Annual Energy Consumption of a Commercial Building

A PARAMETRIC STUDY ON THE VARIATION OF WALL CHARACTERISTICS & LOCATION

Chen Rujing | Verí Alessandra | Gopalsamy Sakthivel Anujraaj
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Introduction

A medium-sized commercial building has been modelled through SketchUp 2016. The thermal load data, weather data and wall construction data have been rendered to the model via OpenStudio 2.3.1. Moreover, a parametric study has been conducted on the variation of wall construction and the location of the building. Piacenza was initially chosen as the base case city, and then energy simulations were also conducted on Belem and Helsinki.

Building Geometry

The building has been modelled with three stories with the dimensions of 40 x 40 x 4 meters each. Each story comprises of 20 offices, three toilets in the corners, a stairway in the fourth corner, a central hall with a corridor surrounding it. Each wall has been modelled with 40% fenestration with 88.45cm overhang. The building feature is figure1 below.

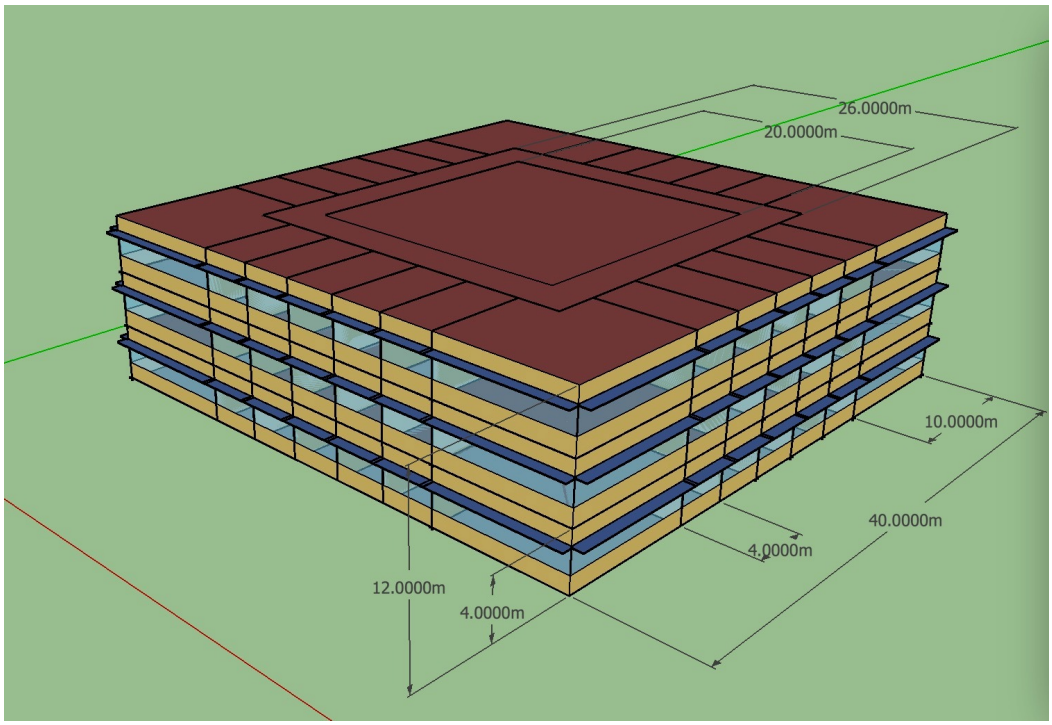

Figure 1 Geometry of the building

Building Description

From the figure 2, it can be seen it has 15 different thermal zones. The central areas are IT room, conference room and relaxing area respectively from top to bottom.

