CoDyBA

Real Size Parametric Tests

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Abstract

The present report describes the results obtained with CoDyBa software in the case of two buildings of different size.

CoDyBa is a software used to determinate the heat flows in a building. CoDyBa is specially oriented toward optimisation of energy performance in buildings.

In order to test this software in cases where the building has a great number of rooms, two cases are examined. The geometries concern a traditional house and a large office building.

The data of the house are quite representative of the treated case. The data of the office building are voluntarily simplified to facilitate the interpretation of the results.

Detailed results are monthly heating and cooling loads, peaks of heating and cooling loads. Those results are usually present in reference tests (BESTEST [BR]).

The parametric data are the orientation of the geometry and the weather (data of 10 cities in France are used).

Classical results are found in the case of heating (correlation between heating energy and number of heating degrees-day). For cooling energy, it is shown that more examination must be carry out, because the importance of the position of the building. Results are presented, which show that CoDyBa gives classical results.

Acknowledgements

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I - Introduction

I - 1 - What CoDyBa is

CoDyBa [CDB] is a software, developed by a freelance engineer [JNL] with the help of some researchers of CETHIL (INSA-Lyon Thermal Center, [CET]), without any state help. This software is aimed for design offices, teaching and research organisms.

CoDyBa is a software used to determinate the heat flows in a building. It permits to estimate the instant heating or cooling powers needed to maintain a given set point, or to calculate the interior temperatures when the heating or cooling system is insufficient. Humidity is treated in the same way.

The tool is aimed to conduct studies of heating and cooling strategy, air conditioning or ventilation options, insulating materials to be installed. The room occupancy is included. CoDyBa does not permit the study of the dynamic behaviour of a set of technological components : the main objective is to forecast the energy consumption and temperature evolution range.

CoDyBa runs on classical PC. The building is described accurately and the building description is given by the use of a graphical interface. CoDyBa is based on simply bricks assembled to form a complex building with its equipment. The assembly is conducted in a way to minimise data size and calculation time. The physical models of CodyBa are those commonly admitted, but numerical algorithms are specific.

CoDyBa passes successfully the benchmark BESTEST [BR], developed by the International Agency of Energy. This benchmark is the most precise and most reliable which currently exists. Thus CoDyBa can simulate the performances of the 155 geometries of the benchmark, and in almost all the cases is in agreement with the results of the reference programs.

Calculations of this report have been made using the version V641b of CoDyBa.

I - 2 - Cases description

The calculation cases presented in this report are intended to show the capacity of calculation of CoDyBa in large real configurations.

The two treated cases correspond to a traditional house and to an office building.

The traditional house is a small house with only one level.

The office building includes 7 floors of 10 offices each one. It is voluntarily simplified to comprise the minimum of data. Its symmetrical form is intended to allow the validation of CoDyBa in cases where one can compare the software with itself.

For each configuration, two types of results are presented :

1. The first one consists in rotating the building by step of 30°, in order to study the sun influence.
2. The other consists in passing the same calculation case with different climates and to relate the results with characteristics from the climates (degrees-day for the results of heating and the average solar fluxes for air-conditioning).

The office building is named "**buro**" and the traditional house "**jaspe**" in the examples provided with the CoDyBa package.

II - Cases data

II - 1 - Weather data

The weather data used are those of 10 cities of France. Their characteristics are summarized in the next tables. Note that for the data over the year, the degrees-day are given for the whole year, and not on a certain number of months.

City	Latitude	Dry-bulb temperature (°C)			Heating degrees day	Horizontal solar radiation (W/m²)		
		Min	Max	Mean	(base 18 °C)	Direct	Diffuse	Total
Agen	44°2	-6,0	35,3	12,0	2526	649	576	1226
Ajaccio	41°55'	-3,9	33,5	14,4	1753	926	553	1480
Carpentras	44°05'	-5,3	35,6	12,9	2331	922	572	1494
LaRochelle	46°09'	-4,6	29,8	12,3	2295	730	540	1270
Limoges	45°85	-5,5	32,0	10,3	2990	609	549	1158
Macon	46°3	-10,1	32,1	10,6	2963	630	557	1187
Millau	44°1	-12,9	31,3	10,2	3038	755	508	1263
Nancy	48°68	-8,1	31,9	9,4	3295	517	562	1079
Rennes	48°04	-4,2	29,5	10,5	2852	545	596	1142
Trappes	48°46	-6,5	33,7	10,0	3091	442	626	1068

Table T1 : weather data over the year for ten French cities

City	Dry-bulb temperature (°C)			Heating degrees day	Horizontal solar radiation (W/m²)		
	Min	Max	Mean	(base 18 °C)	Direct	Diffuse	Total
Agen	-3,1	17	6,4	325	23	28	51
Ajaccio	-0,4	18,1	9,09	250	41	30	71
Carpentras	-1,8	17,1	7,18	303	32	29	61
LaRochelle	-2,7	17,6	7,23	301	22	25	47
Limoges	-3,7	14,9	4,19	387	18	25	43
Macon	-6,1	13,7	3,64	402	10	29	40
Millau	-3,4	14,9	4,44	379	24	24	47
Nancy	-7	8,2	1,64	458	19	26	44
Rennes	-3,8	10,4	4,28	384	18	27	45
Trappes	-4,9	13,5	3,77	398	9,7	25	35

Table T2 : weather data over February for ten French cities

City	Dry-bulb temperature (°C)			Heating degrees day	Horizontal solar radiation (W/m²)		
	Min	Max	Mean	(base 18 °C)	Direct	Diffuse	Total
Agen	7	35,3	19,4	45	103	77	180
Ajaccio	12,1	33,5	21,3	14	145	67	213
Carpentras	11,2	35,6	21,5	25	155	63	218
LaRochelle	11,5	29,8	19	28	117	73	189
Limoges	8,7	30	16,7	83	83	75	158
Macon	9,9	32,1	19	43	115	69	184
Millau	10	29,8	19,3	38	125	66	191
Nancy	6,7	28,8	17,7	62	79	81	160
Rennes	5,9	29,5	17,5	65	88	78	166
Trappes	8,4	28,4	17,5	63	66	91	157

Table T3 : weather data over July for ten French cities

The degrees-day are calculated according to an 'integral' method.

The following general data are used for all the cities :

Wind speed	0 m/s
Ground reflectivity	0,2

Table T4 : general cities data

II - 2 - Materials

Properties of used materials are detailed in Table T5.

