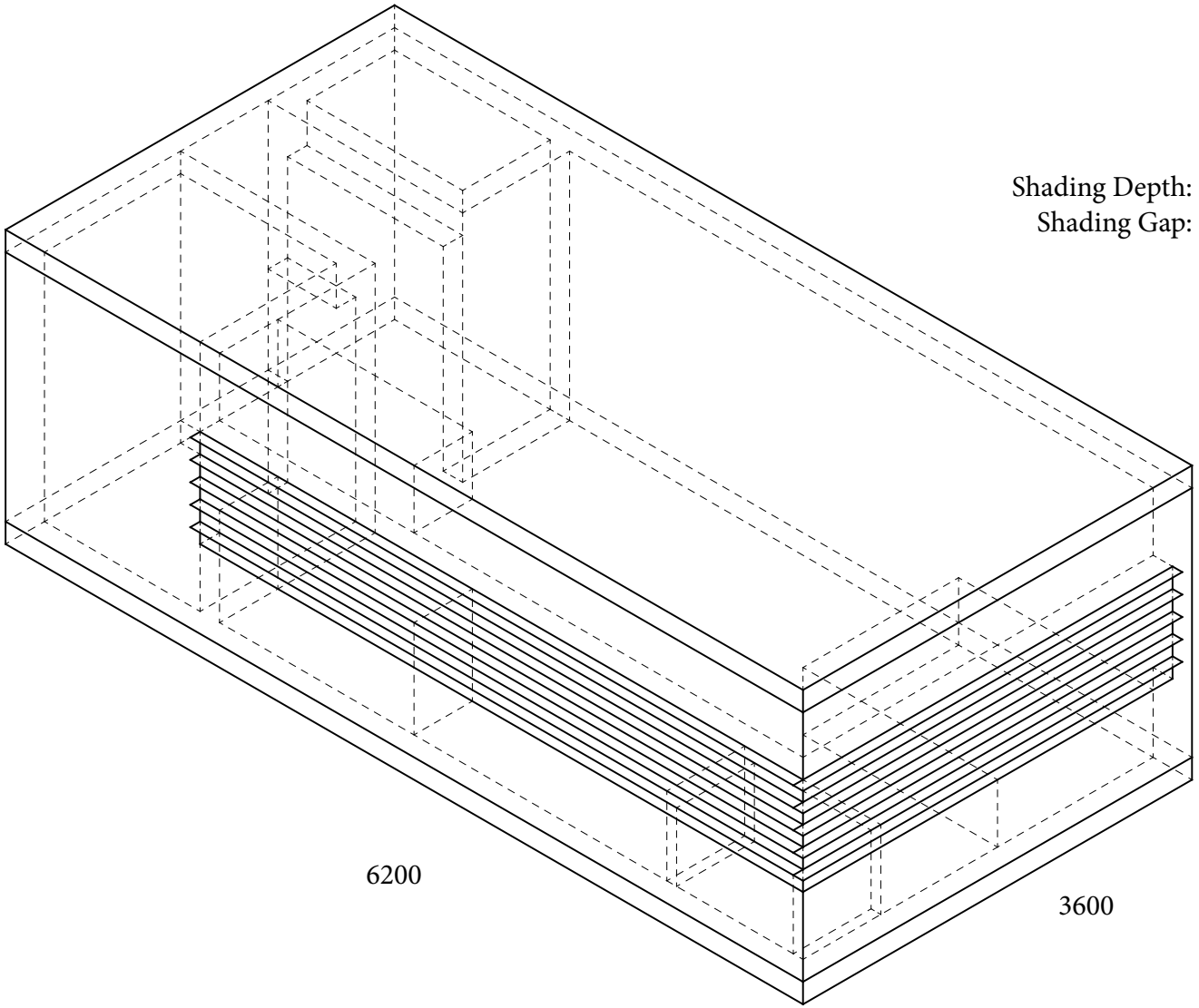
Energy Simulation with Air Flow

171113 Assignment_7
DREAM ROOM in Philadelphia



Shading Depth: 100mm
Shading Gap: 200mm

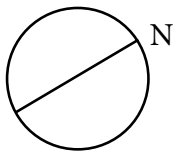
City: Philadelphia, PA

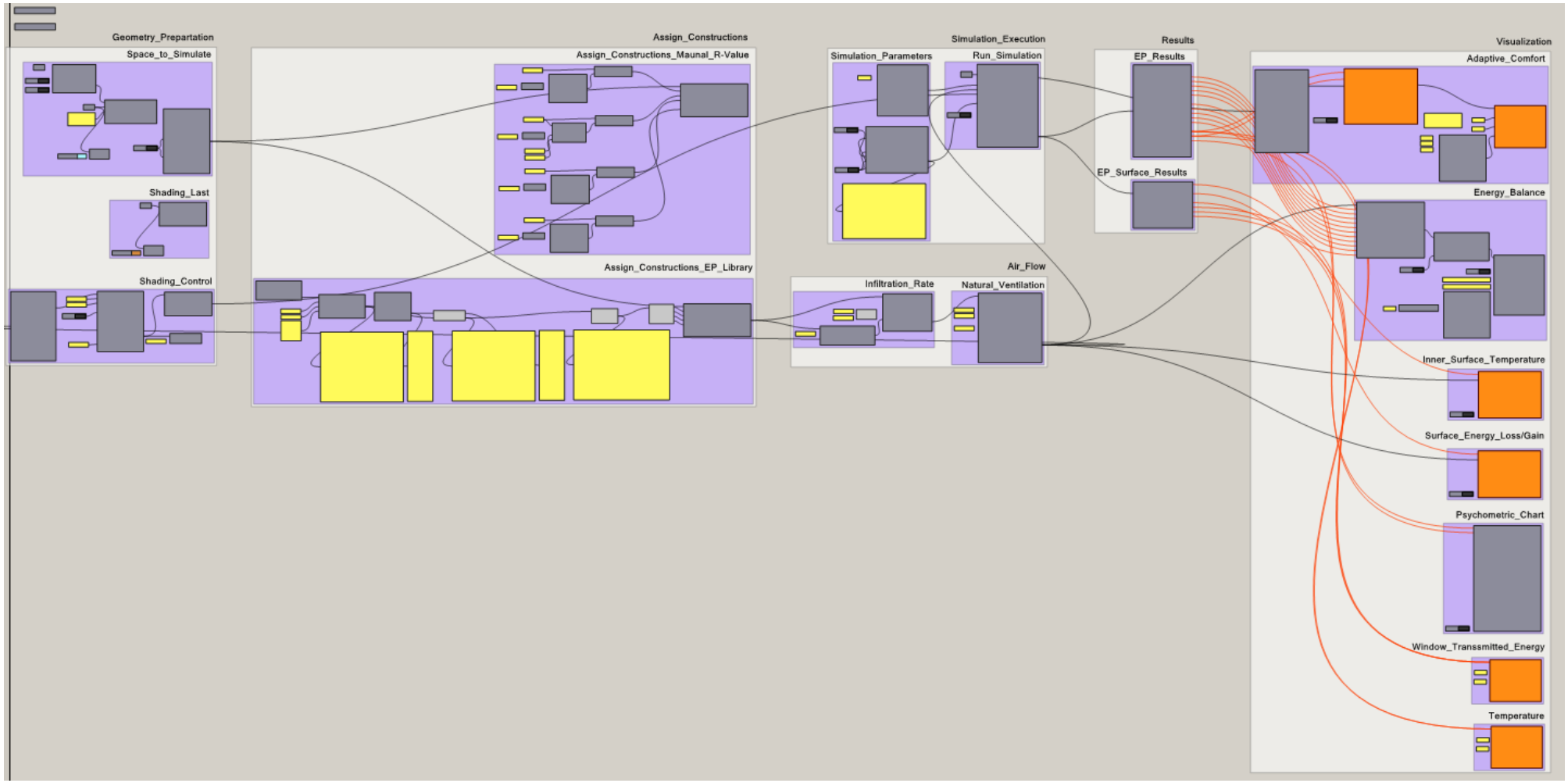
Latitude: 39.8683

Longitude: -75.2311

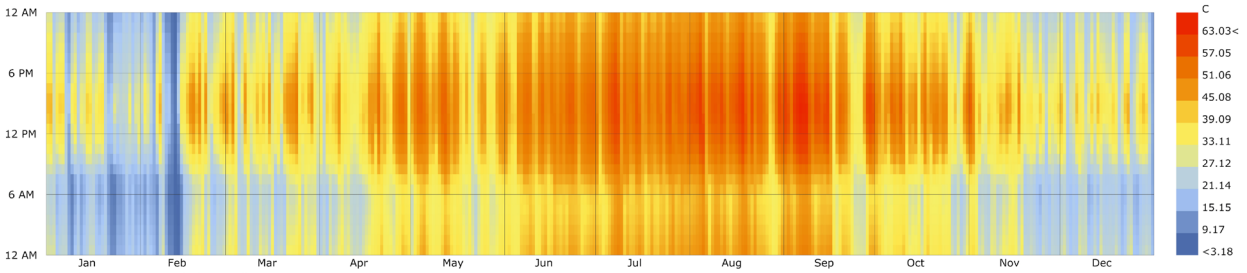
Climate:
According to the Köppen climate classification, Philadelphia falls under the northern periphery of the humid subtropical climate zone (Köppen Cfa),[71] whereas according to the Trewartha climate classification, the city has a temperate maritime climate (Do).[72] Summers are typically hot and muggy, fall and spring are generally mild, and winter is cold. (Wikipedia)

Wind:
Generally, not too extreme, however, sometimes in winter, it's quite strong.

