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Week 6

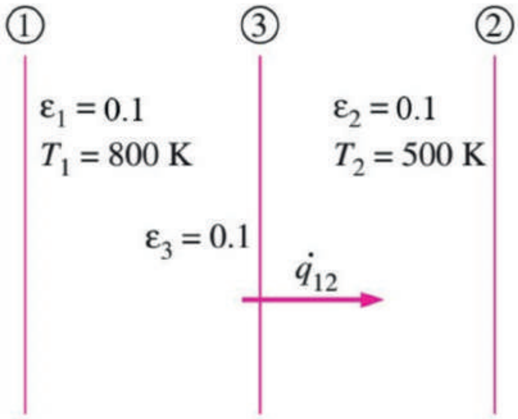
Task1:

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?

Answer:

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

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



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

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

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

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

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

$$\dot{q}_{net_{1-2,\,n\,shiels}} = \frac{\dot{Q}_{net_{1-2,\,n\,shields}}}{A}$$

$$= \frac{A\sigma(T_2^4 - T_1^4)}{\left(\frac{1}{\epsilon_1} + \frac{1}{\epsilon_2} - 1\right) + \left(\frac{1}{\epsilon_{3,1}} + \frac{1}{\epsilon_{3,2}} - 1\right) + \cdots \left(\frac{1}{\epsilon_{n,1}} + \frac{1}{\epsilon_{n,2}} - 1\right)} \div \text{A}$$

$$= \frac{\sigma(T_2^4 - T_1^4)}{\left(\frac{1}{\epsilon_1} + \frac{1}{\epsilon_2} - 1\right) + \left(\frac{1}{\epsilon_{3,1}} + \frac{1}{\epsilon_{3,2}} - 1\right) + \cdots \left(\frac{1}{\epsilon_{n,1}} + \frac{1}{\epsilon_{n,2}} - 1\right)}$$

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

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

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

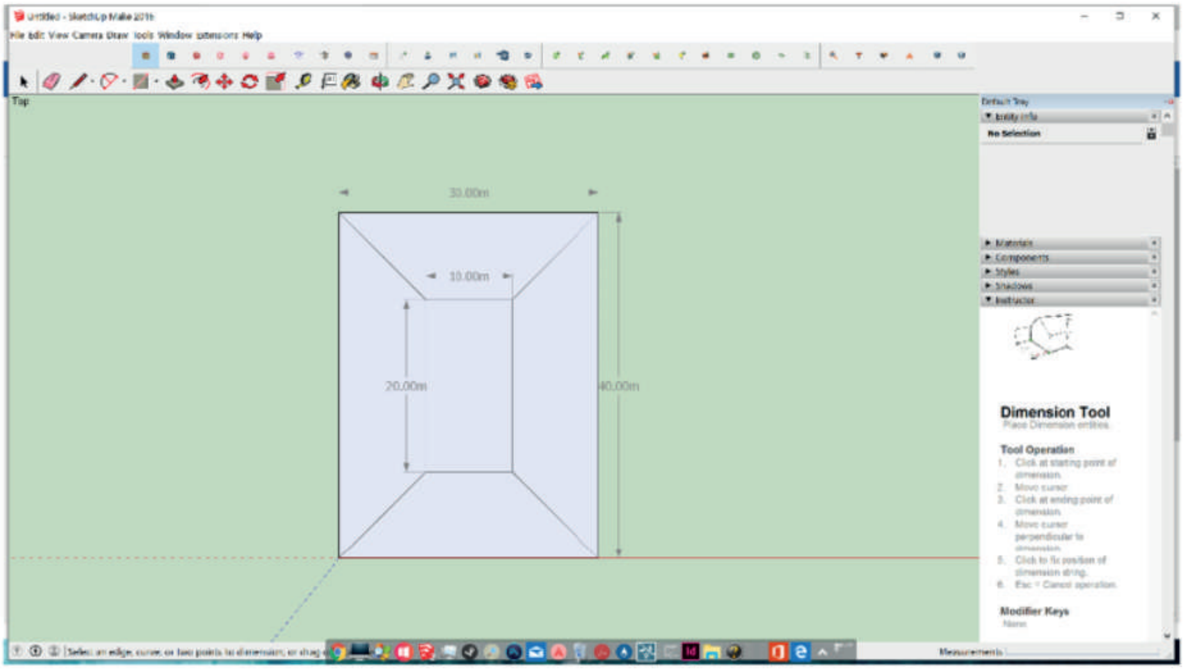
$$Since\ \dot{q}'_{net_{1-2}} = \dot{q}_{net_{1-2,\,n\,shiels}} = \frac{1}{100} \times \dot{q}_{net_{1-2}} = \frac{1}{100} \times \frac{\sigma(T_2^4 - T_1^4)}{\frac{1}{\epsilon_1} + \frac{1}{\epsilon_2} - 1} = \frac{1}{100} \times \frac{\sigma(T_2^4 - T_1^4)}{\frac{1}{\epsilon} + \frac{1}{\epsilon} -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

