Philadelphia Climate Report II

Building Performance Simulation Assignment 2

Yuchi Wang

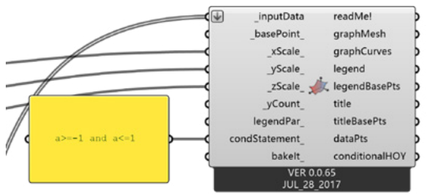
.epw file information :
Location : Philadelphia International Airport
Data Type : TWY 3

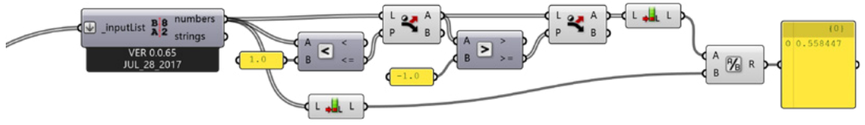
UTCI Analysis

UTCI stands for "The Universal Thermal Climate Index", which takes into consideration of the micro climatic effects in an environment such as radiant temperature, relative humidity, wind speed, etc. This index indicates a thermal value felt by occupants. However, UTCI is only suitable for outdoor analysis.

These charts on the right shows the overall condition of person according to UTCI. -3 means extremely cold, while +3 means extremely hot. This chart divide people's feeling into 7 level. In my analysis, I consider the index above +1 as over heat and below -1 as over cold.

Chart 1 is the overall condition of person index across the year. Chart 2 and Chart 3 separate the comfort zone from the whole year data. After calculation, we know that about 55.84% of the year can be considered comfortable. During the uncomfortable times, we can see that the summer day time and January nights are most discomfortable.





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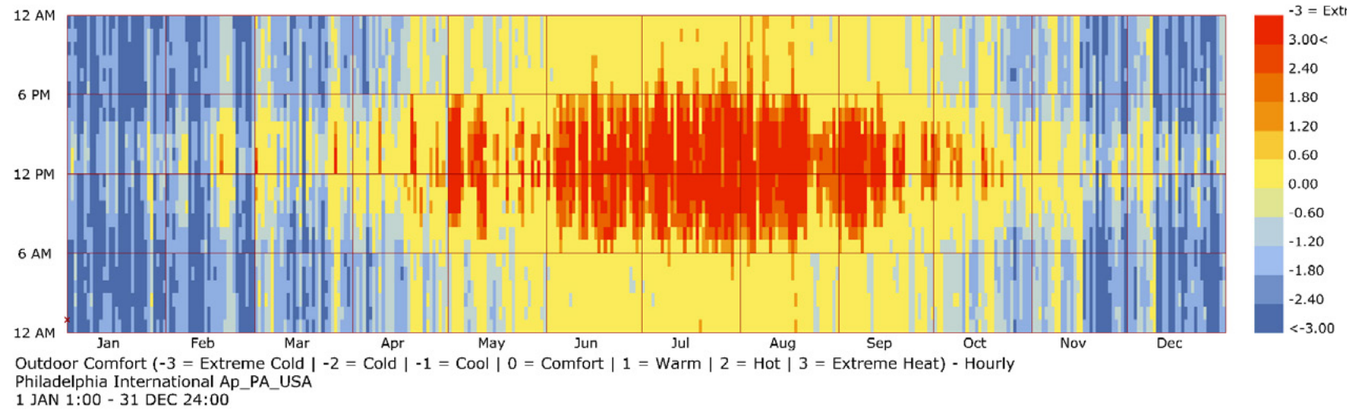
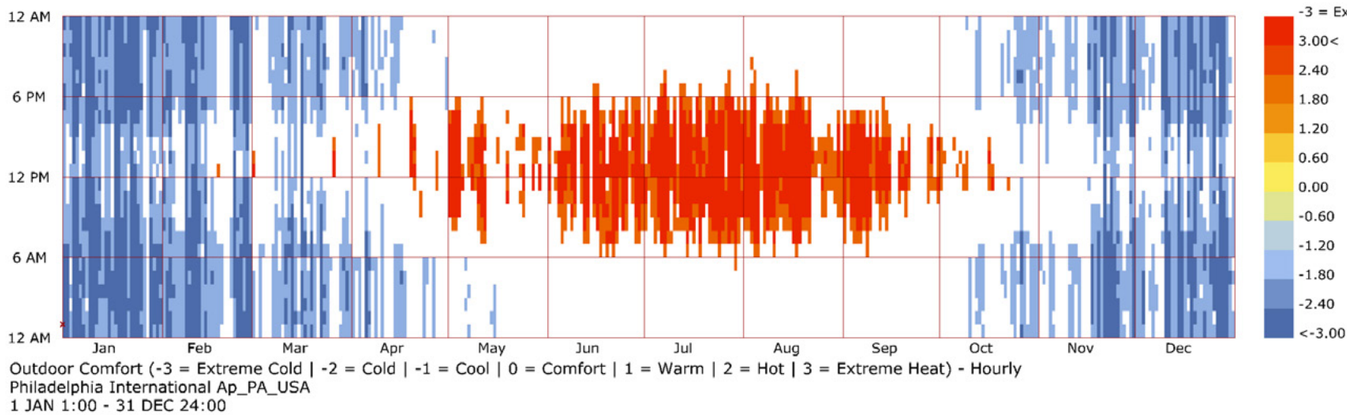
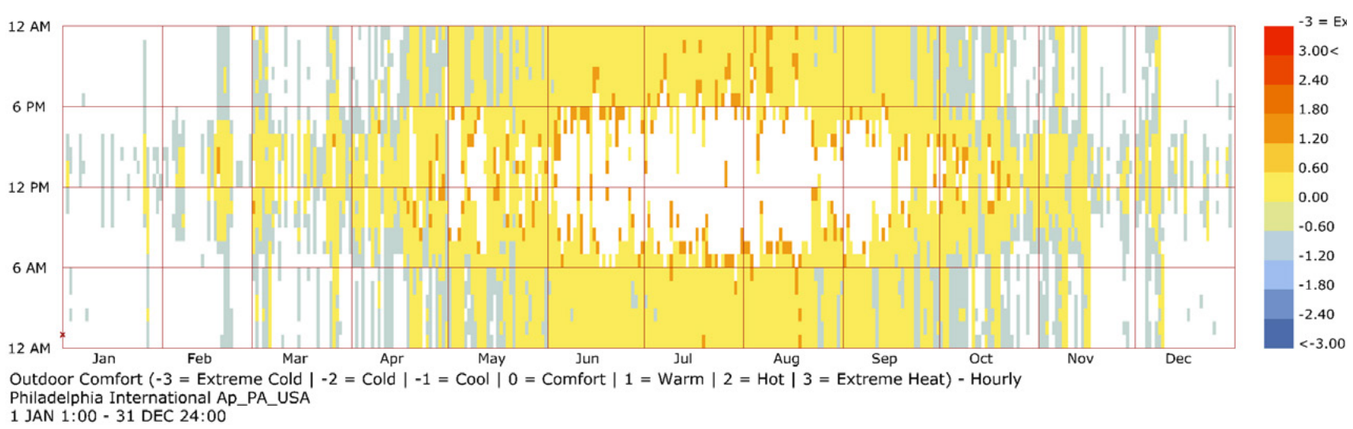


