Name:ZHU CUILING

Personal Code:10640297

summery

1.Heart transfer though a wall is proportional to its Area.

2.It is propornational to the differefce of temperature and conductivity.

Conductivity: willingness of material to transfer heat.

3.IT inversely proportinal to the thickness.

Why ”the thicker the wall, the less heat goes through it” .

week1 submission

1). Simple

$$\dot{Q} = kA\frac{\Delta T}{L} = 0.78 \times 20 \times \frac{25}{0.4} = \cancel{156}\ 975\ W.$$

2) Resistance

$$R_{wall} = \frac{L}{kA} = \frac{0.4}{0.78\times 20} = 0.0256\ ^\circ C/W$$

$$\dot{Q} = \frac{\Delta T}{R_{wall}} = \frac{25}{0.0256} \approx 976.6\ W.$$

WEEK 2_ZHU CUILING

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1-a. Summary about the convective heat transfer

Convective heat transfer is a basic way of heat transfer, divided into natural convection and forced convection. This is because the cause of fluid motion is different. If the fluid motion is caused by a difference in local density caused by the temperature difference inside the fluid, it is called natural convection. If the fluid moves due to the action of a water pump, fan or other external force, it is called forced convection.

What we need to highlight is that convective heat transfer is relying on the movement of fluid particles for heat transfer, so it is depends on: 1) temperature, 2) velocity of liquid or, 3) kind of liquid or gas.

The convective heat transfer coefficient refers to the heat transfer capacity between the fluid and the solid surface. The basic calculation formula for convective heat transfer coefficient was proposed by Newton in 1701, also known as Newton's law of cooling. Newton pointed out that the heat flow of convective heat transfer between the fluid and the solid wall is proportional to their temperature difference.This formula is:

$$\dot{Q}_{conv} = h \times A_s \times (T_s - T_\infty)$$

$$\dot{Q}_{conv} = \frac{T_s - T_\infty}{R_{conv}}$$

$$R_{conv} = \frac{1}{h \times A_s}$$

The thermal resistance network for heat transfer through a plane wall subjected to converction on both side, and the eletrical analogy. Such as:

$$\dot{Q} = \frac{T_{\infty 1} - T_1}{R_{conv,1}} = \frac{T_1 - T_2}{R_{conv,wall}} = \frac{T_2 - T_{\infty 2}}{R_{conv,2}} \quad \rightarrow \quad \dot{Q} = \frac{T_{\infty 1} - T_{\infty 2}}{R_{total}}$$

The summery of caculated test which we learned in the class is: actually the thermal resistance of wall is less than the thermal resistance of air, and the thermal resistance of glass could nearly be ignored, bcause it nearly don't affect the total resistance.

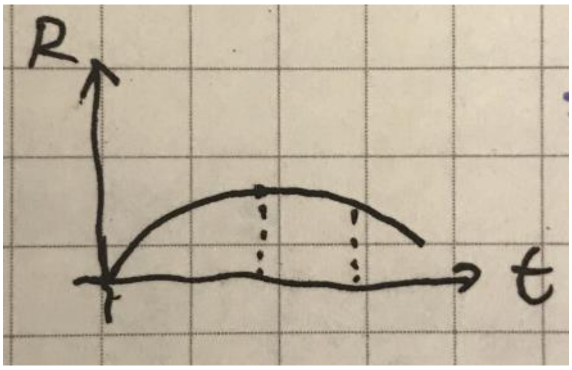
We can also use this formula to caculate the surface temperature, such as:

$$T_1 \ \rightarrow \ \dot{Q} = \frac{T_{\infty 1} - T_1}{R_{conv,1}}$$

$$T_2 \ \rightarrow \ \dot{Q} = \frac{T_{\infty 1} - T_2}{R_{conv,1} + R_{wall}}$$

$$T_3 \ \rightarrow \ \dot{Q} = \frac{T_3 - T_{\infty 2}}{R_{conv,2}}$$

Air convection curve in double glazing:



As the distance increases, there is a critical point in the air convection influence curve.

b. Explain why increasing the thickness of a single pane glass does not increase the total resistane

Because the heat resistance coefficient of glass itself is not on the same order of magnitude as other materials, which is equivalent to one tenth or one percent of the heat resistance coefficient of other materials, the effect of glass thickness increase on the entire resistance is minimal.

2- An explanation about what mistakes you made in the class that resulted in wrong answers.

Because I made a mistake when converting the unit, 1mm = 0.001m, I mistakenly thought that 1mm = 0.01m.

3- Solve the same probelm as that of double pane window with the air-gap thickness of 13 mm and glass thickness of 6 mm, commment on your results and explain why we have an optimal range for the air-gap's distance.

Consider a 0.8m high and 1.5m wide double-pane windiw consisting of two 6-mm-thick layers of glass(k=0.78 W/m^2 · ℃) separated by a 13-mm-wide stagnant air space(k=0.026 W/m^2 · ℃). Determine the steady rate of heat transfer through this double-pane window and temperature of its inner surface.Take the convection heat transfer coefficent on the inner and outer surface of the window to be h_1=10 W/m^2 · ℃ and h_2=40 W/m^2 · ℃, which includes the effects of radiation.

$\mathrm{A} = 0.8 \times 1.5 = 1.2m^2$

$$R_{total} = R_{conv,1} + R_{glass,1} + R_{glass,2} + R_{conv,2}$$
$$= \frac{1}{h_1 \times A} + \frac{L_1}{k_1 \times A} + \frac{L_2}{k_2 \times A} + \frac{L_1}{k_1 \times A} + \frac{1}{h_2 \times A}$$
$$= \frac{1}{10 \times 1.2} + \frac{0.006}{0.78 \times 1.2} + \frac{0.013}{0.026 \times 1.2} + \frac{0.006}{0.78 \times 1.2} + \frac{1}{40 \times 1.2}$$
$$\approx 0.0833 + 0.0064 + 0.4167 + 0.0064 + 0.0208 \approx 0.5336$$

$$\dot{Q}_{conv} = \frac{T_s - T_\infty}{R_{conv}} = \frac{20 - (-10)}{0.5336} \approx 56.22W$$

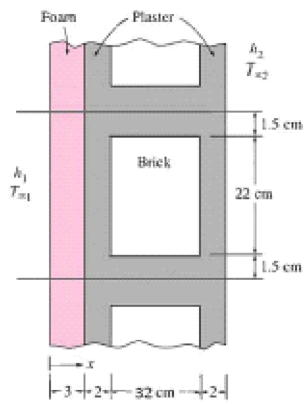
$$56.22 = \frac{T_{\infty 1} - T_1}{R_{conv,1}} \quad \rightarrow \quad T_1 = 20 - (56.22 \times 0.0833) = 15.3°\mathrm{C}$$

WEEK 3_ZHU CUILING

Question1

Heat loss through a composite wall

A 3-m high and 5-m wide wall consists of long 32cm-22cm cross section horizontal bricks(k=0.72 W/m·°C). There are also 3cm thick plaster layers(k=0.22 W/m·°C). There are also 2cm thick plaster layers in each side of the brick and a 3cm thick rigid foam(k=0.026 W/m·°C) on the inner side of the wall. The indoor and the outdoor temperatures are 20°C and -10°C, and the convection heat transfer coefficients on the inner and the outer sides are h_1=10 W/m^2·°C and h_2=40 W/m^2·°C, respectively. Assuming one-dimensional heat transfer and disregarding radiation, determine the rate of heat transfer through the wall.



$$R_{air,1}=\frac{1}{h_{air,1}\times A}=\frac{1}{10\times(0.015+0.22+0.015)\times 1}=0.4°C/w$$
$$R_{foam}=\frac{L_f}{h_f\times A}=\frac{0.03}{0.026\times(0.015+0.22+0.015)\times 1}4.615°C/w$$

$$R_{plaster,1}=\frac{L_{p1}}{h_{p1}\times A}=\frac{0.02}{0.22\times(0.015+0.22+0.015)\times 1}\approx 0.3636°C/w$$
$$R_{plaster,2}=\frac{L_{p2}}{h_{p2}\times A}=\frac{0.032}{0.22\times 0.015\times 1}\approx 96.9697°C/w$$
$$R_{brick}=\frac{L_b}{h_b\times A}=\frac{0.32}{0.72\times 0.22\times 1}\approx 2.0202°C/w$$
$$R_{air,2}=\frac{1}{h_{air,2}\times A}=\frac{1}{40\times(0.015+0.22+0.015)\times 1}=0.1°C/w$$
$$R_{parallel}=\frac{1}{\frac{1}{R_{p2}}+\frac{1}{R_b}+\frac{1}{R_{p2}}}=\frac{1}{\frac{1}{96.9697}+\frac{1}{2.0202}+\frac{1}{96.9697}}\approx 1.9394°C/w$$
$$R_{total}=R_{air,1}+R_{foam}+R_{plaster,1}+R_{parallel}+R_{plaster,1}+R_{air,2}\approx 7.7816°C/w$$
$$\dot{Q}=\frac{\Delta T}{R_{total}}=\frac{20-(-10)}{7.7816}\approx 3.86W$$

The R_{total} while the thickness of brick in this composite wall is 16mm, $R_{total}\approx 6.8118°C/w$

So, $\dot{Q}=\frac{\Delta T}{R_{total}}=\frac{20-(-10)}{6.8118}\approx 4.40W$

Conclusion:
Only add the thickness of a brick inside a composite wall doesn't significantly increase the thermal resistance of the whole wall.

Question2

Determine the overall unit thermal resistance(the R-value) and the overall heat transfer coefficient(the U-factor) of a wall frame wall that is built around 38-mm 90-mm wood studs with a center-to-center distance of 400mm. The 90-mm-wide cavity between the studs is filled with urethane rigif foam. The inside is filled with 13-mm gypsum wallboard and outside with 13-mm plywood and 13-mm 200-mm wood bevel lapped siding. The insulated cavity constitutes 75% heat transmission area while the studs, plates, and sills constitutes 21%. The headers constitutes 4% of the area, and they can be treated as studs.

Find the two R_{unit} values.

	Wood	Insulation

Outside air	0.03	0.03
Wood bevel(13mm-200mm)	0.14	0.14
Plywood(13mm)	0.11	0.11
Urethane rigif foam insulation(90mm)	$\times$	$\frac{0.98}{25} \times 90 = 3.528$
Wood studs(90mm)	0.63	$\times$
Gypsum board(13mm)	0.079	0.079
Inside surface	0.12	0.12

$R_{total,wood} = 0.03 + 0.14 + 0.11 + 0.63 + 0.079 + 0.12 = 1.109°C/w$
$R_{total,ins} = 0.03 + 0.14 + 0.11 + 3.528 + 0.079 + 0.12 = 4.007°C/w$

WEEK 4_ZHU CUILING

Determine the overall unit thermal resistance(the R-value) and the overall heat transfer coefficient(the U-factor) of a wall frame wall that is built around 38-mm 90-mm wood studs with a center-to-center distance of 400mm. The 90-mm-wide cavity between the studs is filled with urethane rigif foam. The inside is filled with 13-mm gypsum wallboard and outside with 13-mm plywood and 13-mm 200-mm wood bevel lapped siding. The insulated cavity constitutes 75% heat transmission area while the studs, plates, and sills constitutes 21%. The headers constitutes 4% of the area, and they can be treated as studs.

Also determine the rate of heat loss through the walls of a house whose perimeter is 50m and wall height is 2.5m in Las Vegas, Nevada, whose winter design temperature is -2°C. Take the indoor design temperature to be 22°C and assume 20% of the wall area is occupied by glazing.

	Wood	Insulation
Outside air	0.03	0.03
Wood bevel(13mm-200mm)	0.14	0.14
Plywood(13mm)	0.11	0.11
Urethane rigif foam insulation(90mm)	×	$\frac{0.98}{25} \times 90 = 3.528$
Wood studs(90mm)	0.63	×
Gypsum board(13mm)	0.079	0.079
Inside surface	0.12	0.12

$$R'_{total,wood} = 0.03 + 0.14 + 0.11 + 0.63 + 0.079 + 0.12 = 1.109 m^2 \cdot °C/w$$
$$R'_{total,ins} = 0.03 + 0.14 + 0.11 + 3.528 + 0.079 + 0.12 = 4.007 m^2 \cdot °C/w$$

$$\because \frac{1}{R_{total}} = \frac{1}{R_{wood}} + \frac{1}{R_{ins}}, R' = R \times A$$
$$\therefore R = \frac{R'}{A}, \frac{1}{\frac{R'_{tot}}{A_{tot}}} = \frac{1}{\frac{R'_{wood}}{A_{wood}}} + \frac{1}{\frac{R'_{ins}}{A_{ins}}} \rightarrow \frac{A_{tot}}{R'_{tot}} = \frac{A_{wood}}{R'_{wood}} + \frac{A_{ins}}{R'_{ins}}$$

Autem, $U = \frac{1}{R'}$

$$U_{tot} \times A_{tot} = U_{wood} \times A_{wood} + U_{ins} \times A_{ins} \rightarrow U_{tot} = U_{wood} \times \frac{A_{wood}}{A_{tot}} + U_{ins} \times \frac{A_{ins}}{A_{tot}}$$
$$= 0.25 \times \frac{1}{1.109} + 0.75 \times \frac{1}{4.007} \approx 0.4126 W/m^2 \cdot °C$$
$$R_{value} = \frac{1}{U_{tot}} \approx \frac{1}{0.4126} \approx 2.4237 m^2 \cdot °C/w$$
$$\dot{Q}_{tot} = U_{tot} \times A_{tot} \times \Delta T = 0.4126 \times 50 \times 2.5 \times (1 - 20\%) \times [22 - (-2)] = 990.24 W$$

Summary about radiation and radiative heat transfer

Definition:

- **Electromagnetic wave**

Electromagnetic waves are oscillating particle waves that are generated by the electric field and magnetic field in the same phase and perpendicular to each other. They are electromagnetic fields that propagate in the form of waves.

The process of relying on electromagnetic wave radiation to achieve heat transfer between hot and cold objects is a non-contact heat transfer that can also be carried out in a vacuum. The electromagnetic waves emitted by the object are theoretically distributed over the entire spectrum, but in the temperature range encountered in the industry, the practical significance is the thermal radiation with a wavelength between 0.38 and 1000 μm, and most of them are located in the infrared (again It is called the heat ray) in the range of 0.76 to 20 μm. The so-called infrared heating is to use the thermal radiation of this section.

- **thermal radiation**

Radiation is a phenomenon in which energy is transmitted by electromagnetic waves. The process in which radiant energy is emitted due to heat is called thermal radiation.

While scattering the emitted radiant energy, the object will continuously absorb the radiant energy emitted by other surrounding objects and convert it into heat energy. The heat transfer process between the objects that emit radiant energy and absorb radiant energy is called radiative heat transfer. It's a basic way of heat transfer.

Any object emits radiant energy while absorbing the radiant energy from surrounding objects. The difference between the energy radiated by an object and the energy absorbed is the net energy it transmits. The radiation capacity of an object (that is, the energy radiated outward from a unit surface per unit time) increases rapidly with increasing temperature.

·If the energy of the heat radiation reaching the surface of the object is completely absorbed, the object is called an absolute black body, referred to as a black body;

·If the energy of the thermal radiation reaching the surface of the object is all reflected; when the reflection is regular, the object is called a mirror;

·If it is a chaotic reflection, it is called absolute white body.

·If the energy of the heat radiation reaching the surface of the object passes through the object, the object is called a heat permeable body.

Formula

- **Electromagnetic wave**

$$\lambda = \frac{c}{v} \qquad c = \frac{c_0}{n} \qquad e = h \times v = \frac{h \times c}{v}$$

c_0: speed of light in a cacunm $c_0 = 2.9979 \times 10^8 m/s$

n: index of refraction of the medium
n=1(air and most gases) n=1.5(glass) n=1.33(water)

$h = 6.626069 \times 10^{-34} J \cdot s$ is **Planck's constant**

- **Stefan—Boltzmann's Law**

$$E_b(T) = \delta \times T^4 (W/m^2)$$

Stefan—Boltzman constant: $\delta = 5.670 \times 10^{-8} W/m^2 \cdot K^4$

- **Plank's Law**

$$E_{b\lambda}(\lambda, T) = \frac{C_1}{\lambda^5 \left[\exp\left(\frac{C_2}{\lambda \times T}\right) - 1\right]} \left(W/m^2 \cdot \mu m\right)$$

$C_1 = 2\pi h c_0^2 = 3.74177 \times 10^8 W \cdot \mu m^4/m^2$
$C_2 = h c_0/k = 1.43878 \times 10^4 \mu m \cdot K$
$k = 1.38065 \times 10^{-23} J/K$ ——Boltzmann's constant

- **Wien's Displacement Law**

$$(\lambda \times T)_{\max power} = 2897.8 \mu m \cdot K$$

WEEK 5_ZHU CUILING

TASK1

Write a summary of the topics about radiative heat transfer we went through including the definitions of emissivity, absorptivity and reflectivity, the view factor, the heat exchange betweeen two black surfaces,the heat exchange between the two gray surface and finally the definition of radiative resistances.