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

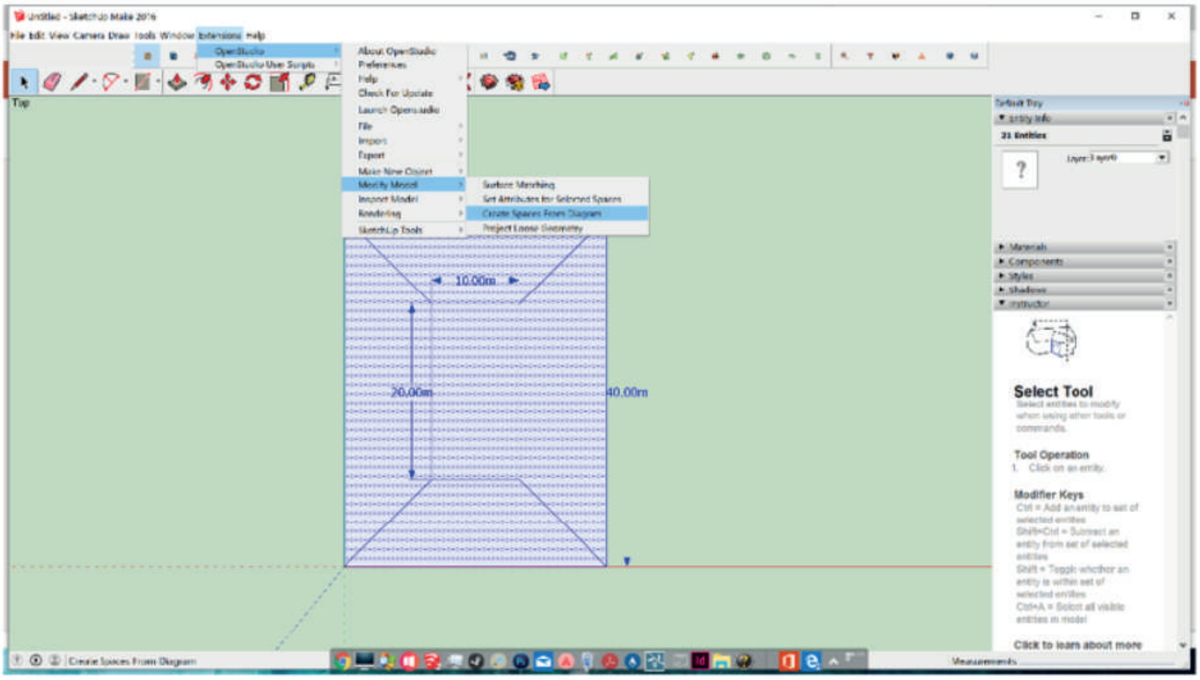
$n = 99$

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

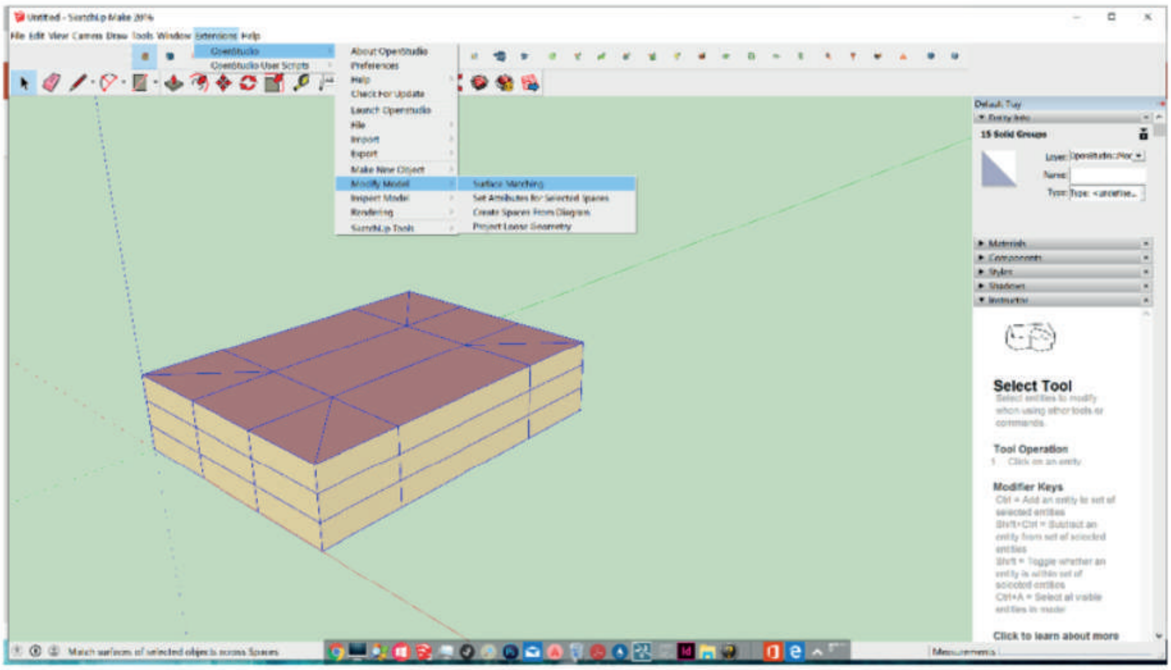
Draw a diagram with the given dimensions



