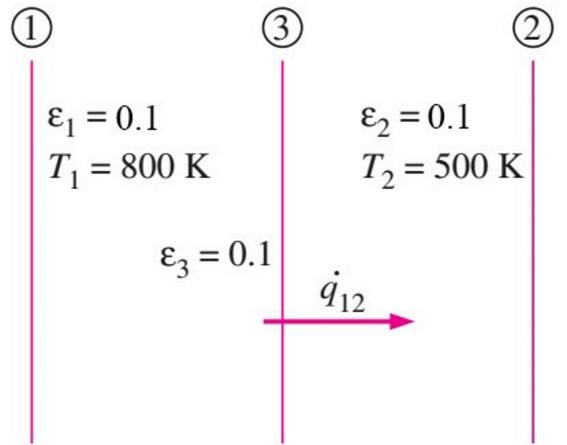


Week6

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

$$\begin{aligned}
 \dot{q}_{net_{1-2}} &= \frac{\dot{Q}_{net_{1-2}}}{A} = \frac{A\sigma(T_2^4 - T_1^4)}{\frac{1}{\epsilon_1} + \frac{1}{\epsilon_2} - 1} \div A \\
 &= \frac{\sigma(T_2^4 - T_1^4)}{\frac{1}{\epsilon_1} + \frac{1}{\epsilon_2} - 1} \\
 &= \frac{\left(5.67 \times 10^{-8} \frac{W}{m^2 K^4}\right) (800^4 - 500^4) K^4}{\frac{1}{0.1} + \frac{1}{0.1} - 1} \\
 &\approx 1035.82 \frac{W}{m^2}
 \end{aligned}$$



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

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

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

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:

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

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

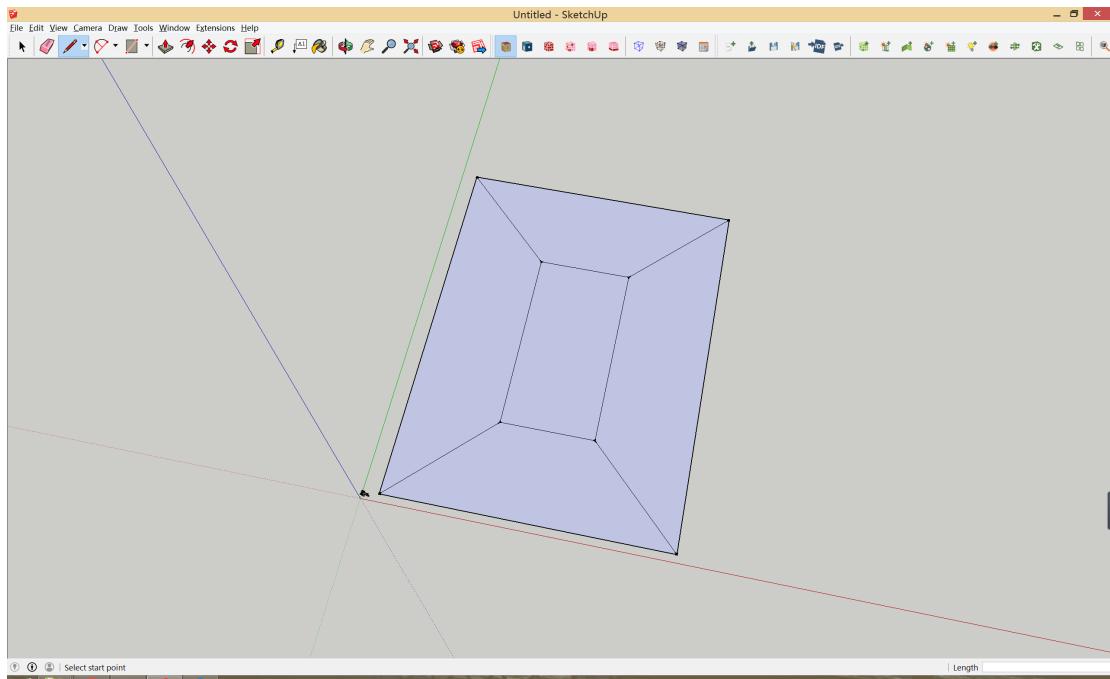
$$i.e., \quad \frac{1}{n+1} \times \frac{\sigma(T_2^4 - T_1^4)}{\frac{1}{\epsilon} + \frac{1}{\epsilon} - 1} = \frac{1}{100} \times \frac{\sigma(T_2^4 - T_1^4)}{\frac{1}{\epsilon} + \frac{1}{\epsilon} - 1}$$

