



ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

DÉPARTEMENT D'ARCHITECTURE - INSTITUT DE TECHNIQUE DU BÂTIMENT
LABORATOIRE D'ÉNERGIE SOLAIRE ET DE PHYSIQUE DU BÂTIMENT

Lesocool Manual

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Lesocool Manual

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For any information please contact the authors:

Flourentzou Florentzos
Jacobus Van Der Maas
Claude-Alain Roulet

EPFL LESO-PB
CH 1015 Lausanne.

Tel: +41 21 693 45 45
fax: +41 21 693 27 22

e-mail: flourentzos.flourentzou@epfl.ch
claude.roulet@epfl.ch

WWW server:

<http://lesowww.epfl.ch>

Lesocool Installation

Minimum system requirements

PC 386

4MB RAM

2.5 MB of free space on hard disc

Windows 3.1x

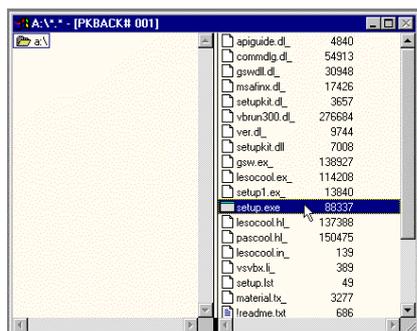
Although Lesocool is a 16 bit program it can work with Windows 95

Installation procedure

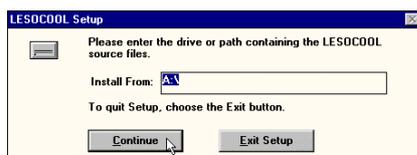
1. Execute "SETUP.EXE" from disc A:\ (you can do this from the WINDOWS file manager).
2. Choose the path from which Lesocool will be installed. "A:" will be proposed. If you agree click on "Continue"
3. Indicate the path to which Lesocool will be copied. C:\LESOCOOL will be proposed. If you agree click on "Continue"
4. Click Ignore to any messages saying that a file is in use. They are just existing windows .dll files in your system
5. Lesocool is automatically installed in your system. A group will be created in the WINDOWS program manager from where Lesocool could be run.
6. Double click on Lesocool icon to run.

The following files must be installed

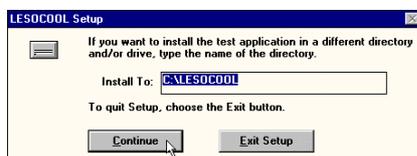
LESOCOOL directory	WINDOWS\SYSTEM
lesocool.exe: main program	grid.vbx
lesocool.hlp: main help file	vsvbx.vbx
lesocool.ini: general informations	theed.vbx
pascool.hlp: help on natural ventilation	vsvbx.lic
material.txt: marerial thermal properties	cmdialog.vbx
lausanne.dat: meteorological file	commdlg.dll
nopoli.dat: meteorological file	graph.vbx
Directoryexamples\	gswdll.dll
	gsw.exe
	apiguide.dll
	msafinx.dll
	vbrun300.dll
7 main files 1.2 MB + 11 example files 0.12 MB	12 files 1.22MB



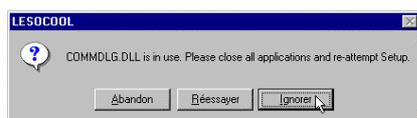
1. Execute Setup.exe



2. Click on "Continue"



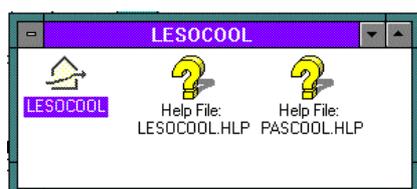
3. Click on "Continue"



4. Click on "Ignore"



5. Click on OK. Lesocool is installed

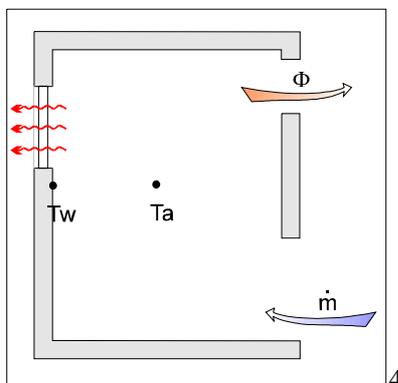
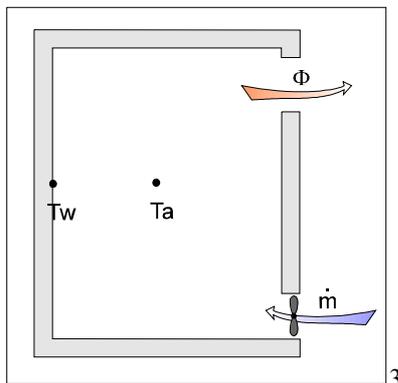
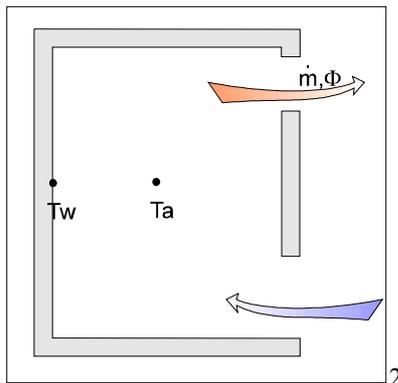
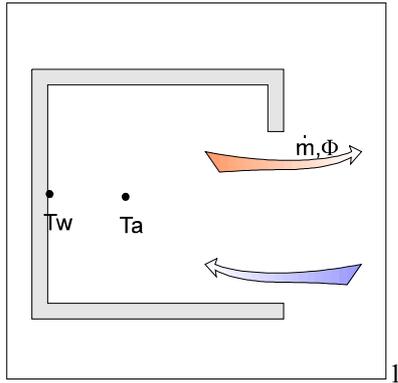


Windows 3.1x



Windows 95

6. Double click on Lesocool icon to run



What can Lesocool do?

What can Lesocool do?

Lesocool is a tool which calculates the cooling effect of natural ventilation, in particular night time ventilation, along a single ventilation path through a building. The ventilation path can be divided into several zones (maximum 9) which are then ventilated in series. For a given internal heat gain, the indoor temperature variation can be compared for different ventilation strategies, for different sizes of ventilation openings and for different types of wall materials.

