ENERGY AND ENVIRONMENTAL TECHNOLOGIES FOR BUILDING SYSTEM PROJECT

PARAMETRIC STUDY OF ENERGY CONSUMPTION IN COMMERCIAL BUILDING

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INTRODUCTION

Objective

The Commercial Building is modelled using SketchUp 2016 and rendered using OpenStudio 2.3.1. In this project, three different cities is used for parametric study of the annual energy consumption regarding the effect of weather, wall construction, and location of the building such as Aberdeen (UK), Nagoya (Japan) and Calgary (Canada).

Building Summary

The Commercial Building is consist of three stories with the dimension of 50m x 40m x 12m. Each floor has two open offices, two conference rooms, one vending room, one storage room, a corridor and stairs on the centre back of the building.

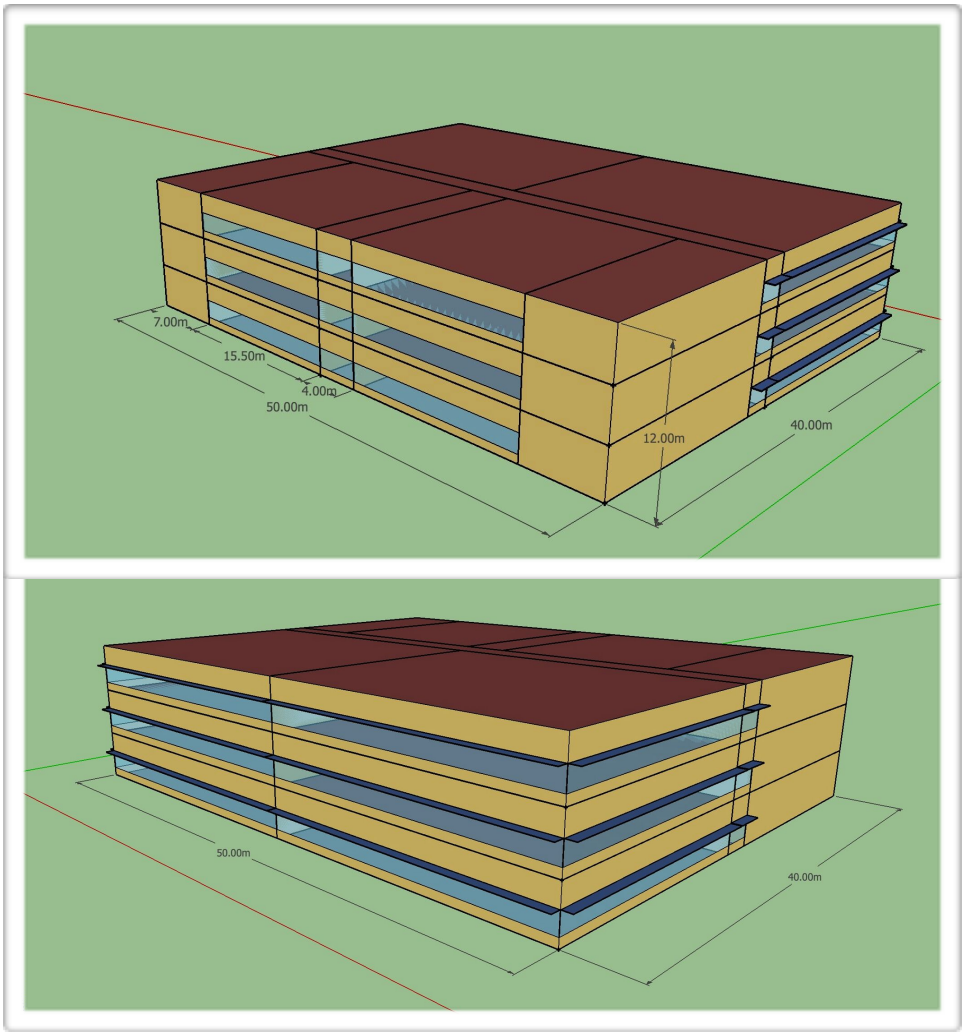


Figure 1. Front and Back View of The Building

BUILDING DESCRIPTION

From the Figure 2 below, it could be seen that in each floor there are several rooms such as :

1. Open Office Room
2. Conference Room
3. Vending Room
4. Storage Room
5. Corridor
6. Stairs

Each of the rooms above has its own thermal zone that also could be seen by the different colour of the different room. It means that in each floor there are six thermal zones, thus eighteen thermal zone is applied on the whole building.