$$n = 99$$

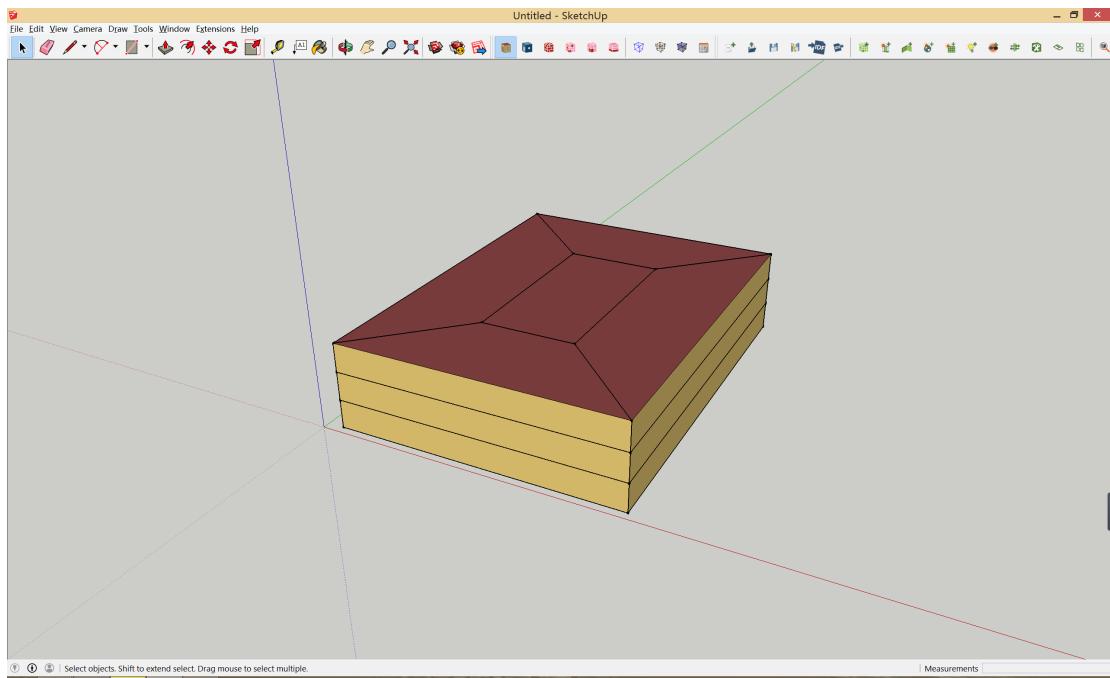
To have the new heat transfer rate be 1% of the previous rate without any shields, we need 99 shields which $\epsilon = 0.1$

Q.E.D.

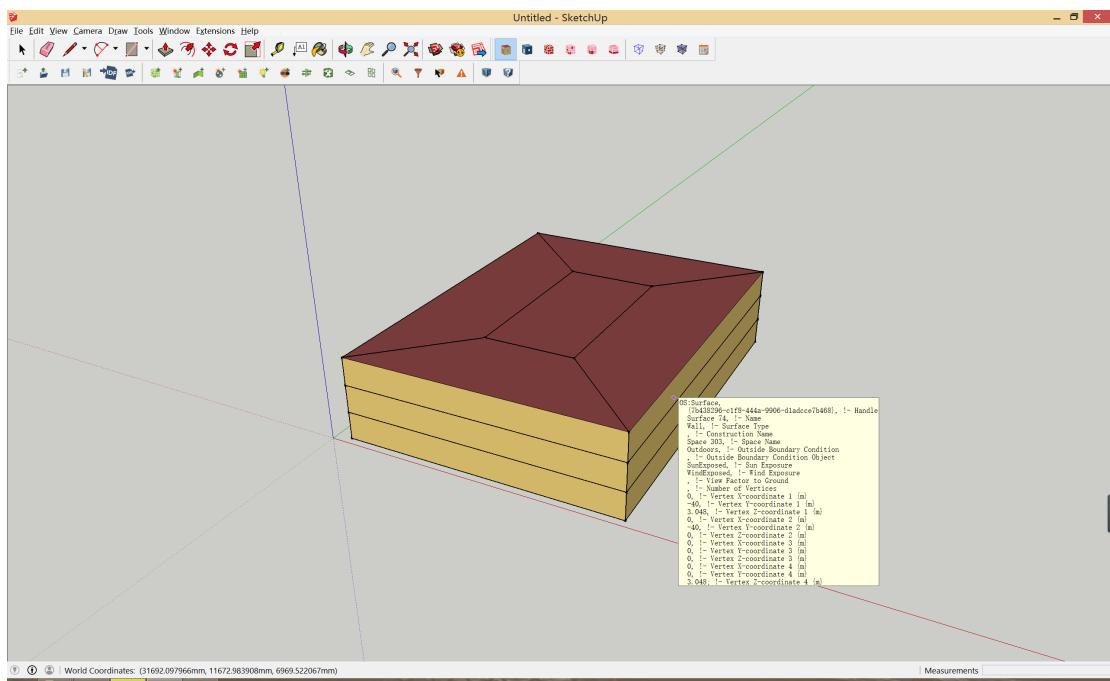
1. Draw the outline and shape of the building in Sketchup.



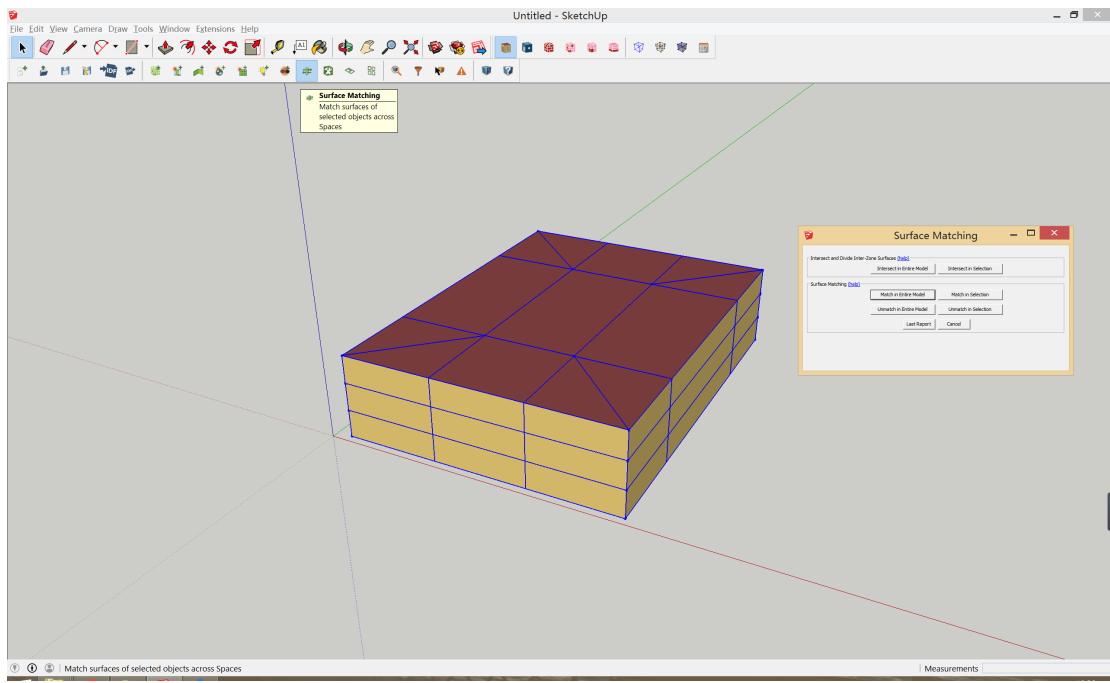
2. Use "Create spaces from diagram" create a 3 floor building.



