



SIMEDIF

Software for the transient thermal calculation of buildings

USERS' MANUAL

**Silvana Flores Larsen
INENCO – U.N.Sa.-CONICET
Salta, Argentina – May 2016**

Table of Contents

SUMMARY.....	4
DOWNLOAD AND INSTALLATION	4
1. INTRODUCTION TO SIMEDIF	5
BEFORE STARTING...SOME IMPORTANT COMMENTS.....	5
A LITTLE BIT ABOUT THE HISTORY OF SIMEDIF	5
WHAT CAN SIMEDIF DO?.....	6
WHAT CANNOT SIMEDIF DO?	6
HOW TO SIMULATE A BUILDING IN SIMEDIF	7
Step 1: Enter the site and weather data and simulation period.	7
Step 2: Divide the building into thermal zones.	8
Step 3: Connect the thermal zones with elements.	8
Step 4: Make calculations.....	10
2. DESCRIPTION OF THE CONNECTING ELEMENTS IN SIMEDIF	11
2.1.MASSIVE WALL	11
2.2. PARTITION	11
2.3. WATER WALL.....	12
2.4. GLAZING.....	12
2.5. DOOR AIR MIXING	12
2.6. VENTS	13
3. PHYSICAL MODEL OF A BUILDING IN SIMEDIF	13
3.1. Assumptions and simplifications of the model	13
3.2. Energy balance for massive nodes	14
3.3. Energy balance for non-massive nodes.....	15
4. EXAMPLE 1: Simulation of a building with two thermal zones.	18
4.1. Step 1: Enter the site and weather data and simulation period.	19
4.2. Step 2: Divide the building into thermal zones.	20
4.3. Step 3: Connect the thermal zones with elements.	21
4.3.1. PARTITIONS:.....	23
4.3.2. GLAZING:.....	23

4.3.3. VENTS AND WATER WALLS:.....	24
4.3.4. ENTERING THE DIRECT SOLAR HEAT GAINS: ORIENTATION INDICATORS, SUNLIT AREA AND SOLAR ABSORPTIVITY	24
4.3.5. ENTERING THE CONVECTIVE/RADIATIVE COEFFICIENT h	27
4.4. Step 4: Make calculation.	30

SUMMARY

Welcome to SIMEDIF! This short manual will try to give you an overview of the possibilities offered by SIMEDIF, what you can do with the software and what you cannot do. At the end of this manual, we include an example of application, in order to facilitate your first contact with SIMEDIF.

SIMEDIF is a design tool to calculate the hourly air temperature inside the spaces of a building, the hourly surface temperature of walls, and the hourly auxiliary heating/cooling energy that is needed to maintain the spaces at a constant setpoint temperature. It allows you to analyze the building behavior in different climatic conditions, to detect problems of thermal comfort (overheating or low temperatures), to evaluate possible alternatives in the design of a building, such as variations in its geometry, orientation, location and size of glazed areas, structure and materials of the envelope, the addition of passive and hybrid systems, etc. In existing buildings the software can be used to validate the building model through measured data, or to quantify the effectiveness of possible alternatives for redesign.

This version for Windows was developed by Dr. Silvana Flores Larsen at INENCO (Research Institute of Non-Conventional Energy, U.N.Sa.-CONICET). The original 1984 version for DOS was developed by Drs. Graciela Lesino, Luis Saravia and Dolores Alía. The present version is an adaptation of the original Spanish version made with VisualBasic 6. Currently, a new one is being developed in Python, which will include improvements and new modules for comfort calculation, green walls, and so on.

DOWNLOAD AND INSTALLATION

The software and updates can be downloaded for free from the Internet:

<http://exactas.unsa.edu.ar/simedif/En/>

Requirements (not much!):

Windows XP and 8 MB of free hard disk space

Internet: not required

For Windows Vista and 7 please check if you need to install the additional software.

Once you have downloaded the Setup on your PC, you can install it automatically by unpackaging the file and by making double-click on the Setup executable file. Once installed, you can find the software on the Windows Start button (Start- > Programs -> SIMEDIF). There you will also find this manual in pdf format and a folder with Weather data files.

VERY IMPORTANT NOTE: For the software to work correctly, the OS setting for decimal numbers must use a point and not a comma (for example: 1.2 is the correct number format). To change the Windows setting of the numbers, go to Start-> Control Panel -> Regional Settings and Language -> Regional Options, click the "Customize" button and there choose:

1. "Decimal symbol" point (if it is not among the options, simply type the a point in the keyboard).
2. In "Symbol for separating thousands" select comma. Click "OK" to save the changes.

1. INTRODUCTION TO SIMEDIF

BEFORE STARTING...SOME IMPORTANT COMMENTS

SIMEDIF does not replace the architect or designer of a building, but it helps him/her take design decisions to improve the thermal behavior and consumption energy of the building. That is why the program:

- **Does not check** whether the entered values are correct (for example, thermophysical properties, or heat transfer coefficients).
- **Does not analyze** or interpret the results. It is essential the interpretation of results by the user to detect mistakes in data entry.
- It is required the user to have a **previous basic knowledge of the fundamentals of heat transfer** in buildings in order to use properly SIMEDIF.

The software was designed to simplify the entry data, so the final decision on what elements should be used to describe the building is left to the user. A wrong choice in data entry will produce wrong results.

Some tools have been added to simplify the control of data:

- SIMEDIF can detect some typing errors (e.g. writing letters instead numbers, empty fields, etc.) and it alerts the user about these errors.
- SIMEDIF provides a material database to help the user, which should be checked in each country. This database can be modified to include the own user materials, if needed.
- SIMEDIF is a perfectible software (so a Beta version is distributed test), coded at the moment by only one person, so errors will occasionally appear during use. In the last years, it has been improved with the help of the users, so your comments will be welcome!.

A LITTLE BIT ABOUT THE HISTORY OF SIMEDIF

The name “SIMEDIF” is a contraction between two Spanish words (“Simulación”-Simulation, and “Edificio”-Building). Early SIMEDIF was born in 1984 at the Institute for No Conventional Energy Research (INENCO, UNSA-CONICET) of the National University of Salta and CONICET, Argentina, as a DOS software. The original programming language was the old GW-Basic (Casermeiro and Saravia, 1984). It was used in the '80 by research groups around the country, so SIMEDIF was largely validated throughout years of experimental work in Argentina by numerous groups that have used it for research, design, and simulation of the thermal behavior of buildings (Caso et al., 1986; Binda and Lesino, 1987; Hernández and Lesino, 1993; Reyes and Evans, 1993; Esteves et al., 1994; Beascochea and Filippín, 1998; Hernández et al., 1999; Hernández and Lesino, 2000). In all cases, comparison between the simulated transients of temperature and the experimental data confirmed the reliability of the numerical code.

Throughout the years and with the arrival of Windows, the software code became obsolete, so it was to be recoded, around the year 2000. The new version, for Windows, was improved by including new elements that allowed a more detailed simulation of the building (e.g., the inclusion of doors, the possibility of defining internal gains in each thermal zone, evaporative cooling

systems, earth tubes, a primitive plot tool, etc.). The number of buildings modeled, monitored and successfully simulated by SIMEDIF grew due to the good results obtained using the program and quickly spread to several research groups in Argentina and other countries.

As a result of this effort, SIMEDIF became a software easy-to-use (and learn) , without the complexity of other (very good and complete) existing softwares. It is an ideal tool for non-experienced users and an excellent tool for teaching.

Many people worked during decades in the development of the software. The original DOS version was developed by Dr. Luis Saravia, Dr. Graciela Lesino and Dr. Dolores Alía de Saravia. The Windows version and the inclusion of new calculation modules were developed by Dr. Silvana Flores Larsen. The program is freely available on the Internet (<http://exactas.unsa.edu.ar/simedif/>) from where you can download the latest updates.

WHAT CAN SIMEDIF DO?

Currently, what SIMEDIF can do is:

- It can simulate the hourly temperature of the spaces of a building and the hourly temperatures of wall surfaces.
- It can help you detect thermal comfort problems.
- It is a *design tool* that allows testing different materials, orientations, building geometry, and climates.
- It can calculate two hybrid systems: evaporative coolers and earth tubes.
- It can calculate the heating/cooling power required to reach a pre-defined indoor temperature.

WHAT CANNOT SIMEDIF DO?

Currently, what SIMEDIF cannot do is:

- It does not include mass transfer (humidity calculations).
- It does not calculate natural lighting.
- It does not check data entry values (only a few basic controls like empty fields, zero values, etc.).
- It does not interpret the results.
- It does not replace the building designer.

