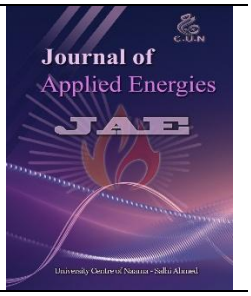
Journal of Applied Energies 2 (2023) 27-35

Journal of Applied Energies



Studying the peak loads of simple single-zone by TRNSYS

Salah-Eddine Jaouaf* and Bourassia Bensaad

Smart Structures Laboratory (SSL), Ain Temouchent, 46000, Algeria.
Email Address: jaouaf.salah@gmail.com (S.E.J.); bourassia.bensaad@gmail.com (B.B.)

Abstract: Energy consumption in residential buildings Algerian very high, especially during the summer season. A comprehensive approach to designing low-energy buildings reduces the size of mechanical systems to offset the additional cost of energy efficiency features. The most important thing in the building is the building envelope and the components in which it was constructed. They contribute to improving thermal comfort. Usually, the external walls are made of heavy construction to avoid drastic temperature changes and save energy. The present paper describes a modelling and simulation for a single zone building, run by using TRNSYS software. The study devoted to calculate heating/cooling loads a single-zone building model in the Wilaya of Ain Temouchent (Algeria), exposed to a hot and subhumid climate. The good comprehension of the outcomes making know what heating and cooling capacity it should use for different components when it wants to design a heating/cooling system and what the technique it should be used to damping this fluctuation between the indoor and exterior?

Keywords: Building envelope; Thermal comfort; Heating Cooling loads; TRNSYS.

1. INTRODUCTION

The building sector accounts for 30% to 40% of annual global energy consumption. A good characterization of the energy performance of the building makes it possible to define the best way to intervene to: (Optimize your energy consumption, Ensure better energy management, Improve energy efficiency, etc.).

In Algeria, the problem of summer weather has created a huge demand for air conditioning systems. Because of that, there is an increase in demand for energy consumption by the population to ensure thermal comfort and to protect against the harmful effects of the potential heat waves. Each summer sets a new record for the highest electricity consumption. Demand for peak power of 9,000 MW was recorded in 2012 and this figure increased to 15,000 MW in July 2019, a level never before achieved on the interconnected national grid [1].

As modern construction techniques continue to place more emphasis on energy conservation, minimising the heat loss from buildings, insulation thicknesses have increased and airtightness is constantly improving. This is the way to achieve good energy performance.

As known, there are two main strategies can be distinguished to improve the energy efficiency of buildings. Active strategies include heating, ventilation and air conditioning (HVAC) and artificial lighting, while passive strategies involve improvements to the building envelope, such as the increase of the building envelope. Thermal insulation and optimization of solar inputs to reduce the energy demand of a building. This study is interested in passive strategies [2].

The purpose of this study is to simulate and calculate the cooling and heating loads of the building in order to know or define the techniques should be used to build an energy-efficient system based on passive methods.

1.1 Literature overview

Several researchers around the world have conducted studies on building envelope improvements and their impact on building energy consumption. mention some of them, they use passive strategies:

- The energy-efficient of walls such as Trombe walls [3] and ventilated walls [4].
- The performance of various fenestration technologies including aerogel [5], vacuum glazing [6] and frames [7].
- The progress of roofs with low energy consumption including the contemporary of green roofs [8] and photovoltaic roofs [9].

2. MATHEMATICAL MODEL/EXPERIMENTAL METHOD

2.1 Geographical coordinate and climatic zone

The geographical coordinate corresponds to the city of Ain Temouchent:

- *Latitude: 30.3072501 ° North.*
- *Longitude: -1.1424514 ° East.*

It is located in climatic zone B, and its altitude is 185 m.

2.2. Building dimensions

The building is 32 m² in size and has a volume of 136 m3. The building's layout is described below in Figure 1.

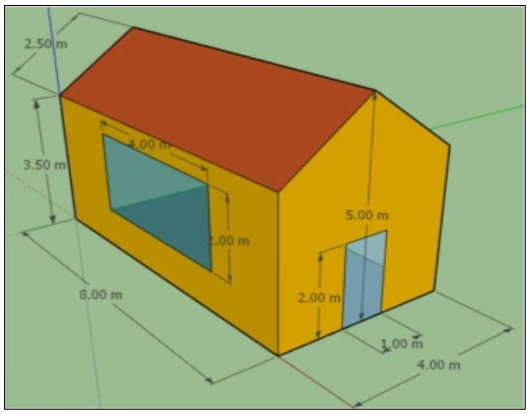


Figure 1: The layout of the building that we studied.