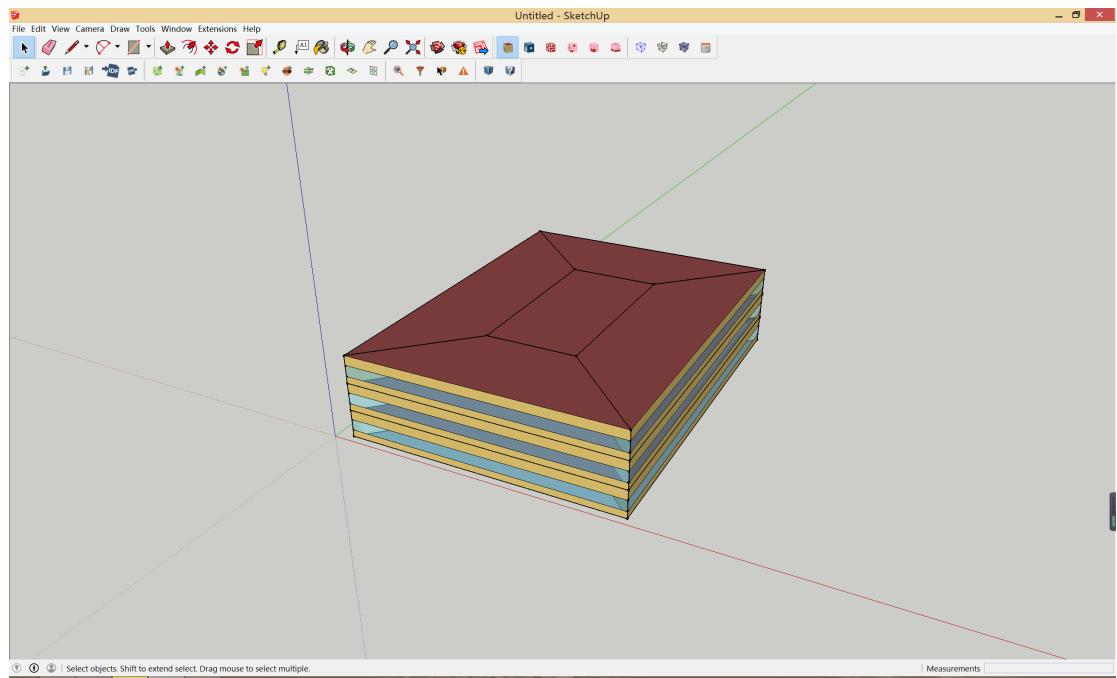
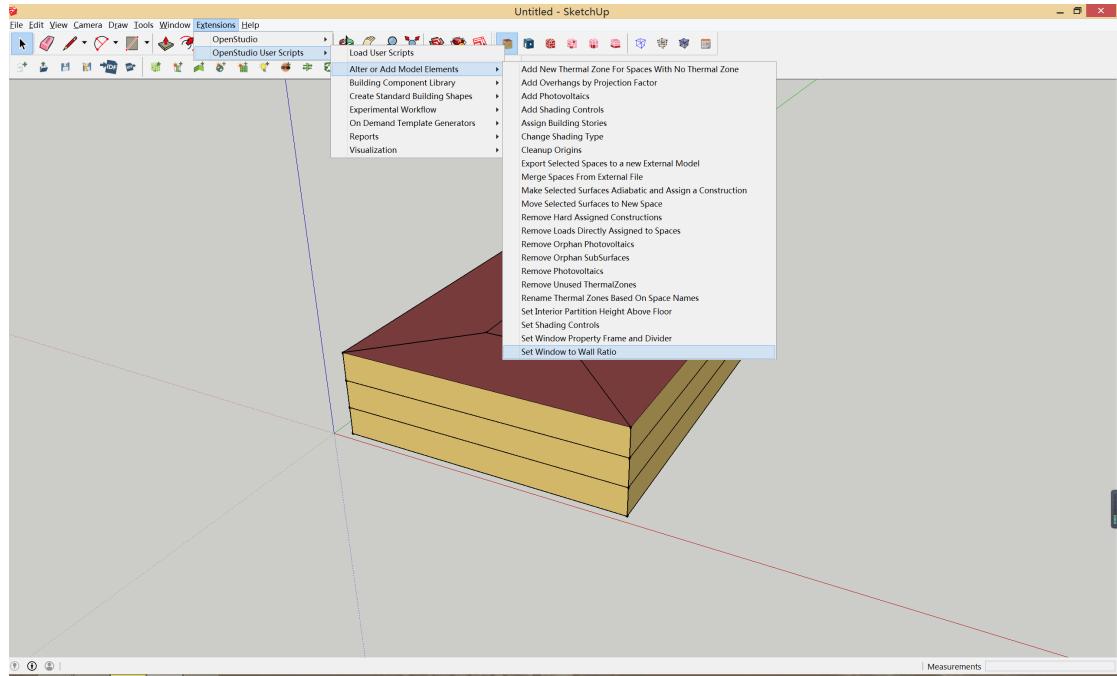
3. We can see the material information using the "Info tool".



