Simulation of the Energy Consumption of a Building in the Form of a Honeycomb

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Abstract

This paper deals with the energy consumption in the residential building in a Mediterranean climate with half level system which is a typology that has not been studied before referring by analogy to the honeycomb.
For this purpose, we used the finite volume method presented by a numerical simulation on the EnergyPlus/openStudio software. Two simulations were made, the first one presents the current use of the house and the second one shows the energetic use with the passive system that was developed with the modifications applied on the shape of the building.
The results show that the cooling needs have decreased by 40% and the consumption per hour in August goes from 2.3 kWh to 1.4 kWh.
Finally, it was found that the modifications applied on the building really decreased the energy consumption by 30%.

Keywords: energy consumption, honeycomb, Energy plus, residential building, thermal comfort.

1. Introduction

The residential sector consumes 36% of the world's energy production [1]. In Algeria, the energy consumption in the field of the building presents 46% of the total production of energies[2], Over the last 10 years (2009-2018), the residential sector's energy usage climbed significantly, rising from roughly 9,000 Ktep to more than 17,700 Ktep[3]., it is for this point there are several researchers who devote their studies just for the minimization of the energy consumption in this sector that consumes the energy and produces nothing, therefore it is an energy consuming sector.

Among the studies that have been done for the consumption of energy in the building[4], in order to verify the consumption of air conditioning in the city of Algiers, in 2014 A. SEMACHE et Al. Conducted a study on the performance of energy efficiency and PV energy in residential building: Case of three areas in Algeria [5] The comparative study of the thermal energy performance of a reference residential building with another conventional building having the same dimensional characteristics, showed the positive effect of energy efficiency measures on the reduction of energy demand in three regions in Algeria: Laghouat, Bechar, and El Oued. Using TRNSYS.

Worldwide environment guidelines and energy security are presently quite possibly of the most ridiculously stressing issue in the contemporary world, in which the built environment is viewed as an essential hub. Particularly, the building area has as of late been perceived for its maximum usage of energy, danger to the climate and the security of energy supplies[6]. The building sector consumes around 48% of complete energy and intensity[7], it is a significant natural concern, which is impacted by the sum and wellspring of energy utilized for exercises in buildings[8]. The area, the shape of the neighborhoods, urban density, building shapes, type of individual house in the city, height, construction type; are criteria that influence energy demand[9] .In this manner, regular energy sources may not be practical today. One method for guaranteeing maintainability is to increment energy efficiency in the residential sector and to change to the utilization of sustainable sources rather than regular energy, which would lessen fossil fuel byproducts [10].

This paper intervenes on the shape of the building without touching its structure and applying materials that are not expensive, the difference between this study and the state of the art is to apply the rules of thermal comfort of the honeycomb on our case study.

2. Methodology

A. Presentation of the case study:

Our case study is located in the center of Boumerdes, climatic zone A (according to the DTR) [11] with an altitude of 50m, latitude 36.72 et longitude 3.25 (figure 1). The building is designed with the system of half level with a stairwell in the middle, with an area of 230 m² and volume of 708.066 m^3 (figure 2).