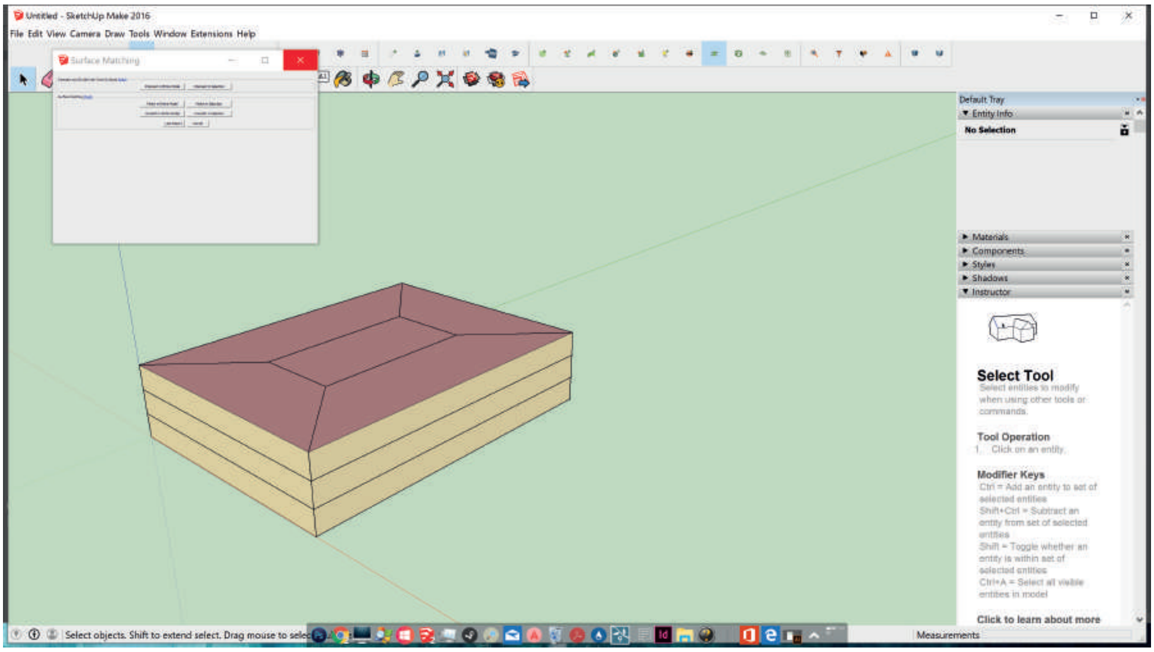
use "Create spaces from diagram" tool to create floors and set the number of floors to 3 and the height of floor to 3



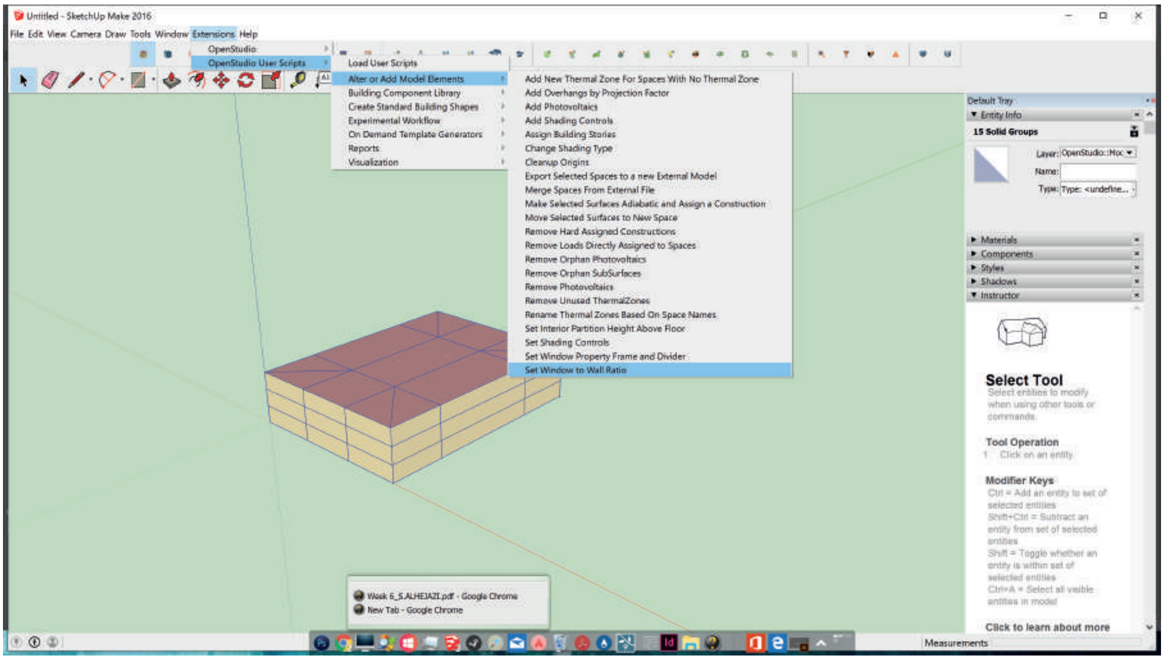
use "Surface matching" tool to match the whole model.



