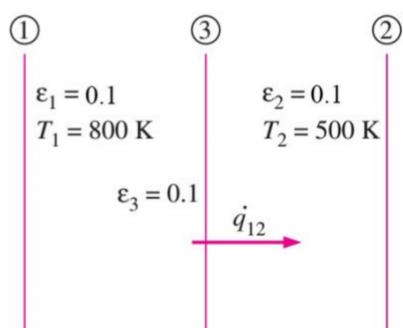


Task 1 Considering the same example you solved in the previous assignment (radiative heat transfer between two parallel plates), how many shields with $\epsilon = 0.1$ should you add in order to have the new heat transfer rate to be 1% of the case without shields?

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



$$\dot{q}_{\text{net}_{1-2}}$$

$$\begin{aligned} &= \frac{\dot{Q}_{\text{net}_{1-2}}}{A} \\ &= \frac{\sigma A (T_1^4 - T_2^4)}{\frac{1}{\epsilon_1} + \frac{1}{\epsilon_2} - 1} \end{aligned}$$

$$\begin{aligned} &= \frac{\sigma (T_1^4 - T_2^4)}{\frac{1}{\epsilon_1} + \frac{1}{\epsilon_2} - 1} = \frac{(5.67 * 10^{-8}) * (800^4 - 500^4)}{\frac{1}{0.1} + \frac{1}{0.1} - 1} \\ &= 1035.82 \text{ W/m}^2 \end{aligned}$$

The new heat transfer rates should be 1% of the $\dot{q}_{\text{net}_{1-2}}$:

$$\dot{q}'_{\text{net}_{1-2}} = \dot{q}_{\text{net}_{1-2,n \text{ shields}}} = \frac{1}{100} * \dot{q}_{\text{net}_{1-2}}$$

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

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

$$\rightarrow \epsilon = 0.1$$

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

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

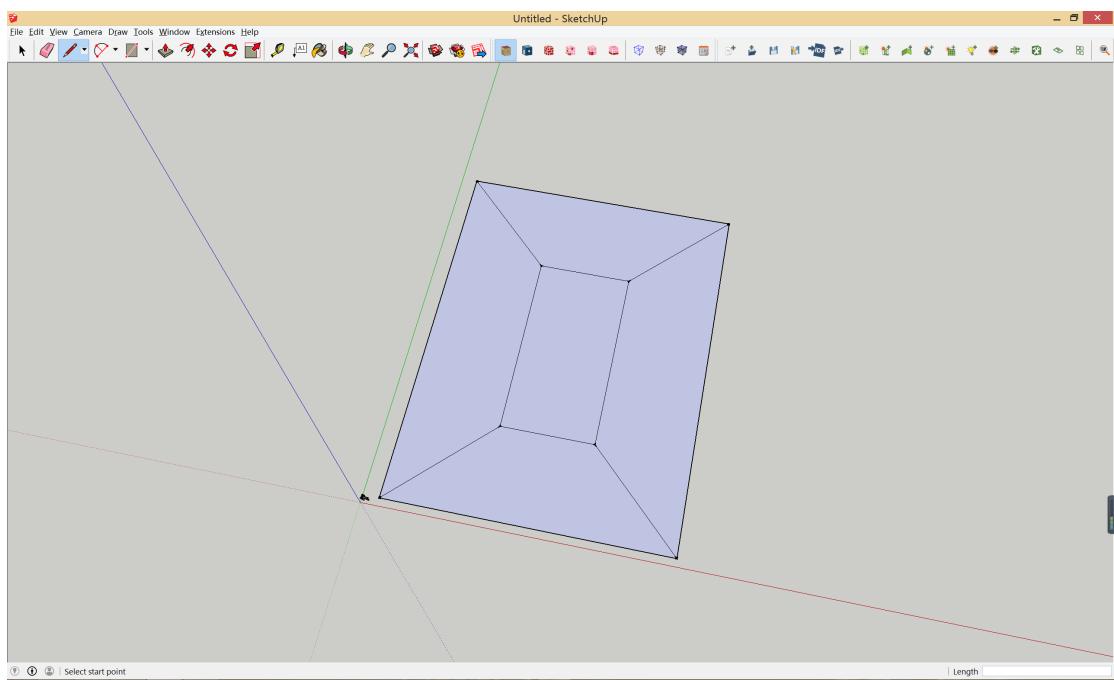
$$\rightarrow \frac{1}{n+1} * \frac{\sigma (T_2^4 - T_1^4)}{\frac{1}{\epsilon} + \frac{1}{\epsilon} - 1} = \frac{1}{100} * \frac{\sigma (T_2^4 - T_1^4)}{\frac{1}{\epsilon} + \frac{1}{\epsilon} - 1}$$

$$\rightarrow n=99$$

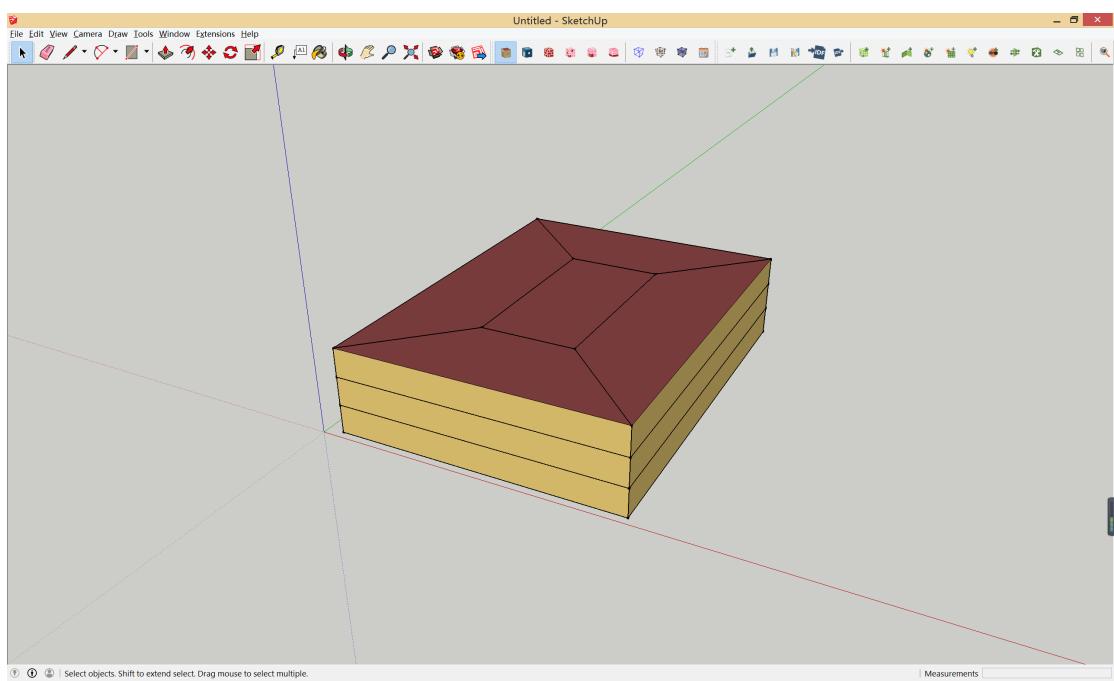
To have the new heat transfer rate be 1% of the previous rate without any shields, we need 99 shields , which $\epsilon = 0.1$.