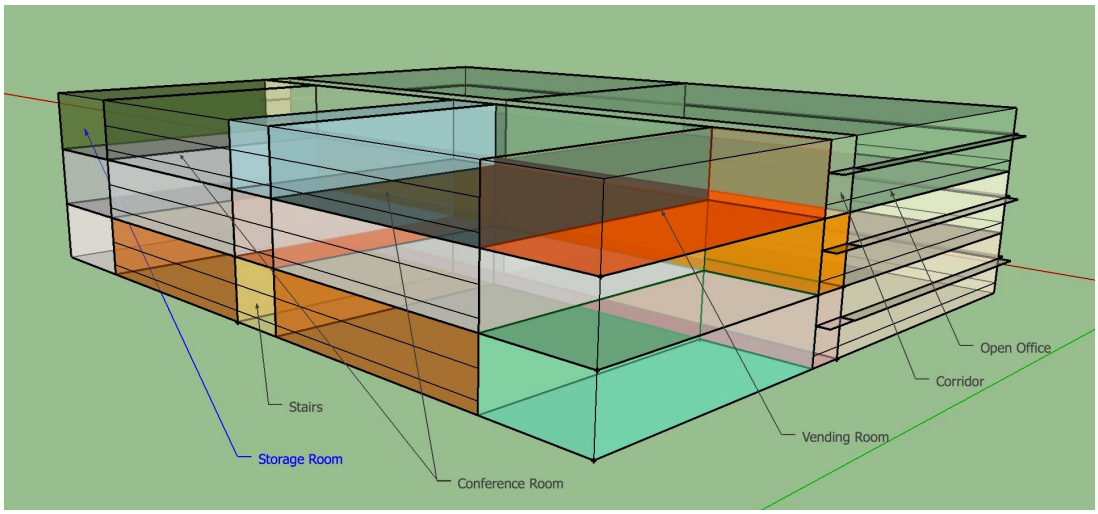


Figure 2. Building Thermal Zone and Room

Occupancy

Room Type	People per Space Floor Area (People/m2)	Watts per Space Floor Area (W/m2)
Open Office Room	0.056511	10.6562
Conference Room	0.538196	12.5938
Vending Room	0.010764	4.8437
Storage Room	NA	7.75
Corridor	0.010764	4.8437
Stairs	NA	5.8125

Table 1. Room type description

SCHEDULE

Occupancy Schedule

To maintain the the efficiency of the energy consumption of the building, it is designed to have eight working hours schedule, from 8 AM to 4 PM in weekdays. In addition, the extra working hours would be limited up to 8 PM only. At weekends, extra working hours would be allowed only in Saturday up to 12 PM. So that there will be no activities at the office in Sunday. The light and equipment activities will follow this activity schedule