The ventilation mechanisms include :

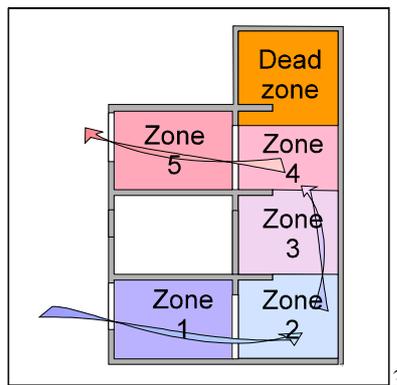
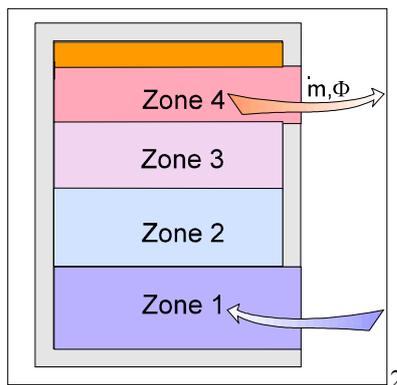
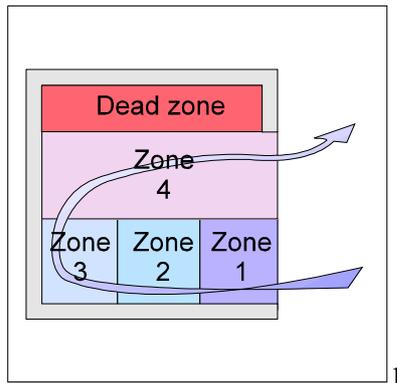
- single sided ventilation (fig. 1)
- cross ventilation with one top and one bottom opening (fig.2)
- mechanical ventilation (fig.3)
- time schedules for ventilation strategies

Zones include :

- time schedules for convective and radiative heat gains
- glazing U-value for heat transfer through a closed window (fig.4)

Output, is the time variation over a typical day, of :

- the air flow rate common to all zones
- the mean zone air temperatures
- the mean zone surface temperatures
- the ventilation cooling rate for each zone.



For most cases of cooling by ventilation, single zone modelling is sufficient. Multi-zone modelling applies only when you have well determined single path ventilation and when you are interested in both the temperature distribution and cooling power along the air flow path.

Here are some examples of zonal modelling

- single sided ventilation (fig.1)
- cross ventilation of a room with two openings, one at the top and one at the bottom (fig.2)
- cross ventilation of a multi-storey building (fig.3)

You can imagine many other situations where a multizone approach is judicious: a long corridor, a staircase, several rooms ventilated in series, etc.

What can Lesocool NOT do?

Lesocool is not a full building simulation program, but it allows rapid parametric studies to evaluate the potential of passive cooling by ventilation with outdoor air. It therefore only includes the parameters which strongly influence this cooling potential. Because Lesocool is designed for simplified modelling of passively cooled buildings with time constants of at least one day, the approximations made in the thermal modelling break down for light weight buildings with small structural thermal storage capacity.

Lesocool cannot at present :

- calculate multi-path air movement; for multi-zone modelling use programs like COMIS and CONTAM instead.
- simulate periods much longer than 1 day (validity limited by the building time constant). However for zones with high thermal inertia and thick walls longer periods could be simulated.
- include interactions with neighbouring zones other than by the ventilation rate of the common flow path.
- directly take into account solar gains (it is assumed that the first rule of a passive cooling strategy applies, which is to have an

effective shading strategy to minimise solar gains); solar gains can be modelled indirectly through the internal heat gain schedule.

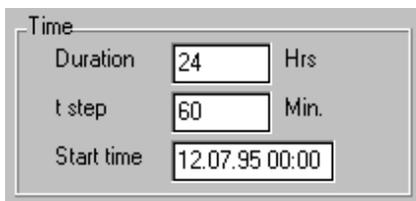
- directly simulate wind induced natural ventilation (use COMIS instead); it is assumed that the worst case for cooling purposes is the case without wind.
- model multi-layer wall elements (it is assumed that the thermal effect of the surface layer dominates)
- model thin walls (the thermal storage effect of thin walls may be overestimated)

For all the cases where detailed results on these issues are needed, it is recommended to run a full building simulation program (for example TRNSYS or ESP-r).

Future developments of Lesocool

- implementation of a multi-layer wall element algorithm including the treatment of thin walls
- generation of an internal heat gain schedule including solar gain
- modelling of mechanical cooling and cooling load

How to create a Lesocool project



Standard Edition

Time characteristics

Starting time

The date and time the simulation starts. Only standard WINDOWS date formats can be accepted. This depends on how WINDOWS is configured on your computer in "International". Default value is the current date and time. The starting time becomes important when you use ventilation strategies 8:00 - 18:00 or when you use external temperatures from a meteorological file.

Duration

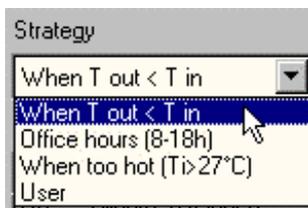
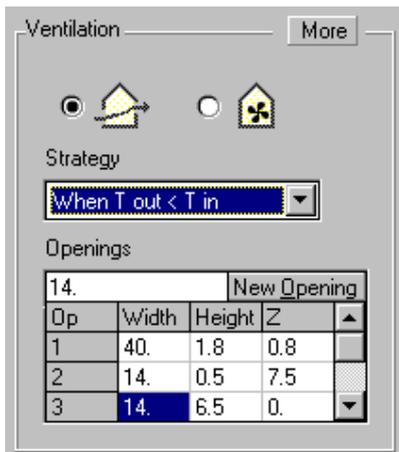
The length of the simulation in hours. The calculation time is proportional to duration. Default value is 24 hours.

The longer the duration, the larger becomes the systematic error, due to the semi-infinite wall hypothesis. For a duration longer or equal to 24 hours, you have the possibility of initial temperature calculation.

Time-step

Simulation time-step in minutes. Default value is 60 minutes. The calculation time is inversely proportional to the time-step. Time-steps down to 1 minute can be used; it is recommended to use this possibility only for a special reason (comparison with experimental data or special cases with short ventilation or heat gain events).

Important ! Enter the duration and the time-step before entering the external temperature, the heat gain or ventilation time schedules. Changing of these time characteristics destroys existing time schedules.



Ventilation.

Ventilation type

Choose whether the type of ventilation is 'natural' (the maximum ventilation rate depends on the indoor-outdoor air temperature difference) or 'mechanical' (the maximum ventilation rate is fixed).

Ventilation strategy

Choose one of the three predefined ventilation strategies or define a ventilation time schedule (user option). The predefined strategies are:

When cool outside ($T_{out} < T_{in}$).