Fig.1. geographical location of the case study

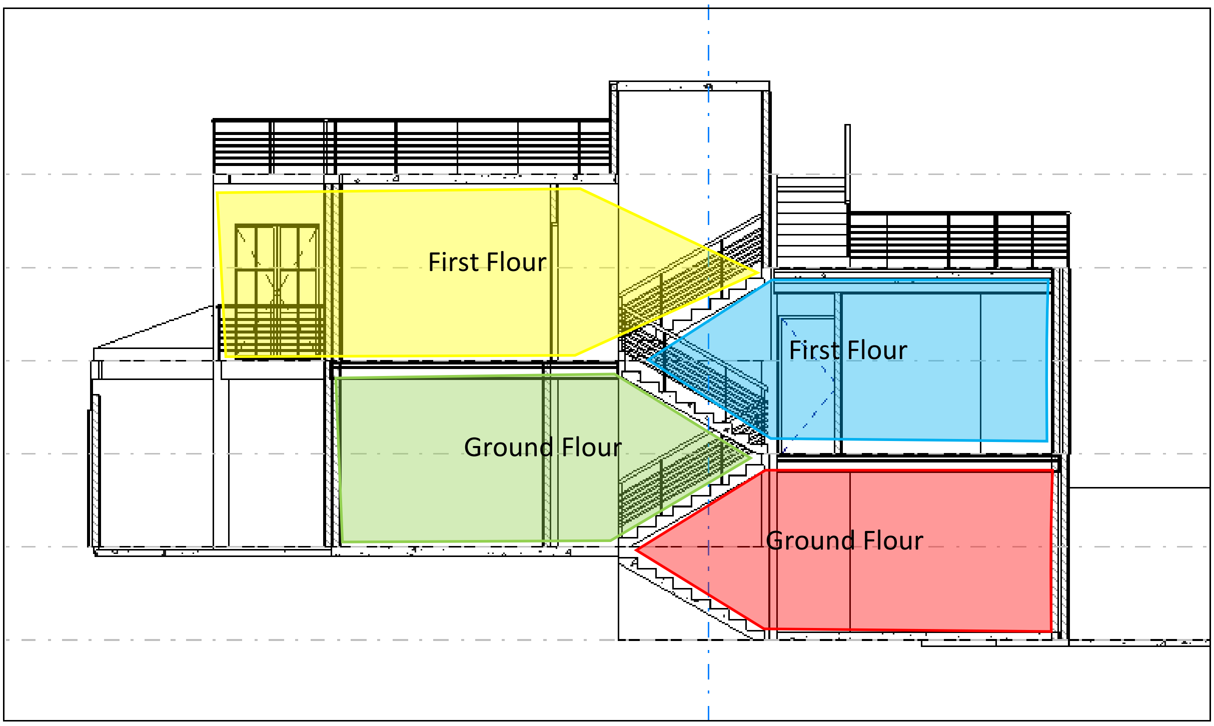


Fig.2. section on the case study

B. Method of calculation:

1) Software definition (physical model): Energy Plus/OpenStudio1.1.0

Energy Plus™ is a whole building energy simulation program that engineers, architects, and researchers use to model both energy consumption for heating, cooling, ventilation, lighting and plug and process loads and water use in buildings.
Energy Plus is a console-based program that reads input and writes output to text files. It ships with a number of utilities including IDF-Editor for creating input files using a simple spreadsheet-like interface, EP-Launch for managing input and

output files and performing batch simulations, and EP-Compare for graphically comparing the results of two or more simulations. Several comprehensive graphical interfaces for Energy Plus are also available. DOE does most of its work with Energy Plus using the Open Studio software development kit and suite of applications[12].

