

## Question 1

As we know from the presentation the radiation heat transfer formula between two surfaces is reconstructed as following:

$$\dot{Q}_{12,one\ shield} = \frac{E_{b1} - E_{b2}}{\frac{1-\varepsilon_1}{A_1 \times \varepsilon_1} + \frac{1}{A_1 \times F_{12}} + \frac{1-\varepsilon_{3,1}}{A_3 \times \varepsilon_{3,1}} + \frac{1-\varepsilon_{3,2}}{A_3 \times \varepsilon_{3,2}} + \frac{1}{A_3 \times F_{32}} + \frac{1-\varepsilon_2}{A_2 \times \varepsilon_2}}$$

By implementing the facts we know from infinite parallel surfaces:

$$- \quad A_1 = A_2 = A_3 = A \quad \text{and} \quad F_{1 \rightarrow 2} = F_{3 \rightarrow 2}$$

$$\Rightarrow \dot{Q}_{12,one\ shield} = \frac{\sigma \times (T_1^4 - T_2^4)}{\left(\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1\right) + \left(\frac{1}{\varepsilon_{3,1}} + \frac{1}{\varepsilon_{3,2}} - 1\right)}$$

In case of having multiple shields the formula can be reshaped like this:

$$\dot{Q}_{12,N\ shields} = \frac{\sigma \times (T_1^4 - T_2^4)}{\left(\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1\right) + \left(\frac{1}{\varepsilon_{3,1}} + \frac{1}{\varepsilon_{3,2}} - 1\right) + \dots + \left(\frac{1}{\varepsilon_{N1}} + \frac{1}{\varepsilon_{N2}} - 1\right)}$$

In the previous assignment, both emissivities were equal to 0.1 as well as the current one for this question. In this case when all epsilons are the same figure, we can use the following formula:

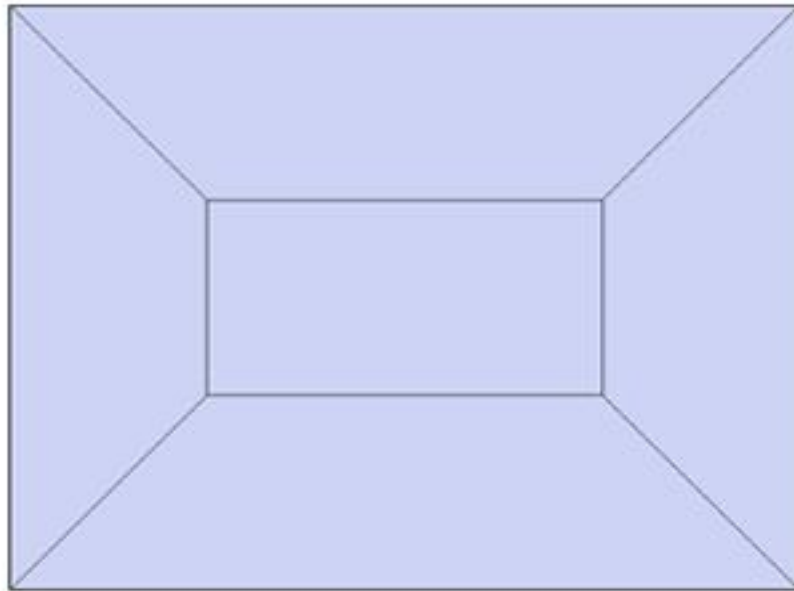
$$\dot{Q}_{12,N\ shields} = \frac{\sigma \times (T_1^4 - T_2^4)}{(N+1) \times \left(\frac{1}{\varepsilon} + \frac{1}{\varepsilon} - 1\right)} = \frac{1}{(N+1)} \dot{Q}_{12,no\ shield}$$

If the heat transfer with N shields is equal to 1% of the heat transfer with no shield then:

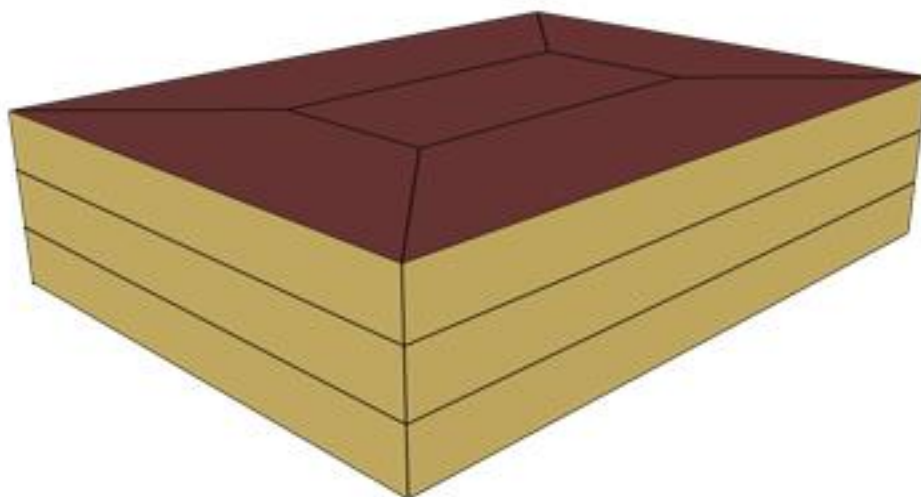
$$\dot{Q}_{12,N\ shield} = \frac{1}{100} \dot{Q}_{12,no\ shield} \Rightarrow (N+1) = 100 \Rightarrow \boxed{N = 99}$$