Radiative heat transfer

Radiation is a phenomenon in which energy is transmitted by electromagnetic waves. The process in which radiant energy is emitted due to heat is called thermal radiation.

While scattering the emitted radiant energy, the object will continuously absorb the radiant energy emitted by other surrounding objects and convert it into heat energy. The heat transfer process between the objects that emit radiant energy and absorb radiant energy is called radiative heat transfer. It's a basic way of heat transfer.

Definitions of emissivity

Emissivity is the ability to measure the relative strength of an object's surface in the form of radiation. The radiance of an object is equal to the ratio of the energy radiated by the object at a certain temperature to the radiant energy of the black body at the same temperature. The emissivity of the black body is equal to 1, and the emissivity of other objects is between 0 and 1.

Definitions of absorptivity

Absorption rate refers to the ratio of the heat radiation energy absorbed by an object onto the object and the total heat radiation energy projected onto the object is called the absorption rate of the object. This is the total absorption rate for all wavelengths.

The absorption rate of the surface of the object is related to the nature of the object, the surface condition and the temperature. It is an inherent characteristic of the object itself, and has nothing to do with the external environment.

Definitions of reflectivity

The radiant energy reflected by an object as a percentage of the total radiant energy is called the reflectivity. The reflectivity of different objects is also different, which depends mainly on the nature of the object itself (surface condition), as well as the wavelength and incident angle of the incident electromagnetic wave. The range of reflectivity is always less than or equal to 1 and the reflectivity can be used to judge the properties of the object.

The view factor

A reflection factor is a portion of the energy emitted (radiated or reflected) from an isothermal, opaque, diffusely reflective surface that is emitted directly to another plane (absorbed or reflected by it).

The heat exchange between two black surfaces

Radiation heat exchange refers to the heat exchange process between two objects with different temperatures and not touching each other, which is the total effect of mutual radiation and absorption between two objects.

Black surface will emit a radiation of E_{b1} per unit area per unit time. If the surface is having A1 unit area, then it will emit $E_{b1} \times A_1$ radiation in unit time. The 2nd black body will emit its radiation $E_{b2} \times A_2$ radiation in unit time.

The net heat transfer is the radiation leaving the entire surface 1 that strikes surface 2 subtracts the radiation leaving the entire surface 2 that strikes surface 1.

The formula is: $A_1 \times E_{b1} \times F_1 - A_2 \times E_{b2} \times F_2$

The heat exchange between the two gray surface

Gray surface will reflect or absorb a given fraction of the thermal radiation a blackbody surface would absorb. More importantly, the fraction of graybody/blackbody is independent of radiation wavelength.

How can I find the net radiation heat exchange between surface 1 and 2?

$\dot{\boldsymbol{Q}}_{\boldsymbol{net\ between\ 1\ and\ 2}} = \dot{\boldsymbol{Q}}_{\boldsymbol{emitted\ by\ surface\ 1\ and\ received\ in\ surface\ 2}} - \dot{\boldsymbol{Q}}_{\boldsymbol{emitted\ by\ surface\ 2\ and\ received\ in\ surface\ 1}}$

$\because \dot{\boldsymbol{Q}}_{1\to 2} = \boldsymbol{A_1 \times F_{12} \times \sigma T^4 - A_2 \times F_{21} \times \sigma T^4} \quad \boldsymbol{A_1 F_{12} = A_2 F_{21}}$

$\therefore \dot{\boldsymbol{Q}}_{1\to 2} = \boldsymbol{A_1 \times F_{12} \times \sigma (T_1^4 - T_2^4)}$

Definition of radiative resistances

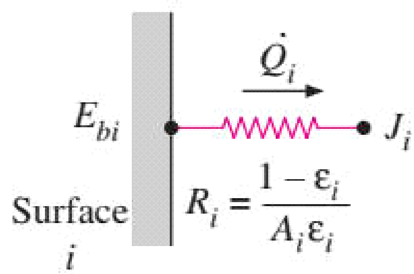
The radiation resistance is part of the feed point resistance of an antenna. The radiation resistance is caused by the radiation of the electromagnetic waves of the antenna; in contrast, the loss resistance usually causes the temperature of the antenna to rise. The radiation resistance and the loss resistance add up to the resistance of the antenna.

Radiosity: radiation leaving a surface

$j_i = (Radiation\ emitted\ by\ surface\ i) + (Radiation\ reflected\ by\ surface\ i) = \varepsilon_i E_{bi} + \rho_i G_i$
$= \varepsilon_i E_{bi} + (1 - \varepsilon_i) G_i \quad (W/m^2)$

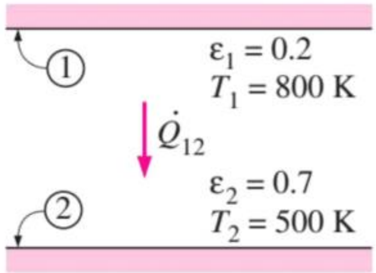
Radiosity of a blackbody: $J_i = E_{bi} = \sigma T^4$

$\dot{Q}_i = \frac{E_{bi} - J_i}{R_i} \qquad R_i = \frac{1 - \varepsilon_i}{A_i \varepsilon_i}$



Task2

Find the net radiative heat exchange between the surface 1 and 2 where $A_1 = 1.5m^2$, $\boldsymbol{\varepsilon_1 = 0.1}$, $\boldsymbol{\varepsilon_2 = 0.1}$, $T_1 = 800K$, $T_2 = 500K$, $\sigma = \mathbf{5.67 \times 10^{-8} W/m^2 \cdot K^4}$. (PREVIOUS $\boldsymbol{\varepsilon_1 = 0.2}$, $\boldsymbol{\varepsilon_2 = 0.7}$)

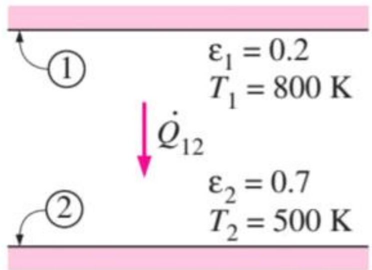


When

$\varepsilon_1 = 0.2, \qquad \varepsilon_2 = 0.7$

$$\dot{Q}_{net2\to1} = \frac{A\sigma\left(T_2^4 - T_1^4\right)}{\frac{1}{\varepsilon_2} + \frac{1}{\varepsilon_1} - 1}$$

$$= \frac{1.5 \times \left(5.67 \times 10^{-8}\right) \times \left(500^4 - 800^4\right)}{\frac{1}{0.2} + \frac{1}{0.7} - 1} \approx 3625.41\, W$$



When

$\varepsilon_1 = \varepsilon_2 = 0.1$

$$\dot{Q}_{net2\to1} = \frac{A\sigma\left(T_2^4 - T_1^4\right)}{\frac{1}{\varepsilon_2} + \frac{1}{\varepsilon_1} - 1}$$

$$= \frac{1.5 \times \left(5.67 \times 10^{-8}\right) \times \left(500^4 - 800^4\right)}{\frac{1}{0.1} + \frac{1}{0.1} - 1} \approx 1035.81\, W$$

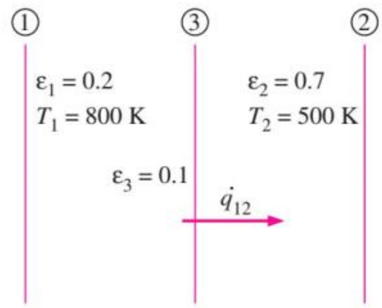
CONCLUSION

If the two surfaces have lower emissivity value, the radiation heat transfer between the surfaces decreases considerably.

WEEK 6_ZHU CUILING

TASK 1

Considering the same example 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 ?



$$q_{net1\to 2} = \frac{\dot{Q}_{net2\to 1}}{A} = \frac{A\sigma\left(T_2^4 - T_1^4\right)}{\frac{1}{\varepsilon_1}+\frac{1}{\varepsilon_2}-1} \div A = \frac{\sigma\left(T_2^4 - T_1^4\right)}{\frac{1}{\varepsilon_1}+\frac{1}{\varepsilon_2}-1}$$

$$= \frac{1.5\times\left(5.67\times 10^{-8}\right)\times\left(500^4 - 800^4\right)}{\frac{1}{0.2}+\frac{1}{0.7}-1} \approx 3625.41\, W$$

The new heat transfer rate should be 1%of the $q_{net1\to 2}$,

$$q'_{net1\to 2} = \frac{1}{100} q_{net1\to 2}$$

$$= \frac{\sigma\left(T_2^4 - T_1^4\right)}{\left(\frac{1}{\varepsilon_1}+\frac{1}{\varepsilon_2}-1\right) + N\cdot\left(\frac{1}{\varepsilon_1}+\frac{1}{\varepsilon_2}-1\right)} = \frac{1}{100}\times\frac{\sigma\left(T_2^4 - T_1^4\right)}{\frac{1}{\varepsilon_1}+\frac{1}{\varepsilon_2}-1}$$

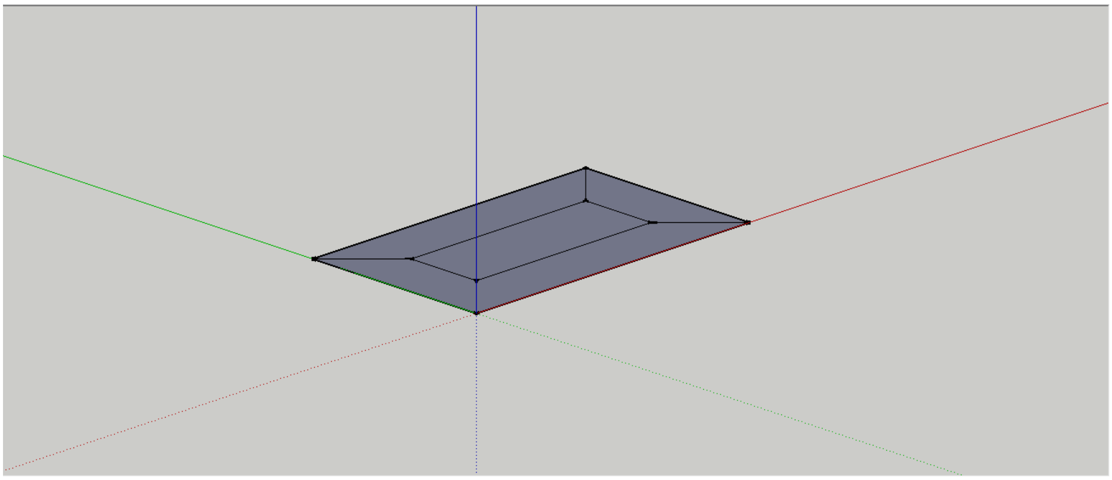
$$\to \quad 100\times\left(\frac{1}{\varepsilon_1}+\frac{1}{\varepsilon_2}-1\right) = \left(\frac{1}{\varepsilon_1}+\frac{1}{\varepsilon_2}-1\right) + N\cdot\left(\frac{1}{\varepsilon_1}+\frac{1}{\varepsilon_2}-1\right)$$

$$\to \quad 99\times\left(\frac{1}{\varepsilon_1}+\frac{1}{\varepsilon_2}-1\right) = N\cdot\left(\frac{1}{\varepsilon_1}+\frac{1}{\varepsilon_2}-1\right)$$

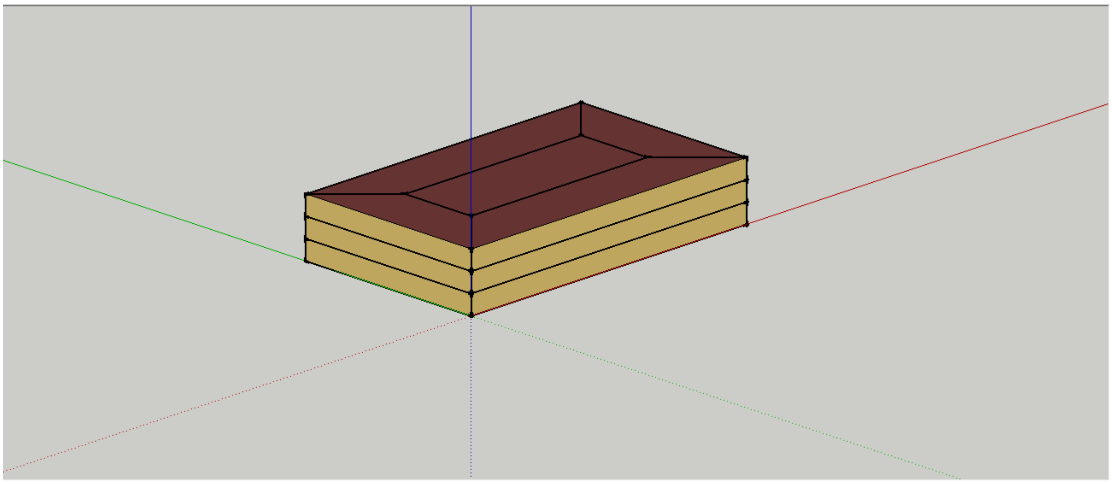
$$\to \quad N = 28$$

So we need 28 shields which $\varepsilon = 0.1$ for the new heat transfer rate be 1% of the previous rate without any shields.

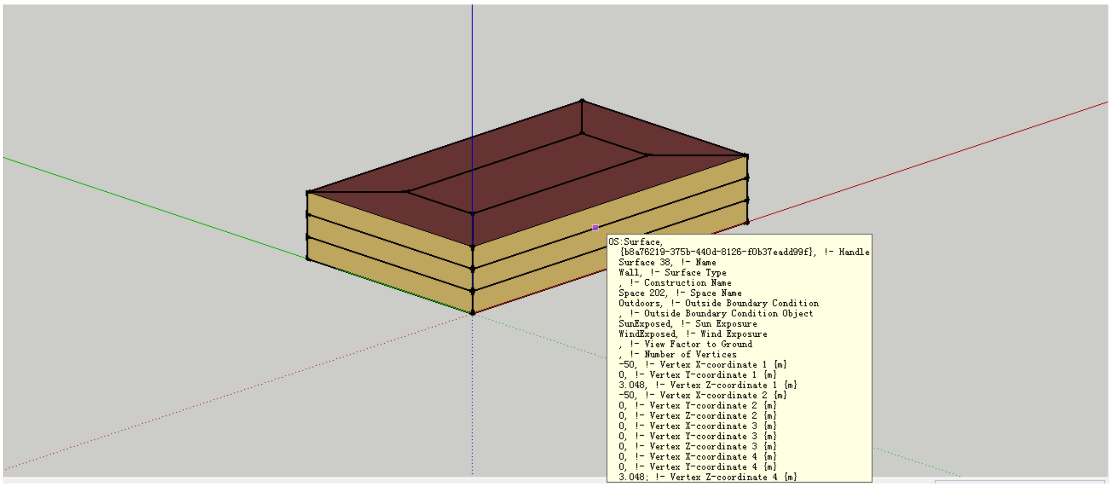
1. Draw the outline and shape of the building in Sketchup.



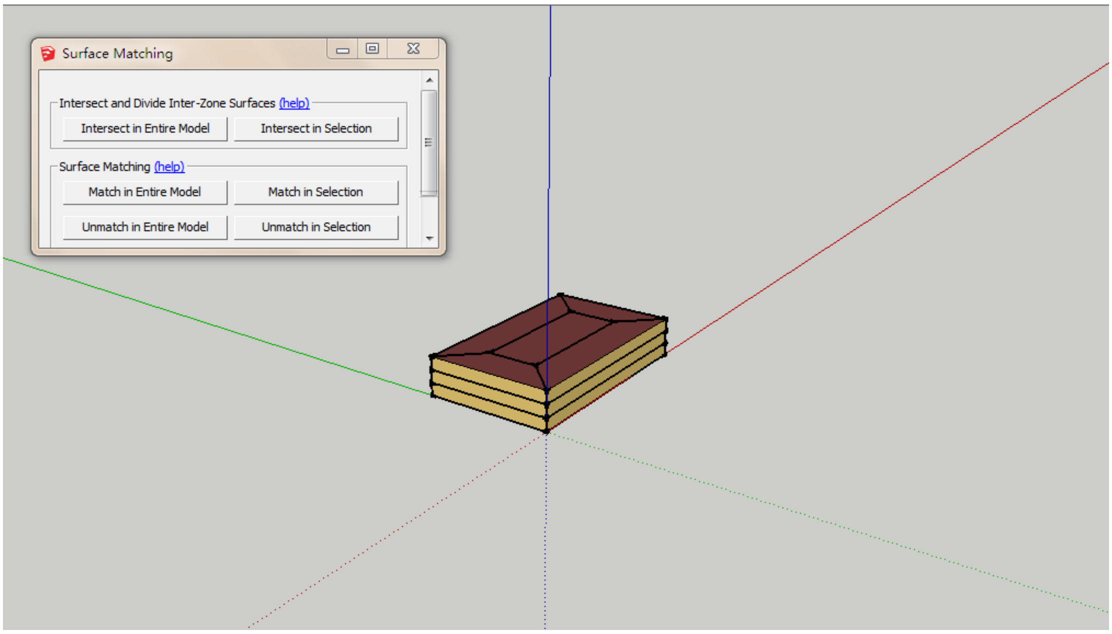
2. Use “Creat spaces from diagram”creat a 3 floor building.



