

# Week6

Define the radiative heat transfer rate between two parallel plates shown in the picture:

$$\dot{q}_{net_{1-2}} = \frac{\dot{Q}_{net_{1-2}}}{A} = \frac{A\sigma(T_2^4 - T_1^4)}{\frac{1}{\epsilon_1} + \frac{1}{\epsilon_2} - 1} \div A$$

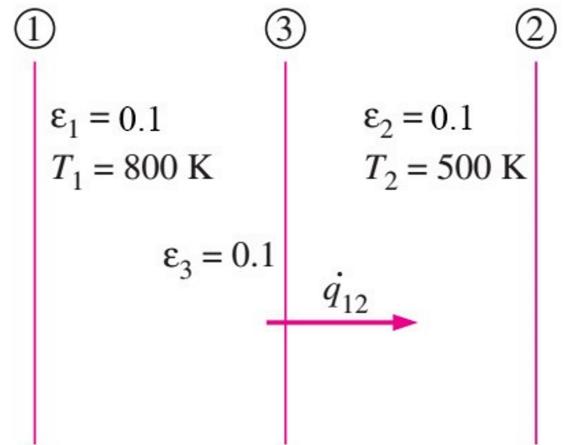
$$= \frac{\sigma(T_2^4 - T_1^4)}{\frac{1}{\epsilon_1} + \frac{1}{\epsilon_2} - 1}$$

$$= \frac{\left(5.67 \times 10^{-8} \frac{\text{W}}{\text{m}^2 \text{K}^4}\right) (800^4 - 500^4) K^4}{\frac{1}{0.1} + \frac{1}{0.1} - 1}$$

$$\approx 1035.82 \frac{\text{W}}{\text{m}^2}$$

The new heat transfer rate should be 1% of the  $\dot{q}_{net_{1-2}}$ ,

$$\text{i.e., } \dot{q}'_{net_{1-2}} = \dot{q}_{net_{1-2, n shields}} = \frac{1}{100} \times \dot{q}_{net_{1-2}},$$



$$\begin{aligned} \dot{q}_{net_{1-2, n shields}} &= \frac{\dot{Q}_{net_{1-2, n shields}}}{A} \\ &= \frac{A\sigma(T_2^4 - T_1^4)}{\left(\frac{1}{\epsilon_1} + \frac{1}{\epsilon_2} - 1\right) \left(\frac{1}{\epsilon_{3,1}} + \frac{1}{\epsilon_{3,2}} - 1\right) \dots \left(\frac{1}{\epsilon_{n,1}} + \frac{1}{\epsilon_{n,2}} - 1\right)} \div A \\ &= \frac{\sigma(T_2^4 - T_1^4)}{\left(\frac{1}{\epsilon_1} + \frac{1}{\epsilon_2} - 1\right) \left(\frac{1}{\epsilon_{3,1}} + \frac{1}{\epsilon_{3,2}} - 1\right) \dots \left(\frac{1}{\epsilon_{n,1}} + \frac{1}{\epsilon_{n,2}} - 1\right)} \end{aligned}$$

Autem,  $\epsilon_1 = \epsilon_2 = \epsilon_3 = \dots = \epsilon_n = 0.1$

Substitute  $\epsilon = 0.1$  for  $\epsilon_1, \epsilon_2, \epsilon_3, \dots, \epsilon_n$ , and introduce to the equation:

$$\dot{q}_{net_{1-2, n shields}} = \frac{\sigma(T_2^4 - T_1^4)}{(n+1)\left(\frac{1}{\epsilon} + \frac{1}{\epsilon} - 1\right)} = \frac{1}{n+1} \times \frac{\sigma(T_2^4 - T_1^4)}{\frac{1}{\epsilon} + \frac{1}{\epsilon} - 1}$$

$$\text{Since } \dot{q}'_{net_{1-2}} = \dot{q}_{net_{1-2, n shields}} = \frac{1}{100} \times \dot{q}_{net_{1-2}} = \frac{1}{100} \times \frac{\sigma(T_2^4 - T_1^4)}{\frac{1}{\epsilon_1} + \frac{1}{\epsilon_2} - 1} = \frac{1}{100} \times \frac{\sigma(T_2^4 - T_1^4)}{\frac{1}{\epsilon} + \frac{1}{\epsilon} - 1}$$

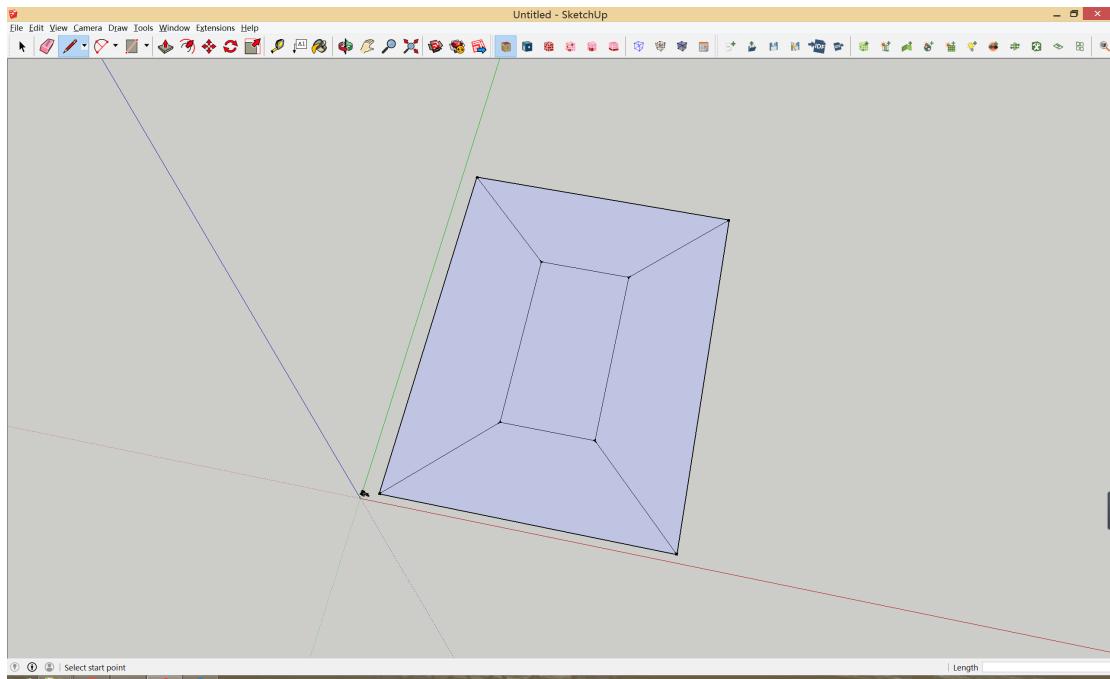
$$\text{i.e., } \frac{1}{n+1} \times \frac{\sigma(T_2^4 - T_1^4)}{\frac{1}{\epsilon} + \frac{1}{\epsilon} - 1} = \frac{1}{100} \times \frac{\sigma(T_2^4 - T_1^4)}{\frac{1}{\epsilon} + \frac{1}{\epsilon} - 1}$$