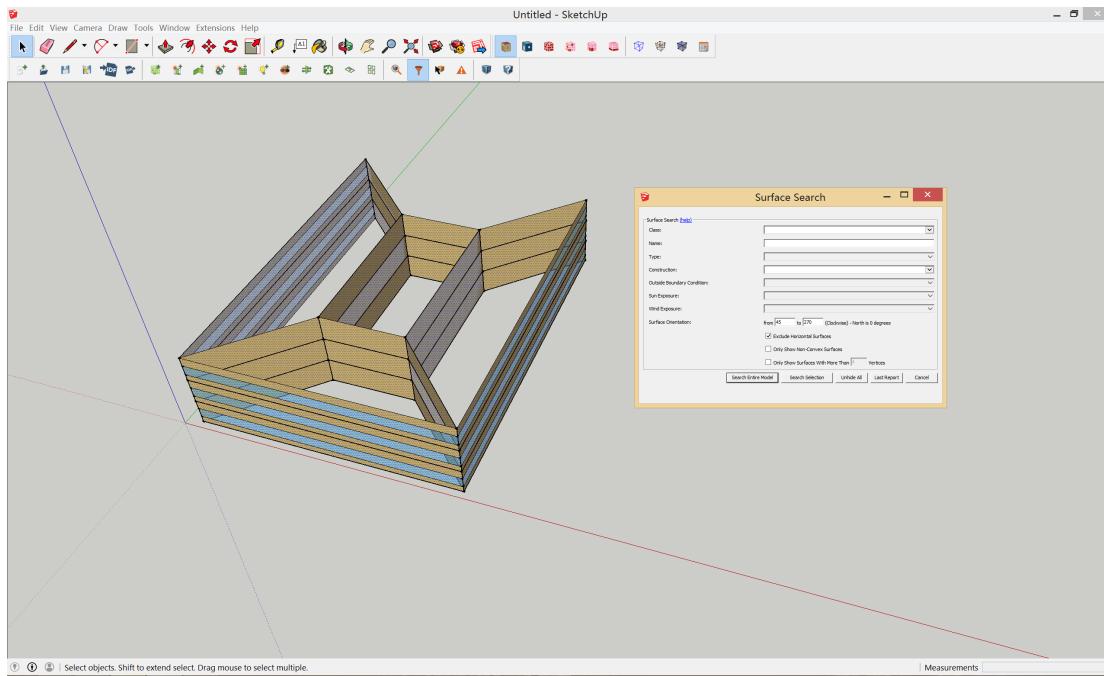
4. Click "Surface matching".



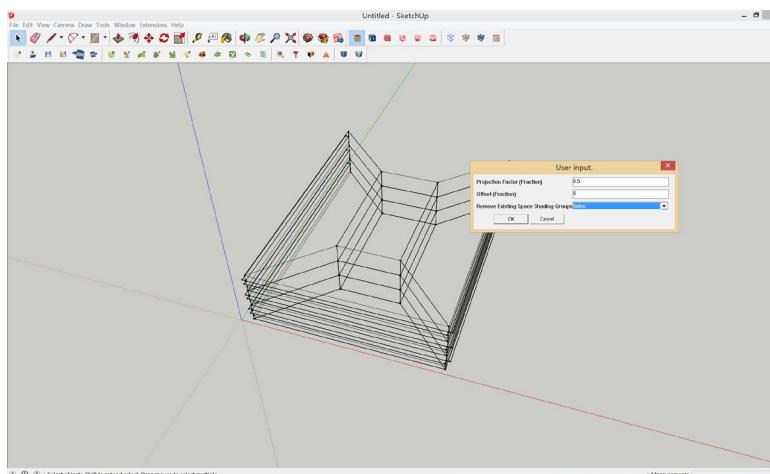
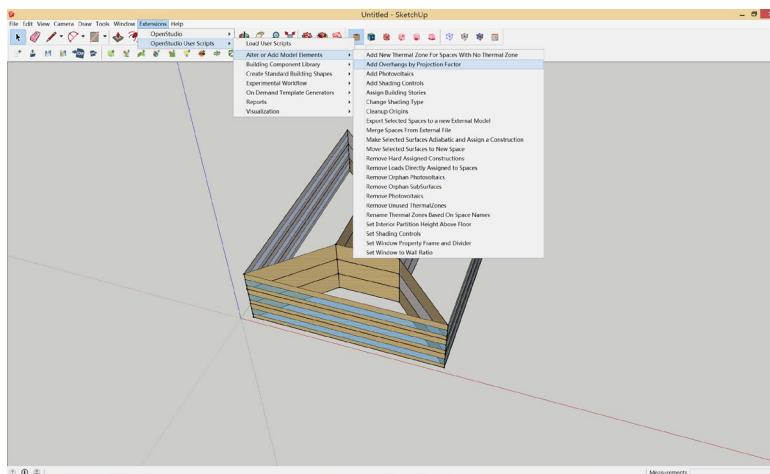
5. Click "Set Window to Wall Ratio" to built the windows.



