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A SOLAR PASSIVE HOUSE IN AN URBAN CONTEXT: SIMULATIONS

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ABSTRACT

In the frame of the task 13 of the International Energy Agency,we had to design an advanced solar low-energy residential building. We selected the urban location of Louvain-la -Neuve (Belgium). During the design process of the two pre-projects,simulations have been realized to help the architect to answer a few questions.

The following topies have been studied

-the location of the thermal inertia
-the impact of a greenhouse
-the constitution of the wall separating the living from the greenhouse
-the advantages of a ventilation with air extracted from the greenhouse
-the heating economy if the same house was placed in a well-oriented street
-the determination of the heating power in a well insulated house
-the overheating problems

1. Introduction

When an architect designs in an urban context, he has always to face strict rules imposed by the town planner. Indeed, the latter doesn't think about the restricting impact of the streets layout and of the impositions on the buildings themselves (such as outlines, alignment, roof slope, maximum height..) on a possible passive solar design.

In Louvain-la-Neuve, the urbanistic rules are numerous and very strict. Taking all those rules into account, we intended to establish pre-projects with an objective of passive solar design.

The house is a row house along a street running north-west to south-east. Thus, the street façade is north-east oriented and the garden side is south-west. The greenhouse could make the link between the livingroom and the garden.

Since the house will be build in the frame of the IEA-task 13, it must be an advanced solar low-energy residentiel building.

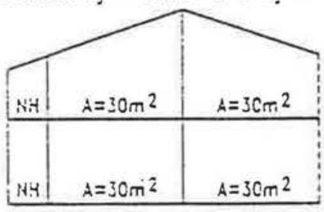
Simulations have been realized by the programs:

-LPB4 :a multizone static program
-MBDS :a multizone dynamic program
-SOLPA1:a unizone dynamic program adapted for greenhouse calculations.

2. Our approach to help the architect

2.1. At the beginning of our research we thought that the location of the inertia would have n importance because the house is a solar passive house (with the idea of direct heat storage) and a well insulated building.

To test this, we first simulated an imaginary house with an outline corresponding to those imp by the urbanistic rules. The imaginary house was ideal, protected by a non-heated space on the n east side and closed by windows only at the south-west side.



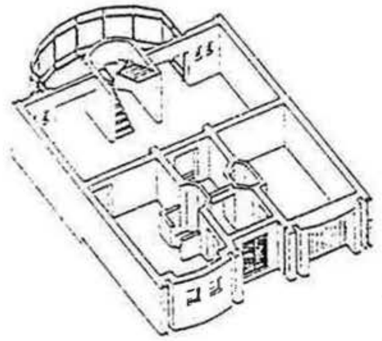
We then reached the following simulation results.

house without inertia	100%
house with inertia	89.4%
south inertia only	89.2%

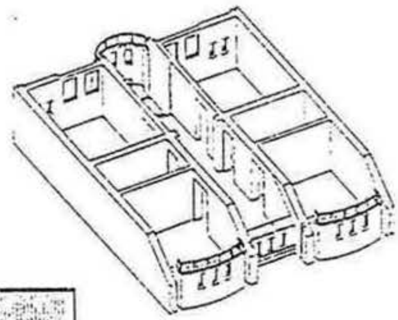
2.2. The second step took the following constraints into account:

- the strict urbanistic rules,
- the idea of a passive solar design,
- the necessity of a very well insulated house,
- the problematic of the location of the inertia,
- the outlines of the two adjoining not builded houses.

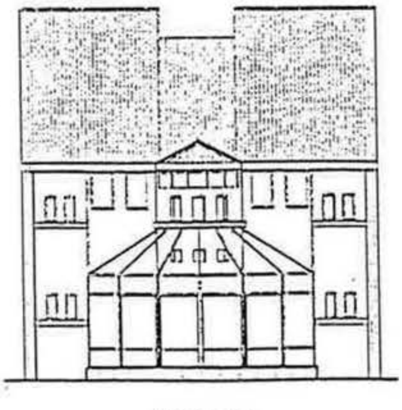
Two pre-projects were established, of which the second was the following one :