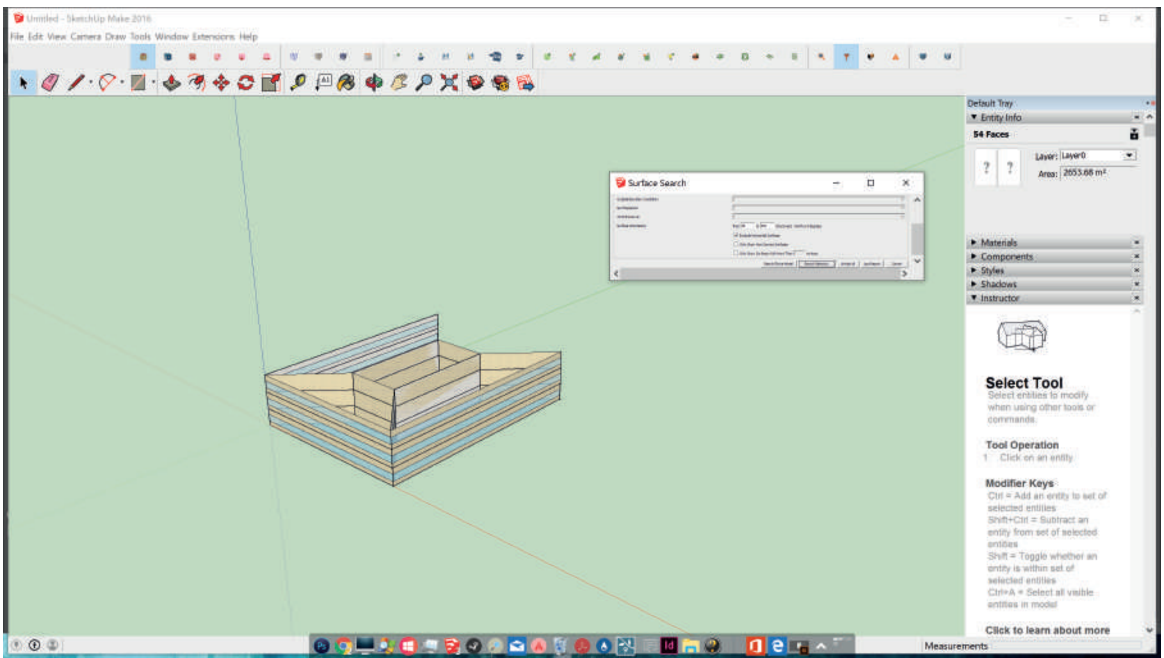
Select «match in entire model» to match the whole model



