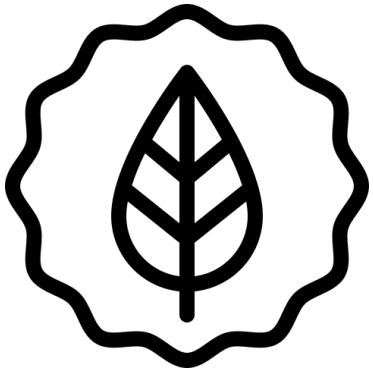

# Eco-Office


# *Politecnico Di Milano*

*School Of Architettura Urbanistica Ingegneria Delle Costruzioni*

*Sustainable Architecture and Landscape Design*

# *Technical Environmental Systems*

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## INTRODUCTION

**Eco-Office** is a project of a commercial building modelled using SketchUp 2016 and rendered using OpenStudio 2.3.1.

In this project, three different cities were used for parametric study of the annual Heating and Cooling Consumption regarding:

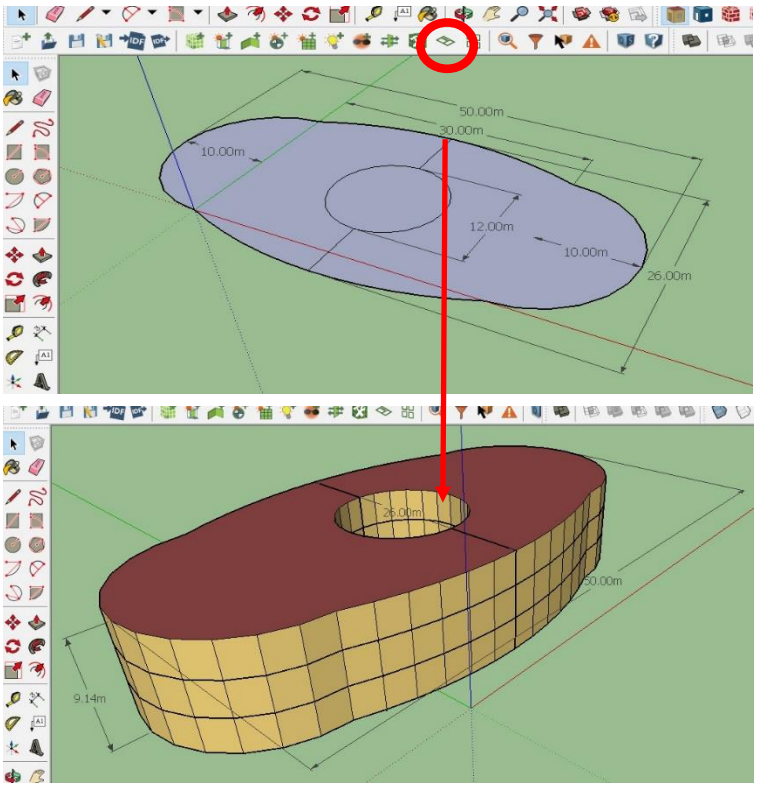
- The effect of weather by changing the location of the building among Roma, Las Vegas and Moscow.
- External wall construction. Three types of walls are used in these three different cities.
- External glazing characteristics where three designs of windows are applied on each one of the three cities.

## OBJECTIVE

The aim of this project is to determine the best design characteristics concerning walls and windows of the same building that would be constructed in three different cities of different weather characteristics in order to minimize the energy used for heating and cooling services, which will result in minimizing the cost.

