TREES
Training for Renovated Energy Efficient Social housing

Intelligent Energy -Europe programme, contract n° EIE/05/110/SI2.420021

Intelligent Energy Europe

Section 2 Tools
2.2 Thermal simulation

Bruno PEUPORTIER

ARMINES – CEP

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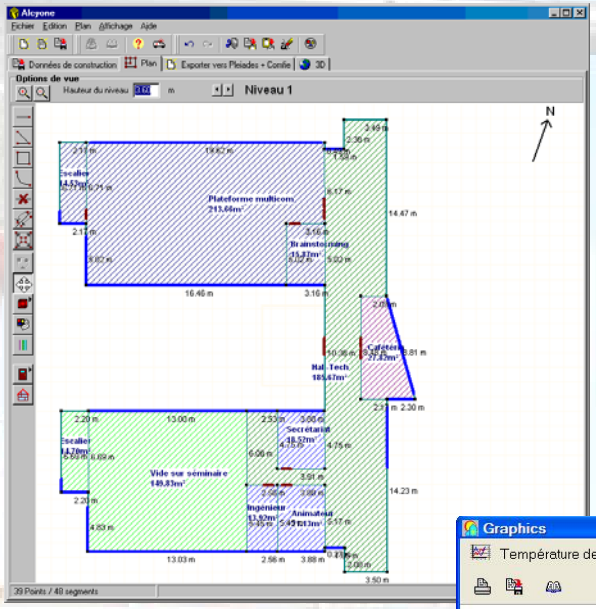
Main issues and definition

- **Evaluation of hourly heating load, accounting for intermittent heating, solar gains, equipment, control and occupants**
- **More accurate than monthly / annual calculation, accounting for temporal variation of temperatures, energy storage e.g. from noon to evening,**
- **Evaluation of thermal comfort, in summer and mid-season, study of passive cooling measures**
- **Aid in the design of a renovation project, comparison of alternatives, certification**

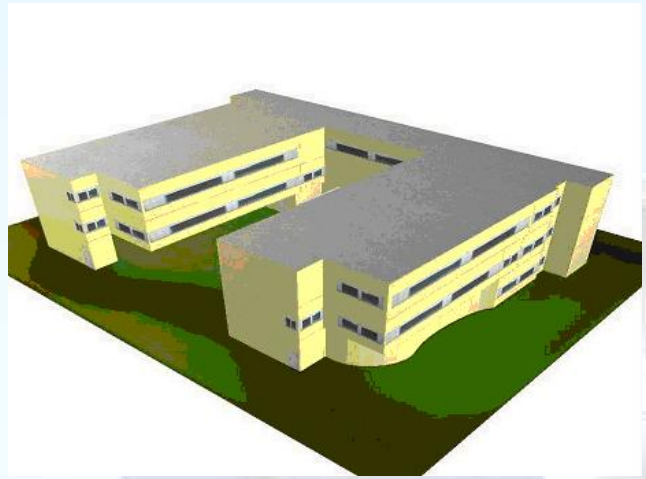
Use in a renovation project and main limits

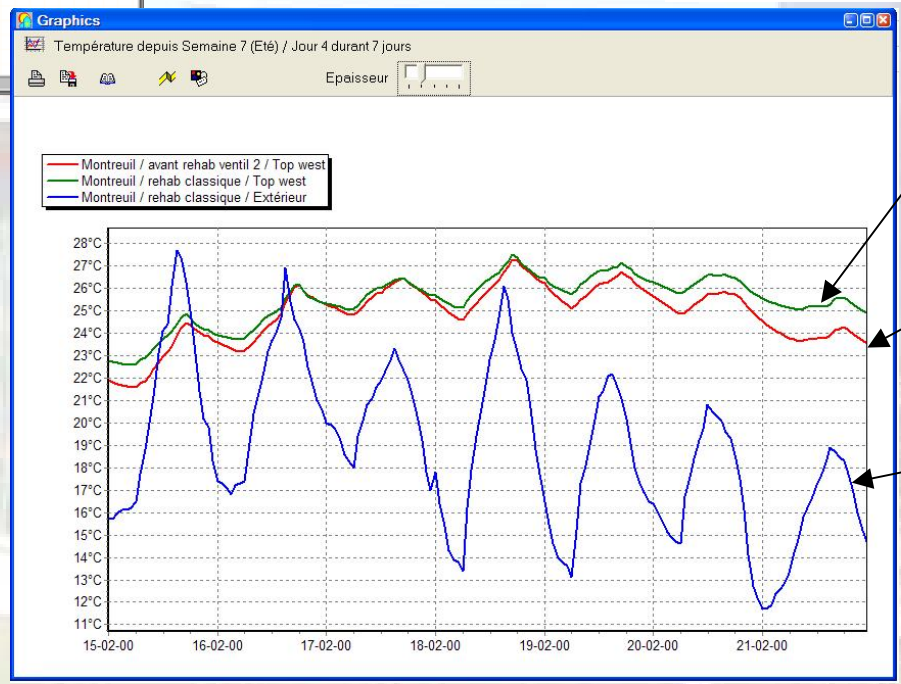
- **Modelling the existing building, then assessment of renovation measures (heating load + comfort)**
- **Same problems as for simplified calculation : difficulty to evaluate thermal bridges and air renewal rate, wall characteristics sometimes unknown (thermal insulation ?)**
- **possibility to identify these parameters using the measured energy consumption**
- **average inhabitants' behaviour (internal gains, window opening, use of solar protection…)**
- **Around 5 man-days to model a building and study a renovation project**

Example tool : COMFIE, www.izuba.fr



2D plan -> 3D image export data to energy calculation tool





Graph editor, temperature profiles

after renovation

before renovation

external

Contents

- **Objectives of thermal simulation,**
- **Principles and models, main hypotheses and limits,**
- **list of tools and web sites, tool validation and inter-comparison,**
- **example application in the retrofit of social housing : improvement of the performance obtained by various technical measures,**
- **sensitivity studies,**
- **Conclusions**

Introduction, objectives of thermal simulation

- **More accurate than monthly / annual calculation, accounting for temporal variation of temperatures, energy storage e.g. from noon to evening,**
- **Evaluation of hourly heating load, accounting for intermittent heating, solar gains, equipment and control, comparison of alternatives, certification**
- **Evaluation of thermal comfort, in summer and mid-season, study of passive cooling measures**
- **Aid in the design phase, for a new construction but also when designing a renovation project**

Principles and modelling

- **Building described as « zones », i.e. spaces at a homogeneous temperature : same orientation (north / south), same use (living, bedroom…)**
- **Heat balance in a building element (e.g. wall layer) : gains – losses = stored energy**
- **Evaluation of temperature profiles : stored energy = thermal mass x temperature variation**
- **Use of hourly climatic data (temperature, solar radiation)**

Thermal zones, example

North / South orientation, last floor (higher heat losses through the roof), ground floor and underground (different use)