The ventilation rate is maximum when the outdoor temperature is below the indoor temperature. This is the best ventilation strategy for maximum night cooling and minimum day heat gains by ventilation. When $T_{out} > T_{in}$ the ventilation rate is 0. Recommend to induce air movement with a ceiling fan with closed windows and $T_{in} > 27^{\circ}\text{C}$.

Office hours (8:00-18:00).

The ventilation rate is maximum during office hours but otherwise there is no ventilation. Out of office hours the ventilation rate is 0. This is a commonly used ventilation strategy but not good for cooling purposes.

When too hot ($T_{in} > 27^{\circ}\text{C}$)

The ventilation rate is maximum when the indoor temperature becomes too high. Often people open the windows fully when the inside temperature becomes too high. This case is the worst ventilation strategy for cooling of the building structure. Body cooling can result from cross-ventilation but the heat storage in the thermal mass is not operative.

The user option allows you to change the air flow rate for each time step. For natural ventilation you must enter a percentage and for mechanical ventilation you give directly the air flow rate in m^3/h (or in m^3/s or in kg/s). The percentage for natural ventilation corresponds to the percentage of the opened part of the window. (0% is closed and 100% is completely opened). Note that the CUT and PASTE (Ctrl + C, Ctrl + V) editing possibilities allow you to copy values for example from a spreadsheet.

Ventilation openings

Single zone.

In the case of a single zone, up to 9 large openings for natural ventilation can be defined. Additional air infiltration through cracks and small openings is not made explicit. The model then considers the zone to be homogeneous and at a single air temperature, that is perfect air mixing is assumed.

For each opening, the width, the height, and the vertical distance from a reference level (ground) are needed. The height from ground (Z) is defined as the distance from the bottom of the opening.

If there are more than 9 openings, as can happen for example in a large atrium, the openings can be combined into larger openings with an equivalent area.

Openings with the same height and Z are grouped by adding the widths. For example, two doors of 2 m height, 1.5 m width and $Z = 0$, can be considered as one opening of $W = 1.5 + 1.5 = 3$ m, $H = 2$ m and $Z = 0$.

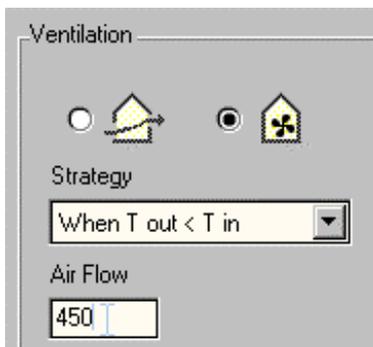
Multizone

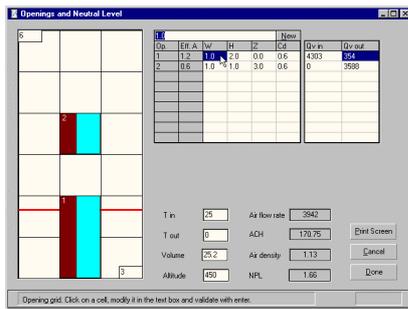
For a multizone project, not more than two openings can be defined at the beginning and end of the flow path. The inlet is then in the first zone (usually bottom) and the outlet opening in the last zone (usually top). If only one large opening is defined, there is single-sided ventilation with two-way flow in the opening.

Mechanical air flow

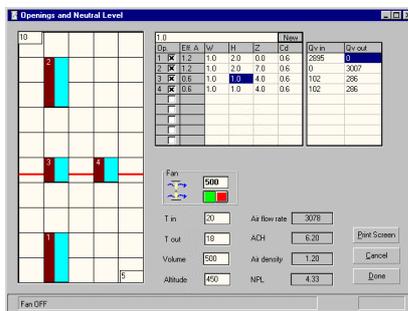
If you select one of the predefined ventilation strategies you just give one air flow rate value in m^3/h which will be applied on the predefined time schedule. You can also define your own ventilation strategy choosing the “user” option.

More

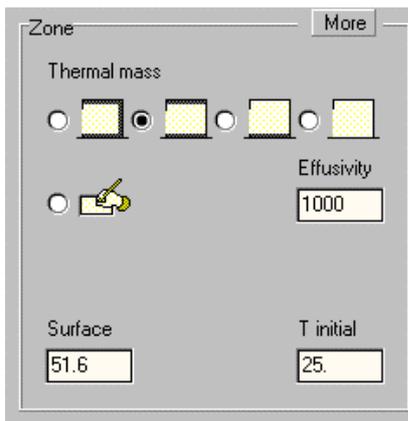




This window is useful to play with different opening configurations and visualise the neutral pressure level and the air flow rate for each opening. Before closing it you can copy the openings to the Lesocool project



With menu Tools-Window Design a similar window appears giving the possibility to couple natural and mechanical ventilation. This window is completely disconnected from Lesocool project and you cannot copy the openings to the Lesocool project.



It is possible to visualise the influence of the opening configuration by clicking on “ More ” A special window then appears and one can play with the size and discharge coefficient of the ventilation openings. In this window the openings and the neutral pressure level are visualised on a scaled grid. For a given temperature difference, the in and outgoing air flows are available for each opening.

Neutral Pressure Level visualisation

This window can help you to position ventilation openings. You can visualise the neutral pressure level on the scaled grid as well as air flow in every window. The calculation is not related to the Lesocool project and it is done for a given inside - outside temperature difference.

The default temperatures are the initial inside and outside temperatures of the project. The default values for the openings are also the project openings. You can change all the parameters of this window to visualise different opening and temperature configurations. If you click on “ cancel ” there is no effect on the Lesocool project. If you click on “ OK ” only the opening size, position and discharge coefficient will be taken into account for the Lesocool Project.

Every time you change a parameter the new values replace the old ones and the openings and the Neutral Pressure Level (NPL) are positioned on the big square. The NPL is drawn with a red line. This square can be scaled by changing its height or its width (in meters).

Zone thermal characteristics

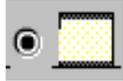
Zone thermal inertia

The zone thermal inertia is characterised by the zone mean thermal effusivity.

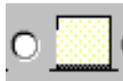
You can give the numerical value of the zone mean thermal effusivity but you can also choose one of the 4 available standard zones:



very heavy: massive material are exposed on 90% of all surfaces (floor, ceiling and side walls). The mean effusivity has a high value $b_m=1500(Ws^{0.5}/m^2K)$.