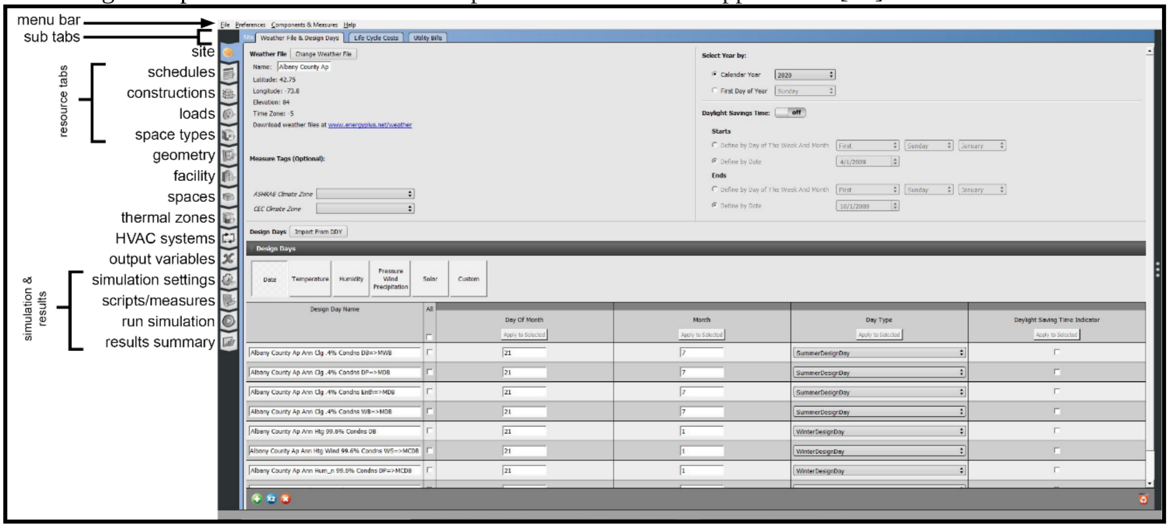
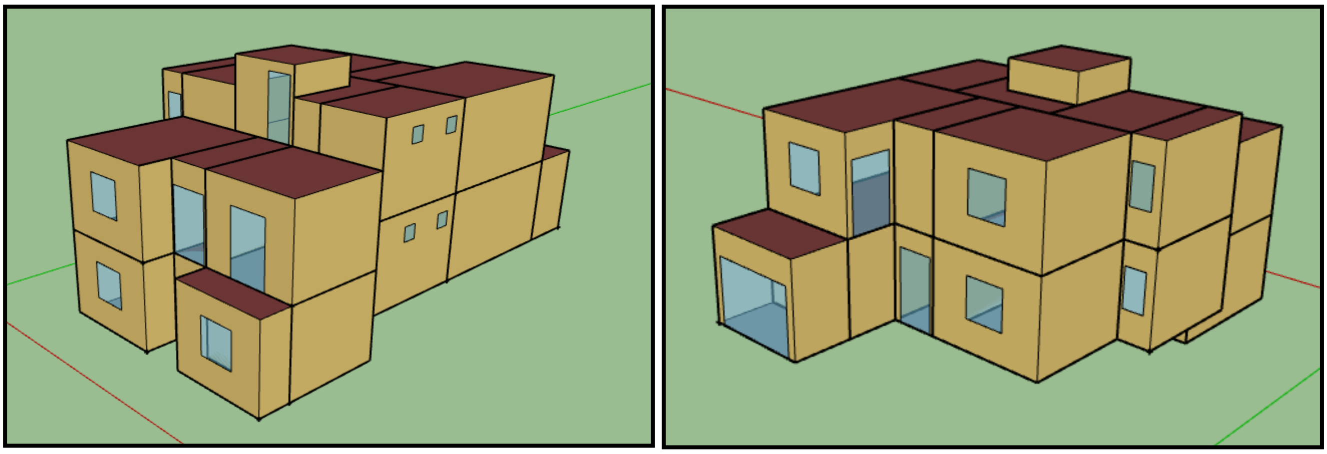


Fig.3. Open Studio Interface

Open Studio® is a cross-platform (Windows, Mac, and Linux) collection of software tools to support whole building energy modeling using Energy Plus and advanced daylight analysis using Radiance. Open Studio is an open source (LGPL) project to facilitate community development, extension, and private sector adoption [13] .

2) Mathematical model

The Finite Volume methods are constructed from an integral formulation based directly on the strong form of the equations to be solved. The integrals do not cover the whole domain in which the equations are posed, but only disjoint cells called control volumes. In comparison, the Finite Element method is also based on an integral formulation of the equations, called variational formulation (or weak formulation) using "test functions" and where the integrals cover the whole domain. In the Finite Volume method, the divergence terms appearing in the PDEs to be solved are treated using the divergence theorem. Thus, the volume integrals of a divergence term are transformed into surface integrals. These flow terms are then evaluated at the interfaces between the control volumes and the flows at the interfaces are approximated by an approximated by a numerical flux function. (Figure 4).



(a) **(b)**

Fig.4. Volume of the case study: (a) north west orientation (b) south east orientation

3. Results and discussion

A. current scenario of the study case

The following circle (figure 5) shows the percentage of annual energy use in our case study, there are 5 different types of consumption with different percentage. The biggest part presents 40% of the consumption by air conditioning, 30% of lighting and 20% of internal equipment, so 50% of the annual consumption presented by the electric tools, on the other hand the heating and ventilation do not exceed 15% together of the total consumption of the building. What proves that our house is located in a warm climatic zone and the enormous consumption present in the summer period is due to two different factors the climate and the electric tools that present an overheating in the summer period and a gain for the winter period that's why the winter consumption is very low compared to the summer consumption.