$$n = 99$$

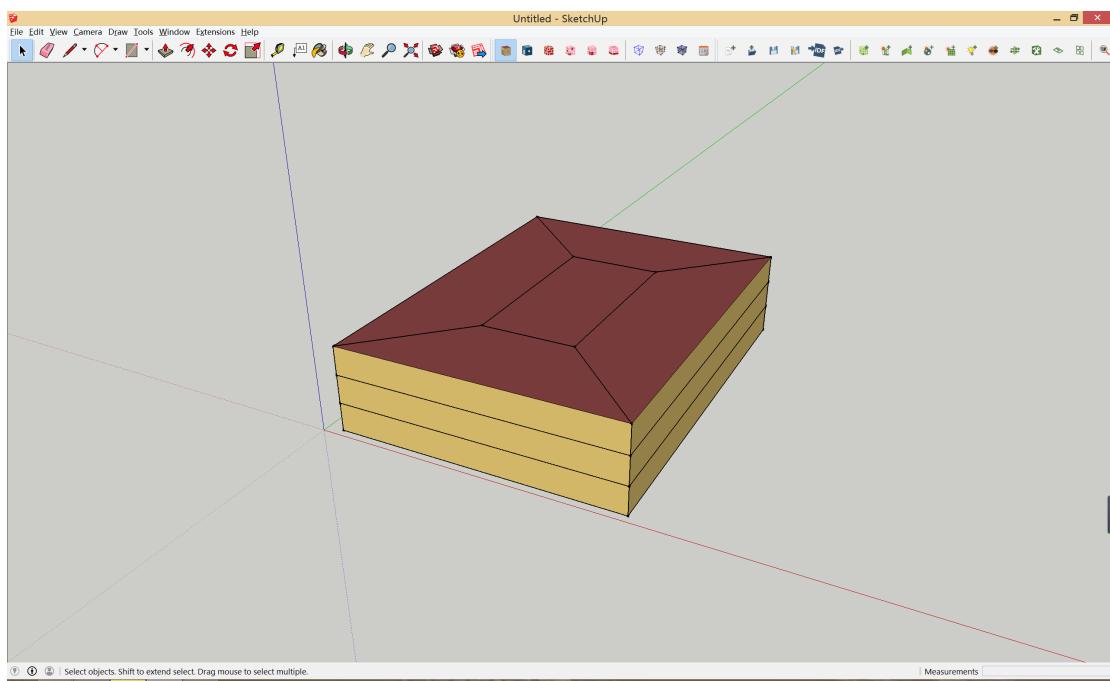
To have the new heat transfer rate be 1% of the previous rate without any shields, we need 99 shields which  $\epsilon = 0.1$

Q.E.D.

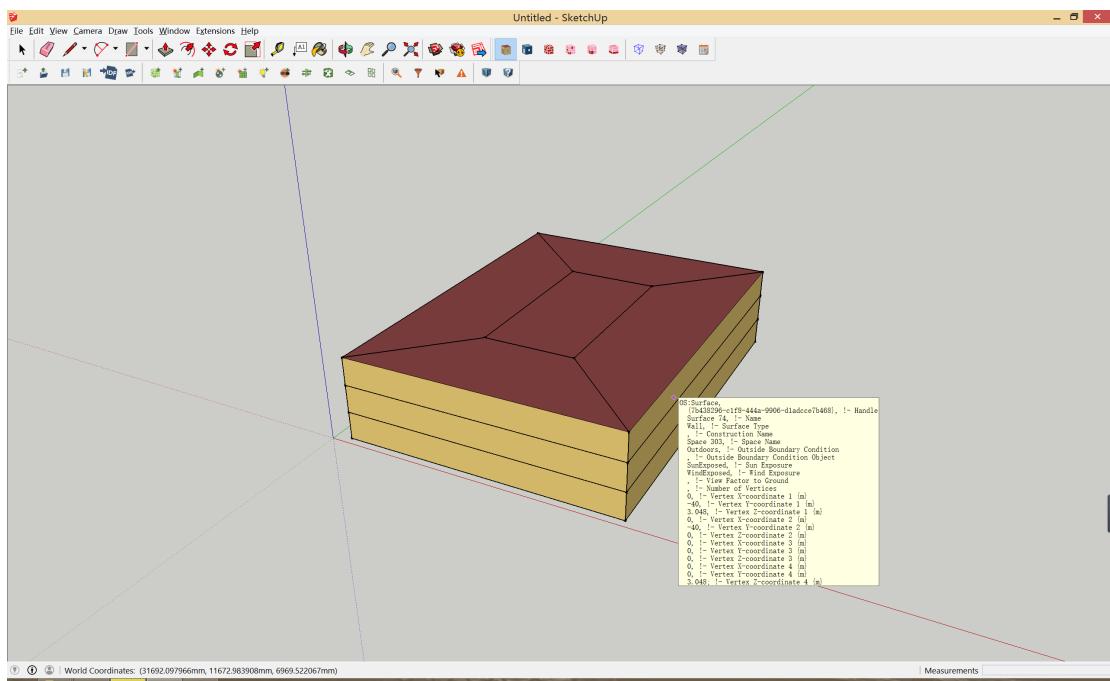
1. Draw the outline and shape of the building in Sketchup.