## STEPS

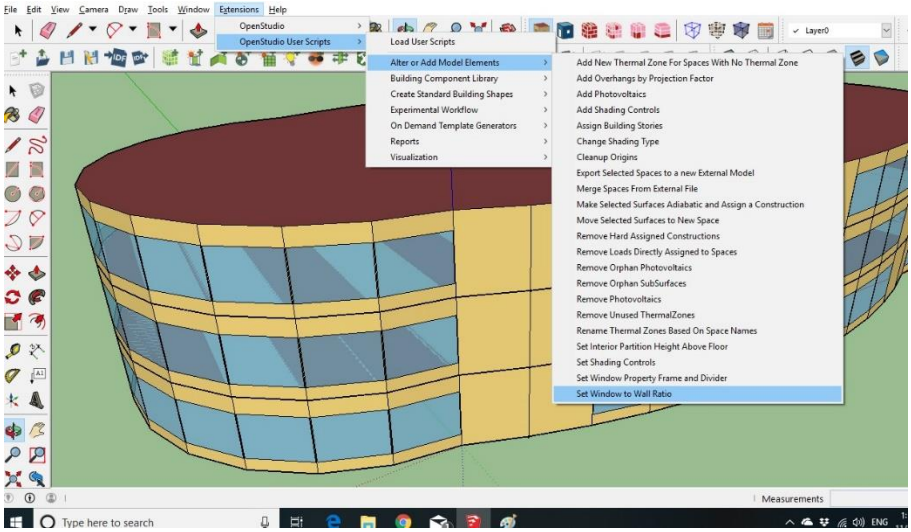
### 1. Building Geometry



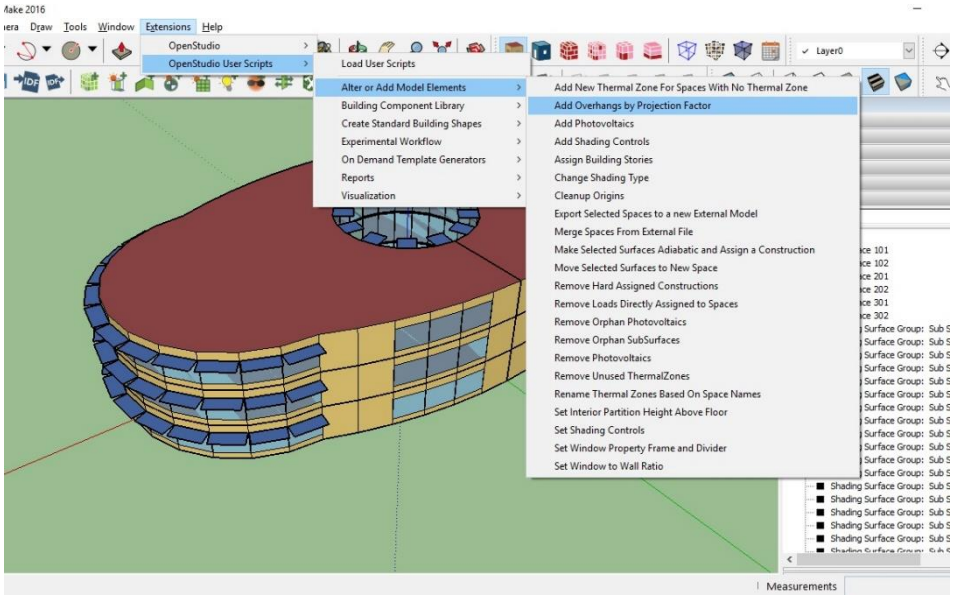

| Information | Value | Units |
|---|---|---|
| Building Name | Building 1 | building_name |
| Net Site Energy | 1,707,521 | kBtu |
| Total Building Area | 29,672 | ft^2 |

- Building Area = 29,672 $ft^2$ (2756.62 $m^2$)
- Building height = 30 $ft$ (9.14 $m$)
- Windows for all walls, and overhangs for all windows except the ones on northern side.
- It's a 3-floor Commercial Building, each floor is divided into two rooms
    - First Floor: lobby and conference room.
    - Second floor: open office and closed office.
    - Third floor: mech./elect. room and breakroom.

