"Thermal Performance of Residential Buildings with Large Glazing Areas in Temperate Climate "

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INTRODUCTION

This work presents the results of an experimental and numerical study of a residential building, in a temperate climate, the particularity of these buildings is the large glazing areas around 65% to 85% of exterior façade.

- **The main heat exchange in a building usually occurs through the transparent elements;**
- **The non-opaque envelope (glazing) can be considered a major factor in the control of radiation, ventilation and natural lighting;**
- **Glass and other transparent and translucent materials are considered essential for the successful implementation of most passive solar heating systems;**
- **The interest in glass materials in construction has increased;**
- **Can be noticed the increase of glazing areas on the Portuguese residential buildings over the past decades (actually residential buildings with 65% -85% of façade in glazing).**

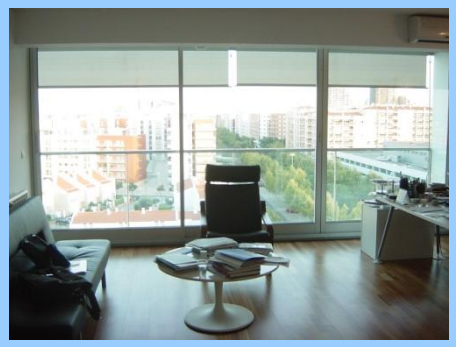
1º Thermal Regulation In Portugal (RCCTE) 1991

OBJECT OF STUDY

These building present important features to this study:

- glazing areas over 65% of the main façade.
- construction and architecture practiced in recent years in Portugal.

was selected a housing unit



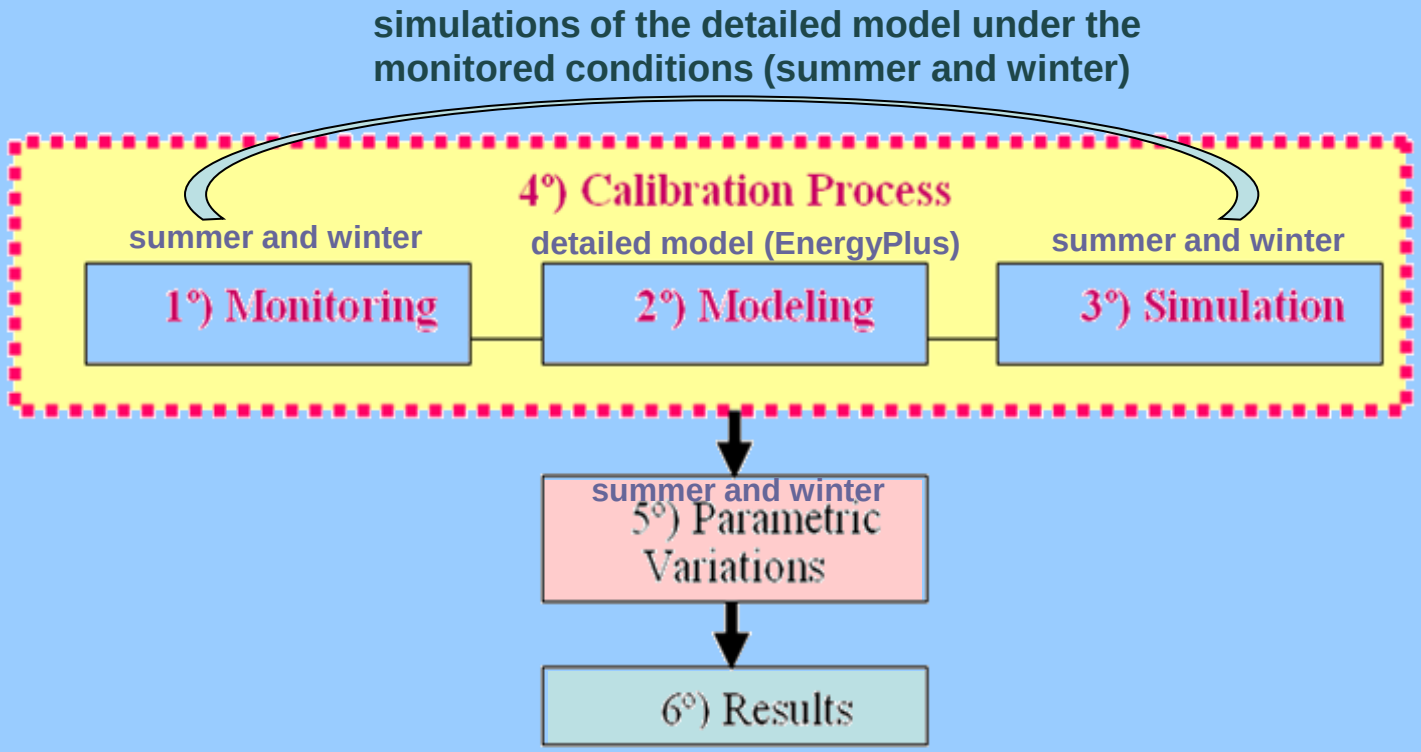
	Facade(s) Exposed Orientation	Housing Unit	Compartment	Location in Building	FF (Form Factor)	Glazing Facade(s) Orientation	Glazing Area/ Facade Area in Corresponding Exposition (%)	Total Glazing Area/ Floor Area (%)	Exterior Shading
South	SSE	H 2	living room	Intermediate	0.16	SSE	85%	34%	horizontal shading
			bedroom		0.34		77%	69%	