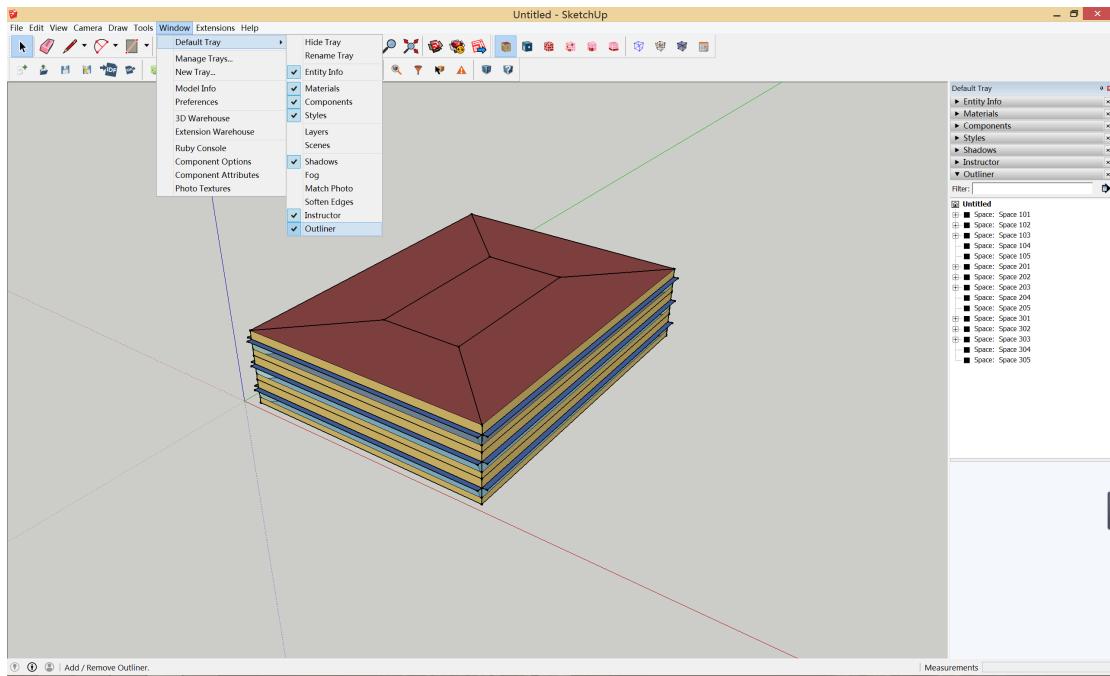
6. Check other directions besides the north.



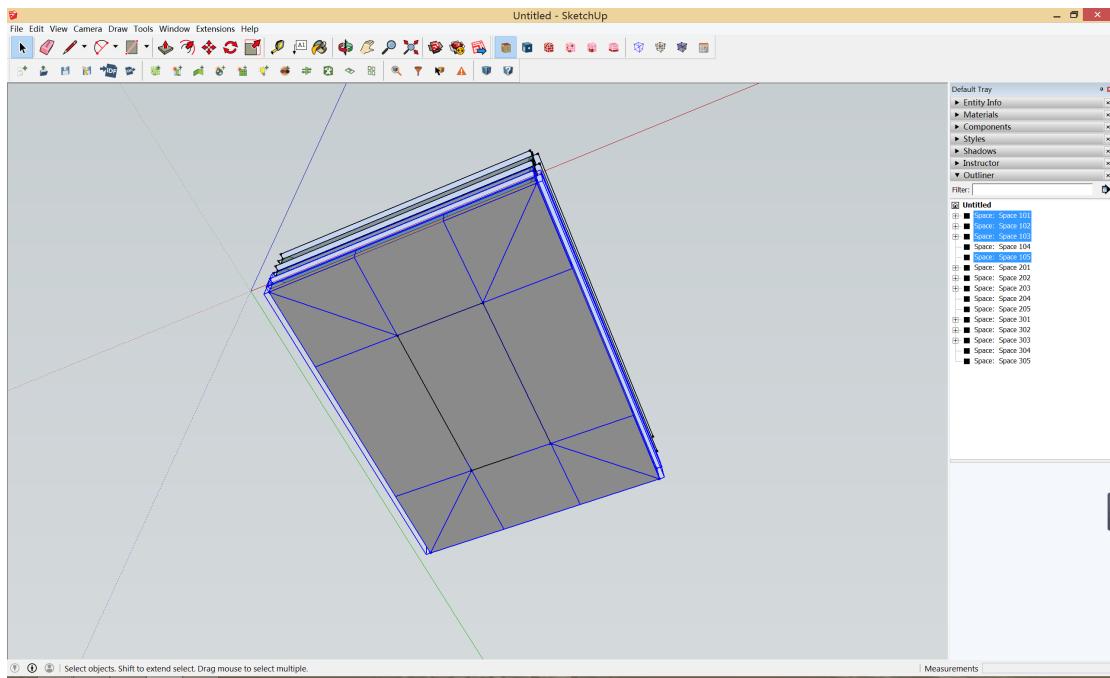
7.Click "Add Overhangs by Projection Factor" to built overhangs.