## Open Studio Exercise

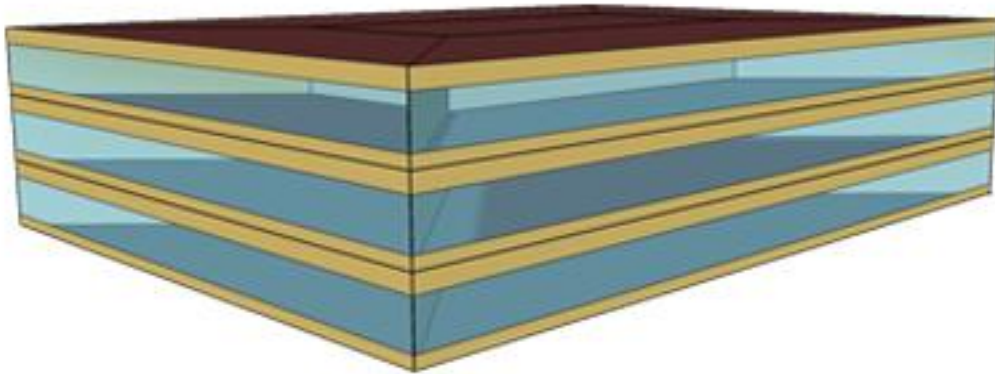
In the first step we need to draw a  $30 \times 40$  cm rectangle in Sketchup which contains another rectangle inside with the offset of 10 cm. Then we connect the corners of outer rectangle to the inner one's. This represents our diagram.



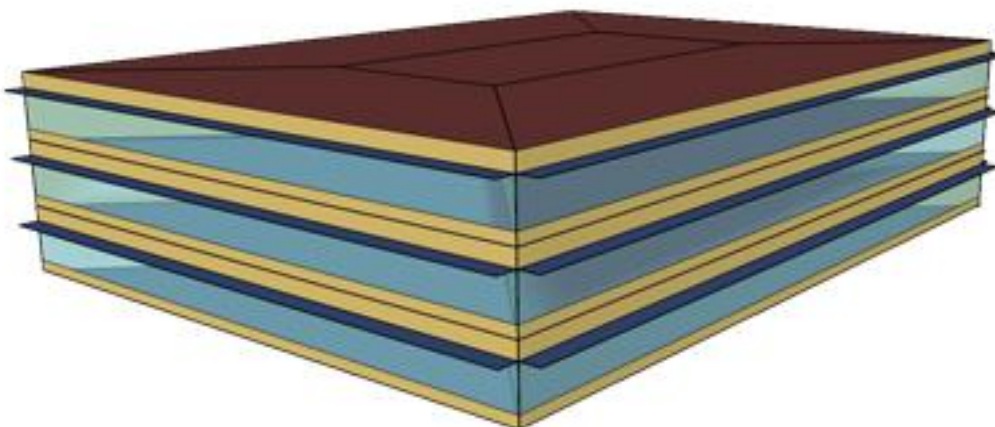
What we do next is to select the diagram and click on **“Create Spaces From Diagram”** icon from open studio extension menu and choose the desired number of floors and their heights.