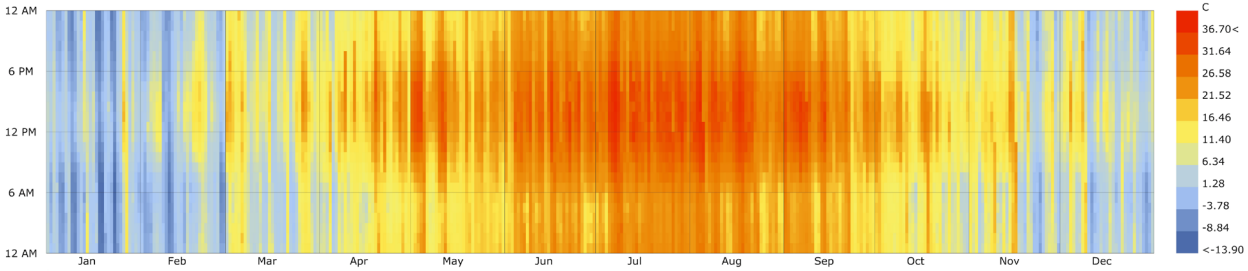




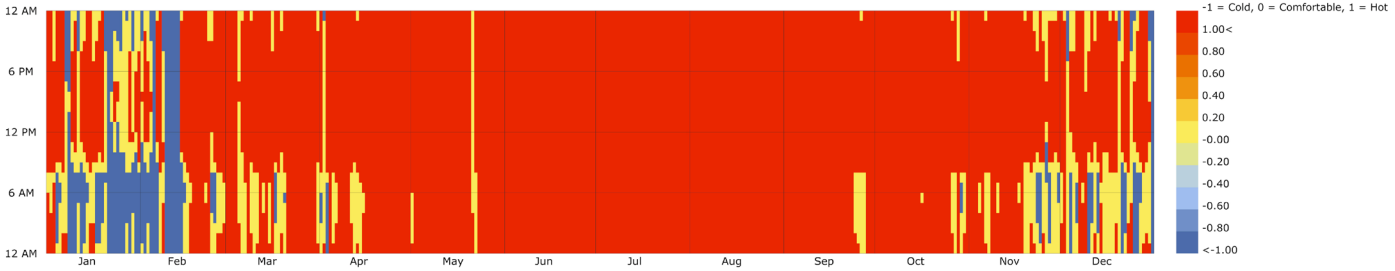
After I apply air flow parameters, I siumated my energy model for my dream room. What I examined is adamptive comfort, energy balance, inner surface temperature, surface energy loss and gain, psychometric chart, window transmitted energy, and overall temperature of the room. I tried to apply two windows in different orientations, different shading angles, and various construction conditions of each components of the room.



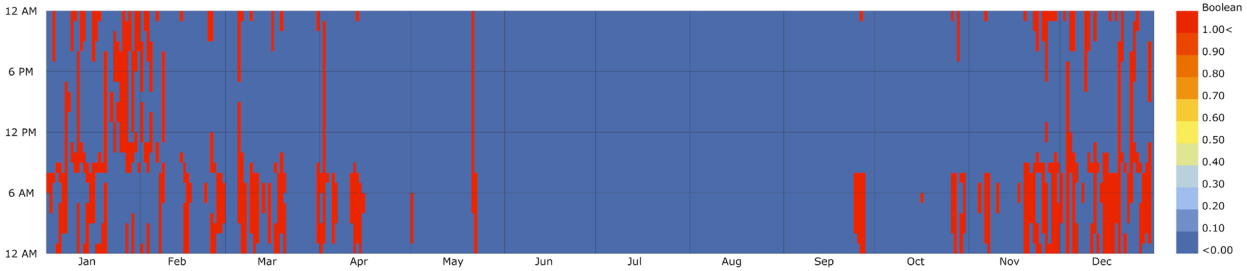
Air Temperature for ZONE_0 (C) - Hourly
Philadelphia International Ap PA USA TMY3
1 JAN 1:00 - 31 DEC 24:00



Dry Bulb Temperature (C) - Hourly
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00

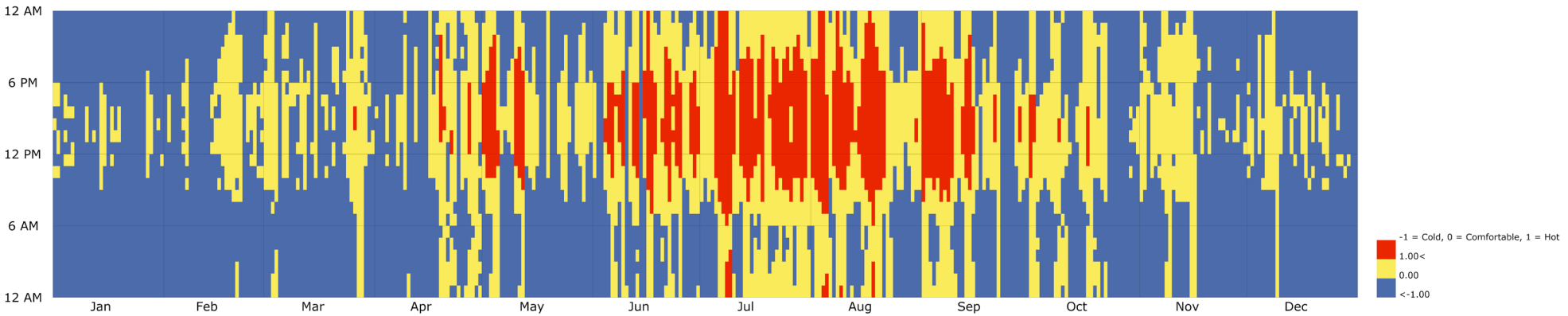


Adaptive Comfort for ZONE_0 (-1 = Cold, 0 = Comfortable, 1 = Hot) - Hourly
Philadelphia International Ap PA USA TMY3
1 JAN 1:00 - 31 DEC 24:00