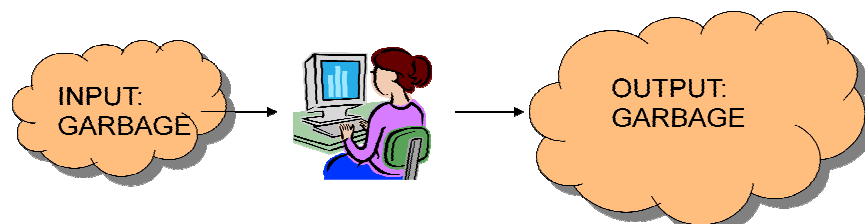


Fig. 1: SIMEDIF is not intelligent. If you enter wrong data, the results will be wrong too.

HOW TO SIMULATE A BUILDING IN SIMEDIF

You have to follow the steps of the following scheme:

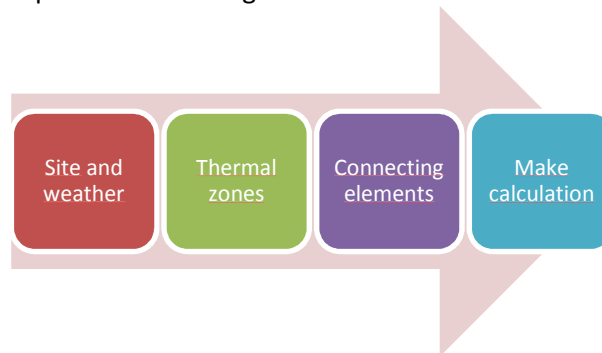


Fig. 2: Steps of data entry and calculation with SIMEDIF.

Step 1: Enter the site and weather data and simulation period.

By clicking in Edit->Site and simulation, a screen will ask you to enter the name of the weather file. SIMEDIF reads TMY3 files¹. You can use your own files or the files provided with the installation, which are included in the folder “Climate”. Once you selected the weather file, you must select the number of days to simulate (from 1 to 365), and the first day of simulation, in case the number of days is lower than 365. Then click on “Save file” button. You will be asked for a file name to save the data.

Site and simulation

Site and weather

Weather file: C:\Silvana\Alemania 2016\Climatic data\Ansbach-hour.csv

Site: Ansbach

Latitude: 49.303

Longitude: 10.573

Altitude (m): 407

Air density (kg/m3): 1.17

Time zone: 1

Simulation period

Number of days to simulate: 366

First day of simulation: January 1

Fig. 3: Screenshot of data entry for site, weather and simulation period in SIMEDIF.

¹ For help about TMY3 format, please go to NREL web page, <http://www.nrel.gov/docs/fy08osti/43156.pdf>

Step 2: Divide the building into thermal zones.

A thermal zone is a volume of air that can be considered at a uniform temperature. A thermal zone can be a space, part of a space, or a group of spaces. The software will calculate the evolution in time of the temperature of each thermal zone, by making an energy balance on the air volume. The zone can be either, forced to have a uniform temperature (in this case, a value of the thermostat setpoint temperature must be defined by the user) or allowed to freely fluctuate.

For each thermal zone you must enter:

1. Name of the thermal zone: a representative name for the space.
2. Air Volume (in m^3)
3. Air renewals (in average): this value is used for all the hours of the simulation
4. Thermostatized (yes/no, and thermostat temperature)

Then click on “Save file of thermal zones”.

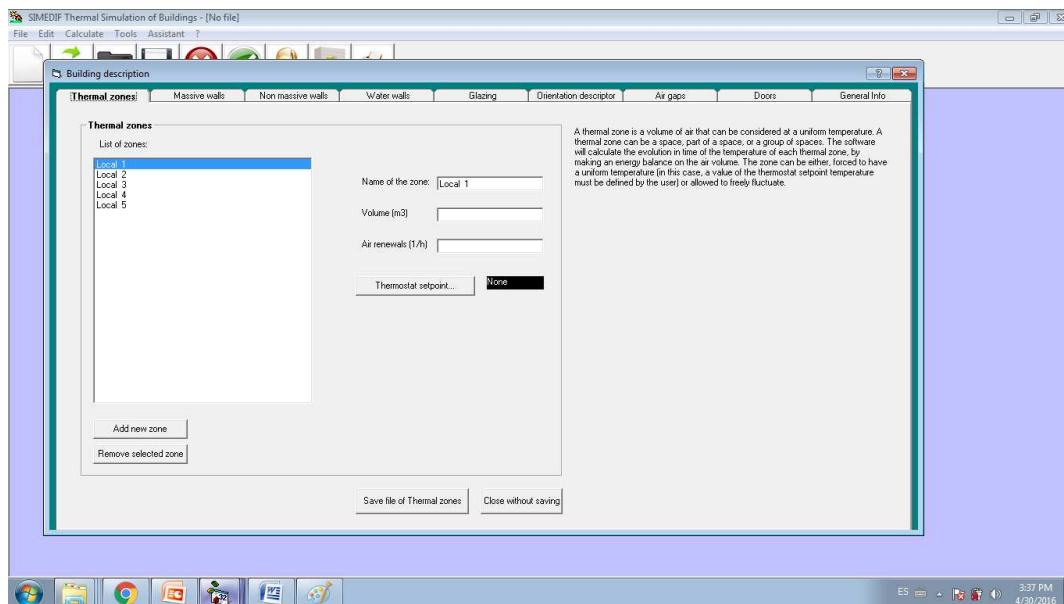


Fig. 4: screenshot of data entry for Thermal zones.

Step 3: Connect the thermal zones with elements.

Each thermal zone can be connected to another thermal zone or with the outdoor environment. This connection is performed through building elements (if you not define any element, there is no connection of this type between thermal zones). These elements in SIMEDIF are of two kinds:

- Solid elements: MASSIVE WALLS, PARTITIONS, GLAZING, and WATER WALLS.
- Air-to-air connections: DOORS and VENTS (one-directional or bi-directional air exchange).

Each element has properties and characteristics that must be defined in the corresponding screen. You can access the elements through 'Edit'. Table 1 shows the fields to be filled for each element. A brief description of the physical modeling of each element is given in the following section.

Fig. 5: data entry for MASSIVE WALLS, one of the connecting elements of SIMEDIF.

MASSIVE WALL	PARTITION	WATER WALL	GLAZING	DOOR AIR MIXING	VENT
Area (m ²)	Area (m ²)	Area (m ²)	Area (m ²)	Height (m)	Area (m2)
Sunlit area (m ²)	Sunlit area (m ²)	Sunlit area (m ²)	U-value day (W/m ² -K)	Width (m)	Height (m)
Solar absorptivity	Solar absorptivity	Solar absorptivity	U-value night (W/m ² -K)	Discharge coefficient	Discharge coefficient
Orientation indicator	Orientation indicator	Orientation indicator			
Convective/radiative coefficient (W/m ² -K)	Convective/radiative coefficient (W/m ² -K)	Convective/radiative coefficient (W/m ² -K)			
Nº of layers & properties	Thermal conductance (W/m ² -K)	Thickness (m)			

Table 1: Properties of each element.

ORIENTATION INDICATORS

While not strictly an “element” of connection, the ORIENTATION INDICATORS will be described here.

Orientation is important for solar radiation. For example, in the South hemisphere, a MASSIVE WALL oriented towards the North receives more solar radiation than other oriented towards the South. Because the data entry in SIMEDIF is not graphical, we have

to indicate manually the orientation of each element. This orientation together with the number of transparent covers the radiation overpasses until reaching certain surface, are described by the ORIENTATION INDICATORS. Thus, the software calculates the solar radiation that reaches the different surfaces depending on their orientation. This calculation uses the hourly global horizontal, diffuse and direct solar radiation data (read from the weather file). For defining an ORIENTATION INDICATOR you must enter: the slope of the surface (from 0° to 90°), the azimuth of the surface (0° towards South, 90° towards East, 180° towards North, and 270° towards West), the albedo, and the number of transparent covers. For example: a MASSIVE WALL oriented to North, on the outside, we will define the ORIENTATION INDICATOR N°1, with slope 90°, azimuth 180°, albedo 0.3 (surroundings covered by grass), and Number of transparent covers 0. This ORIENTATION INDICATOR can be used for all the elements with the same configuration (for example, a PARTITION oriented towards North, another MASSIVE WALL with the same orientation, etc.).

A MASSIVE WALL (or a PARTITION) can be illuminated in one or in its two sides (for example, an exterior wall with a window in front of it that illuminates the interior side of the wall). Thus, the ORIENTATION INDICATORS must be defined for both sides of the element.

