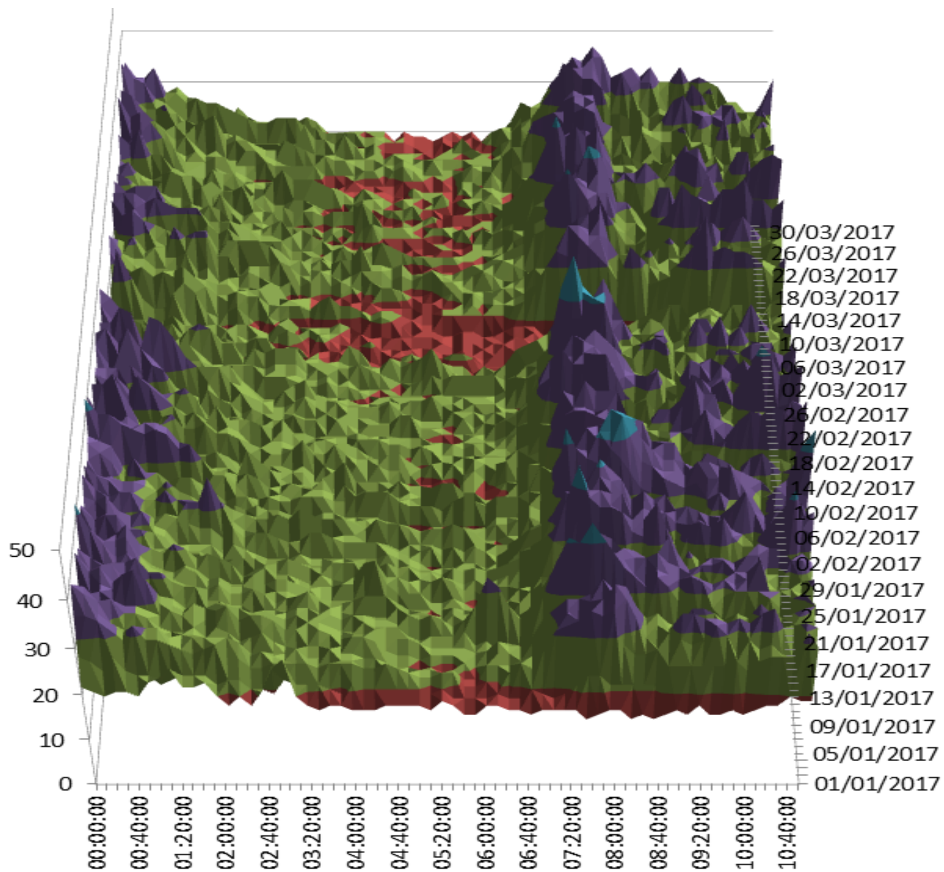
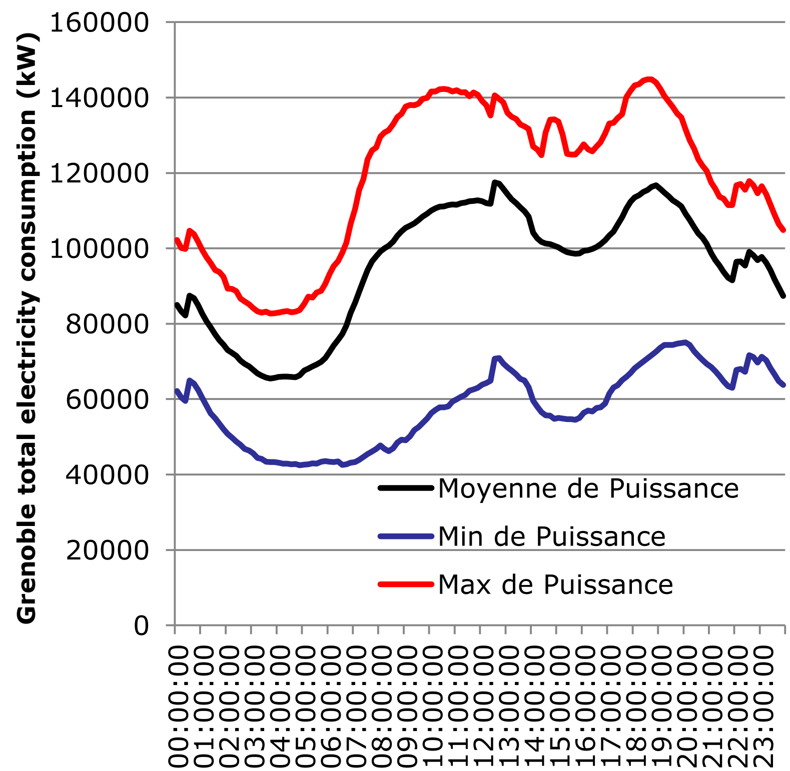
Peak power problematic