This is a combination of all the losses coefficients are shown in Table 1.

Table 1: Heat loss coefficients of Areas.

	U [kJ.h^{-1}.m^{-2}. k^{-1}]	A [m^2]	UA [kJ.h^{-1}. k^{-1}]
Floors	0.9	32	28.8
Roofs	0.6	40	24
Walls	1.3	80	104
Windows/ Doors	7.2	10	72
Overall	1.4	162.0	226.8

The thermal capacitance is calculated from these equations:

$$Cap_x = Area.Thickness.Density.Capacity \quad (1)$$

$$Cap_{Overall} = \sum Cap_x \quad (2)$$

Table 2 shows the result of calculating the thermal capacitance for all of the single zone building.

Table 2: The overall thermal capacitance of the zone.

	Area [m^2]	Thickness [m]	Density [$kg.m^{-3}$]	Capacity [$kJ.kg^{-1}.k^{-1}$]	Capacitance [$kJ.k^{-1}$]
Wall	80	0.1	1600	1	12800
Roof	40	0.1	1800	0.8	5760
Floor	32	0.1	2200	1.2	8448
Air	32	4.25	1.2	1	163.2
Overall					27171.2

2.3. Meteorological data

The meteorological data used for the thermal simulation was established by the Metronome meteorological program on the climate of Ain Temouchent. The weather data have been taken: Temperature, Moisture, Speed and direction of the wind and Solar radiation.

It taken account the set temperature for heating and cooling according to the regulatory technical document in application in Algeria, the comfort temperatures for heating and air conditioning in the rooms are respectively (21 °C, 24 °C) and the other spaces (kitchen, bathroom and corridor) are (18 °C, 27 °C).

2.4. Simulation software

The software used in this study is TRNSYS version 18. TRNSYS is:

- A program that performs dynamic simulations.
- A program based on a modular approach.
- A method to create new models in addition to those of the library of models of thermal systems and auxiliary components (weather data, histograms, etc.).
- A solver for solving systems of equations.

2.5. Detailed description

Analyzed a simplified model for single-zone Building. By applying dimensions, thermal properties, occupancy schedules and so on to this building. By using the type 88 (Single-Zone

"Lumped Capacitance") to find a load structure. This model allows using a single-zone structure subject to internal gains. It neglects solar gains and assumes an overall U value for the entire structure (including both walls and windows). Its usefulness comes from the speed with which a building heating and/or cooling load can be added to a system simulation. While the model accounts for the overall thermal capacitance of the structure, the model is too simplistic.

The component is governed by balance equations: an energy balance that predicts the zone temperature.

The energy balance for the zone is:

$$\frac{dT}{dt} = \frac{UA}{Cap}(T_{amb} - T) + \frac{\dot{m}_v Cp_a}{Cap}(T_{vent} - T) + \frac{\dot{m}_{inf} Cp_a}{Cap}(T_{inf} - T) + \sum Q_{gains} \quad (3)$$

With internal sensible gains coming from people, equipment and lights [11].

3. RESULTS AND DISCUSSION

After the installation of the model and how the components were connected, shown in Figure 2.