Step 4: Make calculations

Once all the elements were described, the calculation is made by selection “Make calculation” in the “Calculate” menu on the toolbar. This launches:

1. A control step of all data entry. If any problem with data is detected (for example, negative/missing values, typing error, etc.), a warning message is shown. In this case, a window will alert about the error and the element where this error was detected.
2. A calculation based on meteorological data is made. SIMEDIF calculates the hourly solar radiation corresponding to each of the ORIENTATION INDICATORS. To do this, solar global on horizontal surface, solar diffuse on horizontal surface and solar direct (beam) radiation is read from the meteorological TMY3 file. Then a conversion to the plane orientation is made and finally the effect of glazing covers on the transmitted solar radiation is calculated. A text file with extension *.rrr is created, that contains the hourly total solar radiation calculated for each ORIENTATION INDICATOR and the hourly temperature.
3. A calculation of the heat transfer coefficients for each element is made. Each element contributes to the heat transfer between zones via a heat transfer coefficient. This coefficient is calculated from the geometry and thermal properties of the element. For details about them, please go to the section about physical modeling.
4. A heat balance for each zone is performed. Firstly, a heat balance on massive nodes is performed (nodes of massive walls and water walls). Once the convergence is achieved, the calculation on air nodes is performed. The results are saved in a text file with extension *.res. This file is used to generate a plot.

2. DESCRIPTION OF THE CONNECTING ELEMENTS IN SIMEDIF

2.1.MASSIVE WALL

A **MASSIVE WALL** is an opaque building element with thermal mass which connects two thermal zones. It is involved in the thermal storage and allows the calculation of the transient conduction effects. Heavy construction elements are considered **MASSIVE WALLS** (even the floor and the roof, if they are massive). A wall can have one or several successive layers of different materials. The number of layers and materials are defined in **WALL LAYERS** section. Each layer may be massive or not, except the two layers at the beginning and at the ending of the wall, which must have mass. For each side of a **MASSIVE WALL** the following properties are needed: total wall area and sunlit area, solar absorption coefficient, convective coefficient, and orientation indicator. A heat balance is performed in the wall that considers solar absorption, convective/radiative heat transfer to air, and heat storage in the thermal mass of the wall. Each layer of the wall is divided into slices (whose number is defined by the user in **WALL LAYERS** section). A heat balance is made for each slice by using the electrical-thermal analogy (in walls, this model includes resistances and condensers). The thermal contact between the wall surfaces and room air is described by means of complexive convective-radiative heat transfer coefficients. The wall surface may or may not receive solar radiation (the solar absorption coefficient and the sunlit area describes this phenomenon).

- ✓ Total wall area: the area involved in the heat transfer (one side of the wall), m^2 .
- ✓ Sunlit wall area: the area of the wall which receives solar radiation (m^2). It should be estimated as an average value in the day. The interior wall surfaces can receive solar radiation from a window. In this case, the sunlit area is the window area and the **ORIENTATION INDICATOR** is related to the window geometry and material.
- ✓ Solar absorption coefficient: it is the absorptivity of the surface in the solar spectrum.
- ✓ Convective heat transfer coefficient: it is the heat transfer coefficient that accounts for convection and radiation (a linearized coefficient), in $W/(m^2 \cdot K)$. A usual way of estimating it is: $h = 5.7 + 3.8 \times V$, where V is the wind speed in m/s (Duffie and Beckman, 2005).
- ✓ Orientation indicator: the indicator defined in **ORIENTATION INDICATOR** section that describes orientation of the wall and the number of transparent covers that solar radiation crosses in its way to the wall surface. If sunlit area is 0, the **ORIENTATION INDICATOR** has no effect.

NOTE: in SIMEDIF, floors in direct contact with ground are defined as MASSIVE WALLS. They can have different layers, but the last one must be the ground (of around 1m of thickness). For the ground side, 0 sunlit area is used, and the convective/radiative coefficient must be very small (for example, $0.001 W/m^2 \cdot K$, because a zero value will return an error of "Division by zero").

2.2. PARTITION

It is an opaque building element with parallel faces with relatively small thermal mass. Some examples are interior gypsum partitions, wood panels, insulating panels, metal sheets, etc. Doors always closed should be described by a **PARTITION**. For a **PARTITION** the following properties are needed: total wall area and sunlit area, solar absorption coefficient, convective-radiative coefficient, orientation indicator, and thermal conductance (that is, the inverse of the thermal resistance).

2.3. WATER WALL

Tank of parallel faces, with total thickness “ d ” (or cylindrical with equivalent diameter “ d ”), filled with water and placed in front of a solar aperture. Water is mixed by natural convection and therefore a uniform temperature of the whole water mass is assumed. There is some question about how isothermal the water is in tanks, but vertical stratification is considered to have little influence on performance (Balcomb, 1992).

2.4. GLAZING

It is an element connecting two zones by means of thermal transmission coefficients that can vary from day to night. This allows simulating night insulation due to the use of wickets, curtains, roll-down blinds, etc. The **GLAZING** elements are neither associated to solar gain (which in fact must be considered in the sunlit area of the wall receiving the solar radiation that enters through the window) nor to ventilation (which is considered in the air renewals of the THERMAL ZONE where the window belongs to).

2.5. DOOR AIR MIXING

A **DOOR AIR MIXING** is an opening between thermal zones that could have different air temperatures. Both zones should be at the same elevation. Thus, there is air exchange between zones by natural convection (air mixing), due to the difference of air density between the two THERMAL ZONES. Its dimensions correspond to the dimensions of the opening. The heat transfer coefficient is a function of the temperature difference between the zones connected by the door under consideration (see the description of DOORS in the Physical Model section). The file with the description of the doors of a building is saved with the extension *.pue. A permanently closed door does not allow convective exchange between thermal zones, so it should be represented by a **PARTITION**. The increase or decrease the flow of air through the door opening because of geometrical factors (as the shape of vane or position of the door sheet) are taken into account through the discharge coefficient ranging between 0 and 1, which depends on the Reynolds number. An indicative value for this coefficient is 0.6. The period when a door is opened -allowing the convective exchange between the thermal zones- is entered into the boxes Opening hour and Closing hour (both integer numbers). This value cannot be a decimal one: if you enter 8 as Opening hour and 8.2 as Closing hour, the code will consider that door is open between 8:00 to 9:00.

The **DOOR AIR MIXING** element has the following characteristics:

- ✓ Height: it is the height of the door opening (m).
- ✓ Width: it is the width of the door opening (m).
- ✓ Discharge Coefficient: the discharge coefficient accounts for the increase or decrease the flow of air through the door opening because of geometrical factors (as the shape of vane or position of the door sheet). An indicative value for this coefficient is 0.6.
- ✓ Opening hour: time when the door becomes open (integer, from 0 to 23).
- ✓ Closing hour: time when the door becomes closed (integer, from 0 to 23).

2.6. VENTS

VENTS are paired openings on the top and bottom of a wall that allow the air circulation from a hotter zone to a colder one due to natural convection. They are used in vented Trombe walls. Their characteristics are the opening area and the distance between the top and bottom vent centers. Vents work as thermal diodes and are important in Trombe wall description. The air movement is unidirectional (from hotter to colder zone), unlike a *door*, in which the convective exchange is bidirectional. For a **VENT** the following properties are needed: THERMAL ZONE of the top vent (the zone heated by the airflow during daytime), area (m^2), height between gap centers (m), and discharge coefficient (usually 0.6).

3. PHYSICAL MODEL OF A BUILDING IN SIMEDIF

3.1. Assumptions and simplifications of the model

The physical model of a building in SIMEDIF has been developed under the following assumptions:

- ✓ The heat fluxes through the walls are considered unidirectional.
- ✓ The heat transfer between the indoor air and the inner surfaces of massive walls, water walls, and Partitions is of convective/radiative nature.
- ✓ The convective-radiative heat transfer coefficients of the surfaces account for convection and radiation. Radiation is therefore linearized.
- ✓ No view factors are taken into account in the computation of radiant energy exchange between surfaces.
- ✓ The temperature distribution at the starting time is known. For the first time step, the soft considers that all the building (spaces and elements) are at the mean outdoor air temperature.
- ✓ Solar incident radiation on any wall is uniformly spread over the entire wall surface.
- ✓ Mass balances are not considered (humidity is not calculated).