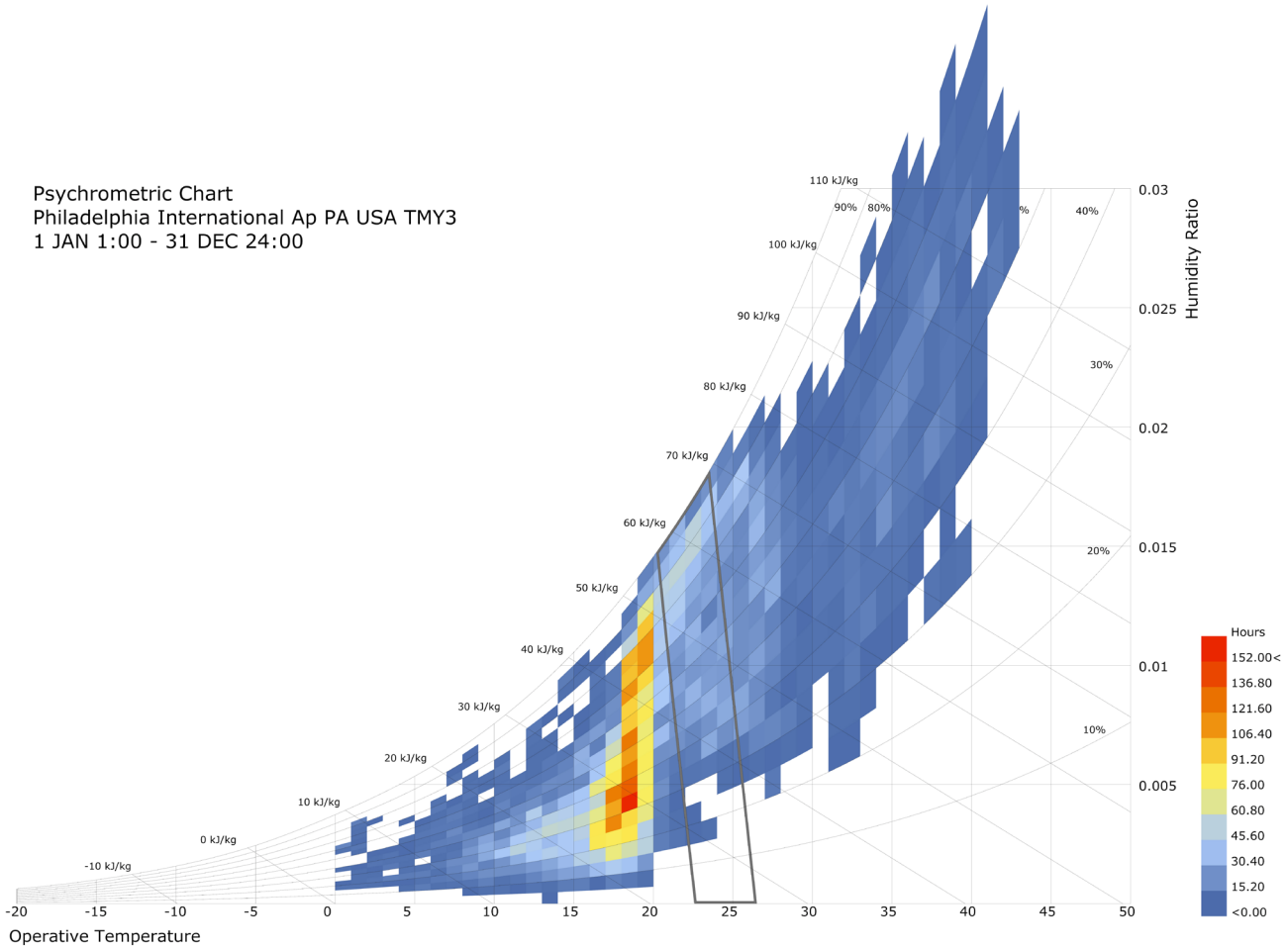


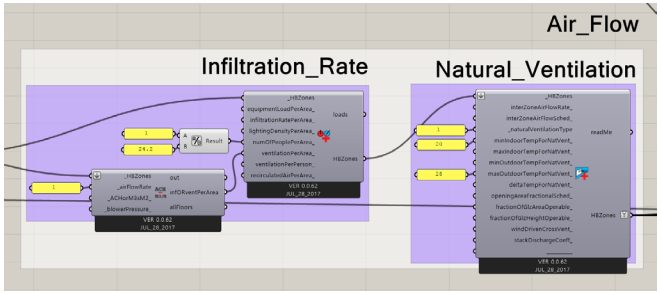
Comfortable Or Not for ZONE_0 (Boolean) - Hourly
Philadelphia International Ap PA USA TMY3
1 JAN 1:00 - 31 DEC 24:00

In the last simulation, without applying air flow, even if I changed R-value of the construction materials and window conditions, adaptive comfort of my room was drastically bad. Also, it was changed not much by applying different factors and maintained almost extreamly hot.



Adaptive Comfort for ZONE_0 (-1 = Cold, 0 = Comfortable, 1 = Hot) - Hourly
Philadelphia International Ap PA USA TMY3
1 JAN 1:00 - 31 DEC 24:00





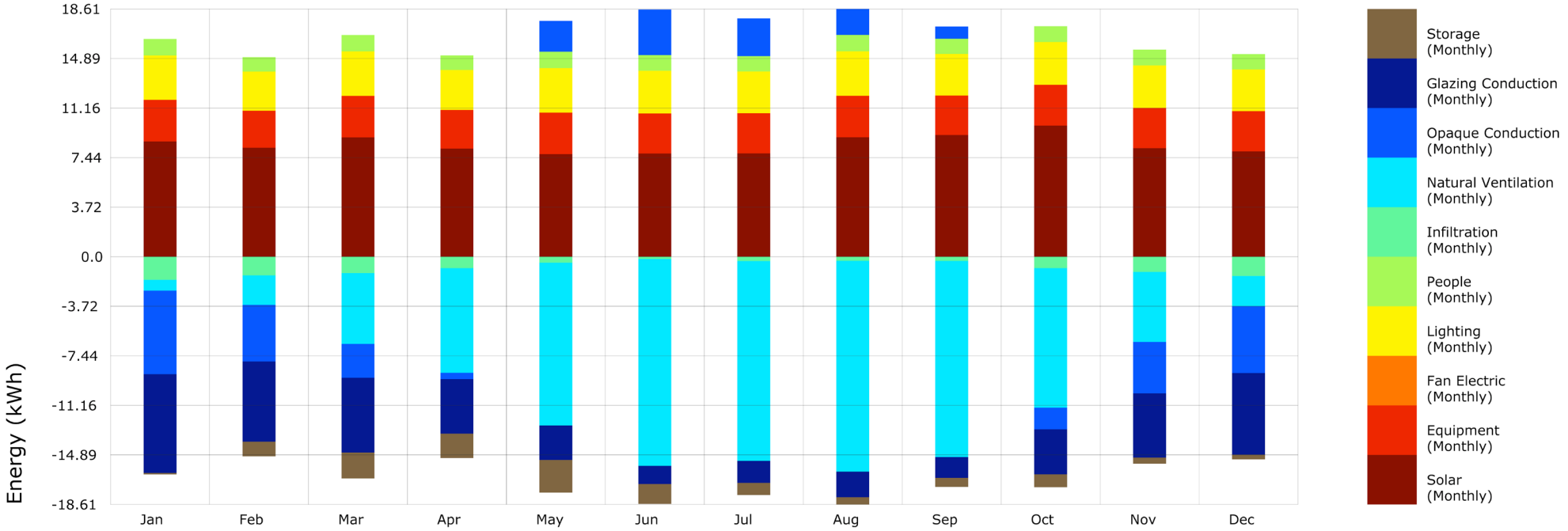
Air Flow Rate:
0.000667 cubic meter per seccond per sqm of floor

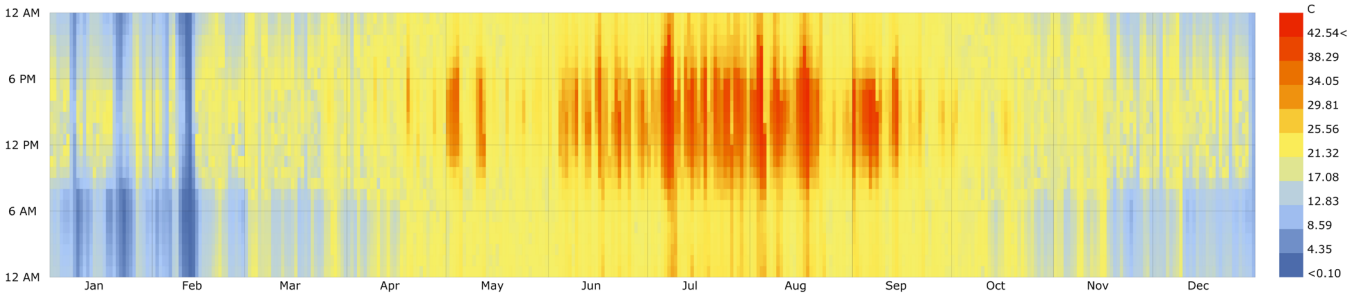
Natural Ventilation Type: Window Natural Vent

Min Indoor Temp for Natural Vent: 20 degree

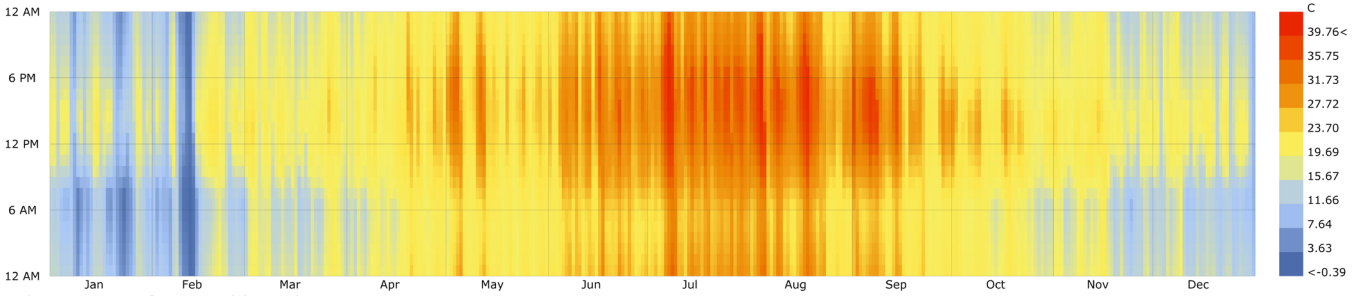
Max Ondoor Temp for Natural Vent: 28 degree

Firstly, after applying air flow parameter, the result become more normalized than the former simulation. For the temperature for natural ventilation, I prefer cooler temperature than common preference.





