ProCasaClima 2013: CasaClima building simulation software

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Abstract

Since 2002 the CasaClima building quality certification system has been a widely recognized method. Certification of buildings is carried out with standard parameters of calculation. For this reason the results obtained do not show the real consumption, but they are indexes that allow us to compare different buildings from each other. However, the CasaClima Program has been developed in order to guarantee a high level of quality of the construction process for low-energy buildings. Looking not only at the certification, but also at a proper building design, CasaClima has integrated into its software a dynamic simulation of the building, whose characteristics and results will be presented in this paper. Having to deal with technicians, whose work is focused on the rapidity of the design, the goal, from the beginning of the development, was to allow these professionals to make the calculation for energy certification and at the same time, without further additional working, offer them the results of a dynamic simulation. For this reason some input of the calculation is fixed and unchangeable. In the CasaClima philosophy, the energy efficiency starts from the building envelope, which is associated with a system that is simple, but efficient, and able to cover the small energy needs required. For this reason, the building envelope plays a leading role and CasaClima dynamic simulation serves mainly to its design. Thus, the results show the air and operating temperature within the environment, without any air conditioning system, from which it is also possible to obtain an evaluation of the indoor comfort.

1. Introduction

Many designers still make the mistake of thinking that the results of an energy certification represent the real consumption of the building, not considering that many inputs in that calculation are standardized (e.g. internal loads, hours of operation of the systems, etc.) and then, that the results are simply indexes used to make comparisons between buildings. CasaClima has integrated a dynamic simulation within its software certification to enable designers to perform a correct design of the building envelope. Modern buildings cannot be designed and built only with the idea of reducing consumption, but also the results of comfort must be evaluated along with the energy ones. The living comfort cannot be ignored inside a modern building. In this paper the interesting approach of CasaClima is analyzed, which allows the designer to make a dynamic simulation with the input of steady-state calculation, which means no further work

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compared to the certification of the building. This paper analyzes the input needed, the characteristics of the calculation algorithm and the results that are obtained. In the final section strengths and weaknesses of the calculation tool are also highlighted, with a reflection on future developments.

2. Methodology

With the CasaClima calculation tool it is possible to:

- Calculate heating, cooling, domestic hot water and lighting demand (UNI TS 11300: 2008 and UNI EN 15193: 2008)
- Calculate the internal temperature of a room during the summer without air conditioning systems (UNI EN ISO 13791: 2012)
- Classify the internal environment based on thermal comfort and humidity according to UNI EN 15251: 2008 and according to the adaptive comfort method of Nicol and Humphreys.

To obtain the numerical and graphical output, it is necessary to enter the characteristics of the site, of the building envelope and of the systems.

3. Simulation parameters

3.1 Weather data

The weather data used in the heating and cooling steady-state calculation are referred to the UNI 10349: 2008. Whereas the data of all Italian municipalities are not available, the software allows us to carry out an interpolation of the climatic conditions of the two neighboring provinces to the municipality, taking into account the relative distances and height differences. For the dynamic simulation hourly weather data provided by the Italian Heat Technology Committee (CTI) on its website are used.

3.2 Building elements

All the external elements, both vertical and horizontal, opaque and glazed, must be included in the calculation. The inclusion of the interior walls and floors is also recommended to take into account the real heat capacity of the building and then to make a better assessment of the use of solar and internal gains.

To characterize the opaque elements it is necessary to specify the characteristics of the materials that compose them, defining the following parameters for each material.

Table 1 – Material parameters

Parameters	**Units**
Conductivity (λ)	W/mK
Density	Kg/m^3
Thermal capacity	kJ/kgK
Water vapor permeability (μ)	-
Water content of material (k)	Kg/kg

It is possible to evaluate up to four non homogeneous sections within a single stratigraphy.