GROUND FLOOR



FIRST FLOOR



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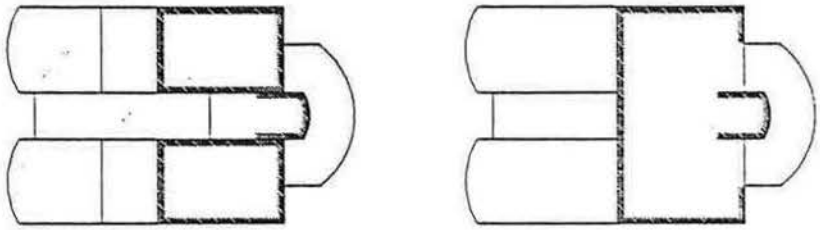
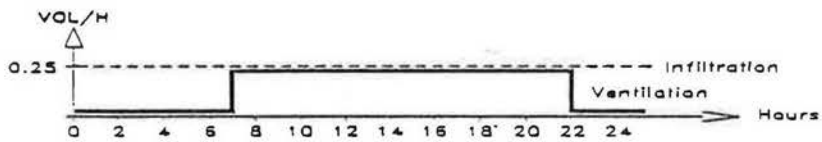
Real simulations could then begin.
The chosen assumptions are detailed here under :

- Constitution of the walls : well insulated
  Examples: opaque walls : 12 cm of insulation
  roof : 20 cm of insulation
  windows : k = 1.3 W/m2°C

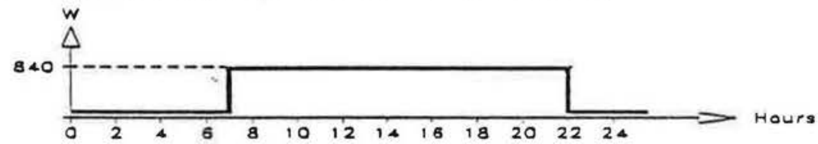
  But : wall between the living and the greenhouse : 20cm of bricks
- Position of the inertia



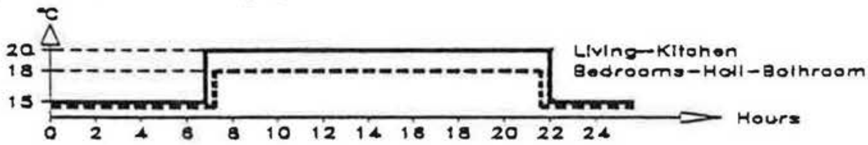
- Infiltration, ventilation



- Free gains for the whole house
  (for simulation needs, they are distributed in the rooms)



- Regulation of the heating system



Result of the simulation on that basic case :

3646 kWh or 22.8 kWh/m2 heated

The table below shows the great importance of the losses by infiltration and ventilation.

	infiltration and ventilation rate	consumption
	0.1	28%
	0.25	51%
basic case	0.5	100%
	1.0	198%

2.3. **Orientation** of the house.
If the house was oriented N-S, the consumption would only represent 91.5% of the basic case.

2.4. With or without sunspace ?

Assumptions : the wall living-sunspace which was an uninsulated storage wall (20cm bricks) replaced by an external insulated wall.

The results of simulation show that the consumption is decreased by about 10% when the greenhou is removed.

Why ???

-Because of the insulation of the wall living-sunspace.

-Because the window between the living and the sunspace is a very good window and t external windows of the sunspace is only single glazed.

-Because the solar radiation is filtered by the second layer of glass of the greenhouse.

In this basic case, the advantages of the greenhouse were not used very well. We then decided to r new simulations with new hypothesis :

-the wall living-sunspace is insulated

-the ventilation of the living (O.25 vol/h between 7h and 22h) is provided by the air of the sunspac

The gains obtained were

12% as compared with the basic case

3% as compared with the case without sunspace.

The energetic gain provided by the sunspace still remains low because of :

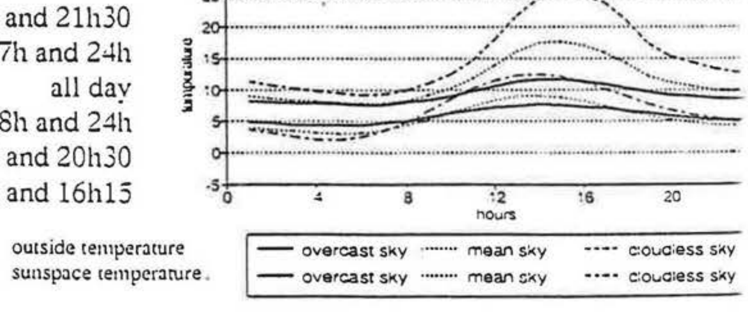
-the very good window between the living and the sunspace

-the filtration of the solar radiation.