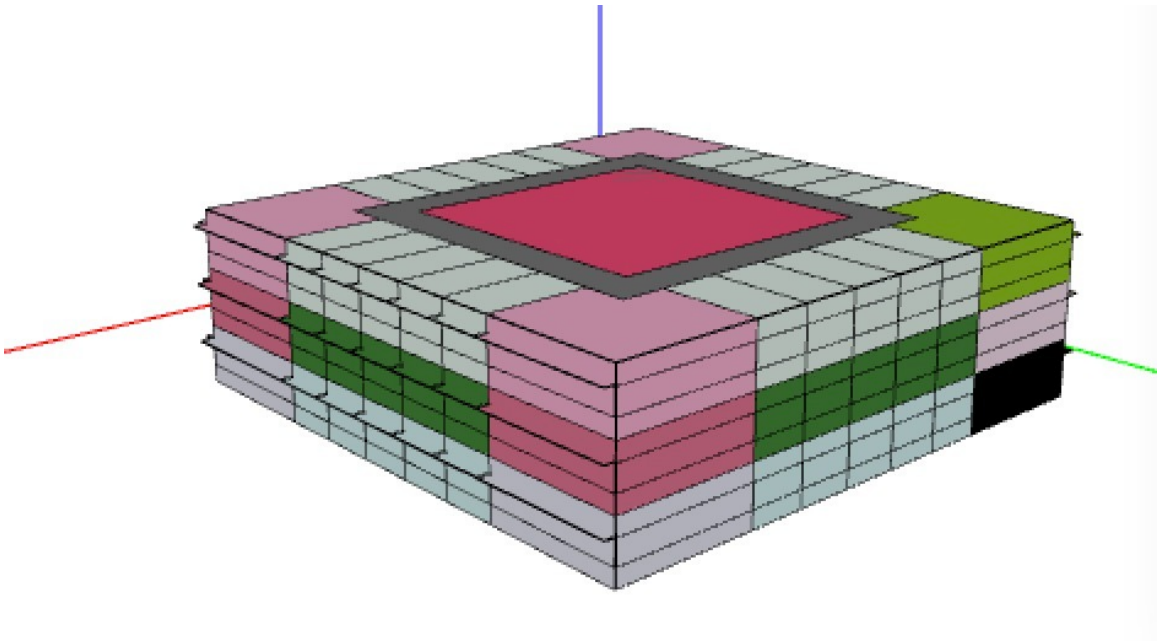

Figure 2 The thermal zones of the building

Each closed office is assigned to 2-3 people working. Detailed room average people per space per unit floor area are described in table 1. Moreover, average light load for the building is 11.625 W/m^2.

Table 1 People per unit floor area and the average lighting load.

Room Types	***People per Space Floor Area People/m2***	***OurModifiedLight (W/m2)***
ConferenceRoom	0.538196	11.625023
IT Room	0.053820	
Restroom	0.039216	
Corridor	0.005	
ClosedOffice	0.1	
RelaxingRoom	0.03	

The schedules and lighting load profile for this building can be seen from the figures below. The standard work schedule for this company is from 9 am to 6 pm, from Monday to Friday. However, some people might work overtime depending on the situation.

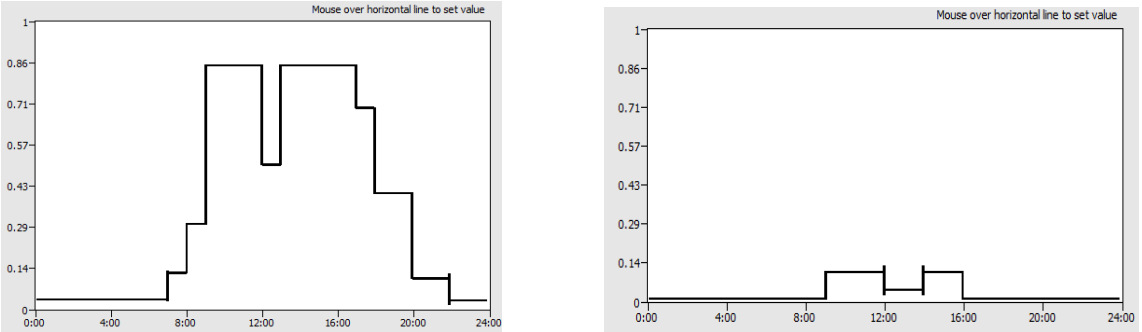

Figure 3 Work Occupation Figures for the weekdays and the weekend.