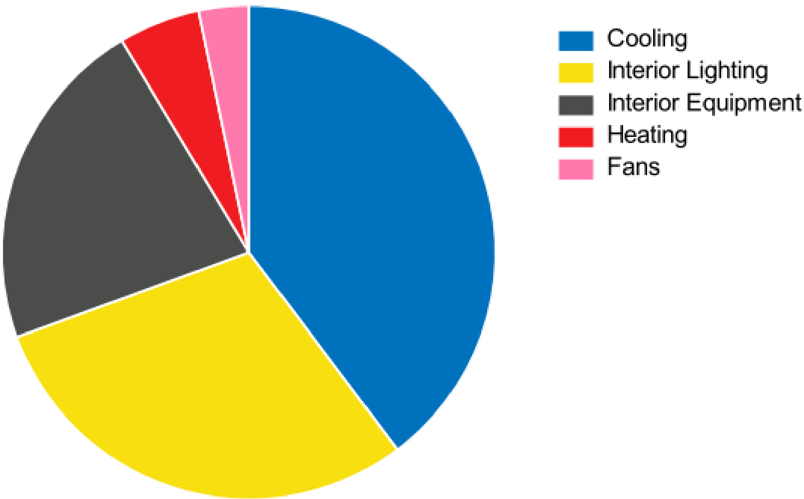


Fig.5. The current energy use of the house

This histogram (figure 6) represents the variation of the electrical consumption of our house for each month of the year, we can see that the consumption of indoor lighting and indoor equipment are stable throughout the year. These two factors that influence the rest of the electrical consumption as the air conditioning ventilation and heating, the latter is almost zero compared to the air conditioning that represents the major part of energy consumption through the site and electrical equipment.
The aim of this work is to minimize the consumption of air conditioning by intervening on the geometric shape of the different rooms of the building. This has created a hexagonal shape that resembles the shape of the honeycomb (figure 1), hence the choice of the circular shape at the corners. This is a new idea that has never been studied before.

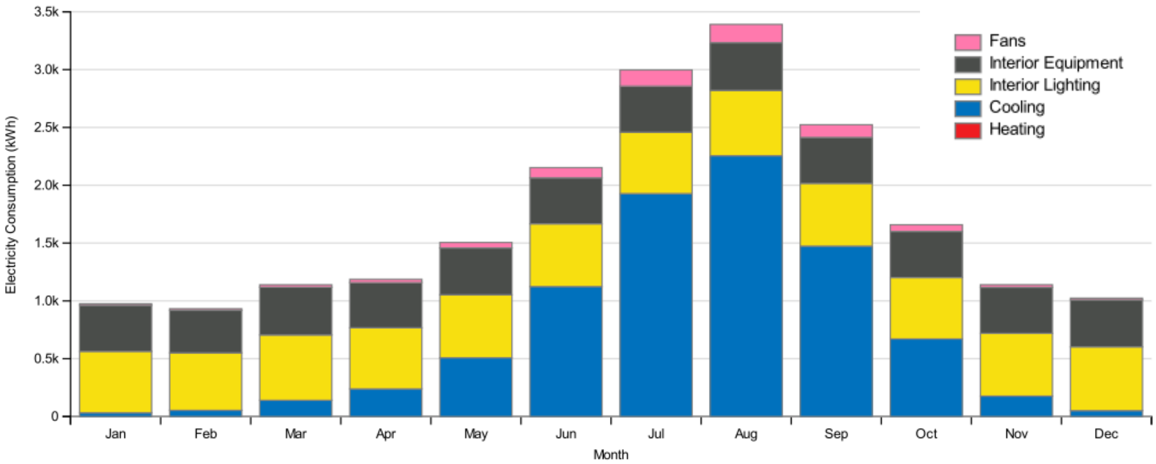
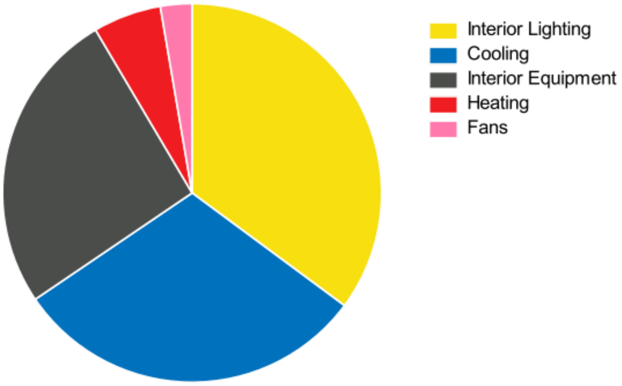


Fig.6. Annual electricity Consumption (kWh), current case

B. The proposed scenario

The intervention proposed for our case is to reinforce the corners and separations between the walls and slabs as a circle the same insulation system as a honeycomb. (figure 8).