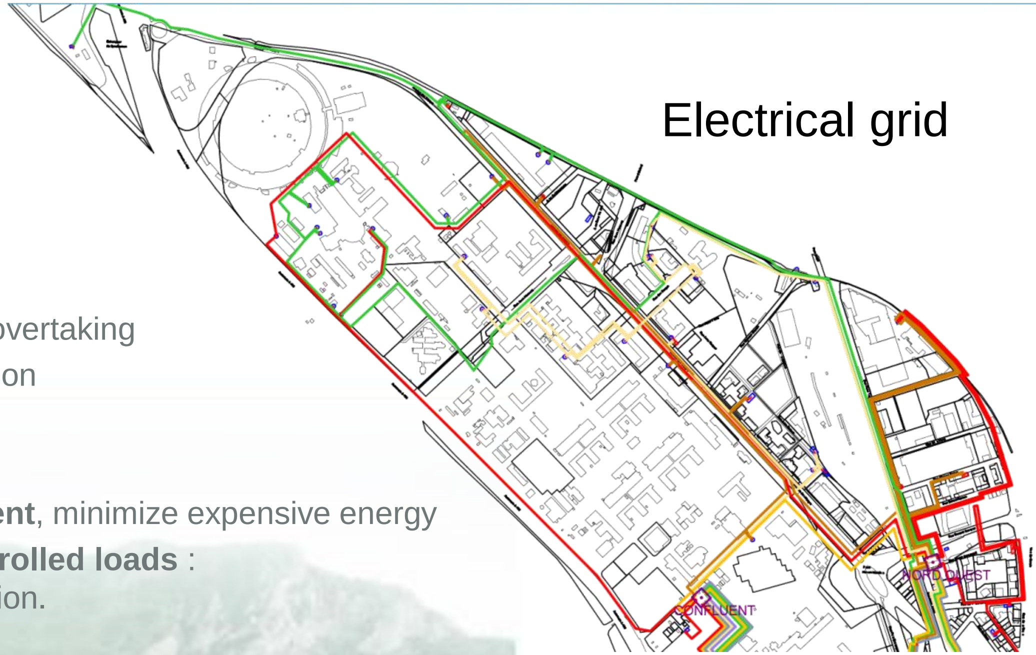
- **Residential building heating consumption**



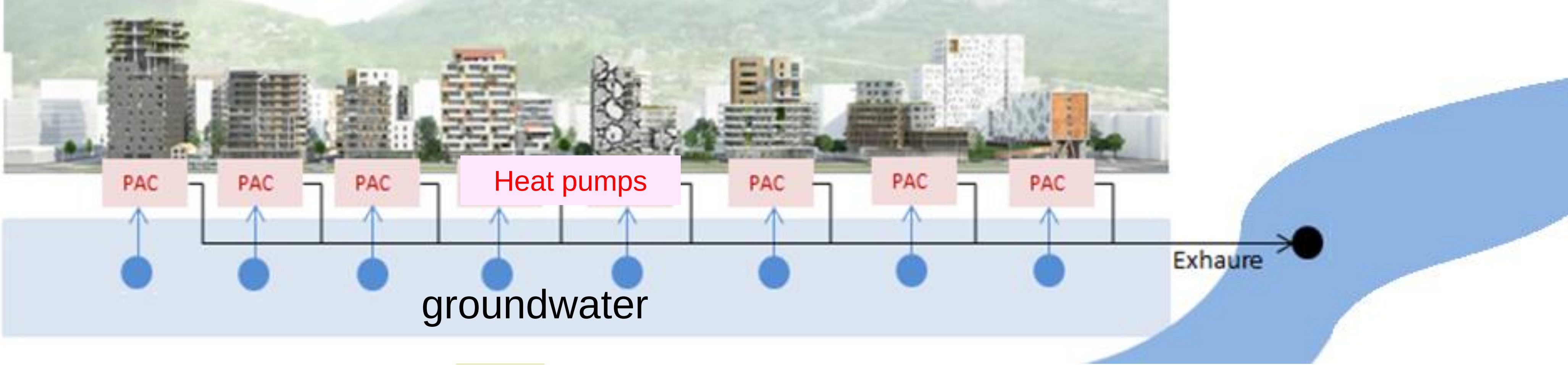
- **Grenoble daily electricity consumption (min, mean, max)**



Peak power due to heating at distric level



- **Cambridge :**
  - 20 buildings, 31400m² heated
  - **Peaks load of 200kW in the morning**
- **Flexibility objectives :**
  - For clients :
    - Optimization of the **subscribed power** and avoid overtaking
    - Optimization of electricity **bill** by shifting consumption on the most advantageous **tariff periods**
  - For DSO :
    - Reduce peak load : avoid power lines **reinforcement**, minimize expensive energy
    - **Stability** of power equilibrium, considering **uncontrolled loads** : renewable production and electric vehicle anticipation.



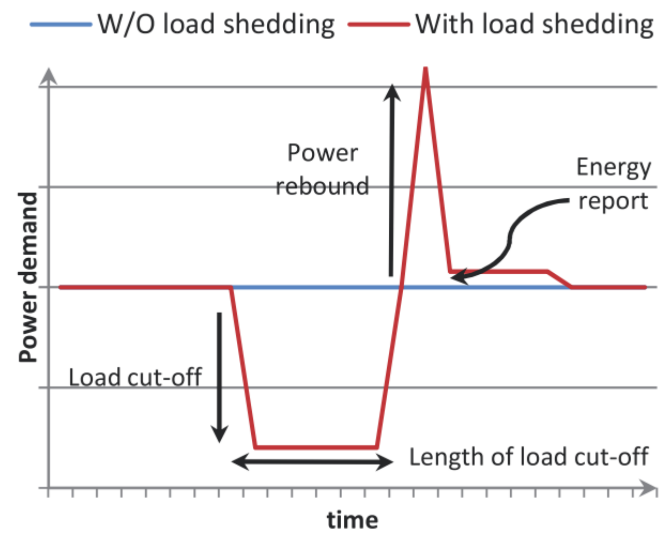
Our objectives

- **Quantify** load shedding effects
- **Model** building heating needs, with available information
- **Optimize** load shedding sequences, minimizing discomfort and maximizing benefits.

Indicators to quantify the rebound effects

Two indicators : dynamic and long-term

- How the energy is transferred each hour following the load shedding ?



Dynamic

$$\text{Transfer rate } [h; h+1] = \frac{E_{transfered}[h; h+1]}{E_{cut\ off}}$$

- How much energy is saved ?