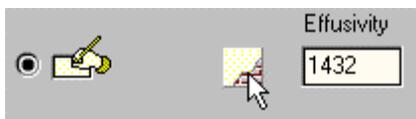
heavy: massive material are exposed on 60% of all surfaces (either floor and ceiling, or floor and side walls, or ceiling and side walls). The mean effusivity has a medium value $b_m=1000(Ws^{0.5}/m^2K)$.



medium: massive material are exposed on 90% of all surfaces (either the floor, or the ceiling, or the side walls). The mean effusivity has a low value $b_m=500(Ws^{0.5}/m^2K)$.



light: there are no exposed heavy weight surfaces; floor, ceiling and side walls are of light construction or covered with light weight material. The mean effusivity has the very low value of $b_m=200(Ws^{0.5}/m^2K)$.



A material list giving thermal effusivity values is available when you choose the “User ” option.

Material List

Material: Effusivity:

Matériaux	Densité	Cp	Lambda	b
BETON MORTIERS				
Beton arme	2400	1080	1.8	2160
BETON MAIGRE CP 150	2200	936	1.3	1636
Mortier batard	1900	1080	1	1432
Mortier de ciment	2200	1080	1.4	1823
Mortier de chaux	1800	1080	0.87	1300
MORTIER GYPSE	1200	1080	0.58	866
Beton argile exp.	1000	1080	0.3	569
Beton argile exp.	1250	1080	0.5	821
Beton argile exp.	1500	1080	0.7	1064
Beton argile exp.	1700	1080	1	1354
BETON PS 600 KG/M3	600	1044	0.18	335
BETON PS 800 KG/M3	800	1044	0.22	428
CREPI SYNTHETIQUE	1500	1044	1	1251
Crepi interieur	1400	936	0.7	957
Crepi exterieur	1800	1080	0.87	1300
Enduit au platre	1200	936	0.58	807
Enduit au platre	1400	936	0.7	957

Buttons:

With the user option for the thermal mass a list of materials is available

Remark: for the standard zones it is assumed that for a common office size, floor, ceiling and side walls are representing each about 30% of the total wall surface area, and the façade the remaining 10%. It is further assumed that the heat storing massive surface areas (exposed concrete or dense brick) are at least 10 cm thick and all other surface elements have a minimum U-value of $1W/m^2K$ (5 cm of insulation). The heat storage capacity of the window surface and all surfaces which have no exposed mass are neglected (e.g. light walls, false ceiling, suspended floor, thick carpet on floor).

Zone surface area

This is the total geometrical surface area of the solid walls (floor, ceiling, side walls, external walls). Any heat gain is distributed over this area and 'zone surface area' is therefore a key parameter.



A high value of the surface area reduces the effect of heat gain on temperature and increases the rate at which heat storage can take place.

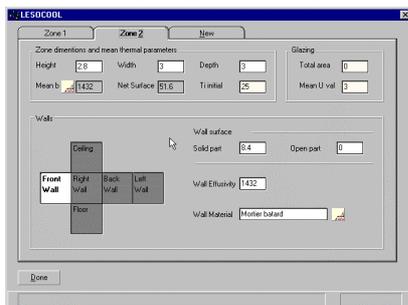
Zone initial temperature

This temperature is the temperature of the zone at which the simulation starts. Resulting temperatures can be shifted up or down by changing this initial temperature.

When the heat gains and ventilation losses are in equilibrium over a 24h cycle, the temperature at the beginning and end of a cycle are the same. Inversely, when the gains (losses) are dominating over a 24h cycle, the temperature will steadily increase (decrease).

For periods longer than or equal to 24 hours the initial temperature can be precalculated if an equilibrium can be achieved (supposing that all days are identical to the first day).

More...



A special window can help you to calculate the net zone surface area and effective thermal effusivity by entering the zone dimensions and the composition of each wall. In order to take heat losses and heat gain through glazed surfaces into account, the glazed surface area and the U-value of the glazing can be specified here.

Analytical calculation of zone parameters

In this window, by entering the shoe box dimensions of the zone, the overall surface area is calculated including the areas of the surfaces making up the shoe box. By changing the wall materials, the resulting mean thermal effusivity is directly available.

Zone dimensions

Only a shoe box geometry is proposed. Enter zone height, width and depth.

Zone dimensions and mean thermal parameters

Height Width Depth

Mean b Net Surface T_i initial

Zone Surface Area

The net zone surface area is automatically calculated every time you change a zone dimension or wall. If you enter directly the surface area, the zone dimensions and wall characteristics are ignored (the corresponding text boxes are greyed).

Mean effusivity

By changing the material of a particular wall area, the mean thermal effusivity is recalculated.

Glazing

Direct thermal transmission through a glazed area separating the outdoor air and the indoor air is included here. This factor becomes important when the product of glazing area, U-value and inside-outside temperature difference is significant with regard to the heat gain.

Glazing

Total area

Mean U val

Walls

The material of each wall can be different. In this case a weighted mean

effusivity will be calculated according the formula $b_{mean} = \frac{\sum b_i S_i}{\sum S_i}$. Only

thick solid walls are included for thermal storage. The opening and window surface area must be subtracted here for each wall. To modify the parameters of an individual wall click on it on the zone development. You can delete a non existing wall (click on it and press Del). A deleted wall can be recalled when you double click on it.

Every time a wall effusivity or surface is changed the program calculates the effective zone surface and mean effusivity. If the mean zone effusivity is entered directly the data for every individual wall are lost and all the walls have the same mean effusivity.

Walls

Ceiling Wall surface Open part

Front Wall Right Wall Back Wall Left Wall Floor

Wall Effusivity

Wall Material

Wall thermal response.

Distinction is made between *heat transfer* and *thermal inertia*. A larger area allows better heat exchange to take place and brings the air temperature closer to the structure temperature. The heat exchange depends also on the *heat transfer coefficient*. Lesocool takes a default of 6[W/m²K] and this value can only be changed in the professional edition.

The effectiveness of the surface materials at loosing and absorbing heat increases with thermal conductivity, density and heat capacity. This effectiveness is proportional to the **effusivity** which is determined by the material properties $b = \sqrt{\lambda\rho c}$. To reduce surface temperature variation, the surface material shall have a large effusivity and the heat gains are distributed over a large surface .

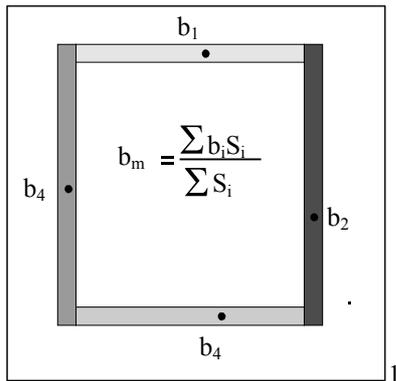
It can be shown that materials with a high effusivity have a high density as well. The three orders of magnitude variation of the effusivity can be remembered as follows: Metal 20'000, Heavy concrete 2000, Light Wood 200, Light Insulation 20 (SI-units : Ws^{1/2}/m²K).