After this modification we can see that the percentage of consumption is modified with respect to the first circle (figure 7) which proves that there is an impact concerning the modifications used on the thermal bridges.



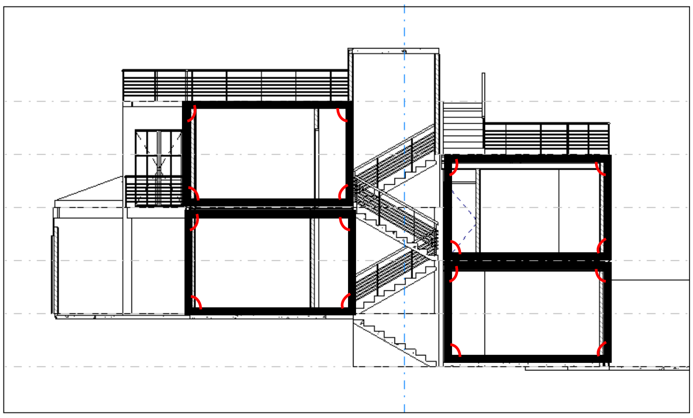


Fig.7. The energy use after modification

Fig.8. schematic section on the changes made to the shape

his histogram (figure 9) proves our remark on the circle so we see that the consumption of the air conditioning is decreased by a value of 1.1kWh from 2.5 to 1.4 although the electric consumption remains stable in the same previous value. And the rate of ventilation is increased compared to the previous study, so the movement and speed of the air increases compared to the classic system.

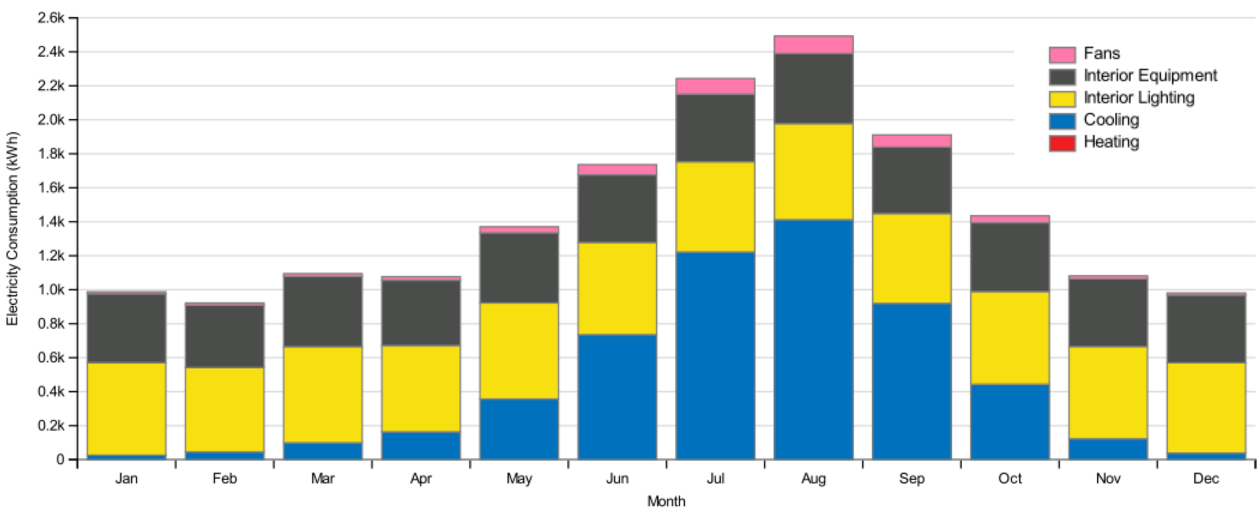


Fig.9. Annual electricity Consumption (kWh), after modifications on the shape

4. Conclusion :

The modeling and simulation of the thermal comfort of our house shows that it consumes a lot of energy (up to 3.4 kwh per hour). Depending on the shape of the house, we proposed a passive solution or we used the thermal comfort system of the honeycomb and we applied it to our case study (analogical method). The results showed that this system is effective, it managed to decrease the cooling needs up to 40%.

As the software used is very detailed, the calculation method is satisfied and the results are reliable.

The applied method has shown very promising results, so we can be inspired by nature and use the hexagonal shape of the honeycomb to work on the thermal comfort of buildings.

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