Long-term

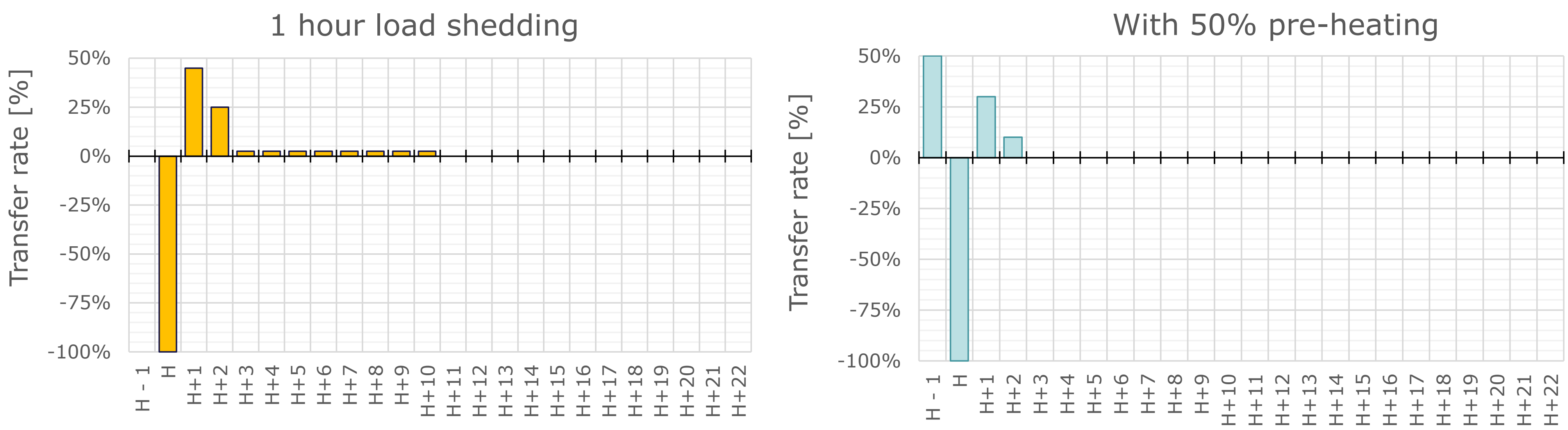
$$\text{Savings rate } [h; h+1] = \frac{E_{cut\ off} - E_{anticipated} - E_{transfered}}{E_{cut\ off}}$$

Rte Le réseau de transport d'électricité

Experimental results from the GreenLys project

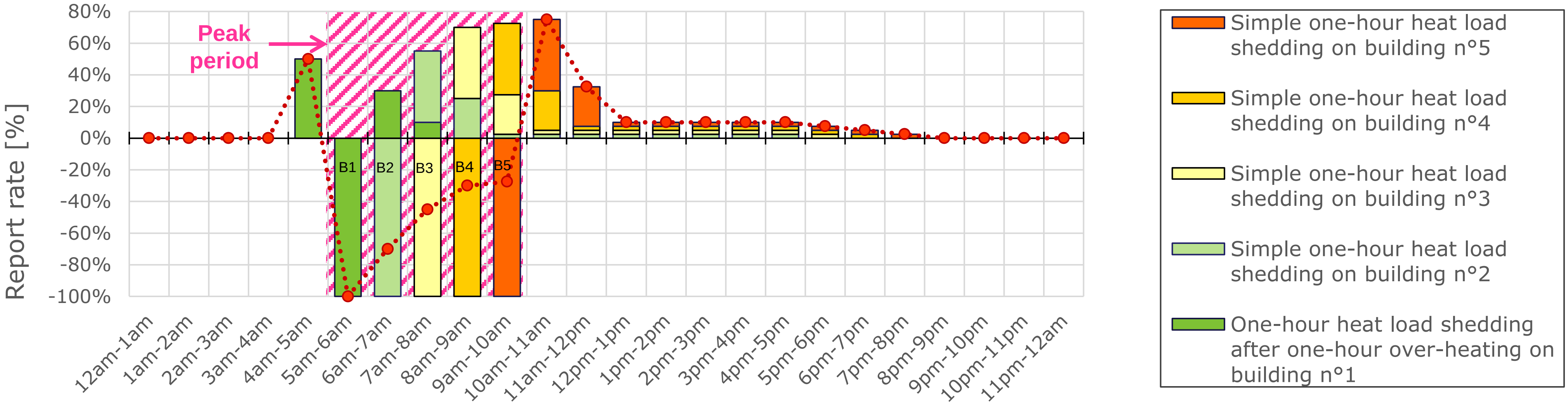
Construction of a standard transfer profile

- One-hour residential heat load shedding
- Without and with pre-heating



Quantify flexibility at district scale

- **Goal : Local peak-shaving**
  - Morning consumption peak from 5am to 10am
- **Strategy : Multiple one-hour heat shedding**
  - Differing the heat load shedding building per building through the entire district



⇒ What about thermal comfort ?

Thermal comfort evaluation

- **Comfort evaluation :** Thermal Building Simulation
- Building model **using available data.**

How to model Buildings ?