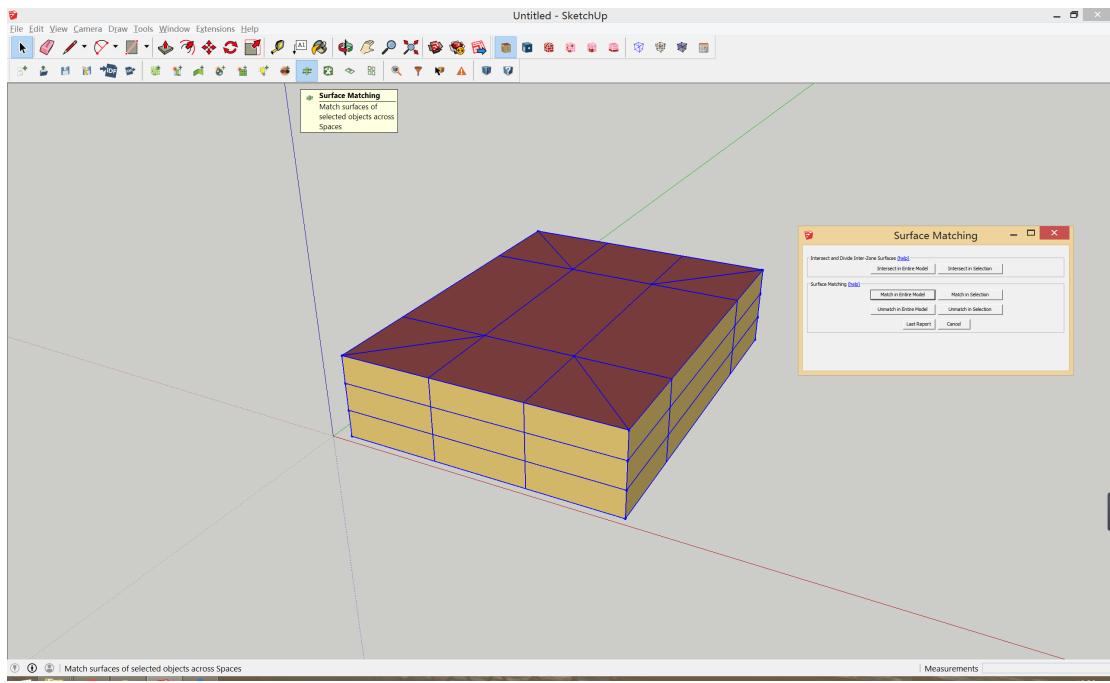
2. Use "Create spaces from diagram" create a 3 floor building.



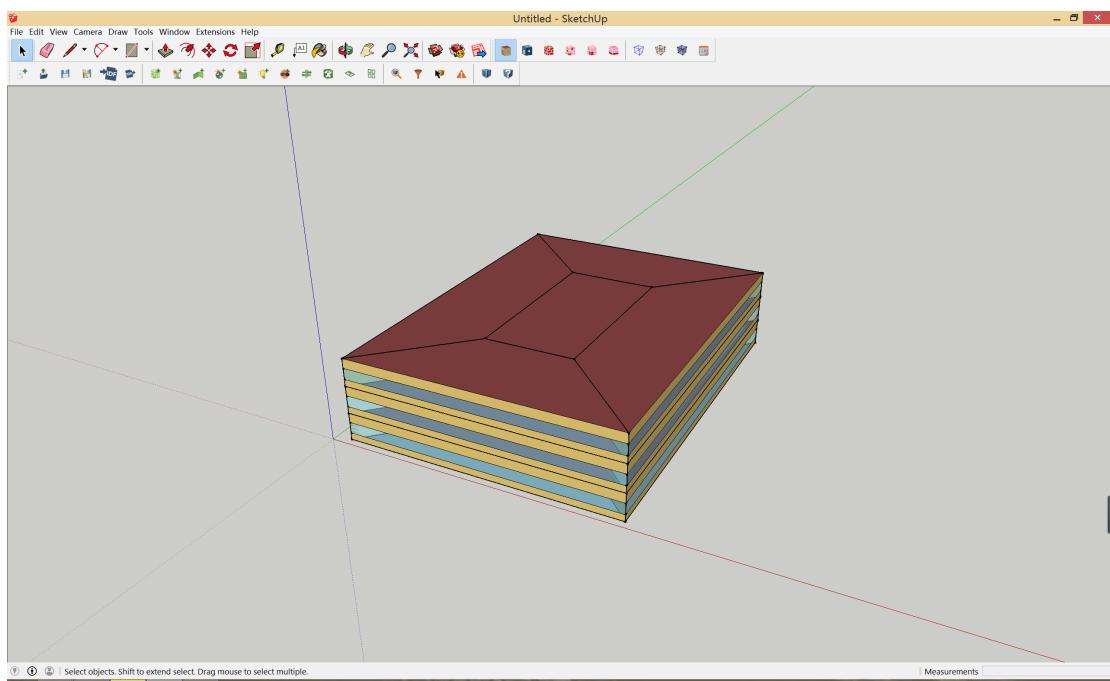
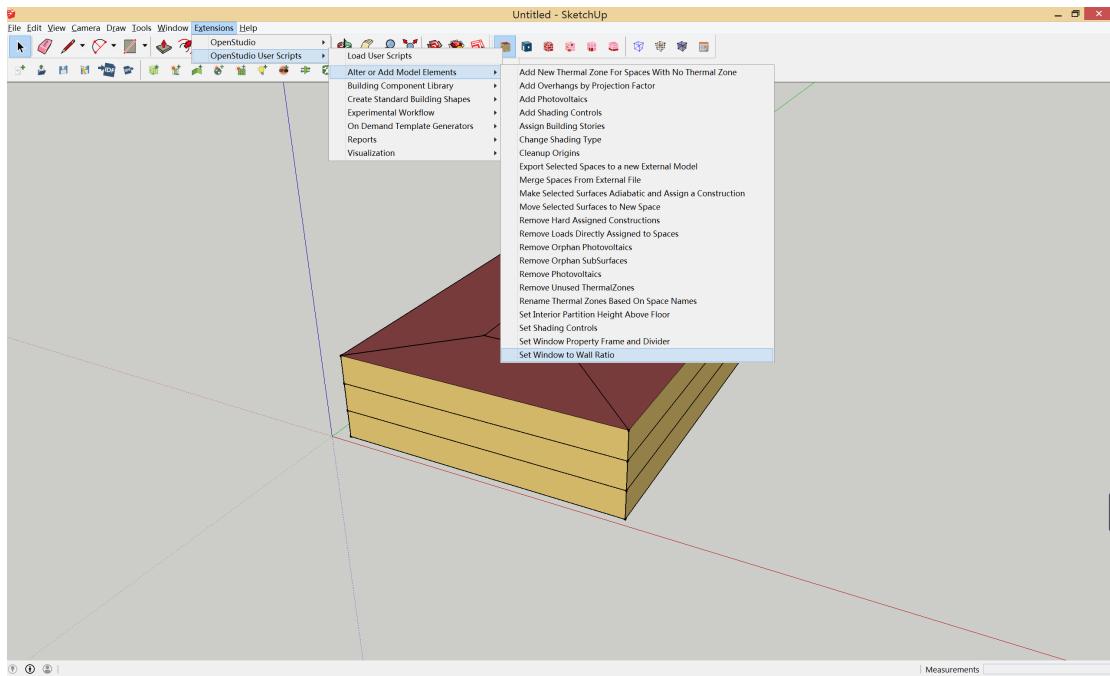
3. We can see the material information using the "Info tool".