Materials	Conductivity (W/m²/K)	Density (kg/m^3)	Specific heat (J/kg.°C)	Absorption (---)	Transmission (---)
Air	0,026	1,2	1007	--	--
Plasterboard	0,25	825	1000	--	--
Concrete	2	2450	1000	--	--
Wood	0,2	750	1600	--	--
Curved tile	0,7	1700	1000	--	--
Masonry	0,7	1300	800	--	--
Cladding	1,75	1000	600	--	--
Wall Insulation	0,04	100	900	--	--
Ceiling Insulation	0,04	100	900	--	--
Floor Insulation	0,04	100	900	--	--
Glass	1,15	2700	840	0,08	0,85

Table T5 : materials summary

II - 3 - Surface convective thermal exchange coefficients

The surface convective thermal exchange coefficients used in CoDyBa are detailed in Table T6 :

Surface	Surface convective coefficients (W/m².K)		Emissivity (---)	Absorptivity (---)
	Exterior	**Interior**	**Interior / Exterior**	**Interior / Exterior**
Roof	20,5	5,5	0,9	0,6
Vertical	20,5	3,19		
Floor	20,5	1,38		

Table T6 : convective thermal exchange coefficients

The glass exterior and interior convective surface coefficients are supposed as the same as walls.

The floor in contact with the ground has a null flow boundary condition.

II - 4 - Mechanical systems

Following conditions are used :

- There are no internally generated sources of heat (no equipment, no light, no people).
- There is no ventilation (excepted for one specific case) nor infiltration.
- The buildings are empty (no furniture).
- The set point of the heating system is fixed at 18 °C, at 27 °C for the cooling system.

Ventilation is only considered for the isolated office building, in order to compare the effects of night ventilation and shading devices.

II - 5 - Calculation data

The number of initialization days is 20 for all the calculation cases.

The time step is hourly.

III - Traditional house

III - 1 - Data

III - 1 - 1 - Geometry

The geometry of the traditional house is :

Figure F1 : general view of the traditional house

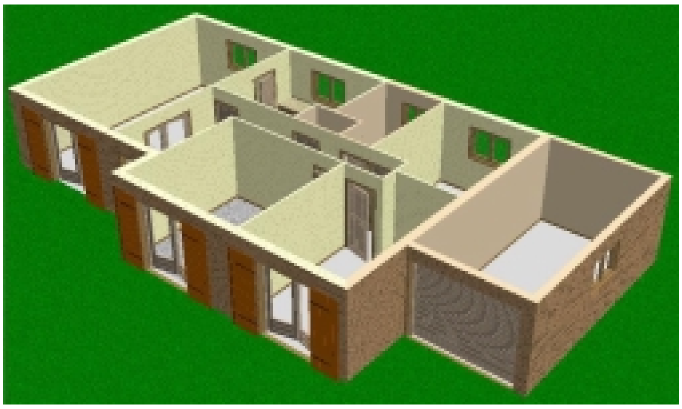


Figure F2 : internal view of the traditional house

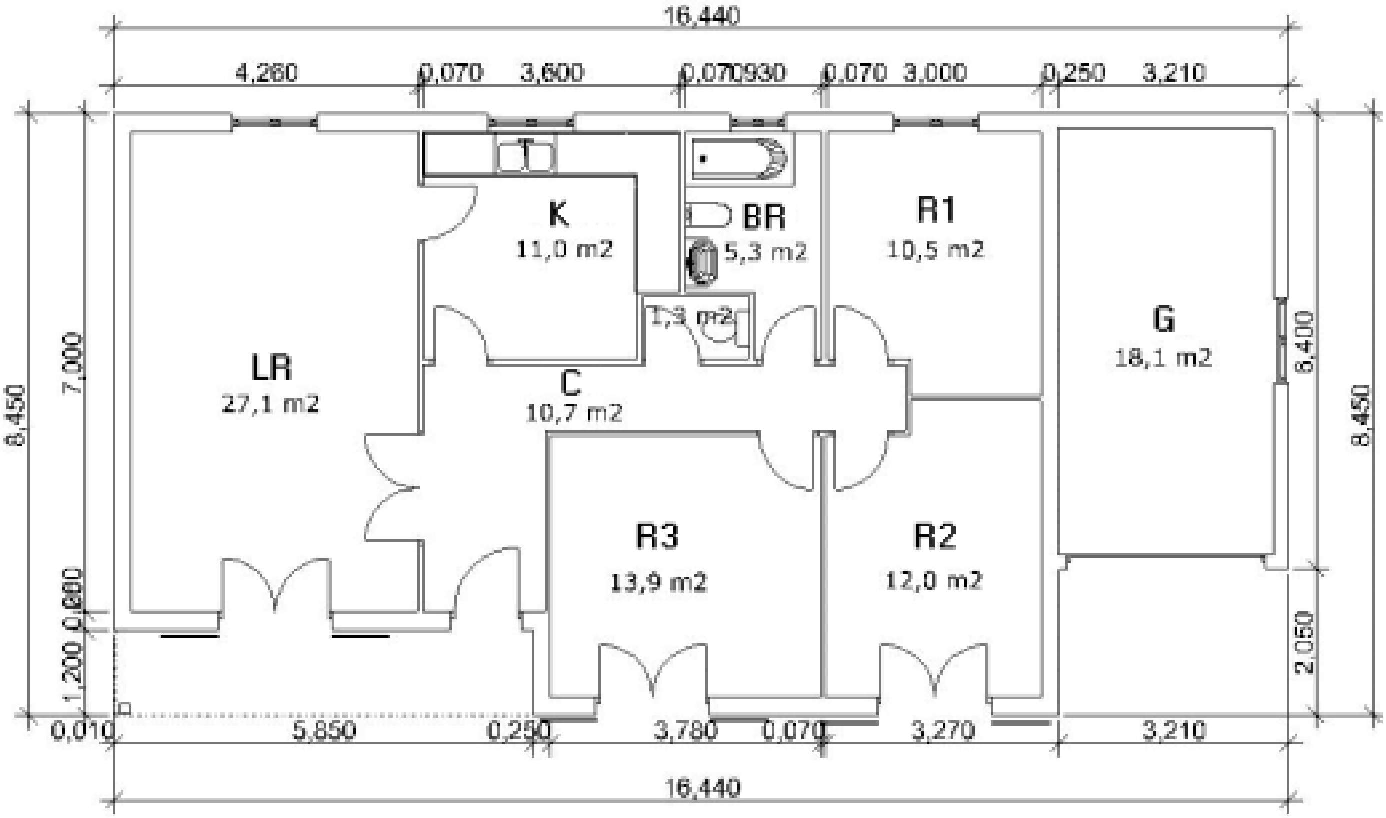


Figure F3 : drawing of the traditional house

LR : living room - **K** : kitchen - **R1,2,3** : rooms - **BR** : bathroom - **G** : garage

The projection of the roof is taken into account by the mean of masks associated with the windows.