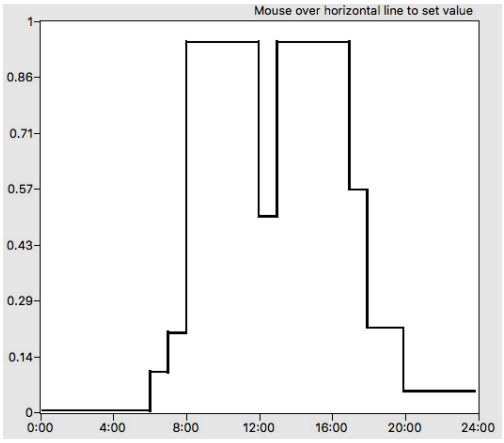


Figure 3. Weekdays Occupation Activity

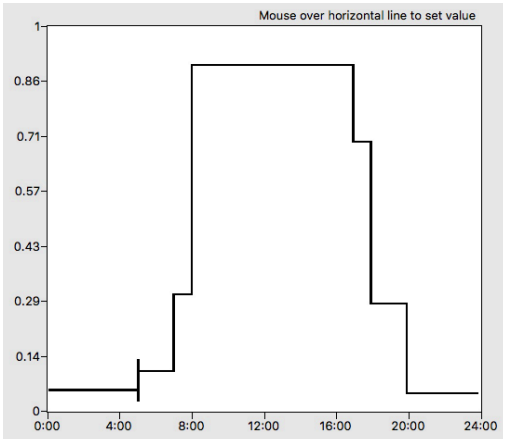


Figure 4. Weekdays Light Activity

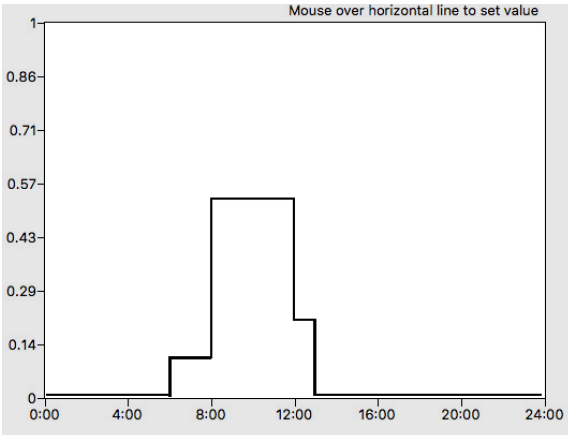


Figure 5. Weekend Occupation Activity

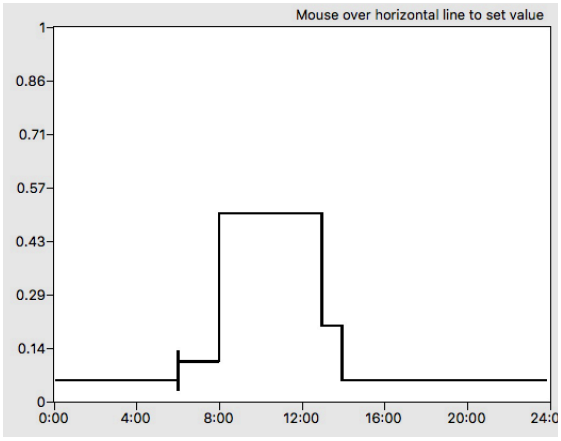


Figure 6. Weekend Light Activity

WEATHER DATA

This study used three different weather data from three different cities such as :

1. Aberdeen (Base City)
2. Nagoya
3. Calgary

The table below represent the design temperature condition of each city :

City	Summer Design Condition	Winter Design Condition
Aberdeen	DB 20 degC / WB 15.5 deg C	DB -2.6 deg C
Nagoya	DB 33.8 degC / WB 24.7 deg C	DB -1.1 deg C
Calgary	DB 26.6 degC / WB 15.4 deg C	DB -25 deg C

Table 2. Heating and Cooling design condition

In order to understand the effect of total energy consumption regarding to different wall material used, the wall material will be varied in three different combination of materials. The total width of the wall applied here is 10. 82 Inch or 0.274828 meters. The table below represent the material used and the conductivity of each wall material type. Since the concrete take 73% of the total wall material in basis wall (Wall A), half of the concrete will be replaced using 4 Inch Insulation Board in Wall B and 4 Inch Wood in Wall C so that the total resistance will be lower than the basis wall (Wall A). The configuration of material and layer of each wall represent by table below :

Wall A	Conductivity (W/mK)	Wall B	Conductivity (W/mK)	Wall C	Conductivity (W/mK)
1 Inch Stucco	0.6918	1 Inch Stucco	0.6918	1 Inch Stucco	0.6918
8 Inch Concrete HW	1.7296	8 Inch Concrete HW	1.7296	8 Inch Concrete HW	1.7296
		4 Inch Insulation Board	0.03	4 Inch Wood	0.15
1.32 Inch Wall Insulation [31]	0.0432	1.32 Inch Wall Insulation [31]	0.0432	1.32 Inch Wall Insulation [31]	0.0432
1/2 Inch Gypsum	0.16	1/2 Inch Gypsum	0.16	1/2 Inch Gypsum	0.16