Task 2 You should create a pdf file with screenshots of all of the steps we went through (clearly from your own file) and explain briefly the reason behind the use of each step (in your own words!)

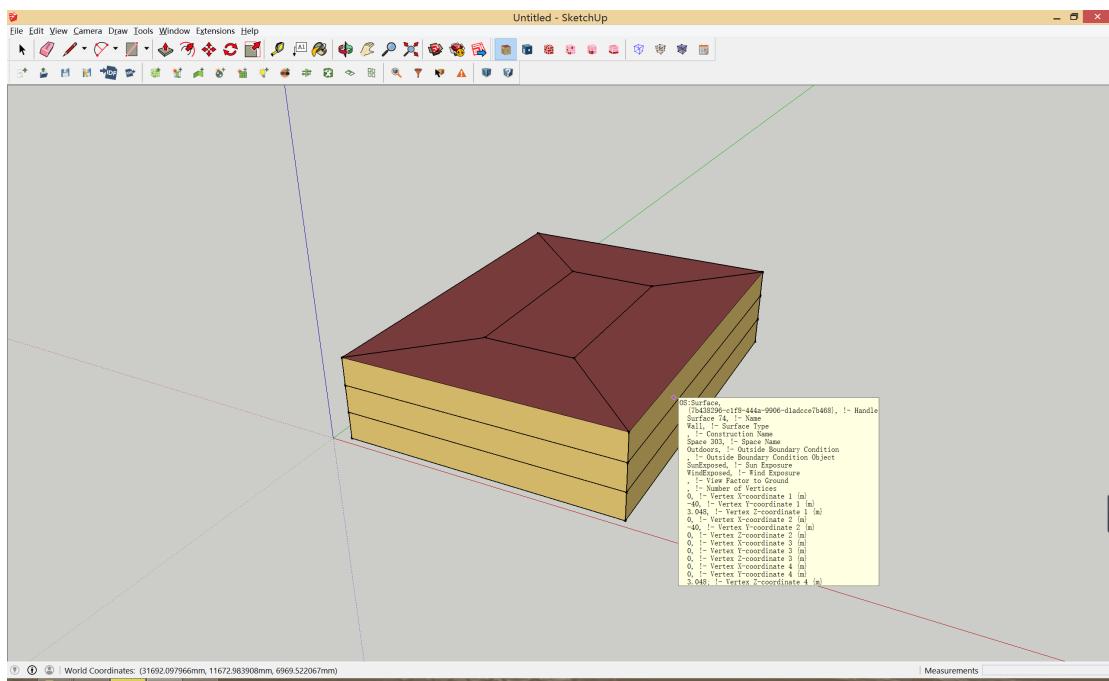
1. Draw the outline and shape of the building in Sketchup.



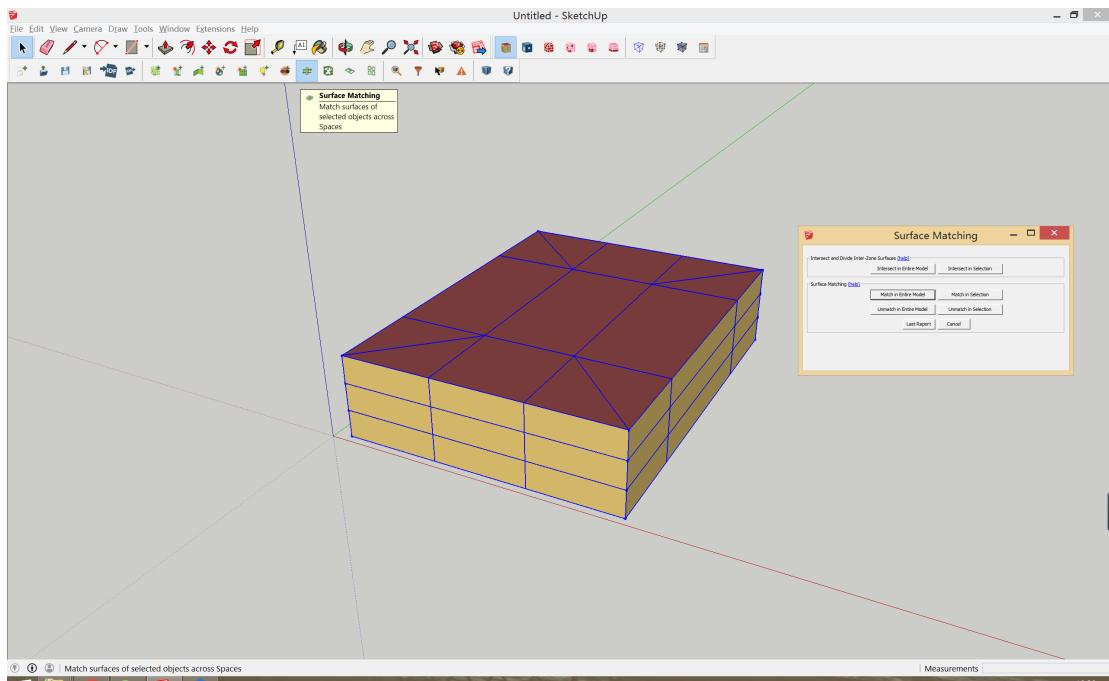
2. Use "Create spaces from diagram" create a 3 floor building.