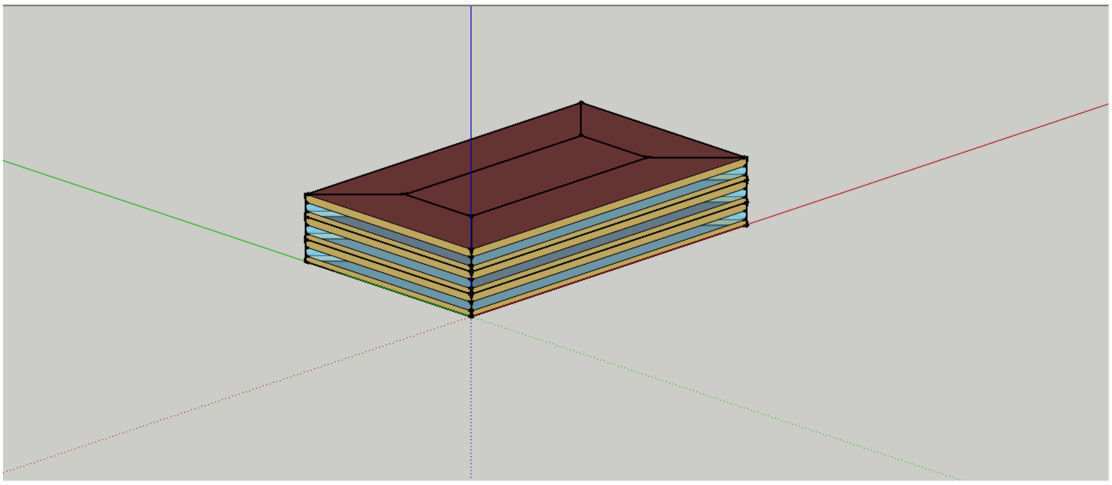
3. We can see the material information using the "Info tool".



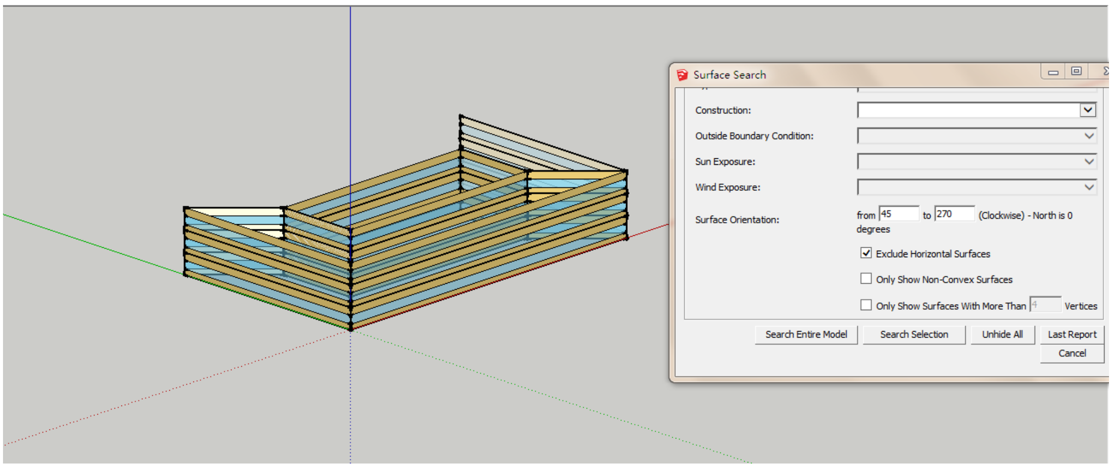
4. Click”Surface matching”.



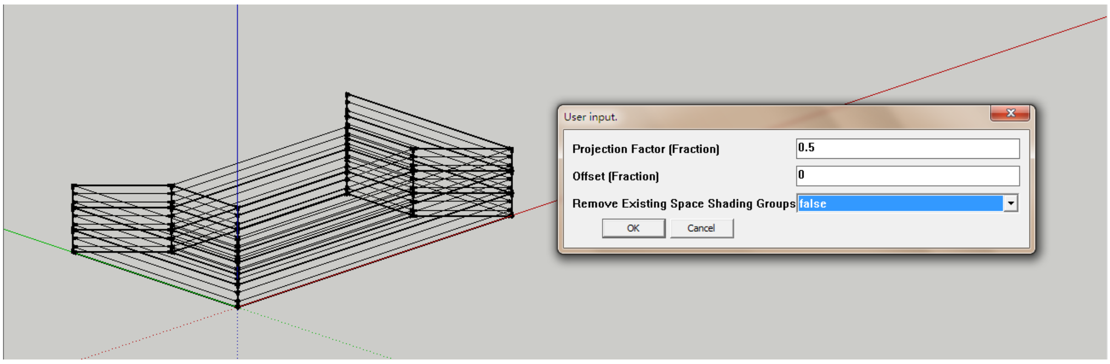
5. Click “Extensions-OpenStudio User Scripts-Alter or Add Model Elements- Set Window to Wall Ratio” to built the windows.

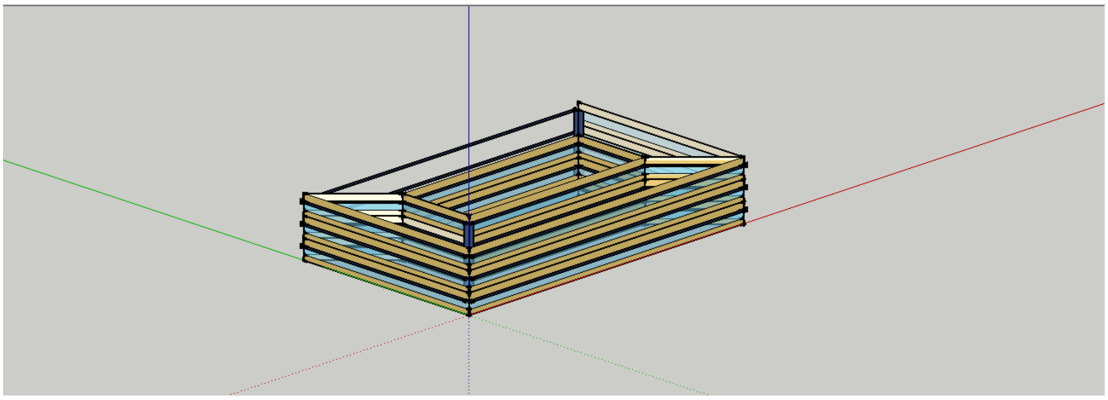


6. Check other directions besides the north.

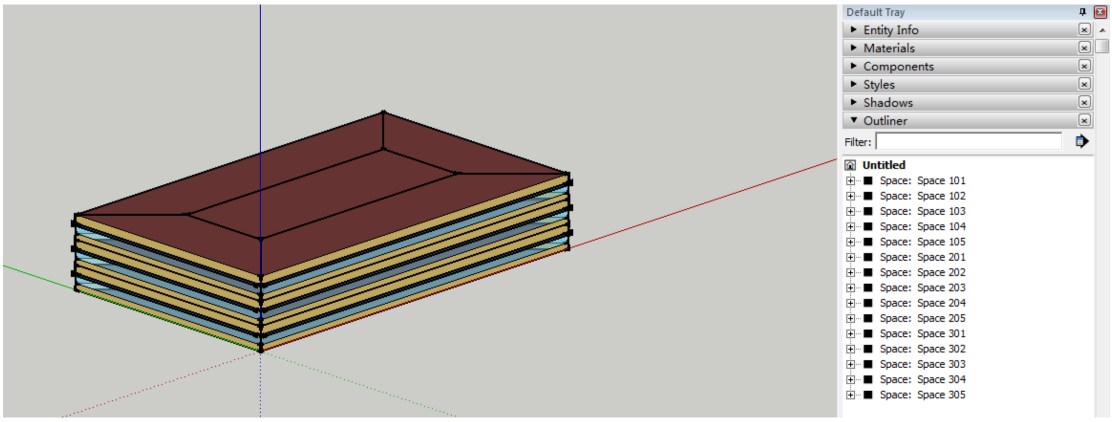


7.Click “Extensions-OpenStudio User Scripts-Alter or Add Model Elements Add Overhanges by Projection Factor” to built overhangs.

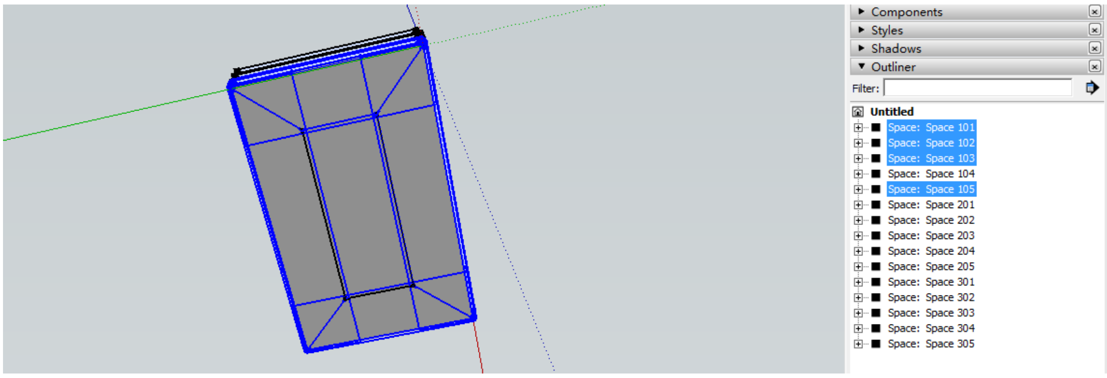


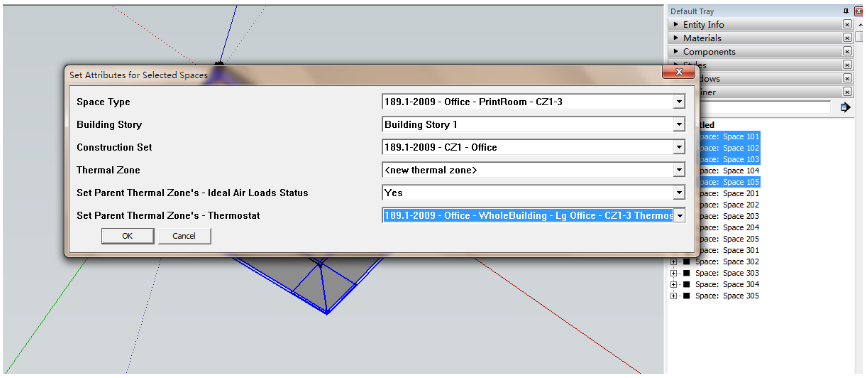


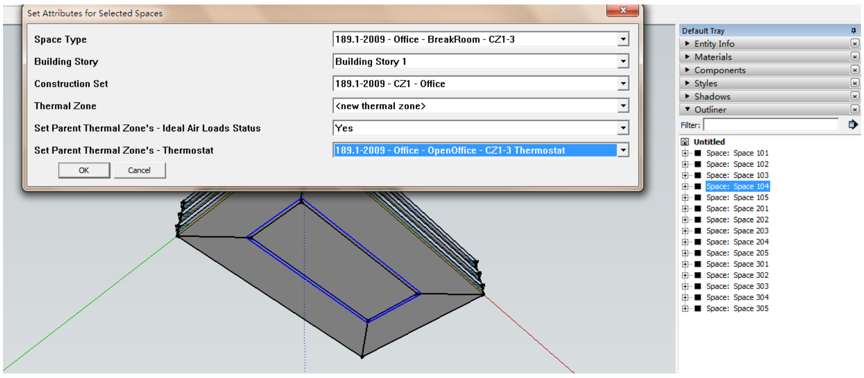
8. Open the “Window-Default Tray-Outliner”

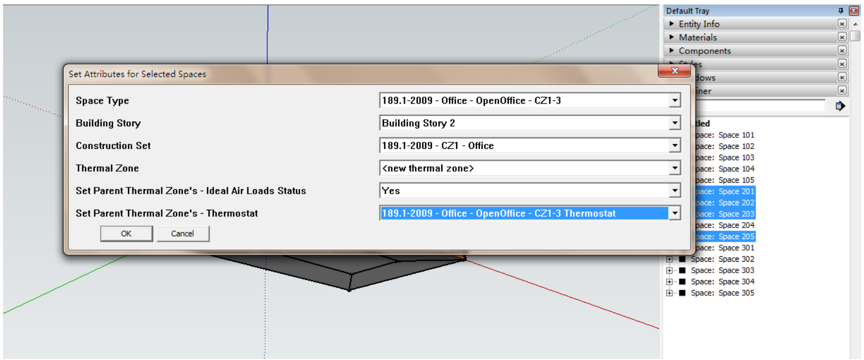


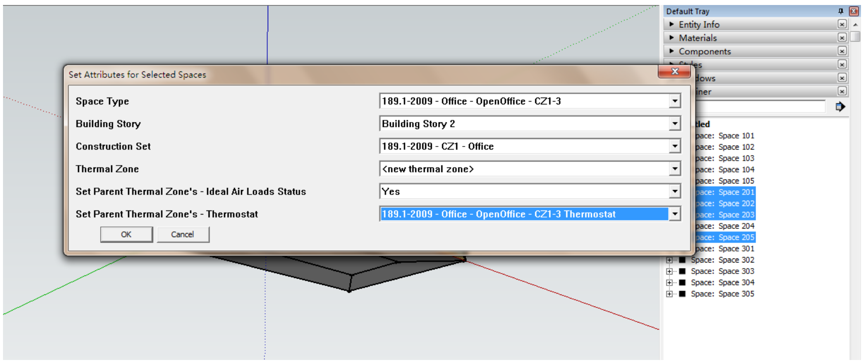
9. Choose the space of each thermal zone.