The simulated building is divided by the user into “thermal zones”. A “thermal zone” is a building space that can be considered isothermal (thus a zone can be a group of various rooms in the building or a part of a room). Thus, each zone has a unique temperature whose hourly evolution is determined by the software, using the building data, materials, site, orientation, outdoor temperature, and solar radiation in the simulation period. The thermal zones are connected to each other and with the environment by elements that have any of the following thermal characteristics:

- ✓ Storage and heat transfer by conduction, such as brick walls, adobe walls, concrete walls, etc. These elements are called massive walls.
- ✓ Storage into a uniform temperature mass such as water walls where the water is supposed to convect and has a uniform temperature.
- ✓ Heat transfer by conduction without storage, such as wood, expanded polystyrene, etc. In SIMEDIF, these elements are called lightweight walls.
- ✓ Heat transfer by conduction with two heat transfer coefficients (day and night), such as windows with night insulation. These elements are called windows, and they do not describe to solar gain or ventilation.

- ✓ Heat transfer by convection, such as openings in the walls that allow a convective air exchange. These elements are DOORS and VENTS in SIMEDIF.

Each thermal zone is an “air” node. For each element, nodes are defined in surfaces (“surface” nodes) and in massive and water walls extra nodes are defined in the interior (for example, in a wall, the user can select the number of slices used to divide the wall). Thus, an energy balance at each node is made, for which the temperature is to be determined.

3.2. Energy balance for massive nodes

Typically, a MASSIVE WALL is represented as one dimensional and it is sliced into a number of layers of thickness Δx (inner nodes) and $\Delta x/2$ (edge nodes). The inner and surface massive nodes of a wall are separately analyzed (see Figure).

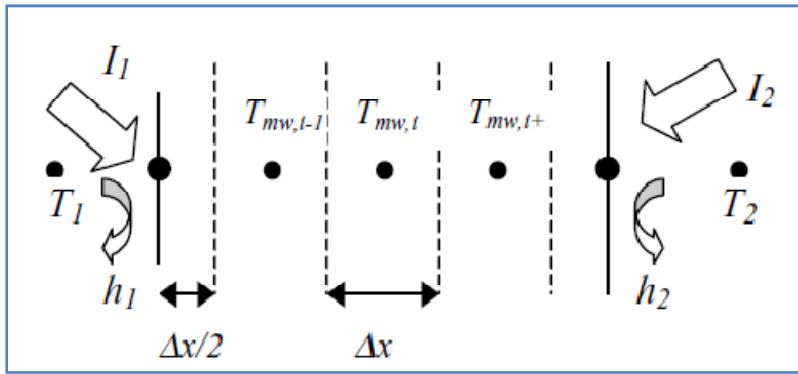


Fig. 6: discretization of a MASSIVE WALL. Each dark circle inside the wall is a “node”.

The energy balance on the inner nodes gives:

$$\rho_{wall} c_{pwall} \frac{\partial T_{mw,i}}{\partial t} = k_{wall} \frac{\partial^2 T_{mw,i}}{\partial x^2}$$

while an energy balance on the left surface node gives:

$$\begin{aligned} \rho_{wall} c_{pwall} A_{wall} \frac{\Delta x}{2} \frac{\partial T_{mw,i}}{\partial t} = \\ \alpha_1 I_1 A_1 - h_1 A_{wall} (T_{mw,i} - T_1) + \\ - \left(-k_{wall} A_{wall} \frac{\partial T_{mw,i}}{\partial x} \right) \end{aligned}$$

A similar expression is obtained for the node on the right surface.

In the case of a WATER WALL, only one node is used (see Fig.), representing the temperature of the whole water mass.

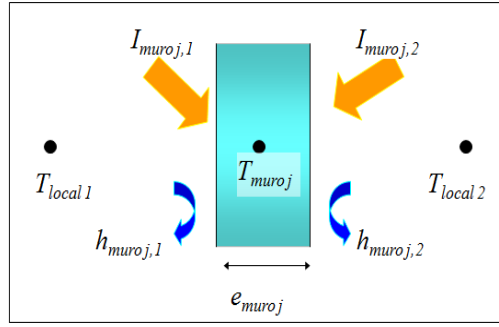


Fig. 7: heat transfer on a **WATER WALL**.

In a **WATER WALL**, the heat balance is:

$$\begin{aligned}
 (\rho c_p)_{agua} (Ae)_{muro j} \frac{\partial T_{muro j}}{\partial t} = & \\
 = (I \alpha Arad)_{muro j,1} + (I \alpha Arad)_{muro j,2} & \\
 - h_{muro j,1} A_{muro j} (T_{muro j} - T_{local 1}) - h_{muro j,2} A_{muro j} (T_{muro j} - T_{local 2}) &
 \end{aligned}$$

The finite-difference explicit method is used to replace the time and spatial derivatives by finite differences. The result is a set of equations for m massive nodes. The temperature at time $t + \Delta t$ can be evaluated from temperatures at the previous time t . This set of equations constitutes an initial value problem. Initial conditions, consisting of the starting storage mass temperatures and air temperatures, are needed (usually the average outdoor air temperature is used).

3.3. Energy balance for non-massive nodes

There are two kinds of non-massive nodes: the nodes on **PARTITIONS** and the nodes on air. The temperatures at the nodes of **PARTITIONS** can be eliminated by combining the conductances between the node and the air into a single conductance.

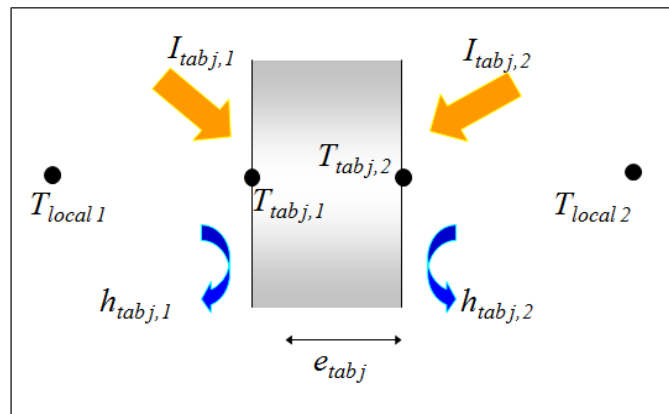


Fig. 8: heat transfer on a **PARTITION**.

In a **PARTITION**, the heat balance is:

$$-h_{tab\ j,1}A_{tab\ j}(T_{tab\ j,1}-T_{local\ 1})+(I\alpha A_{rad})_{tab\ j,1}+C_{tab\ j}A_{tab\ j}(T_{tab\ j,2}-T_{tab\ j,1})=0$$

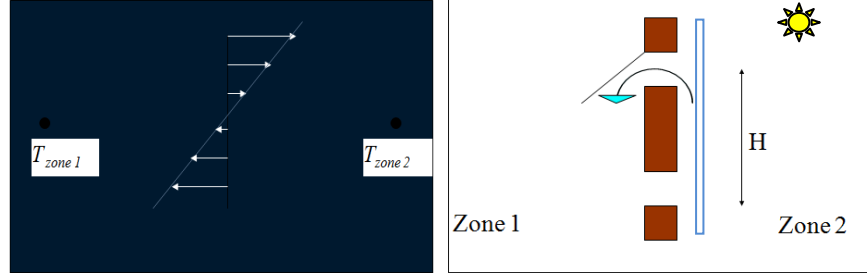


Fig. 9: **DOORS** (left) and **VENTS** (right) in a Trombe wall.

For **DOORS**, the bi-directional air exchange leads to a heat transfer between **THERMAL ZONES** given by:

$$Q_{door} = C_{door} \sqrt{(T_{zone\ 1}^t - T_{zone\ 2}^t)^3}$$

$$C_{door} = 62,66 Width_{door} \frac{C_D}{\sqrt{\theta_{door}}} (Height_{door})^{3/2}$$

For **VENTS**, the one-directional air exchange leads to a heat transfer between **THERMAL ZONES** given by:

$$Q_{airgap} = C_{airgap} \sqrt{(T_{zone\ 1}^t - T_{zone\ 2}^t)^3}$$

$$C_{airgap} = Area_{airgap} (c_p \rho)_{air} C_D \sqrt{\frac{gH_{airgap}}{\theta_{airgap}}}$$

The energy balance for an air node, referred to the control volume of the zone, considers energy contributions due to indoor heat sources, and losses and gains due to the elements which connect a **THERMAL ZONE** to another one:

$$\begin{aligned}
& \frac{(\rho c_p)_{aire} V_i N_{R_i}}{3600s} (T_{local\ i}^t - T_{amb}^t) = Q_{aux_i^t} + Q_{suelo_i^t} + Q_{eva_i^t} + \\
& - \sum_j^{Ntab} U_{tab\ j} A_{tab\ j} (T_{local\ i}^t - T_{local\ (tab\ j, lado\ 2)}^t) - \sum_j^{Npar} h_{pared\ j,1} A_{pared\ j} (T_{local\ i}^t - T_{pared\ j,1}^t) + \\
& - \sum_j^{Nmuros} h_{muro\ j,1} A_{muro\ j} (T_{local\ i}^t - T_{muro\ j}^t) - \sum_j^{Nven} C_{ven\ j}^t A_{ven\ j} (T_{local\ i}^t - T_{local\ (ven\ j, lado\ 2)}^t) + \\
& \sum_j^{Ntab} I_{tab\ j,1}^t \alpha_{tab\ j,1} A_{rad\ tab\ j,1} frac_{tab\ j,1} + \sum_j^{Ntab} I_{tab\ j,2}^t \alpha_{tab\ j,2} A_{rad\ tab\ j,2} (1 - frac_{tab\ j,2}) +
\end{aligned}$$

In this equation the summatory in k indicates a sum over all THERMAL ZONES k in contact with the THERMAL ZONE i ., and the supraindex t indicates the hourly value for the referred quantity.