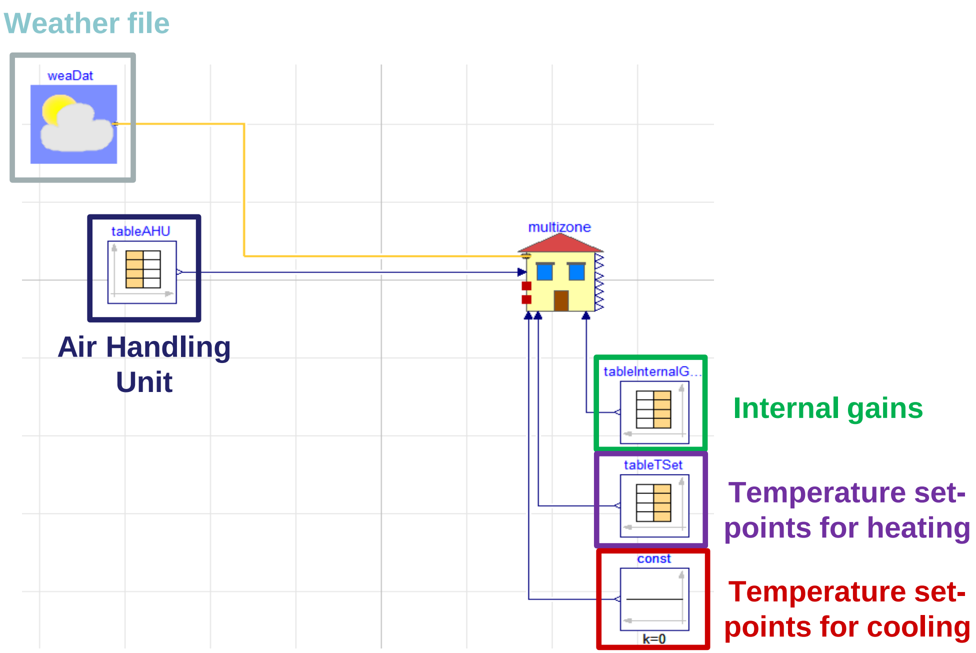
- Use of **statistical data** and archetype models
- Use of building **envelope data** if available
- Re-use existing thermal models from **mandatory studies**