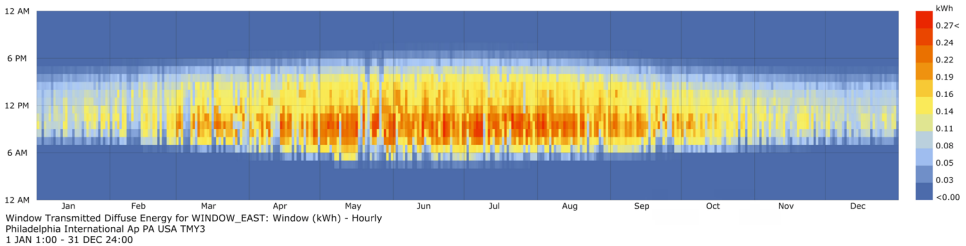
Air Temperature for ZONE_0 (C) - Hourly
Philadelphia International Ap PA USA TMY3
1 JAN 1:00 - 31 DEC 24:00



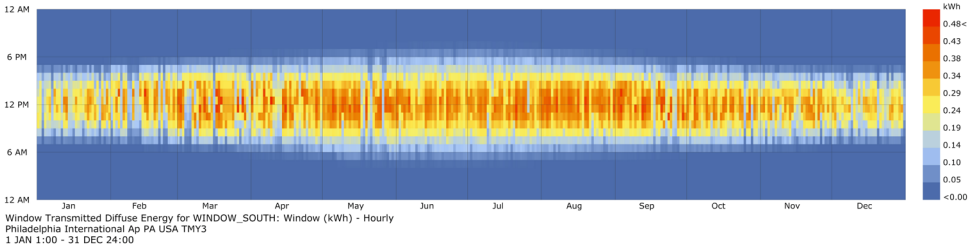
Radiant Temperature for ZONE_0 (C) - Hourly
Philadelphia International Ap PA USA TMY3
1 JAN 1:00 - 31 DEC 24:00

Regarding energy balance, the amount of solar energy in summer is less than the winter, which means solar radiance is well controlled now. Also, in summer, natural ventilation eliminates energy efficiently, and in winter, it doesn't.

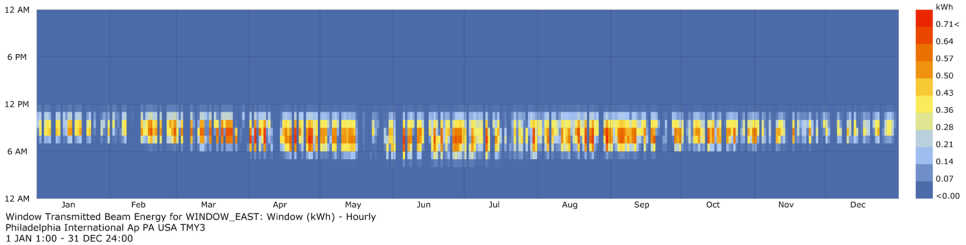
Yet, air temperature in summer is still high.



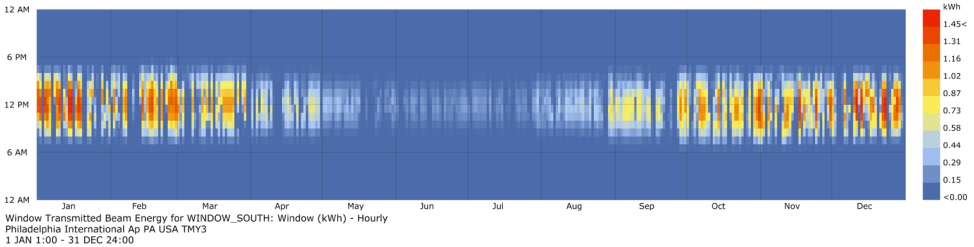
Window Transmitted Diffuse Energy for WINDOW_EAST: Window (kWh) - Hourly
Philadelphia International Ap PA USA TMY3
1 JAN 1:00 - 31 DEC 24:00



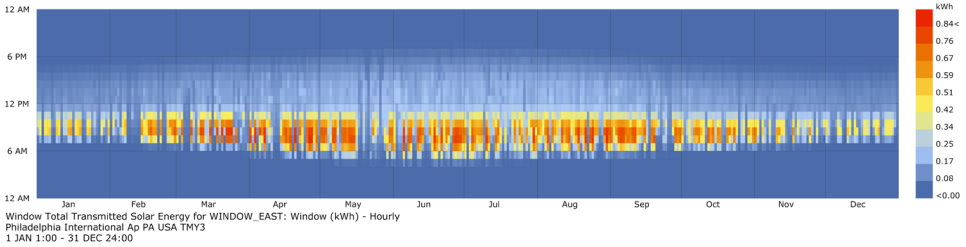
Window Transmitted Diffuse Energy for WINDOW_SOUTH: Window (kWh) - Hourly
Philadelphia International Ap PA USA TMY3
1 JAN 1:00 - 31 DEC 24:00



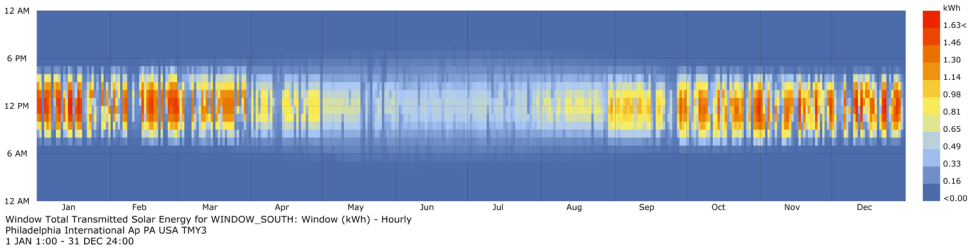
Window Transmitted Beam Energy for WINDOW_EAST: Window (kWh) - Hourly
Philadelphia International Ap PA USA TMY3
1 JAN 1:00 - 31 DEC 24:00



Window Transmitted Beam Energy for WINDOW_SOUTH: Window (kWh) - Hourly
Philadelphia International Ap PA USA TMY3
1 JAN 1:00 - 31 DEC 24:00



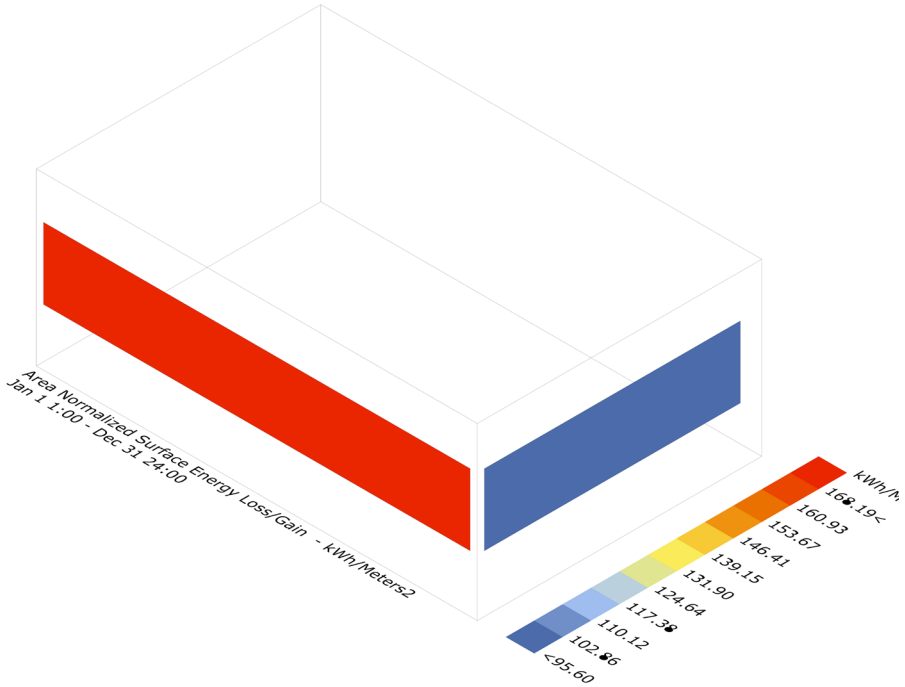
Window Total Transmitted Solar Energy for WINDOW_EAST: Window (kWh) - Hourly
Philadelphia International Ap PA USA TMY3
1 JAN 1:00 - 31 DEC 24:00

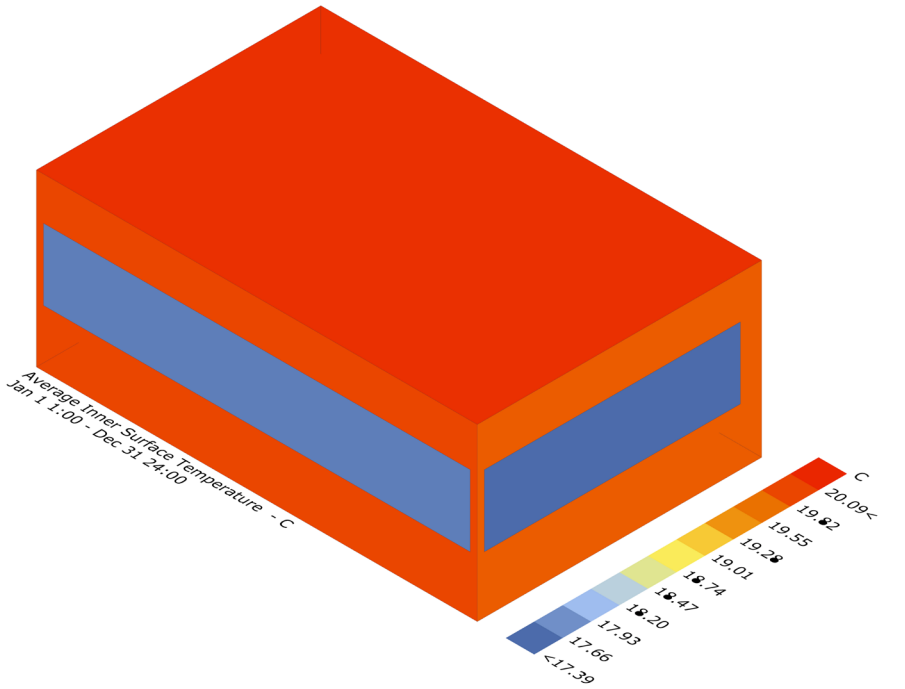


Window Total Transmitted Solar Energy for WINDOW_SOUTH: Window (kWh) - Hourly
Philadelphia International Ap PA USA TMY3
1 JAN 1:00 - 31 DEC 24:00