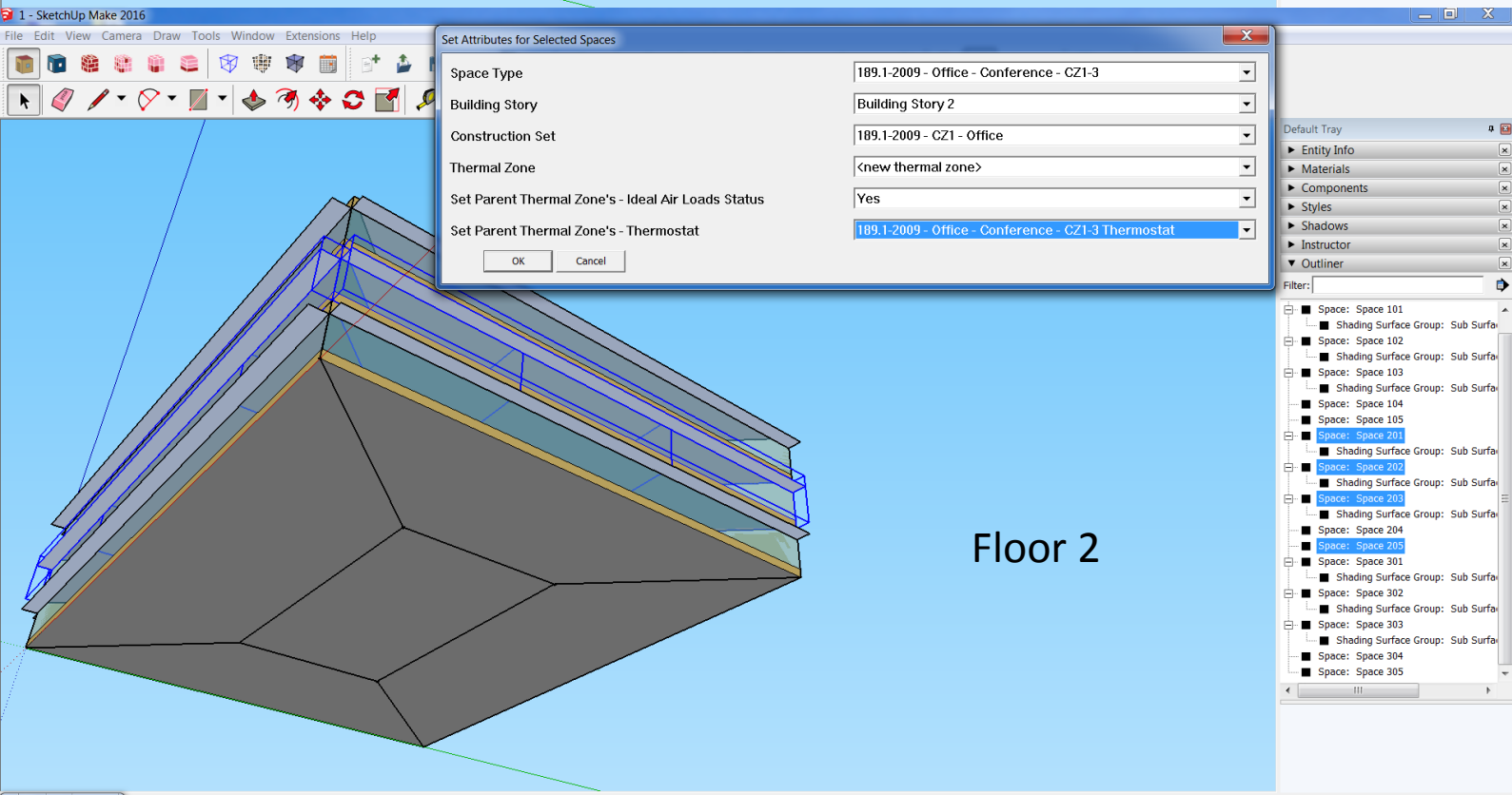
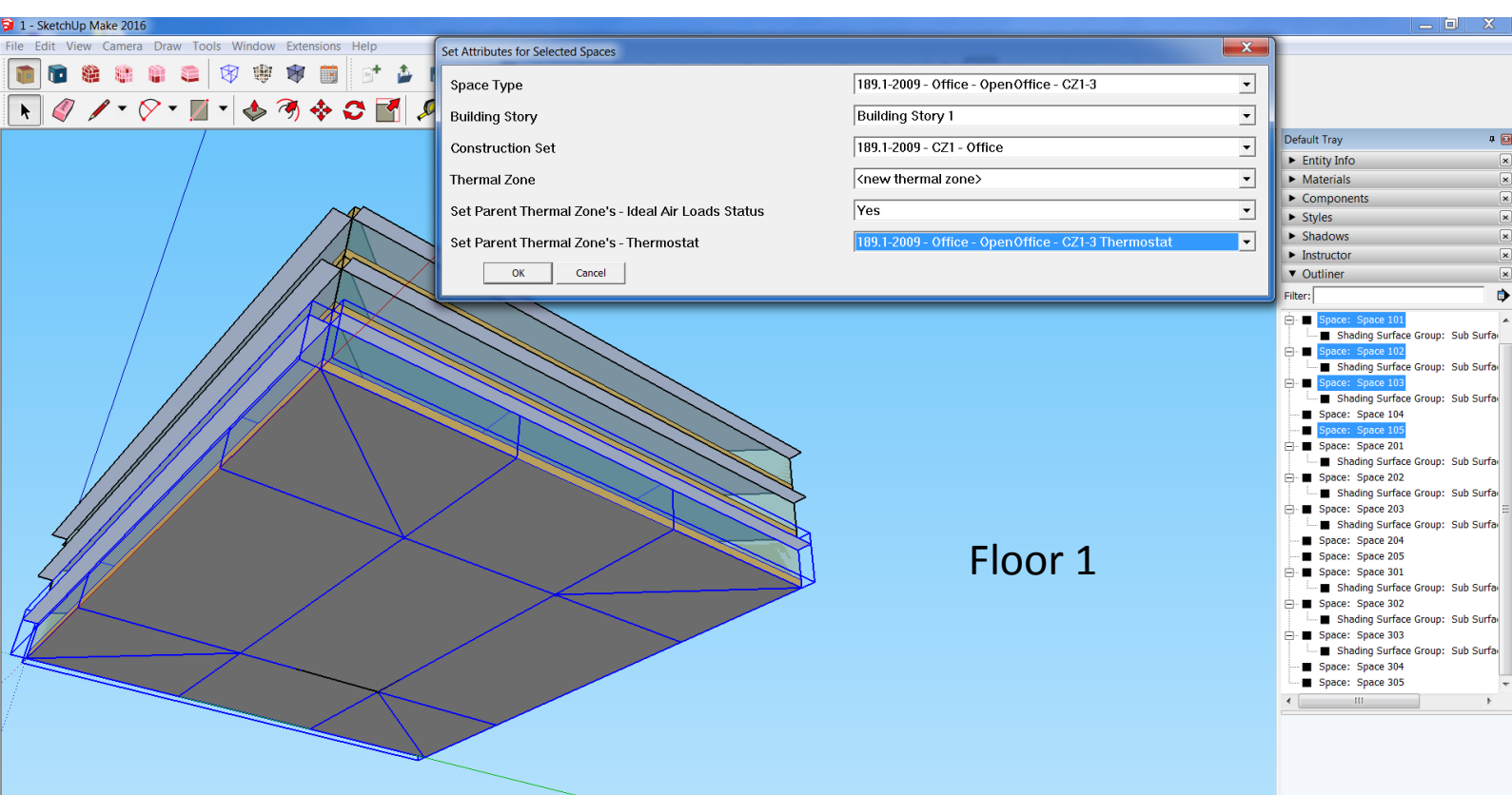
After matching all surfaces (**Extensions ---> OpenStudio ---> Modify Model ---> Surface Matching**) then we can create windows by selecting all surfaces and clicking on **Extensions ---> OpenStudio User Scripts ---> Alter or Add Model Elements ---> Set Window to Wall Ratio** and insert our desired figures.