III - 1 - 2 - Walls and doors

The next table summarises the elements of surfaces, from inside to outside :

Surface	Material	Thickness (mm)
Internal wall	Plasterboard	13
	Wall insulation	40
	Plasterboard	13
External wall	Plasterboard	13
	Wall insulation	80
	Masonry	150
	Cladding	10
Roof	Curved tile	20
Floor	Concrete	200
	Floor Insulation (1)	80
Ceiling	Plasterboard	13
	Ceiling Insulation	160
Indoor/ Outdoor doors	Wood	40
Garage door		

Table T7 : walls summary

(1) The floor has a null flow boundary condition (under the insulation of the floor).

III - 1 - 3 - Windows

General data of the windows are presented in Table T8 :

Number of panes	2
Pane thickness	3 mm
Air-gap thickness	12 mm
Glass ratio	77 %
U-Value from interior air to ambient air	2,55 W/m².K

Table T8 : general window data

The next table summarizes the data of windows used in the presented case :

	Largeur	Hauteur	Profondeur (1)
Small window (BR)	0,75	0,75	0,05
Large window (LR, R1, K)	1,2	0,9	0,05
French window (R2 & 3, LR)	1,5	2	0,05

Table T9 : window sizes summary

(1) The depth is the distance between the external surface of the pane and the external surface of the wall.

The projection of the roof is taken into account by the mean of masks associated with the windows. The horizontal roof overhang for the south (north) facing windows is assumed to travel the entire length of the south (north) wall.

In this version of the report, the shutters which one can see on the drawing (figure F3) are regarded as always open.

III - 1 - 4 - Mechanical systems

The roofs and the garage are ventilated to 1/2 ACH. All the rooms are heated in the same way, except the roofs and the garage, which are not heated.

This house has a heating whose set point is fixed at 18 °C. There is no air-conditioning.

III - 1 - 5 - Count of the elements present in the traditional house

Elements	Count
Air volumes	10
External ceilings	4
External floors	9
External walls and doors	16
Windows	8
Internal floors	0
Internal walls and doors	24
Heaters	8
Coolers	0

Table T10 : count of various elements present in the traditional house

III - 2 - Results

III - 2 - 1 - Geometry rotation

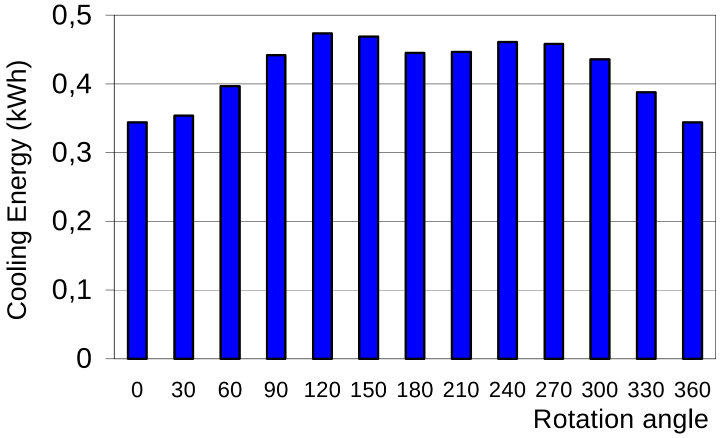
The building is rotated by step of 30°. The weather is that of the city of Carpentras, and the month considered is that of February.

Geometry Rotation Angle	February - Heating	
	Energy (kWh)	Max Power (kW)
0	0,344	0,494
30	0,354	0,493
60	0,397	0,496
90	0,442	0,501
120	0,474	0,504
150	0,469	0,505
180	0,445	0,503
210	0,447	0,502
240	0,461	0,503
270	0,458	0,504
300	0,436	0,503
330	0,388	0,5
360	0,344	0,494

Table T11 : results of the rotation of the traditional house during February in Carpentras

The results obtained by a rotation of the building are presented on the figure R1.

Fig. R1 : influence on the heating of the rotation of the traditional house during February in Carpentras



It can be noted that the rotation of the building has only little influence on the energy of heating (+/- 16 %).

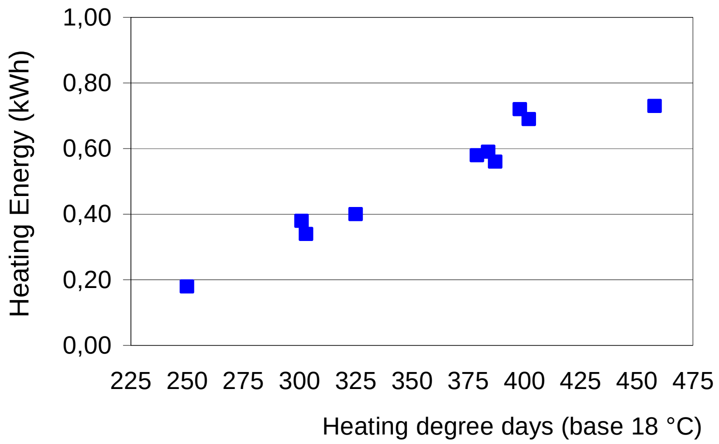
III - 2 - 2 - Weather influence

City	February - Heating			
	Results		Weather Data	
	Energy (kWh)	**Max Power** (kW)	**HDD18** (---)	**HSF** (W/m²)
Agen	0,40	0,46	*325*	*51*
Ajaccio	0,18	0,32	*250*	*71*
Carpentras	0,34	0,49	*303*	*61*
LaRochelle	0,38	0,53	*301*	*47*
Limoges	0,56	0,49	*387*	*43*
Macon	0,69	0,61	*402*	*40*
Millau	0,58	0,52	*379*	*47*
Nancy	0,73	0,59	*458*	*44*
Rennes	0,59	0,53	*384*	*45*
Trappes	0,72	0,64	*398*	*35*

Table T12 : results of various climates on the traditional house for February

HDD18 : Heating Degrees Day (base 18 °C)
HSF : Mean Horizontal Solar Fluxes

Fig. R2 : energies of heating during February related to the number of degrees-day for the traditional house



One observes good agreement between the number of degrees-day and the heating energy.

IV - Office building

IV - 1 - Data

IV - 1 - 1 - Geometry

The geometry corresponds to an office building with 7 floors.

Each stage includes 10 offices, 5 per face of the building. A corridor separates the offices.

The stairwells are located at the ends of the building. They are separated from the corridors by a double swing door.

The building has a symmetry such as a rotation of 180° makes it identical to itself. This symmetry is desired for tests where one compares the building with itself : a result obtained for a rotation angle of θ+180° must be identical to a result obtained for an angle θ.