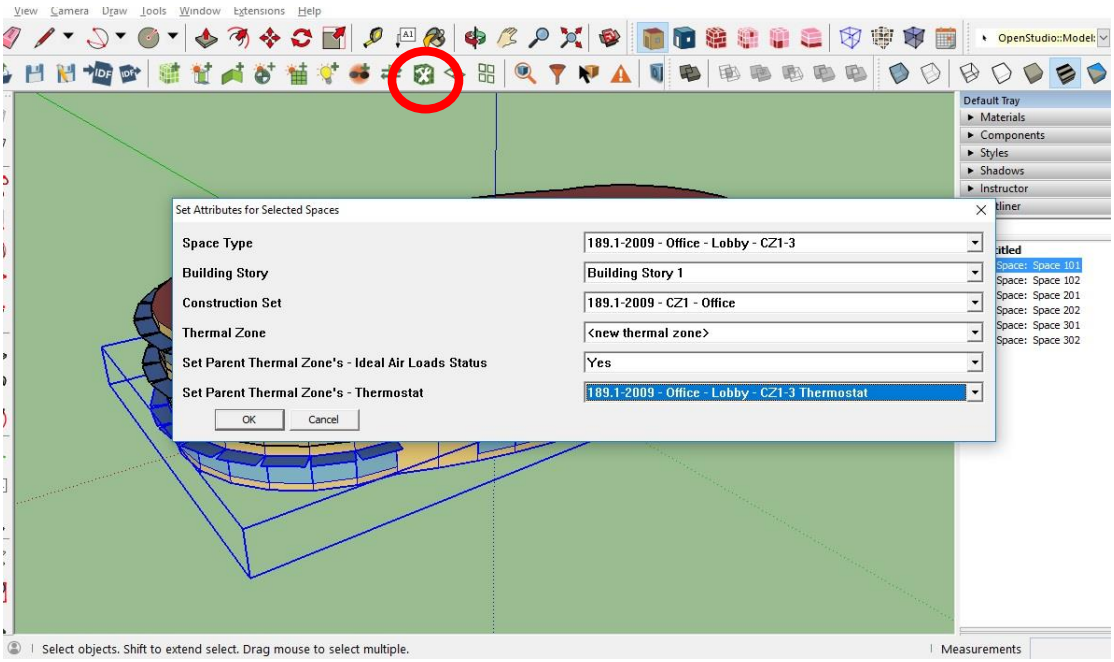
## Windows



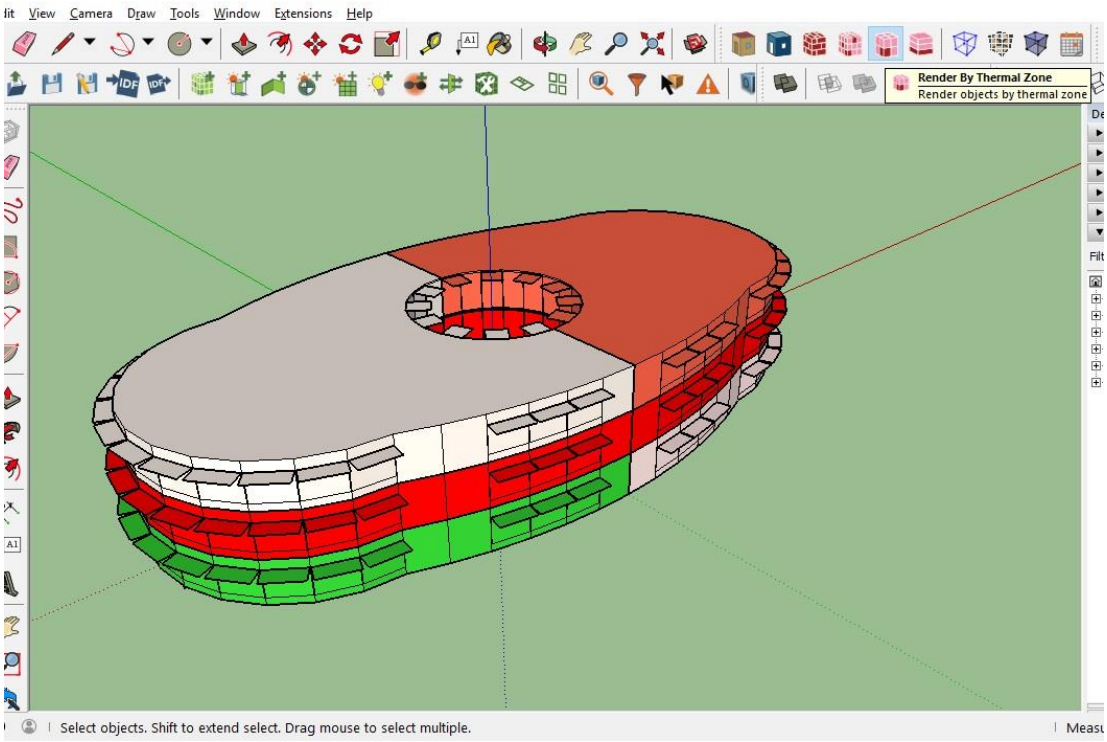

## Overhangs



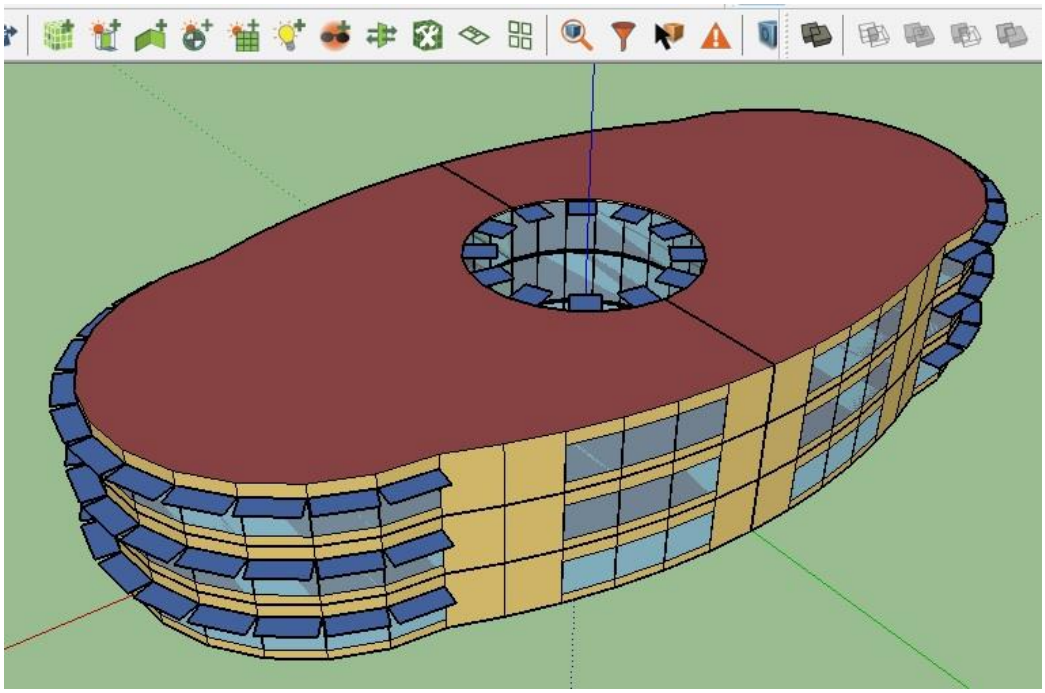
## Thermal Zones




The following figure shows the thermal zones. Each color represents a different zone attributed to each one of the 6 rooms.



**The Final Model**



## 2. OpenStudio Simulation

### Weather Data

### Moscow

| | |
|---|---|
| Weather File | MOSCOW - RUS IWEC Data WMO#=276120 |
| Latitude | 55.75 |
| Longitude | 37.63 |
| Elevation | 512 (ft) |

### Rome

| | |
|---|---|
| Weather File | ROME - ITA IWEC Data WMO#=16242( |
| Latitude | 41.80 |
| Longitude | 12.23 |
| Elevation | 10 (ft) |

### Las Vegas

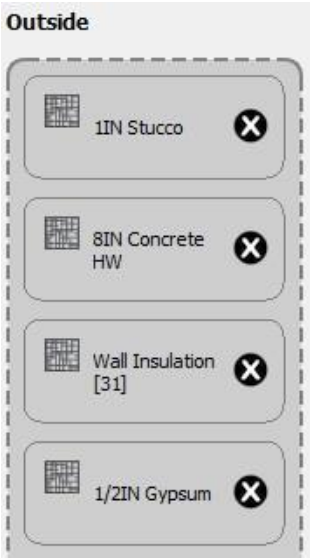
| | |
|---|---|
| Weather File | LAS_VEGAS NV USA TMY2-23169 WMO#=72386( |
| Latitude | 36.08 |
| Longitude | -115.2 |
| Elevation | 2178 (ft) |

The HVAC calculations are performed based on the weather data of these three cities taken from EnergyPlus Database: [www.energyplus.net/weather](www.energyplus.net/weather) to consider considers the monthly average outdoor Temperature as a reference of performing the annual simulation for optimum results.