⇒ **Fast building models generation**

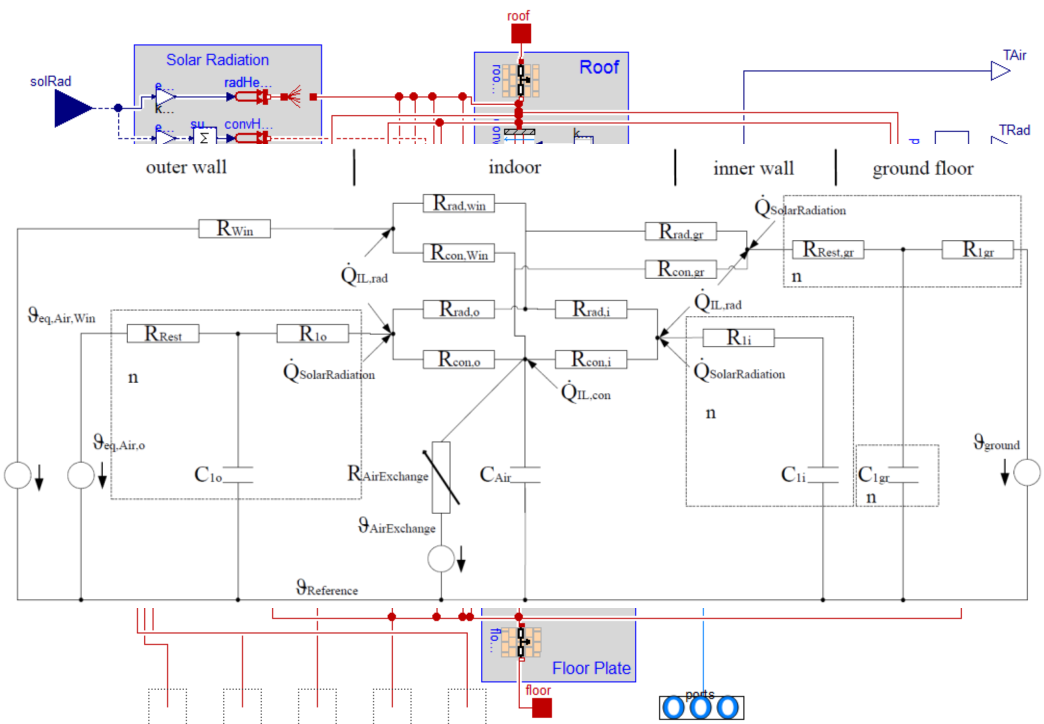
Automatic generation of thermal models

- Python script generates modelica models

Dymola interface for the generated model

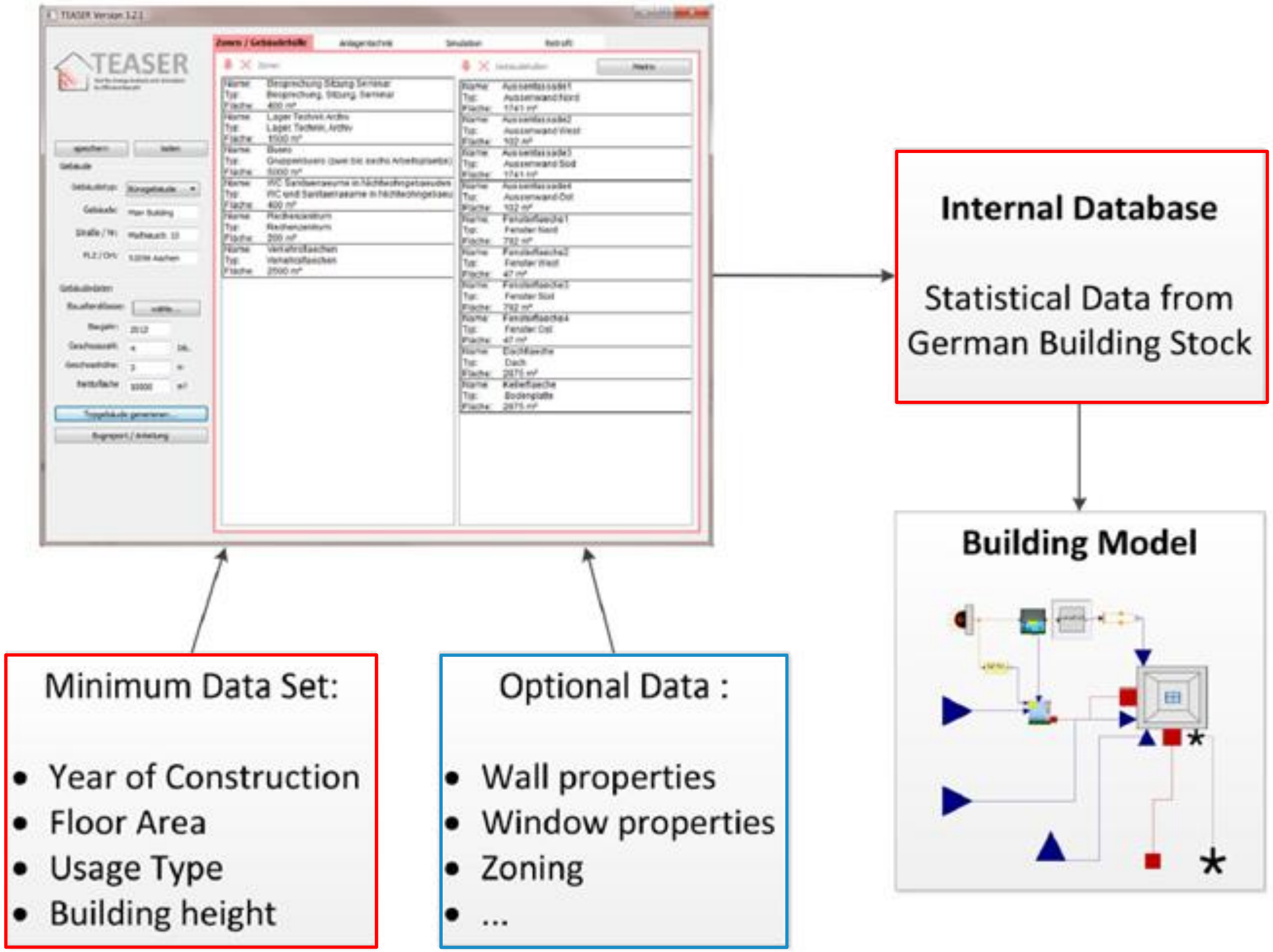


Single zone RC-model



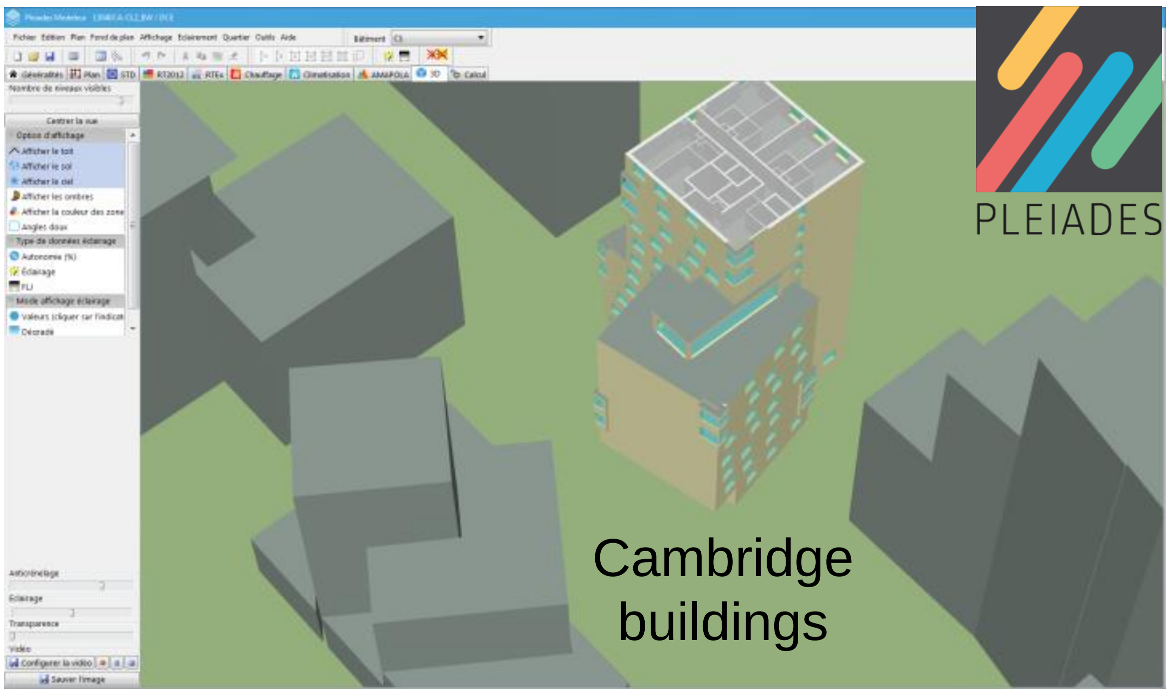
Two possibilities :

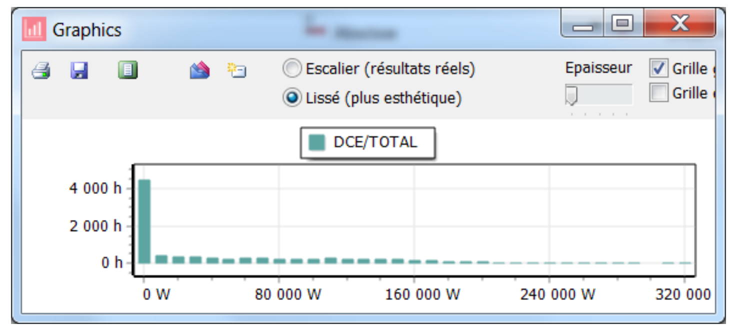
- Data enrichment from statistical databases :
  - TEASER can generate a building model with few parameters
  - Main advantage : requires few information about the building
- Data enrichment by hand :
  - TEASER can be used with the construction data
  - Main advantage : more accurate data