$U_{lw,j,i}$, $C_{vent,j}$, $C_{door,j}$, $frac_{lw,i,k}$ and Clw,j are given by the following expressions:

$$\begin{aligned}
U_{lw,j} &= \frac{h_{lw,j,i} h_{lw,j,k} C_{lw,j}}{h_{lw,j,i} C_{lw,j} + h_{lw,j,k} C_{lw,j} + h_{lw,j,i} h_{lw,j,k}} \\
C_{vent,j} &= A_{vent,j} c_p \rho C_{Dvent,j} \sqrt{\frac{g H_{vent,j}}{\theta_{vent,j}}} \\
C_{door,j} &= 62,66 W_{door,j} \frac{C_{Ddoor,j}}{\sqrt{\theta_{door,j}}} (H_{door,j})^{3/2} \\
C_{lw,j} &= \frac{k_{lw,j}}{W_{lw,j}} \\
frac_{a,b,c} &= \frac{h_a^b C_a + h_a^b h_a^c}{h_a^b C_a + h_a^c C_a + h_a^b h_a^c}
\end{aligned}$$

The energy balance must repeated for each building THERMAL ZONE. The result is a set of equations for n non-massive nodes. Thus, a system with as many equations as unknown variables is obtained and solved with the usual numerical techniques. Because of the non-linearity of the coefficients, iterations are performed until the convergence is achieved.

The calculation method consists of an explicit finite difference scheme advancing in Δt steps, with Δt a submultiple of one hour (its value is chosen during the data input). The results are saved hour by hour in a file. By using the temperature values at time t and the finite difference explicit method, the temperatures at $t + \Delta t$ in the massive nodes are calculated. These temperatures are introduced in the system of non-massive nodes to obtain the temperatures at $t + \Delta t$. Once all the nodal temperatures are estimated, a balance of the heat gain provided by the solar radiation, the heat loss of the building, and the heat accumulated in the different masses is performed. These calculations allow the detection of possible problems with the input data.

The use of the explicit finite difference scheme restricts the possible values of Δt to avoid oscillations in the numerical solutions. This instability causes the calculated node temperatures to oscillate with increasing error in each step, which is a common error when using finite-difference algorithms.

4. EXAMPLE 1: Simulation of a building with two thermal zones.

Take a look at the building of the Figure. It is a small house with a livingroom, a bathroom and a bedroom, placed in Salta city, in the North of Argentina. Exterior walls are 3-layered (massive ceramic brick 0.12m thick + expanded polystyrene 0.05m + massive ceramic brick 0.12m). The interior partitions between spaces are made of gypsum board (gypsum board 0.02m thick + air camera 0.05m thick + gypsum board 0.02m thick). The roofing construction – from outdoors to indoors- is a galvanized iron sheet with 0.045m of thermal insulation (expanded polystyrene) and pine wood. Floor is a concrete layer (0.1m thick) on the ground, with a ceramic gray cover (0.005m thick). Interior walls are painted with beige color. Wood doors are 2m height, 0.8m width and 0.045m thick. Both windows have double glazing (glass 4mm + air camera 6mm + glass 4mm) and they are 2m x 1m. The window in bedroom has a wood shutter that remains closed during the night. We want to know the thermal of the building in winter (June) and in summer (December).

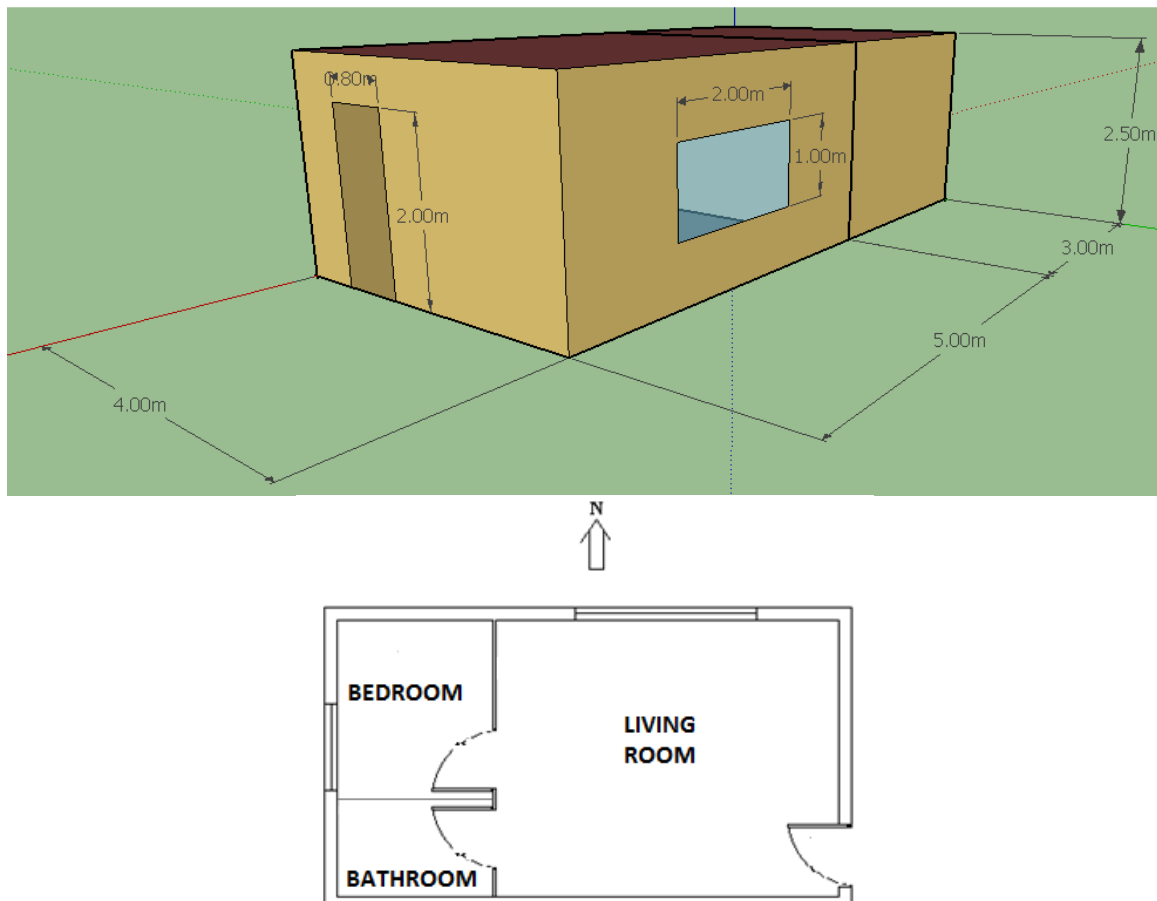


Fig. 1: building of the example.

4.1. Step 1: Enter the site and weather data and simulation period.

Click on File ->New file and type a generic name for the group of files of the simulation. The file name (in this case, “example1”) will appear in the top of the SIMEDIF screen. All future files for this simulation will be named with this name and with different extensions. When you open an existing file, you can click on any of them; all the files will be read and loaded in SIMEDIF.

By clicking in Edit->Site and simulation, a screen will ask you to enter the name of the weather file. In this case, we select the file for Salta city (see Fig). The software reads the file and completes data of latitude, longitude, altitude, and time zone. The air density is automatically calculated from the altitude value.

In “Simulation period” frame you can select the number of days to simulate and the first day of simulation. In this case, we could simulate 365 days starting on January 1st, or all the days of June and then, in a new simulation, all the days of December². There are two reasons to simulate the building once by month. The first one, because of the calculation time (it is higher if you simulate a whole year). The second one, and more important, because a unique constant value is used for the air renewals in the THERMAL ZONES, which could be not the case if you want different ventilation levels in winter than in summer.