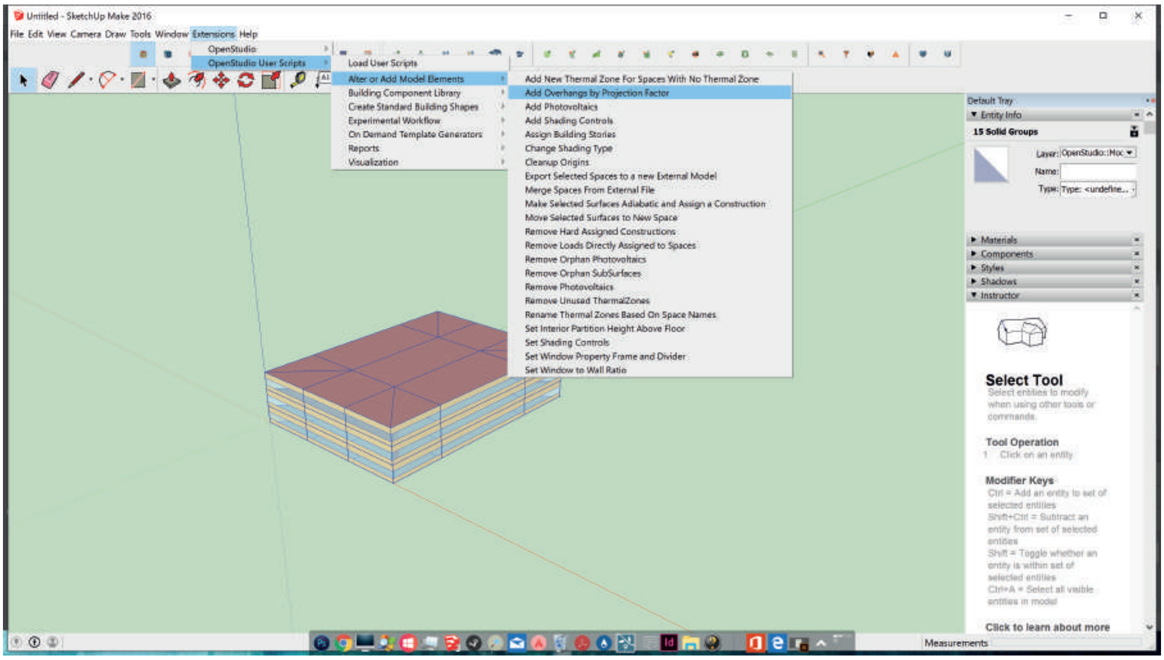
Use «set window to wall ratio» tool to add windows.



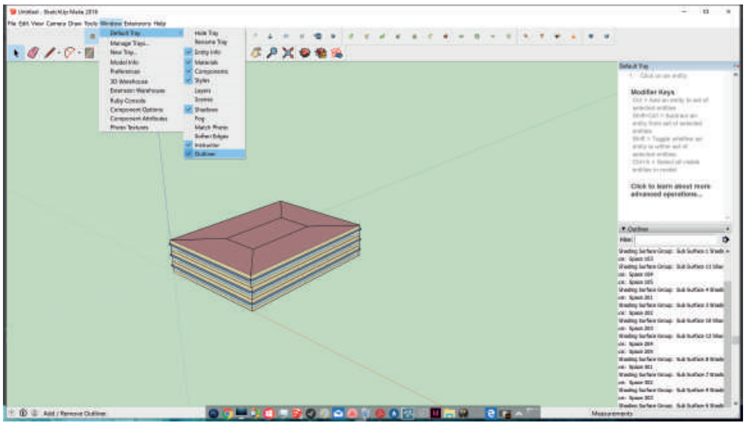
Set the orientation to be 45 to 270 and select «search selection»