Lesocool makes use of the fact that the dynamic thermal behaviour is determined by the first layer of the heat storage elements, and as a approximation the wall thickness is not required as input parameter. The thickness of this heat storing layer varies from a few centimetres for an afternoon to typically 10 cm for a 24h. Due to this approximation Lesocool is not indicated for thin walls or for long simulation periods.

Zone thermal response.

The internal air temperature of a zone varies in response to a sudden change in heat gain, and it is explained here how this air temperature variation is related to the wall properties and to the radiative fraction of the heat gain.

When heat gain is 100% radiative in character (for example solar radiation), the air temperature is not directly affected because air is transparent to radiation. The air temperature varies then only because the surfaces surrounding the air volume heat up. Indeed, in a non-furnished room with solar radiation it can be observed that the air temperature remains close to the mean temperature of the wall surfaces. When light furniture is added to the room (including curtains and internal solar



1

protection devices) part of the radiative heat gain is intercepted and given off to the air. The air temperature and the mean wall temperature are no longer the same, and it is as if the heat gain had become partly convective.

Heat gain which is purely convective in character (0% radiative), first causes the air to heat and subsequently, the walls are heated by the warm air. Similarly, in the case of cooling by ventilation, the air is first cooled below the wall temperature and the walls are then cooled by convective heat transfer from this cooled air.

The heat transfer resistance decreases with an increasing wall surface area; the air-wall temperature drop will decrease when the surface area with which heat can be exchanged increases. It should be noted that this air-wall temperature drop is proportional to the convective fraction of the heat gain but is *independent of the choice* of wall material.

Therefore in response to a sudden change in heat gain, the zone air temperature can be seen to vary rapidly followed by a much slower change with time. It is this slower change which represents the fabric heat storage process and therefore depends on the choice of the wall material.

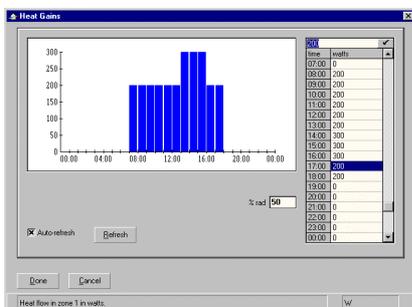
The thermal response of all the surfaces making up the zone envelope is proportional with a weighted mean of the thermal effusivities, b_m . (figure 1)

The summation goes over the various surface areas enclosing the space.

Heat gains



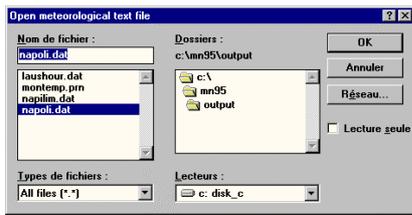
or F5 or menu Environment - Heat Gains



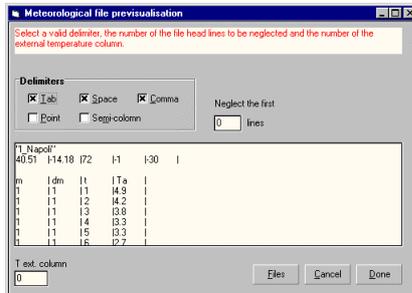
2 Heat gain window

The heat gain time-schedules comprise all the effects of lighting, office equipment, appliances, presence of people and solar gain. Instead of calculating in detail the heat gain in Watts, use the floor surface area, and the typical heat gain during office hours (8-18h) :

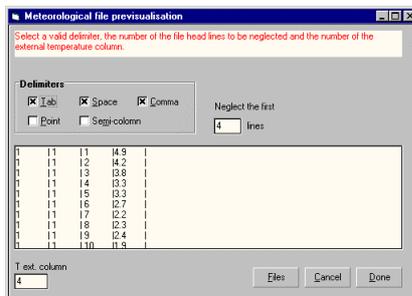
- high heat gain 40W/m² floor area, 50% radiative.
- medium heat gain 20W/m² floor area, 50% radiative.
- low heat gain 10W/m² floor area, 50%



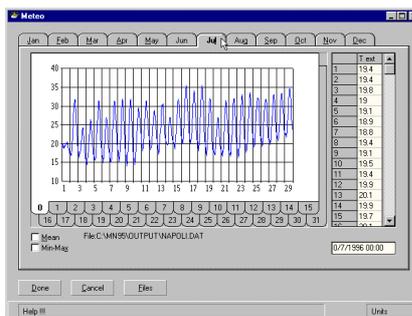
I. Select a meteorological file.



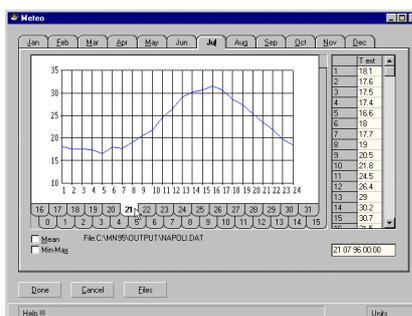
II A window with a previsualisation of the headings and delimiters will appear.



III. Give the appropriate delimiter, the number of lines to neglect in order to ignore the headings and the number of the temperature column.



IV. Choose the month



V. Choose the day of the month

It is assumed that an efficient external solar protection is installed and therefore solar heat gains are not generated automatically by Lesocool. When one wants to simulate the effect of a solar protection transmitting a given fraction of the solar radiation, the heat gains need to be estimated from the radiation data (climate file), the orientation and the window size.

To estimate the significance of solar gains, determine

- the surface area transmitting solar radiation, S (m^2)
- the hourly solar irradiance normal to the façade plane at time t , $I_n(t)$ (W/m^2)
- the transmitted solar fraction, f_{tr}

The hourly solar gains are approximated with the product $S * I_n(t) * f_{tr}$ (W)

The radiative fraction of the solar gains can be taken to be 100% for radiation impinging on a massive floor or side-wall and 50% for radiation impinging on furniture

Note that for internally mounted solar protection devices, the transmitted solar fraction is determined by the glazing only and the heat gain should be taken to be 20% radiative.

If you have a heat gain schedule in a spread sheet (EXCEL for example) or in a text file (one column) you can copy and paste the data in the heat gains grid. To do so copy the values from the other application, go to the heat gains window, select the cells in which you want to paste, press ctrl + v or ctrl + Ins. Values from the heat gains grid can be copied by selecting them and pressing ctrl + c or Shift + Ins

External Temperature

There are two ways to give the external temperature.