Once entered the data, you must click on “Save file” to save the data of this screen. If you did not enter previously a file name, you will be asked for a file name and folder. A new file *example1.gen* will be created.

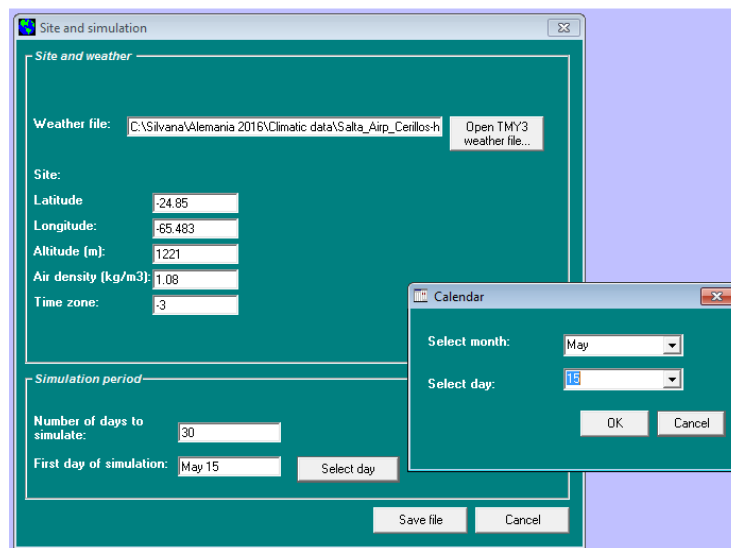


Fig. 2: Site and simulation screen.

When the format of numbers in Windows is not correct, a warning message will appear when you try to save the file. Check “Download and installation” section to fix the error.

² Current SIMEDIF version does need to enter a few previous days of simulation to reach the conditions of the first day of simulation you want. Usually it is around 10-12 days for massive buildings and around 3-5 days for lightweight buildings. Thus, if you are interested in simulating June, the first day of simulation should around May 15th.

4.2. Step 2: Divide the building into thermal zones.

In this example we could simulate three THERMAL ZONES (Bathroom, Bedroom, and Living room). Because we want a quicker approach to the building thermal behavior, we could simulate two THERMAL ZONES or even only one for the whole building. We will work in this case with two THERMAL ZONES (one for the Living room and one for the Bedroom/Bathroom). The geometry of each THERMAL ZONE is shown in the following Table 1.

THERMAL ZONE name	Width	Length	Height	Volume	Air renewals
Living_room	5m	4m	2.5m	50 m ³	2 (1/h)
Bedroom/bathroom	3m	4m	2.5m	30 m ³	2 (1/h)

Table 1: geometry of the THERMAL ZONES and air renewals assumed for each one.

The data for THERMAL ZONES is entered by clicking in Edit->Thermal zones, as shown in Fig. 3. Five zones appear by default. You have to delete the non-used zones. Because we will calculate the indoor temperature without thermostatizing, we don't enter a value for the thermostat. Once all the data was entered, you must click on "Save file of Thermal zones" button. This action will create a new file named *example1.loc*.

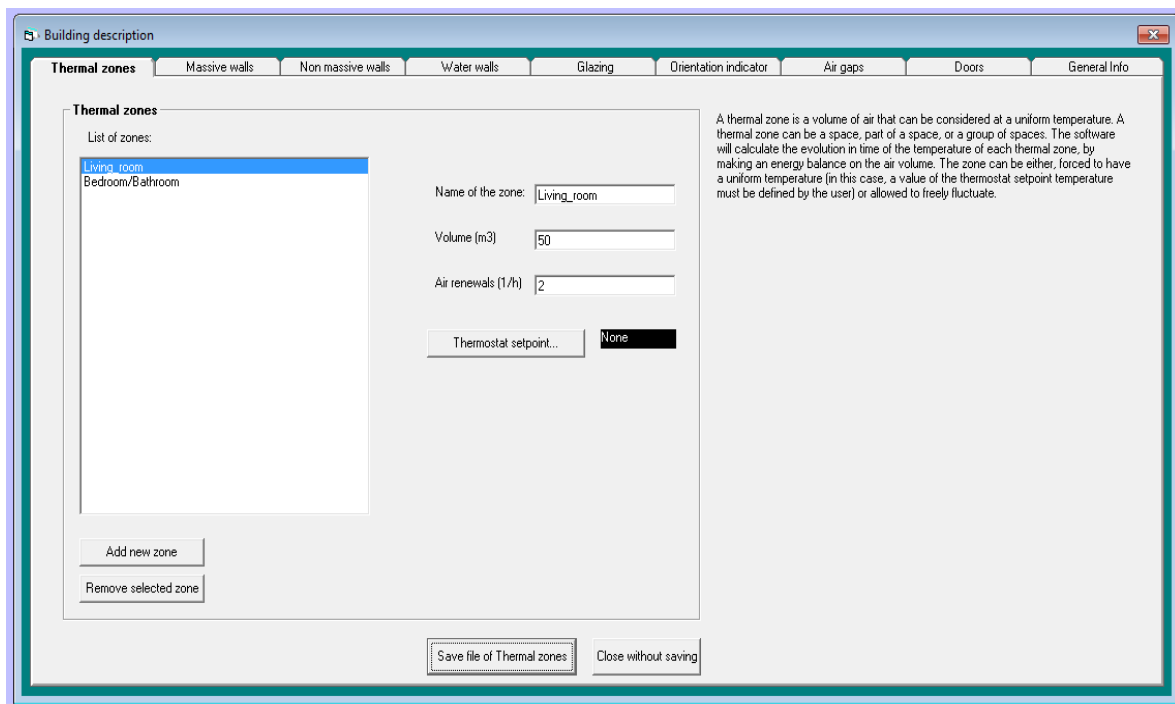


Fig. 3: THERMAL ZONES screen.

4.3. Step 3: Connect the thermal zones with elements.

The following step consists in detecting the type of element that connects the THERMAL ZONES. Usually you will need a plane of the building, where you will detect the elements. In this example, we have seven MASSIVE WALLS (the walls of the envelope which are of massive brick, and the floor, which in SIMEDIF is defined as a MASSIVE WALL because it is in direct contact with ground), which are named from M1 to M7 in Fig. 4 (colors identify the elements). We have two doors (D1 and D2) and two glazed windows (G1 and G2). Also we have three PARTITIONS: an interior partition N1 and two roofs (N2 and N3). A list of the elements and their sizes is shown in Table 2.

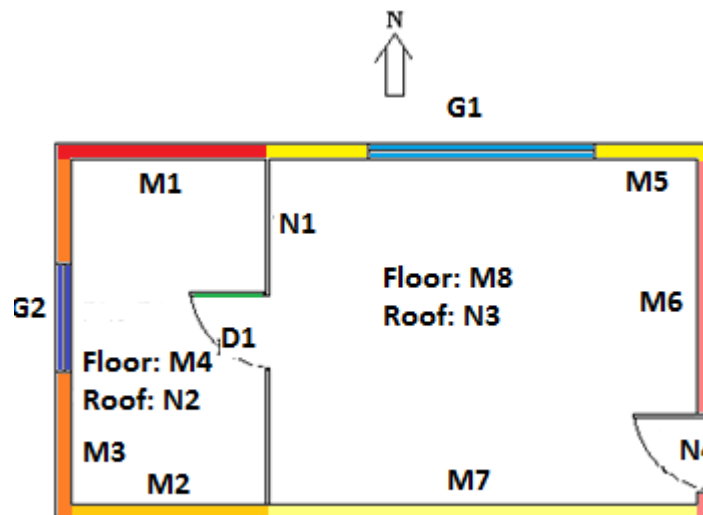


Fig. 4: scheme of the elements of the building (M: MASSIVE WALLS, N: PARTITIONS, D: DOORS, G: GLAZING).