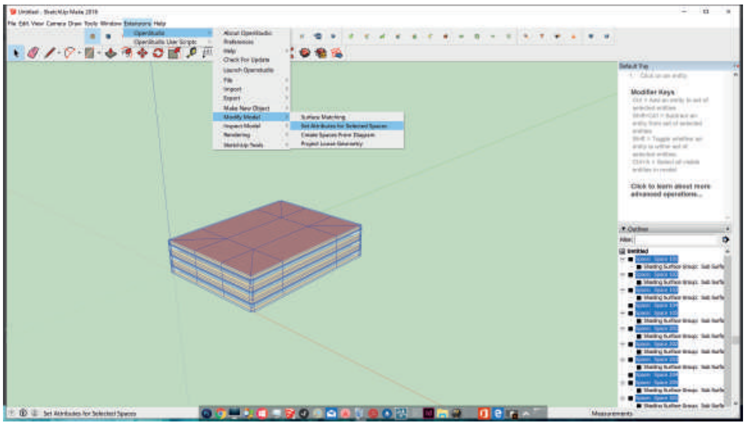


Add overhangs with the «add overhangs by projection fctor» tool

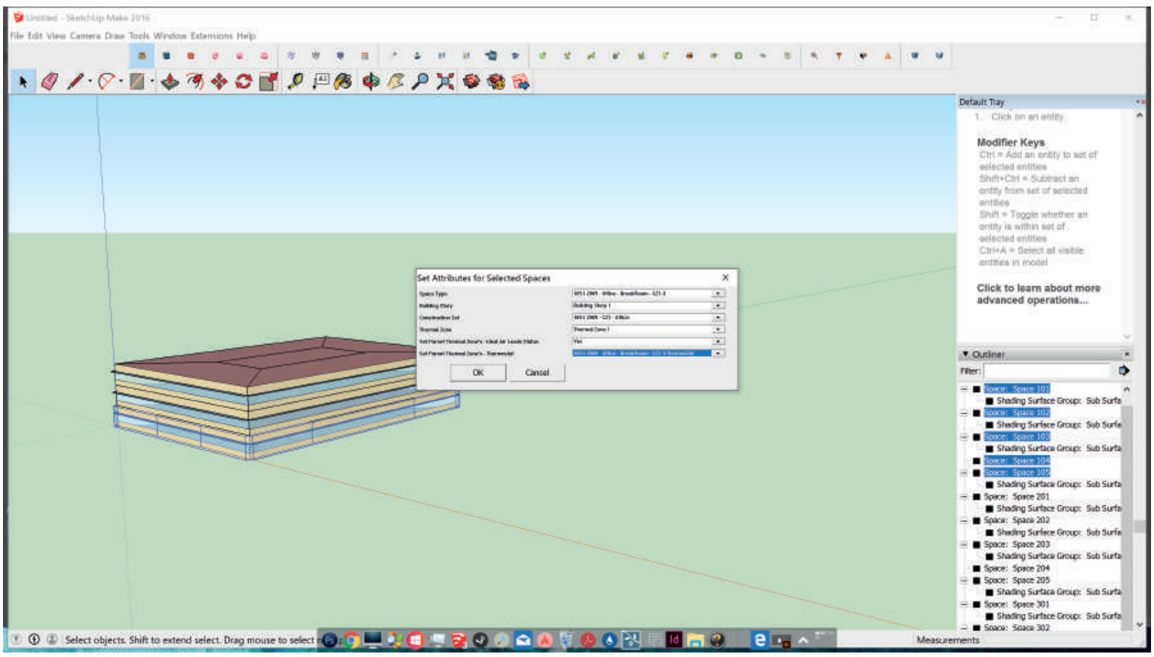


Set the attribute of selected spaces by first, setting the «outline» tool then use the «set attributes for selected spaces» tool