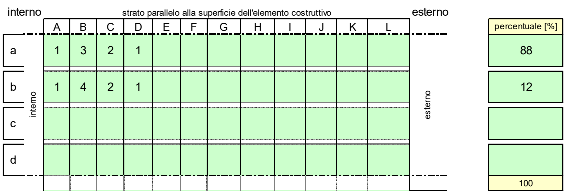

Fig. 1 – Building envelope

For each stratigraphy the following are obtained:

- thermal transmittance
- periodic thermal transmittance
- internal heat capacity
- external heat capacity
- time shift
- decrement factor
- internal thermal admittance

To characterize the glazed elements the characteristics of their glass, frame and spacer must be included.

3.3 Ventilation

In the software there is a sheet dedicated to the evaluation of the building ventilation, both natural and mechanical, during summer and winter. For the natural ventilation it is possible to enter the air change rate (vol / h) directly as well as to assess more in detail the benefits that a night ventilation has on the cooling demand, selecting among six different configurations of the openings, according to the UNI EN ISO 13791: 2012. For the mechanical ventilation, it is possible to insert up to ten ventilation devices with recuperative or regenerative heat exchanger and even up to three ventilation devices with heat pump inside.

3.4 Internal gains

The calculation tool provides standard values [W/m²] for the internal gains, according to the use of the building. The values are normally identical for both winter and summer. However, it is possible to assign different values between the two periods

3.5 Solar gains

The software takes into account the solar gains both on the opaque and glazed building elements. It is possible to evaluate the effect of solar shading devices, mobile or fixed, placed in correspondence of windows.
The mobile shading devices are characterized by the shading factor Fc, which can be entered directly (certified value of the product), or calculated according to:

- The position of the shading device (internal or external);
- type of shading device;
- optical parameters of absorption and transmission of the shading device.

The overhangs can be assessed through both a simplified or detailed method.
While the simplified method uses a fixed factor for the reduction of the solar radiation, the detailed one takes into account the actual geometry of the overhangs. Thanks to this method, it is also possible to consider not only the overhangs of the building, but also those due to external obstacles, modeled through azimuthal coordinates.

3.6 Schedule

The hourly schedule of the internal loads (people, equipment and lighting) and ventilation cannot be changed by the user. In order to simplify and speed up the work of the technicians, some standard profiles have been defined according to the intended use of the building.

4. Discussion and results

The results are expressed both in final (thermal or electric) and primary energy.

Final energy	Montepulciano		Siena		
	Thermal	Electric	Therma	Electric	
Heating	1.080	1.002	822	689	kWh/a
Cooling		1.179		1.700	kWh/a
Hot water	316	2.411	282	2.533	kWh/a
Lighting		1.977		1.977	kWh/a
electrical auxiliaries		1.384		1.247	kWh/a
Qu=	**1.396**	**7.952**	**1.104**	**8.145**	**kWh/a**

Primary Energy	Montepulciano		Siena		
	kWh/a	kWh/m²a	kWh/a	kWh/m²a	
Heating	3.257	24,5	2.319	17,5	EP_i
Cooling	2.562	19,3	3.696	27,8	EP_c
Hot water	5.558	41,8	5.789	43,6	EP_{ACS}
Lighting	4298	32,4	4.298	32,4	EP_{ill}
electrical auxiliaries	3009	22,7	2.710	20,4	EPaux,e
Q_P=	**18.684**	**140,7**	**18.812**	**141,7**	**kWh/a**

Fig. 2 – Energy results

The CasaClima rating takes into account the demand for the heating of the building envelope and the CO_2 emissions for the use of heating, cooling, domestic hot water and lighting.

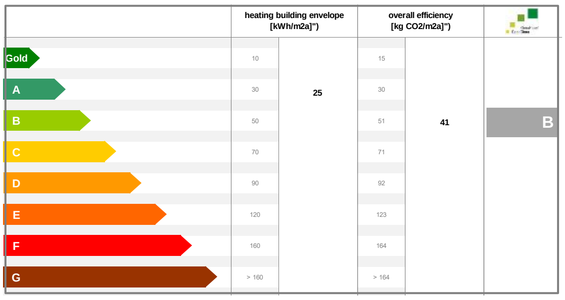

Fig. 3 – CasaClima rating

The graph of the dynamic simulation shows the annual trend of the air temperature as well as the absolute humidity inside and outside the building, the operative temperature and the perceived temperature. The perceived temperature also takes into account the internal humidity; in this way the comfort is more accurately evaluated.