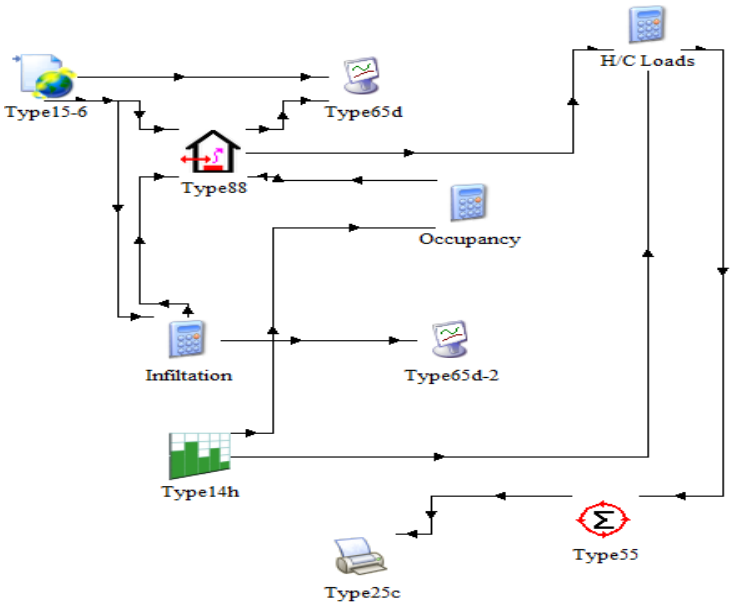


Figure 2: Model components and connections (TRNSYS SIMULATION STUDIO).

This simulation to obtain the evolution of Annual change in internal and external temperature, to give suggestions for some techniques available to ensure thermal comfort. And to calculate the maximum of heating and cooling loads of the zone, this information helpful to build a system of heating and cooling. As can seen in Figure 3, the temperature and the ambient

temperature fluctuating in due to the thermal capacitance of the building, the zone temperature it's fluctuating much more slowly than the ambient temperature.

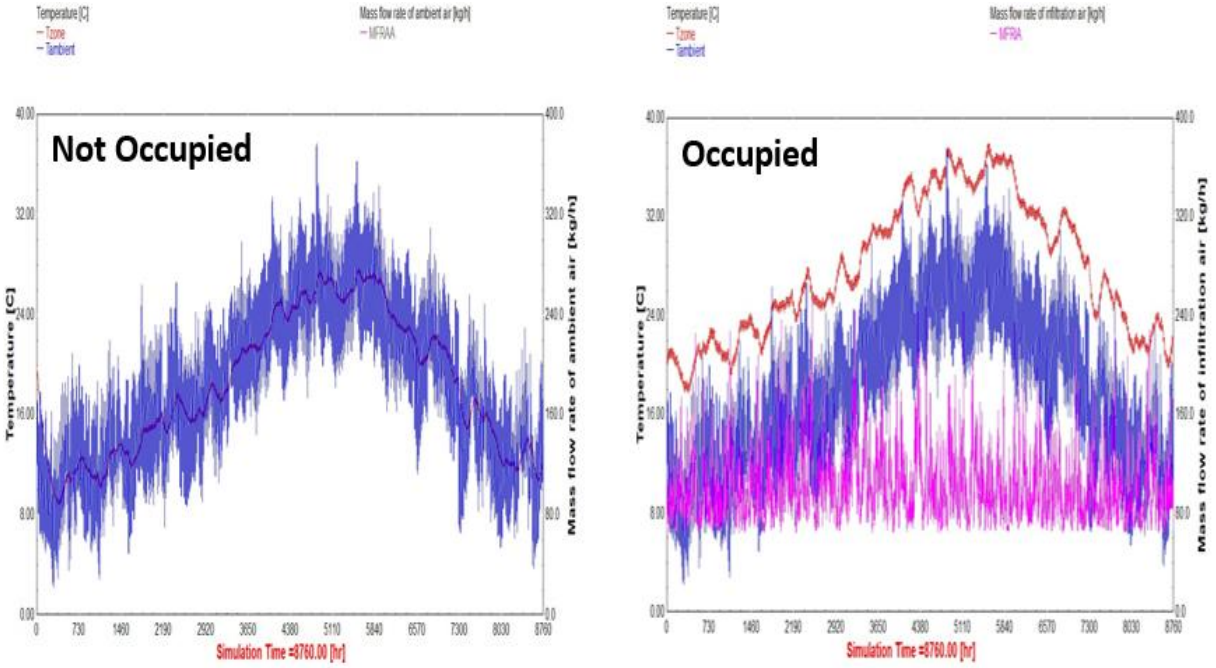


Figure 3: Annual change in zone temperature and ambient temperature.

One month in each season was chosen, namely January, April, July and October, to study the evolution of the comfort temperature of the indoor area. It is noted that the reference mean reference temperature is taken equal to 24.5 ° C in Figure 4 are shown the results of each month.