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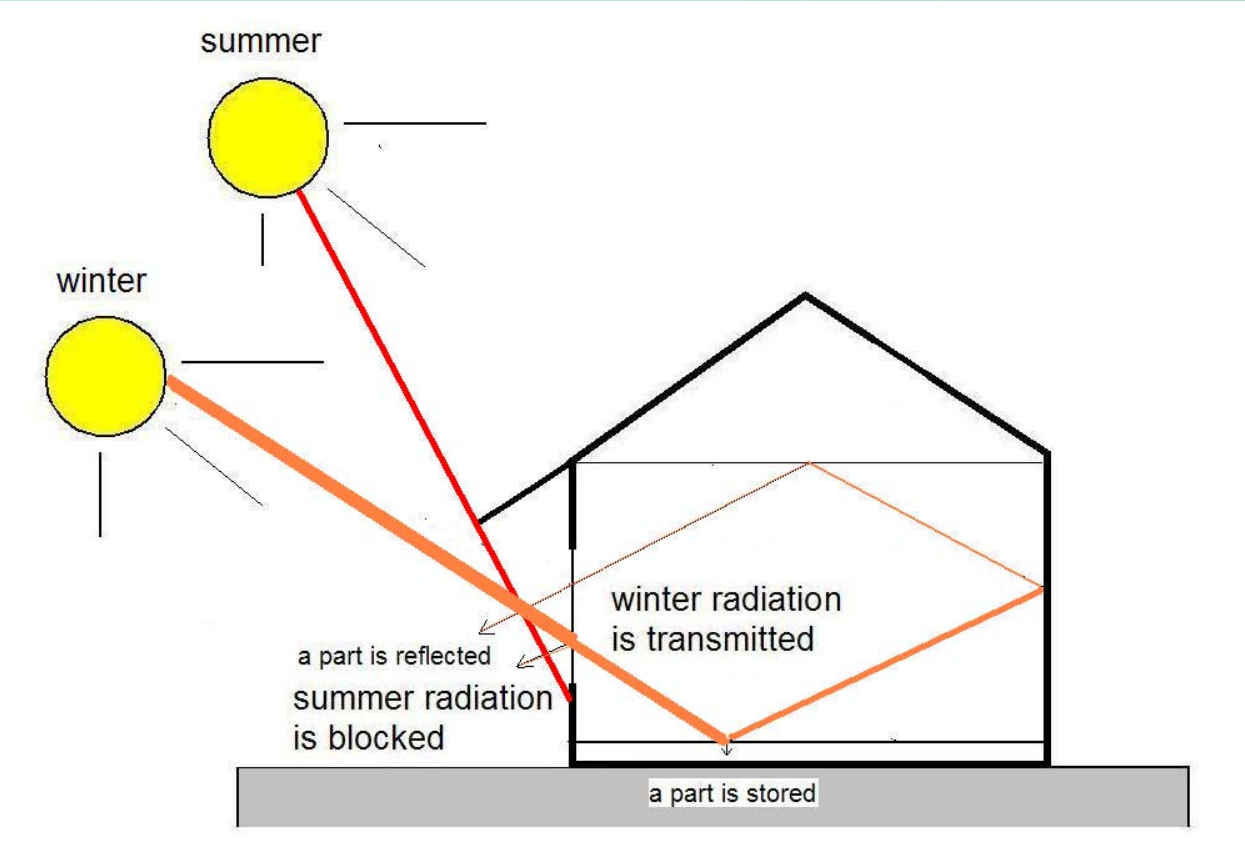
Gains

- **Gains : net transmitted solar radiation (a part is reflected), internal gains (persons, lighting, domestic appliances), heating equipment**



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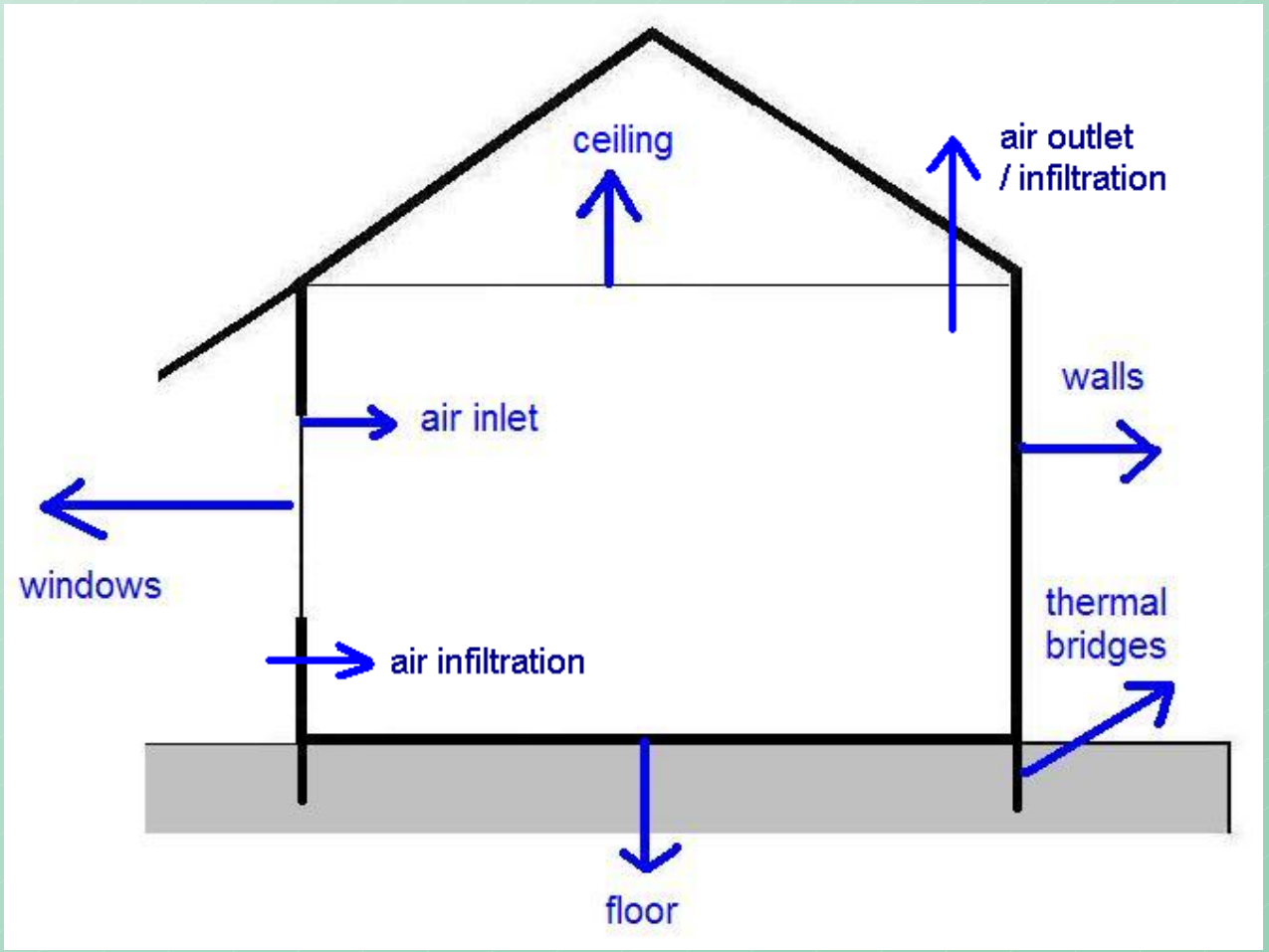
Solar gains