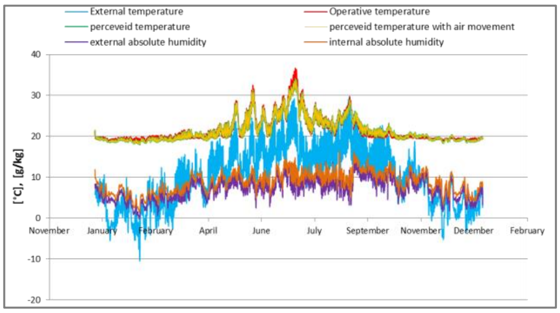

Fig. 4 – Dynamic simulation diagram

The results of the dynamic simulation, besides on the graph, are also summarized as numbers. It is possible to know the maximum and minimum values of the quantities listed in the graph above along with the time in which they occur. It is also very useful to know the percentage of the hours of the year in which the internal air temperature and the internal absolute humidity exceed certain fixed values.

Internal temperature	Air temperature	Operative temperature	Perceived temperature	day of the year	hour
max	35,9 °C	36,7 °C	34,2 °C	188	14
min	20,0 °C	18,4 °C	17,9 °C	42	5
hour above 26°C	9%	11%	10%		
hour above 28°C	4%	5%	4%		
Hour below 20°C	0%	50%	46%		
Internal absolute humidity			RH	Day of the year	Hour
max			79%	256	15
min			8%	41	16
hour above 70%			3%		
Hour below 30%			9%		
External temperature			T_{ext}	Day of the year	Hour
max			29,8 °C	239	15
min			-10,5 °C	42	3
External absolute humidity			AH	Day of the year	Hour
max			16 g/kg	243	18
min			0 g/kg	41	15

Fig. 5 – Dynamic simulation results

The results of the dynamic simulation allow us to classify the comfort of the indoor environment according to the UNI EN 15251: 2008. The first class was further divided to provide a more detailed assessment of the highest levels of comfort. The results are shown as the percentage of hours of the year outside of each class.

Free running (without thermal systems)					
comfort					
I+++	I++	I+	I	II	III
10,2%	9,8%	8,8%	6,9%	4,9%	3,4%

Fig. 6 – comfort results

The results of comfort can be viewed even in graphical form. The red points represent the internal temperature and internal relative humidity of each day of the year. The internal grey trapeze represents the area of optimum comfort, while the external trapeze the zone of minimum comfort. Figure 7 shows there are some summer days outside the comfort zone, as highlighted by the peak of the internal temperature between June and July in figure 4.

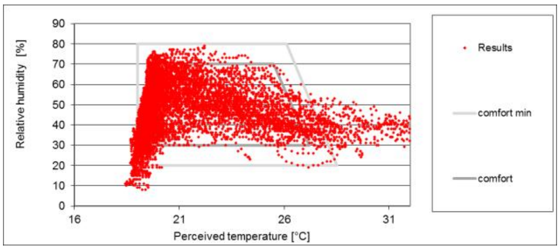

Fig. 7 – comfort diagram

5. Conclusions

The limits of the instrument are represented mainly by the fact that the analysis is carried out for a single zone. Therefore there is the risk of making a slightly inaccurate calculation in the analysis of an entire building. For this reason, the instrument should be used to assess single portions of interest of the building. Another limit is represented by not considering the thermal plants in the hourly calculation and, thus, the energy demand is obtained by the steady-state calculation. However, a tool that integrates a steady-state calculation with a dynamic one that uses its same input is certainly a very powerful tool for a technician who works daily in the design of high-energy efficient buildings. The data entry is in fact simple and results can be obtained both in terms of energy requirements and indoor comfort.

Furthermore, thanks to the hourly calculation, the results are much more reliable and realistic than a simple steady-state calculation. The inclusion of the set point of heating and cooling in the dynamic calculation is probably the main future development of the software.

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