1 or F7 or menu Environment- External Temp Files

With this option you can open any annual meteorological text file where the hourly external temperature records are in a single column (8760 lines). The program can read files of any number of columns and any separator. After choosing the file (step I) a previsualisation window will help you to choose a convenient delimiter and the number of the

temperature column. If there is a heading in the file you also have to indicate the number of lines to be omitted (step III).

If the format of the file is correct (it has the correct number of lines, you gave the correct delimiter and number of lines to neglect) you will have a new window with two thumb indexes. One for the month and one for the days. You can visualise the temperatures of the hole month by clicking on “ 0 ” on the day index (step IV). You choose the day you wish (step V) and then “ Done ”.

Lesocool will copy the temperature values starting from the indicated day and time.



2 or F3 or menu Environment - External Temp. to go to external temperature window

If you have external temperatures in a spread sheet (EXCEL for example) or in a text file (it must be in one column) you can copy it and past it in the external temperature grid. To do so copy the values from the other application, go to the external temperature window, select the cells in which you want to paste, press ctrl + v or ctrl + Ins.

You can also copy values from the external temperature grid by selecting them and pressing ctrl + c or Shift + Ins.

In this window you can also modify values selected in a file by the first method.

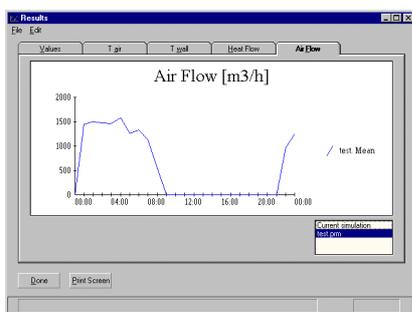
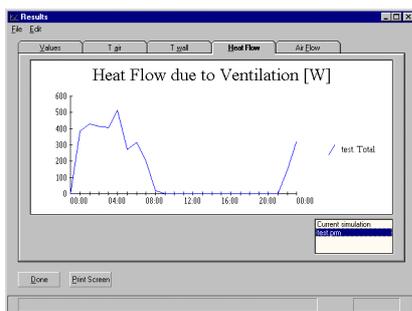
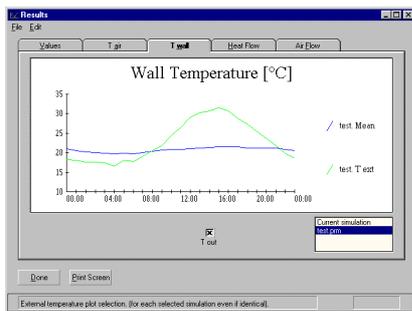
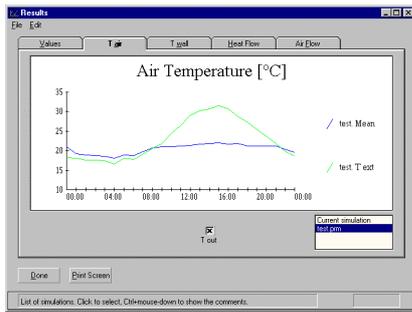


Run and visualise results

Press ctrl + r or click on Go button or choose menu Environment - Results to calculate and show the results.

Graphs

You can plot simultaneously graphs from different simulations but not for different variables. You can plot and compare for example the air temperatures of all the simulations you have chosen in the simulation



'listbox', but you cannot plot air and surface temperatures on the same chart.

The 'grid with the results' contains only the results of the current simulation. T_{ex} is the external temperature in [°C], Q_v is the air flow in [m³/h], T_{a_i} is the air temperature of the zone i in [°C], T_{w_i} is the wall temperature of the zone i in [°C], Φ_{i_j} is the heat flow transferred by ventilation from the zone i in [W]

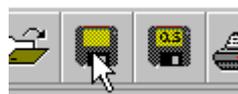
If you need more sophisticated charts you can read the results files ".res" , with EXCEL or other charting programs.

Trick: If you want to compare simulations directly with experimental results then:

1. Save an extra simulation under a name you like, say "exper.prm"
2. "exper.prm" should not be the active simulation. Close it and open another existing simulation or start a new one.
3. Replace air and wall temperatures in the file "exper.res". You can open and modify ".res" files with any text editor (ASCII files) or a spread sheet (EXCEL etc.).
4. Return to Lesocool and compare experimental results in "exper.prm" with other simulations

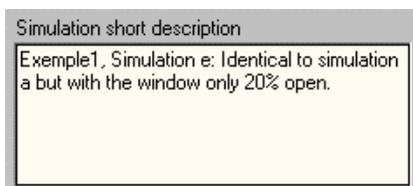
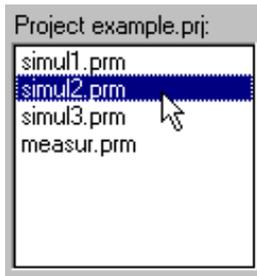
Be careful not to reopen and save the simulation "exper", because saving will replace the experimental values with calculated ones.

Save.



Save. You have to give first the project name (if it is a new project) and then the simulation name.

All Lesocool files are text files. You can open and modify them with any text editor. Project (.prj) and parameter (.prm) files have the structure of a WINDOWS ".ini" file.



Open or delete an existing simulation

To open an existing simulation of the project double click on it in the simulation list.

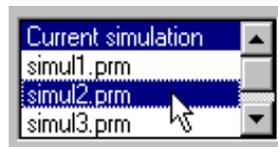
To remove an existing simulation from the project select it and press DEL. This action does not delete the simulation parameter and result files.

To delete a simulation press Ctrl + DEL. The simulation parameter file (.prm) as well as the simulation result file (.res) will be deleted.

Short simulation description

If you performed to many simulations it will be difficult to identify them only by the file name. You can give a short description (max. 256 letters) which may be very useful especially when you want to compare different simulations in the result window.

To visualise this description when you are comparing simulation results press Ctrl and click on the simulation list. As long as the mouse button is kept down the text will appear.



(Ctrl + click)

Check list

A check list is available in order to help the user to remember the parameters changed. When a parameter is changed, automatically a cross fills the corresponding box in the check list. To visualise the list press Ctrl+F1 or click on menu Environment - Check List. The list is a top most window.

Where the default values are kept you can click on the check box manually to mark it "x" and recall it without any effect on the project check up.



Professional Edition

Professional edition includes everything the standard edition does. There are three main differences:

- Multizone modelling is possible
- Some secondary parameters are available for the specialist to change
- There are no standard zones. The thermal effusivity of the zone must be given numerically or calculated analytically in the secondary window clicking on “ More ”

The project organisation (file opening and saving), the external temperature, heat gain and ventilation schedules, as well as calculation and result visualisation are identical for the two editions.