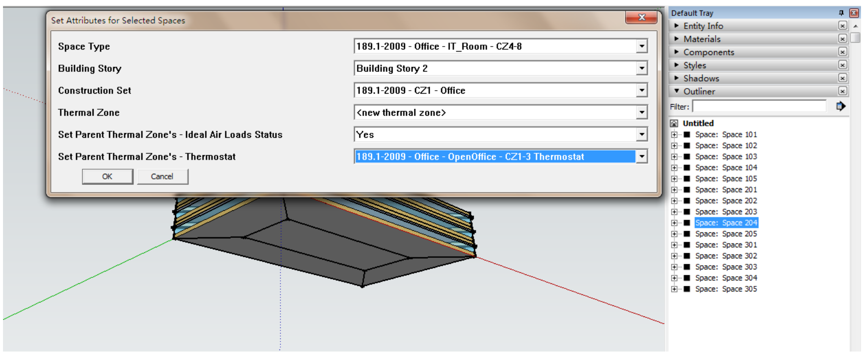



Set Attributes for Selected Spaces
Space Type
189.1-2009 - Office - PrintRoom - CZ1-3
Building Story
Building Story 1
Construction Set
189.1-2009 - CZ1 - Office
Thermal Zone
<new thermal zone>
Set Parent Thermal Zone's - Ideal Air Loads Status
Yes
Set Parent Thermal Zone's - Thermostat
189.1-2009 - Office - WholeBuilding - Lg Office - CZ1-3 Thermos
OK
Cancel
Default Tray
Entity Info
Materials
Components

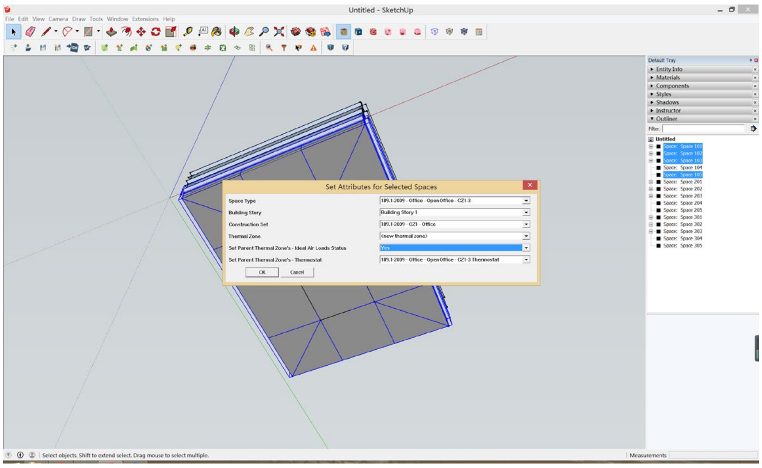

Set Attributes for Selected Spaces
Space Type
189.1-2009 - Office - BreakRoom - CZ1-3
Building Story
Building Story 1
Construction Set
189.1-2009 - CZ1 - Office
Thermal Zone
<new thermal zone>
Set Parent Thermal Zone's - Ideal Air Loads Status
Yes
Set Parent Thermal Zone's - Thermostat
189.1-2009 - Office - OpenOffice - CZ1-3 Thermostat
OK
Cancel
Default Tray
Entity Info
Materials
Components
Styles
Shadows
Outliner
Filter:
Untitled
Space: Space 101
Space: Space 102
Space: Space 103
Space: Space 104
Space: Space 105
Space: Space 201
Space: Space 202
Space: Space 203
Space: Space 204
Space: Space 205
Space: Space 301
Space: Space 302
Space: Space 303
Space: Space 304
Space: Space 305

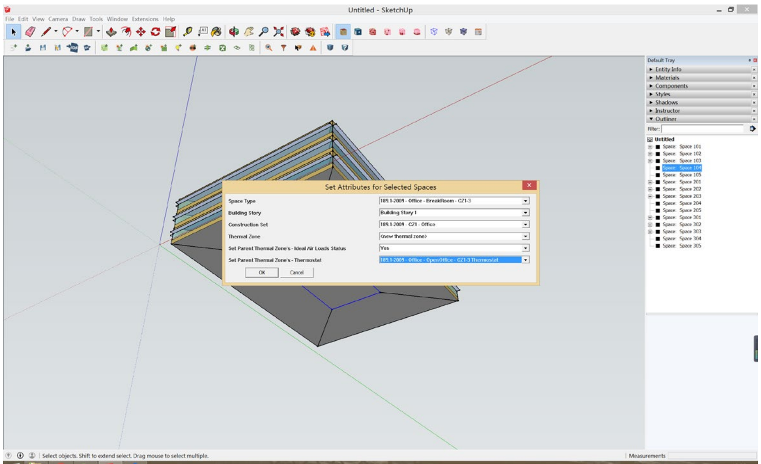

Set Attributes for Selected Spaces
Space Type
189.1-2009 - Office - OpenOffice - CZ1-3
Building Story
Building Story 2
Construction Set
189.1-2009 - CZ1 - Office
Thermal Zone
<new thermal zone>
Set Parent Thermal Zone's - Ideal Air Loads Status
Yes
Set Parent Thermal Zone's - Thermostat
189.1-2009 - Office - OpenOffice - CZ1-3 Thermostat
OK
Cancel
Default Tray
Entity Info
Materials
Components

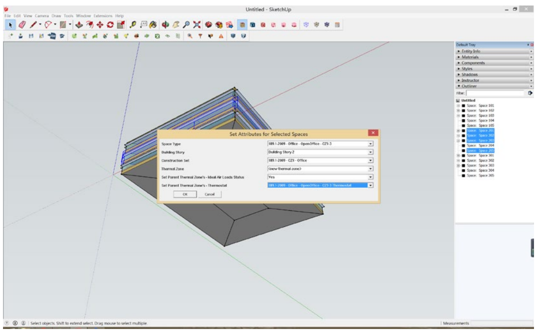

Set Attributes for Selected Spaces
Space Type
189.1-2009 - Office - OpenOffice - CZ1-3
Building Story
Building Story 2
Construction Set
189.1-2009 - CZ1 - Office
Thermal Zone
<new thermal zone>
Set Parent Thermal Zone's - Ideal Air Loads Status
Yes
Set Parent Thermal Zone's - Thermostat
189.1-2009 - Office - OpenOffice - CZ1-3 Thermostat
OK
Cancel
Default Tray
Entity Info
Materials
Components

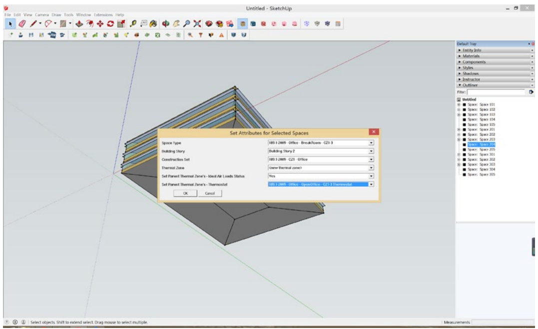

Set Attributes for Selected Spaces
Space Type
189.1-2009 - Office - IT_Room - CZ4-8
Building Story
Building Story 2
Construction Set
189.1-2009 - CZ1 - Office
Thermal Zone
<new thermal zone>
Set Parent Thermal Zone's - Ideal Air Loads Status
Yes
Set Parent Thermal Zone's - Thermostat
189.1-2009 - Office - OpenOffice - CZ1-3 Thermostat
OK
Cancel
Default Tray
Entity Info
Materials
Components
Styles
Shadows
Outliner
Filter:
Untitled
Space: Space 101
Space: Space 102
Space: Space 103
Space: Space 104
Space: Space 105
Space: Space 201
Space: Space 202
Space: Space 203
Space: Space 204
Space: Space 205
Space: Space 301
Space: Space 302
Space: Space 303
Space: Space 304
Space: Space 305

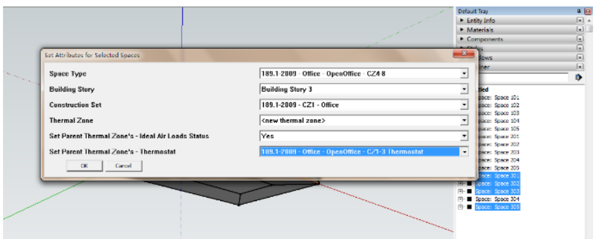
10. Click “Set Attributes for Selected Space” to set parameters.

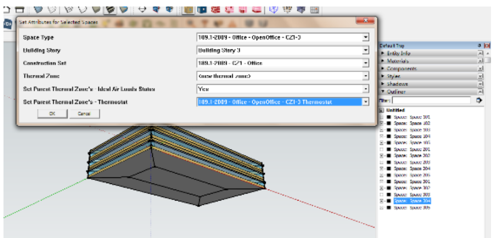




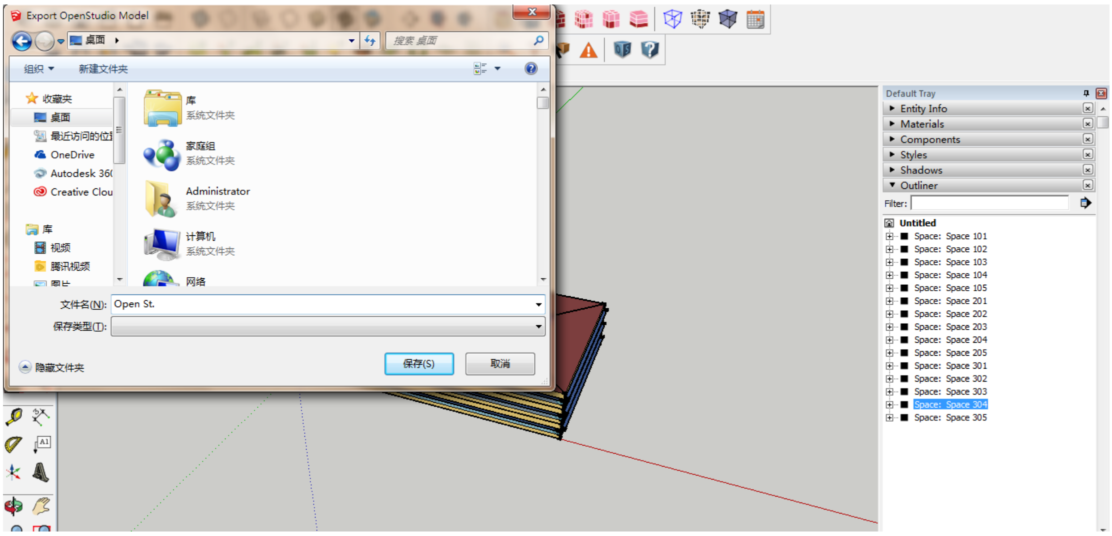




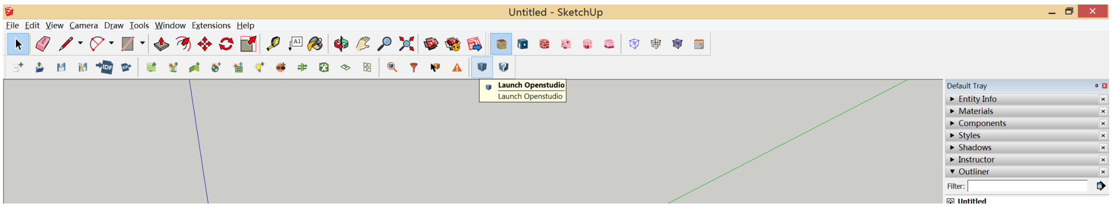




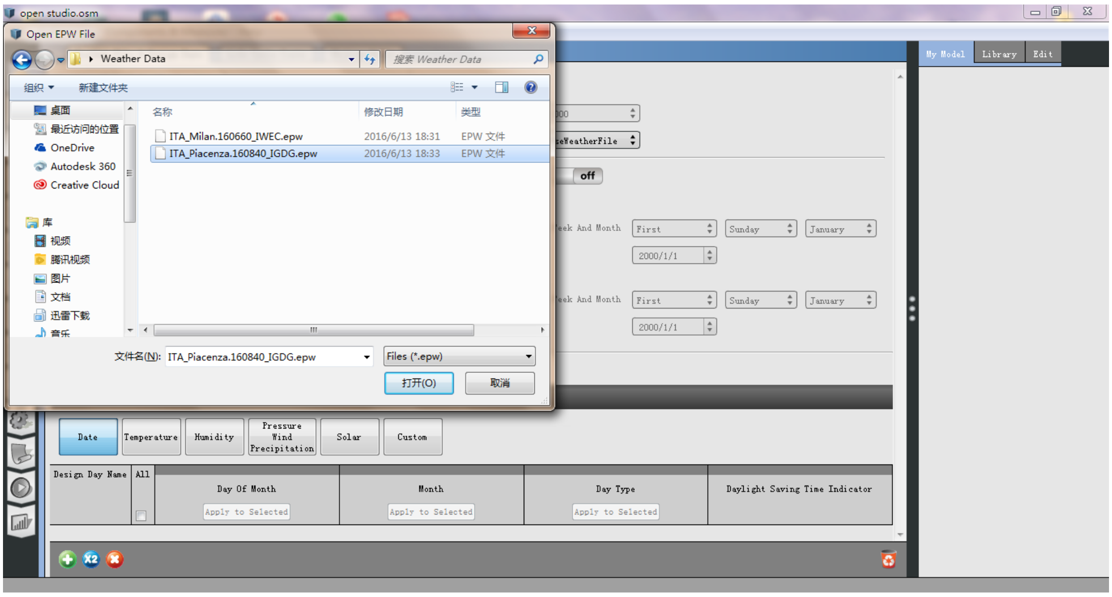
11. Save the model.



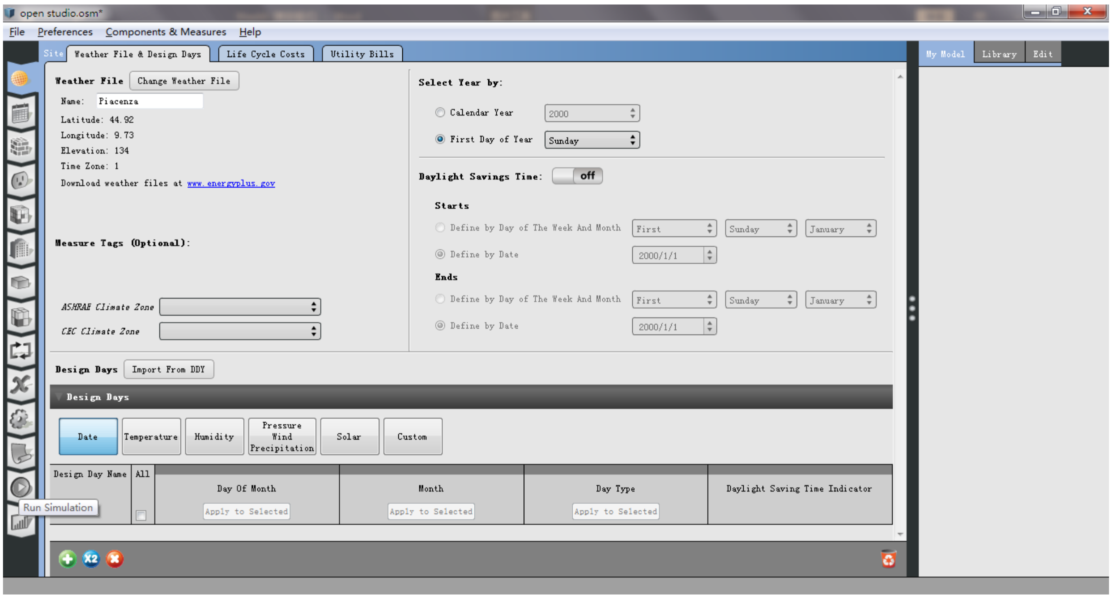
12. Run the “Launch Openstudio”.

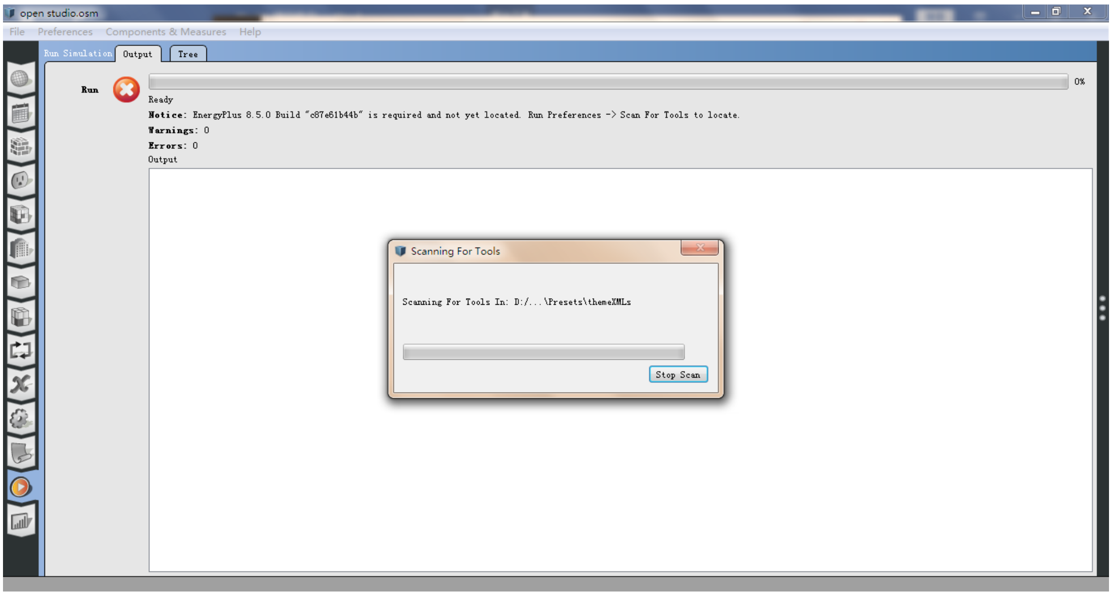


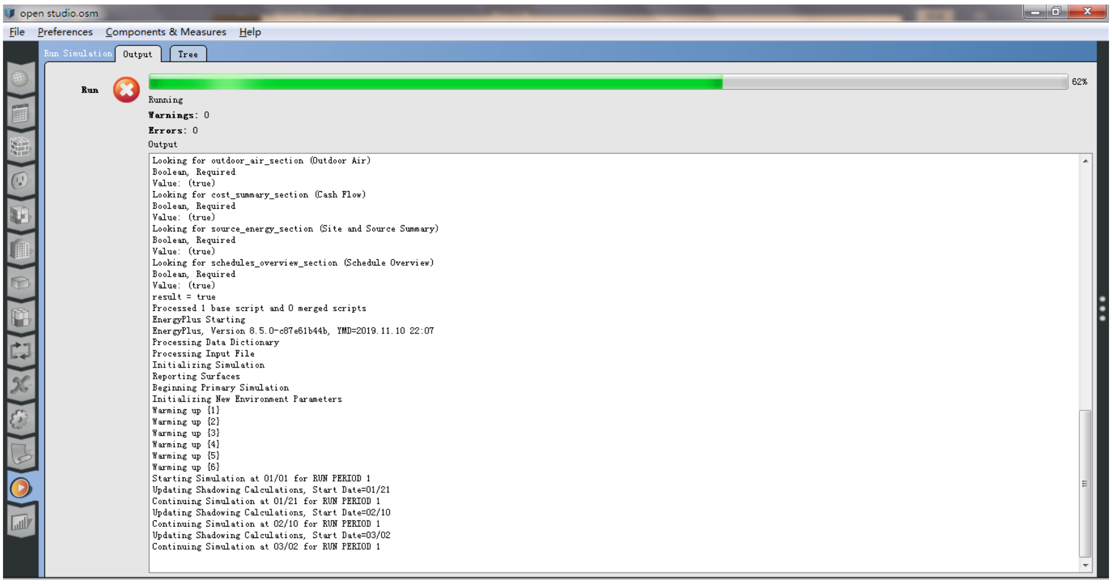
13. Add the weather data.