Regarding the East window, energy gained in summer is not much but still higher than in winter. I guess this is because the louver is horizontal. Beam energy and total energy gained is usually high in the daytime before noon. Yet, I like intense morning energy to make me wake up, so this result is what I expected to achieve.

Concering the South window, energy gained through the window in summer is less than in winter, which means the louver functions properly. Also, during the whole year, diffuse energy is quite even, so energy distribution would be good.



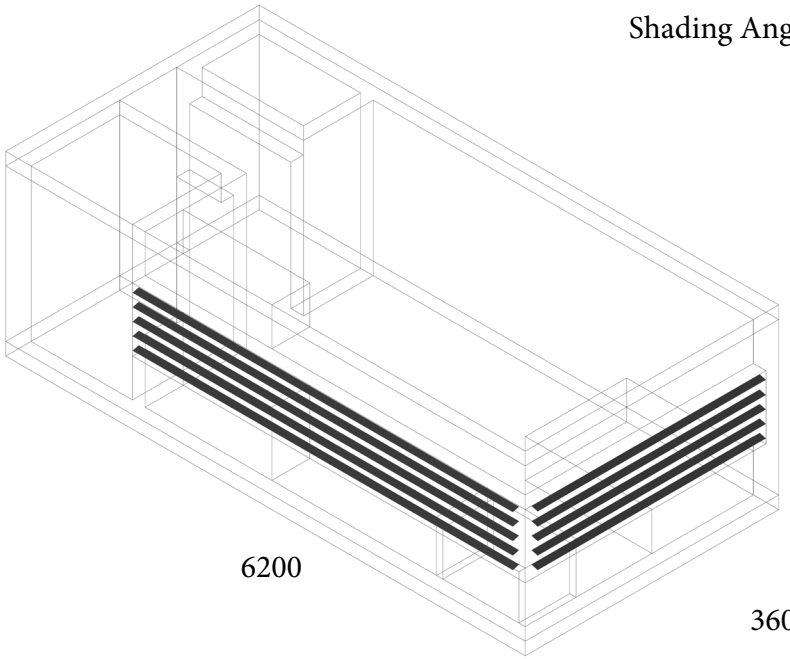


In area normalized surface energy loss and gain simulation, energy flow of the South window is more than three times than that of the East window.

Average inner surface temperature is what I prefer now.

Shading Depth: 100mm
Shading Gap: 200mm

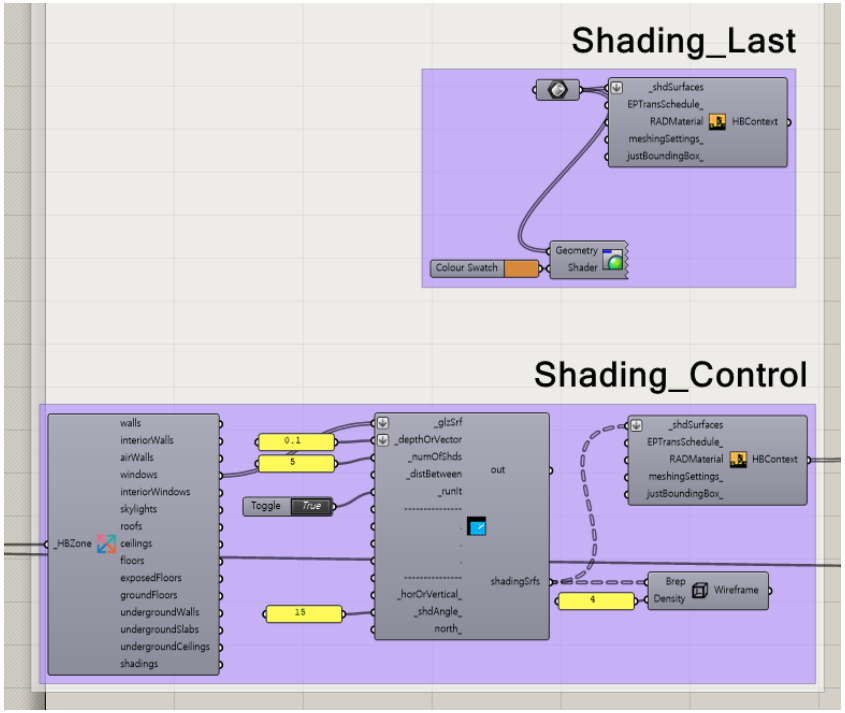
Shading Angle: 15 degree

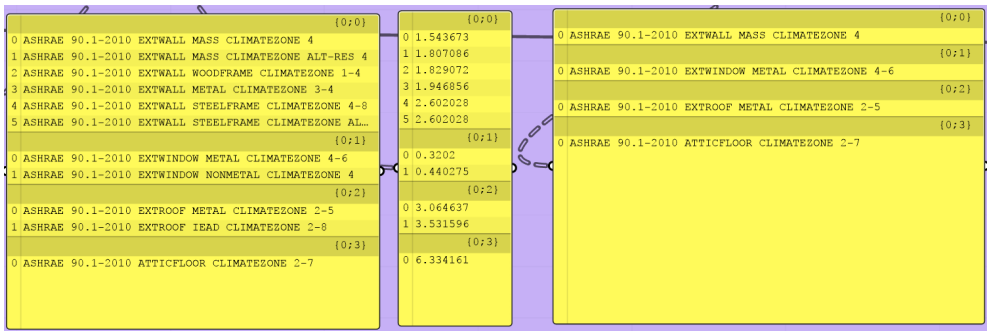


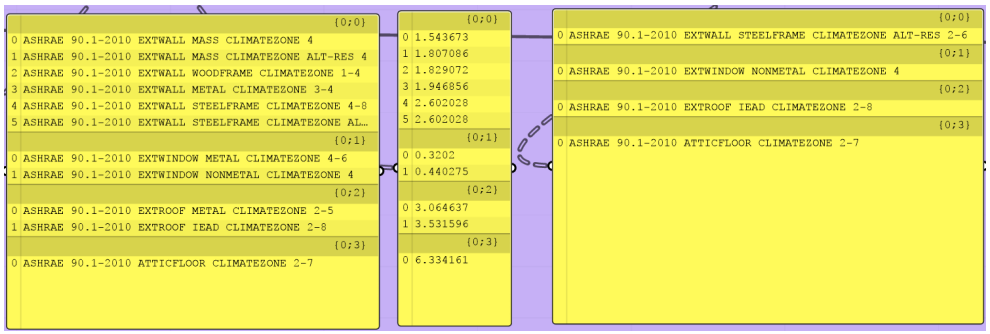
600

1000

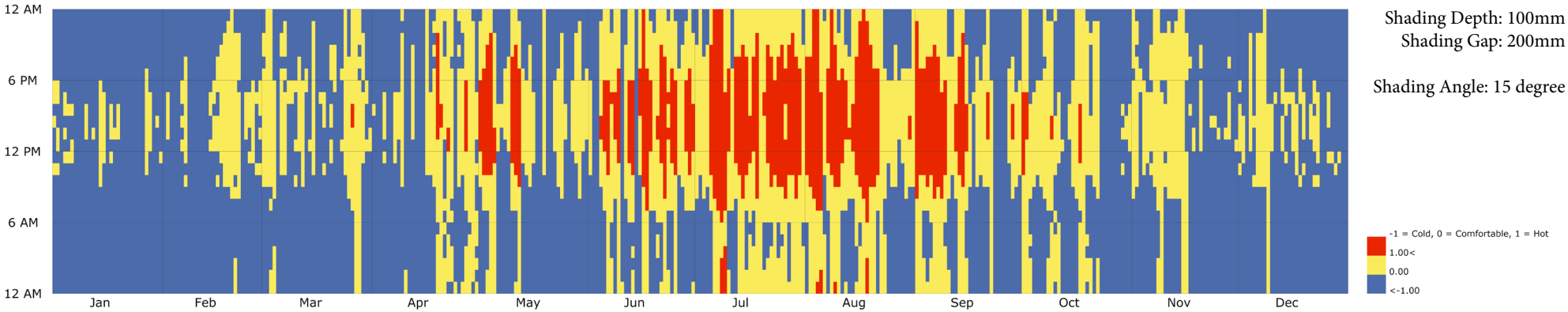
800







I've done several more simulations, by changing depth, numbers, and angles of louvers. Simultaneously, different construction materials were applied with changing R-Value of them.