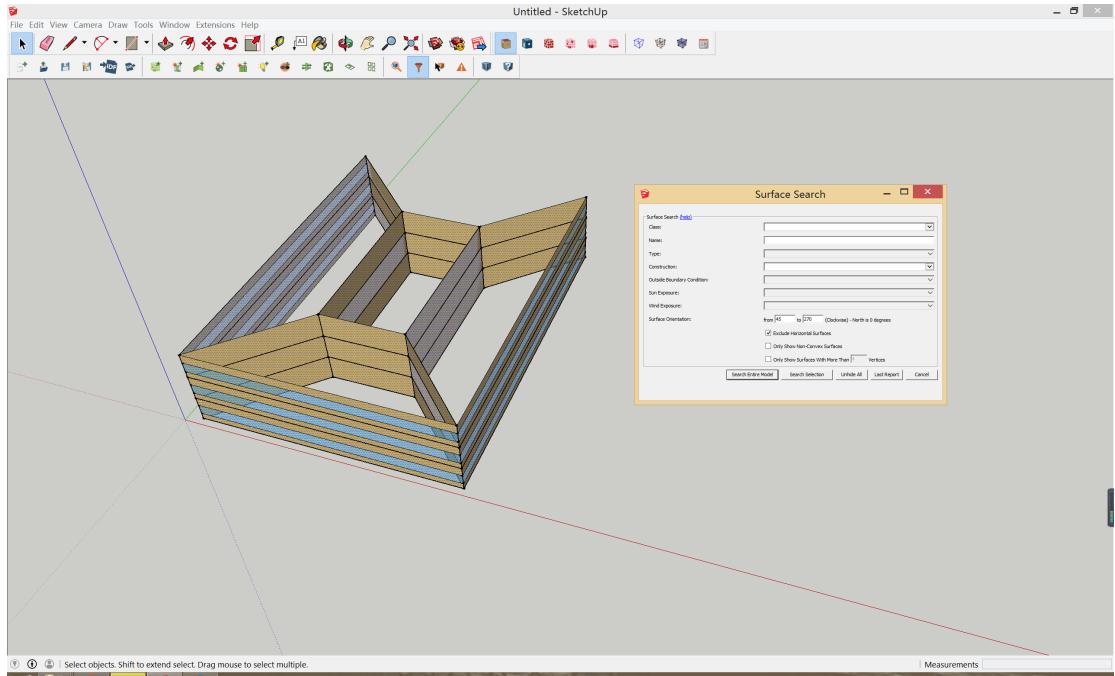
4. Click "Surface matching".



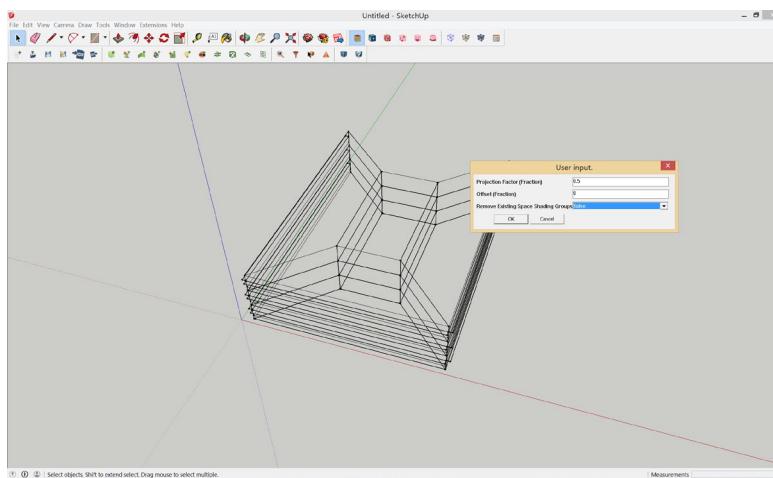
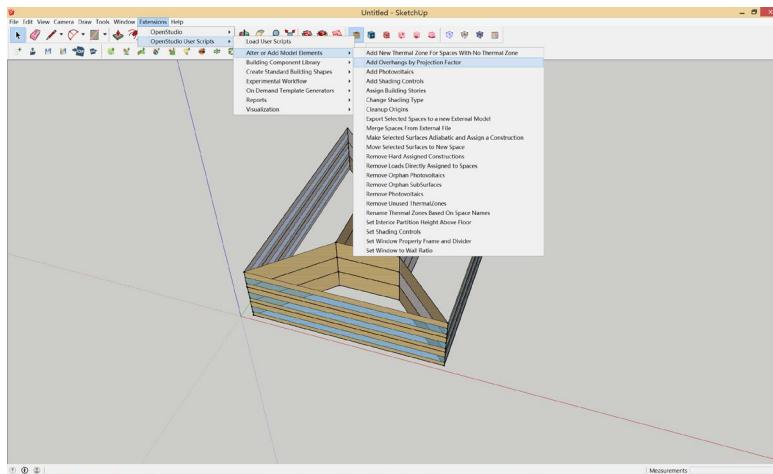
5. Click "Set Window to Wall Ratio" to built the windows.



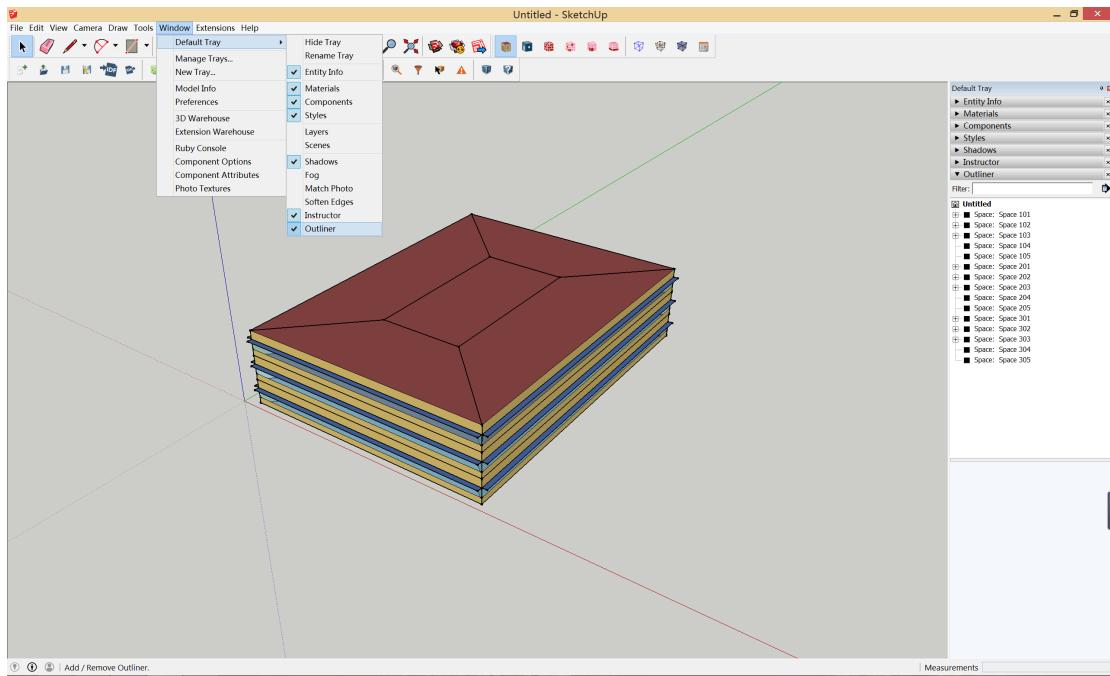
6. Check other directions besides the north.