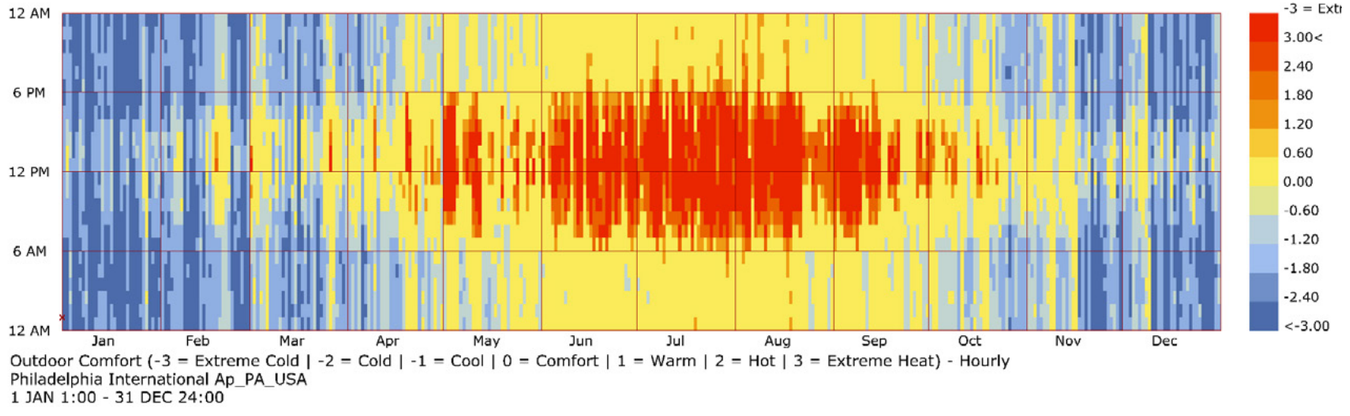


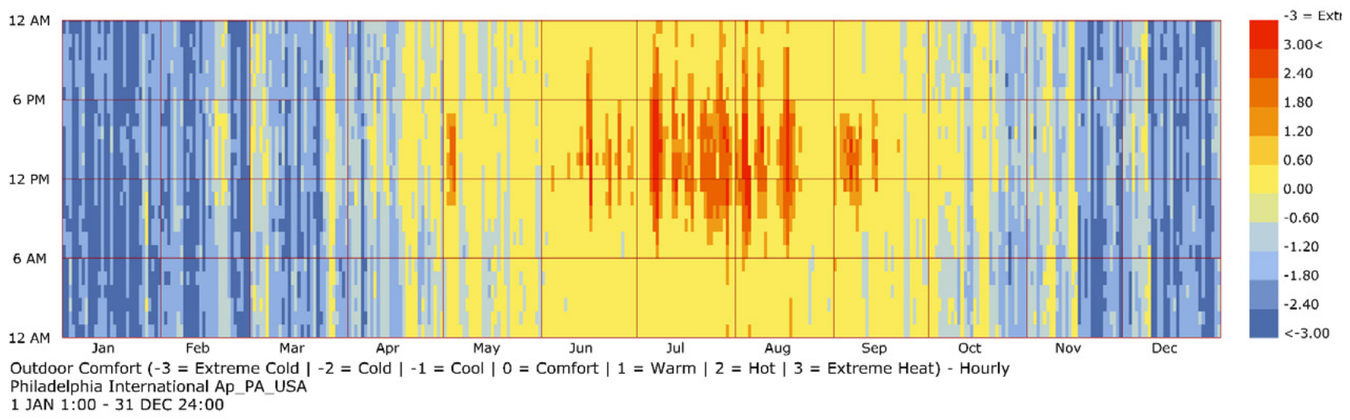


Perfect Sun Shader Imagination

The two charts on the right shows the difference of outdoor comfort condition between total sun shader and total exposed to solar radiation.

In this case, we can calculate how much percentage of hours a perfectly smart sun shader can improve during the year. Before sun shader, the overheat time period is 12.51%, and after the perfect sun shader, the overheat time period is 3.14%, meaning the smart shader can add 9.38% of a whole year hour to comfort zone.





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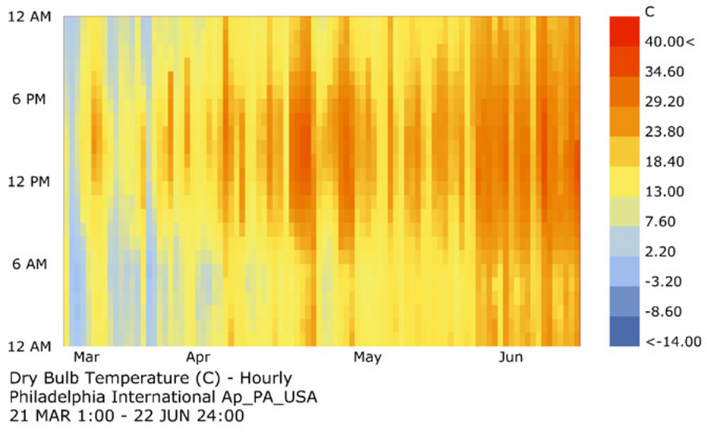
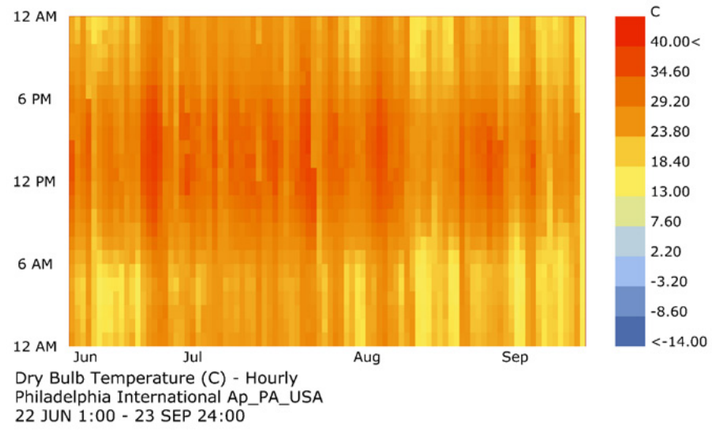
Overall Dry Bulb Temperature Analysis