Shading Depth: 100mm
Shading Gap: 200mm

Shading Angle: 15 degree

Adaptive Comfort for ZONE_0 (-1 = Cold, 0 = Comfortable, 1 = Hot) - Hourly
Philadelphia International Ap PA USA TMY3
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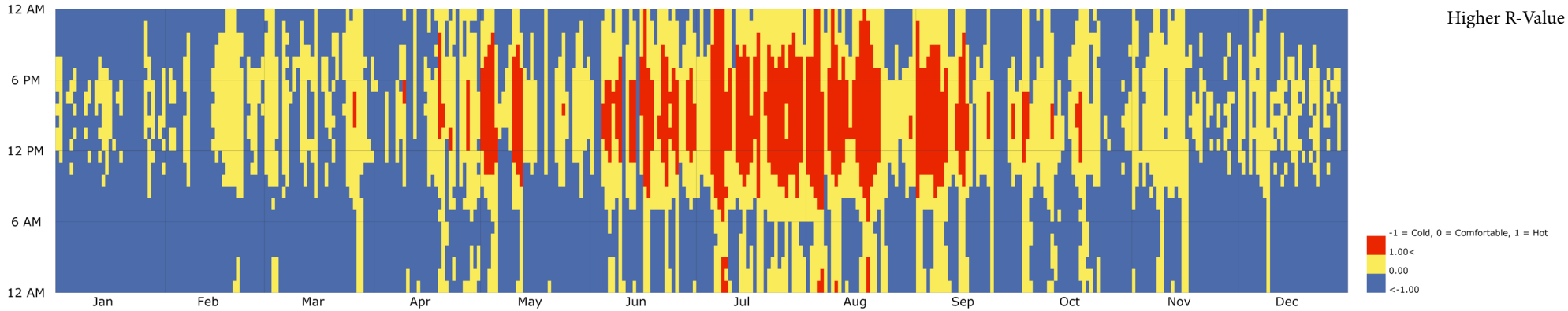
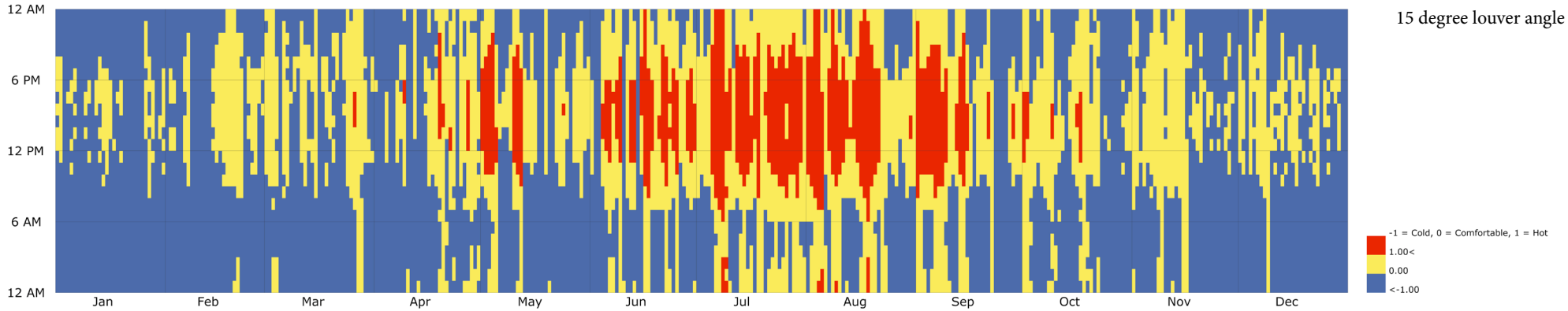


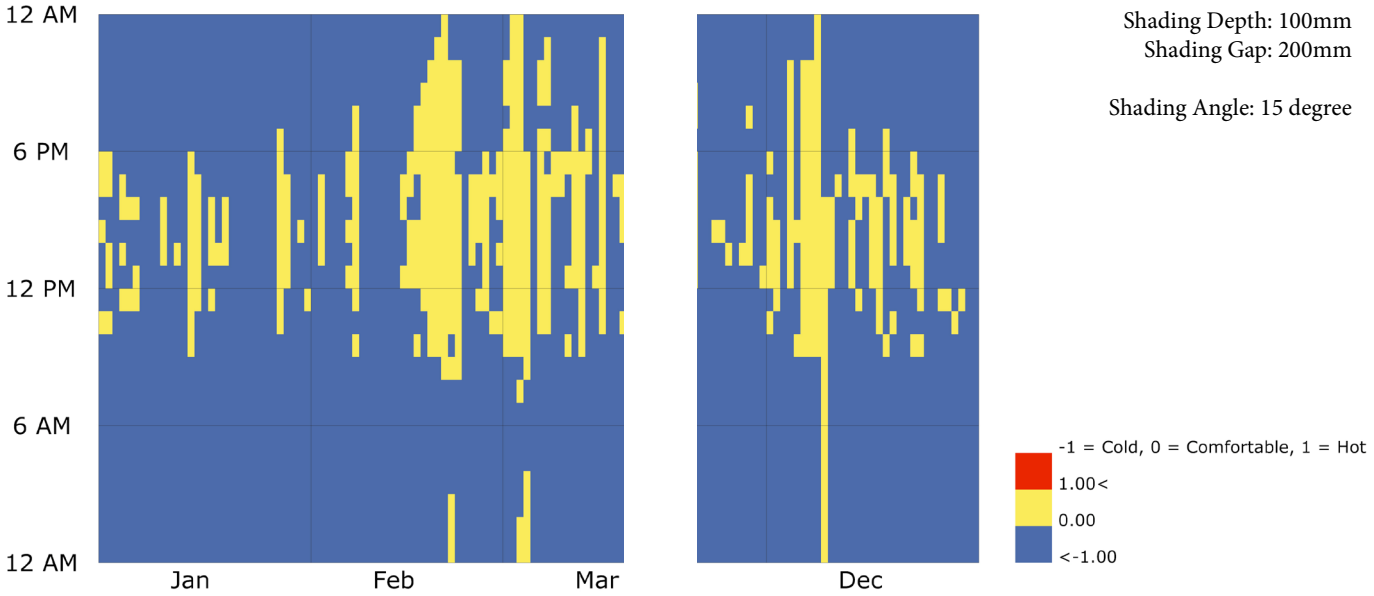
Higher R-Value

Adaptive Comfort for ZONE_0 (-1 = Cold, 0 = Comfortable, 1 = Hot) - Hourly
Philadelphia International Ap PA USA TMY3
1 JAN 1:00 - 31 DEC 24:00



15 degree louver angle

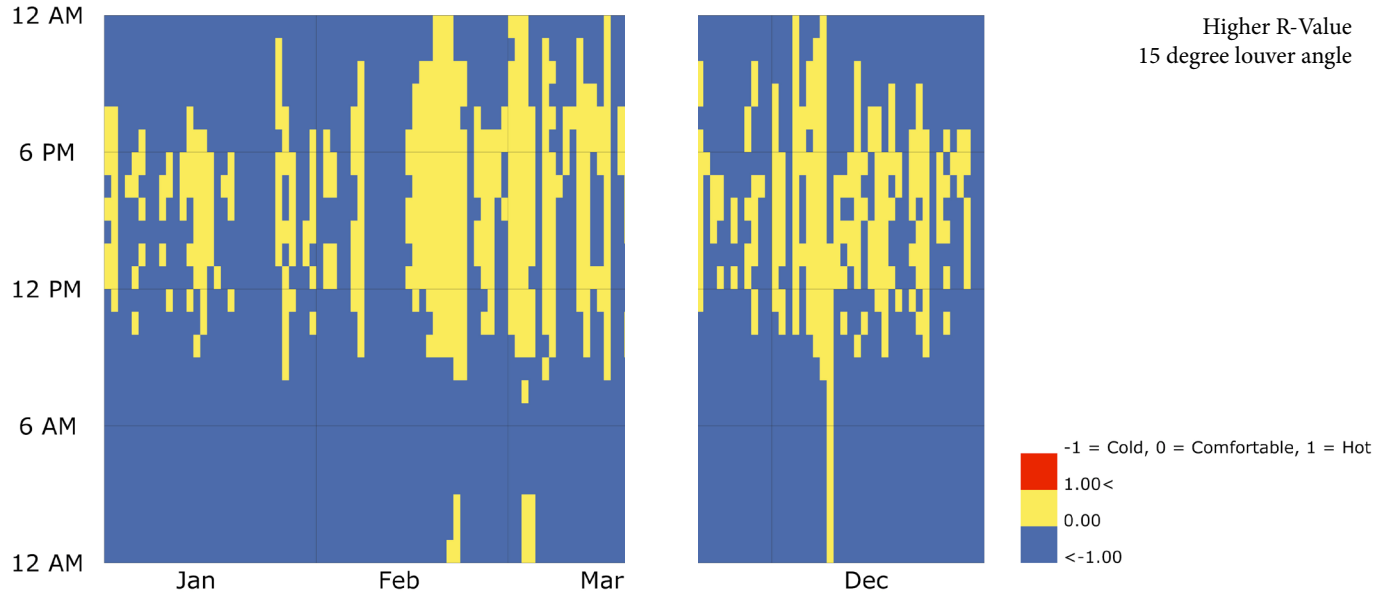
Adaptive Comfort for ZONE_0 (-1 = Cold, 0 = Comfortable, 1 = Hot) - Hourly
Philadelphia International Ap PA USA TMY3
1 JAN 1:00 - 31 DEC 24:00