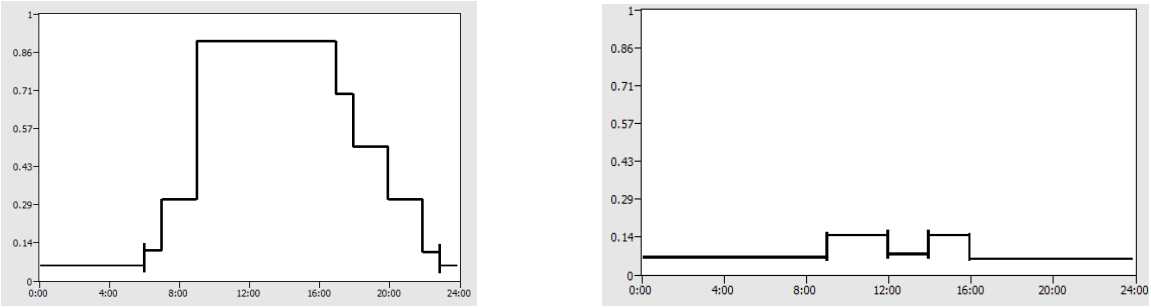

Figure 4 Lighting Load Profile for the weekdays and the weekend.

Data Chosen

The building is modelled in three different cities below. The design conditions are described in table2. Piacenza is the base case city. Helsinki has extreme cold weather of below 19.1 °C. Three different walls are also applied in this building to measure the heating and cooling load to compare the difference, which can be seen in table 3. The main idea is changing the percentage of wood and insulation in the wall to make a higher resistance to see if we can reduce the energy consumption of this building.

Table 2 Design Cities Chosen

Design Cities	Summer Design Conditions	Winter Design Conditions
Piacenza	DB 31.9 °C, WB 22.4 °C	DB -4.8 °C
Belem	DB 32.8 °C, WB 25.9 °C	DB 22.8 °C
Helsinki	DB 24.8 °C, WB 16.7 °C	DB -19.1 °C

In the base wall-Wall1, there are three layers including concrete which accounts for around 80% of total materials. Then we replace 10% of concrete into the wood and then insulation respectively in wall2 and wall 3.

Table 3 Different Walls Construction Properties

	Wall1-Base Wall	Wall2	Wall3
	1/2In Gypsum_1.27cm	1/2In Gypsum_1.27cm	1/2In Gypsum_1.27cm
	1In Stucco_2.53cm	1In Stucco_2.53cm	1In Stucco_2.53cm
	8In Concrete_25.99cm	8In Concrete_20.33cm	8In Concrete_20.33cm
		G05Wood_5.66cm	Insulation36_5.66cm
Total Unit Resistance K/W	0.266212	0.61082	1.543673

Data Analysis

From table 4, it can be seen our base wall has a unit resistance of 0.266K/W. When wall1 is applied to Piacenza base city, the yearly heating and cooling load are calculated to be 2665 GJ and 594 GJ. When we used wall1 to Helsinki and Belem, the following data are obtained as described in table 5. For Belem city, it only consumes 0.35 GJ heating load as a result of that its design temperature for winter is 22.8°C.

Table 4 The heating and cooling loading in different conditions

	Wall1		Wall2		Wall3	
	Heating [GJ]	Cooling [GJ]	Heating [GJ]	Cooling [GJ]	Heating [GJ]	Cooling [GJ]
Piacenza	2665.19	593.68	2447.49	558.03	2305.37	547.41
Helsinki (Finland)	5279.57	120.62	4773.74	137.3	4459.89	165.49
Belem (Brazil)	0.35	3958.6	0.54	3620.23	0.81	3404.07

In the Piacenza base city, it can be seen by changing the wall, the heating load for wall2 is reducing 8% from wall1 and wall 3 decreases 9.8% from wall1. For cooling load, the wall2 and wall3 are falling 6% and 7.8% respectively compared with wall1.