Element	Connecting:		Size	Area
MASSIVE WALLS	M1	Outdoors-Bedroom/Bathroom	3m x 2.5m	7.5 m ²
	M2	Outdoors- Bedroom/Bathroom	3m x 2.5m	7.5 m ²
	M3	Outdoors- Bedroom/Bathroom	4m x 2.5m-G2	8 m ²
	M4	Outdoors- Bedroom/Bathroom	3m x 4m	12 m ²
	M5	Outdoors-Living_room	5m x 2.5m - G1	10.5 m ²
	M6	Outdoors- Living_room	4m x 2.5m-N4	8.4 m ²

	M7	Outdoors- Living_room	5m x 2.5m	12.5 m ²
	M8	Outdoors- Living_room	5m x 4m	20 m ²
	N1	Bedroom/Bathroom – Living_room	4m x 2.5m - D1	8.4 m ²
PARTITION	N2	Outdoors- Bedroom/Bathroom	3m x 4m	12 m ²
	N3	Outdoors- Living_room	5m x 4m	20 m ²
	N4	Outdoors- Living_room	0.8m x 2m	1.6 m ²
GLAZING	G1	Outdoors- Living_room	2m x 1m	2 m ²
	G2	Outdoors- Bedroom/Bathroom	2m x 1m	2 m ²
DOORS	D1	Bedroom/Bathroom – Living_room	0.8m x 2m	1.6 m ²

Table 2: elements of the building and their sizes.

4.3.1. MASSIVE WALLS: you have seven MASSIVE WALLS. Thus, M1 is the wall of the Bedroom/Bathroom facing North, while M5 is the wall of the Living_room facing North. They belong to different THERMAL ZONES, so we need to split the whole wall in this two M1 and M5. With the same reasoning, the building floor is splitted into two MASSIVE WALLS: M4 is the floor of the Bedroom/Bathroom (that is, it connects this zone with outdoors) and M8 is the floor of the Living_room. For each wall you will need to enter the total area (from Table 2). Remember to subtract the areas of doors and windows of the wall area!. The other coefficients will be explained in the next section.

For each wall you have to define the number of layers. The order of layers appears in the legend in the top “Layer 1 faces:” (it depends on the order you selected in the connections, so it can be different from one wall to the other). For each layer, you have to indicate if the layer has thermal mass (yes/no, si/no in Spanish). You must select “no” only for layers of thermal insulation, otherwise select “si”. Also you will must enter the layer thickness, the layer thermal properties (thermal conductivity, density, and specific heat at constant pressure, you have a list of materials if you), and the number of internal points you want to calculate in each layer (usually one point every 4-5 cm). Remember that, because of the physical model, the first and last layer must have thermal mass.

4.3.2. DOOR AIR MIXING: doors, in the colloquial sense of the word, have two functions: 1- exchange of air between two rooms (when open), which is simulated by the DOOR element in SIMEDIF; and 2- surface that avoids the air exchange (when closed), which is simulated by a PARTITION in SIMEDIF. That is, when a door is closed most of the time (as

would be the case of a main door in the entrance of a house), in SIMEDIF it is preferable to define it as a PARTITION. While for a door that most of the time is open (partially or totally) and it allows the air exchange, then you have to define it as a DOOR element in SIMEDIF (always remember that, in SIMEDIF, the DOOR and VENT elements are related with the exchange of air). In our example, we will consider that the door connecting the Bedroom/Bathroom with the Living_room is half open most of the time, allowing the convective exchange between the two THERMAL ZONES, so it is simulated as DOOR D1 (for which you must enter the height, the width, the discharge coefficient that is usually 0.6, and the timing of opening and closing the door). The door in the house entrance is closed most of the time, so it will be considered as a NON MASSIVE element (N4).

4.3.3. PARTITIONS: besides PARTITION N4 corresponding to the door in the house entrance, there are other constructions that do not accumulate heat (materials with poor thermal mass). These are: the interior partition of gypsum board that separates the Bedroom/Bathroom from the Living_room (N1) and the ceilings of both THERMAL ZONES (N2 and N3, made of metal + thermal insulation + wood). For PARTITIONS you need to enter: the total area, the coefficient of solar absorption, the heat transfer coefficient (explained later) and the thermal conductance C (that is, thermal conductivity/thickness).

In this case, the PARTITION N1 corresponds to a gypsum board (27mm thick) + air camera (50mm) + gypsum board (27mm thick). The thermal conductivity of the gypsum board is 0.58 W/m-K. Because it is 3-layered, the global thermal conductance C_{total} is calculated as:

$$1/C_{total} = 1/C_{gypsum} + 1/C_{air} + 1/C_{gypsum}$$

$$\text{Thus, } C_{total} = (0.027/0.58 + 0.05/0.025 + 0.027/0.58)^{-1} \text{ W/m}^2\text{-K} = 0.48 \text{ W/m}^2\text{-K}.$$

The PARTITIONS N2 and N3 are three-layered: galvanized sheet (thickness 0.7 mm, thermal conductivity 58 W/m-K) with thermal insulation of expanded polystyrene (45mm thick, thermal conductivity 0.041 W/m-K) and pine wood roofing (25mm thick, thermal conductivity 0.153 W/m-K). Following the same procedure for the calculation of the thermal conductance previously described, the obtained value is $C_{total} = 0.79 \text{ W/m}^2\text{-K}$. The PARTITION N4 corresponds to a wooden plate 45 mm thick, thermal conductivity 0.153 W/m-K, and thermal conductance of 3.4 W/m-K.

4.3.4. GLAZING: in the example there are two double glazed windows, G1 and G2, with shutters for darkening (it is assumed that they are closed at night), so that heat transfer will be different during the day (when the heat passes only through the double glazing) than during the night (when heat passes through the double glazing and the shutters). Therefore, two values for the heat transfer coefficients (U-value) must be defined, one for the day and one for the night. The common value of U-value for a double glazing is around 3.3 W/m-K, while for double glazing plus wood shutters is around 2.8 W/m-K. The exact values depend on the materials and they are provided by the manufacturer.

It is important to note that a window has two functions in a building: it allows the solar radiation to enter, it allows the outdoor air to enter, and it is an element of heat transfer between outdoors and indoors. In SIMEDIF the functions of a building are separately entered: solar radiation is accounted for via the ORIENTATION INDICATORS, air flow coming from outdoors (ventilation) is accounted for via the air renewals value defined for the THERMAL ZONE or via the definition of a DOOR element. Only the third function is accounted for by the GLAZING element.

Until this point in our example, we have not included the solar radiation coming through the windows G1 and G2 and entering to the Living_room and the Bedroom/Bathroom. This will be done when we define the ORIENTATION INDICATORS (explained later). As in our example we considered a winter period, it is assumed that the windows are closed, so we have not added a ventilation function for them. If it was summer and the windows are open permanently, we might consider entering the outside air by the number of air changes. If they were open, say, 8 to 10 am, we could enter this ventilation through a door element D2 with those hours of opening and closing.

4.3.5. VENTS AND WATER WALLS: in this example these elements are not used. Whenever an item is not used, you must delete all them that appear on the list by default. If you forget to do this, when you control the files (Run-> File Control), the software will indicate which elements should be deleted.

4.3.6. ENTERING THE DIRECT SOLAR HEAT GAINS: ORIENTATION INDICATORS, SUNLIT AREA AND SOLAR ABSORPTIVITY

ORIENTATION INDICATORS

At this point, the orientation of the building has not been considered at all. Orientation is important for solar radiation. For example, in the South hemisphere, a MASSIVE WALL oriented towards the North receives more solar radiation than other oriented towards the South. Because the data entry in SIMEDIF is not graphical, we have to indicate manually the orientation of each element. This orientation together with the number of transparent covers the radiation overpasses until reaching certain surface, are described by the ORIENTATION INDICATORS. Thus, the software calculates the solar radiation that reaches the different surfaces depending on their orientation. This calculation uses the hourly global horizontal, diffuse and direct solar radiation data (read from the weather file). For defining an ORIENTATION INDICATOR you must enter: the slope of the surface (from 0° to 90°), the azimuth of the surface (0° towards South, 90° towards East, 180° towards North, and 270° towards West), the albedo, and the number of transparent covers. For example: a MASSIVE WALL oriented to North, on the outside, we will define the ORIENTATION INDICATOR N°1, with slope 90°, azimuth 180°, albedo 0.3 (surroundings covered by grass), and Number of transparent covers 0. This ORIENTATION INDICATOR can be used for all

the elements with the same configuration (for example, a PARTITION oriented towards North, another MASSIVE WALL with the same orientation, etc.).