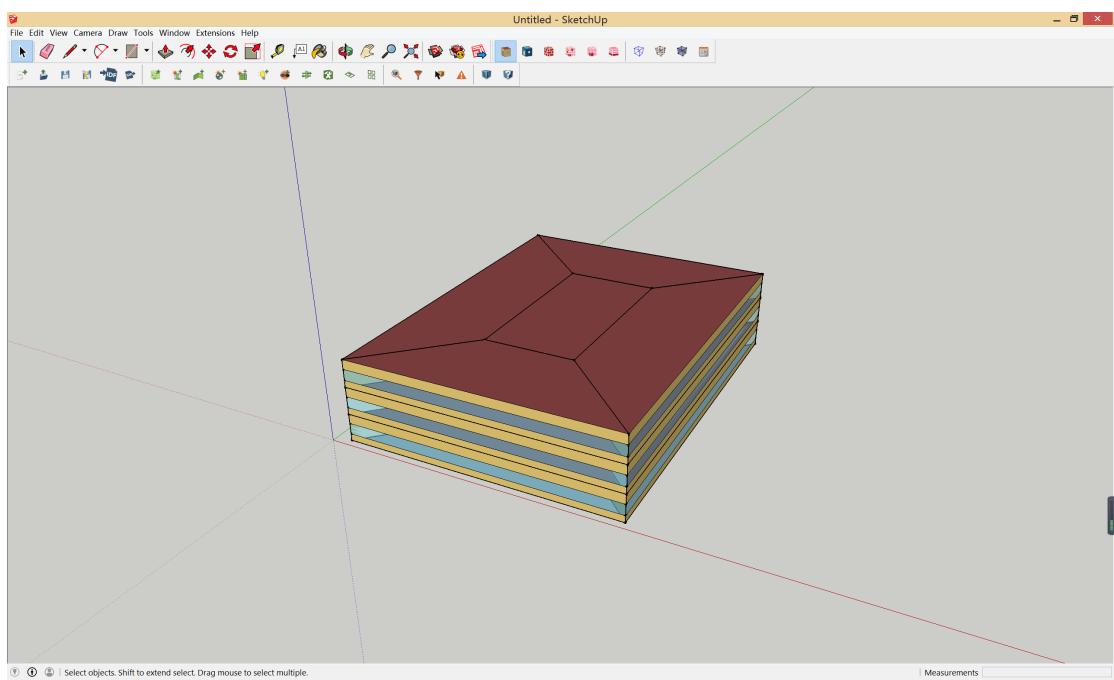
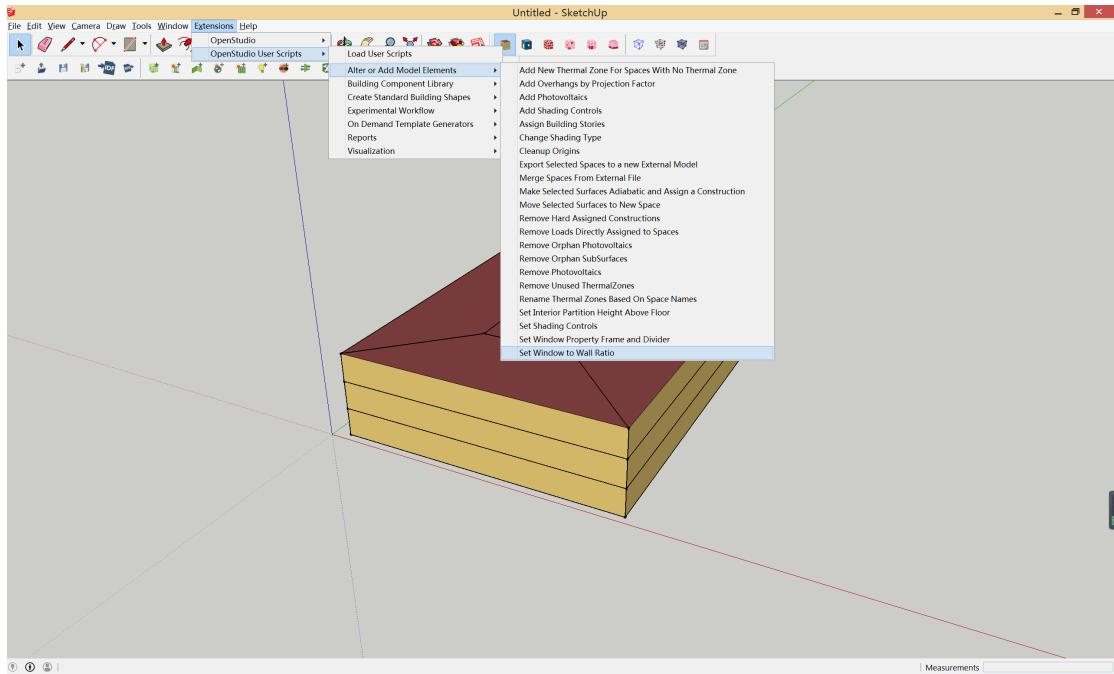
3. We can see the material information using the "Info tool".