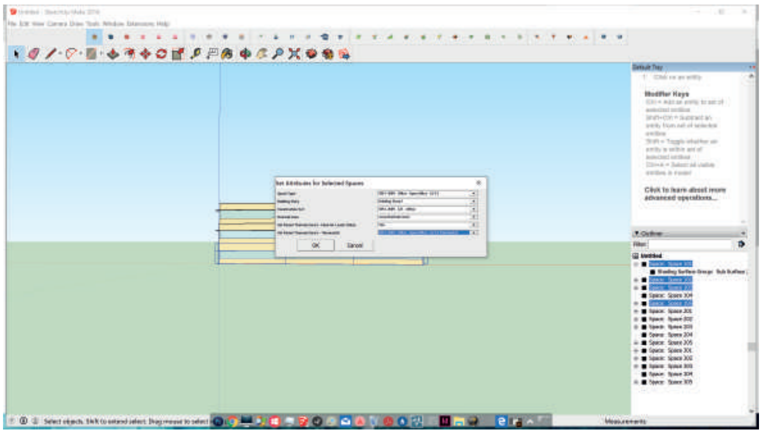


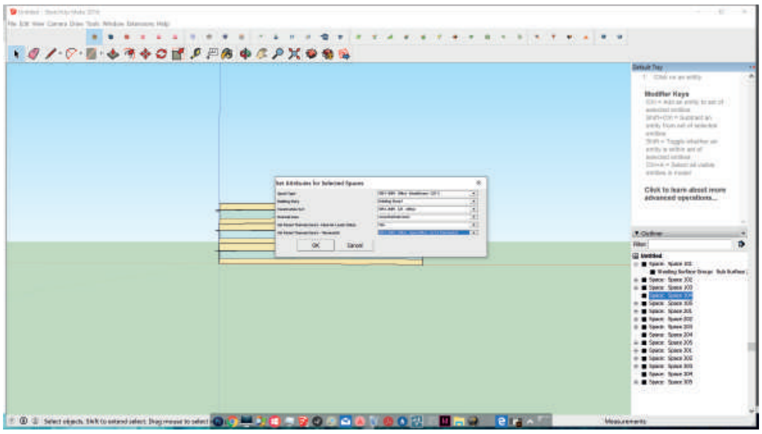


Set the attributes for each floor

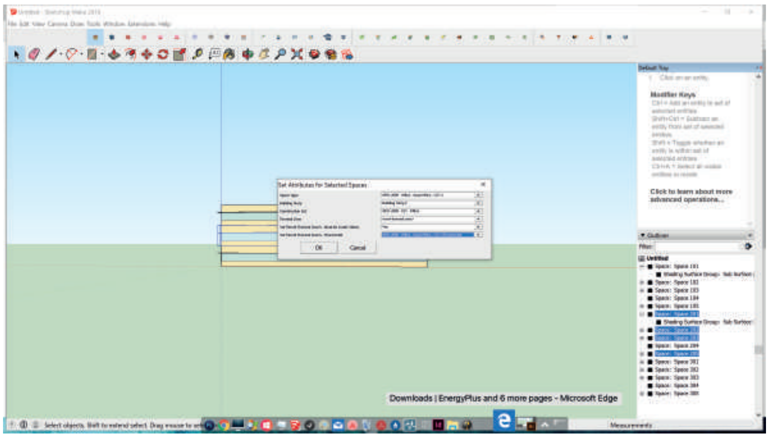


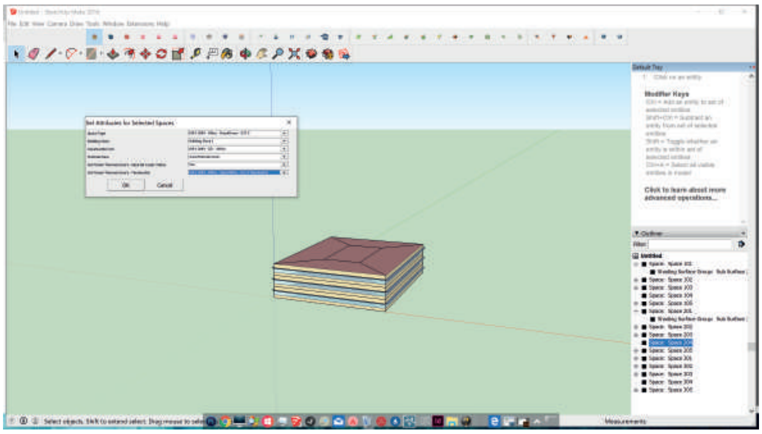
First floor



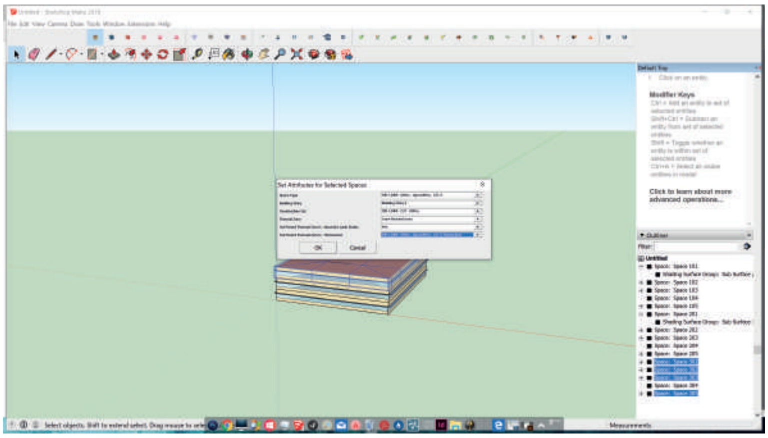


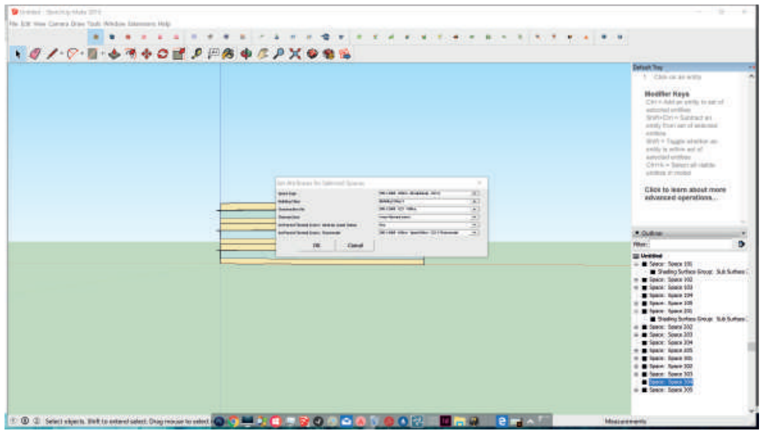