- Is located an intermediate floor (Lisbon, Latitude 40 º N) with a single façade in contact with the outside (facing to the south);

- Without any protection device in the glazing areas (80% of the façade is glazed);
- Has a balcony (0.85m wide) over the entire glazing (this balcony provides shading on the glazing).

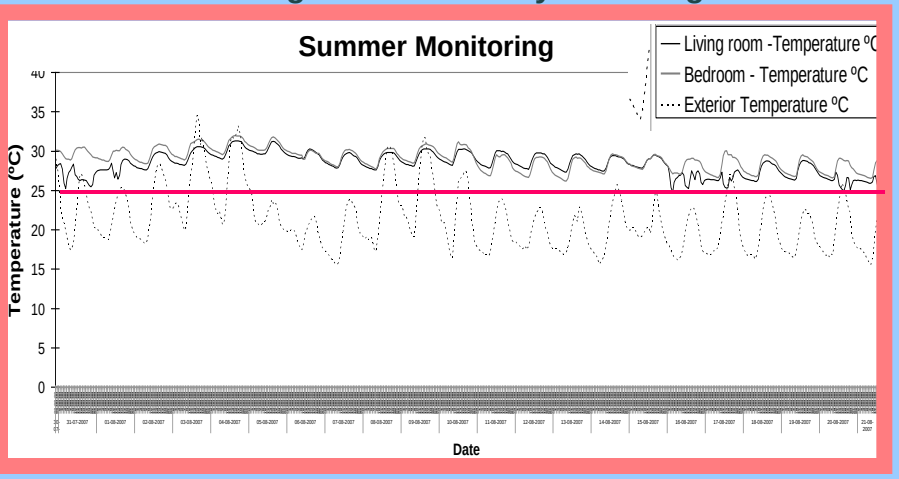
PHASES OF THE STUDY

The study was developed in different phases:



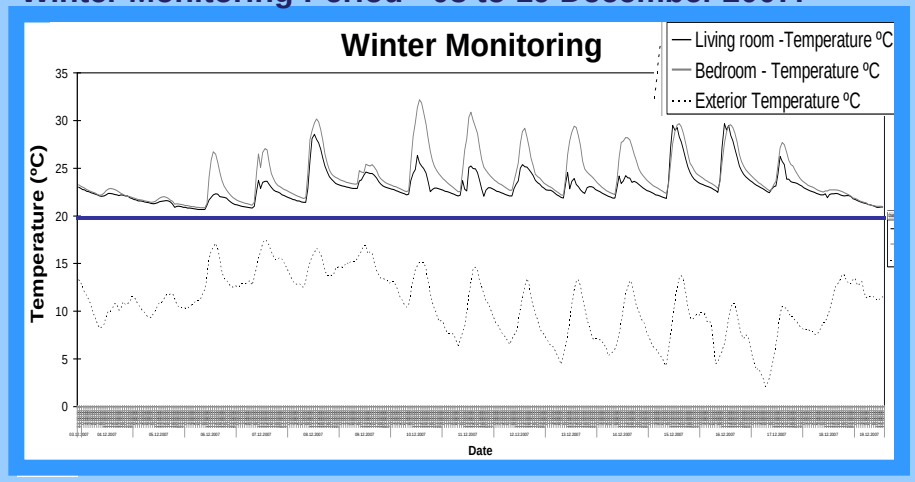
SUMMER and WINTER MONITORING

Summer Monitoring Period - 30 July to 21 August 2007:



- Mean temperature: living room 28.5 ºC, and bedroom 29 ºC;
- Mean thermal amplitude: 6.5 ºC living room, and 6 º C bedroom;
- Temperatures in the living room and bedroom were: above 25 °C (temperatures above the comfort level) in 100% of the time;
- Temperatures in the living room were between 27 ºC and 31 ºC in 80% of the time;
- Temperatures in the bedroom were between 27 ºC and 31 ºC in 90% of the time;
- Approximately 84% of the time the outside temperatures were below 25 °C.

Winter Monitoring Period - 03 to 19 December 2007:



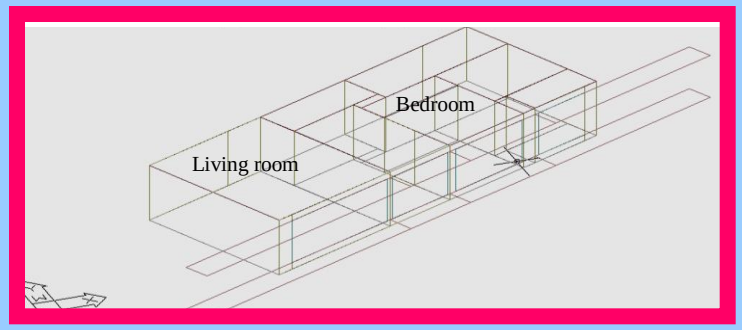
- Mean temperature: living room 23 ºC, and bedroom 24 ºC;
- Mean thermal amplitude: 9 ºC living room, and 11 ºC bedroom;
- Temperatures in the living room were between 20°C and 25 °C in 90% of the time and 73% of the time in the bedroom;
- Approximately 4.5% of the time temperatures in the living room were above 27 °C and in 6% of the time temperatures in the bedroom were above 29 ºC;
- There were no temperatures below 20 ºC in these compartments;
- The outside air temperatures were below 15 °C in 85% of the time, and in 37% of the time the temp. were between 5 ºC and 10 ºC.

- Sensors installed in the living room and bedroom (hygrothermal behaviour - mini datalogers)
- The use and occupancy pattern of housing unit was also recorded during the measurements
- External conditions were obtained from the LNEG Meteorological Station (installed Solar XXI)