But the sunspace can't only be seen as an element providing energetic gain : it provides a freely heat space during many months in the year. It is also a privileged space for the senses through the surfa aspects, the variations of the light, the transparencies, the presence and the odors of the plants, a the physic sensation of the outdoor climate.

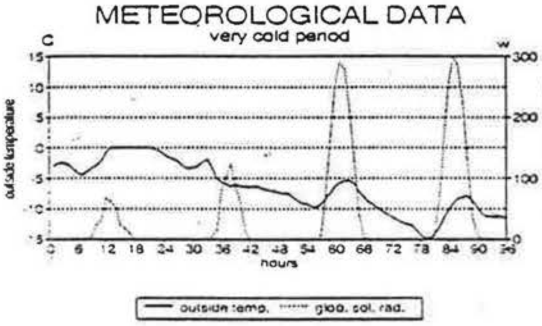
When the sky is clear, the comfort temperature (20°C) is reached in the sunspace during the followi periods :

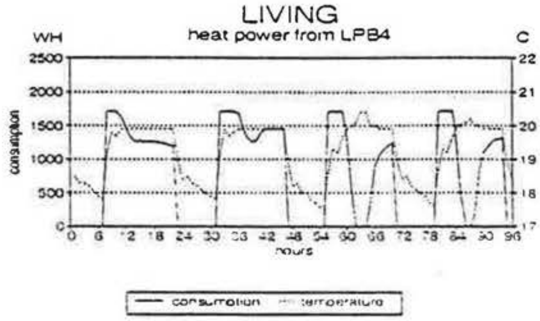
March:	between 12h30 and 18h
April:	between 10h and 21h30
May:	between 07h and 24h
June, July, August:	all day
September:	between 08h and 24h
October:	between 12h30 and 20h30
November:	between 14h and 16h15



The graph above shows the greenhouse temperature evolution during the month of March for thr different sky conditions (overcast, mean and cloudless).

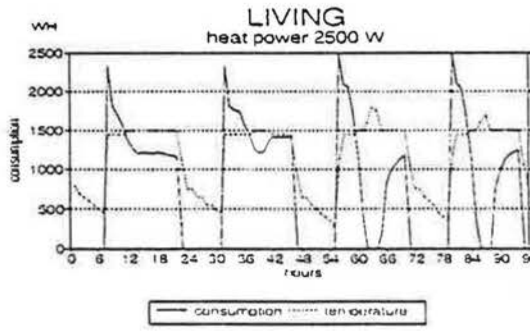
2.5. **Problematic of the heat power determination in a solar low-energy house with inertia.**
Usualy heat power determination in the various zones of a building is calculated using a multizone static program.
So, in MBDS, we used the heat power calculated by the LPB4 program to study the response of the heating system during a cold period.
The chosen period (15/1 - 18/1) includes sunny and clouded cold days. Simulations are made without the sunspace.
The climatic data and the graph wich gives the evolution of the temperature and the heat demand in the livingroom (south zone with inertia) are represented here below. It allows us to see that four hours are needed to reach the desired temperature.
It also shows that the heating system can be stopped during one or two hours in spite of very low outside temperature (-7°C, -8°C) and that thanks to the sun.





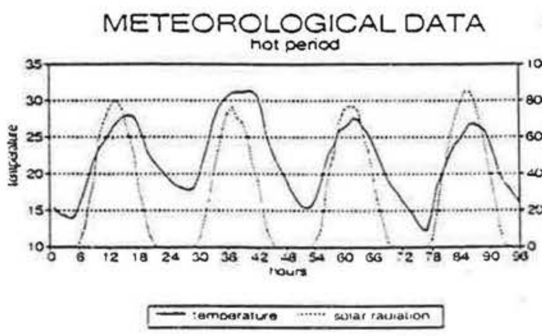
If the heating system is stopped during four days,the living temperature don't decrease under 14°C.But **36 hours** are needed to reach the chosen temperatures.