Shading Depth: 100mm
Shading Gap: 200mm

Shading Angle: 15 degree

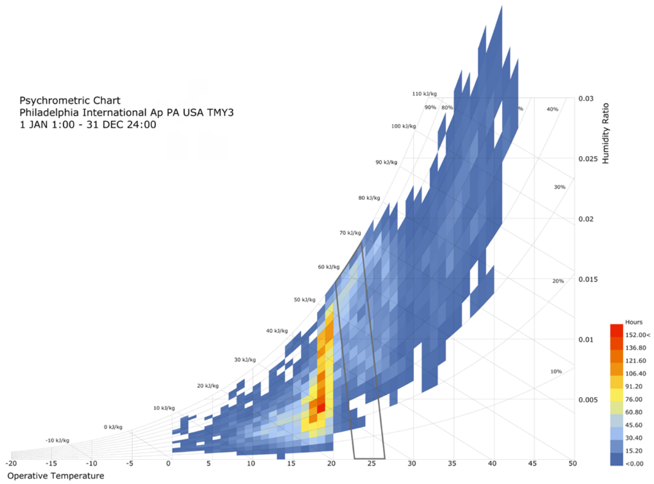
Adaptive Comfort for ZONE_0 (-1 = Cold, 0 =
Philadelphia International Ap PA USA TMY3
1 JAN 1:00 - 31 DEC 24:00

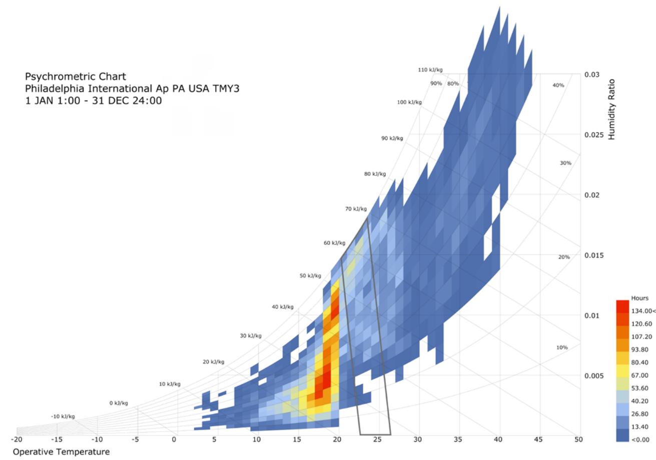


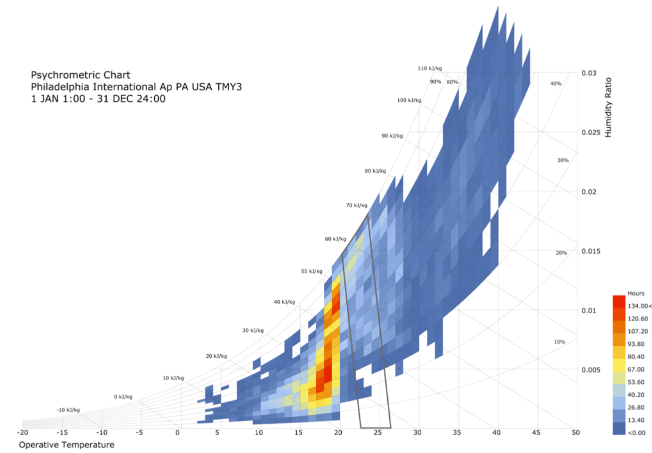
Higher R-Value
15 degree louver angle

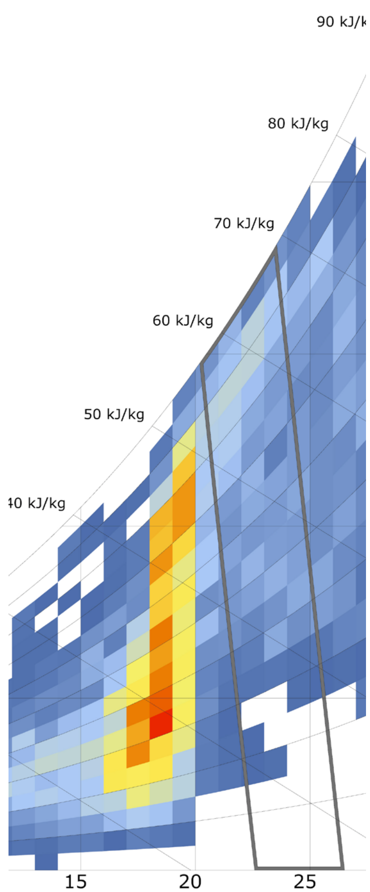
Adaptive Comfort for ZONE_0 (-1 = Cold, 0 =
Philadelphia International Ap PA USA TMY3
1 JAN 1:00 - 31 DEC 24:00

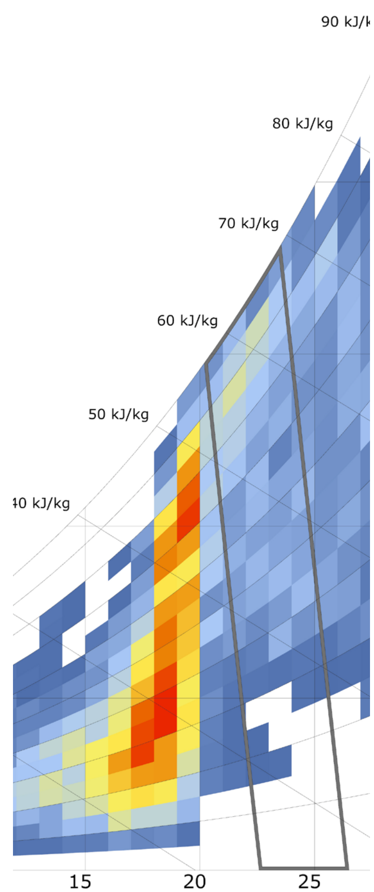
Until the last simulation, I maximized comfortable daylighting and adaptive comfort, so the change is not extreme. Still, I could find improvement of adaptive comfortm, especially in winter.