- **Hourly calculation of solar radiation on the different facades**
- **Possible distant shading (other buildings, trees…), architectural shading (balcony over a window, overhang…), shading devices (shutters, roller blinds, Venetian blinds…)**
- **Transmission through windows (solar factor, frame), absoption or reflection on floors, walls etc.**
- **Storage in floors, walls etc.**

Losses

- **Losses : walls, roof, floor, windows, thermal bridges, ventilation + air infiltration**



Use in a renovation project and main limits

- **Modelling the existing building, then assessment of renovation measures (heating load + comfort)**
- **Same problems as for simplified calculation : difficulty to evaluate thermal bridges and air renewal rate, wall characteristics sometimes unknown (thermal insulation ?)**
- **possibility to identify these parameters using the measured energy consumption**
- **average inhabitants' behaviour (internal gains, window opening, use of solar protection…)**
- **Around 5 man-days to model a building and study a renovation project**

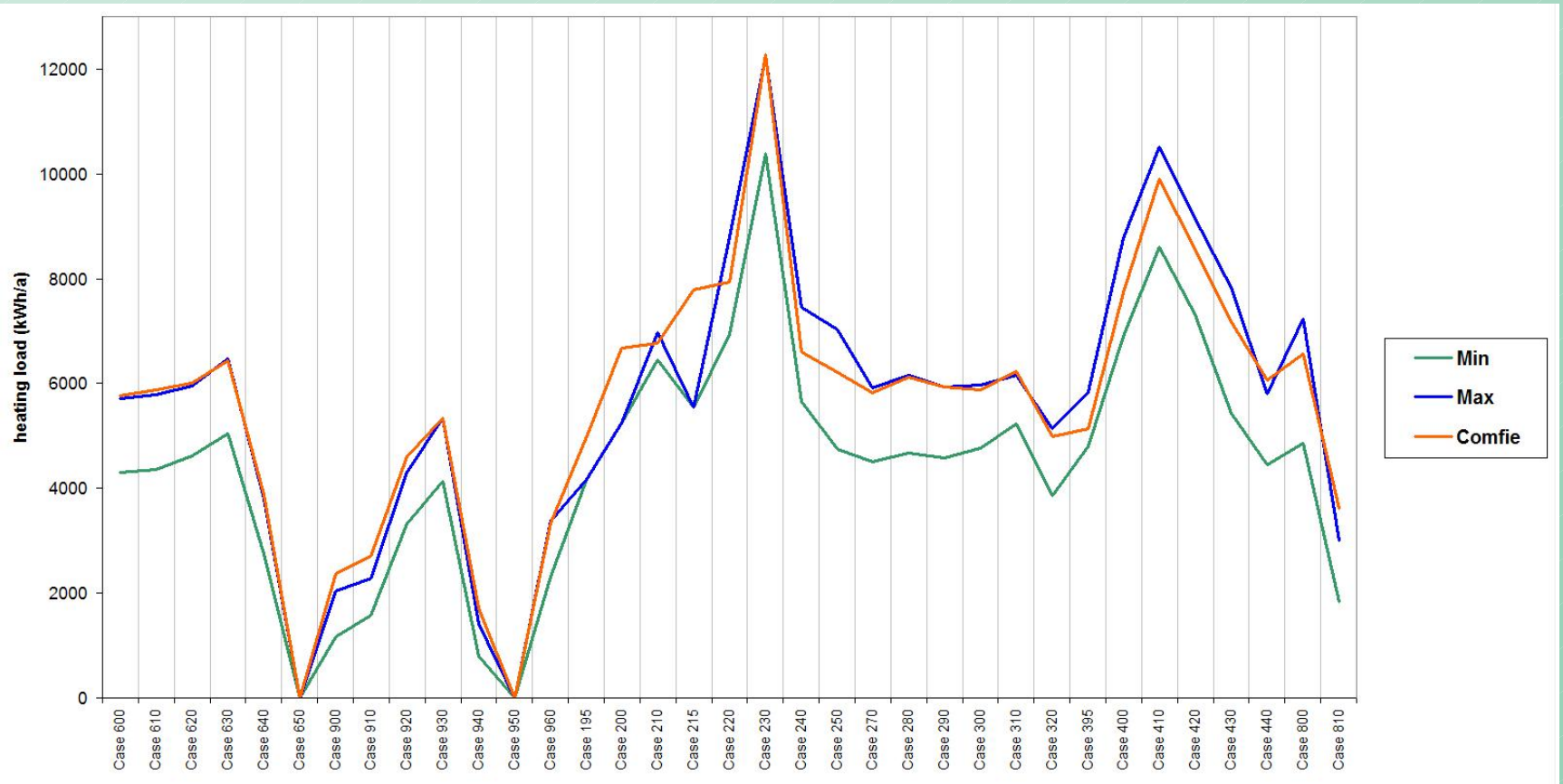
List of tools and web sites

- **Directory of thermal simulation and other building software tools : http://www.eere.energy.gov/buildings/tools_directory/**
- ENERGY PLUS : http://www.energyplus.gov
- TRNSYS : http://sel.me.wisc.edu/trnsys/downloads/download.htm
- ESP-r : http://www.esru.strath.ac.uk/
- TAS : http://ourworld.compuserve.com/homepages/edsl
- COMFIE : www.izuba.fr
- LESOCOOL : http://lesowww.epfl.ch
- SIMBAD : http://ddd.cstb.fr/simbad
- SUNREL : http://www.nrel.gov/buildings/sunrel/
- TSBI3 : http://www.by-og-byg.dk/english/publishing/software/tsbi3e/index.htm
- IDA : http://www.equa.se

Software validation, intercode comparison

« Bestest » Procedure , International Energy Agency

Comparison with 8 codes (TRNSYS, DOE, SUNREL, ESP,…)



35 cases (window size and orientation, intermittent heating, thermal mass, ventilation, internal gains…)