In the coldest days of January, it should be using an active heating system. In the rest of the days, the use of a passive heating system is sufficient to heat the interior, it is enough. In the moderate days of April, passive cooling may be necessary only in the few days when the temperature of zone deviates 24.5 ° C.

for the very hottest days of July, an active cooling system is needed. In parallel a passive form of cooling can be used; the reduction of Temperature is obtained through the use of thermal inertia, night ventilation, sun protection and the use of clear coatings. In the other days, it should have a passive cooling system by Ventilation to increase the speed of air.

For October, a passive heating or cooling system is needed to maintain Temperature of the zone equal to 24.5°C. To calculate the Cooling and the heating load for all the points during the year is used a periodic integrated workout the maximum of these values and by that, it could know what heating and cooling capacity should be used for different components.

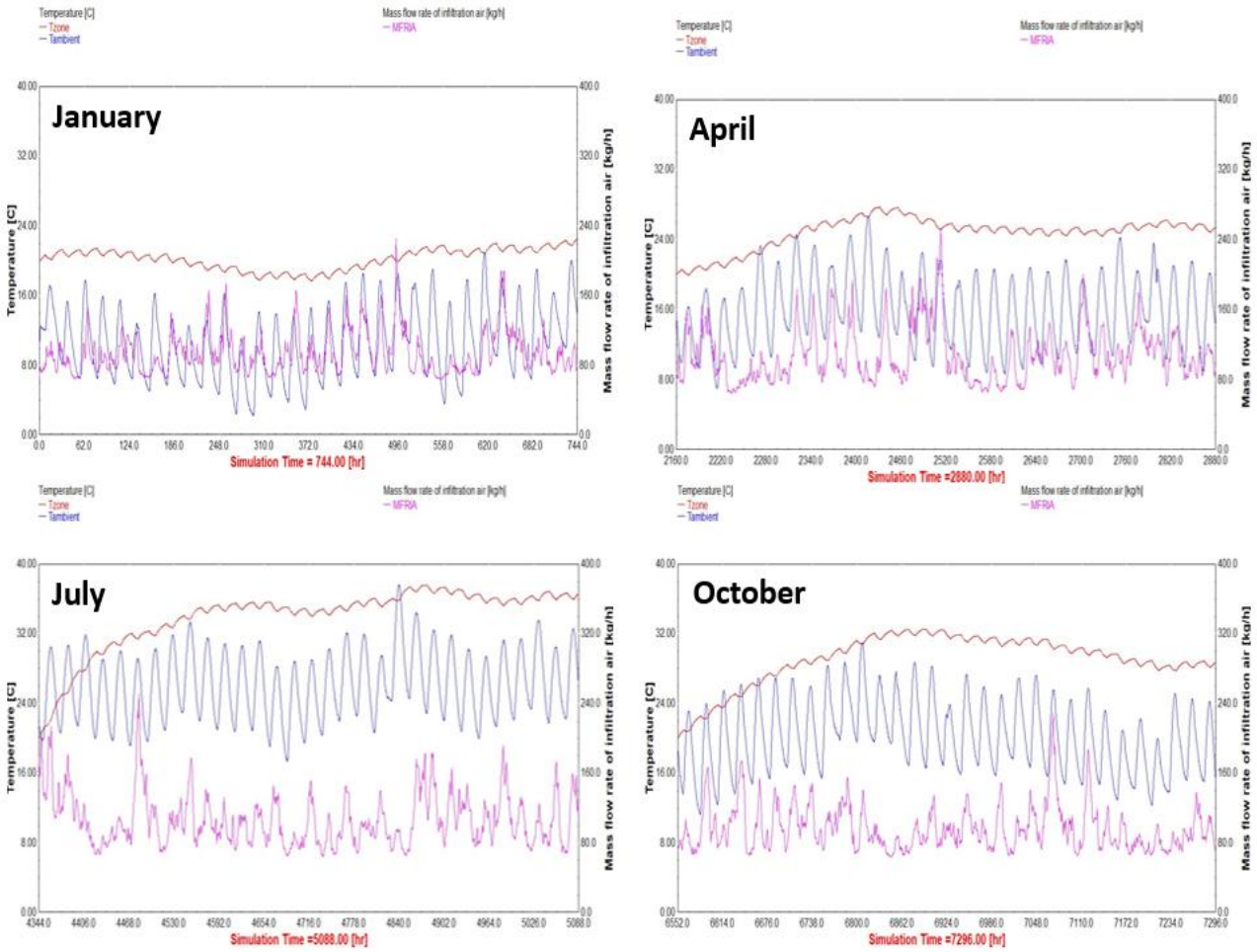


Figure 4: the monthly distribution of the temperature and mass flow rate of infiltration air.