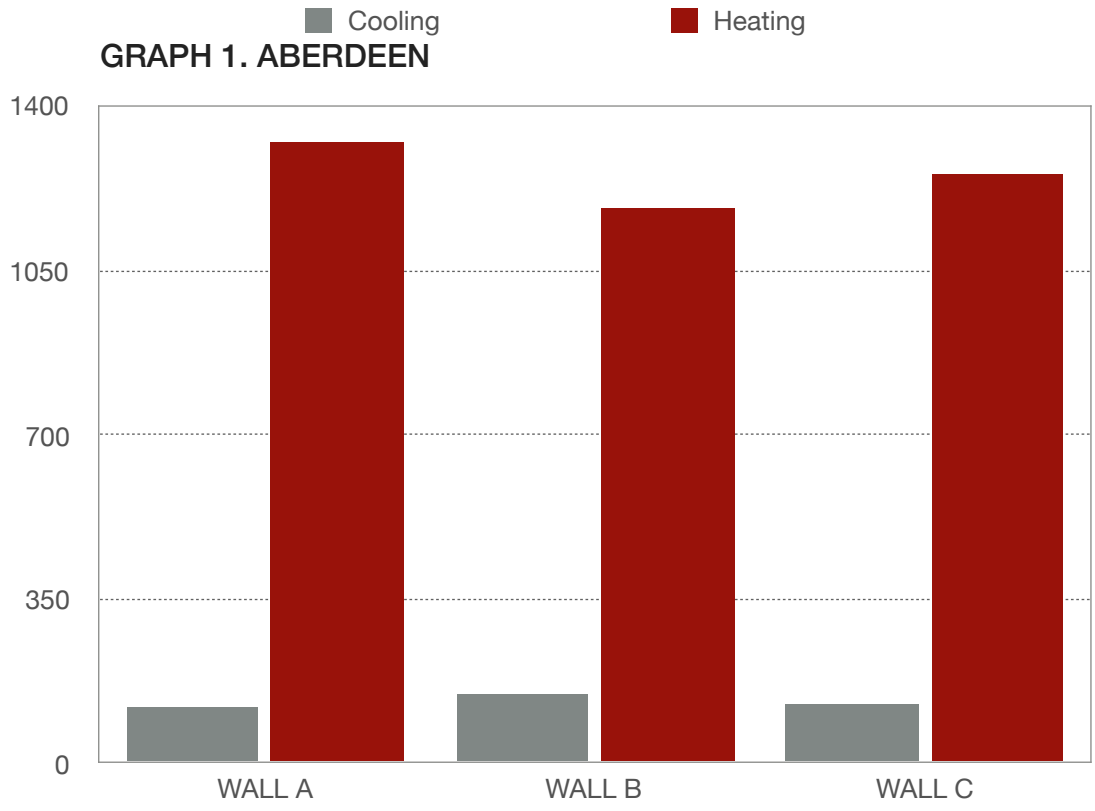
Table 3. Wall material and conductivity

DATA ANALYSIS

After changing the wall material and load the weather data for each city, it could be seen that there are significant effect regarding to the annual heating and cooling load of the building. In every city, it could be seen that wall A has the highest amount of heating load compared to other type of wall, meanwhile the lowest heating load is shown by wall B. it is caused by the total resistance value of wall B is higher than wall C and Wall A and it is indicated by the new material introduced in wall B (4 Inch insulation board) to replace 4 Inch concrete has the lowest conductivity (0.03 W/mK) compare with other type of materials. In other word, Wall B has the highest resistance value, follow by Wall C and Wall A respectively,

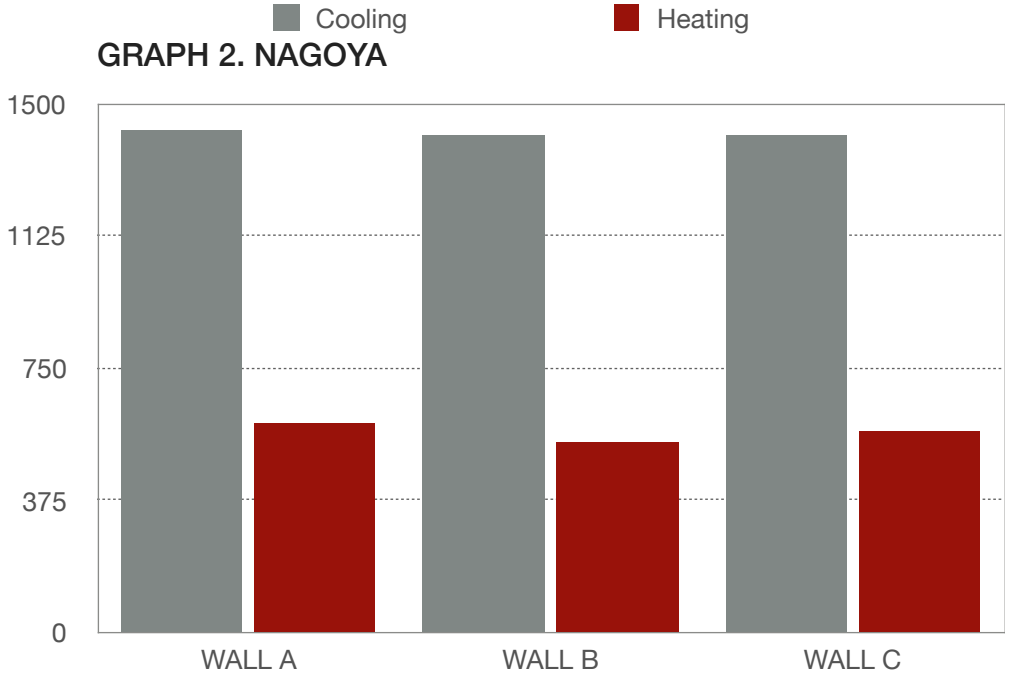
	WALL A (GJ)		WALL B (GJ)		WALL C (GJ)	
	Heating	Cooling	Heating	Cooling	Heating	Cooling
Aberdeen	1321.56	117.48	1180.64	148.58	1255.02	125.54
Nagoya	593.57	1426.58	537.30	1411.55	567.13	1413.35
Calgary	2253.70	279.42	2049.72	295.29	2157.19	277.81