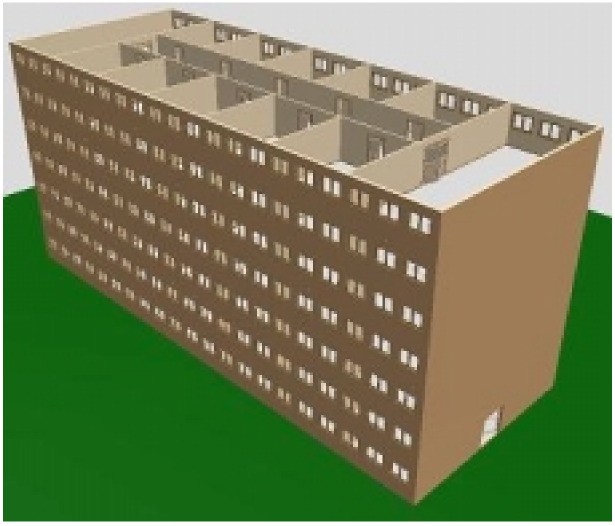


Figure F4 : general view of the office building

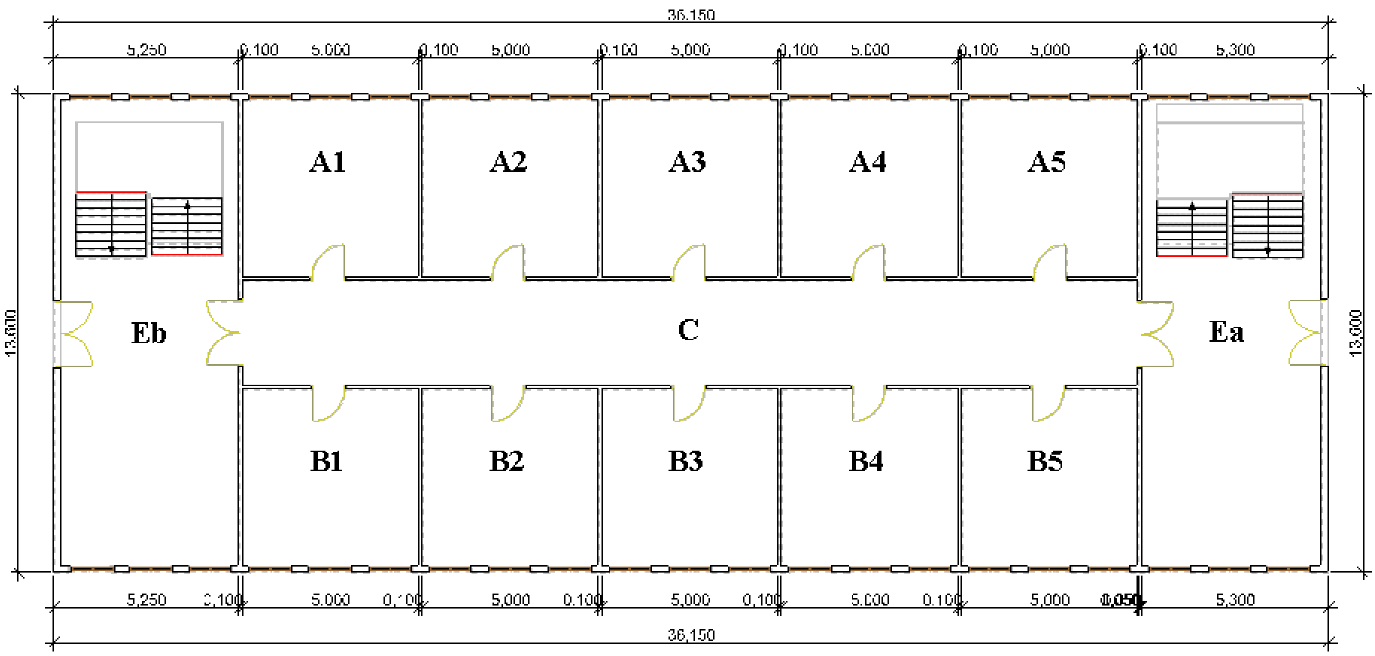


Table T13 : drawing of the office building

Height of each stage	2,5 m
Corridor surfaces	3x25 m²
Office surface (A1-5/B1-5)	5x5 m²
Surface of a staircase stage	5x13 m²
Door surface	0,9x2 m (1 battant) ou 2x0,9x2 m (2 battants)

Table T14 : office building dimensions

To simplify inputs, one neglects the walls thicknesses for the areas of walls and floors.

IV - 1 - 2 - Walls and doors

Surface	Material	Thickness (mm)	Surface (mm)
Internal wall (between offices)	Plasterboard	50	
External walls (staircase, external offices walls)	Concrete	100	
Floor, Ceiling	Concrete	200	
Internal door	Wood	40	1,8 (single swing)
External door	Wood	40	3,6 (double swing)

Table T15 : walls summary

Not insulated building : all the walls in contact with outside are given in Table T15.

Insulated building : all the walls in contact with outside comprise an additional layer of 8 cm insulation (on the internal face). That relates to all the external vertical walls, as well as the ceiling of the last stage.

The floor of the first level has a null flow boundary condition.

The stairwells are supposed to form each one only one thermal zone. The external doors and the doors separating the corridor from the staircase are with double swing. Each swing has the characteristics of an office door. All the doors are closed permanently.

IV - 1 - 3 - Windows

IV - 1 - 3 - 1 - Glasses and frame

General data of the windows are presented in Table T16 :

Number of panes	2
Pane thickness	3 mm
Air-gap thickness	13 mm
Glass ratio	66 %
U-Value from interior air to ambient air	3 W/m².K

Table T16 : general window data

The next table summarizes the data of windows used in the presented case :

	Largeur	Hauteur	Profondeur (1)
Window	1,2	0,9	0

Table T17 : window sizes summary

(1) The depth is the distance between the external surface of the pane and the external surface of the wall.

IV - 1 - 3 - 2 - Shading devices

For the building with shading devices, all the windows are protected with a venetian blind (offices and staircases). Slats data of the venetian blind are summarized in Table T18 :

Slats Data		Values
Absorption	α	0,67 (--)
Reflection	ρ	0,33 (--)
Transmission	τ	0 (--)
Emissivity	ε	0,9 (--)
Width	W	28 mm
Spacing	P	22 mm

Table T18 : slats data of the venetian blind

Three cases are considered : internal, integrated or external blinds.

The definition of the angle of the slats is clarified on the figure F5.

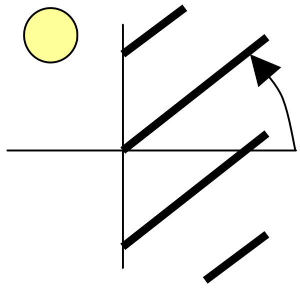


Figure F5 : definition of the slats angle

IV - 1 - 4 - Mechanical systems

In each office are a heating (set point 18 °C, activity during February only) and an air-conditioning (set point with 27 °C, activity during July only). The air-conditioning and heating systems are active all the time. The two staircases neither are air-conditioned, nor heated.

There is no ventilation.