Second Floor



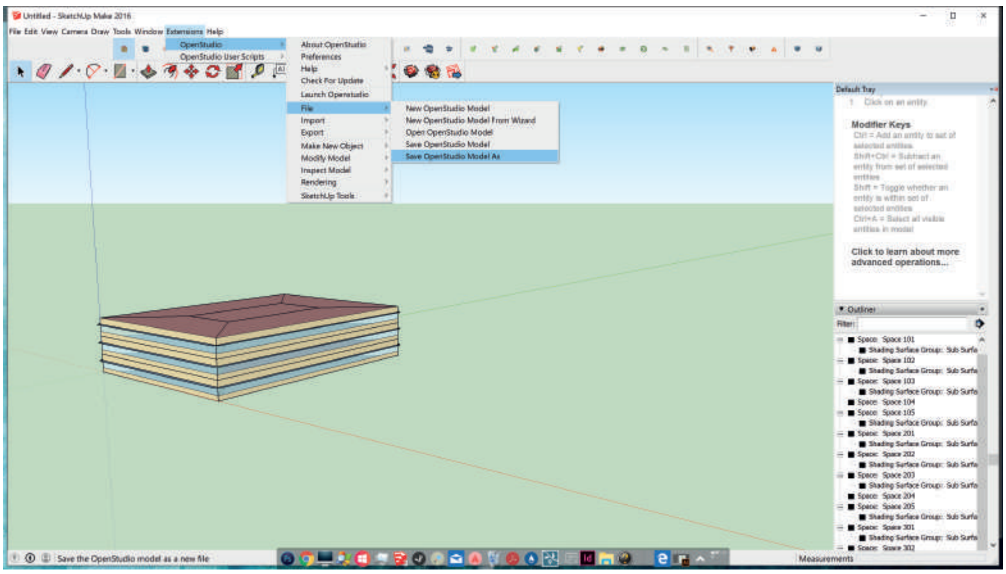


Third Floor

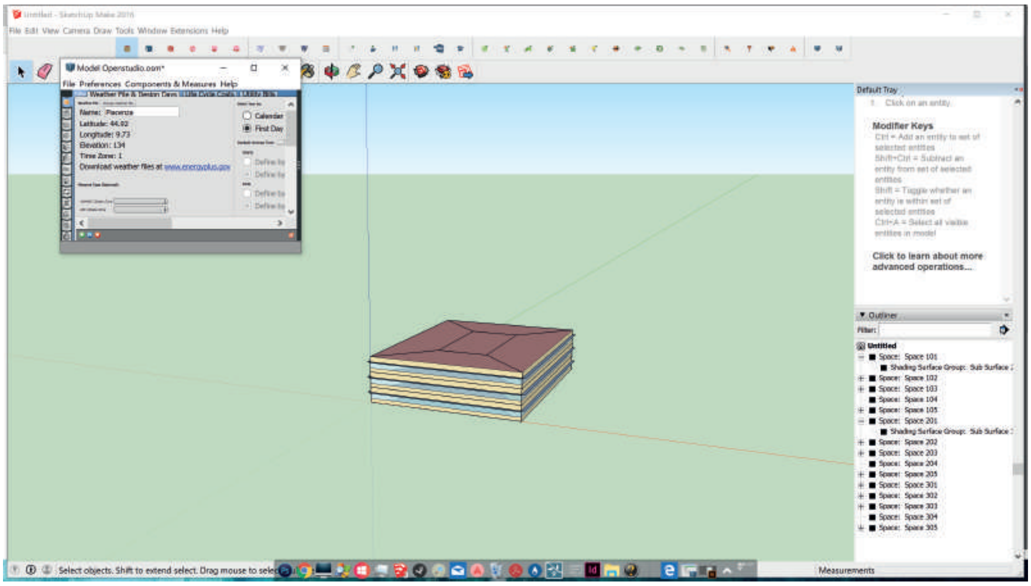




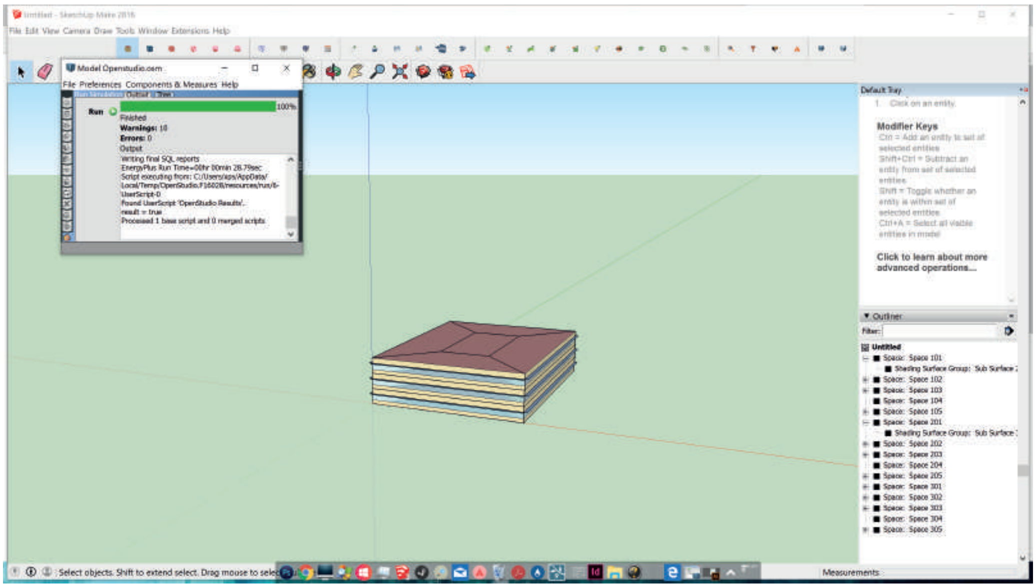
Save the open studio file from the «save openstudio model as» tool



Add the weather data to the open studio.



Run Simulation



Energy Plus results