SUMMER and WINTER SIMULATION

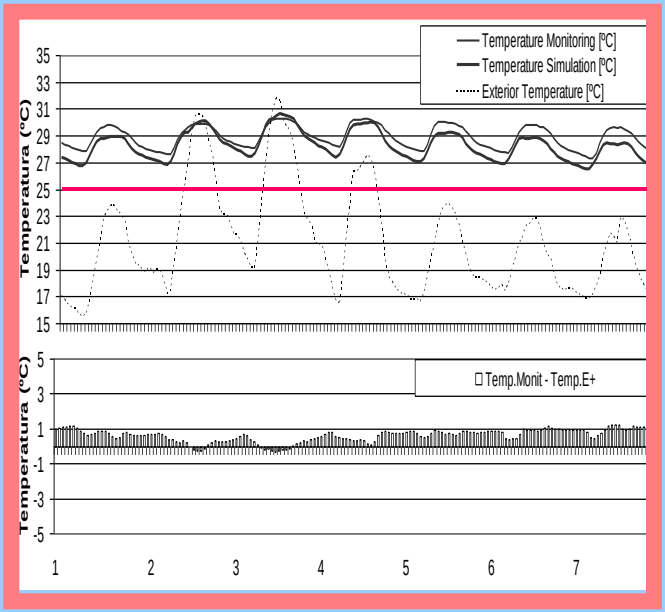
Based on information obtained from the housing unit in question a detailed model was constructed in the EnergyPlus (E+). The detailed model took into account:

- **The features of the housing unit;**
- **The conditions under which it was monitored during the summer and winter (geometry, orientation, location, construction solutions, pattern of use and occupation, renewal rates by time, equipment ...);**
- **Special care was taken to introduce into the thermal simulation software the climatic data (climate file) obtained from the meteorological stations of the National Laboratory for Energy and Geology (LNEG, Lisbon) the same periods of monitoring.**

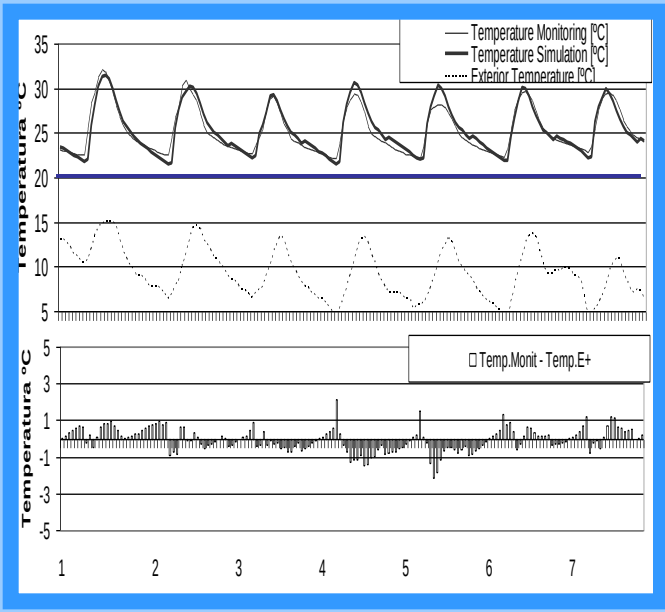


DETAILED MODEL (E+)

SUMMER and WINTER SIMULATION



The difference between the temperatures obtained during the monitoring and those obtained through simulations for the environment living room (during the seven days selected to represent the summer season) was on average 0.62 ° C, and for the bedroom was 0.44ºC.

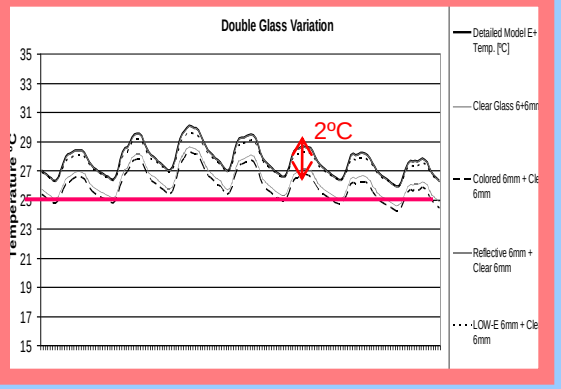


The difference between the temperatures obtained during the monitoring and those obtained through simulations for the environment living room (during the seven days selected to represent the winter season) was approximately 0.32 ° C; and for the bedroom was 0.04ºC.