Ventilation acts only in the insulated office building : each office receives 250 m^3/h drawn from outside (either 4 ACH) and an equivalent flow towards the corridor ensures mass balance. Then a flow of 5*250 m^3/h of the corridors towards the staircase ensures mass balance again, while a flow of 7*5*250 m^3/h is rejected from staircases towards outside. Ventilation is in service from 0 to 6 am (night ventilation).

IV - 1 - 5 - Count of the elements present in the office building

Elements	Count
Air volumes	79
External ceilings	13
External floors	13
External walls and doors	114
Windows	98
Internal floors	66
Internal walls and doors	252
Heaters	70
Coolers	70

Table T19 : count of various elements present in the office building

In the case of the building with night ventilation, it is necessary to add 105 objects of ventilation ("pressure regulators").

IV - 2 - Results for the non isolated office building

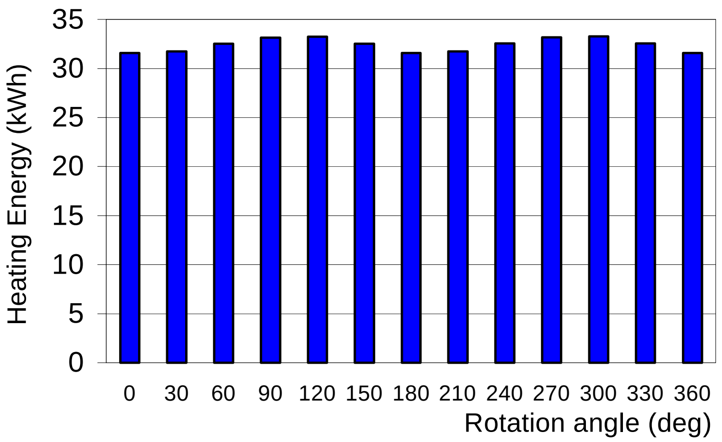
IV - 2 - 1 - Geometry rotation

The building is rotated by step of 30°. The weather is that of the city of Carpentras, and the months considered are those of February and July.

Building Rotation Angle	February - Heating		July - Cooling	
	Energy (kWh)	Max Power (kW)	Energy (kWh)	Max Power (kW)
0	31,58	2,57	7,59	1,80
30	31,74	2,58	8,98	1,93
60	32,54	2,58	11,74	2,07
90	33,17	2,58	12,79	2,09
120	33,27	2,58	11,99	2,02
150	32,55	2,58	9,60	1,85
180	31,57	2,57	7,61	1,80
210	31,74	2,57	8,98	1,94
240	32,57	2,57	11,74	2,08
270	33,20	2,56	12,77	2,10
300	33,30	2,57	11,97	2,03
330	32,57	2,57	9,58	1,86
360	31,58	2,57	7,59	1,80

Table T20 : results of the rotation of the not insulated building for February and July in Carpentras

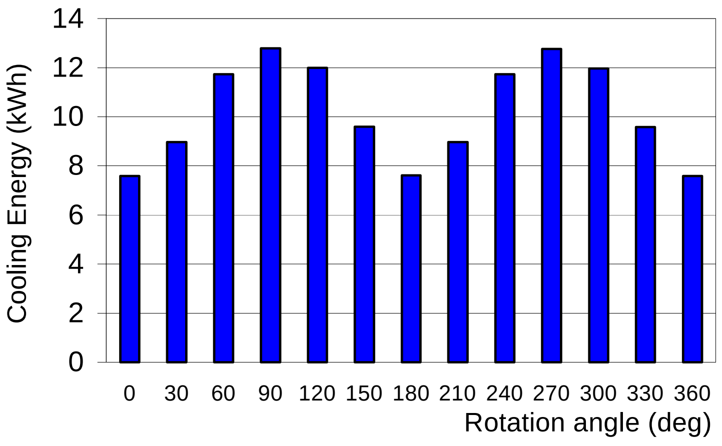
Fig. R3 : influence on the heating of the rotation of the not insulated building during February in Carpentras



One observes the similarity of the results (result(θ+180°) = result(θ)).

It can be noted that the rotation of the building has only little influence on the energy of heating (+/- 3 %).

Fig. R4 : influence on the cooling energy of the rotation of the not insulated building during July in Carpentras



One observes the similarity of the results (result(θ+180°) = result(θ)).

One observes the very important influence of the building orientation on the cooling energy (+/- 26 %).

IV - 2 - 2 - Weather influence

City	February - Heating				July - Cooling			
	Results		Weather Data		Results		Weather Data	
	Energy (kWh)	Max Power (kW)	HDD18 (---)	HSF (W/m²)	Energy (kWh)	Max Power (kW)	Avr Temp. (°C)	HSF (W/m²)
Agen	34,20	2,58	*325*	*51*	1,95	1,53	*19,4*	*180*
Ajaccio	22,94	1,99	*250*	*71*	2,45	1,01	*21,3*	*213*
Carpentras	31,60	2,57	*303*	*61*	7,59	1,80	*21,5*	*218*
LaRochelle	32,42	2,86	*301*	*47*	0,65	1,05	*19*	*189*
Limoges	42,22	2,88	*387*	*43*	0,29	0,80	*16,7*	*158*
Macon	47,32	3,18	*402*	*40*	1,98	1,58	*19*	*184*
Millau	41,96	2,76	*379*	*47*	1,84	1,23	*19,3*	*191*
Nancy	52,78	3,39	*458*	*44*	0,97	1,12	*17,7*	*160*
Rennes	43,61	3,02	*384*	*45*	0,41	1,01	*17,5*	*166*
Trappes	48,11	3,29	*398*	*35*	0,76	1,06	*17,5*	*157*

Table T21 : results of various climates on the not insulated building during July and February

HDD18 : Heating Degrees-Day (base 18 °C)
HSF : Mean Horizontal Solar fluxes

Fig. R5 : energies of heating in February related to the number of degrees-day for the not insulated building

One observes good agreement between the number of degrees-day and the heating energy.