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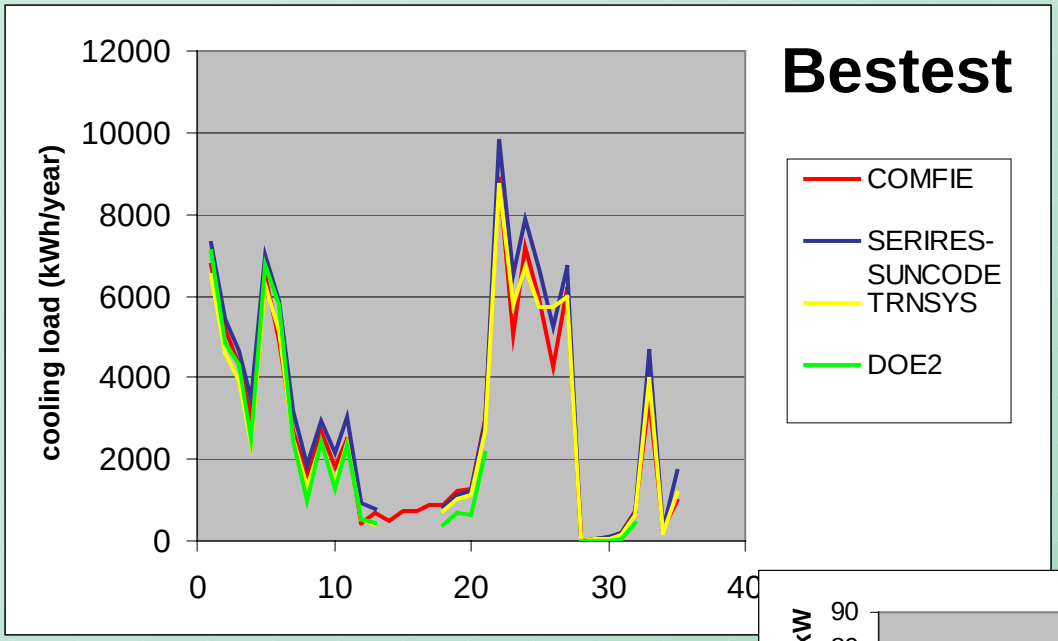
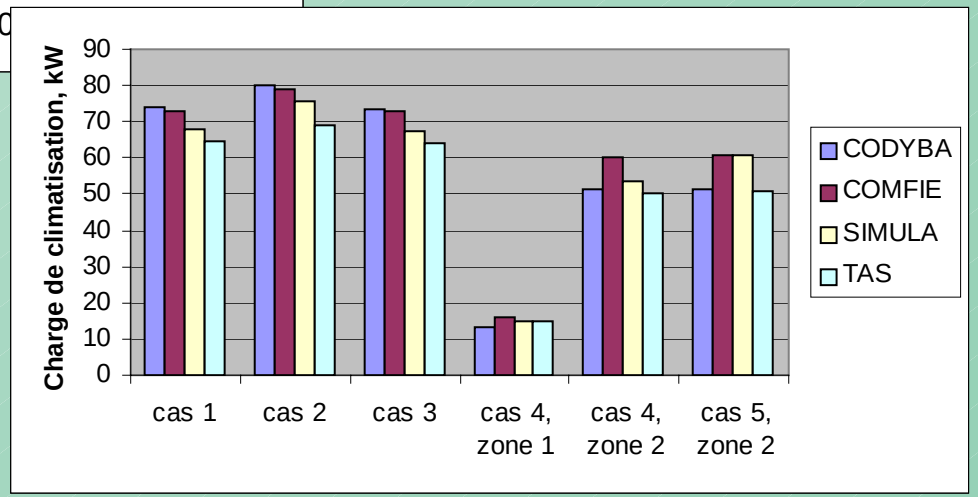
Benchmarks for cooling loads



AICVF



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Experimental validation, IEA task 34, EMPA test cell

Figure 1a Outdoor test facility with removable façade element.

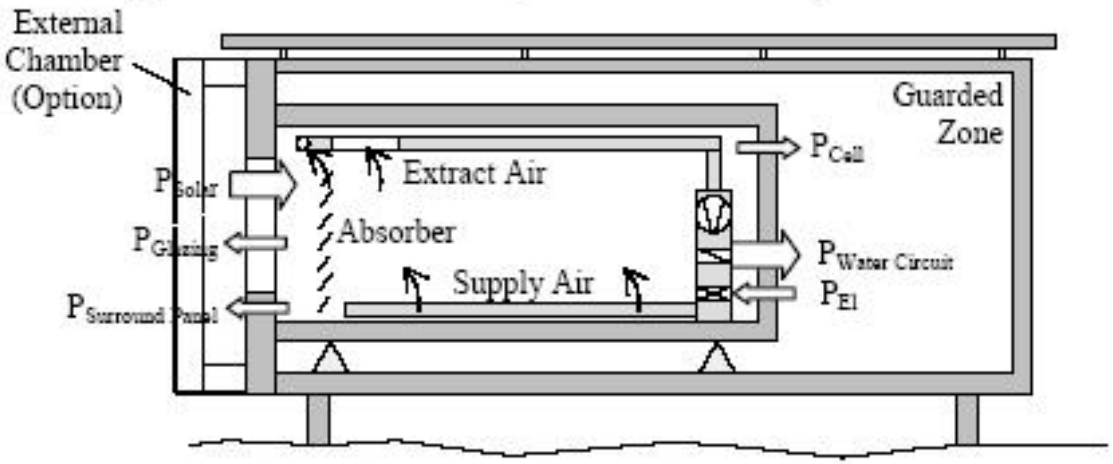

Figure 1b Diagram of test toom with an optional external chamer.

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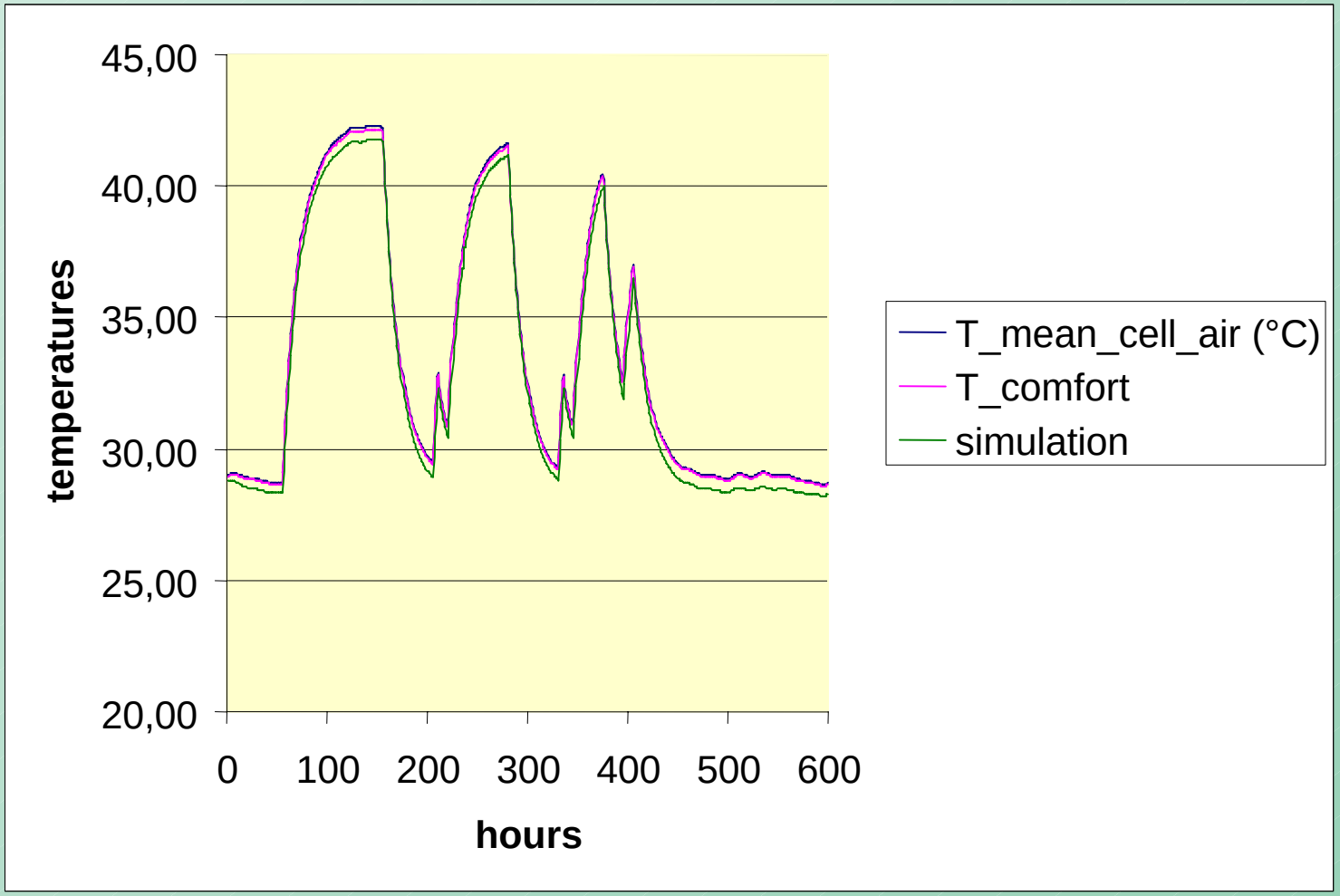
Example result, IEA task 34, EMPA test cell