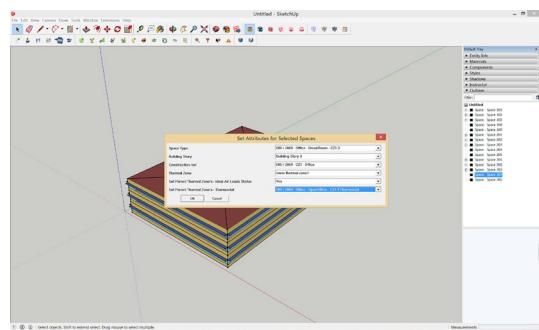
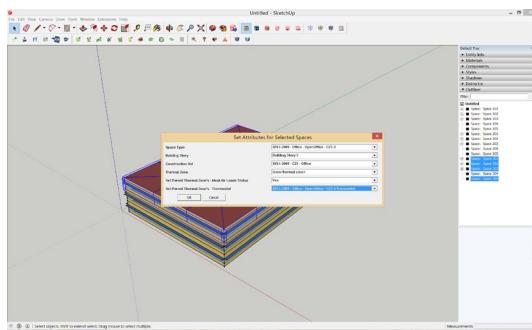
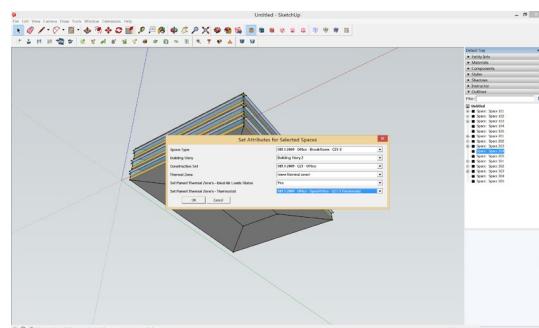
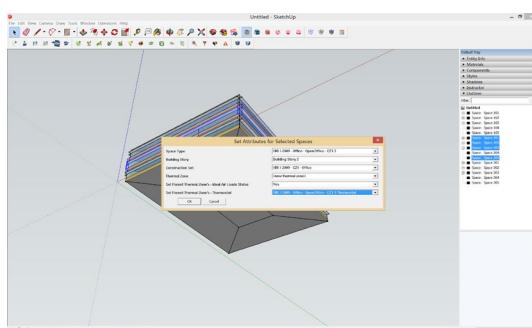
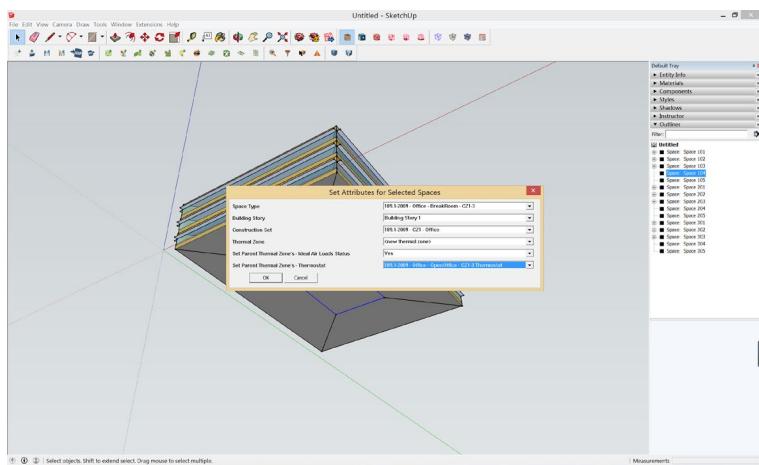
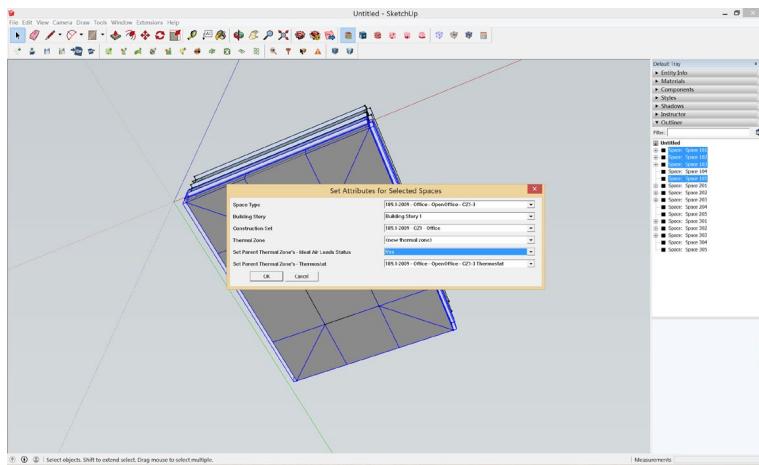
8. Open the "Outliner"



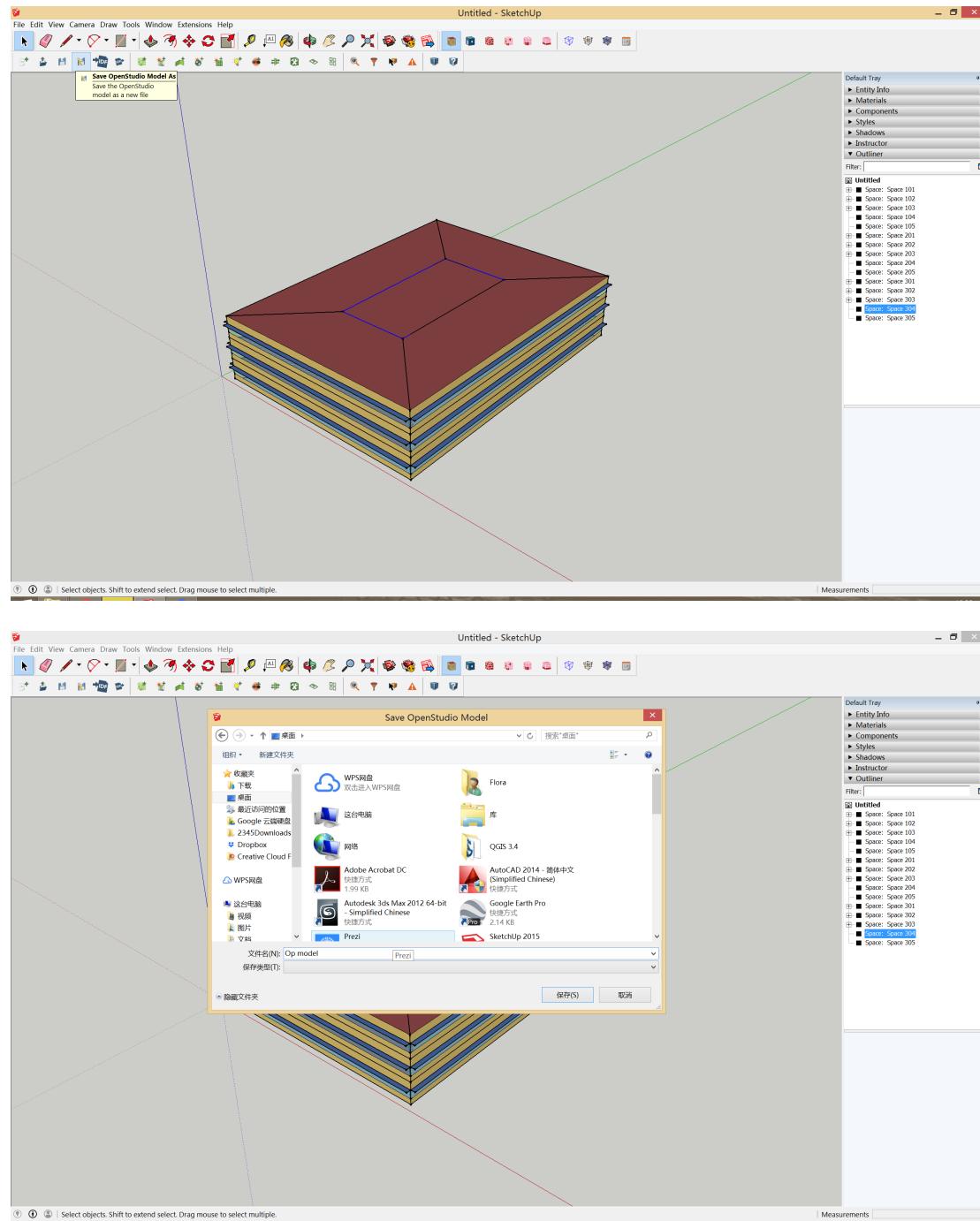
9. Choose the space of each thermal zone.