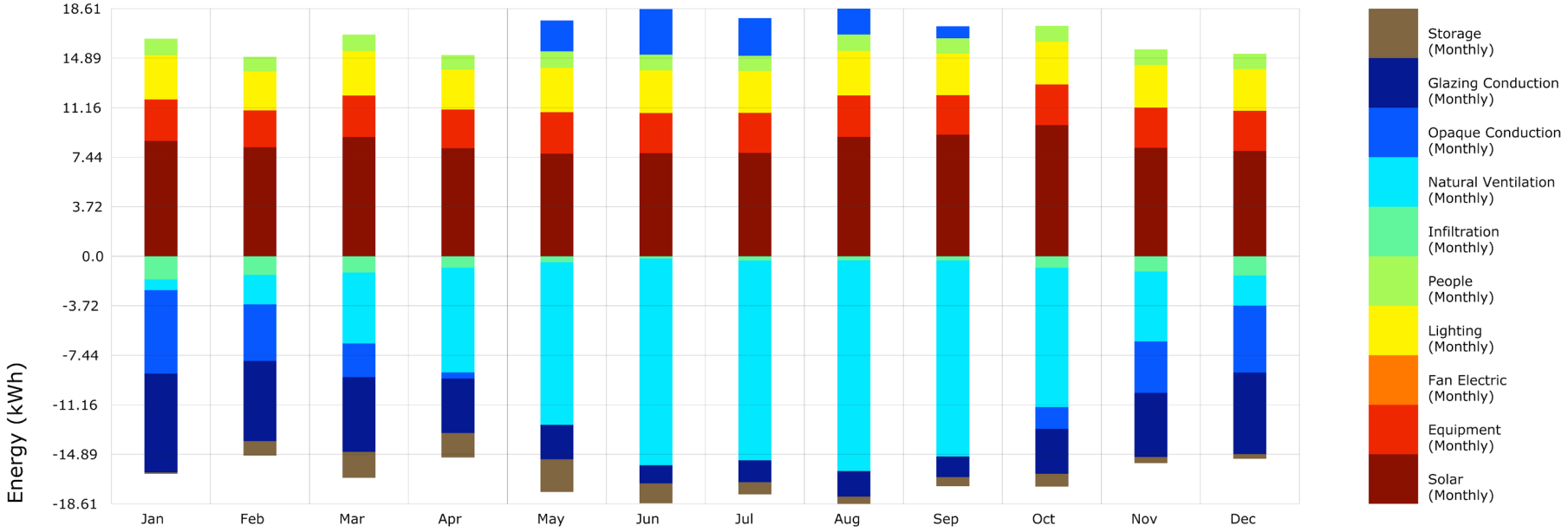


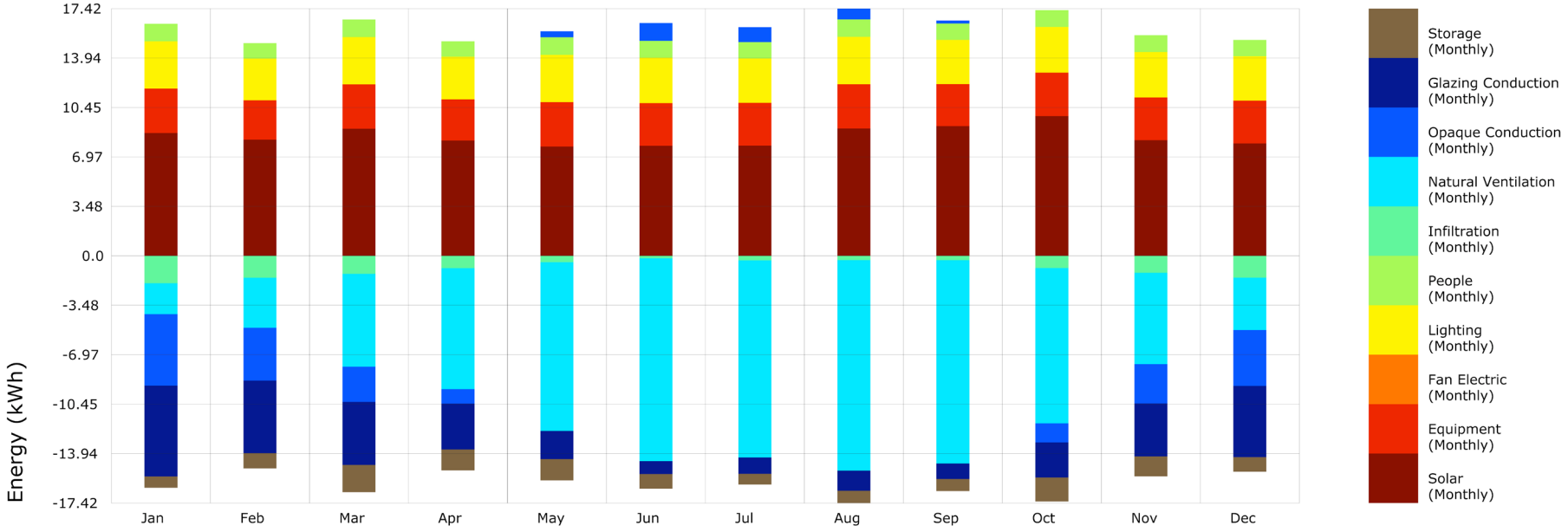




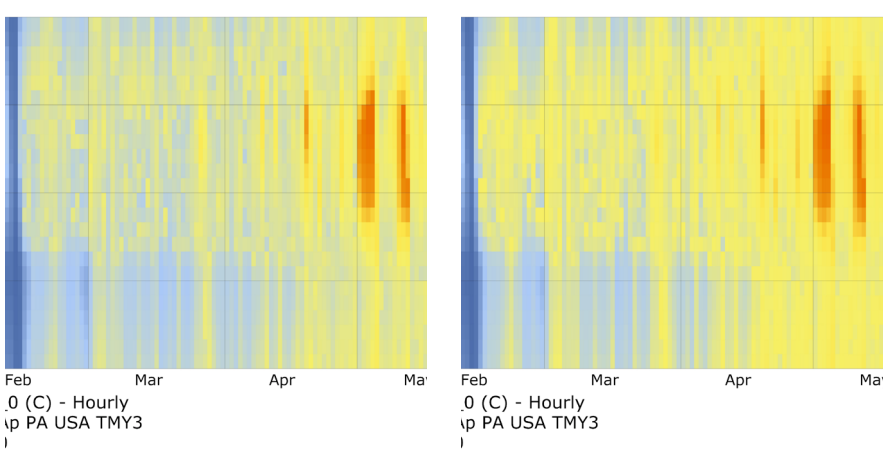
In psychometric chart, the most operative hours are lower temperature of recommended comfort zone. However, from the beginning of the simulation, I assigned my preference of the temperature lower then that of common one. Thus, the result is what I expected.

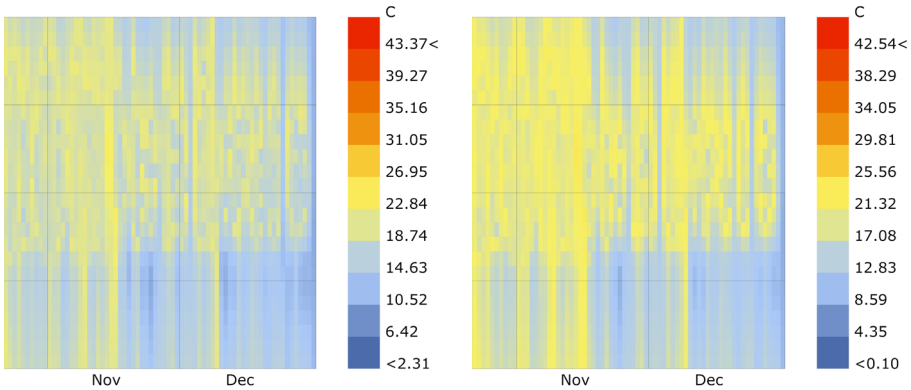
After applying better R-Value and angled louver, more operative times are located where I want them to be

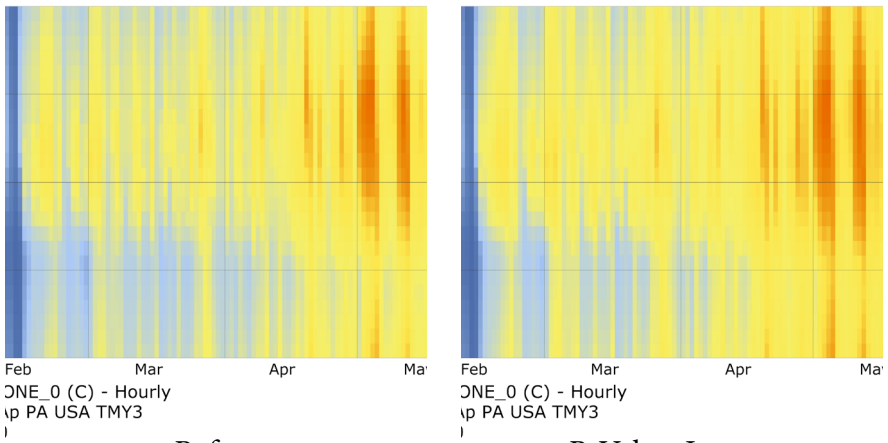


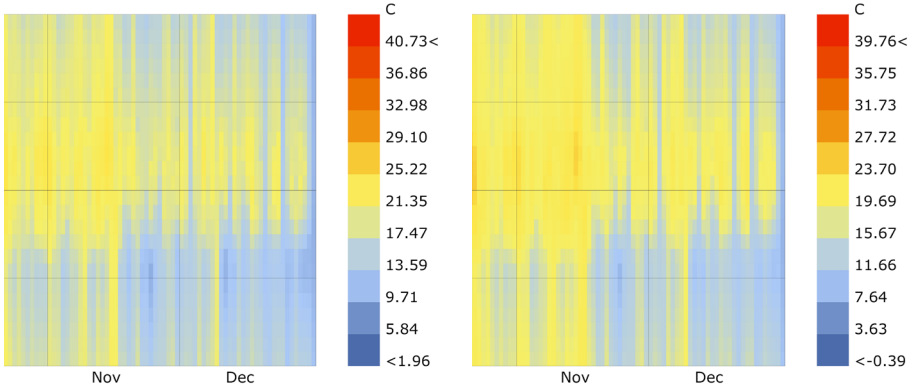


After applying higher R-Value construction materials, energy loss and gain of opaque conduction become less. Moreover, although it is small amount, overall energy flow become less and stabilized.









Before R-Value, Louver Before R-Value, Louver

After changing louver angle and applying higher R-Value construction materials, air temperature and radiant temperature of the room are improved. In winter, it become warmer inside of the room