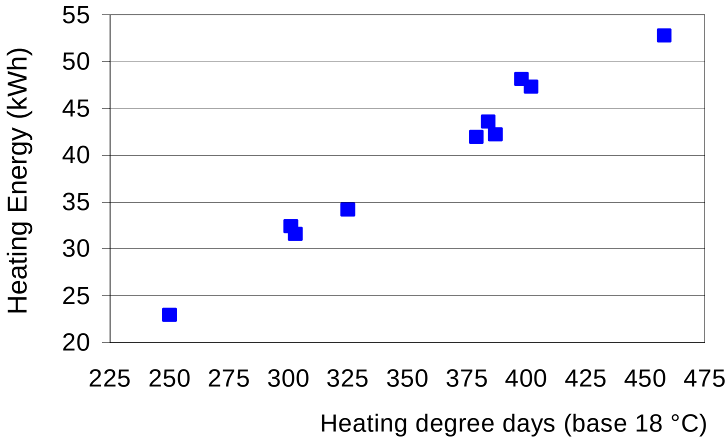
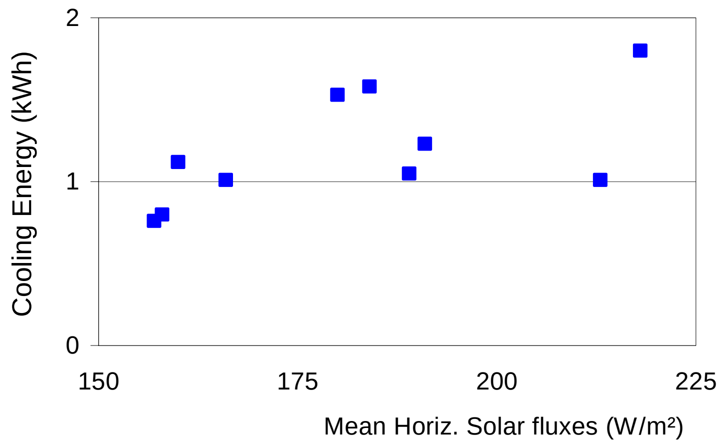


Fig. R6 : cooling energies during July related to the mean solar fluxes for the non insulated building

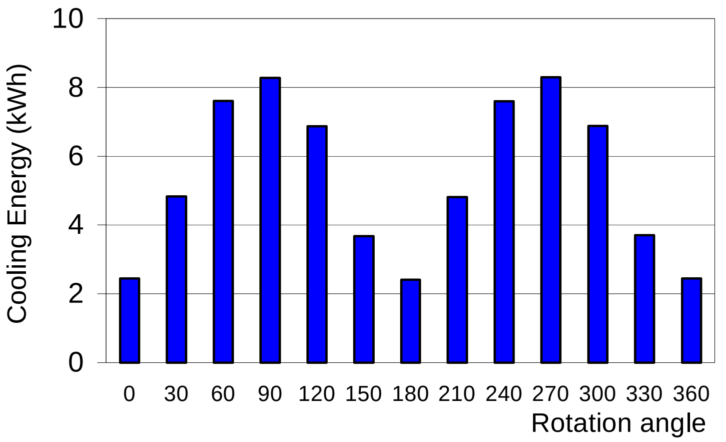
One notes the lack of obvious correlation.

Moreover, one observes an anomaly between the two points on the right of the layout (cities of Ajaccio and Carpentras) : cooling energies are very different whereas average solar flows are equivalent.



IV - 2 - 3 - Comparison between Carpentras and Ajaccio for cooling in July

Fig. R7 : influence on the cooling of the rotation of the not insulated office building during July in Ajaccio



One observes the similarity of the results (result(θ+180°) = result(θ)).

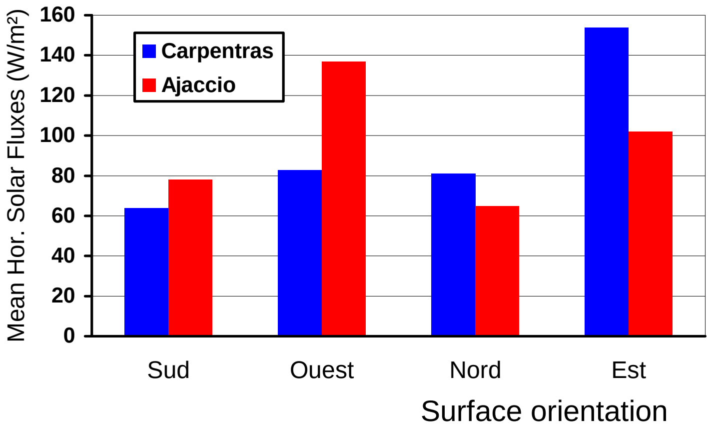
One observes the very important influence of the building orientation on the cooling energy (+/- 54 %).

The weather of the city of Ajaccio is not very different from that of Carpentras during July. Indeed, the same average temperatures and same horizontal solar flows are observed (see Table T3).

One observes despite everything a strong difference in cooling energy.

The observed difference between the cooling energy in Ajaccio and Carpentras is explained by the different distribution of solar flows during the day. The figure R8 gives the distribution of average solar fluxes during the day on differently directed surfaces (July).

Fig. R8 : received total solar fluxes by surfaces for the cities of Ajaccio and Carpentras



A dissymmetry of the distributions clearly is noted. The fact that for Carpentras the sun acts as of the morning led to higher temperatures, and thus with a more important air-conditioning.

IV - 3 - Results for the isolated office building

IV - 3 - 1 - Geometry rotation

The building is rotated by step of 30°. The weather is that of the city of Carpentras, and the month considered is those of February and July.

Building Rotation Angle	February - Heating		July - Cooling	
	Energy (kWh)	Max Power (kW)	Energy (kWh)	Max Power (kW)
0	7,34	0,671	7,07	0,68
30	7,47	0,671	8,60	0,83
60	8,03	0,672	11,59	0,96
90	8,41	0,674	12,83	1,02
120	8,48	0,674	12,00	0,96
150	7,98	0,674	9,41	0,78
180	7,34	0,672	7,07	0,68
210	7,47	0,671	8,60	0,83
240	8,02	0,672	11,59	0,97
270	8,41	0,673	12,84	1,03
300	8,47	0,673	11,99	0,97
330	7,98	0,673	9,41	0,79
360	7,34	0,671	7,07	0,68

Table T22 : results of the rotation of the insulated building during February and July in Carpentras

Fig. R9 : influence on the heating of the rotation of the not insulated building during February in Carpentras

It can be noted that the building rotation has only little influence on the energy of heating.

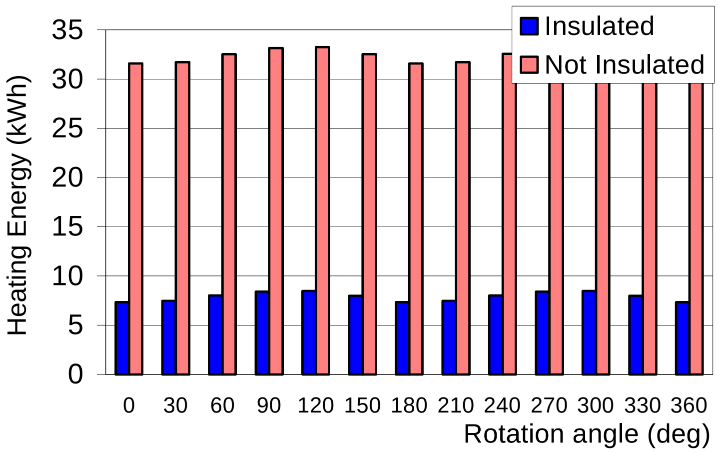
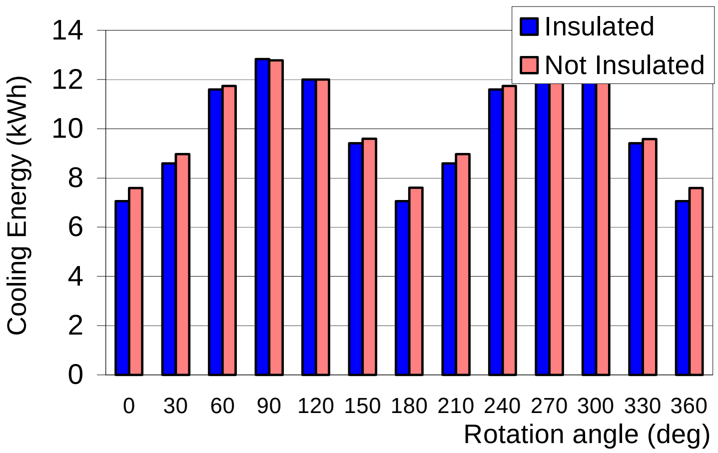