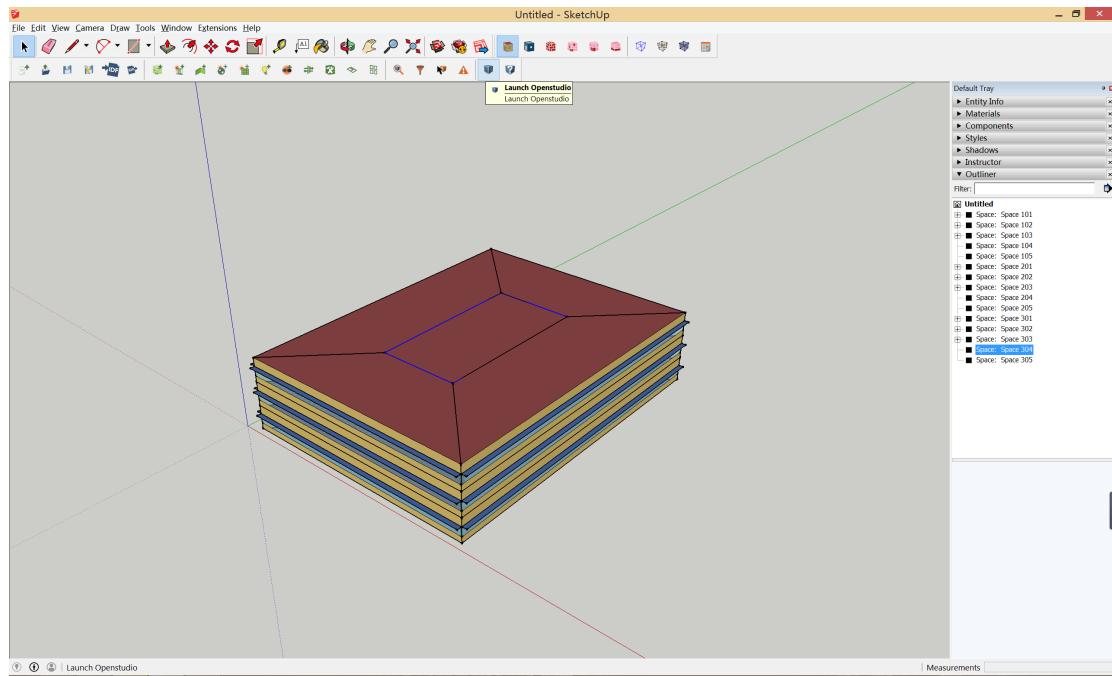
10. Click “Set Attributes for Selected Space” to set parameters.



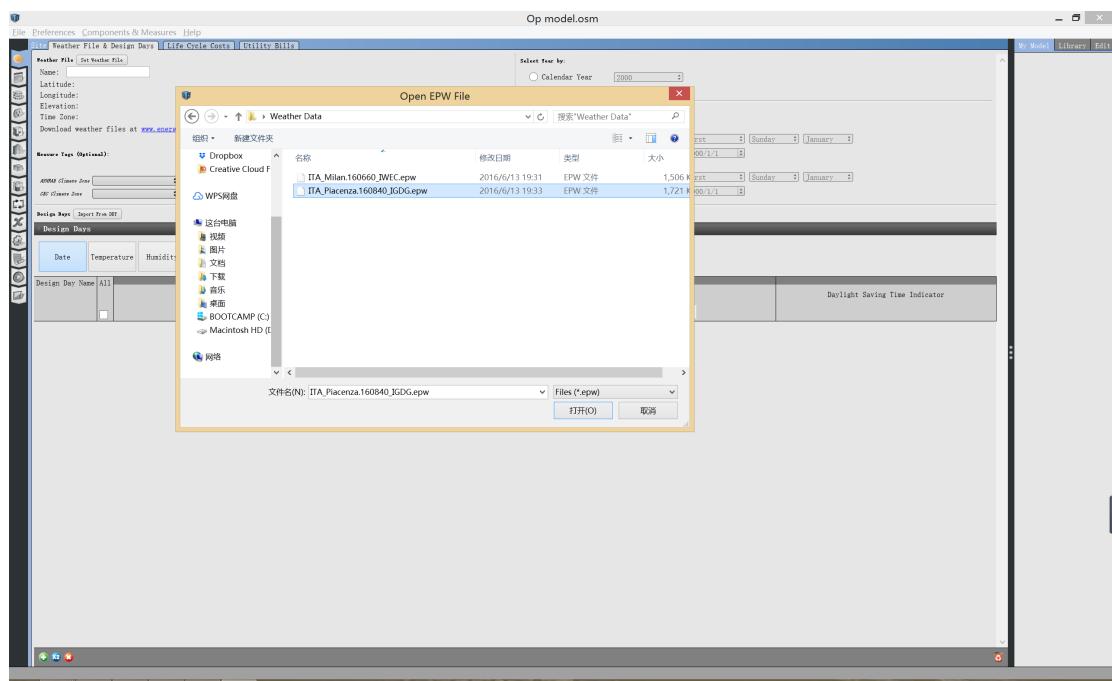
11. Save the model.