### Walls

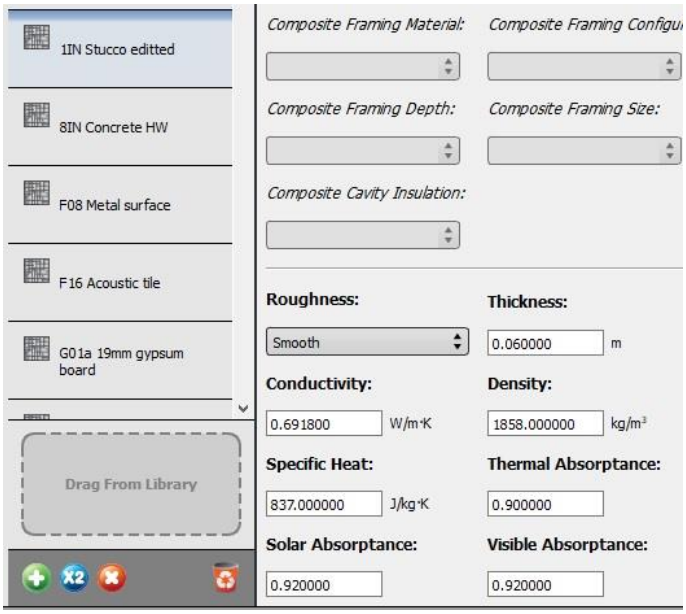
Base Case

- 1 in stucco
- 8 in concrete
- 0.03 m wall insulation
- ½ in Gypsum



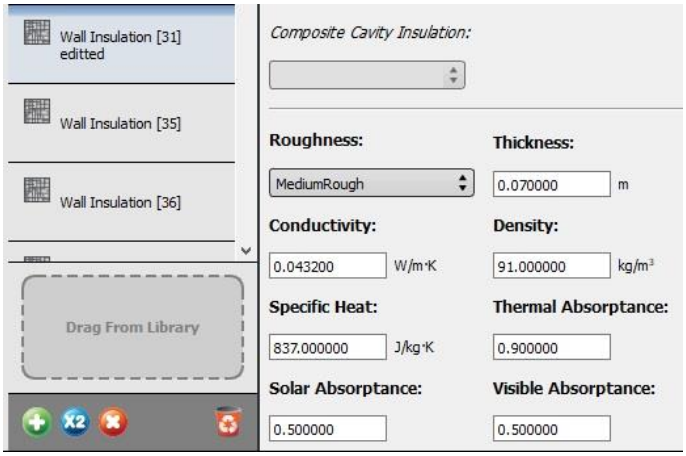
Case A

- Increased the stucco thickness to 2.36 in. (0.06 m).
- The others are the same as the base case.




Case B

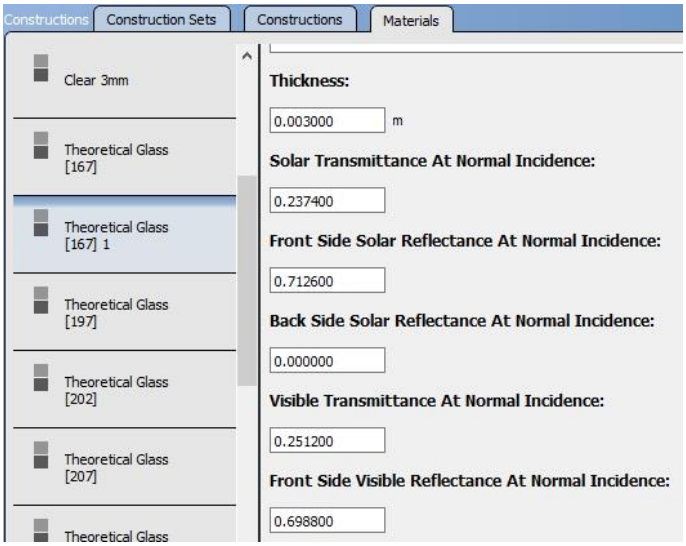
- increasing the thickness
- of wall insulation to
- 2.76 in (0.07 m)
- by keeping the others
- as the base case