Less than 1°C discrepancy

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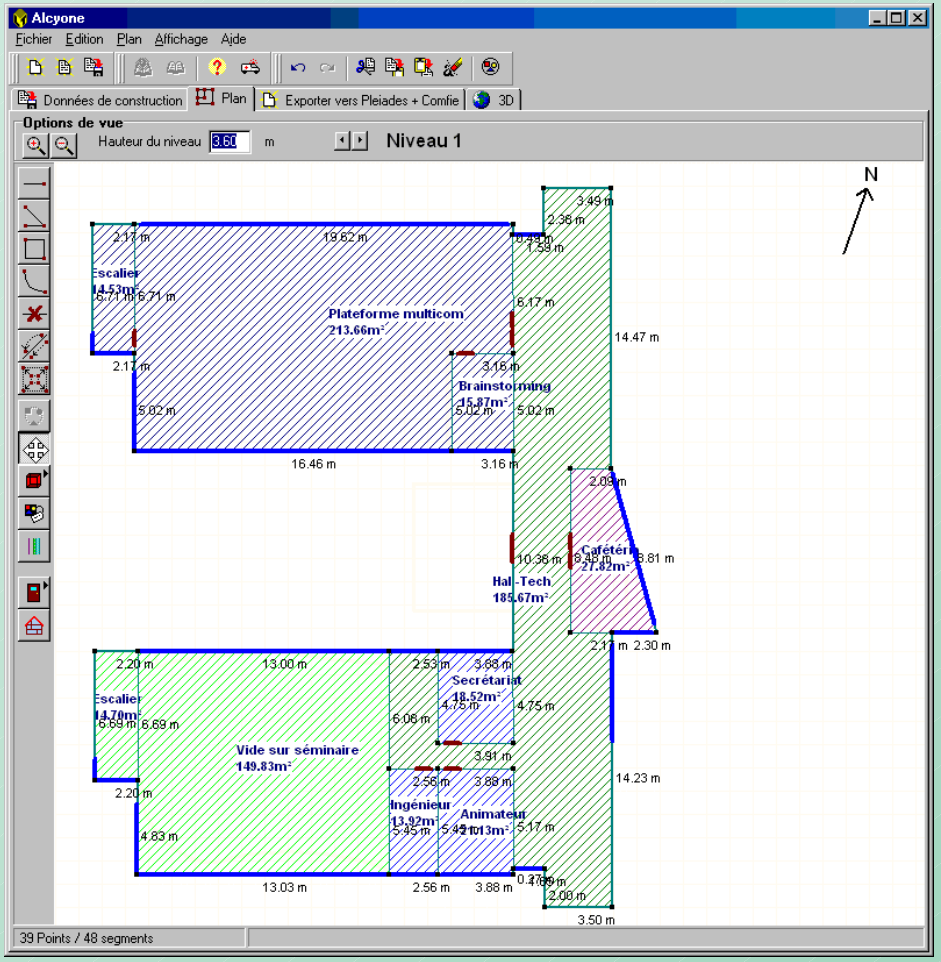
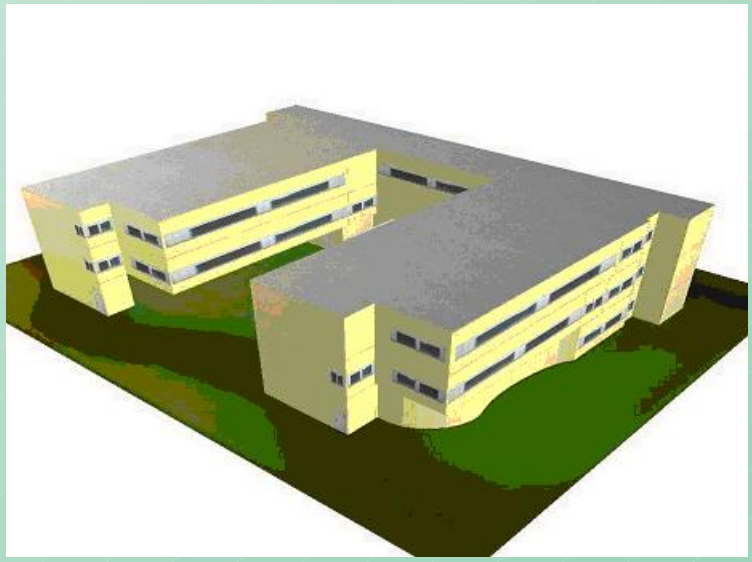
Example graphic interface : ALCYONE