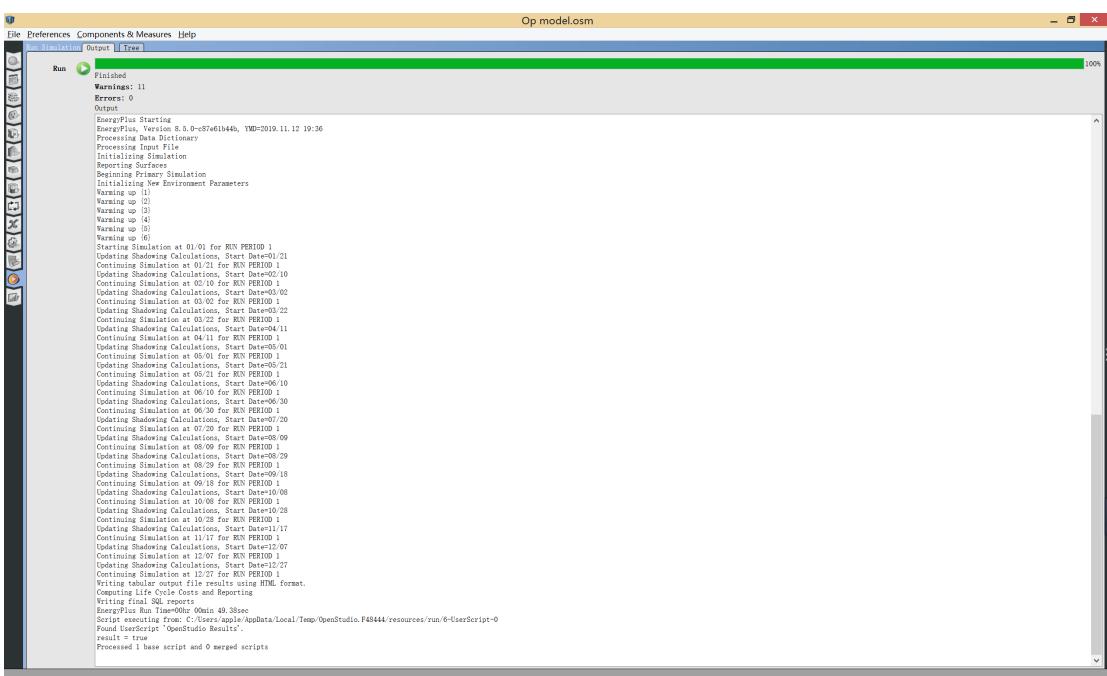
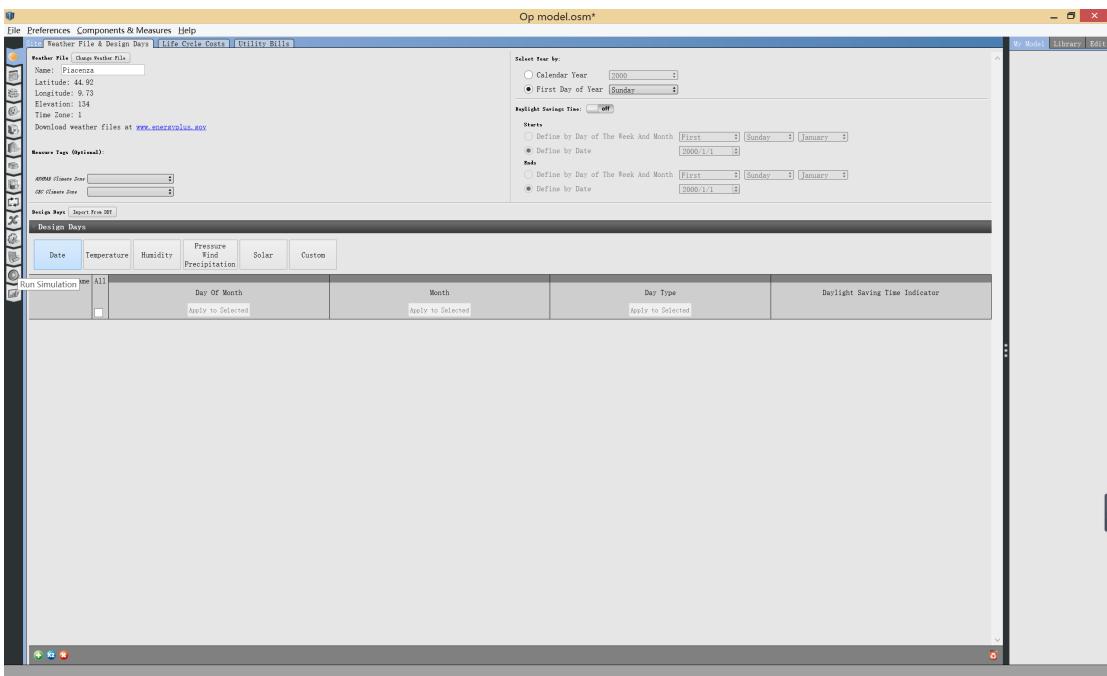
12. Run the Open studio.



13. Add the weather data.



14. Run the analysis.



15. Show the result.

Screenshot of the EnergyPlus Results window showing detailed energy usage data:

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 WMGR=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 ²)	Energy Per Conditioned Building Area (MWh/m ²)
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 ²)
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 use distribution:

- End Use - view table
- Energy Use - view table
- EU - Electricity - view table

Monthly Overview