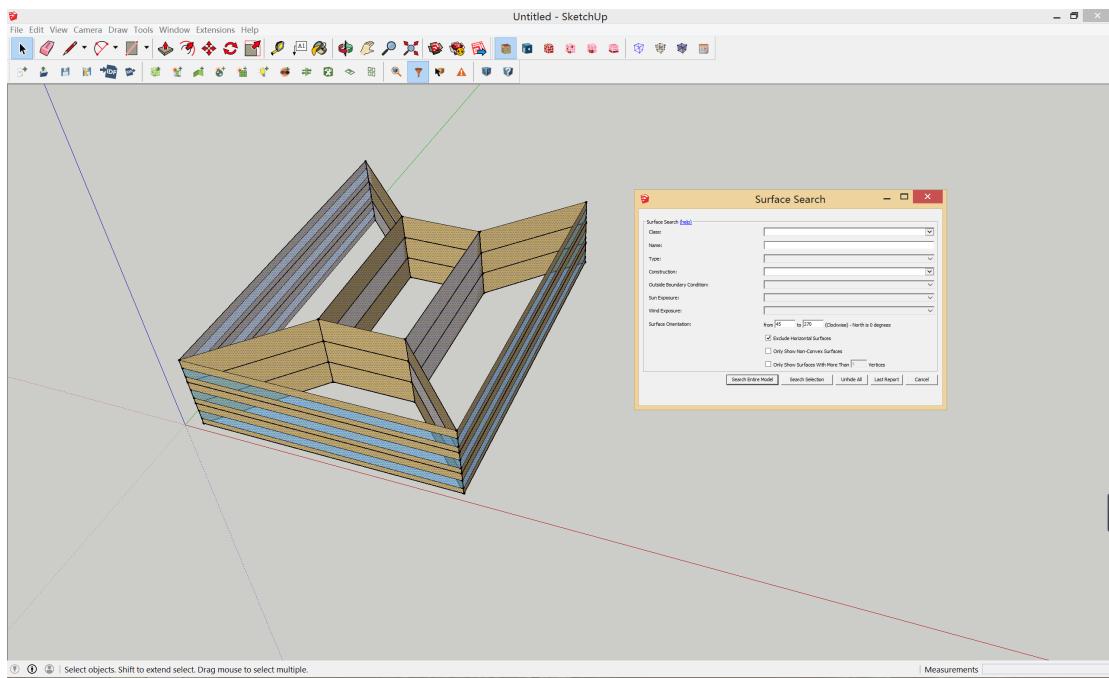
4. Click "Surface matching".



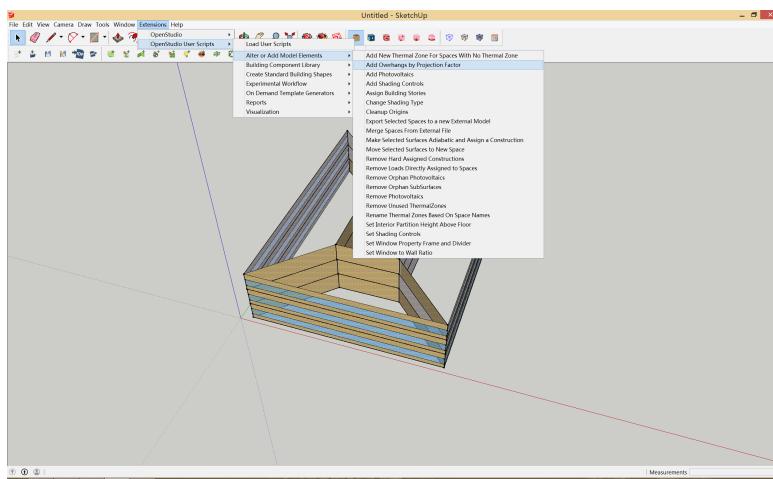
5. Click "Set Window to Wall Ratio" to built the windows.