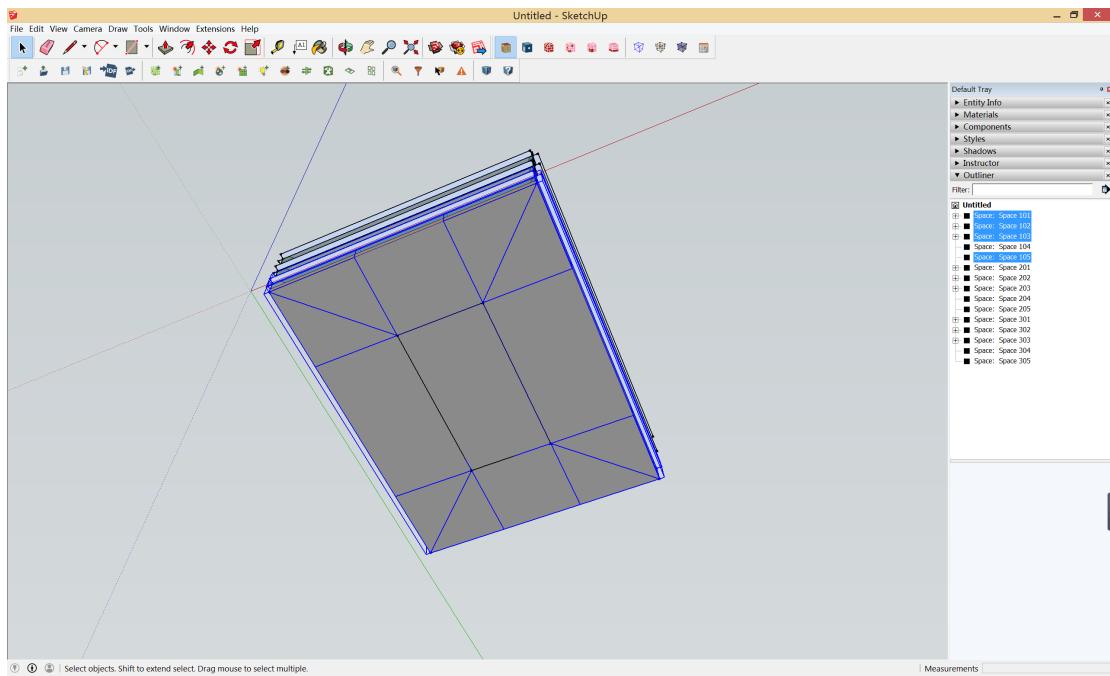
7. Click "Add Overhangs by Projection Factor" to built overhangs.



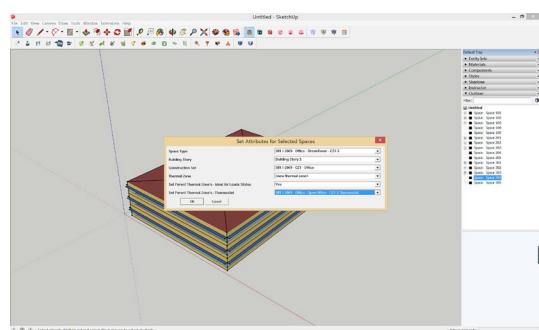
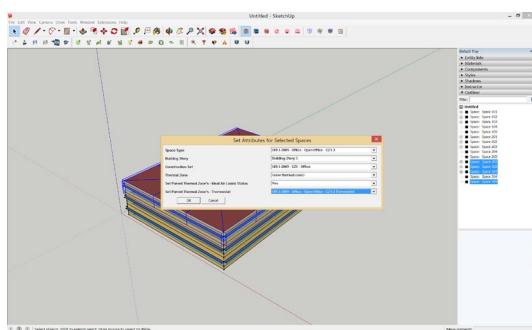
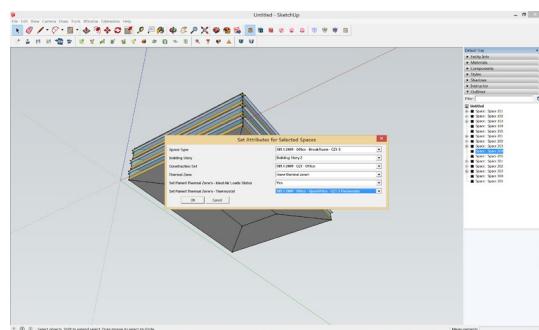
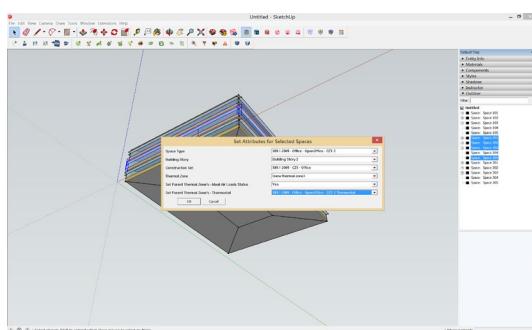
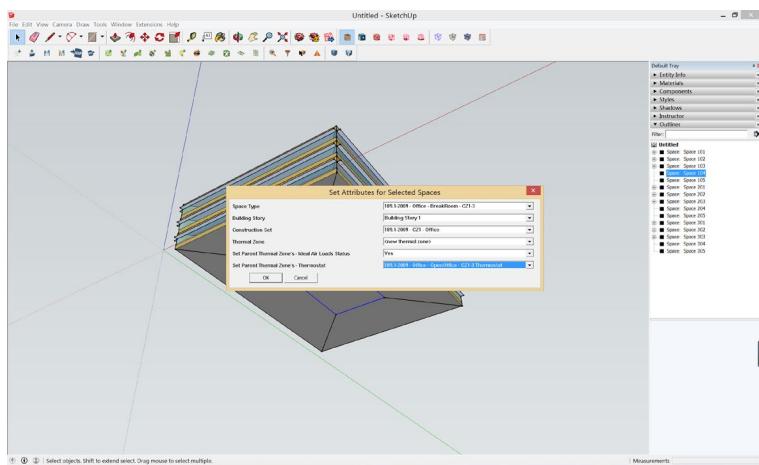
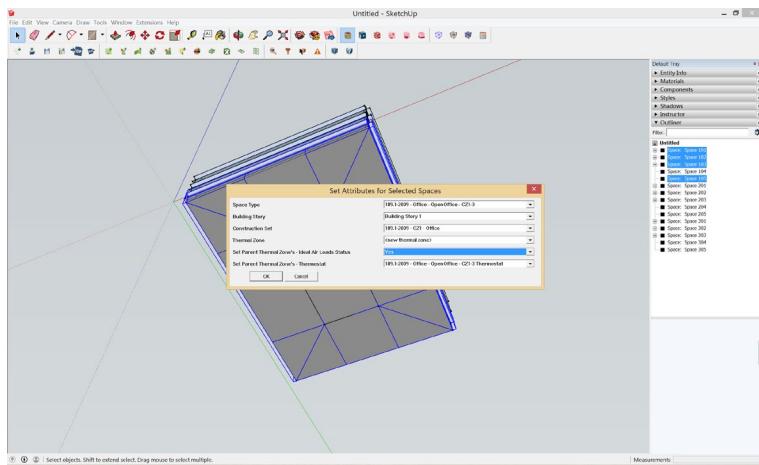
## 8. Open the "Outliner"