Issues common to standard and professional edition

- Time characteristics.
- Ventilation.
- Heat gains.
- External Temperature.
- Run and visualise results.
- Save.
- Carry out a new simulation.
- Open or delete an existing simulation.
- Short simulation description.
- Check list.

Issues only for standard edition

Multizone modelling

Multizone modelling is possible if there is a well determined single air flow path. In the figures 1,2,3 of page 3 there are some examples of zonal modelling. One can imagine many other situations where a multizone approach is judicious: a long corridor, a staircase, several rooms ventilated in series, etc.

Furniture

Empty Heavy

Light User

Convective coef.

6 User

If there are two openings you have to be sure that both openings are not near the neutral pressure level i.e. there is only one way flow in both openings. You can control this by clicking on “ more ” on the ventilation square.

The only interaction between the zones is the air flow through them. The other interactions, radiation, heat transfer through thin walls or glazing, are neglected. If these interactions are not negligible compared to ventilation heat flow, Lesocool multizone modelling is not indicated.

Additional input parameters

Convective heat transfer coefficient (h [W/m²K])

The default value is 6 W/m²K. This value can vary and it depends on the air-wall temperature difference and the air velocity near the wall. If there is no air movement you can give a value down to 3W/m². For very turbulent air movements values up to 10 W/m² could be used.

Furniture

This determines the time constant for changes in zone air temperature. The heat capacity of the air and furniture will delay air temperature changes.

The empirical value for a standard empty room is a 5 minute time constant. For large rooms this value may be higher. The presence of furniture increases this apparent time constant.

There are three standard options for the air time constant, empty - 5 minutes, light -15 minutes, heavy -30 minutes. There is also a user defined option for special cases.

Zones More

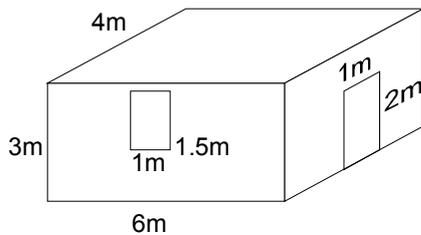
Zone	Surface	Effusivity	T initial
1	51.6	1000	25.
tot/mea	51.6	1000	25.0

Interface for the thermal zone characteristics

The professional edition interface is rather different concerning the thermal zone parameters. The standard zones are not available and the zone parameters (thermal effusivity, surface area, initial temperature) are given on a grid.

In order to understand better the parameter of the grid it might be useful to see the standard edition explications.

Examples simulated with Lesocool



Example 1.

Calculate the temperature evolution and the heat losses of a room after opening the window for 1 hour.

Input parameters:

- Room dimensions as in the figure
- All walls are made of concrete bricks of thermal effusivity 1000 [$\text{Ws}^{1/2}/\text{m}^2\text{K}$]
- Window width 1 m, height 1.5 m, 1.3 m above floor
- External temperature is assumed constant 10°C
- There is no other glazing than the window
- No internal heat gains.
- Initial temperature 20°C

Proposed simulations:

- Observe the air and wall temperature evolution over a duration of 8 hours, as well as the cooling power and the air flow rate when the window is open.
- What will happen if the concrete bricks are replaced by wooden walls ($b=500$)?
- What will happen if the concrete bricks are replaced by light separation panels ($b=100$)?
- What is the effect of replacing the right wall by a light separation panel and putting in a false ceiling? Both panel and false ceiling are of light material ($b=100$).
- What is the effect of leaving the window only 20% open?

Step 1: Time parameters.

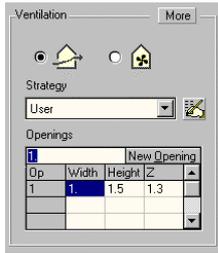
Time		
Duration	<input type="text" value="8"/>	Hrs
t step	<input type="text" value="15"/>	Min.
Start time	<input type="text" value="15.02.96 00:00"/>	

Simulation a.

Run Lesocool

- Leave the default start time, change the duration to 8h and the time step to 15 min (the start time is only an important parameter when reading the external temperature from meteorological files).

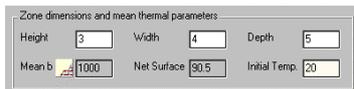
Step 2. Ventilation



Step 3: Surface area and effusivity.



click on “ More ”



enter only the dimensions (the surface area is calculated).

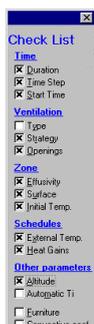


subtract the door and window from solid part of two side walls

Step 4: External temperature.



Step 8: Check list



2. Ventilation

- Choose natural ventilation and “ user ” as the ventilation strategy. A window with the ventilation time schedule will then appear. Leave 100% only in the four cells from 1:00 to 2:00. In the time schedule grid you can do a multiple selection. In this case be careful when dragging not to go out of the grid limits; it may cause problems. Note that you have to press “ Enter ” after every input.

- Delete existing default ventilation openings (select the hole grid line and press Del), and give the new opening dimensions: W:1, H:1.5, Z:1.3 (in this case Z has no importance because there is only one opening).

3. Zone thermal parameters.

- Thermal effusivity: enter 1000.
- Surface area: either you calculate it yourself (sum of wall surface areas minus door surface area, minus window surface area = 90.5 m²), or you click on “ More ” and give the zone dimensions. Prefer the second option because you will need the zone dimensions for the simulation d. Neglect glazing heat losses. Enter the zone dimensions and subtract the window and door surface area because they do not participate in the heat storage. To subtract a surface from a side wall, click on it and enter the open surface part, in the case of the door 2 m²

- Initial temperature: 20°C.

4. External Temperature: Click on the “ edit ” button (figure). Be careful not to confuse it with the “ file ” button. The external temperature is edited in a similar way as the ventilation time schedule.

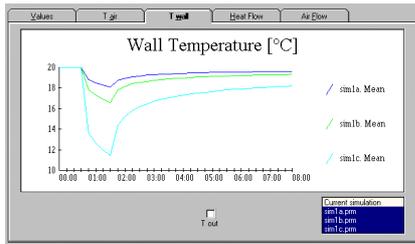
5. Heat gains: No heat gains.

6. Altitude: if the level above the sea is a few hundred meters this is not a significant parameter, but for high altitudes (mountains over 1000 m for example) the air density may be considerably reduced reducing the air cooling effect.