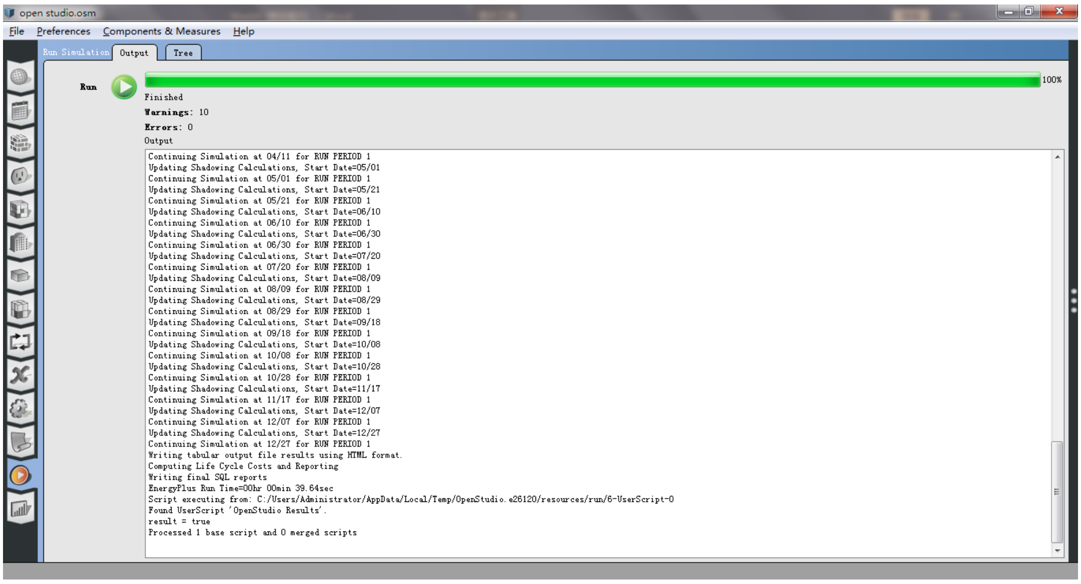


14. Click the “Run Simulation”.

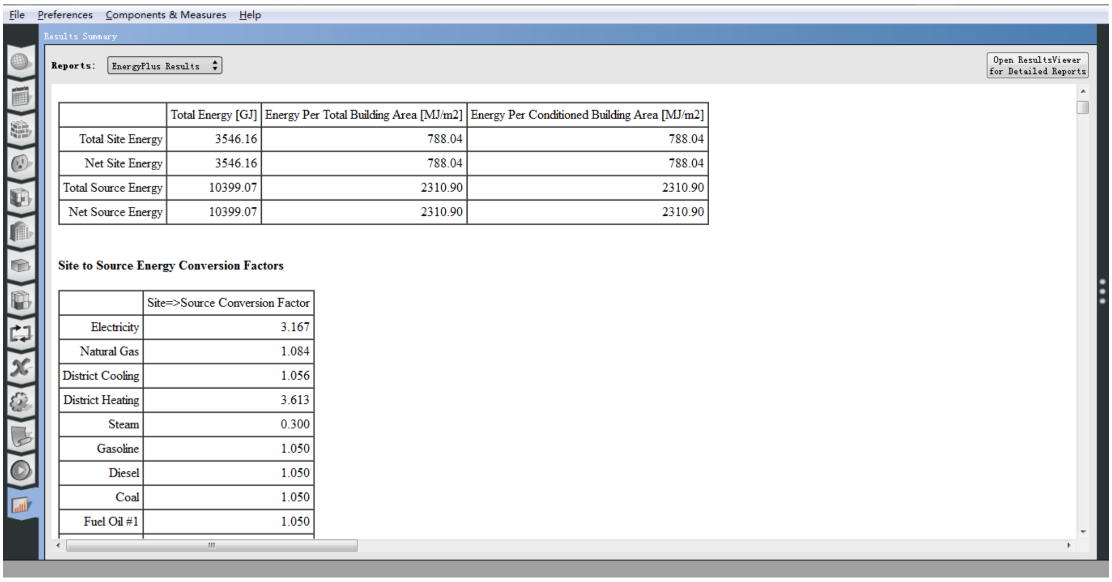

open studio.osm*
File Preferences Components & Measures Help
Site
Weather File & Design Days
Life Cycle Costs
Utility Bills
My Model
Library
Edit
Weather File
Change Weather File
Name: Piacenza
Latitude: 44.92
Longitude: 9.73
Elevation: 134
Time Zone: 1
Download weather files at www.energyplus.gov
Measure Tags (Optional):
ASHRAE Climate Zone
CEC Climate Zone
Select Year by:
Calendar Year
2000
First Day of Year
Sunday
Daylight Savings Time:
off
Starts
Define by Day of The Week And Month
First
Sunday
January
Define by Date
2000/1/1
Ends
Define by Day of The Week And Month
First
Sunday
January
Define by Date
2000/1/1
Design Days
Import From DDY
Design Days
Date
Temperature
Humidity
Pressure Wind Precipitation
Solar
Custom
Design Day Name
All
Day Of Month
Month
Day Type
Daylight Saving Time Indicator
Apply to Selected
Apply to Selected
Apply to Selected
Run Simulation

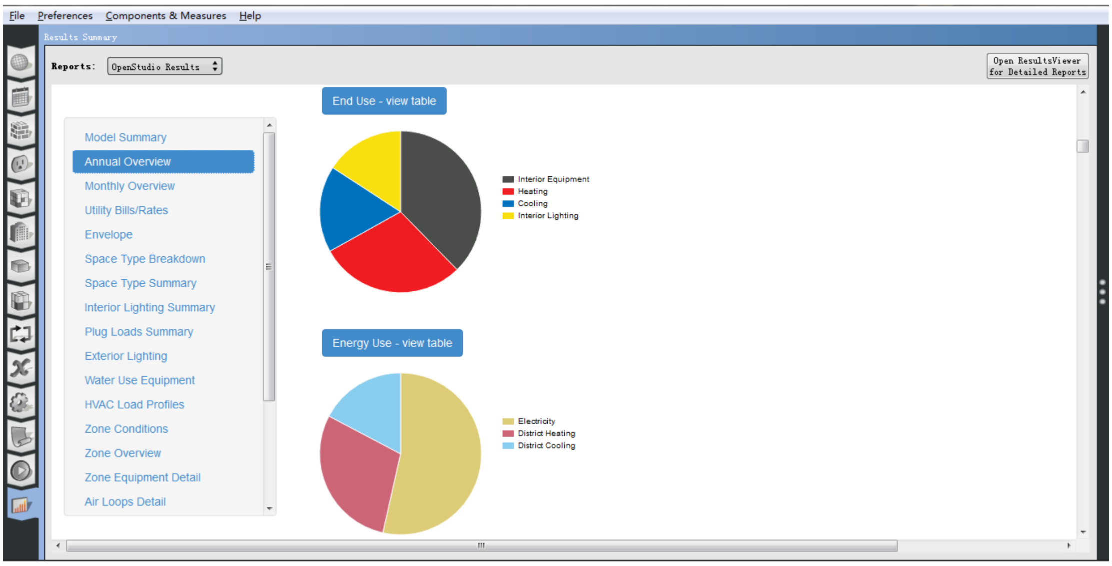

open studio.osm
File Preferences Components & Measures Help
Run Simulation
Output
Tree
Run
0%
Ready
Notice: EnergyPlus 8.5.0 Build "c87e61b44b" is required and not yet located. Run Preferences -> Scan For Tools to locate.
Warnings: 0
Errors: 0
Output
Scanning For Tools
Scanning For Tools In: D:/...\Presets\themeXMLs
Stop Scan

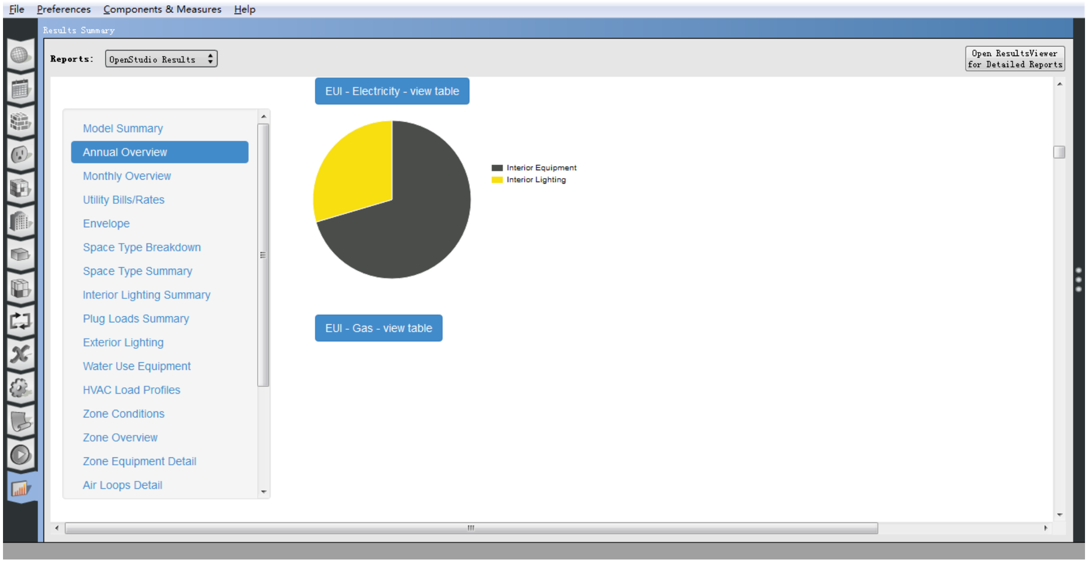

open studio.osm
File Preferences Components & Measures Help
Run Simulation
Output
Tree
Run
62%
Running
Warnings: 0
Errors: 0
Output
Looking for outdoor_air_section (Outdoor Air)
Boolean, Required
Value: (true)
Looking for cost_summary_section (Cash Flow)
Boolean, Required
Value: (true)
Looking for source_energy_section (Site and Source Summary)
Boolean, Required
Value: (true)
Looking for schedules_overview_section (Schedule Overview)
Boolean, Required
Value: (true)
result = true
Processed 1 base script and 0 merged scripts
EnergyPlus Starting
EnergyPlus, Version 8.5.0-c87e61b44b, YMD=2019.11.10 22:07
Processing Data Dictionary
Processing Input File
Initializing Simulation
Reporting Surfaces
Beginning Primary Simulation
Initializing New Environment Parameters
Warming up {1}
Warming up {2}
Warming up {3}
Warming up {4}
Warming up {5}
Warming 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=02/10
Continuing Simulation at 02/10 for RUN PERIOD 1
Updating Shadowing Calculations, Start Date=03/02
Continuing Simulation at 03/02 for RUN PERIOD 1



15. Show the result.






File
Preferences
Components & Measures
Help
Results Summary
Reports:
OpenStudio Results
Open ResultsViewer 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
EUI - Electricity - view table
Interior Equipment
Interior Lighting
EUI - Gas - view table

WEEK 7_ZHU CUILING

Task 1

Provide a summary of the main concepts that went through about solar radiation (formulas are not needed)

Solar radiation is the fact that the sun transmits energy in the form of electromagnetic waves, which refers to the electromagnetic waves and particle flows emitted by the sun into space.

Since the wavelength of solar radiation is much smaller than the wavelength of the ground and atmospheric radiation (about 3 to 120 microns), it is often called **solar radiation** as **short-wave radiation**, and the **ground and atmospheric radiation** is called **long-wave radiation**.

Solar radiation passes through the atmosphere, **part of which reaches the ground**, called **direct solar radiation**; the other part is the absorption, scattering and reflection of molecules in the atmosphere, dust in the atmosphere, and water vapor. Part of the scattered solar radiation **returns to space** and another **part reaches the ground**. This part of the ground is called **scattered solar radiation**. The **sum** of scattered solar radiation and direct solar radiation reaching the ground is called **total radiation**.

The physical quantity indicating the strength of solar radiation is called the solar radiation intensity. $J/cm^2 \cdot min$ is the unit, which is the solar radiation energy that is projected perpendicularly to the unit area per unit time. The intensity of solar radiation at the upper boundary of the atmosphere depends on the altitude angle of the sun, the distance between the sun and the earth, and the time of sunshine. The greater the solar elevation angle, the greater the solar radiation intensity. Because of the same beam of light, the direct irradiation area is the smallest, and the solar radiation per unit area is increased. Conversely, when the oblique beam is irradiated, the irradiation area is large, and the solar radiation per unit area is small.

Solar radiation intensity refers to the intensity of solar radiation reaching the ground. The main factors affecting the strength of solar radiation are:

1. Latitude position

2. weather

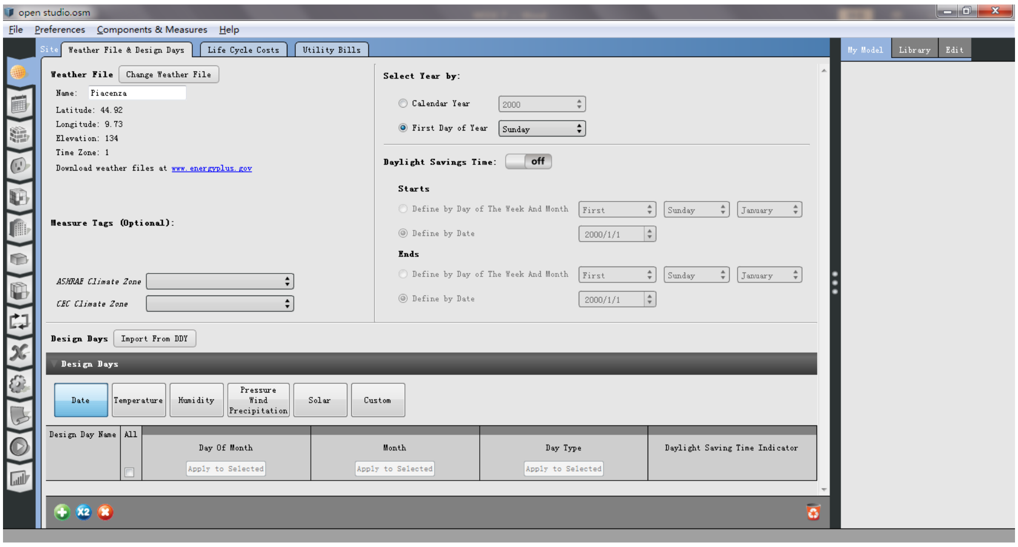
3. Altitude

4. Length of sunshine

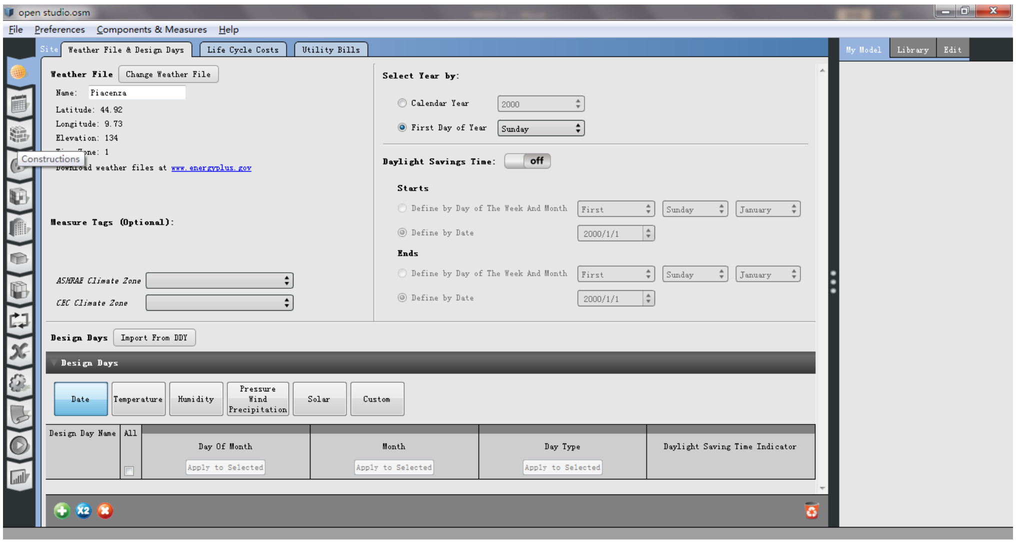
Task 2

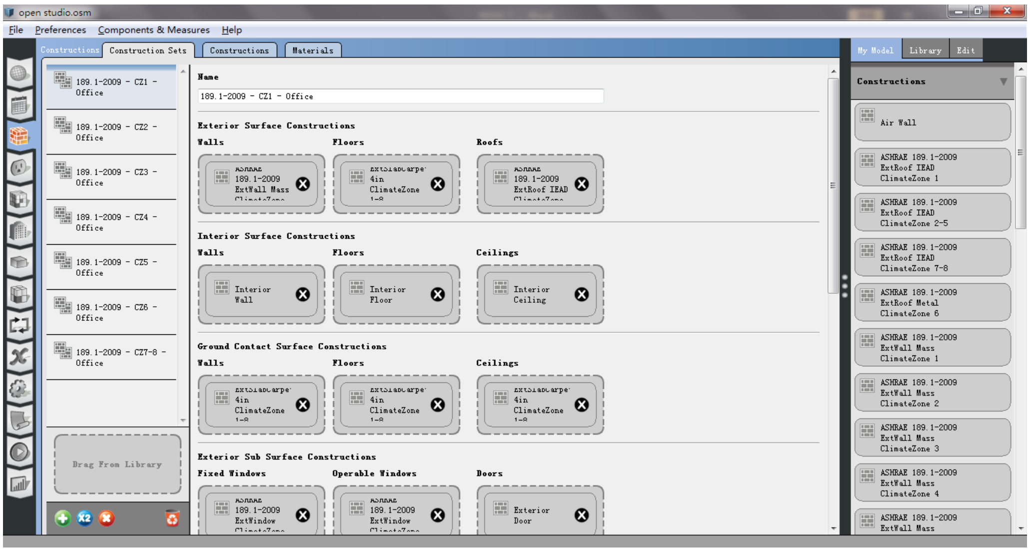
Create a pdf file with screenshots of all of the steps we went through in the second lesson on openStudio and explain briefly the reason behind the use of each step.