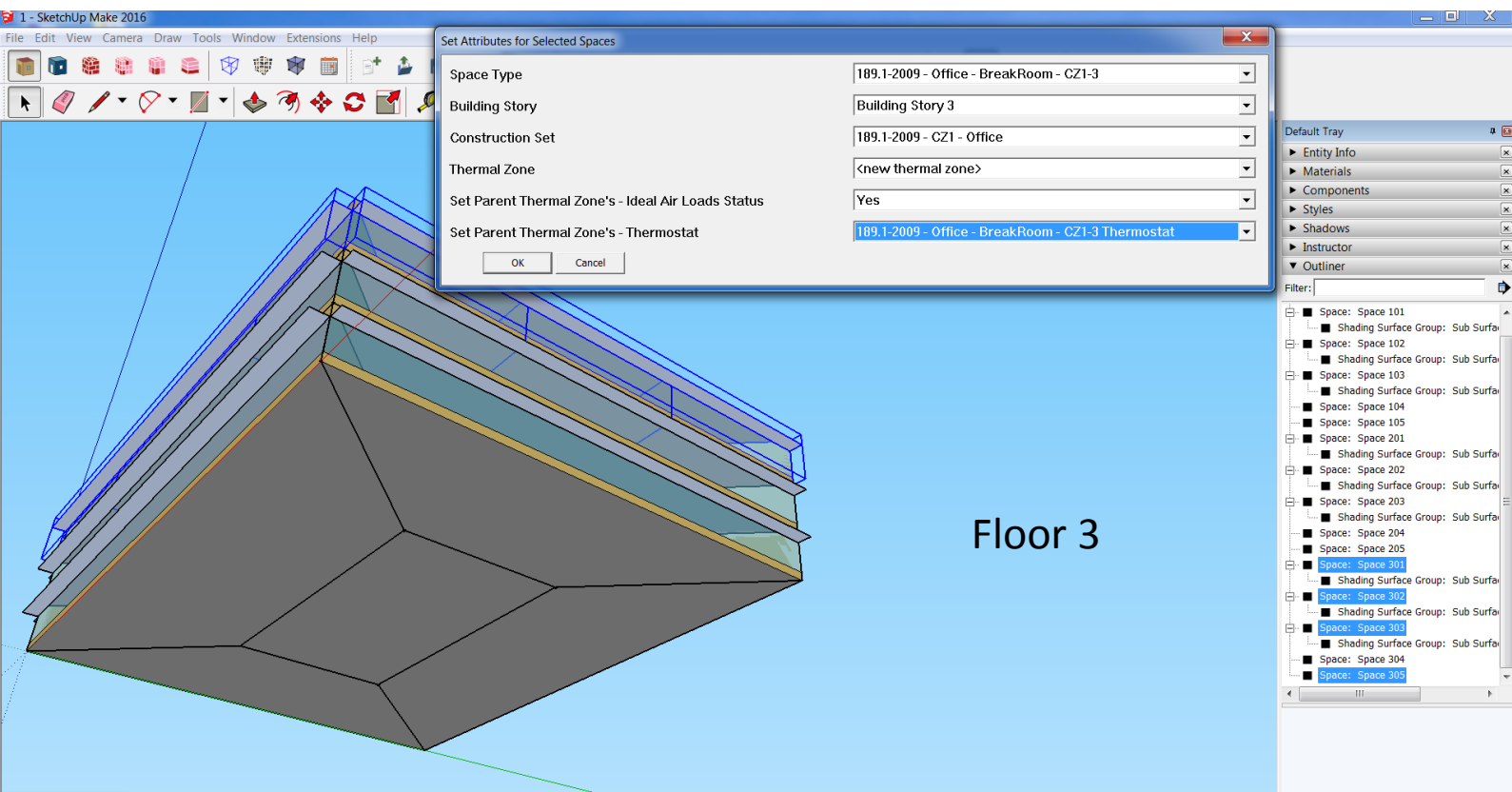


We can also add overhangs by first selecting the base surfaces (Search Surfaces from the OpenStudio extension menu and then choose the 90-270 degree orientation for surfaces and tick the box for inclusion of horizontal surfaces) and then clicking on **OpenStudio User Scripts ---> Alter or Add Model Elements ---> Add Overhangs by Projection Factor** and insert the desired projection factor and offset.