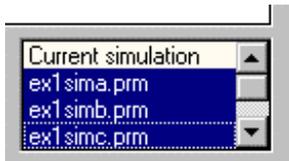
7. Do not choose initial temperature precalculation. This option only works for periods longer than 24 h.

8. Control with the check list if you have entered all parameters (to call up the list click on menu Enviroment - Check Up or press Ctrl+F1).

9. Save project and simulation.



The results of the three simulations.



Simulations a,b,c are compared

Click on “ Go ” to visualise the results. You can see the air temperature, wall temperature, ventilation heat loss and air flow rate.

Simulation b

To replace concrete blocks by wooden walls return to Lesocool main page. Change the effusivity to 500 and use “ Save as... ” to save the new simulation under the name “ sim1b.prm ” (or another name of your choice). It is useful to write a short description for every simulation in the appropriate text box.

Simulation c

Change the effusivity and save as a new simulation with a different name. Click on “ Go ” to visualise the results and compare simulations.

In the result window you can select on the file list the simulations to be plotted. In the file list all the saved simulations as well as the current simulation are available. In the figure, the simulations a, b and c are compared. You can see the influence of the wall material on the temperature evolution.

Simulation d.

This simulation is a bit more complicated than b and c. Material properties must be introduced separately for each wall so that the mean thermal effusivity can be calculated.

Open the first simulation by a double click on it in the file list.

Click “ More ” on the zone square to call up the window for the wall details. All the walls floor and ceiling of the old simulation have an effusivity of 1000. Click on the right wall and change the effusivity to 100. Do the same for the ceiling . The calculated mean thermal effusivity must be 652. Click on “ Done ” to return to the main window and calculate.

Save as a different name before proceeding to the next simulation

Simulation e

There are three ways to simulate a window whiche is only 20% open:

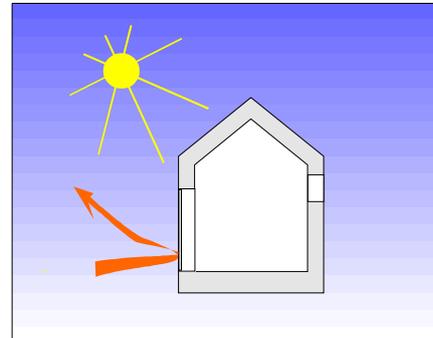
1. Reduce the window width to 0.2 m in stead of 1 m. Attention: reducing the window height to 20% has not the same effect as the air flow rate is a function of $\sqrt{H^3}$
2. Reduce the ventilation percentage to 20% instead of 100% in the natural ventilation time schedule.
3. Reduce the opening discharge coefficient. The discharge coefficient for a sharp opening is generally taken $C_d = 0.6$. Lesocool takes this as the default value. Closing the opening to 20% is equivalent to multiplying C_d by 0.2. In this case $c_d = 0.6 \times 0.2 = 0.12$. To change discharge coefficient click on “ More ” on the ventilation square and change C_d in the grid with the opening characteristics.

Some design guidelines for passive cooling by night time ventilation

Principle

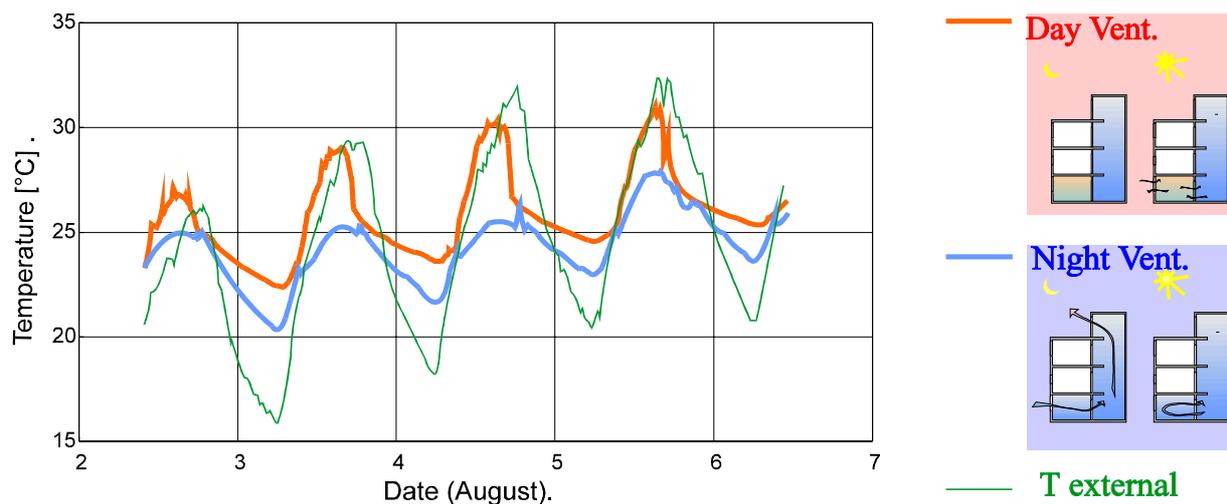


During the night the building is naturally ventilated at a maximum rate in order to remove the heat and to cool the internal side of the walls. These cool wall surfaces provide comfort during daytime.



During the day the heat gain is limited to a minimum level : the ventilation openings are closed to keep warm air outside and blinds protect from solar radiation.

Example : measurements at the LESO building



Two identical offices (40m³) of the LESO have been ventilated following different strategies : (i) the usual strategy with ventilation during the day but not at night (ii) the new strategy with natural ventilation at night.

The office spaces have considerable thermal inertia and external solar blinds. The night ventilation rate is 10-12 air changes per hour. The offices are occupied by one person during 8 hours per day, often with a personal computer.

Requirements to fulfil:

For the architect

- **Large thermal inertia**

To keep the heat out, use heavy walls with external insulation. No need to exaggerate the wall thickness (a thickness of the heavy wall layer of 10cm is sufficient).

- **Exposed thermal mass**

Maximise the surface area of the massive wall materials which are in direct thermal contact with the room air : no false ceiling or hollow floor, use massive materials for the internal walls where possible, avoid covering massive walls with lighter, lower effusivity, materials.

- **Ventilation openings**

Design sufficiently large ventilation openings which can be kept open during the night without security problems. The air outlet of the building should be large and be placed as high as possible.

For the user

- **Limit heat gains**

Use blinds to avoid direct solar gain, close windows and shutters when it is warmer outside. Reduce heat generation by choosing high efficiency appliances and by shutting down non-used apparatus.

- **Intelligent ventilation**

Ventilate as little as possible during the warmest period of the day. Use ceiling fans if necessary, to create air movement. When the outdoor temperature becomes lower than indoors maximise ventilation.

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