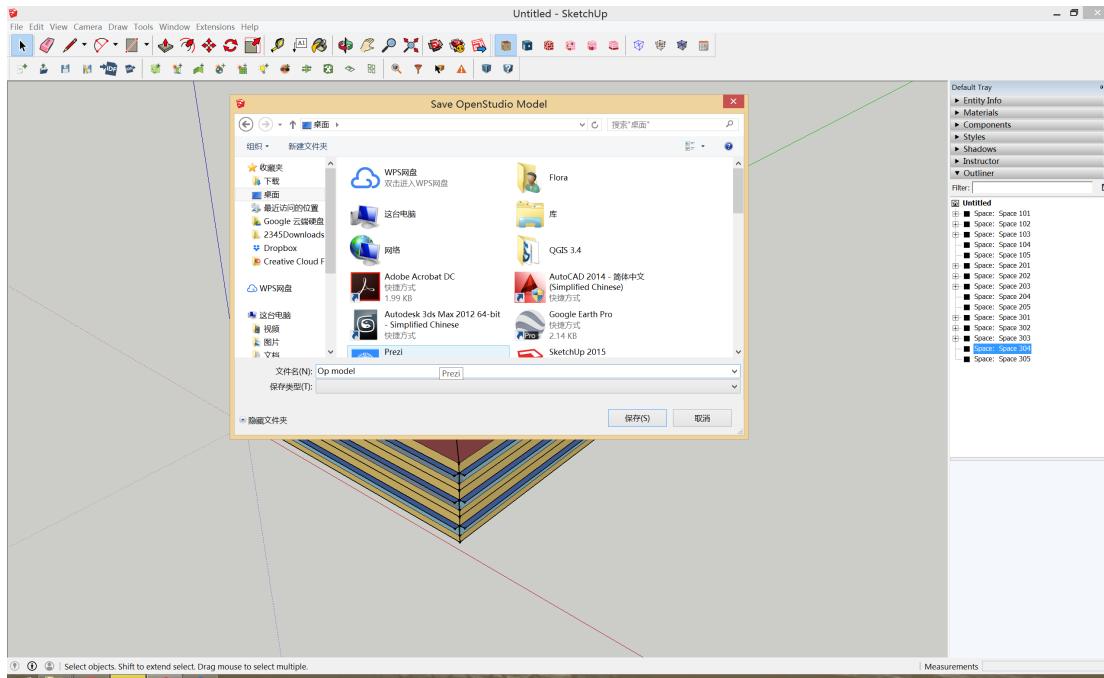
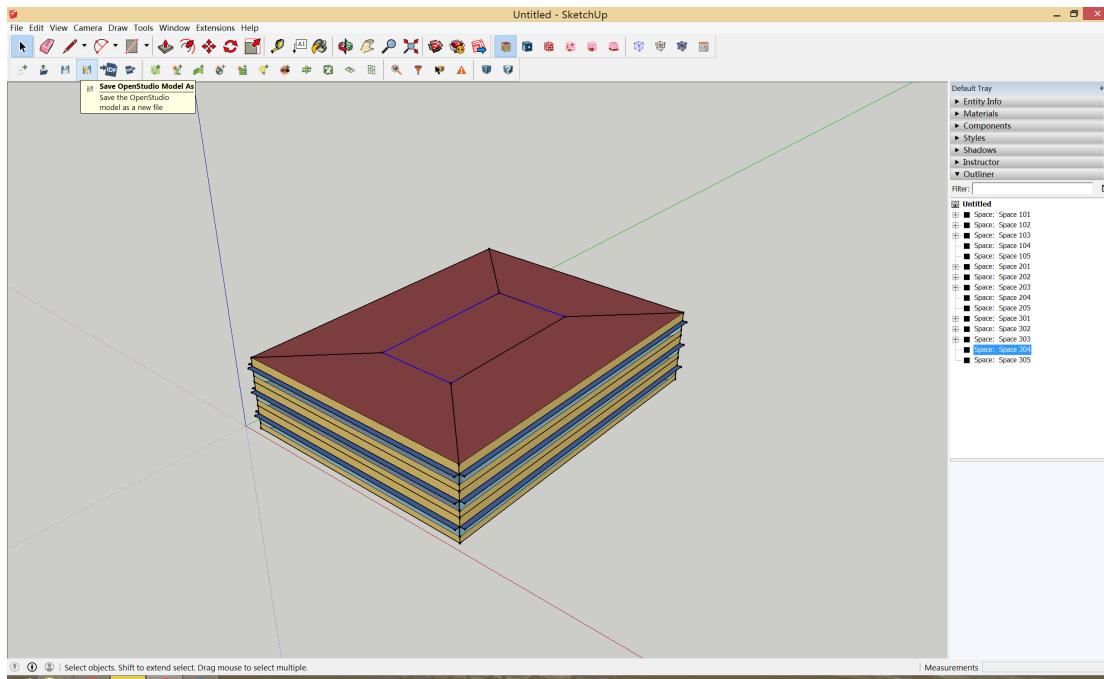
## 9. Choose the space of each thermal zone.