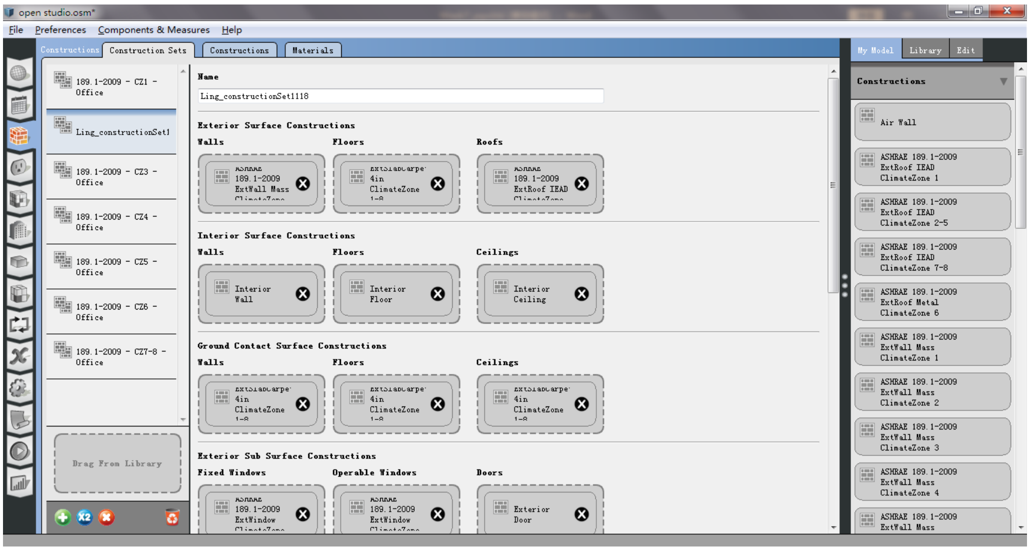
1. Click the “Weather File” to add the weather data of Piacenza in OpenOffice.



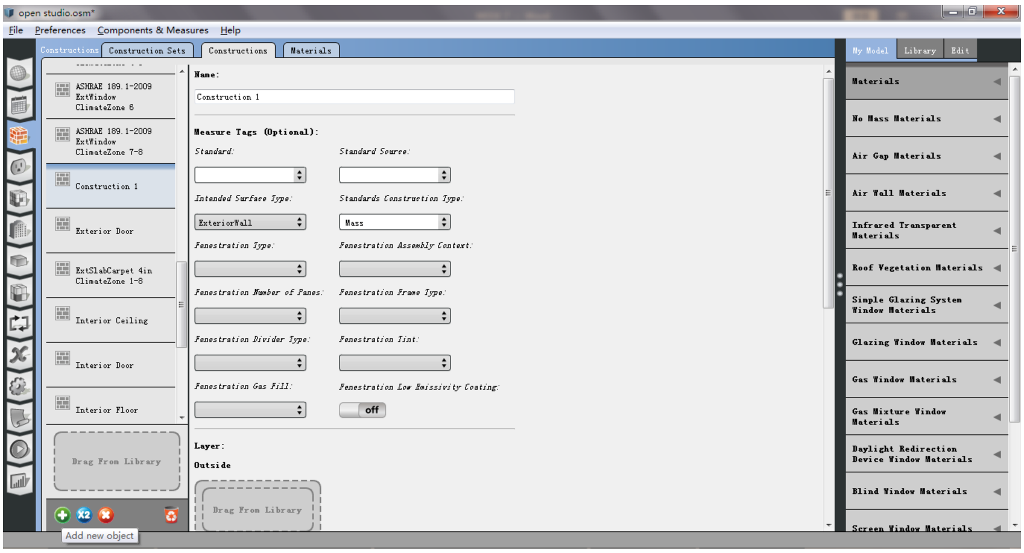
2. Click the “construction”, start customize the building, renaming it.

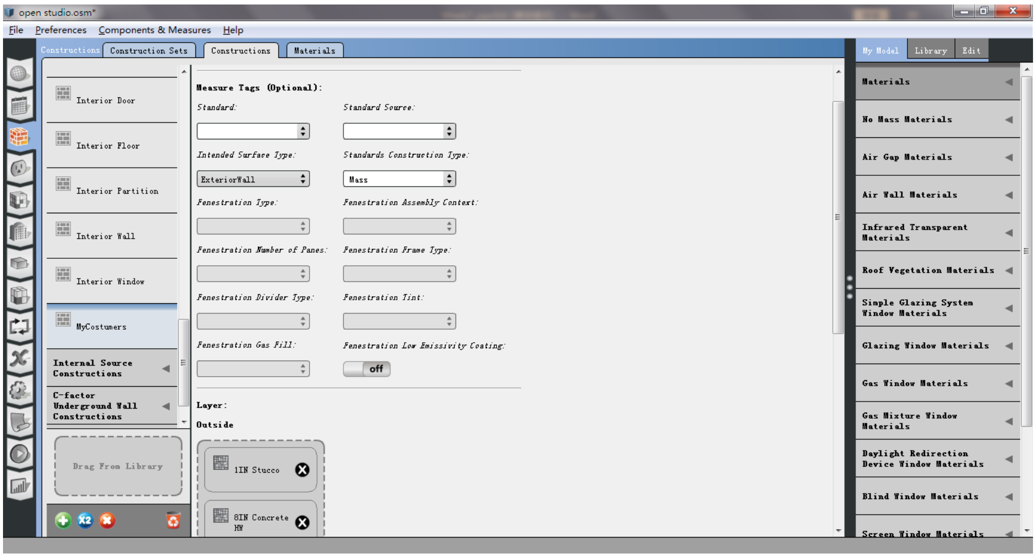




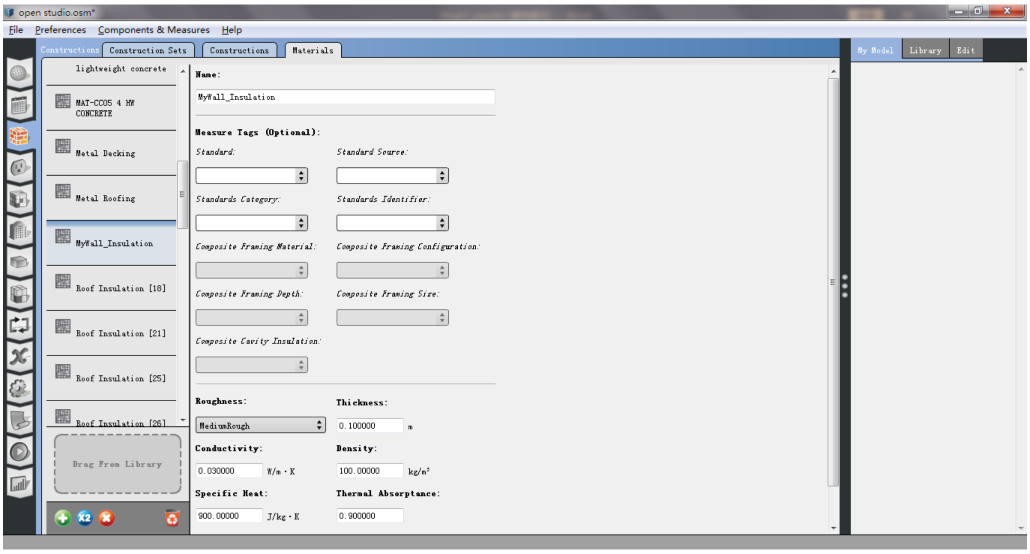


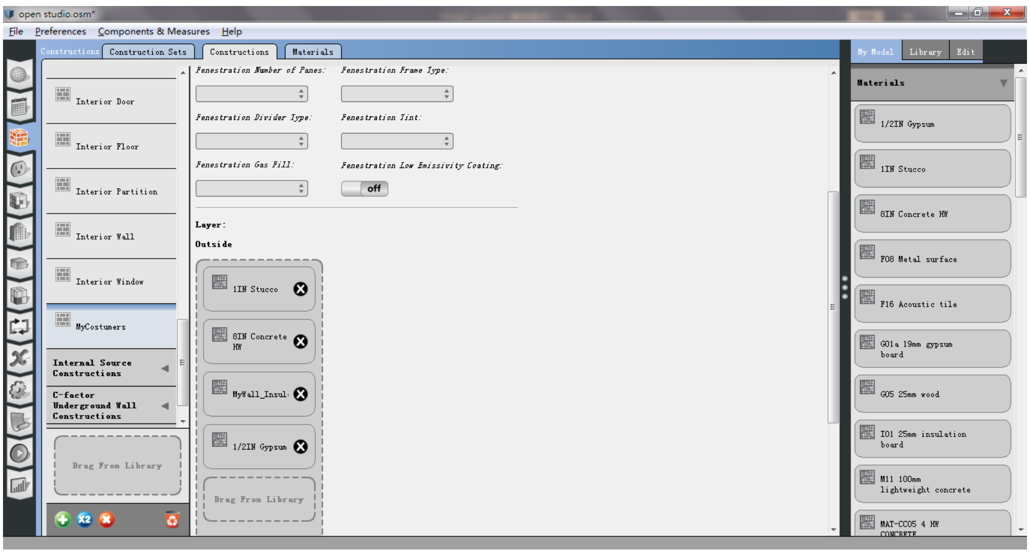
3. Click “construction” to add a new project and start customizing the wall package in the “construction sets” window.