2D plan -> 3D image

Export data to several energy calculation tools

www.izuba.fr

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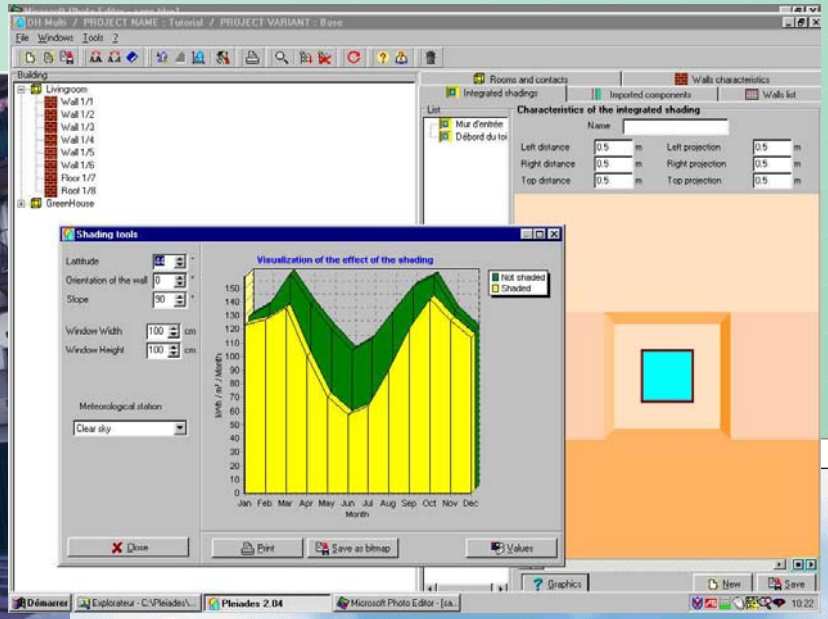
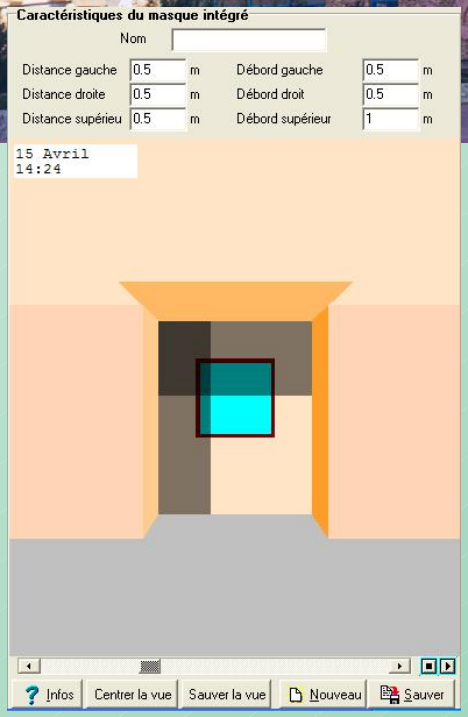
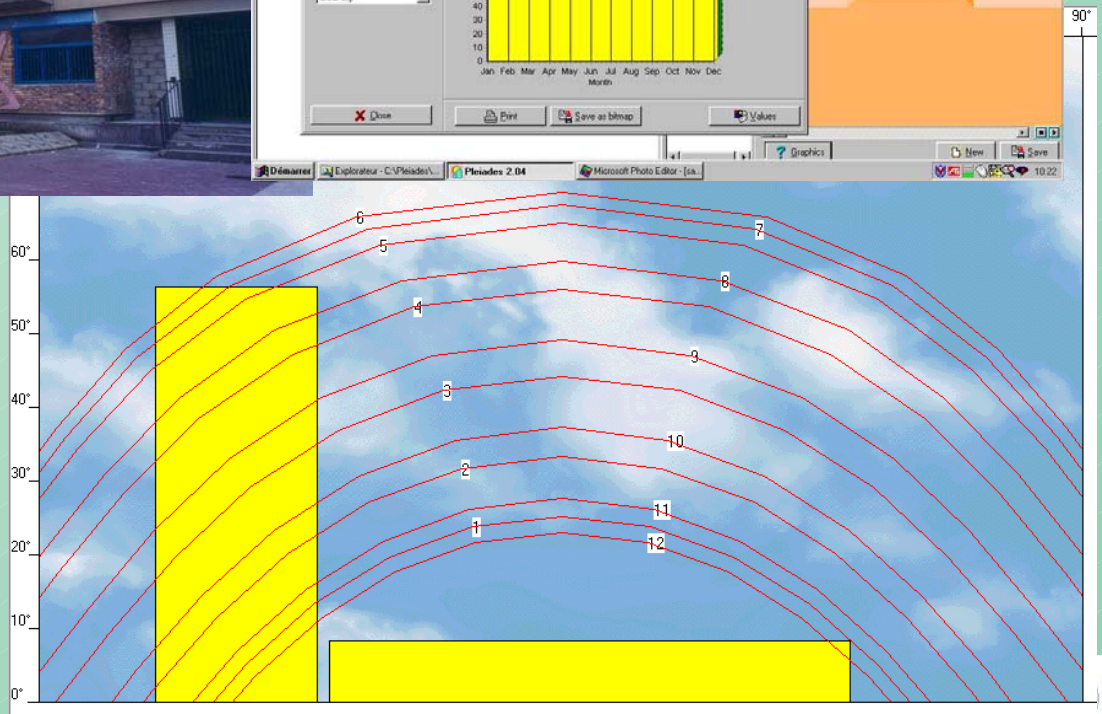
Example user interface, PLEIADES, input