Fig. R10 : influence on the cooling of the rotation of the not insulated building during July in Carpentras

One observes the similarity of the results (result(θ+180°) = result(θ)).

It can be noted that the insulation has only little influence on the energy of cooling.



IV - 3 - 2 - Weather influence

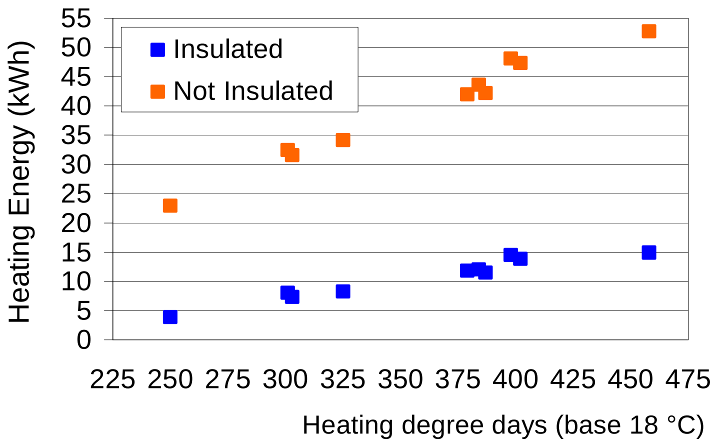
City	February - Heating				July - Cooling			
	Results		Weather Data		Results		Weather Data	
	Energy (kWh)	Max Power (kW)	HDD18 (---)	HSF (W/m²)	Energy (kWh)	Max Power (kW)	Avr Temp. (°C)	HSF (W/m²)
Agen	8,29	0,65	*325*	*51*	3,28	0,61	*19,4*	*180*
Ajaccio	3,90	0,48	*250*	*71*	5,07	0,64	*21,3*	*213*
Carpentras	7,34	0,67	*303*	*61*	7,07	0,68	*21,5*	*218*
LaRochelle	8,06	0,79	*301*	*47*	2,82	0,51	*19*	*189*
Limoges	11,49	0,77	*387*	*43*	0,99	0,43	*16,7*	*158*
Macon	13,86	0,90	*402*	*40*	3,81	0,62	*19*	*184*
Millau	11,83	0,78	*379*	*47*	3,35	0,54	*19,3*	*191*
Nancy	14,95	0,90	*458*	*44*	2,59	0,51	*17,7*	*160*
Rennes	12,04	0,81	*384*	*45*	1,48	0,47	*17,5*	*166*
Trappes	14,53	0,94	*398*	*35*	1,80	0,49	*17,5*	*157*

Table T23 : results of various climates on the insulated building during July and February

HDD18 : Heating Degrees Day (base 18 °C)
HSF : Mean Horizontal Solar fluxes

Fig. R11 : heating energies during February related to the number of degrees-day for the insulated building

One observes good agreement between the number of degrees-day and the heating energy.



IV - 4 - Results for the isolated office building with venetian blinds for all windows

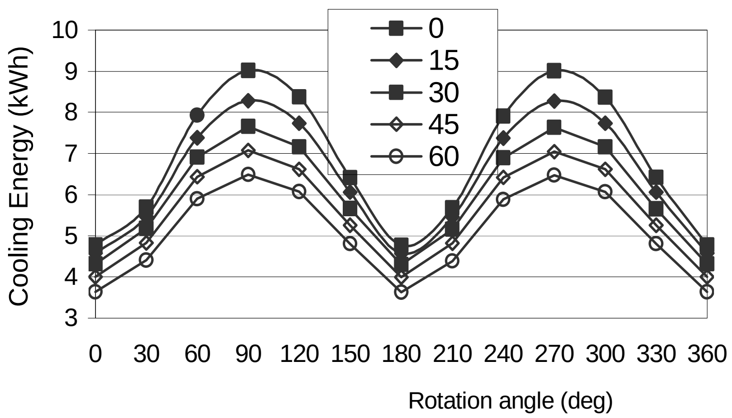
IV - 4 - 1 - Geometry Rotation

The calculation conditions are identical to those given in the paragraph IV-2-1.

Rot. Angle	Results for various slats angles									
	0		15		30		45		60	
	Energy (kWh)	**Max Power** (kW)	**Energy** (kWh)	**Max Power** (kW)	**Energy** (kWh)	**Max Power** (kW)	**Energy** (kWh)	**Max Power** (kW)	**Energy** (kWh)	**Max Power** (kW)
0	4,774	0,619	4,574	0,616	4,318	0,608	4,004	0,596	3,637	0,58
30	5,694	0,794	5,466	0,787	5,177	0,776	4,827	0,76	4,406	0,739
60	7,934	0,932	7,385	0,953	6,908	0,935	6,436	0,913	5,897	0,886
90	9,018	0,979	8,286	0,998	7,656	0,997	7,074	0,972	6,486	0,944
120	8,379	0,912	7,736	0,931	7,165	0,942	6,62	0,938	6,074	0,91
150	6,414	0,763	6,06	0,781	5,664	0,793	5,255	0,776	4,804	0,754
180	4,768	0,62	4,568	0,616	4,302	0,608	3,998	0,596	3,629	0,58
210	5,679	0,797	5,458	0,79	5,158	0,779	4,818	0,763	4,388	0,742
240	7,915	0,937	7,374	0,958	6,896	0,941	6,421	0,918	5,885	0,891
270	9,013	0,985	8,28	1,005	7,637	1,005	7,048	0,98	6,475	0,952
300	8,372	0,92	7,734	0,939	7,164	0,951	6,622	0,947	6,071	0,92
330	6,422	0,771	6,062	0,789	5,658	0,802	5,254	0,785	4,803	0,763
360	4,774	0,619	4,574	0,616	4,318	0,608	4,004	0,596	3,637	0,58

Table T24 : results of the rotation of the insulated building with venetian blinds during July in Carpentras

Fig. R12 : influence on the cooling of the rotation of the insulated building with venetian blinds during July in Carpentras for various slats angles



One observes the similarity of the results (result(θ+180°) = result(θ)).