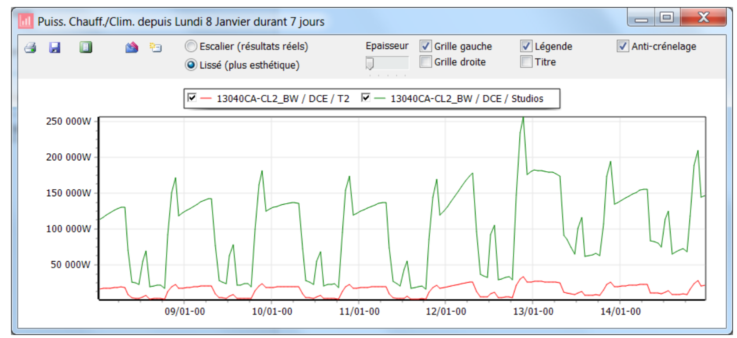


Building Energy Simulation sometimes available

- **design offices perform dynamic thermal simulation of buildings during their design** (it is mandatory)







Models comparison (Standard and from BES)

- **Comparison of transfer profiles obtained by a standard profile or BES results**

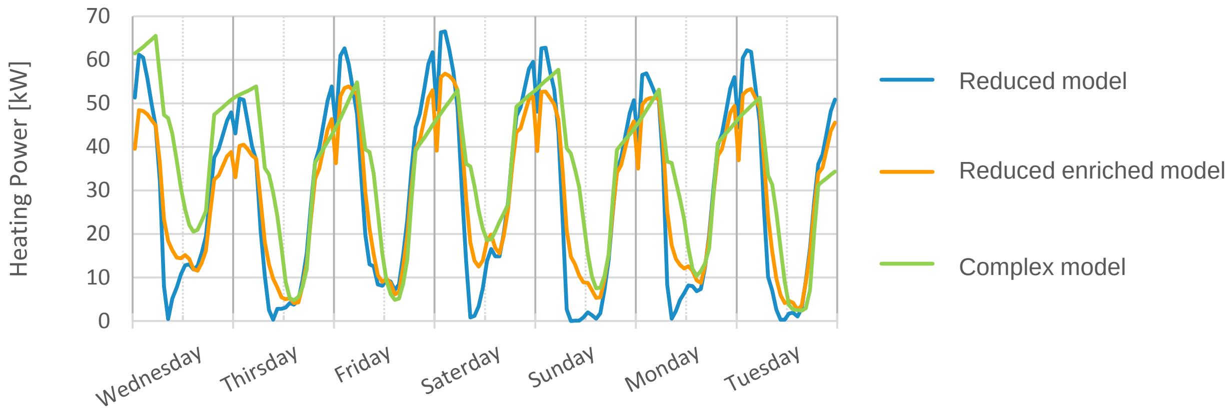
Accuracy ↓

Modelling Speed ↑

- Standard profiles model established from experimental results (**standard model**)
- Automatic model generation with only the 5 minimal parameters (**reduced model**)
- Automatic model generation with building envelope data (**reduced model with enriched data**)
- Detailed model from the mandatory BES study with Comfie-Pléiades software (**complex model**)

Model comparison :
Heating profiles for constant temperature

Example of simulated heating profiles during a week of January

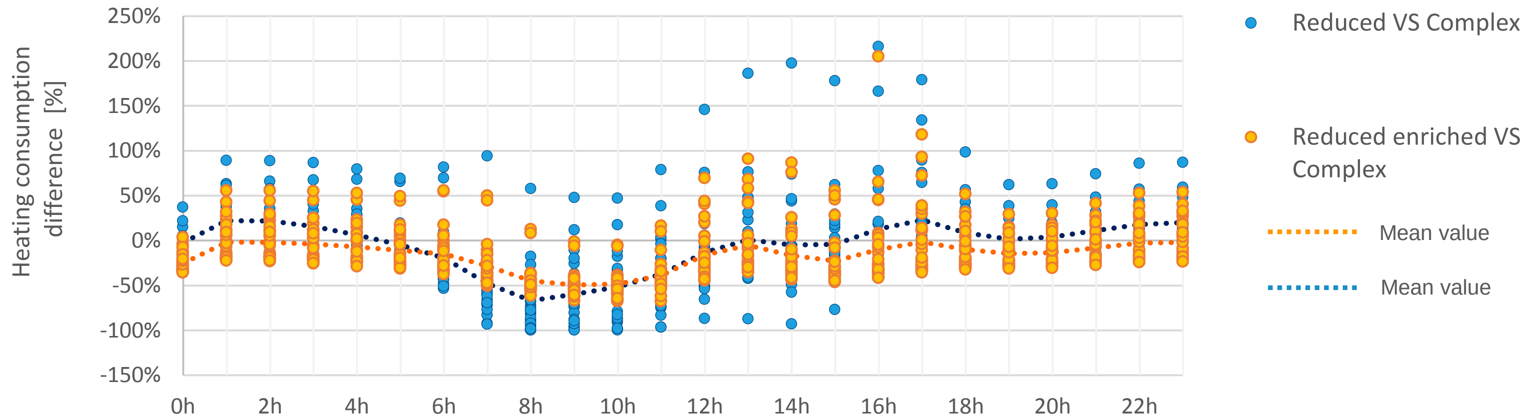


Accuracy results :

1. Complex model
2. Reduced enriched model
3. Reduced model (stat. data)

Similar dynamic estimation

Heating consumption difference relative to complex BES model heating consumption during January