## Glazing

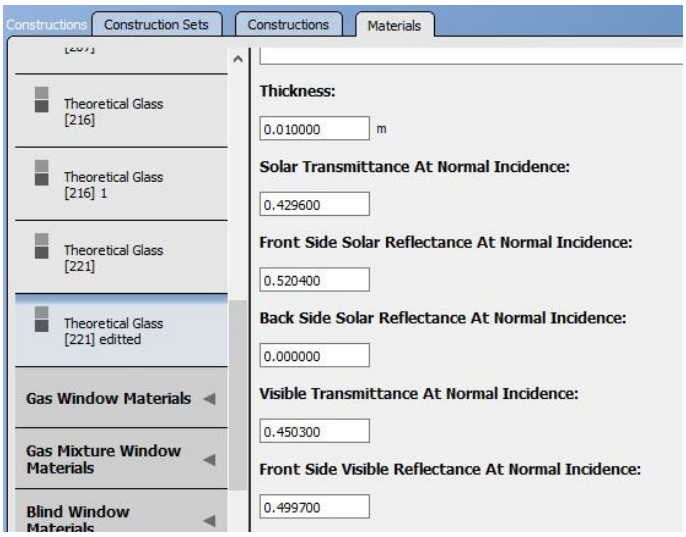
Base Case

- Theoretical glass [167]
- Of thickness 0.003m



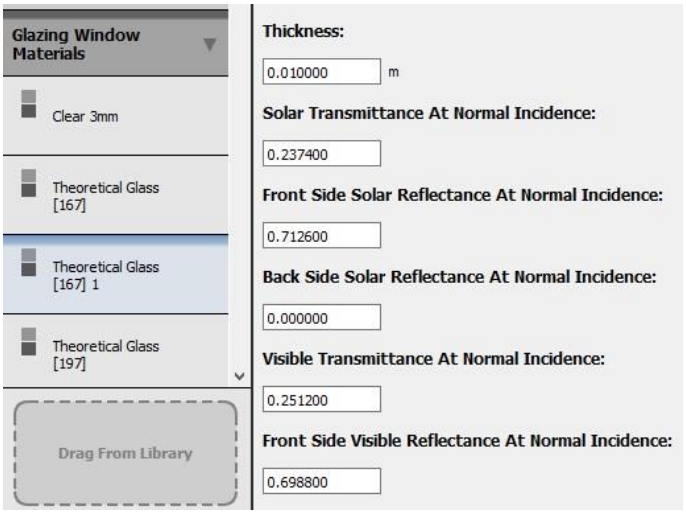
Case C

- Theoretical Glass [221]
- Of thickness 0.01 m



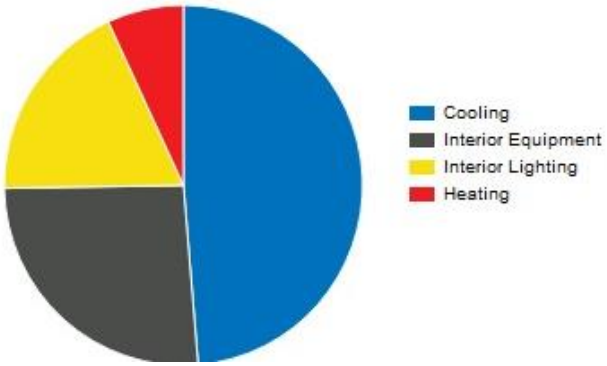

Case D

- Theoretical Glass [167]
- Of thickness 0.01 m



### 3. Data Analysis for the Base Case

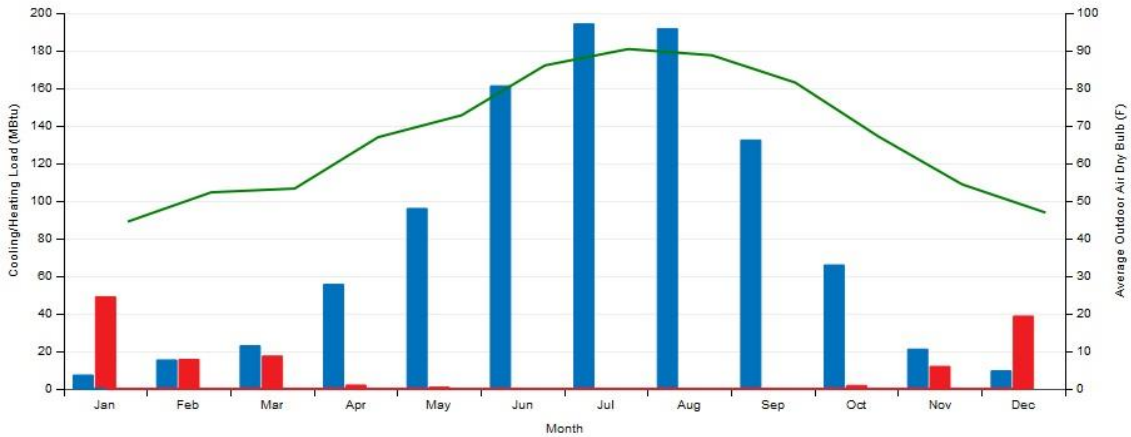
**Las Vegas**



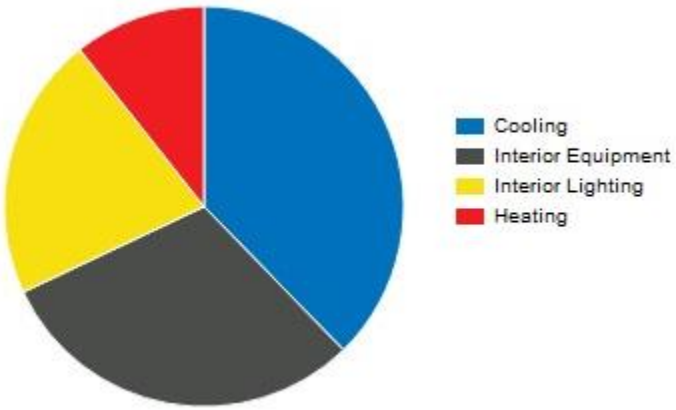

Yearly heating, cooling interior lighting and interior equipment consumption of the building for the base case in Las Vegas:

| End Use | Consumption (kBtu) |
|---|---|
| Heating | 137,708 |
| Cooling | 973,730 |
| Interior Lighting | 367,345 |
| Exterior Lighting | 0 |
| Interior Equipment | 521,110 |

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average Outdoor Air Dry Bulb (F) | 44.5 | 52.3 | 53.3 | 67.0 | 72.8 | 86.1 | 90.4 | 88.8 | 81.5 | 67.1 | 54.4 | 46.9 |
| Cooling Load (MBtu) | 7.34 | 15.37 | 23.0 | 55.6 | 96.01 | 161.25 | 194.24 | 191.74 | 132.45 | 65.94 | 21.15 | 9.64 |
| Heating Load (MBtu) | 49.04 | 15.68 | 17.48 | 2.02 | 0.91 | 0.02 | 0.0 | 0.0 | 0.04 | 1.8 | 11.97 | 38.73 |