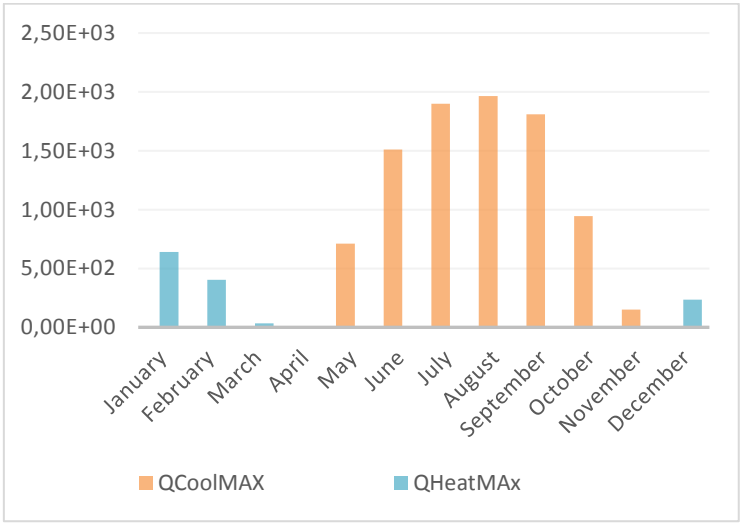


Figure 5: Building heating/cooling loads.

The outcomes show that the maximum of the heating load is 639 kJ recorded in January and the maximum of cooling load is recorded in August it's 1956 kJ. These results are illustrated

in Figure 5. However, these values represent the maximum load for just one day in the entire year.

4. CONCLUSION

This paper aims to investigate the techniques should be used to build an energy-efficient system based on passive methods and to give suggestions for some techniques available to ensure thermal comfort, as well as their characteristics (good price, environment). In this study, the simplified model for single-zone Building is presented. Are applied dimensions, thermal properties, occupancy schedules in this model of building. Results show that a passive system of cooling or heating can cover all needs.

During a few days of extreme heat (cold or heat wave) an active auxiliary system will ensure thermal comfort.

REFERENCES

[1] Medjelekh, D., Ulmet, L., Abdou, S., Dubois, F. (2016). A field study of thermal and hygric inertia and its effects on indoor thermal comfort: Characterization of travertine stone envelope. *Building and Environment*, 106, 57-77.

[2] Verbeke, S., Audenaert, A. (2018). Thermal inertia in buildings: A review of impacts across climate and building use. *Renewable and sustainable energy reviews*, 82, 2300-2318.

[3] Ji, J., Luo, C., Sun, W., Yu, H., He, W., Pei, G. (2009). An improved approach for the application of Trombe wall system to building construction with selective thermo-insulation façades. *Chinese Science Bulletin*, 54(11), 1949-1956.

[4] Zalewski, L., Lassue, S., Duthoit, B., Butez, M. (2002). Study of solar walls—validating a simulation model. *Building and Environment*, 37(1), 109-121.

[5] Bahaj, A. S., James, P. A., Jentsch, M. F. (2008). Potential of emerging glazing technologies for highly glazed buildings in hot arid climates. *Energy and buildings*, 40(5), 720-731.

[6] Sullivan, R., Beck, F.A., Arasteh, D.K., Selkowitz, S.E. (1996). Energy performance ofevacuated glazings in residential buildings. *Transactions—American Society of Heating Refrigerating and Air Conditioning Engineers*, 102, 220–227.

[7] Gustavsen, A., Arasteh, D., Jelle, B. P., Curcija, C., Kohler, C. (2008). Developing low-conductance window frames: Capabilities and limitations of current window heat transfer design tools—State-of-the-art review. *Journal of building physics*, 32(2), 131-153.

[8] Castleton, H. F., Stovin, V., Beck, S. B., Davison, J. B. (2010). Green roofs; building energy savings and the potential for retrofit. *Energy and buildings*, 42(10), 1582-1591.

[9] Bahaj, A. S. (2003). Photovoltaic roofing: issues of design and integration into buildings. *Renewable energy*, 28(14), 2195-2204.

[10] TRNSYS 18 Manual.