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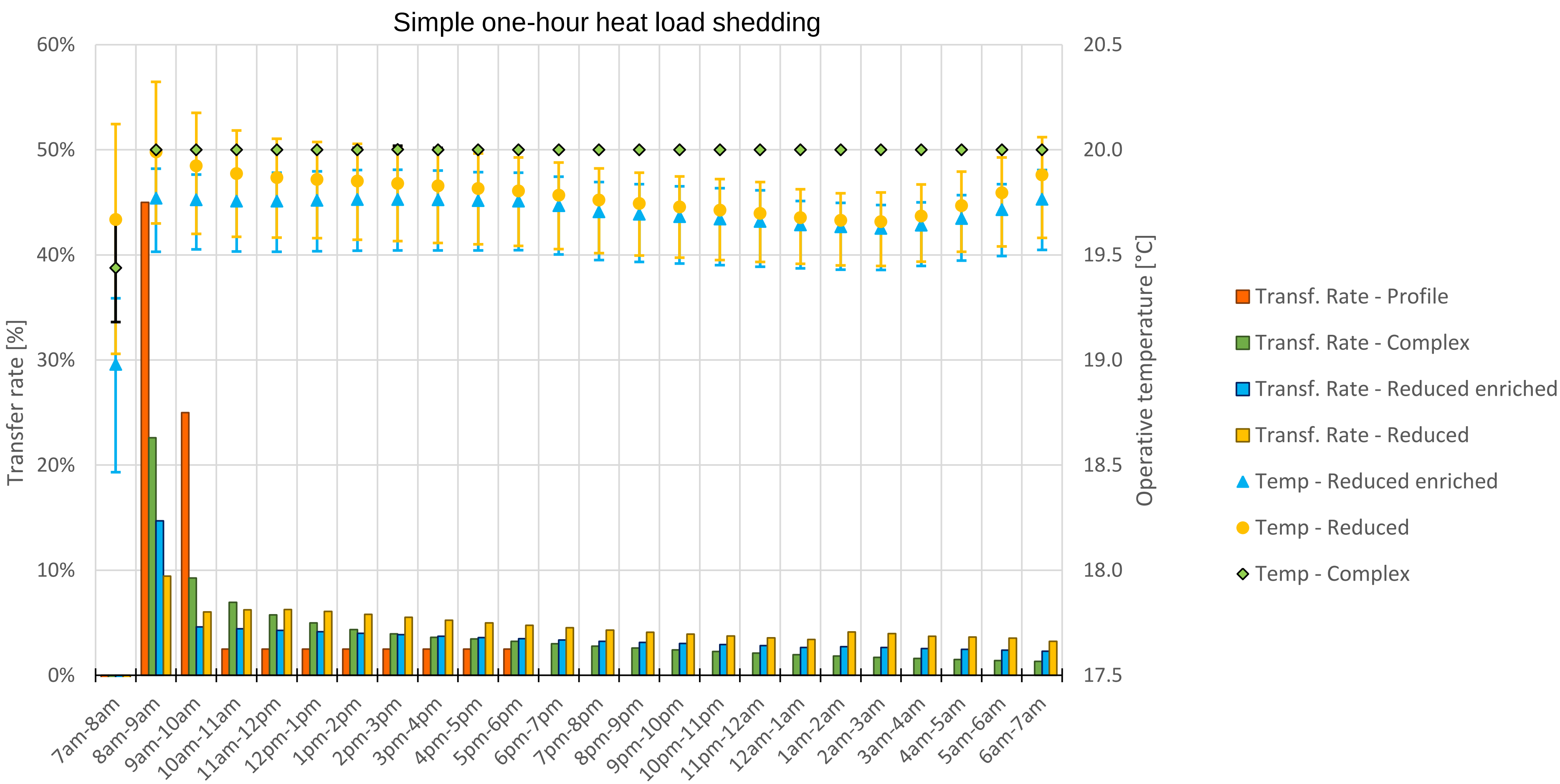
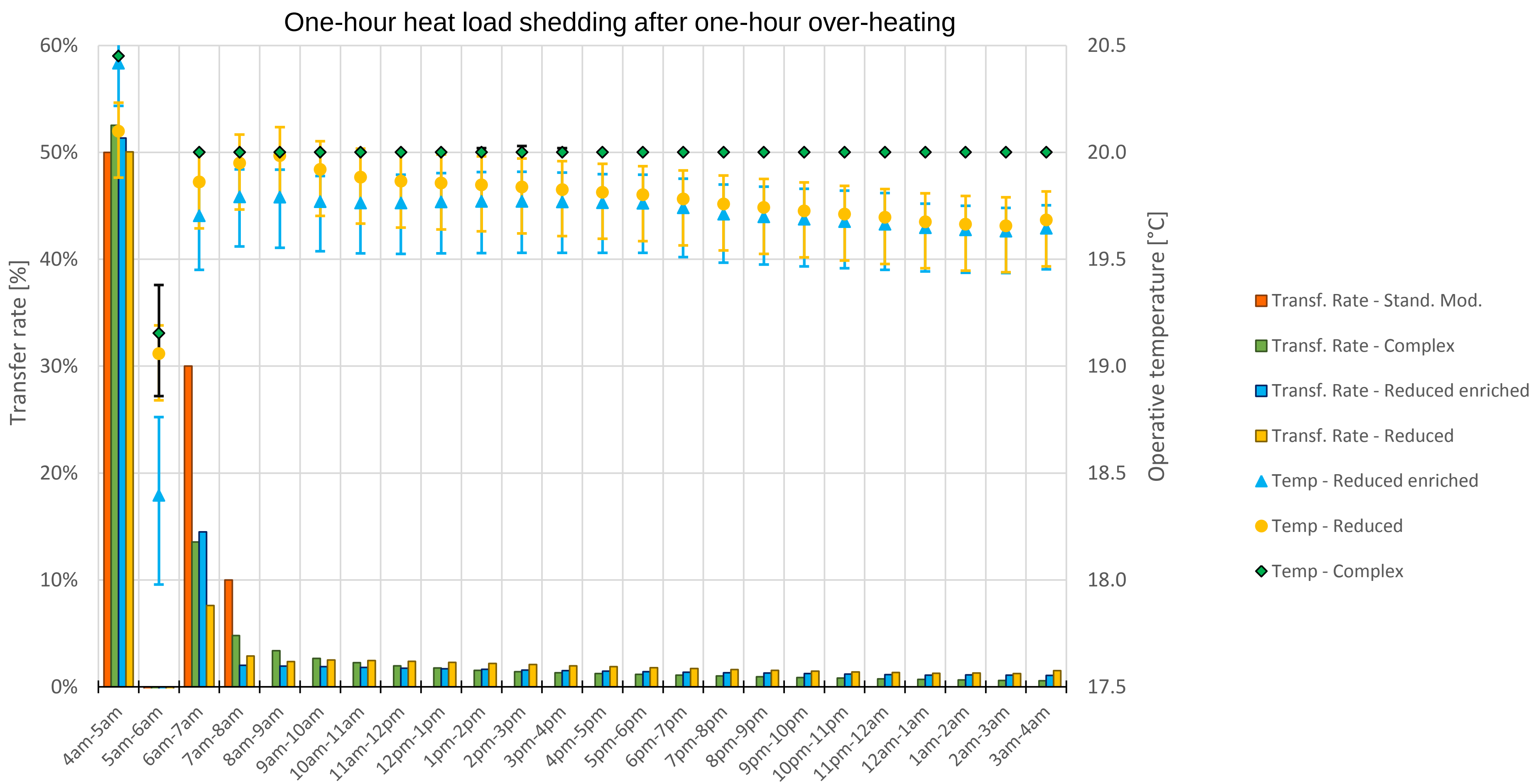
Comparison on transfer rate & temperature
One-hour heat shedding