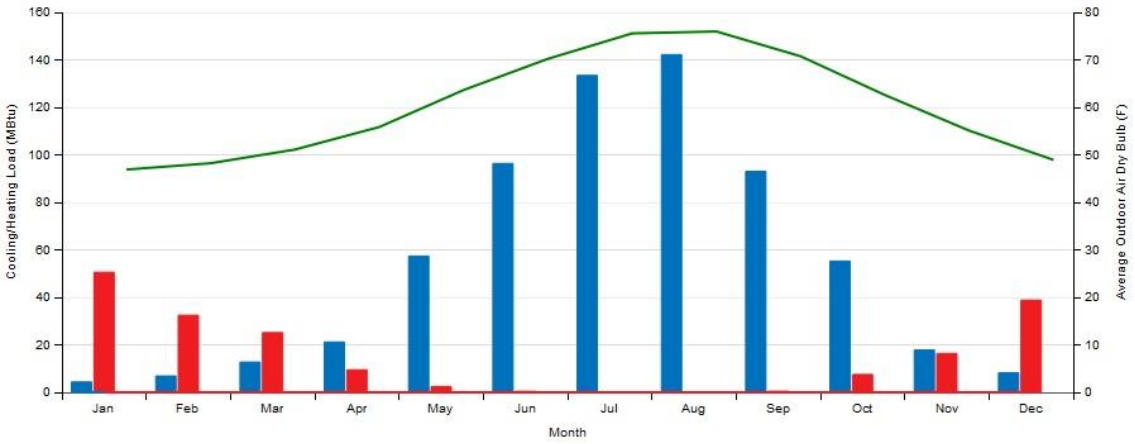
**Rome**



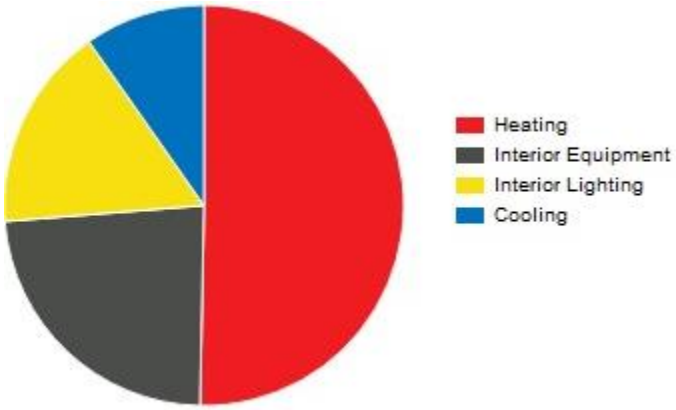

Yearly heating, cooling interior lighting and interior equipment consumption of the building for the base case in Rome:

| End Use | Consumption (kBtu) |
|---|---|
| Heating | 183,877 |
| Cooling | 649,094 |
| Interior Lighting | 367,345 |
| Exterior Lighting | 0 |
| Interior Equipment | 521,110 |

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average Outdoor Air Dry Bulb (F) | 46.9 | 48.2 | 51.1 | 55.9 | 63.7 | 70.2 | 75.6 | 76.0 | 70.7 | 62.6 | 55.1 | 48.9 |
| Cooling Load (MBtu) | 4.38 | 6.9 | 12.76 | 21.21 | 57.39 | 96.39 | 133.45 | 142.23 | 93.07 | 55.29 | 17.82 | 8.21 |
| Heating Load (MBtu) | 50.56 | 32.46 | 25.15 | 9.5 | 2.45 | 0.43 | 0.05 | 0.1 | 0.46 | 7.51 | 16.37 | 38.82 |