Table 4. Heating and Cooling load variations due to wall



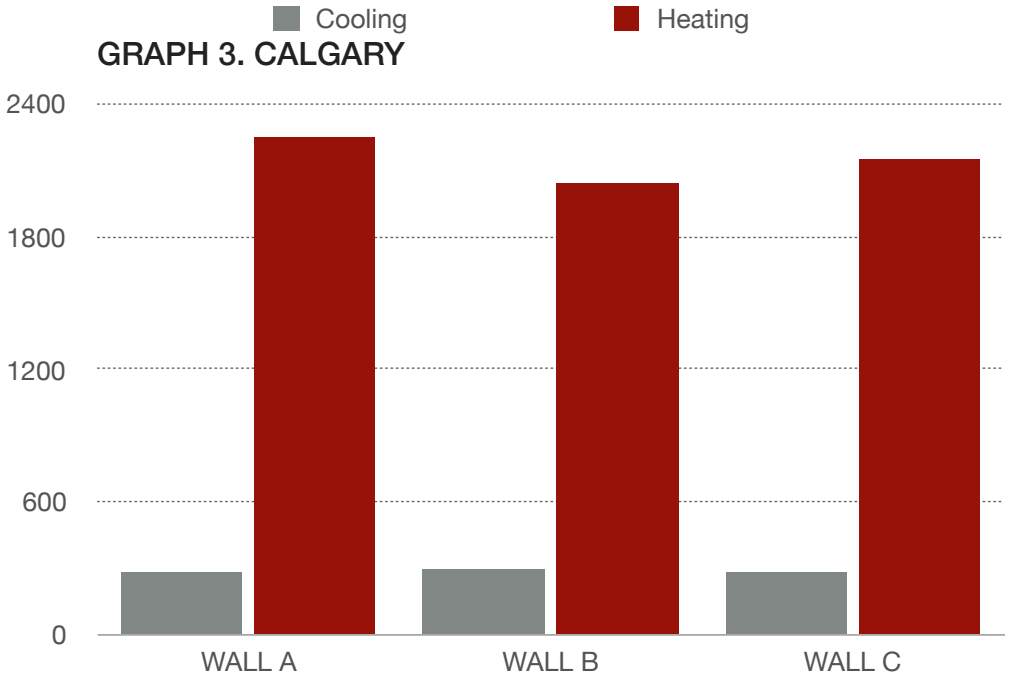
Graph 1. Aberdeen

On Graph 1, It could be seen clearly that the effect of lower conductivity applied on Wall B and Wall C has decrease the value of the annual heating load significantly in Aberdeen. In contrast, the cooling load slightly increase on Wall C and Wall B compare to Wall A.