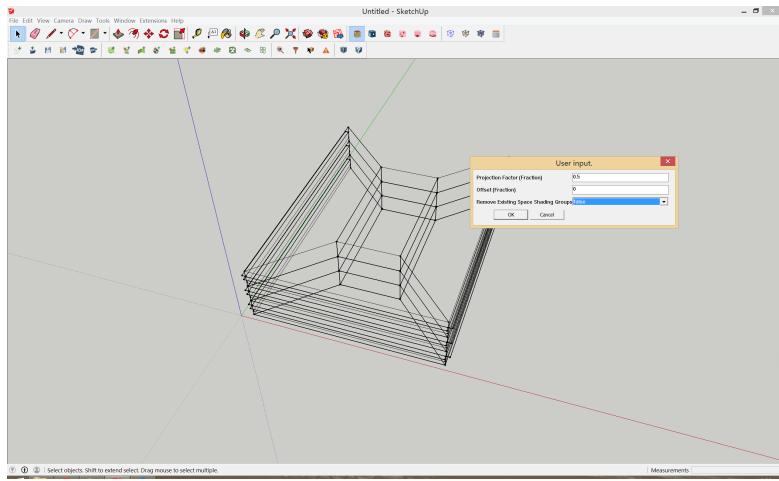


6. Check other directions besides the north.

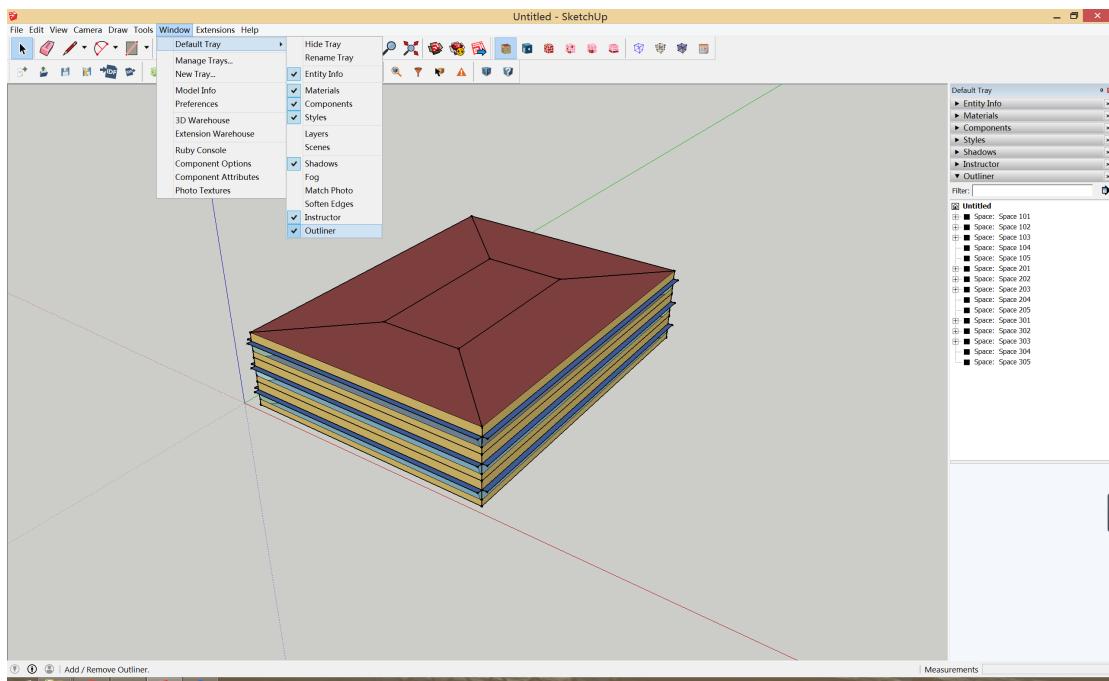


7. Click "Add Overhangs by Projection Factor" to built overhangs.

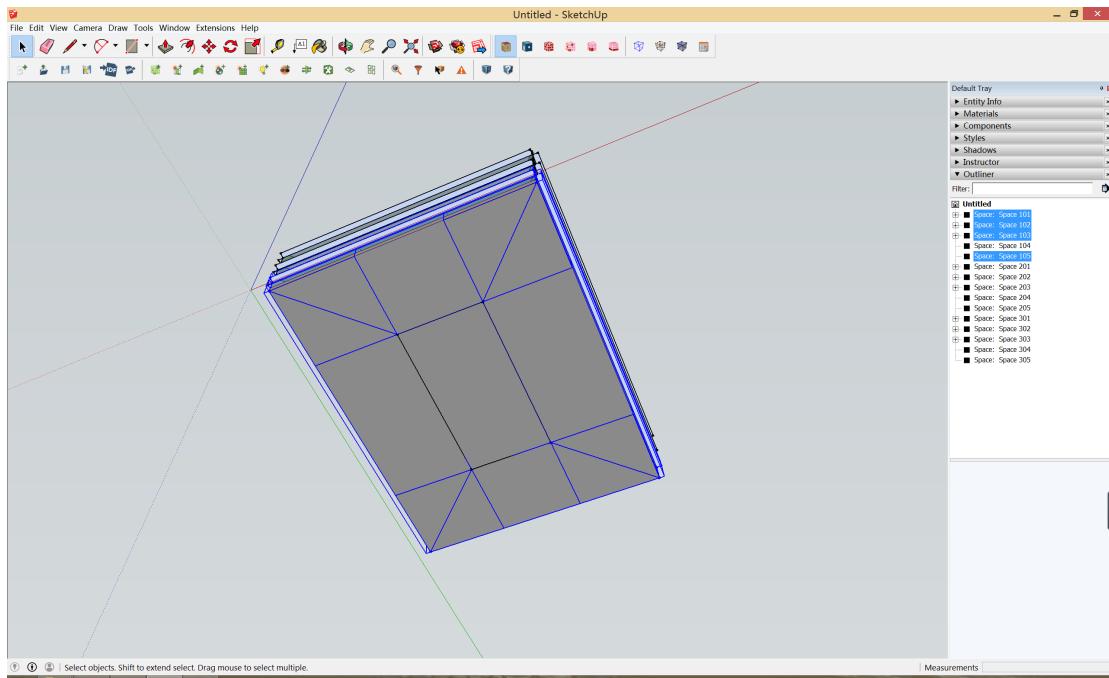




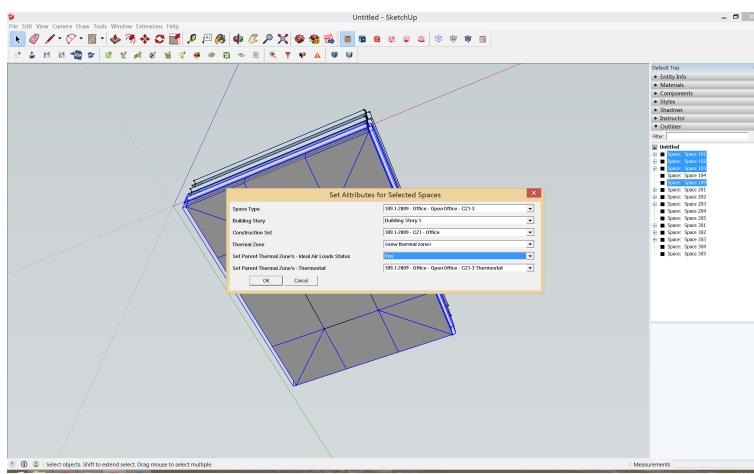
8. Open the "Outliner"