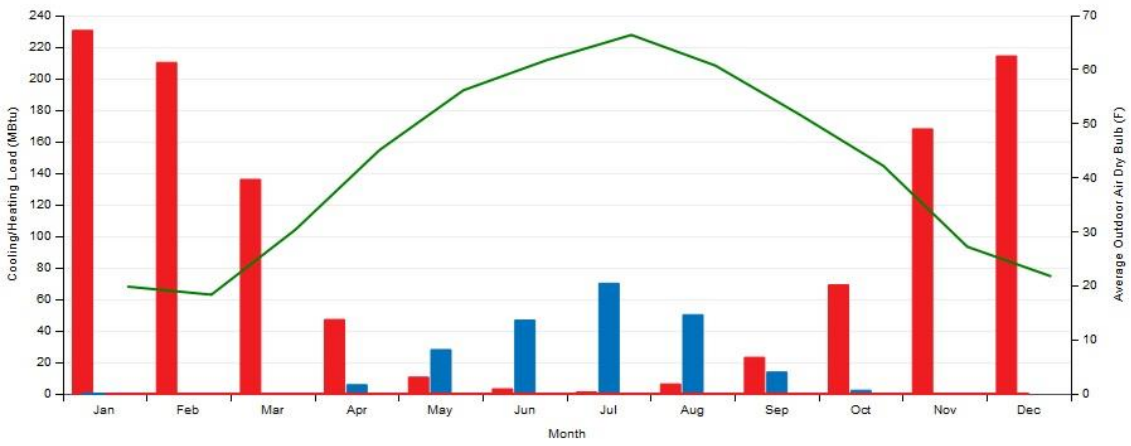
**Moscow**



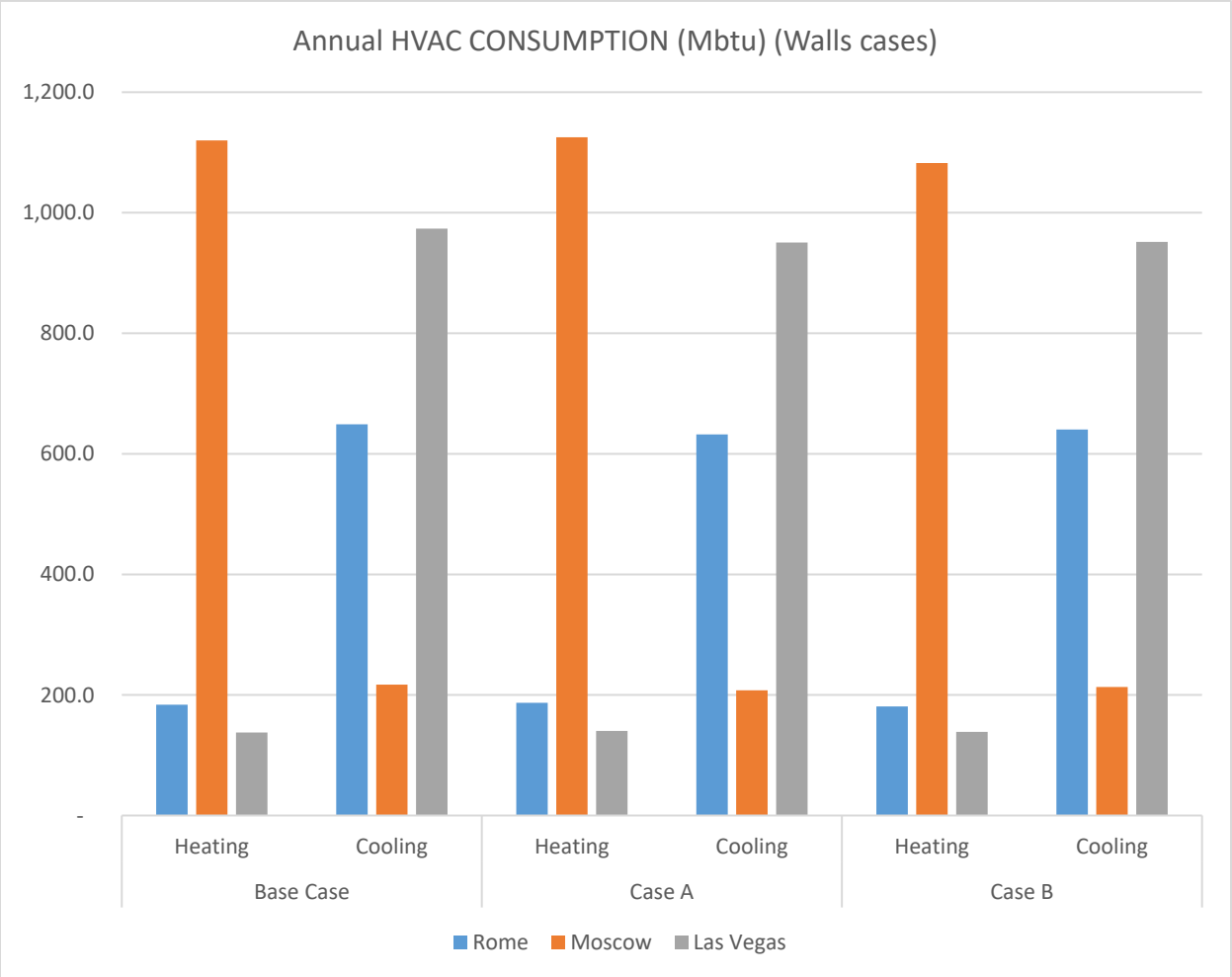

Yearly heating, cooling interior lighting and interior equipment consumption of the building for the base case in Moscow:

| End Use | Consumption (kBtu) |
|---|---|
| Heating | 1,119,874 |
| Cooling | 217,202 |
| Interior Lighting | 367,345 |
| Exterior Lighting | 0 |
| Interior Equipment | 521,110 |

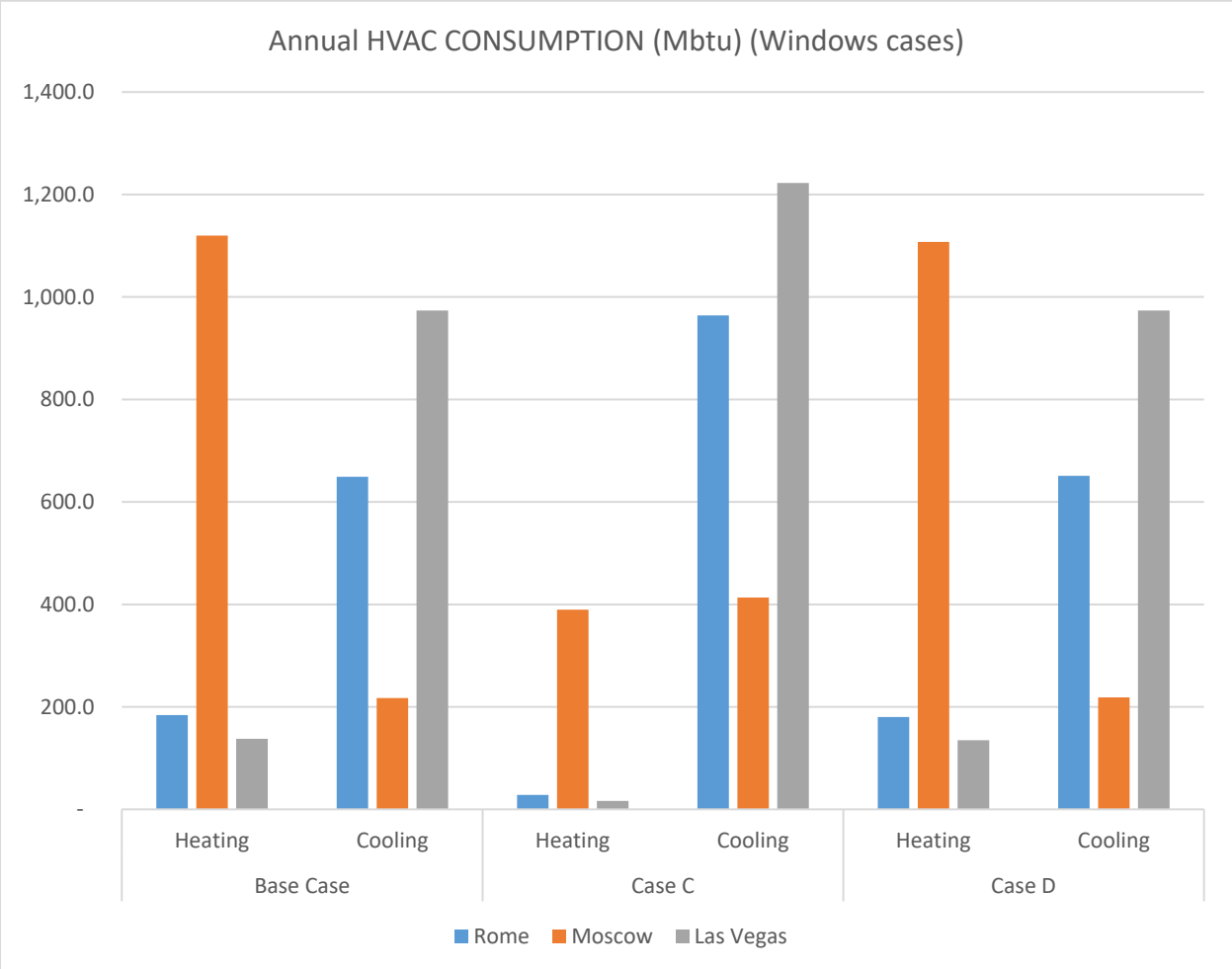
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average Outdoor Air Dry Bulb (F) | 19.8 | 18.3 | 30.4 | 45.1 | 56.2 | 61.8 | 66.4 | 60.7 | 51.7 | 42.2 | 27.2 | 21.7 |
| Cooling Load (MBtu) | 0.0 | 0.02 | 0.21 | 5.75 | 28.03 | 46.76 | 70.13 | 50.21 | 13.84 | 2.26 | 0.0 | 0.0 |
| Heating Load (MBtu) | 230.56 | 210.26 | 136.02 | 47.16 | 10.58 | 3.14 | 1.2 | 6.25 | 23.15 | 69.15 | 168.06 | 214.34 |