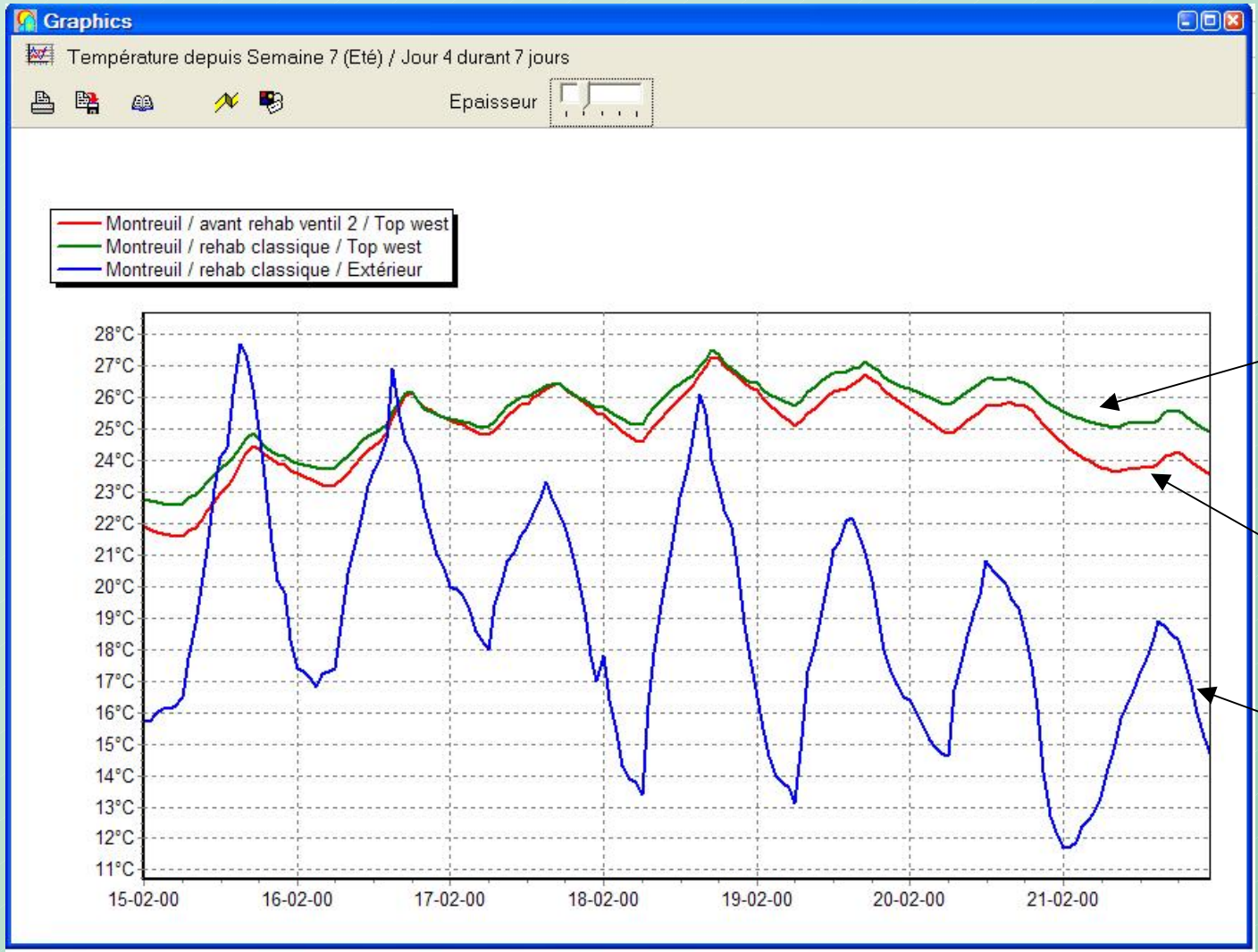






Solar exposure analysis, COMFIE

Example user interface, PLEIADES, output



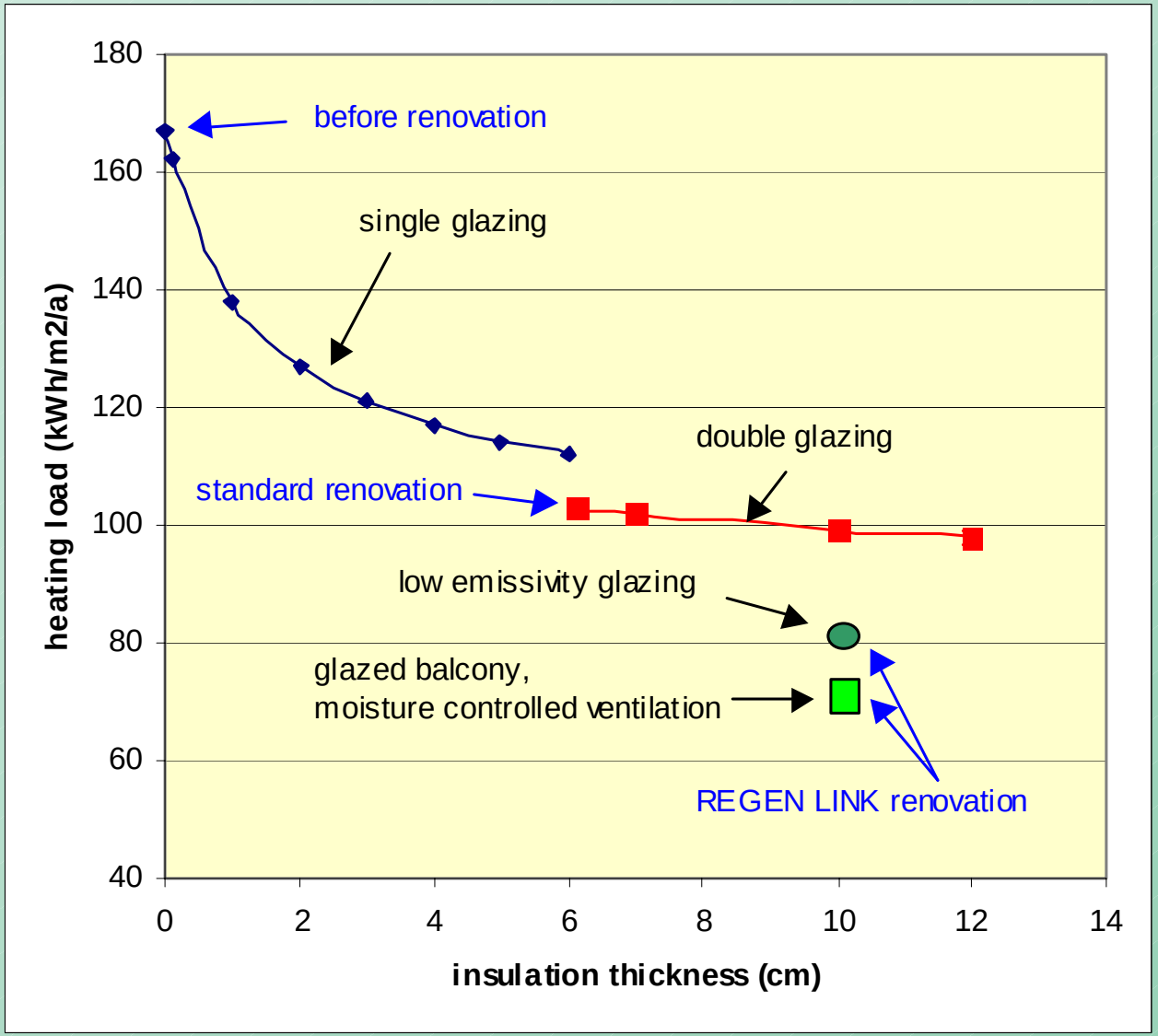
after renovation

before renovation

external

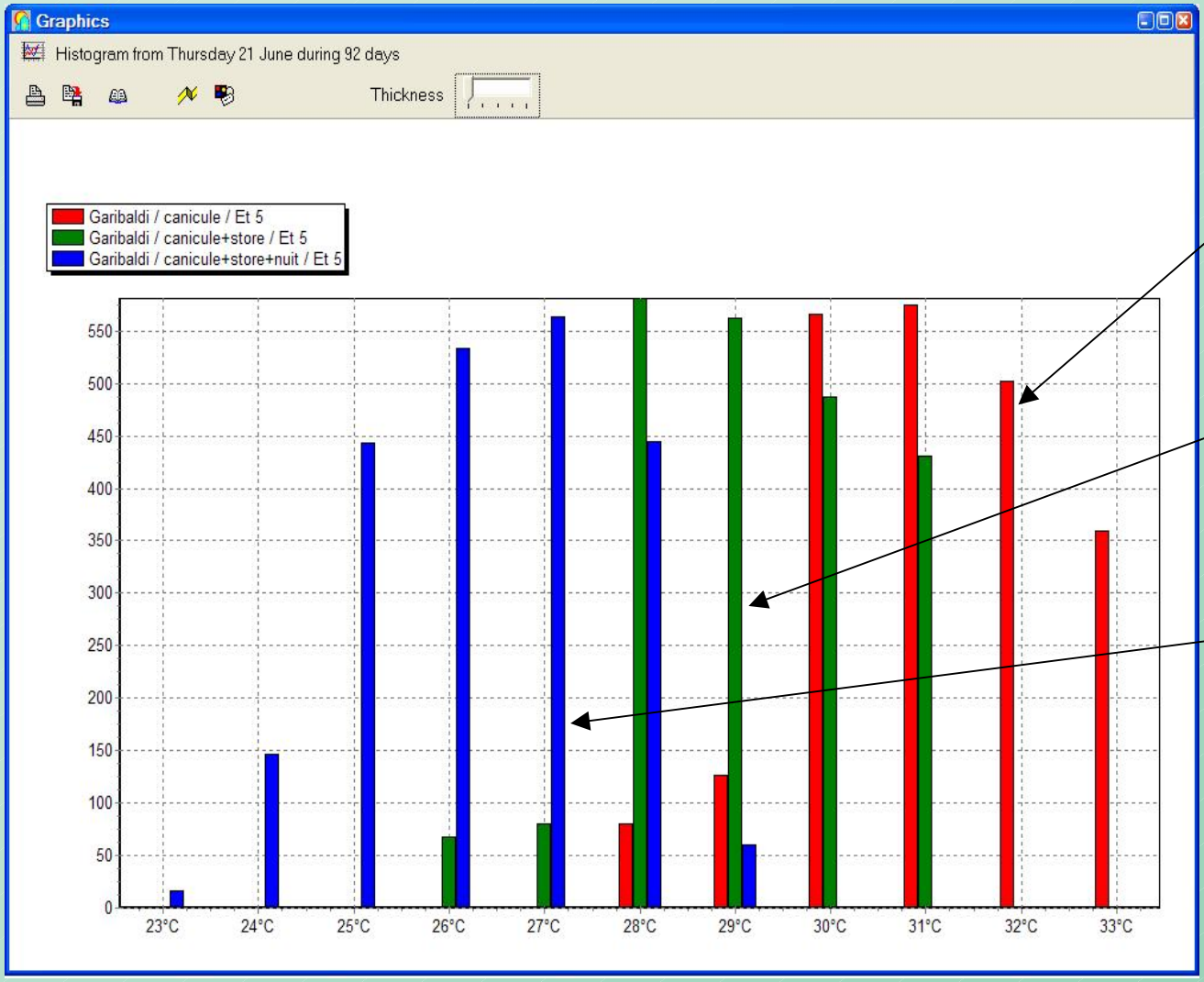
Graph editor, temperature profiles

Example result of thermal simulation, COMFIE



Assessing different renovation measures

Example passive cooling study



No passive cooling

Solar protection

Night ventilation

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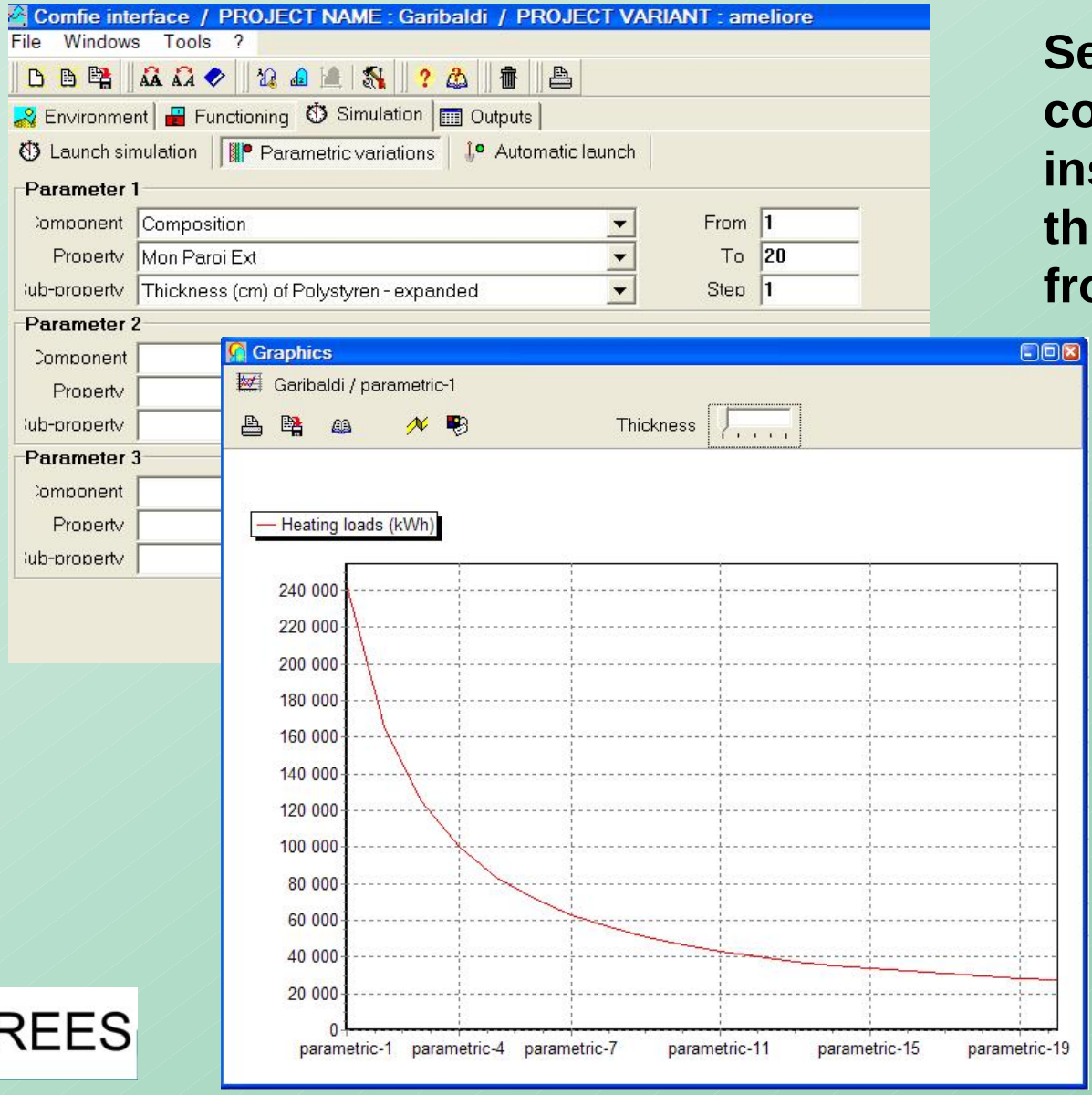
Example sensitivity study



Selection : wall composition, insulation, thickness, from 1 to 20 cm

Automatic series of simulations, parametric variation graph

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Conclusions

- **Thermal simulation is now widely available**
- **Allows evaluation of energy saving and comfort**
- **Easy use in practice thanks to user friendly interfaces, e.g. 2D-3D graphical tools**
- **Around 5 days to study a renovation project : modelling of the existing building, assessment of renovation measures, sensitivity studies**
- **Can also be used for energy certification**

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