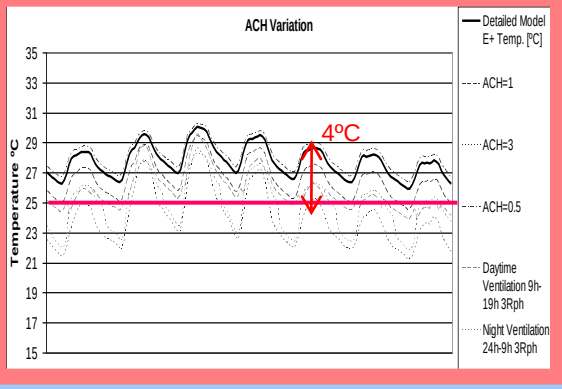
CALIBRATION MODEL

The manufacturer of the equipment uses a margin of error of + or - 0.5 ºC and and the mean differences obtained in both seasons (monitoring and simulations), which were no more than + or - 0.62 º C.

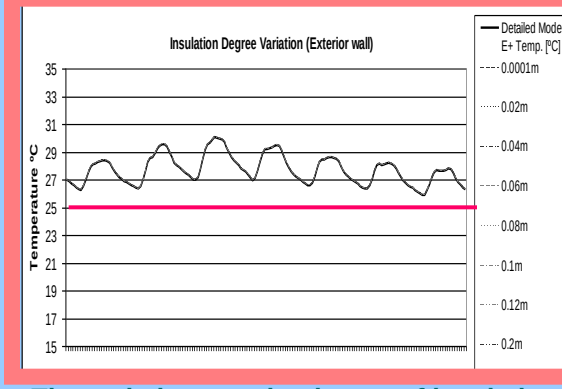
PARAMETRIC VARIATIONS: SUMMER



Double glass Variations: showed a potential to reduce the indoor temperature, 2ºC on average.

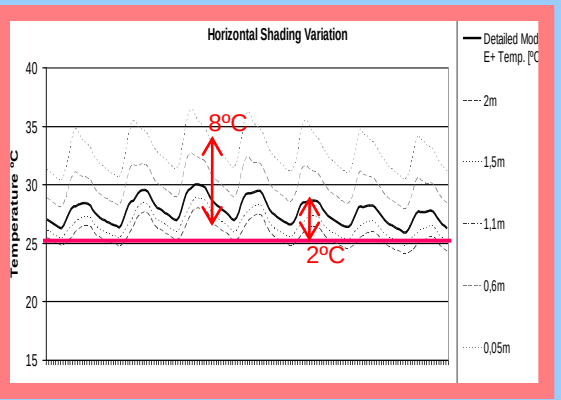


Air change per hour Variations (ACH): showed a great potential to reduce the indoor temperature, 4ºC on average.

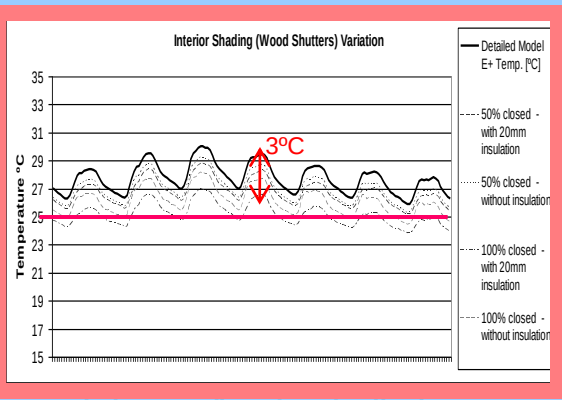


The variations on the degree of insulation (outside elements), and on the type of cloth wall (s. wall) had little influence on results.