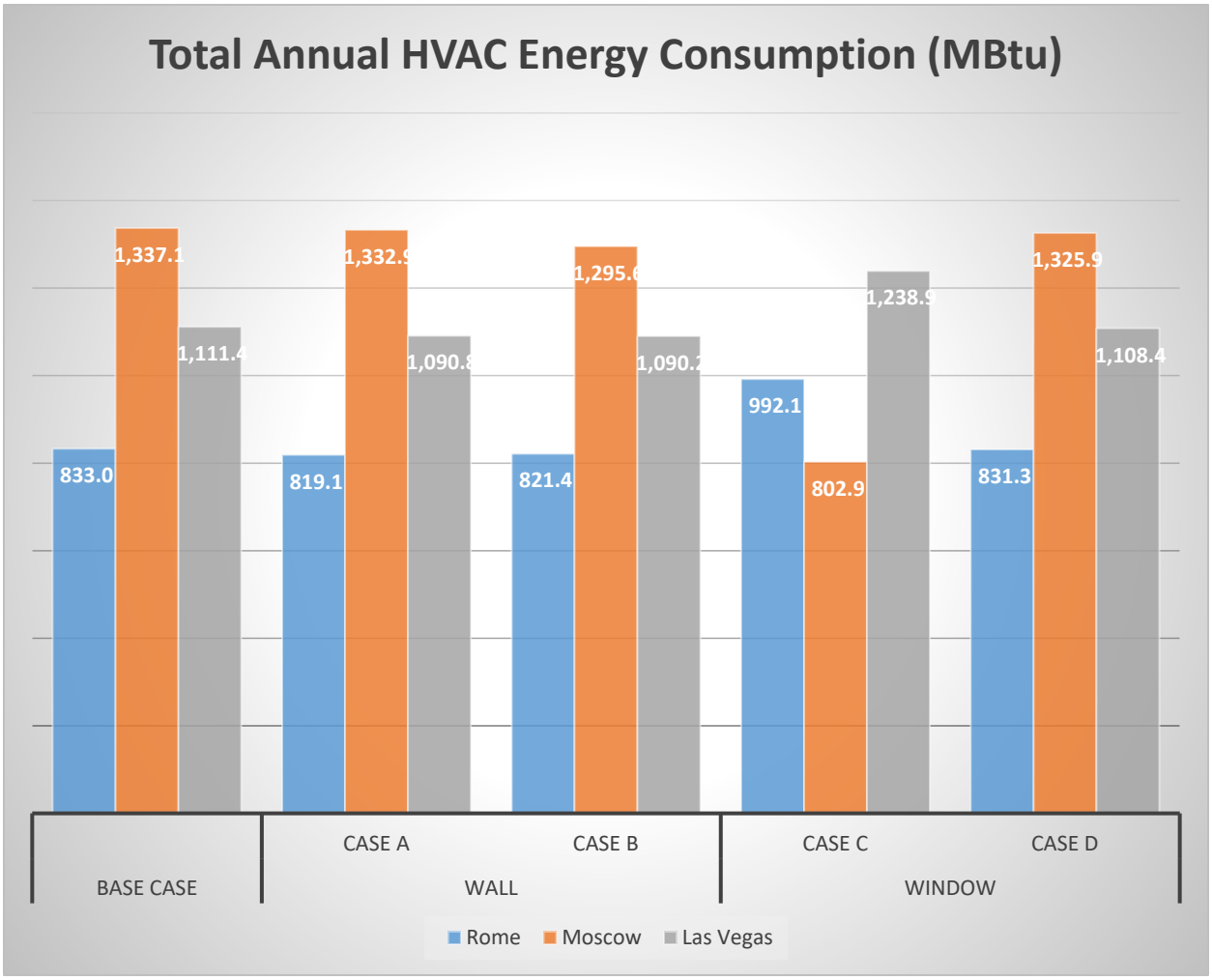


| ANNUAL HVAC CONSUMPTION (Mbtu) (Walls) | | | | | | |
|---|---|---|---|---|---|---|
| Cities | **Base Case** | | **Case A** | | **Case B** | |
| | Heating | Cooling | Heating | Cooling | Heating | Cooling |
| Rome | 183.9 | 649.1 | 186.9 | 632.2 | 180.9 | 640.4 |
| Moscow | 1,119.9 | 217.2 | 1,125.3 | 207.6 | 1,082.3 | 213.2 |
| Las Vegas | 137.7 | 973.7 | 140.3 | 950.5 | 138.7 | 951.5 |



| ANNUAL HVAC CONSUMPTION (Mbtu) (Windows cases) | | | | | | |
|---|---|---|---|---|---|---|
| Cities | Base Case | | Case C | | Case D | |
| | Heating | Cooling | Heating | Cooling | Heating | Cooling |
| Rome | 183.9 | 649.1 | 28.2 | 963.9 | 180.3 | 651.0 |
| Moscow | 1,119.9 | 217.2 | 389.6 | 413.3 | 1,107.5 | 218.4 |
| Las Vegas | 137.7 | 973.7 | 16.5 | 1,222.4 | 134.8 | 973.6 |






## 4. Conclusion

By observing the above chart that shows the total annual consumption of the HVAC system of the building in three cities for the three different cases, then comparing the results, we can now design our building in each city regarding the best walls and windows characteristics as follows:

- Rome: A combination of Case A (wall) & Case D (window).
- Moscow: A combination of Case B (wall) & Case C (window).
- Las Vegas: A combination of Case B (wall) & Case D (window).