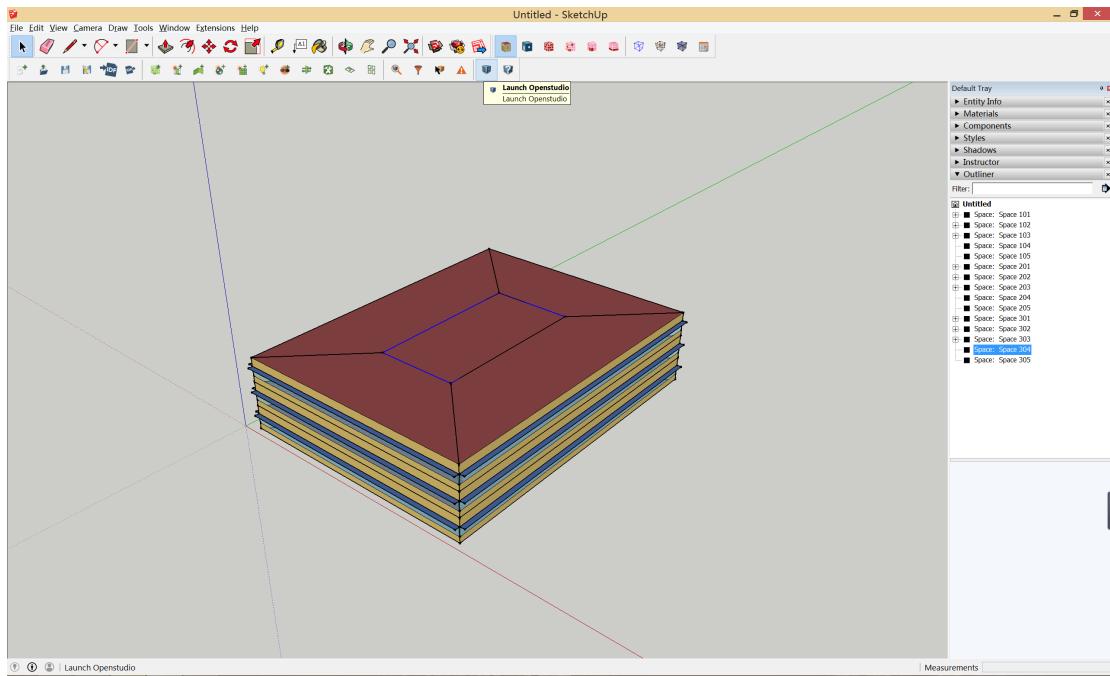
10. Click “Set Attributes for Selected Space” to set parameters.



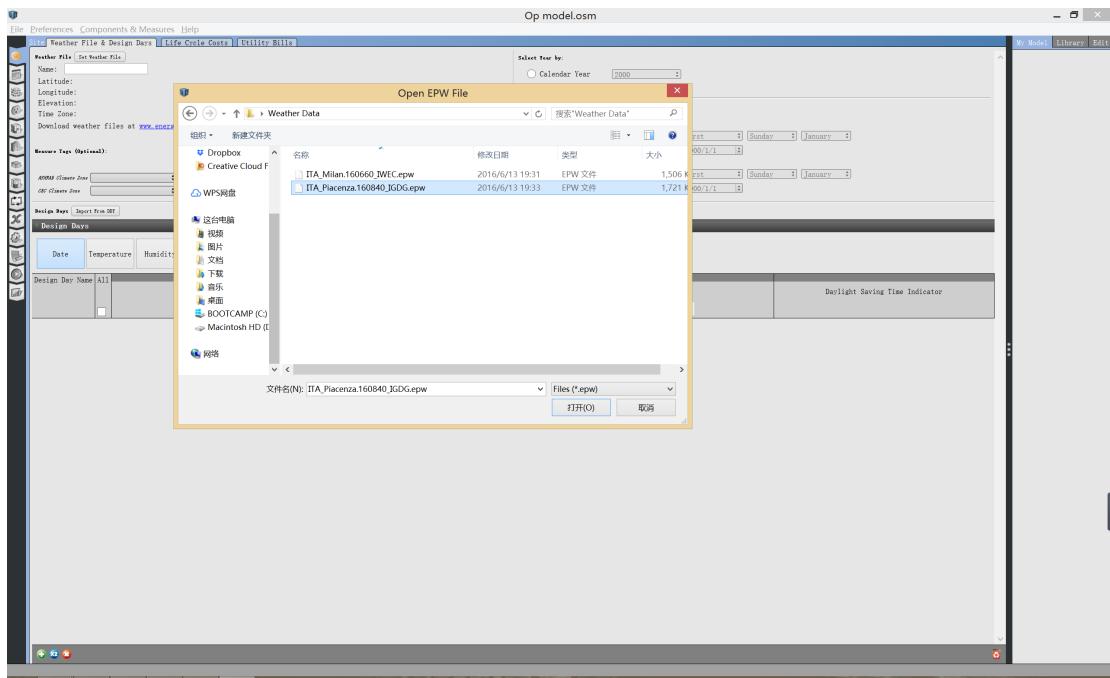
## 11. Save the model.



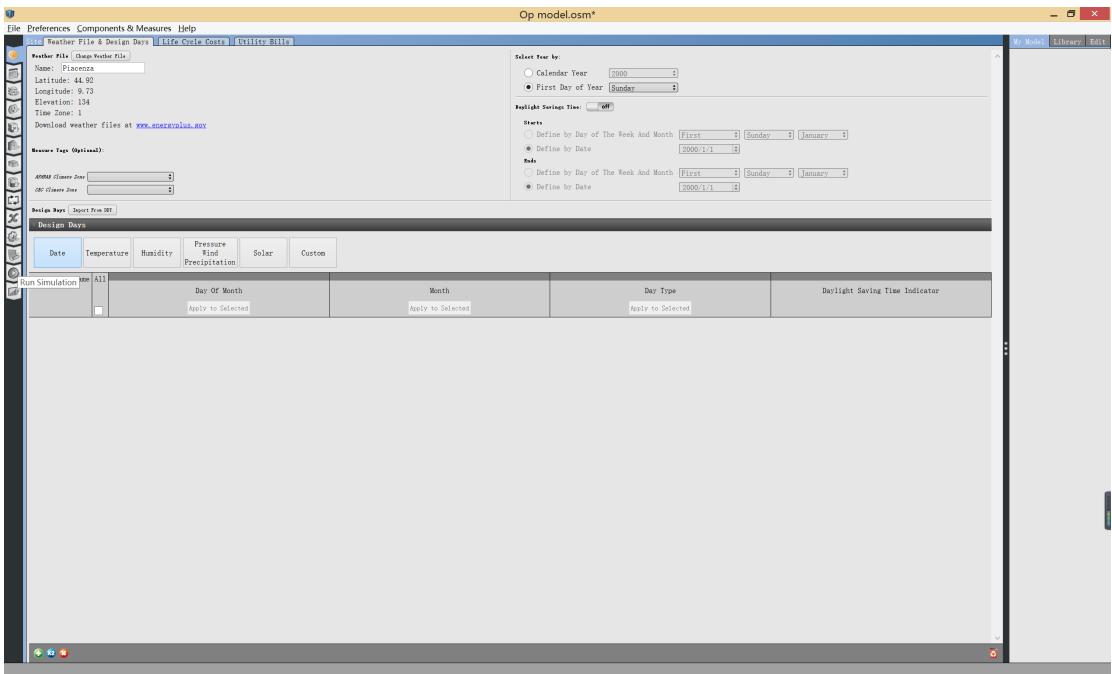
## 12. Run the Open studio.