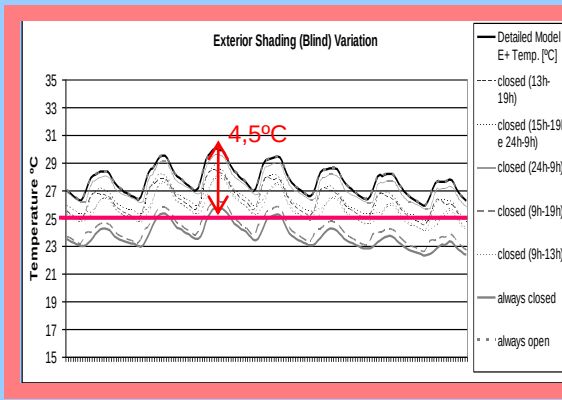
The charts demonstrates the importance of natural ventilation and the presence of sun protection devices near the windows to achieve a better thermal performance in housing units with characteristics similar to that adopted for this study.



Horizontal shading (Size of the width) Variations: showed the possibility to reduce temperatures by up to 8ºC on average,

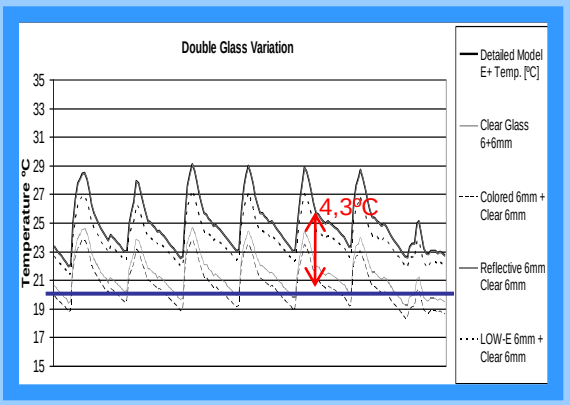


Wood shutters (interior shading) Variations: the possibility to reduce temperatures were between 1ºC and 3ºC,

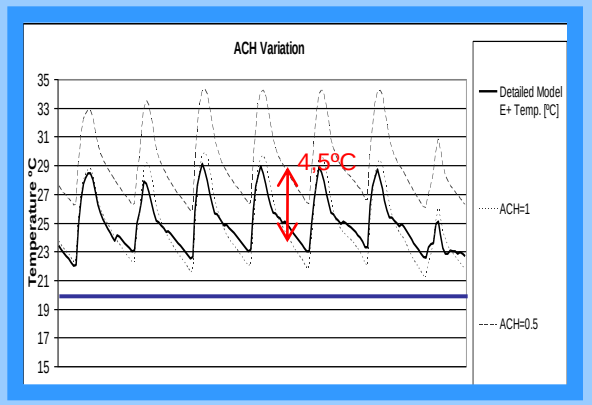


Exterior blinds (exterior shading) : the possibility to reduce temperatures were between 1.5 ºC and 4.5ºC.

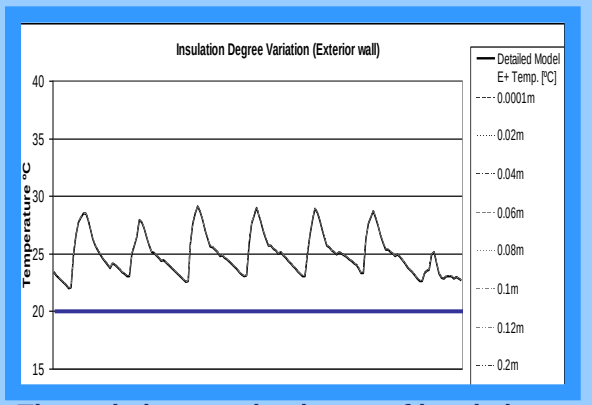
PARAMETRIC VARIATIONS: WINTER



Double glass Variations: The best glass solution for this season was the clear double glass (difference above 4ºC with coloured double glass)