When the heating power is increased by about 50%, the wished temperature is reached immediately.



2.6. **Overheatings.**

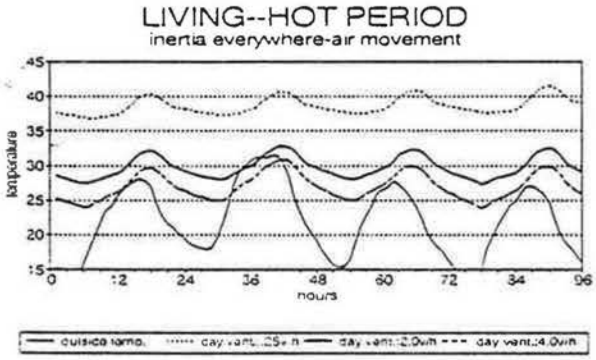
We have then examined a very hot period to try to solve the overheating problems.The simulations are made without the sunspace.The chosen climatic data are represented here below.

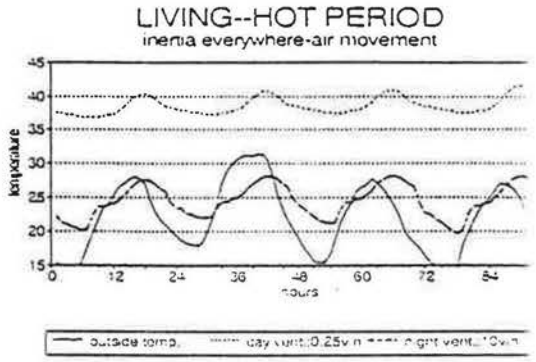


We have analyzed what would hapen if inertia was placed only in south zones or in the whole h
and if air movement was created between south and north zones.

Results: When inertia is placed in the whole house, temperature decreases by about 2.5°C in the s
zones and 4.0°C in the north zones
When air movement is created, temperature still decreases by about 1°C in the south z
and increases by about 1°C in the north zones.

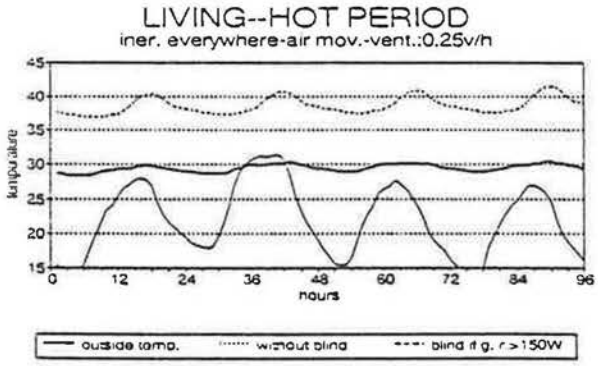
We have then examined the influence of an increase in the ventilation rate during the day and du
the night (air movement maintained).

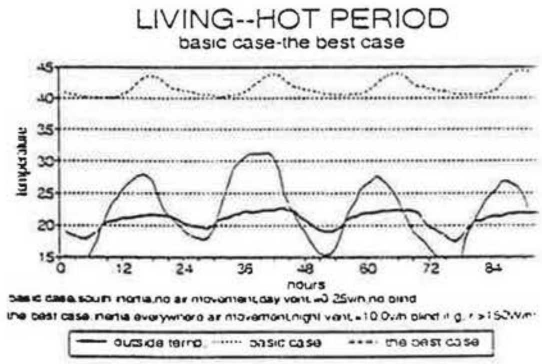




The use of blinds when solar radiation penetrating by the windows is greater than 150 W/m2 is also effective (air movement maintained)

The graphs below compare the basic case
the case using all strategies.





3. Conclusions

The simulations have shown that

-the inertia located in the south zones decreases the energetic consumption

-the inertia located in the north zones decreases the overheatings

-the energetic gain given by the sunspace is low but it provides a freely heated space during m
months in the year

-the heat power determined by static program is underestimated

-overheatings are decreased by placing inertia in the whole house, by creating air movement betw
south and north zones, by increasing the ventilation rate and mainly during the night, by u
blinds.