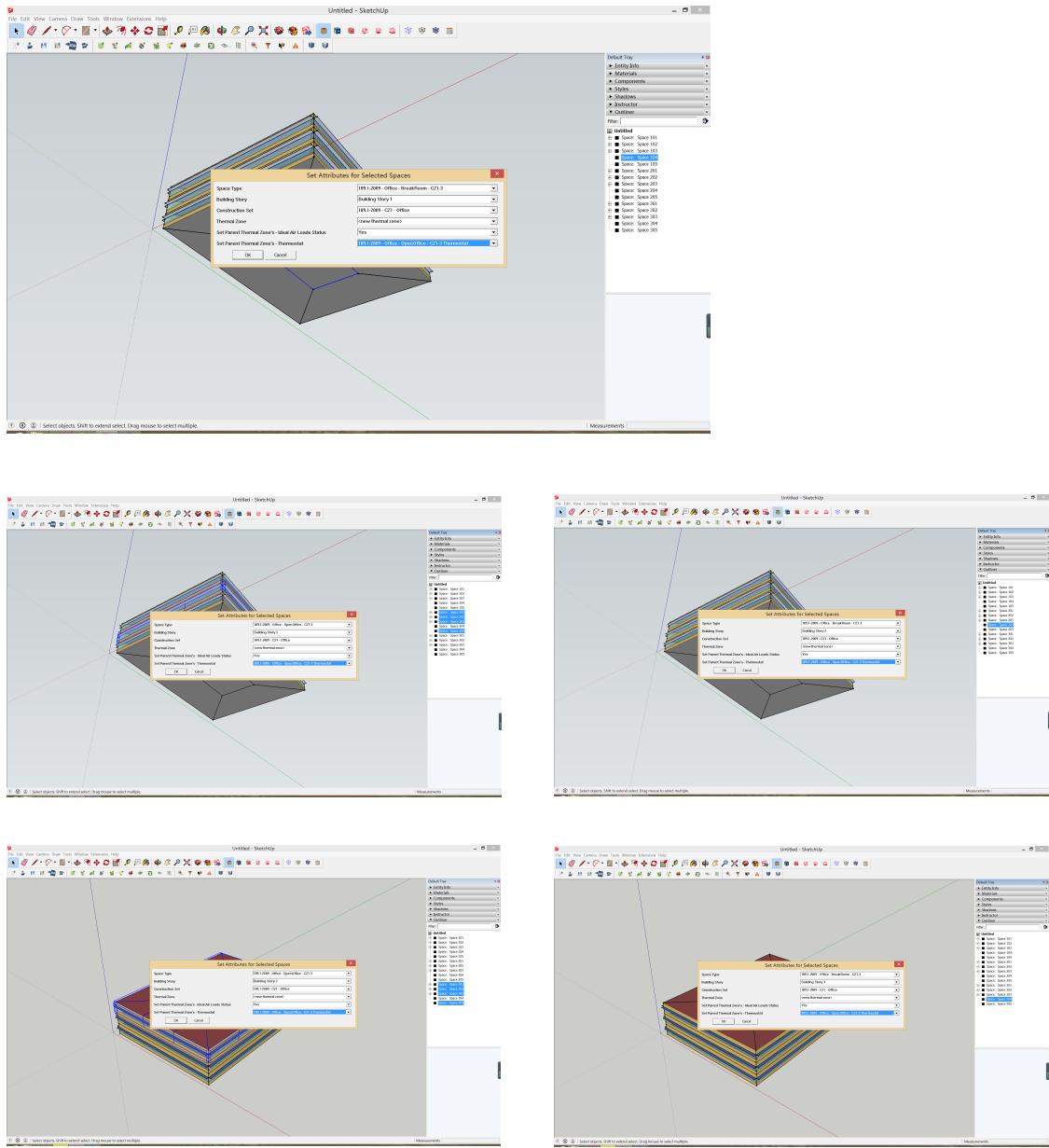


9. Choose the space of each thermal zone.

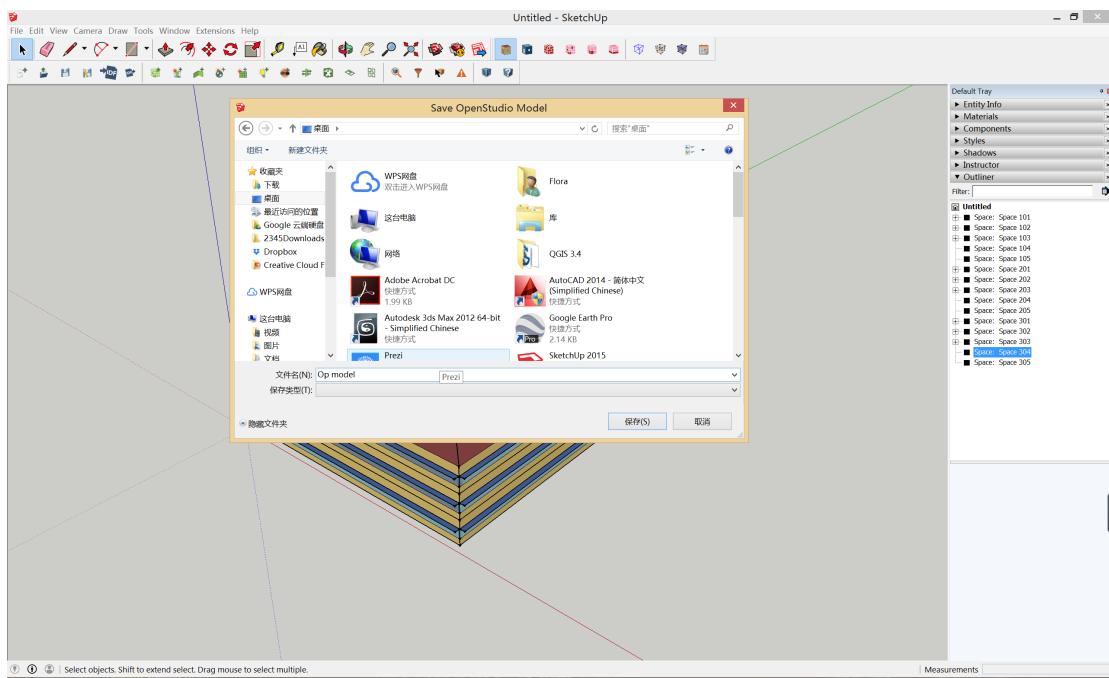
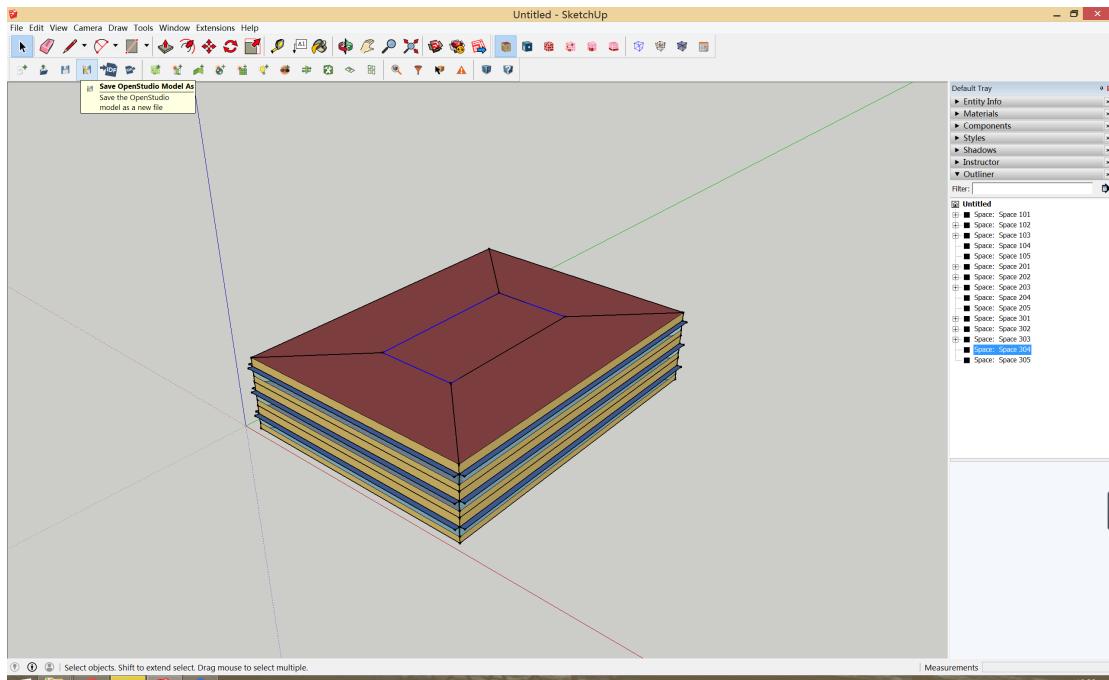