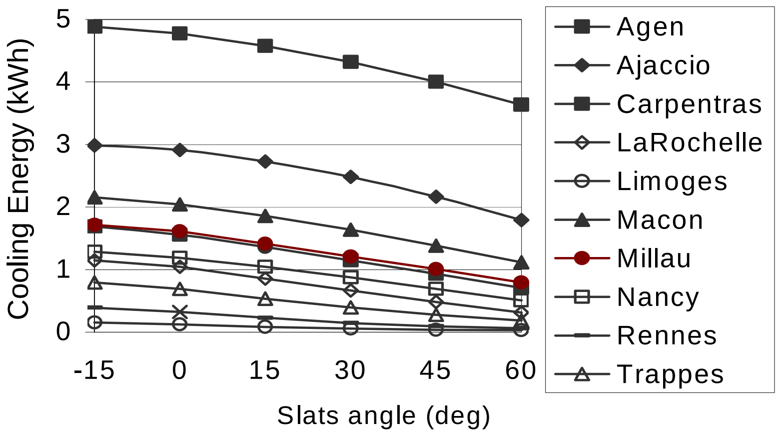
One observes the influence of the slats angle on the cooling, for all the angles of the building.

IV - 4 - 2 - Influence of the slats angle for various climates

City	Results for various slats angles											
	-15		0		15		30		45		60	
	Energy (kWh)	Max Power (kW)	Energy (kWh)	Max Power (kW)	Energy (kWh)	Max Power (kW)	Energy (kWh)	Max Power (kW)	Energy (kWh)	Max Power (kW)	Energy (kWh)	Max Power (kW)
Agen	1,691	0,554	1,553	0,551	1,36	0,542	1,146	0,53	0,927	0,512	0,705	0,489
Ajaccio	2,985	0,601	2,913	0,599	2,724	0,59	2,477	0,577	2,165	0,558	1,794	0,535
Carpentras	4,877	0,62	4,774	0,619	4,574	0,616	4,316	0,608	4,004	0,596	3,637	0,58
LaRochelle	1,146	0,444	1,043	0,437	0,854	0,422	0,665	0,4	0,483	0,371	0,311	0,341
Limoges	0,152	0,348	0,12	0,335	0,083	0,312	0,058	0,283	0,039	0,251	0,026	0,221
Macon	2,152	0,551	2,044	0,549	1,856	0,542	1,638	0,533	1,379	0,522	1,116	0,508
Millau	1,714	0,507	1,612	0,502	1,411	0,489	1,206	0,474	1,006	0,456	0,792	0,434
Nancy	1,285	0,439	1,189	0,434	1,043	0,423	0,872	0,407	0,694	0,401	0,508	0,382
Rennes	0,39	0,397	0,32	0,387	0,226	0,369	0,146	0,347	0,092	0,32	0,059	0,295
Trappes	0,793	0,419	0,692	0,409	0,533	0,391	0,396	0,37	0,275	0,348	0,179	0,32

Table T25 : results of various slats angles on the insulated building with venetian blinds

Fig. R13 : cooling energies in July related to the slats angle for the insulated office building



IV - 4 - 3 - Influence of the venetian blind position for different climates

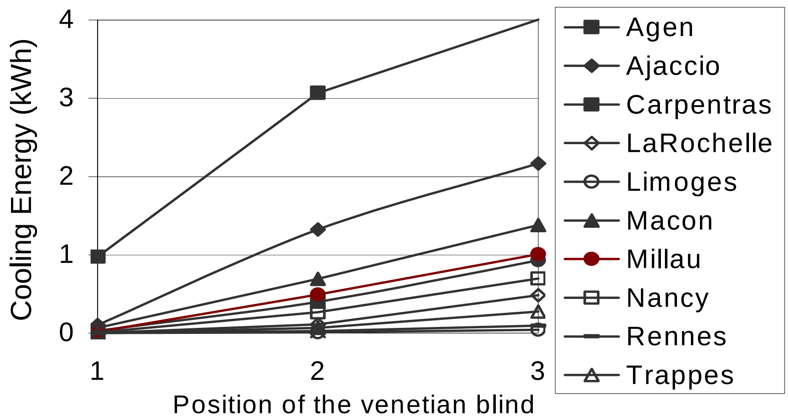
City	Position of the venetian blind					
	External		Integrated		Internal	
	Energy (kWh)	Max Power (kW)	Energy (kWh)	Max Power (kW)	Energy (kWh)	Max Power (kW)
Agen	0,03	0,201	0,398	0,44	0,927	0,512
Ajaccio	0,099	0,192	1,321	0,469	2,165	0,558
Carpentras	0,973	0,425	3,066	0,551	4,004	0,596
LaRochelle	0	0	0,111	0,276	0,483	0,371
Limoges	0	0	0,008	0,15	0,039	0,251
Macon	0,064	0,314	0,691	0,483	1,379	0,522
Millau	0,015	0,137	0,49	0,38	1,006	0,456
Nancy	0,007	0,106	0,263	0,327	0,694	0,401
Rennes	0	0	0,025	0,237	0,092	0,32
Trappes	0	0	0,067	0,256	0,275	0,348

Table T26 : results of the blind position on the insulated building with venetian blinds for various climates

Fig. R14 : cooling energies during July related to the position of the venetian blind for the insulated building

The slats angle is fixed at 45°.

(1 : external, 2 : integrated, 3 : internal)



IV - 5 - Results for the isolated office building with night ventilation

City	Results			
	No ventilation		With night ventilation	
	Energy (kWh)	Max Power (kW)	Energy (kWh)	Max Power (kW)
Agen	3,28	0,61	0,257	0,464
Ajaccio	5,07	0,64	1,33	0,546
Carpentras	7,07	0,68	2,069	0,572
LaRochelle	2,82	0,51	0,151	0,354
Limoges	0,99	0,43	0,014	0,188
Macon	3,81	0,62	0,259	0,497
Millau	3,35	0,54	0,569	0,454
Nancy	2,59	0,51	0,093	0,297
Rennes	1,48	0,47	0,021	0,254
Trappes	1,80	0,49	0,109	0,328

Table T27 : results of night ventilation on the insulated building during July for various climates

It is noted easily that night ventilation lowers largely the needs of air-conditioning.

V - Conclusions

The treatment of large building is a need for a thermal simulation software.

Indeed, if one wants to limit the human intervention in the modeling of the thermal zones, it is necessary to represent each part of the building by a thermal zone. The objective is in the long term to have an automatic translation of a drawing of building in calculation data.

The results presented in this report shows in a qualitative way that CoDyBa is able to treat a large building.

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