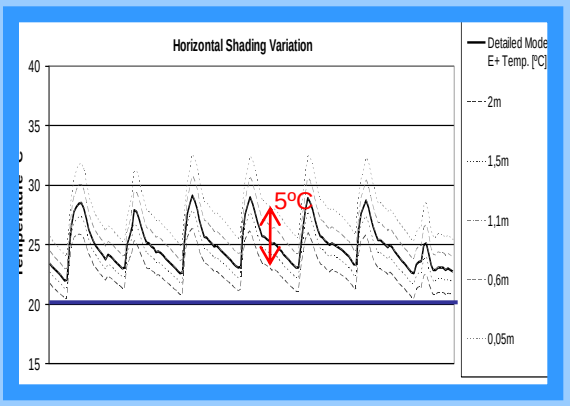


Air change per hour Variations (ACH): the difference between 0.5ACH and 1ACH in terms of temperature, can be of 4.5 ° C on average.

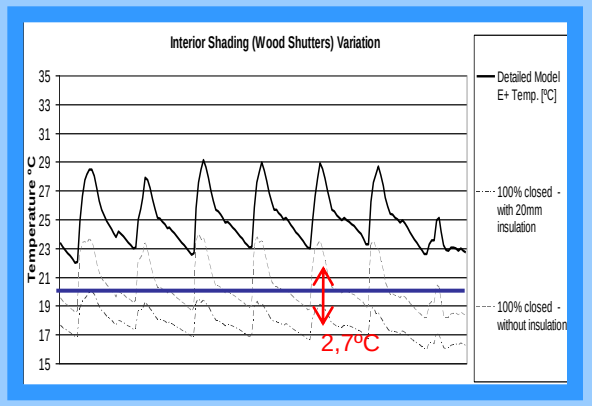


The variations on the degree of insulation (outside elements), and on the type of cloth wall (s. wall) had little influence on results.

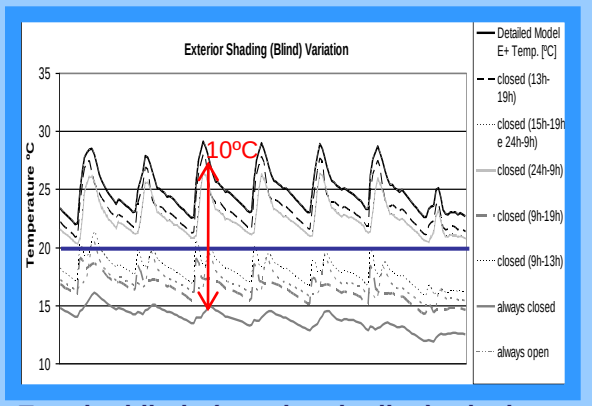
The charts demonstrates the importance of the solution type of glass as well as the influence of infiltration on the results



Horizontal shading (size of the width) Variations: Temperature varied on average 5ºC between the extreme solutions (2m and 0.05m).



Wood shutters (interior shading) Variations: Temperature varied on average 2.7ºC between the solutions with and without insulation.



Exterior blinds (exterior shading) : the best results was that considers the device closed between the 24h-9h (Night). The solution blind closed 24 hours showed temp. below the reference (Tsimulation) at 10ºC on average.

CONCLUSIONS

- This study showed the influence of various parameters on the thermal behaviour of housing units with large glazing areas.

- It was verified (within the range studied) that the interior temperatures ranged up to 8ºC in summer and 10 ºC in winter depending on the adopted solution.

- During the summer: the natural ventilation and the type of protection contributed significantly to a better thermal behaviour of the model in question.

- During the winter: the point of greatest care is the infiltration (reducing infiltration while maintaining levels of indoor air quality) as well as how to use the protection devices by the users (to provide better reception of solar radiation available).

- Thus, this study aims to help and alert the professionals to some solutions that can be adopted for buildings with large glazing areas in temperate climates.

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Thank You!

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