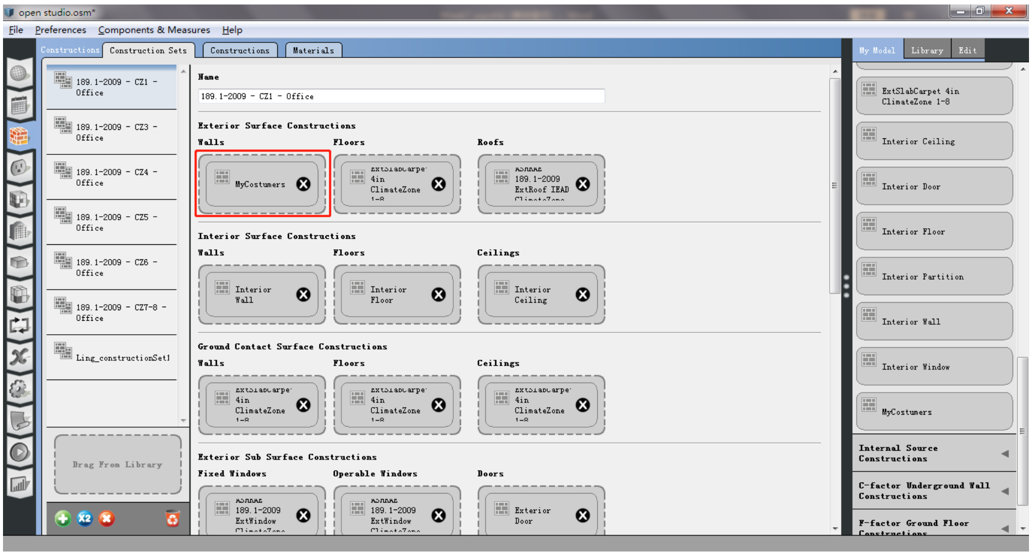


4. Click “Material” to add a new material and decide the type of wall insulation and insert it later in the package.

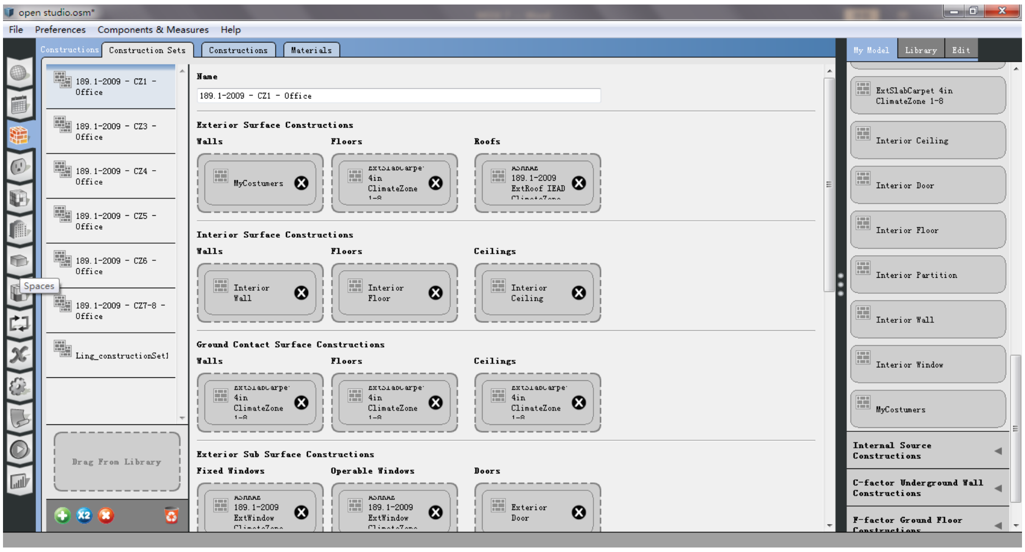


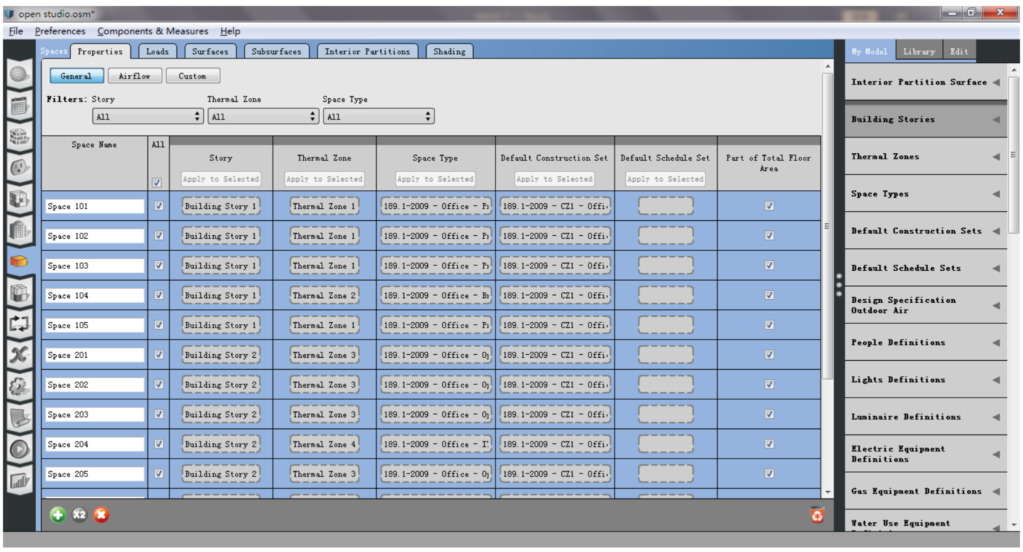


5. Insert the wall in the building data.

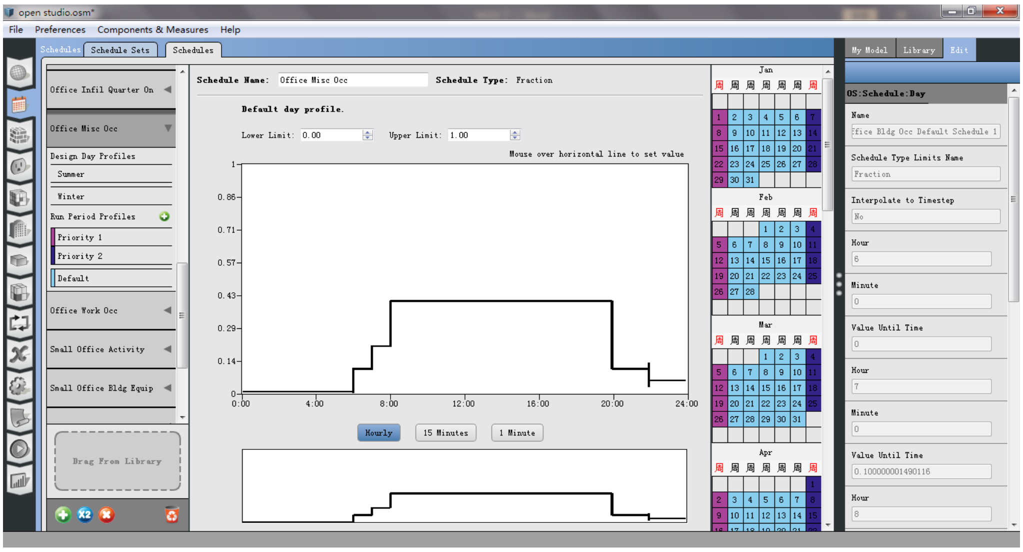


6. Click “space” window and insert the project layer with our modifications applying it to the whole building.

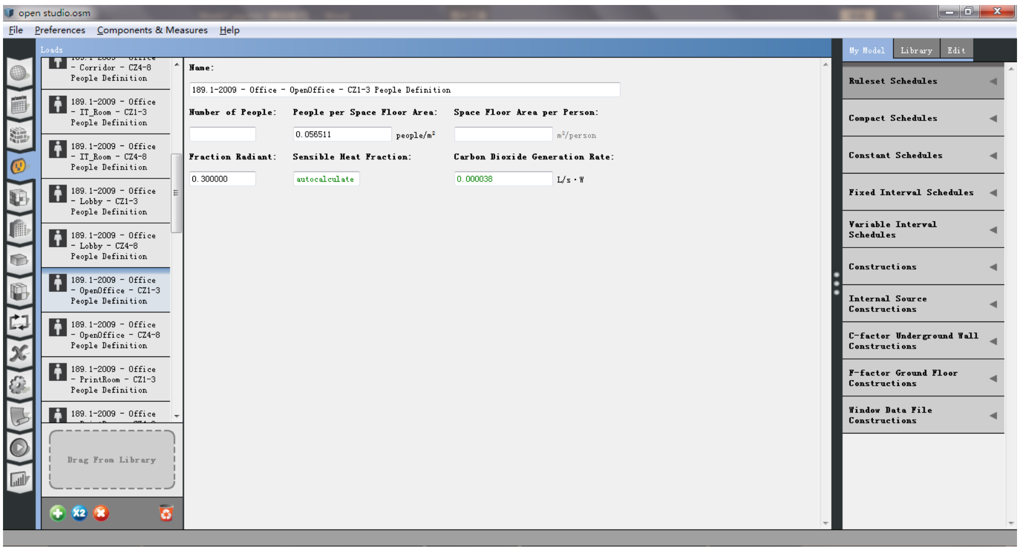


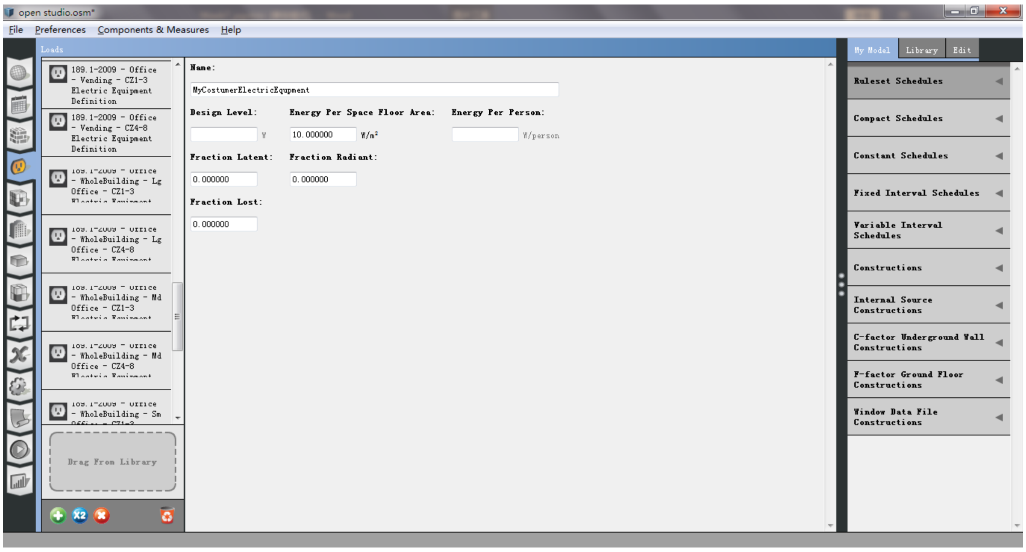


7. Return to “schedule sets” to enter all the information relating to activities, equipments, etc and their schedules.



8. Click the “loads” command to change other specifications, like people, light, electricity, etc.

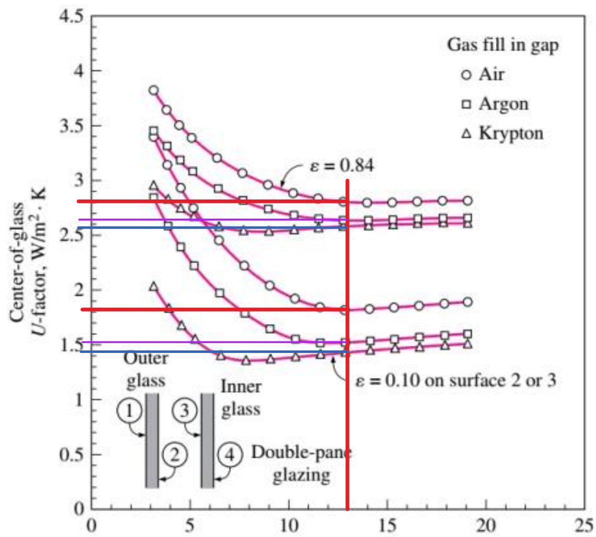


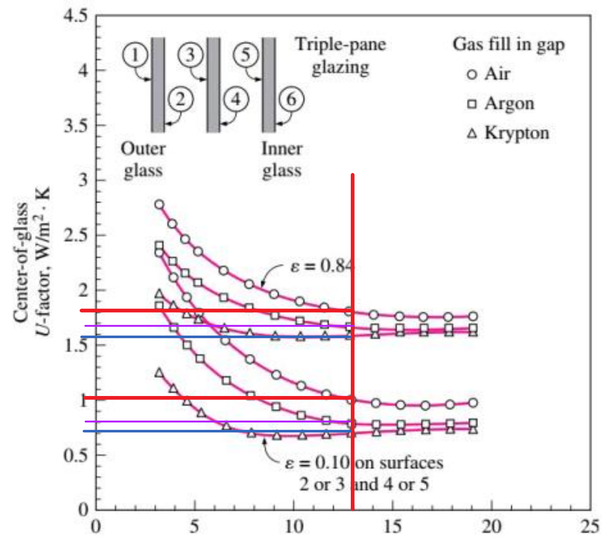

open studio.osm*
File
Preferences
Components & Measures
Help
Loads
189.1-2009 - Office - Vending - CZ1-3 Electric Equipment Definition
189.1-2009 - Office - Vending - CZ4-8 Electric Equipment Definition
Drag From Library
Name:
MyCostumerElectricEquipment
Design Level:
Energy Per Space Floor Area:
Energy Per Person:
10.000000
W/m²
W/person
Fraction Latent:
Fraction Radiant:
0.000000
0.000000
Fraction Lost:
0.000000
My Model
Library
Edit
Ruleset Schedules
Compact Schedules
Constant Schedules
Fixed Interval Schedules
Variable Interval Schedules
Constructions
Internal Source Constructions
C-factor Underground Wall Constructions
F-factor Ground Floor Constructions
Window Data File Constructions

WEEK 8_ZHU CUILING

\Task 1

Using the diagrams given in the presentation calculate how much (%) is the effect of applying different modifications (changing the gas, adding an extra pane, using a low emissivity coating) on the U value with respect to a benchmark case of double layer with air and no coating ? (keep the gap thickenss to be 13 mm)





$$U_{window} = \frac{\ldots amA_{fram}}{A_{window}} = \frac{1}{\frac{1}{h_i} + \frac{1}{h_{space}} + \frac{1}{h_o}}$$

$$h_{space} = h_{rad,space} + h_{conv,space}$$

	Benchmark	Window1	Window2	Window3	Window4
GAP	13mm	13mm	13mm	13mm	13mm
ε	0.84	0.84	0.84	0.84	**0.10**
PANES	2	2	2	**3**	2
GAS	AIR	**ARGON**	**KRYPTON**	AIR	AIR
U_{factor}	$2.8W/m^2 \cdot K$	$2.65W/m^2 \cdot K$	$2.6W/m^2 \cdot K$	$1.8W/m^2 \cdot K$	$1.8W/m^2 \cdot K$
%	100	94.64	92.86	64.29	64.29

1. Changing the gas

So, from the graph is can be see that by comparing the benchmark with the different gas(**ARGON/KRYPTON**), the $U_{factor} - value$ decreases by **5.36%/7.14%**, little improving the thermal transmittance of the window.

2. Adding an extra pane

From the graph is can be see that by comparing the benchmark with the **triple-pane window**, the $U_{factor} - value$ decreases by **35.71%**, more improving the thermal transmittance of the window.

3. Using a low emissivity coating

From the graph is can be see that by comparing the benchmark with **a low emissivity coating**, the $U_{factor} - value$ decreases by **35.71%**, more improving the thermal transmittance of the window.

\Task 2

Consider the house that we analysed in the alst two examples, calculate the heating and cooling load of the other windows which are fixed 14.4 m^2 on the west, fixed 3.6 m^2 on the south and an operable 3.6 m^2 on the south (the same window and frame type). How much does the total value change if I change the frame of the window from wooden one to aluminium ?

PIACENZA
LAT: 44.92 N
LONG: 9.73 E
ELEV :138
T_{summer}: 24°
T_{winter}: 20°
HEATING DB 99%: - 4.8
COOLING DB/MCWB 1%: 31.9
$\Delta T_{COOLING} = 31.9 - 24 = 7.9°C = 7.9K$
$\Delta T_{HEATING} = 20 - (-4.8) = 24.8°C = 24.8K$
EAST SIDE OF THE BUILDING
45° LATITUDE
No internal shading – IAC = 1
$DR = 11.9°C = 11.9K$

Table 10 Peak Irradiance, W/m²

Exposure		Latitude 20°	25°	30°	35°	40°	45°	50°	55°	60°
North	E_D	125	106	92	84	81	85	96	112	136
	E_d	128	115	103	93	84	76	69	62	55
	E_t	253	221	195	177	166	162	164	174	191
Northeast/Northwest	E_D	460	449	437	425	412	399	386	374	361
	E_d	177	169	162	156	151	147	143	140	137
	E_t	637	618	599	581	563	546	529	513	498
East/West	E_D	530	543	552	558	560	559	555	547	537
	E_d	200	196	193	190	189	188	187	187	187
	E_t	730	739	745	748	749	747	742	734	724
Southeast/Southwest	E_D	282	328	369	405	436	463	485	503	517
	E_d	204	203	203	204	205	207	210	212	215
	E_t	485	531	572	609	641	670	695	715	732
South	E_D	0	60	139	214	283	348	408	464	515
	E_d	166	193	196	200	204	209	214	219	225
	E_t	166	253	335	414	487	557	622	683	740
Horizontal	E_D	845	840	827	806	776	738	691	637	574
	E_d	170	170	170	170	170	170	170	170	170
	E_t	1015	1010	997	976	946	908	861	807	744

Table 13 Fenestration Solar Load Factors FF_s

Exposure	Single Family Detached	Multifamily
North	0.44	0.27
Northeast	0.21	0.43
East	0.31	0.56
Southeast	0.37	0.54
South	0.47	0.53
Southwest	0.58	0.61
West	0.56	0.65
Northwest	0.46	0.57
Horizontal	0.58	0.73

Window frame with **wooden**

1- Fixed on west/14.4m^2

COOLING LOAD

$U_{window1,west1} = 2.84W/m^2 \cdot K$

$CF_{window1,west1} = U_{window1,west1}(\Delta T_{COOLING} - 0.46DR)$
$= 2.84 \times (7.9 - 0.46 \times 11.9) \approx 6.89W/m^2$

$PXI_{window1,west2} = E_D + E_d = 559 + 188 = 747$
$SHGC = 0.54$
$FF_S = 0.56$
$CF_{window1,west2} = PXI \times SHGC \times IAC \times FF_S$
$= 747 \times 0.54 \times 1 \times 0.56 \approx 225.89W/m^2$

$CF_{window1,west} = CF_{window1,west1} + CF_{window1,west2} = 6.89 + 225.89 = 232.78W/m^2$

$Q_{window1,west-c} = A \times CF_{window1,west} = 14.4 \times 232.78 \approx 3352.03W$

HEATING LOAD

$Q_{window1,west-h} = A \times HF_{window1,west} = A \times U_{window1,west} \times \Delta T_{HEATING} = 14.4 \times 2.84 \times 24.8 \approx 1014.22W$

2- Fixed on south/3.6m^2

COOLING LOAD

$U_{window2,south1} = 2.84W/m^2 \cdot K$

$CF_{window2,south1} = U_{window2,south1}(\Delta T_{COOLING} - 0.46DR)$
$= 2.84 \times (7.9 - 0.46 \times 11.9) \approx 6.89W/m^2$

$PXI_{window2,south2} = E_D + E_d = 348 + 209 = 557$
$SHGC = 0.54$
$FF_s = 0.47$
$CF_{window2,south2} = PXI \times SHGC \times IAC \times FF_s$
$= 557 \times 0.54 \times 1 \times 0.47 \approx 141.37W/m^2$

$CF_{window2,south} = CF_{window2,south1} + CF_{window2,south2} = 6.89 + 141.37 = 148.26W/m^2$

$Q_{window2,south-c} = A \times CF_{window2,south} = 3.6 \times 148.26 \approx 553.74W$

HEATING LOAD

$Q_{window2,south-h} = A \times HF_{window2,south} = A \times U_{window2,south} \times \Delta T_{HEATING} = 3.6 \times 2.84 \times 24.8 \approx 253.56W$

3- Operable on south/3.6m^2

COOLING LOAD

$U_{window3,south1} = 2.87W/m^2 \cdot K$

$CF_{window3,south1} = U_{window3,south1}(\Delta T_{COOLING} - 0.46DR)$
$= 2.87 \times (7.9 - 0.46 \times 11.9) \approx 6.96W/m^2$

$PXI_{window3,south2} = E_D + E_d = 348 + 209 = 557$
$SHGC = 0.46$
$FF_s = 0.47$
$CF_{window3,south2} = PXI \times SHGC \times IAC \times FF_s$
$= 557 \times 0.46 \times 1 \times 0.47 \approx 120.42W/m^2$

$CF_{window3,south} = CF_{window3,south1} + CF_{window3,south2} = 6.96 + 120.42 = 127.38W/m^2$

$Q_{window3,south-c} = A \times CF_{window3,south} = 3.6 \times 127.38 \approx 458.57W$

HEATING LOAD

$Q_{window3,south-h} = A \times HF_{window3,south} = A \times U_{window3,south} \times \Delta T_{HEATING} = 3.6 \times 2.87 \times 24.8 \approx 256.23W$