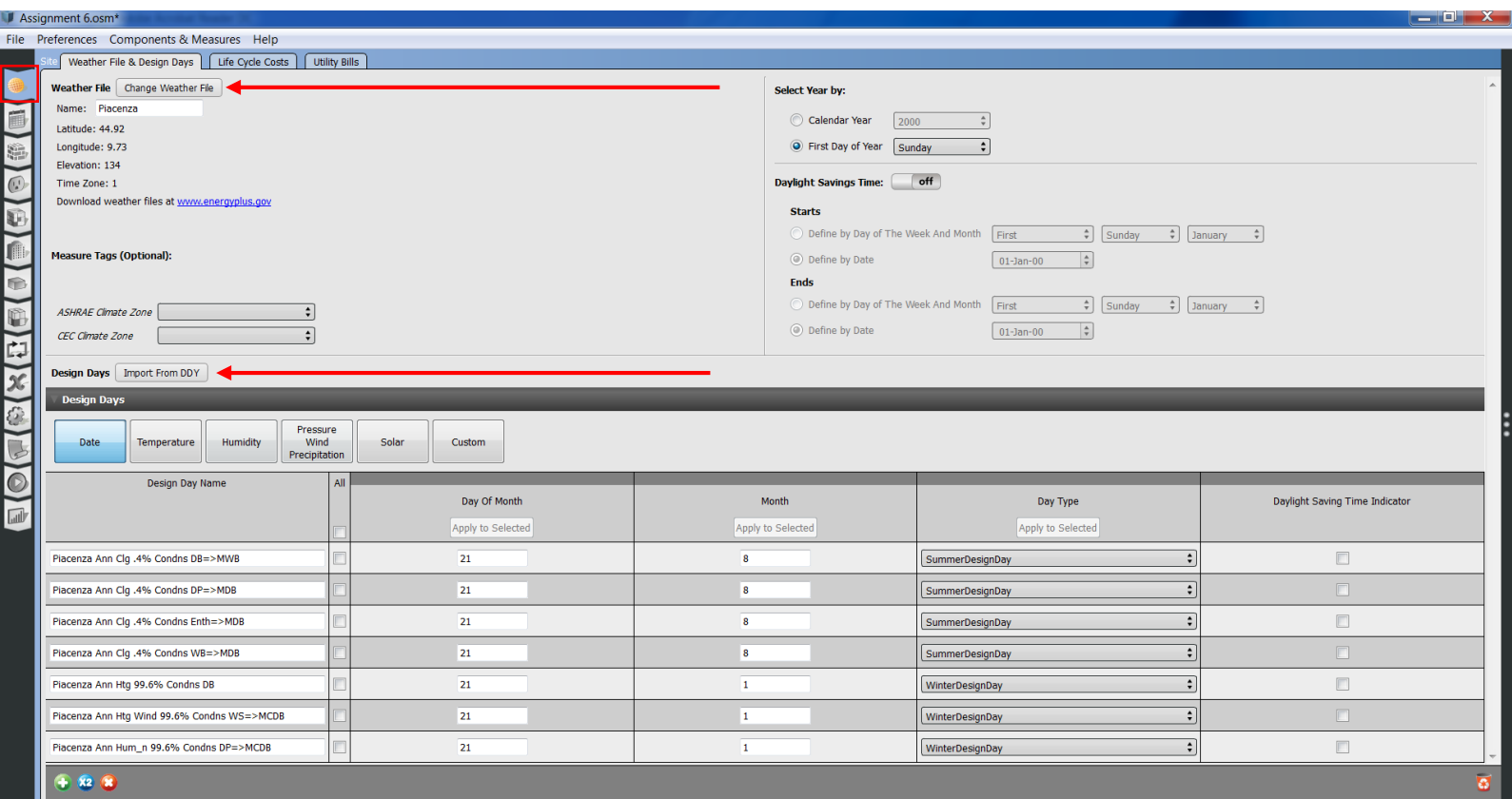


Now we choose the thermal zone for each space within each floor and define some specifications as per our design by selecting our spaces and click on **“Set Attributes for Selected Surfaces”** from the Open Studio extension menu.