10. Click "Set Attributes for Selected Space" to set parameters.

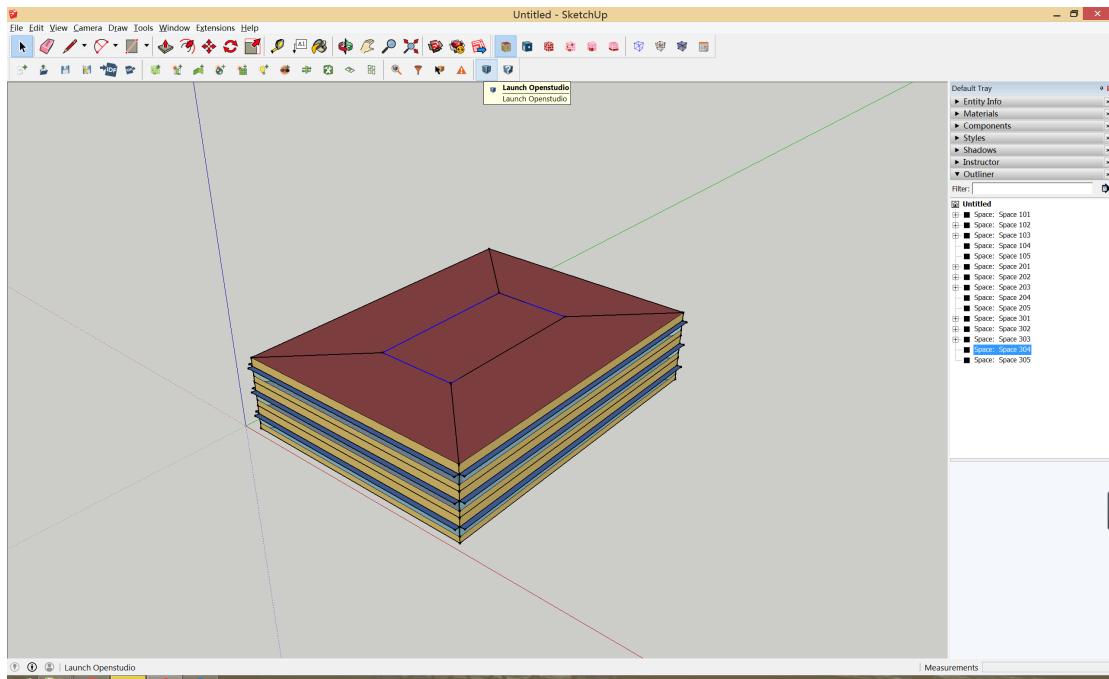




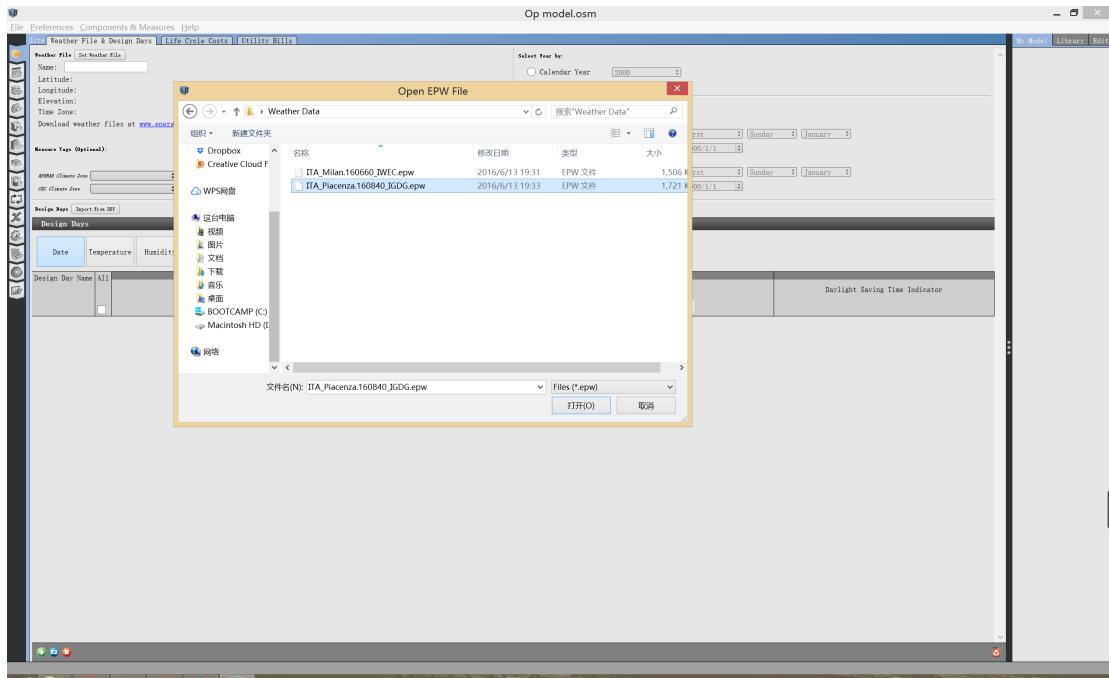
11. Save the model.