$Q_{total-c} = Q_{window1,west-c} + Q_{window2,south-c} + Q_{window3,south-c} = 3352.03 + 553.74 + 458.57 = 4364.34W$
$Q_{total-h} = Q_{window1,west-h} + Q_{window2,south-h} + Q_{window3,south-h} = 1014.22 + 253.56 + 256.23 = 1524.01W$

Window frame with **aluminium**

1- Fixed on west/14.4m^2

COOLING LOAD

$U'_{window1,west1} = 3.61W/m^2 \cdot K$

$CF'_{window1,west1} = U'_{window1,west1}(\Delta T_{COOLING} - 0.46DR)$
$= 3.61 \times (7.9 - 0.46 \times 11.9) \approx 8.76W/m^2$

$PXI_{window1,west2} = E_D + E_d = 559 + 188 = 747$
$SHGC = 0.56$
$FF_s = 0.56$
$CF'_{window1,west2} = PXI \times SHGC \times IAC \times FF_s$
$= 747 \times 0.56 \times 1 \times 0.56 \approx 234.26W/m^2$

$CF'_{window1,west} = CF'_{window1,west1} + CF'_{window1,west2} = 8.76 + 234.26 = 243.02W/m^2$

$Q'_{window1,west-c} = A \times CF'_{window1,west} = 14.4 \times 243.02 \approx 3499.49W$

HEATING LOAD

$Q'_{window1,west-h} = A \times HF'_{window1,west} = A \times U'_{window1,west} \times \Delta T_{HEATING} = 14.4 \times 2.87 \times 24.8 \approx 1289.20W$

2- Fixed on south/3.6m^2

COOLING LOAD

$U'_{window2,south1} = 3.61W/m^2 \cdot K$

$CF'_{window2,south1} = U'_{window2,south1}(\Delta T_{COOLING} - 0.46DR)$
$= 3.61 \times (7.9 - 0.46 \times 11.9) \approx 8.76W/m^2$

$PXI_{window2,south2} = E_D + E_d = 348 + 209 = 557$
$SHGC = 0.56$
$FF_s = 0.47$
$CF'_{window2,south2} = PXI \times SHGC \times IAC \times FF_s$
$= 557 \times 0.56 \times 1 \times 0.47 \approx 146.60W/m^2$

$CF'_{window2,south} = CF'_{window2,south1} + CF'_{window2,south2} = 8.76 + 146.60 = 155.36W/m^2$

$Q'_{window2,south-c} = A \times CF'_{window2,south} = 3.6 \times 155.36 \approx 559.30W$

HEATING LOAD

$Q'_{window2,south-h} = A \times HF'_{window2,south} = A \times U'_{window2,south} \times \Delta T_{HEATING} = 3.6 \times 3.61 \times 24.8 \approx 322.30W$

3- Operable on south/3.6m^2

COOLING LOAD

$U'_{window3,south1} = 4.62W/m^2 \cdot K$

$CF'_{window3,south1} = U'_{window3,south1}(\Delta T_{COOLING} - 0.46DR)$
$= 4.62 \times (7.9 - 0.46 \times 11.9) \approx 11.21W/m^2$

$PXI_{window3,south2} = E_D + E_d = 348 + 209 = 557$
$SHGC = 0.55$
$FF_s = 0.47$
$CF'_{window3,south2} = PXI \times SHGC \times IAC \times FF_s$
$= 557 \times 0.55 \times 1 \times 0.47 \approx 143.98W/m^2$

$$CF'_{window3,south} = CF'_{window3,south1} + CF'_{window3,south2} = 11.21 + 143.98 = 155.19W/m^2$$

$$Q'_{window3,south-c} = A \times CF'_{window3,south} = 3.6 \times 155.19 \approx 558.68W$$

HEATING LOAD

$$Q'_{window3,south-h} = A \times HF'_{window3,south} = A \times U'_{window3,south} \times \Delta T_{HEATING} = 3.6 \times 4.62 \times 24.8 \approx 412.47W$$

$$Q'_{total-c} = Q'_{window1,west-c} + Q'_{window2,south-c} + Q'_{window3,south-c} = 3499.49 + 559.30 + 558.68 = 4617.47W$$
$$Q'_{total-h} = Q'_{window1,west-h} + Q'_{window2,south-h} + Q'_{window3,south-h} = 1289.20 + 322.30 + 412.47 = 2026.67W$$

$$\Delta Q_{COOLING} = Q_{total-c} - Q'_{total-c} = 4364.34 - 4617.47 = -253.13W$$
$$\Delta Q_{HEATING} = Q_{total-h} - Q'_{total-h} = 1524.01 - 2026.67 = -502.66W$$

So, it can be seen that frame with wooden has a greater resistance in cooling and heating than aluminium frame.

WEEK 9_ZHU CUILING

Task 1

Use a weather forecast website, and utilize the psychrometric chart and the formula we went through in the class to determine the absoloute humidity, the wet-bulb temperature and the mass of water vapour in the air in ClassRoom A (Aula A) of Piacenza campus in the moment that you are solving this exercise (provide the inputs that you utilized)

Umidità: Relative humidity, Pressione atmosferica: Air total pressure (1 hPa: 0.1 kPa), Temperatura effettiva: temperature to be utilized.

Il tempo oggi in Piacenza
Martedì, 03 Dicembre 2019

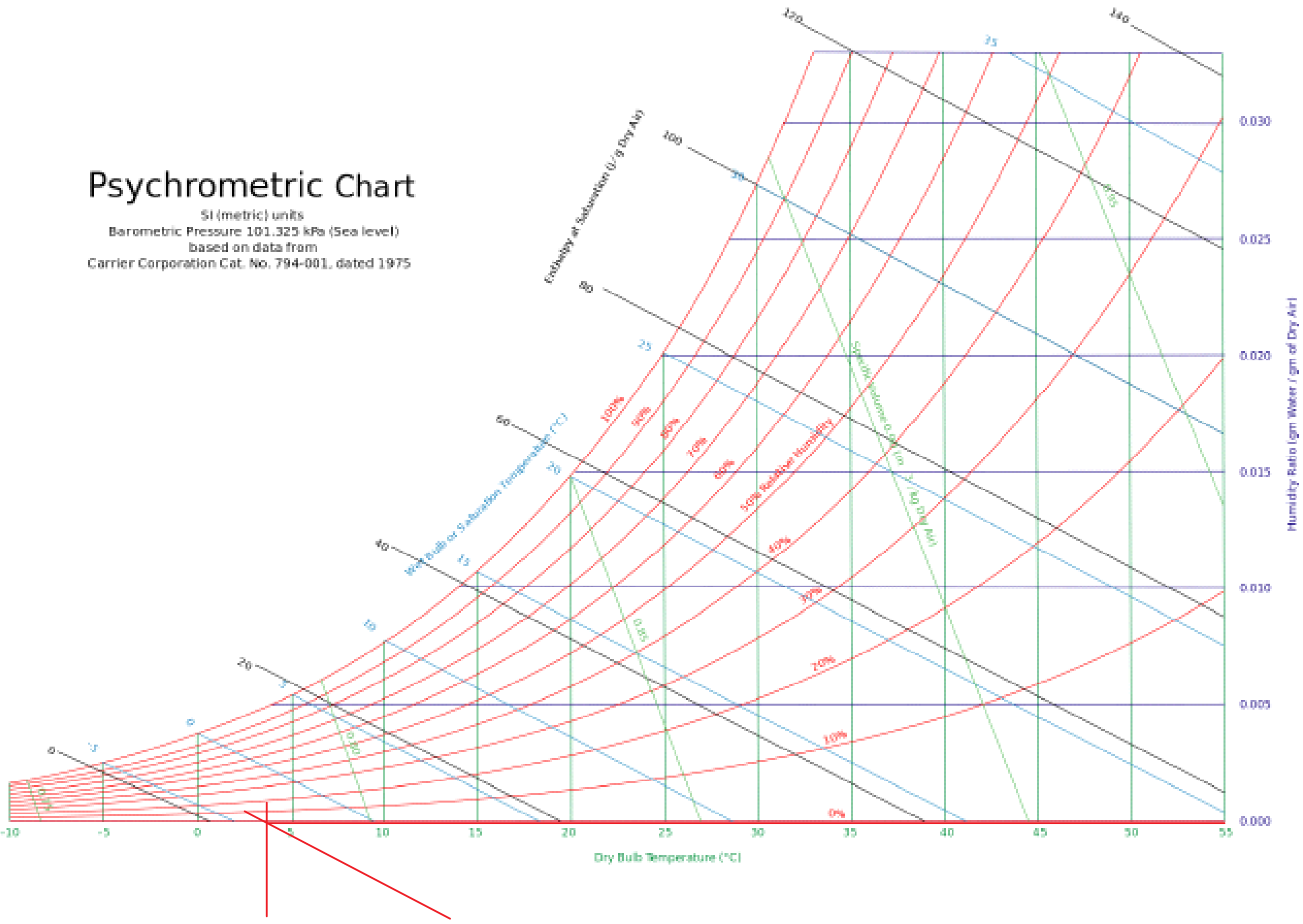
	13:00	14:00	16:00	18:00	20:00	21:00	22:00
	LightCloud	LightCloud	PartlyCloud	LightCloud	Sun	Sun	Sun
Temperatura effettiva	9°C	10°C	8°C	6°C	4°C	2°C	2°C
Temperatura percepita	7°C	10°C	6°C	4°C	2°C	0°C	0°C
Precipitazioni	0 mm	0 mm	0 mm	0 mm	0 mm	0 mm	0 mm
Umidità	67 %	65 %	69 %	70 %	75 %	83 %	87 %
Pressione atmosferica	1025 hPa	1025 hPa	1025 hPa	1026 hPa	1027 hPa	1027 hPa	1028 hPa

NOW, it's nearly 20:00.

The Relative humidity is 75%, $\phi = 75\%$;

Air total pressure is 1027 hPa, P=102.7 KPa;

Temperature to be utilized is 4°C, the temperature in Kelvin temperature scale T=277.15K



Using the psychrometric chart, we can see:

The humidity ratio, the absolute humidity $\omega = 0.0040$

The wet bulb temperature is $T_{wb} = 2.5C$

$$\because \quad \omega = \frac{0.622P_v}{P_a} = \frac{0.622P_v}{P - P_v} = 0.0040, \qquad P = 102.6\ KPa$$

$$\therefore \quad P_v = 0.665\ KPa$$

$$\because \quad \phi = \frac{m_v}{m_g} = 75\%, \qquad for\ ideal\ gases\ m = \frac{P_v}{R_{sp}T}, we\ know\ that\ R_{sp} = 0.4615$$

The volume of Aula A=V

$$m_v = \frac{0.893V}{0.4615 \times 277.15} = 6.98 \times 10^{-3}V$$

$$m_g = \frac{m_v}{75\%} = 9.31 \times 10^{-3}V$$

Task 2

Utilize the same methodology we went through in the class and determine the sensible and latent load corresponding to internal gains, the ventilation, and the infiltration in a house with a *good* construction quality and with the same geometry as that of the example which is located in Brindisi, Italy

BRINDISI, Italy WMO#: **163200**

Lat: **40.65N** Long: **17.95E** Elev: **10** StdP: **101.2** Time Zone: **1.00 (EUW)** Period: **86-10** WBAN: **99999**

Annual Heating and Humidification Design Conditions

	Coldest Month	Heating DB		Humidification DP/MCDB and HR						Coldest month WS/MCDB				MCWS/PCWD to 99.6% DB		
				99.6%			99%			0.4%		1%				
		99.6%	99%	DP	HR	MCDB	DP	HR	MCDB	WS	MCDB	WS	MCDB	MCWS	PCWD	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	
(1)	2	2.9	4.1	-5.1	2.5	7.2	-3.0	3.0	7.4	13.4	10.2	12.4	10.6	3.4	250	(1)

Annual Cooling, Dehumidification, and Enthalpy Design Conditions

	Hottest Month	Hottest Month DB Range	Cooling DB/MCWB						Evaporation WB/MCDB						MCWS/PCWD to 0.4% DB		
			0.4%		1%		2%		0.4%		1%		2%				
			DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB	MCWS	PCWD	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	
(2)	8	7.1	32.8	23.6	31.1	24.3	29.9	24.3	27.2	29.7	26.3	29.0	25.6	28.3	4.2	180	(2)

	Dehumidification DP/MCDB and HR									Enthalpy/MCDB						Hours 8 to 4 & 12.8/20.6	
	0.4%			1%			2%			0.4%		1%		2%			
	DP	HR	MCDB	DP	HR	MCDB	DP	HR	MCDB	Enth	MCDB	Enth	MCDB	Enth	MCDB		
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	
(3)	26.3	21.8	29.2	25.4	20.7	28.5	24.7	19.7	27.9	86.0	30.1	82.2	29.1	78.5	28.3	1236	(3)

Extreme Annual Design Conditions

	Extreme Annual WS			Extreme Max WB	Extreme Annual DB				n-Year Return Period Values of Extreme DB								
					Mean		Standard deviation		n=5 years		n=10 years		n=20 years		n=50 years		
	1%	2.5%	5%		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	
(4)	11.3	9.9	8.7	31.4	0.4	37.3	1.4	3.0	-0.6	39.4	-1.4	41.1	-2.2	42.8	-3.2	44.9	(4)

Noc=2

Height=2.5m^2

Conditioned Floor Area=200m^2

Internal Gains:

$$\dot{Q}_{igsensible} = 136 + 2.2A_{cf} + 22N_{oc} = 136 + 2.2 \times 200 + 22 \times 2 = 620W$$

$$\dot{Q}_{iglatent} = 20 + 0.22A_{cf} + 12N_{oc} = 20 + 0.22 \times 200 + 12 \times 2 = 88W$$

Infiltration:

Table 3 Unit Leakage Areas

Construction	Description	A_{ul}, cm^2/m^2
Tight	Construction supervised by air-sealing specialist	0.7
Good	Carefully sealed construction by knowledgeable builder	1.4
Average	Typical current production housing	2.8
Leaky	Typical pre-1970 houses	5.6
Very leaky	Old houses in original condition	10.4

Situation	Include	Exclude
Ceiling/roof combination (e.g., cathedral ceiling without attic)	Gross surface area	
Ceiling or wall adjacent to attic	Ceiling or wall area	Roof area
Wall exposed to ambient	Gross wall area (including fenestration area)	
Wall adjacent to unconditioned buffer space (e.g., garage or porch)	Common wall area	Exterior wall area
Floor over open or vented crawlspace	Floor area	Crawlspace wall area
Floor over sealed crawlspace	Crawlspace wall area	Floor area
Floor over conditioned or semiconditioned basement	Above-grade basement wall area	Floor area
Slab floor		Slab area

$A_{ul}(GOOD\ CONSTRUCTION) = 1.4\ cm^2/m^2$

$A_{es} = A_{wall} + A_{roof} = 200 + 144 = 344\ m^2$

$A_L = A_{es} \times A_{ul} = 344 \times 1.4 = 481.6\ cm^2$

The cooling temperature in Brindisi is $T_{cooling} = 24$ °C and heating temperature $T_{heating} = 20$°C in Brindisi

$\Delta T_{cooling} = 31.1 - 24 = 7.1°\mathrm{C} = 7.1K$

$\Delta T_{heating} = 20 - (-4.1) = 24.1°\mathrm{C} = 24.1K$

$DR = 7.1°\mathrm{C} = 7.1K$

$IDF_{heating} = 0.073\ L/s \cdot cm^2$

$IDF_{cooling} = 0.033\ L/s \cdot cm^2$

$\dot{V}_{infiltration\ heating} = A_L \times IDF_{heating} = 481.6 \times 0.073 = 35.157\ L/S$

$\dot{V}_{infiltration\ cooling} = A_L \times IDF_{cooling} = 481.6 \times 0.033 = 15.89\ L/$

$\dot{V}_{ventilation} = 0.05A_{cf} + 3.5\left(N_{br} + 1\right) = 0.05 \times 200 + 3.5 \times (1 + 1) = 17\ L/S$

$\dot{V}_{inf-ventilation\ heating} = 35.157 + 17 = 52.157\ L/S$

$\dot{V}_{inf-ventilation\ cooling} = 15.89 + 17 = 32.893\ L/S$

$C_{sensible} = 1.23, C_{latent} = 3010, \Delta\omega_{cooling} = 0.0039$

$\dot{Q}_{inf-ventilation\ cooling\ sensible} = C_{sensible} \times \dot{V} \times \Delta T_{cooling} = 1.23 \times 32.893 \times 7.1 = 287.25W$

$\dot{Q}_{inf-ventilation\ heating\ sensible} = C_{sensible} \times \dot{V} \times \Delta T_{heating} = 1.23 \times 52.157 \times 24.1 = 1546.09W$

$\dot{Q}_{inf-ventilation\ cooling\ latent} = C_{lantent} \times \dot{V} \times\ \Delta\omega_{cooling} = 3010 \times 32.893 \times 0.0039 = 386.13W$