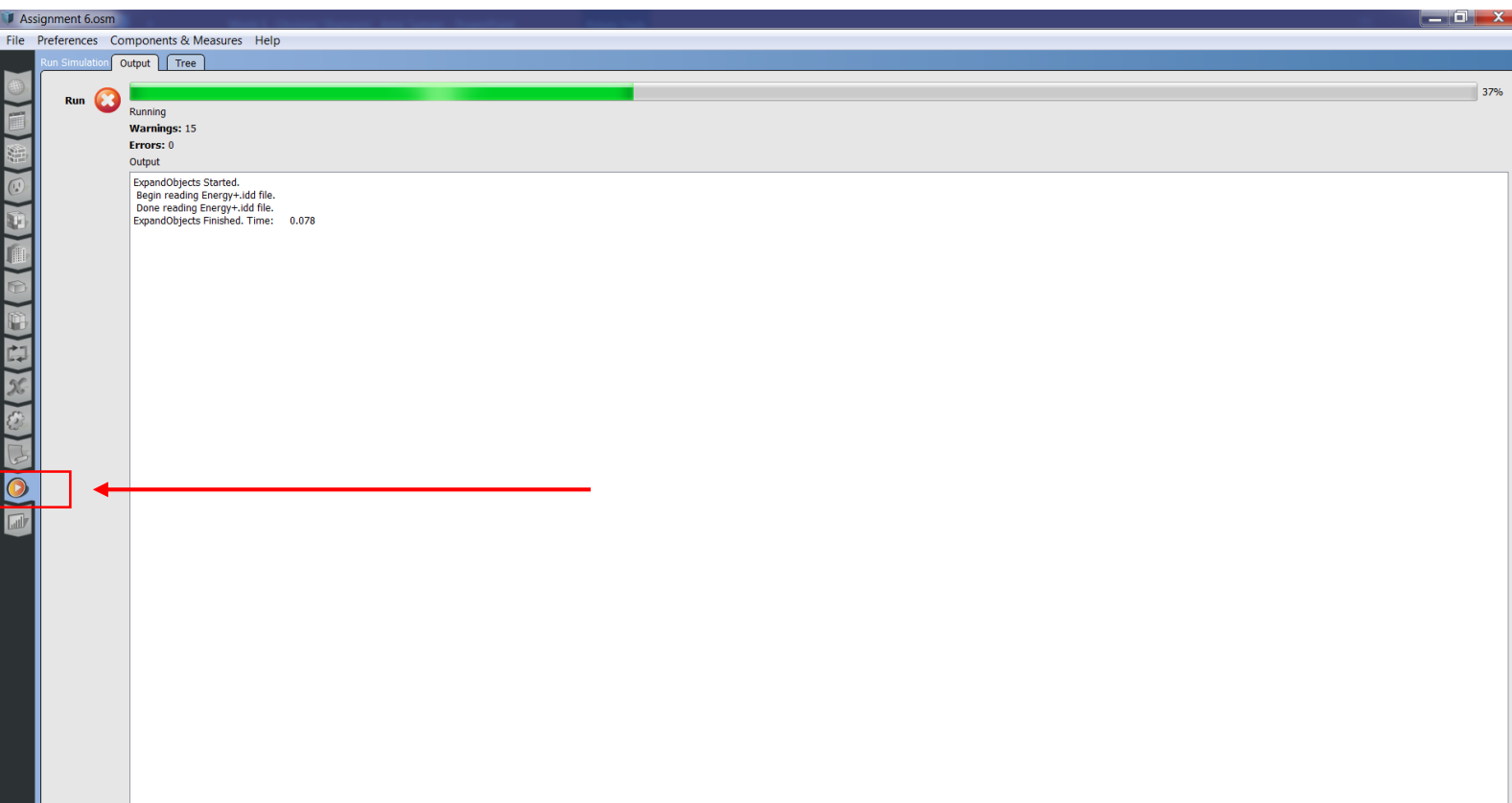


After saving the model as an .osm file by clicking on save icon from OpenStudio extension menu then we can open it and click on **Site** tab from the menu on the left and load the certain weather data.