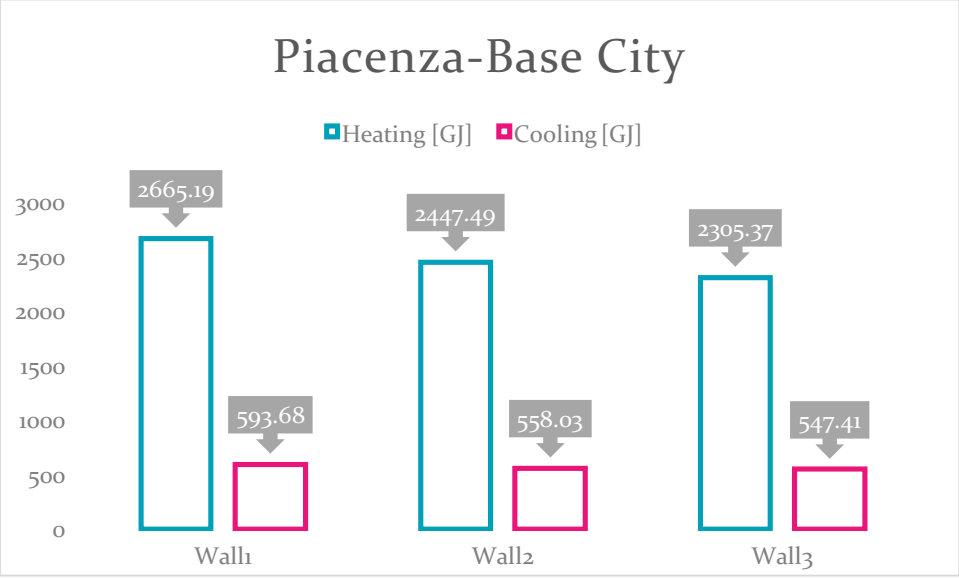

Figure 5 Piacenza yearly heating and cooling load in three different walls

For Helsinki in Finland, the wall2 dramatically improves the energy consumption in winter, decreasing 9.6% of the heating load from wall 1 by replacing 10% of concrete into the wood. Also, the heating load in wall 3 dramatically dropped of 15.5% compared with wall1. However, the cooling capacity is increased from wall1 to wall 3 with increasing resistance of the wall.

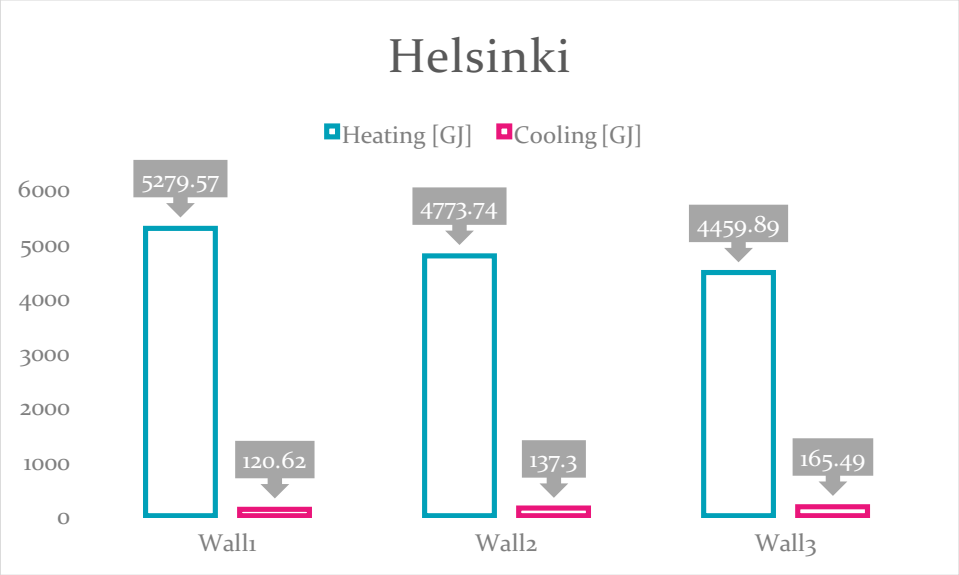

Figure 6 Helsinki yearly heating and cooling load in three different walls

In Belem city, there is a small amount of heating load less than 1 GJ per year for three walls. Moreover, the cooling capacity is decreasing by 8,5% and 14% in wall 2 and wall 3 compared with wall1.