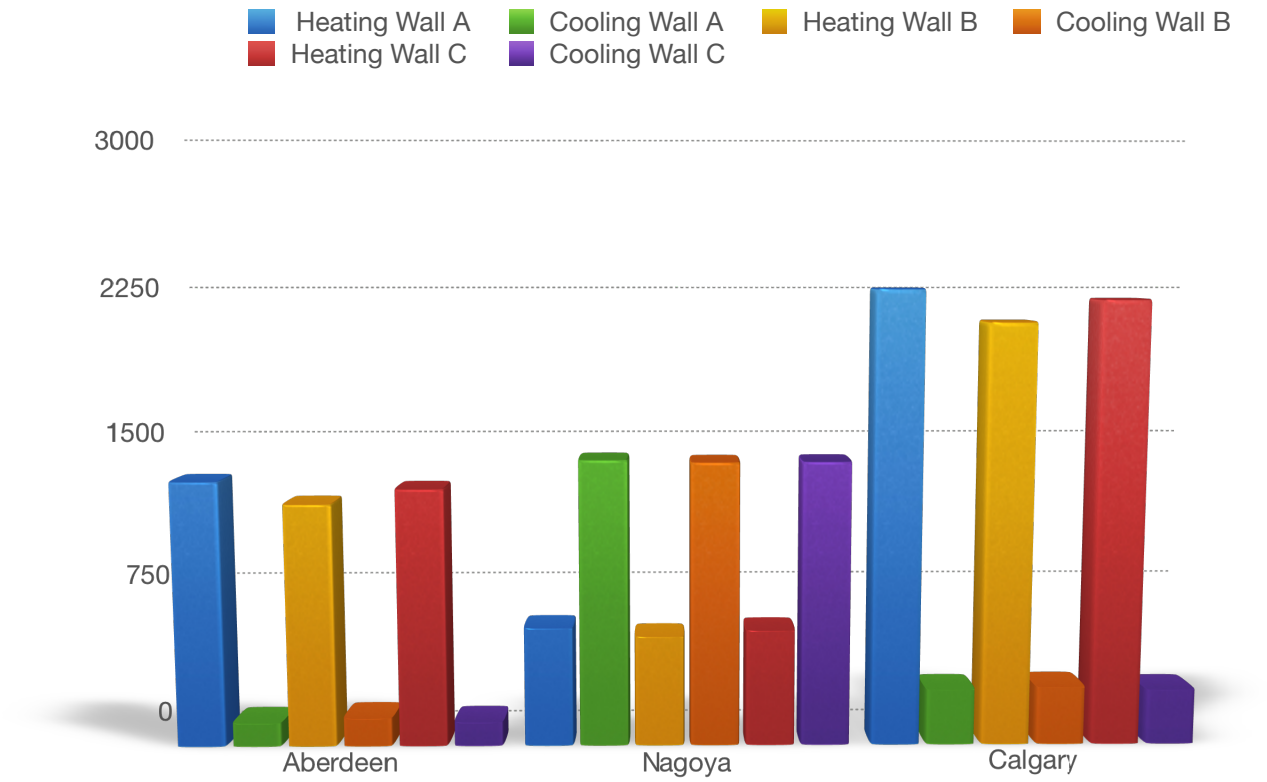
GRAPH 2. NAGOYA

The summer design temperature in Nagoya has significant difference with other two city, specifically in the value of temperature difference between outside and inside design temperature. Due to the considerable temperature difference, higher amount of energy is required for cooling down the room than heat it up. That is why in this graph, the cooling load is much higher than the heating load. In fact, the trending of the load for both heating and cooling still decrease significantly as the resistance of the wall increase from Wall A, Wall C, and Wall B respectively.



GRAPH 3. CALGARY

In Graph 3, it could be seen that Calgary as the highest amount of heating load compare to other two cities. it is because the winter design temperature reach -25 deg C so that higher amount of energy is required to meet the preferred inside temperature condition during winter (20 deg C).



Graph 4. Heating and Cooling load of each city with respect the the type of wall

In Graph 4, it could be observed that the pattern of heating load is similar for all the city with respect to the wall type. For the cooling load, only Nagoya has different pattern compare with Aberdeen and Calgary. it because the design temperature of Nagoya also has significant difference compare to others.

CONCLUSION

From the analysis, by varying the construction and operational features of the building, we can make recommendations for such a building located in any of the three cities. From the above mentioned graphs for all the three different cities, it seems that the opinion 2 or B has resulted in the load or consumption for HVAC system that is lower than the other two set of features. If we cite the building in Aberdeen then the best wall construction should be either wall B or C. For the building to be in Nagoya, wall construction B will be the best to reduce both heating and Cooling load which will eventually reduce energy consumption and save money. Wall type B is also recommended for the building sited in Calgary considering the summer and winter design conditions.