Comparison on transfer rate & temperature With one-hour pre-heating



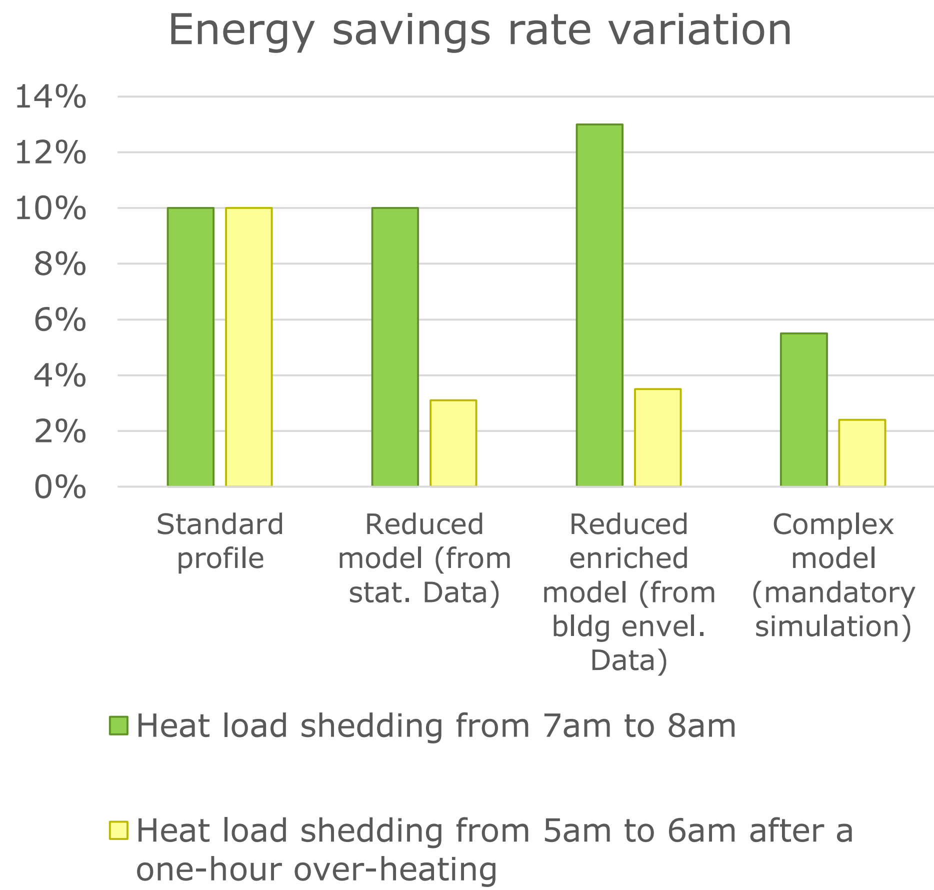
Comparison on Energy savings rate

Simple one-hour heat load shedding

Energy savings rate	
Standard profile	10 %
Reduced model (from stat. data)	10 %
Reduced enriched model (from bldg envel. data)	13 %
Complex model	5,5 %

One-hour heat load shedding after one-hour over-heating

Energy savings rate	
Standard profile	10 %
Reduced model (from stat. data)	3,1 %
Reduced enriched model (from bldg envel. data)	3,5 %
Complex BES model	2,4 %



Conclusions

- **Modeling buildings at district scale is a challenge to get data for all buildings**

- **Require multiple way of modelling :**
  1. **Standard profile** is fast but hazardous solution
  2. **Reduced model** generated from statistical data is a good approach
  3. When building data are available, it is possible to build a **reduced enriched model**
  4. When **detailed model** is already available it has to be used

- **For district simulation you may have to mix these approaches:**
  - Some models are **easier to connect** than others (Modelica VS black box software)
  - **Accuracy** is not guaranty, but it is **sufficient to evaluate flexibility**, and then

  ⇒ **Quantify load shedding effects on power and temperature**
  ⇒ **Optimize load shedding sequences, minimizing discomfort and maximizing profit**
  ⇒ **Evaluate the distributed load shedding capacity of the district**

Thanks,

Questions?

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