A MASSIVE (or NON MASSIVE) WALL can be illuminated in one or in its two sides (for example, an exterior wall with a window in front of it that illuminates the interior side of the wall). Thus, the ORIENTATION INDICATORS must be defined for both sides of the element. In our example, all the exterior walls (M1, M2, M3, M5, M6 and M7), ceilings (N2 and N3) and the entrance wood door (N4) receive solar radiation (the software will calculate how much radiation affects each one depending on your orientation). The radiation entering through G1 and G2 falls mainly on the floors (this is an assumption, an average on the day), that is, the radiation entering through the GLAZING G1 reaches M8 (on its interior side) and the solar radiation entering through G2 reaches M4 (on its interior side). With this data, we can construct the following table (it is suggested to analyze carefully how the index for the walls M4 and M8 are defined):

Element	Element side where solar radiation impings	Slope	Azimuth	Albedo	Number of transparent covers
M1	Outside	90	180 (North)	0.3	0
M2	Outside	90	0 (South)	0.3	0
M3	Outside	90	270 (West)	0.3	0
M4	Inside (Bedroom/Bathr oom)	90	270 (West)	0.3	2
M5	Outside	90	180 (North)	0.3	0
M6	Outside	90	90 (East)	0.3	0
M7	Outside	90	0 (South)	0.3	0
M8	Inside (Living_room)	90	180 (North)	0.3	2
N2	Outside	0	No matter	0.3	0
N3	Exterior	0	No matter	0.3	0

N4	Exterior	90	90 (East)	0.3	0
----	----------	----	-----------	-----	---

Table 3: elements of the example that are illuminated by the sun.

Of course, when the slope is 0, it does not matter which value is chosen for the azimuth (here we use Azimuth=0). The albedo depends on the reflectance of the surroundings. Finally, if you compare the last four columns you will detect repeated elements (in this case, M1 and M5 will use the same ORIENTATION INDICATOR; the same applies to M2 and M7, and to M6 and N4). In our case, six ORIENTATION INDICATORS will be defined, which can be seen in Table 4.

ORIENTATION INDICATOR	Slope	Azimuth	Albedo	Nº of covers	It is applied to:
1	90	180	0.3	0	M1, M5
2	90	0	0.3	0	M2, M7
3	90	270	0.3	0	M3
4	90	270	0.3	2	M4 (interior)
5	90	90	0.3	0	M6, N4
6	90	180	0.3	2	M8 (interior)
7	0	0	0.3	0	N2, N3

Table 4: ORIENTATION INDICATORS defined for the example on Fig. 1.

SUNLIT AREA

The sunlit area in the case of exterior surfaces exposed to solar radiation is the surface area considered, as long as there are no objects around the shade the surface, as large trees or other buildings. In the case of internal surfaces where radiation is reached after it crosses a glazing panel, the sunlit area is the area of the glazing. For example, we will assume that all solar radiation entering through the GLAZING G2 of 2m², will reach M4 -

Bedroom side. Thus the sunlit area of M4-Bedroom side, is 2m^2 . Similarly, for P8 – Living_room we will define a sunlit area of 2m^2 .

ABSORPTION COEFFICIENTS

Absorption coefficients depend on the color of the surface and they can be obtained from tables in the literature. In our example, for the Bedroom floor and the Living_room floor we will use an absorption coefficient of 0.7 (gray cement). For the exterior walls made of solid brick (without plastering) we will use 0.6 (brown-orange). In the case of N2 and N3, we will use an absorption coefficient of 0.3 (assuming the metal sheet is painted with a light color).

Surfaces of MASSIVE and PARTITIONS that do not receive radiation also must have assigned an ORIENTATION INDICATOR, only to avoid crashing of the software. In fact, you can use any of the predefined ORIENTATION INDICATORS together with a zero sunlit area. Thus, for N1 we will use any index (for example 1), with sunlit area equaling zero.

4.3.7. ENTERING THE CONVECTIVE/RADIATIVE COEFFICIENT h

You must define the convective/radiative coefficients for inside and outside surfaces of WALLS (MASSIVE and NON MASSIVE). This coefficient is related to air velocity v . There are several correlations to estimate this coefficient. For plane surfaces, it is usually calculated from the Duffie-Beckman (1991) relationship $h = 5.7 + 3.8v$, where v is the air velocity in m/s, but you can use any other correlation of the literature. In this example, we will use convective/radiative coefficients of $6 \text{ W/m}^2\text{-K}$ (for interior surfaces that do not receive solar radiation), $8 \text{ W/m}^2\text{-K}$ (for interior surfaces heated by direct solar radiation), and $10 \text{ W/m}^2\text{-K}$ (for external surfaces, corresponding to an average wind speed in June in Salta of about 2.5 m/s). Remember that for outside surface of the floor (it is a fictitious concept because you have 1m of ground), we will use a low coefficient, say $0.1 \text{ W/m}^2\text{-K}$ (in fact, this value should be zero, but in this case the software gives an error message of “Division by zero”).

Then, the elements have the coefficients shown in Tables 5 to 10.

MASSIVE WALL	Side	Solar Absorption coeff.	h ($\text{W/m}^2\text{-K}$)	ORIENTATION INDICATOR	Sunlit area (m^2)	Area (m^2)	Nº of layers
M1	Outside	0.6	10	1	7.5	7.5	3

	Inside (Bedroom)	0.6 (Anyone)	6	1 (Anyone)	0		
M2	Outside	0.6	10	2	7.5		
	Inside (Bedroom)	0.6 (Anyone)	6	2 (Anyone)	0	7.5	3
M3	Outside	0.6	10	3	8.5		
	Inside (Bedroom)	0.6 (Anyone)	6	3 (Anyone)	0	8.5	3
M4	Outside	0.7 (Anyone)	0.1	4 (Anyone)	0		
	Inside (Bedroom)	0.7	8	4	1.5	12	3
M5	Outside	0.6	10	1	9.5		
	Inside (Living_room)	0.6 (Anyone)	6	1 (Anyone)	0	9.5	3
M6	Outside	0.6	10	5 (Anyone)	8.4		
	Inside (Living_room)	0.6 (Anyone)	6	5 (Anyone)	0	8.4	3
M7	Outside	0.6	10	2	12.5		
	Inside (Living_room)	0.6 (Anyone)	6	2 (Anyone)	0	12.5	3
M8	Outside	0.7 (Anyone)	0.1	6 (Anyone)	0		
	Inside (Living_room)	0.7	8	6	3	20	3

Table 5: Data entry for MASSIVE WALLS.

PARTITION	Side	Solar Absorption coeff.	h (W/m ² -K)	ORIENTATION INDICATOR	Sunlit area (m ²)	Area (m ²)	Thermal transmittance.
N1	Inside (Bedroom)	0.6 (Anyone)	6	1 (Anyone)	0	8.4	18
	Inside (Living_room)	0.6 (Anyone)	6	1 (Anyone)	0		
N2	Outside	0.3	10	7	12	12	0.8
	Inside (Bedroom)	0.6 (Anyone)	6	7 (Anyone)	0		
N3	Outside	0.3	10	7	20	20	0.8
	Inside (Living_room)	0.6 (Anyone)	6	7 (Anyone)	0		
N4	Outside	0.6	10	5	1.6	1.6	3.6
	Inside (Living_room)	0.6 (Anyone)	6	5 (Anyone)	0		

Table 6: Data entry for PARTITIONS.

GLAZING	Connecting	Area (m ²)	U-value (day)	U-value (night)
G1	Outdoors-Living_room	3	3.3	3.3
G2	Outdoors-Bedroom	1.5	3.3	2.8

Table 7: Data entry for GLAZING.

DOOR	Connecting	Height (m)	Width (m)	Discharge Coeff.
D1	Bedroom- Living_room	2	0.8	0.6

Table 8: Data entry for DOORS.

MASSIVE WALL	Nº of layer	With mass?	k (W/m-K)	Thickness (m)	ρ (kg/m ³)	C_p (J/kg)	Nº of internal points to simulate
M1, M2, M3, M5, M6, M7	1	Yes	0.9	0.12	1800	1130	2
	2	No	0.04	0.05	-	-	-
	3	Yes	0.9	0.12	1800	1130	2
	1(ext)	Yes	0.6	1.00	1600	1130	10
M4, M8	2	No	0.04	0.05	-	-	-
	3	Yes	1.7	0.10	2400	1080	2

Tabla 9: Data entry of MASSIVE WALL layers.

If you are here, congratulations!! You finally finished the data entry.

6.4. Step 4: Make calculation.

The last step is to perform the calculation (look for it in the Toolbar menu). Before starting the mathematical calculations, the software checks the input data, to detect typing errors or null/empty values. Then a new screen appears, asking the user about the initial temperatures to start the calculation (usually the average outside temperature, which in this case is 10.4°C is entered), the internal gains of each local in W (in this case we do not consider the internal gains), the number of time steps to divide one hour (a message in the frame below indicates an approximate value for this box), and the opening and closing hours of shutters of the windows (by default, open at 8 and close to 22). Then click on Calculate button. A plot will be shown with the results. You can open the results file (*.res) with Excel or with a text editor.