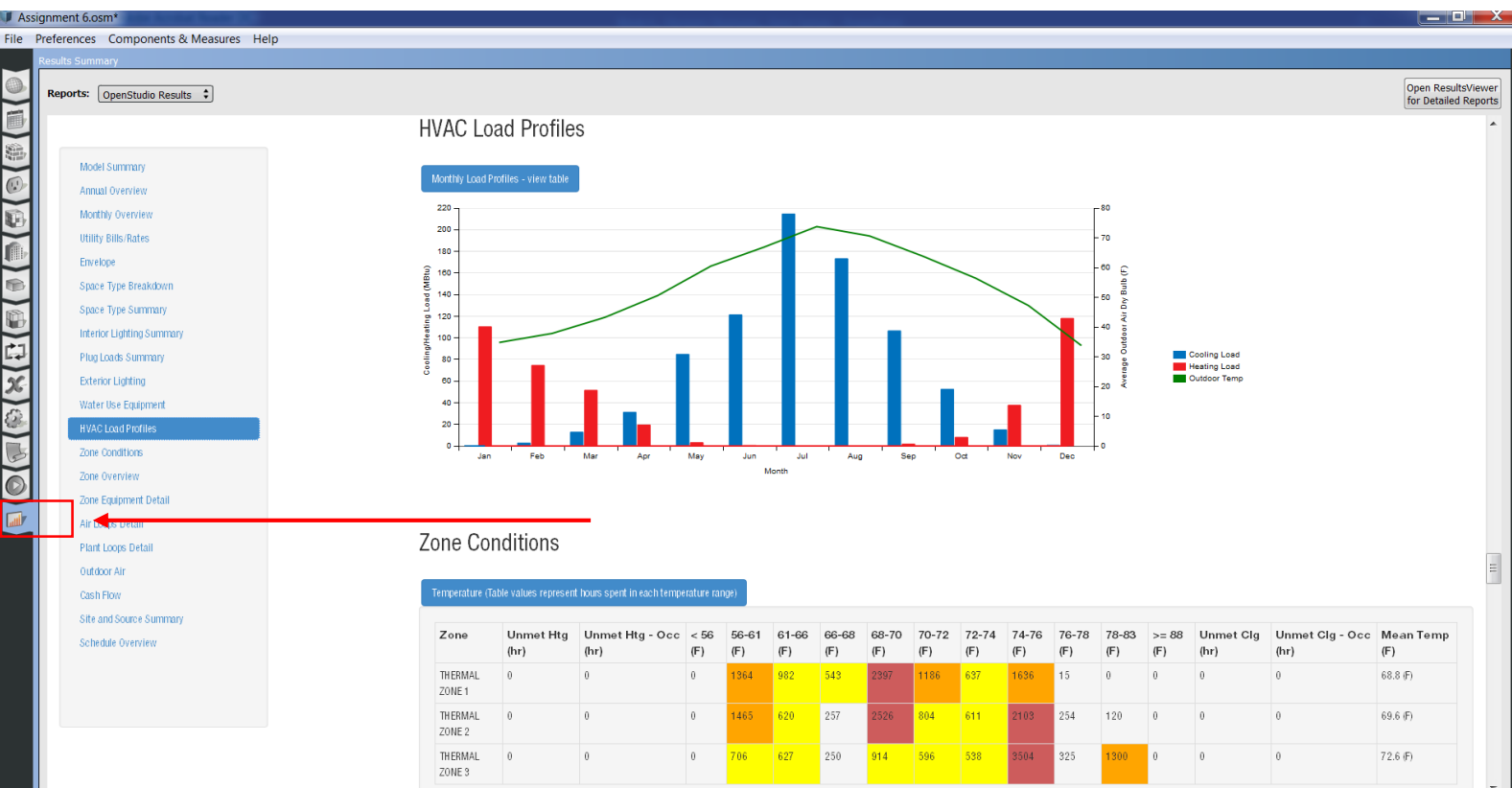




After applying our changes we can click on **“Run”** from the **“Run Simulation menu”** and wait for our results:



Results summary can be seen by click on the last icon down:



Assignment 6.osm\*

File Preferences Components & Measures Help

Results Summary

Reports: OpenStudio Results

Open Results/Viewer for Detailed Reports

Model Summary  
 Annual Overview  
 Monthly Overview  
 Utility Bills Rates  
 Envelope  
 Space Type Breakdown  
 Space Type Summary  
 Interior Lighting Summary  
 Plug Loads Summary  
 Exterior Lighting  
 Water Use Equipment  
 HVAC Load Profiles  
 Zone Conditions  
 Zone Overview  
 Zone Equipment Detail  
 Air Loops Detail  
 Plant Loops Detail  
**Outdoor Air**  
 Cash Flow  
 Site and Source Summary  
 Schedule Overview

### Outdoor Air

Average and Minimum Outdoor Air During Occupied Hours

	Average Number of Occupants	Nominal Number of Occupants	Zone Volume (ft <sup>3</sup> )	Avg. Mechanical Ventilation (ach)	Min. Mechanical Ventilation (ach)	Avg. Infiltration (ach)	Min. Infiltration (ach)	Avg. Simple Ventilation (ach)	Min. Simple Ventilation (ach)
THERMAL ZONE 1	31.55	56.51	113007	0.0	0.0	0.051	0.001	0.308	0.001
THERMAL ZONE 2	207.1	538.2	113007	0.0	0.0	0.051	0.001	1.737	0.008
THERMAL ZONE 3	207.1	538.2	113007	0.0	0.0	0.166	0.002	1.307	0.006

### Cash Flow

No Data to Show for Cash Flow

### Site and Source Summary

Site and Source Energy

	Total Energy (kBtu)	Energy Per Total Building Area (kBtu/ft <sup>2</sup> )	Energy Per Conditioned Building Area (kBtu/ft <sup>2</sup> )
Total Site Energy	2588052.6	80.1	80.1
Net Site Energy	2588052.6	80.1	80.1
Total Source Energy	6664481.2	206.4	206.4
Net Source Energy	6664481.2	206.4	206.4

Site to Source Energy Conversion Factors

Another ability is OpenStudio is to load and define **Construction Sets** by accessing the “**Constructions**” menu and click on one of the available options.

Assignment 6.osm\*

File Preferences Components & Measures Help

Constructions Construction Sets Constructions Materials

My Model Library Edit

### Constructions

189.1-2009 - CZ1 - Office  
 189.1-2009 - CZ2 - Office  
 189.1-2009 - CZ3 - Office  
 189.1-2009 - CZ4 - Office  
 189.1-2009 - CZ5 - Office  
 189.1-2009 - CZ6 - Office  
 189.1-2009 - CZ7-8 - Office

189.1-2009 - CZ2 - Office

#### Exterior Surface Constructions

Walls: ASHRAE 189.1-2009 ExtWall  
 Floors: ExtSlabCarpi 4in ClimateZone  
 Roofs: ASHRAE 189.1-2009 ExtRoof

#### Interior Surface Constructions

Walls: Interior Wall  
 Floors: Interior Floor  
 Ceilings: Interior Ceiling

#### Ground Contact Surface Constructions

Walls: ExtSlabCarpi 4in ClimateZone  
 Floors: ExtSlabCarpi 4in ClimateZone  
 Ceilings: ExtSlabCarpi 4in ClimateZone

#### Exterior Sub Surface Constructions

Fixed Windows: ASHRAE 189.1-2009 ExtWindow  
 Operable Windows: ASHRAE 189.1-2009 ExtWindow  
 Doors: Exterior Door

Glass Doors: Drag From Library  
 Overhead Doors: Drag From Library  
 Skylights: Drag From Library

Tubular Daylight Domes: Interior Window  
 Tubular Daylight Diffusers: Interior Window

Drag & Drop

Constructions

Air Wall  
 ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 1  
 ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 2-5  
 ASHRAE 189.1-2009 ExtRoof IEAD ClimateZone 7-8  
 ASHRAE 189.1-2009 ExtRoof Metal ClimateZone 6  
 ASHRAE 189.1-2009 ExtWall Mass ClimateZone 1  
 ASHRAE 189.1-2009 ExtWall Mass ClimateZone 2  
 ASHRAE 189.1-2009 ExtWall Mass ClimateZone 3  
 ASHRAE 189.1-2009 ExtWall Mass ClimateZone 4  
 ASHRAE 189.1-2009 ExtWall Mass ClimateZone 5  
 ASHRAE 189.1-2009 ExtWall Mass ClimateZone 6  
 ASHRAE 189.1-2009 ExtWall Mass ClimateZone 7-8  
 ASHRAE 189.1-2009 ExtWindow ClimateZone 1  
 ASHRAE 189.1-2009 ExtWindow ClimateZone 2  
 ASHRAE 189.1-2009



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In the second tab we can build our building component by defining adjusted layers starting from outside to inside. By accessing the third tab we can edit the specifications of our materials.