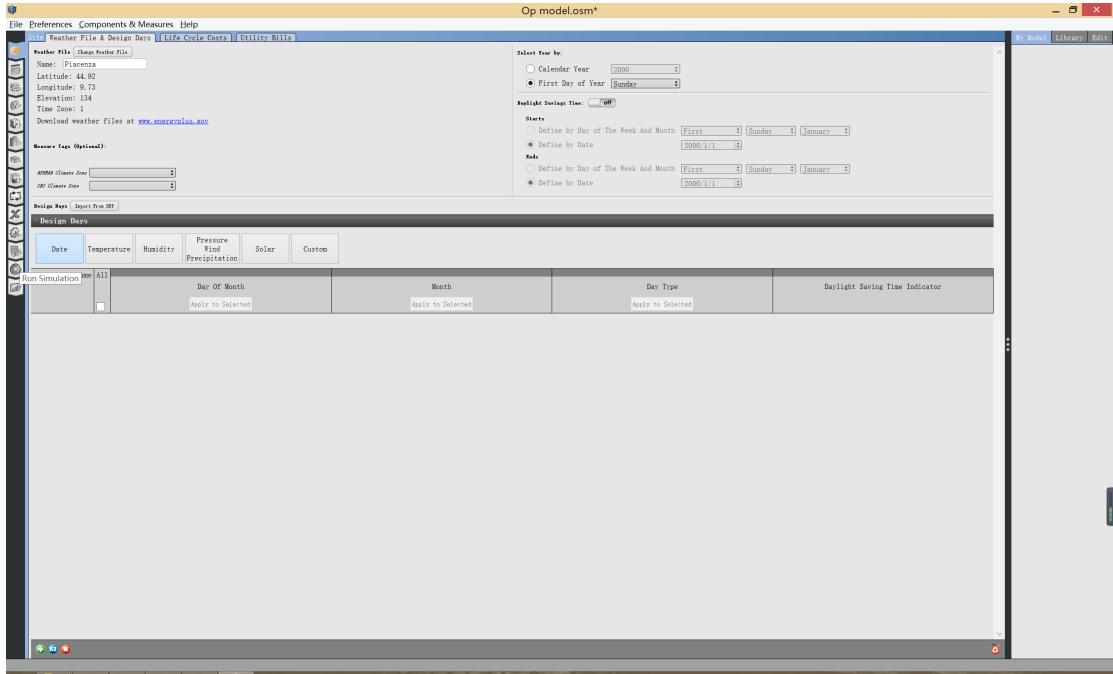
12. Run the Open studio.



13. Add the weather data.



14. Run the analysis.



```

Op model.osm
File Preferences Components & Measures Help
Run Simulation Output Tree
Run [ ] Finished
Warnings: 11
Errors: 0
Output:
EnergyPlus Starting
EnergyPlus, Version 3.5.0-87e61b44b, YMD=2019.11.12 19:36
Processing Input File
Initializing 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=01/01
Continuing Simulation at 01/12 for RUN PERIOD 1
Updating Shadowing Calculations, Start Date=01/10
Continuing Simulation at 02/10 for RUN PERIOD 1
Updating Shadowing Calculations, Start Date=02/09
Continuing Simulation at 03/02 for RUN PERIOD 1
Updating Shadowing Calculations, Start Date=03/22
Updating Shadowing Calculations, Start Date=03/23
Continuing Simulation at 04/11 for RUN PERIOD 1
Updating Shadowing Calculations, Start Date=04/10
Continuing Simulation at 05/01 for RUN PERIOD 1
Updating Shadowing Calculations, Start Date=05/21
Continuing Simulation at 05/20 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=06/20
Continuing Simulation at 06/30 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 EnergyPlus reports
Writing EnergyPlus Run Times to XML 49.38sec
Script executing from: C:\Users\apple\AppData\Local\Temp\OpenStudio.F48444\resources\run\6\UserScript-0
Script script 'OpenStudio Results'.
result = true
Processed 1 base script and 0 merged scripts
100%

```

15. Show the result.

Screenshot of EnergyPlus Results interface showing annual building utility performance summary.

Report: EnergyPlus Results [1]

Program Version: EnergyPlus, Version 8.5.0-87e61b44b, YMD=2019.11.12 19:36

Tabular Output Report is Format: HTML

Building: Building 1

Environment: RUN PERIOD 1 - Parent - ITA (GDDG WMM0)-16940

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 [MJ/m ²] | Energy Per Conditioned Building Area [MJ/m ²] |
|---------------------|---|---|
| 2172.72 | 659.09 | 659.09 |
| Net Site Energy | | |
| 2172.72 | 659.09 | 659.09 |
| Total Source Energy | 1701.86 | 1701.86 |
| Net Source Energy | 1701.86 | 1701.86 |

Site to Source Energy: Conversion Factors

| Site->Source Conversion Factor | |
|--------------------------------|-------|
| Electricity | 1.000 |
| Natural Gas | 1.094 |
| District Cooling | 1.050 |
| 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 ²] | |
|-------------------------------|---------|
| Total Building Area | 3600.00 |
| Net Conditioned Building Area | 3600.00 |
| Unconditioned Building Area | 0.00 |

Screenshot of OpenStudio Results interface showing annual overview.

Report: OpenStudio Results [1]

Open Studio Summary

Annual Overview

Annual Overview

Monthly Overview

Utility Bill Status

Environment

Space Type Breakdown

Space Type Summary

Interior Lighting Summary

Plug Loads Summary

Exterior Lighting

Water Use Equipment

HVAC Load Profiles

Zone Conditions

Zone Summary

Zone Equipment Detail

Air Loops Detail

Plant Loops Detail

Outdoor Air

Cash Flow

Site and Source Summary

Schedule Overview

Annual Overview

End Use - view table

Energy Use - view table

EU - Electricity - view table

TOE - GJ - view table

Monthly Overview