## 13. Add the weather data.



## 14. Run the analysis.



```

File Preferences Components & Measures Help
Run Simulation Output Tree
Run [ ] Finished
Warnings: 11
Errors: 0
OpenStudio
EnergyPlus Starting
EnergyPlus, Version 8.5.0-e87e61b44b, YMD=2019.11.12 19:36
Processing Input File
Initializing Simulation
Primary Simulation
Beginning Primary Simulation
Initializing New Environment Parameters
Warning up [1]
Warning up [2]
Warning up [3]
Warning up [4]
Warning up [5]
Warning up [6]
Starting Simulation at 01/01 for RUN PERIOD 1
Updating Shadowing Calculations, Start Date=01/21
Continuing Simulation at 01/21 for RUN PERIOD 1
Updating Shadowing Calculations, Start Date=02/01
Continuing Simulation at 02/01 for RUN PERIOD 1
Updating Shadowing Calculations, Start Date=02/21
Continuing Simulation at 03/21 for RUN PERIOD 1
Updating Shadowing Calculations, Start Date=03/22
Continuing Simulation at 03/22 for RUN PERIOD 1
Updating Shadowing Calculations, Start Date=04/11
Continuing Simulation at 04/11 for RUN PERIOD 1
Updating Shadowing Calculations, Start Date=04/29
Continuing Simulation at 05/01 for RUN PERIOD 1
Updating Shadowing Calculations, Start Date=05/21
Continuing Simulation at 05/21 for RUN PERIOD 1
Updating Shadowing Calculations, Start Date=06/10
Continuing Simulation at 06/10 for RUN PERIOD 1
Updating Shadowing Calculations, Start Date=06/29
Continuing Simulation at 06/29 for RUN PERIOD 1
Updating Shadowing Calculations, Start Date=07/20
Continuing Simulation at 07/20 for RUN PERIOD 1
Updating Shadowing Calculations, Start Date=08/09
Continuing Simulation at 08/09 for RUN PERIOD 1
Updating Shadowing Calculations, Start Date=08/29
Continuing Simulation at 08/29 for RUN PERIOD 1
Updating Shadowing Calculations, Start Date=09/18
Continuing Simulation at 09/18 for RUN PERIOD 1
Updating Shadowing Calculations, Start Date=10/08
Continuing Simulation at 10/08 for RUN PERIOD 1
Updating Shadowing Calculations, Start Date=10/28
Continuing Simulation at 10/28 for RUN PERIOD 1
Updating Shadowing Calculations, Start Date=11/17
Continuing Simulation at 11/17 for RUN PERIOD 1
Updating Shadowing Calculations, Start Date=12/07
Continuing Simulation at 12/07 for RUN PERIOD 1
Updating Shadowing Calculations, Start Date=12/27
Continuing Simulation at 12/27 for RUN PERIOD 1
Computing Life Cycle Costs and Reporting
Writing final reports
Run Time: Wall= 49.38sec
Script executing from: C:/Users/apples/AppData/Local/Temp/OpenStudio.F48444/resources/run/6-UserScript-0
Processing OpenStudio results.
result = true
Processed 1 base script and 0 merged scripts

```

## 15. Show the result.

Screenshot of the EnergyPlus Results window showing detailed energy usage data for the 'Op model.osm' project.

**Report:** EnergyPlus Results

Program Version: EnergyPlus, Version 8.5.0-87e41b44b, YMD=2019.11.12 19:36

Tableau Output Report is Format: HTML

Building: Building 1

Environment: RUN PERIOD 1 \* Powers - ITA RGDG WMO=169840

Simulation Timestamp: 2019-11-12 19:36:57

Report: Annual Building Utility Performance Summary

For Entire Facility

Timestamp: 2019-11-12 19:36:57\*

Values gathered over 8760.00 hours

**Site and Source Energy**

	Total Energy (GJ)	Energy Per Total Building Area (MWh/m <sup>2</sup> )	Energy Per Conditioned Building Area (MWh/m <sup>2</sup> )
Total Site Energy	2172.72	659.09	659.09
Net Site Energy	2172.72	659.09	659.09
Total Source Energy	6126.68	1701.86	1701.86
Net Source Energy	6126.68	1701.86	1701.86

**Site to Source Energy Conversion Factors**

	Site-to-Source Conversion Factor
Electricity	1.00
Natural Gas	1.094
District Cooling	1.096
District Heating	3.613
Steam	0.300
Gasoline	1.050
Diesel	1.050
Cool	1.050
Fuel Oil #1	1.050
Fuel Oil #2	1.050
Propane	1.050
Other Fuel 1	1.000
Other Fuel 2	1.000

**Building Area**

	Area (m <sup>2</sup> )
Total Building Area	3600.00
Not Conditioned Building Area	3600.00
Unconditioned Building Area	0.00

Screenshot of the OpenStudio Results window showing annual and monthly energy usage summaries.

**Report:** OpenStudio Results

**Model Summary**

- Annual Overview
- Monthly Overview
- Utility Subtotals
- Equipment
- 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 Flow Details
- Plant Loops Detail
- Outdoor Air
- Cash Flow
- Site and Source Summary
- Schedule Overview

**Annual Overview**

Three pie charts showing energy usage by source and end-use category.

- End Use - view table**: Electricity (blue), Natural Gas (yellow), Interior Equipment (grey), Interior Lighting (red), Interior Heating (green).
- Energy Use - view table**: Electricity (blue), Natural Gas (yellow), District Cooling (pink), District Heating (orange).
- EU - Electricity - view table**: Interior Equipment (grey), Interior Lighting (red).

**Monthly Overview**