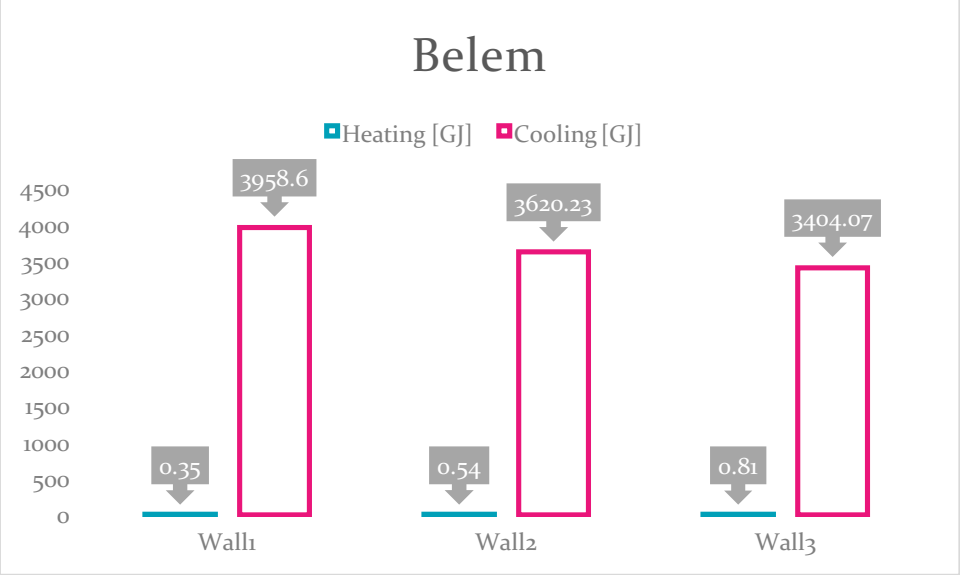

Figure 7 Belem yearly heating and cooling load in three different walls

From the figure 8 below, it is evident that total energy consumption is decreasing with increasing of the resistance in the wall.

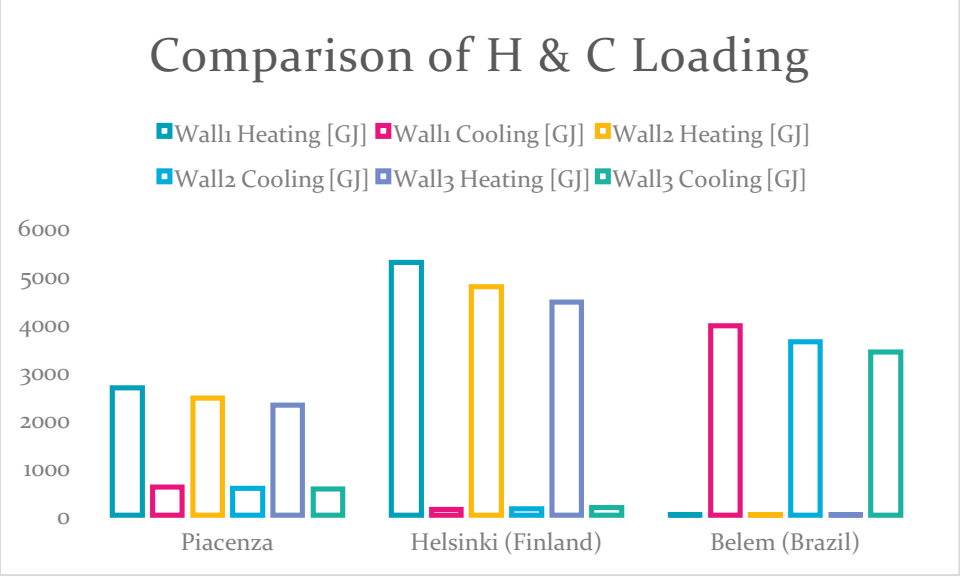

Figure 8 Comparison of heating and cooling load in three different walls and cities