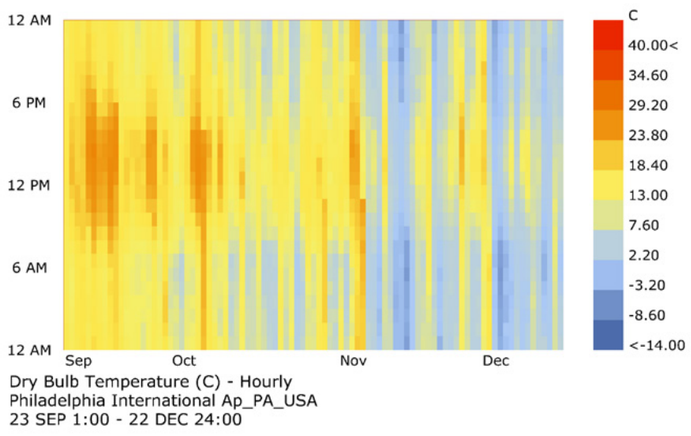
Philadelphia locates in east coast of United States. Greater Philadelphia lies at the southernmost tip of the humid continental climate zone, with some characteristics of the humid subtropical climate.

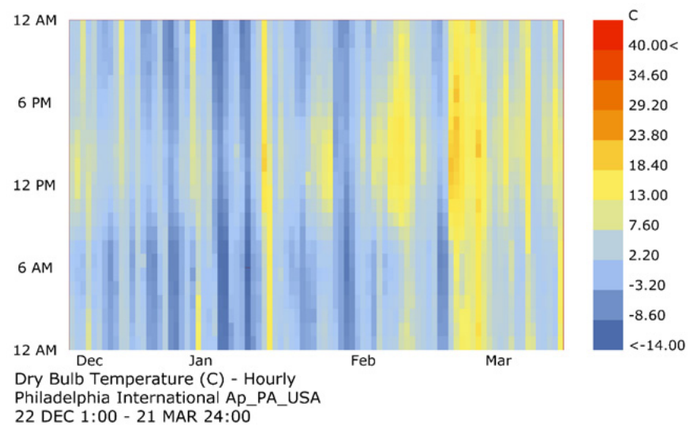
The graph on the right shows that from June to late September, Philadelphia is in high temperature all day, with 20 degree or higher. While from December to late February, the temperature is around or below 0 degree for most of time.

After calculation, the average temperature in these four seasons are as follows:
Spring: 16.1 degree
Summer: 23.7 degree
Fall: 9.2 degree
Winter: 1.31 degree









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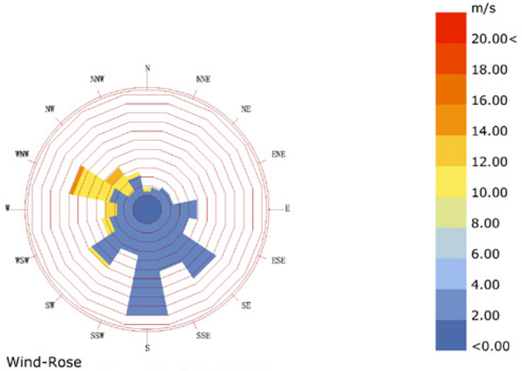
Uncomfortable Wind Directions Analysis

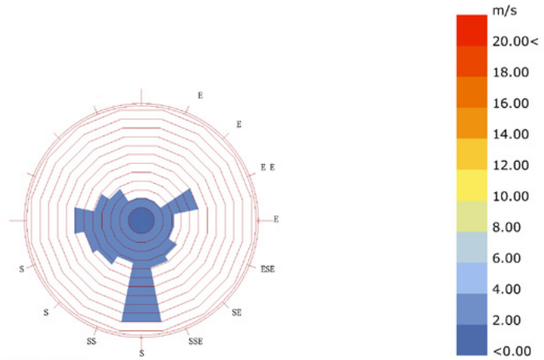
During different seasons, we define different comfortable threshold for wind velocity.

Normally, the preferred wind speed for good ventilation should between 2m/s and 10m/s. As a result, during the cold seasons, the larger the wind velocity, the more heat a house will lose when there is natural ventilation. During the hot seasons, large wind velocity will help reduce the heat inside but slow wind does no good for heat reducing.

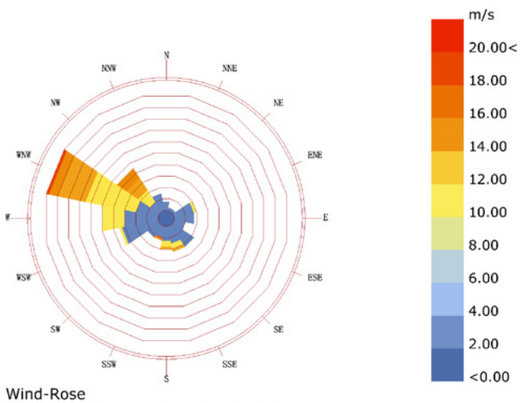
In spring, although there are a lot of slow wind from south, the strong wind are mostly from northwest. During summer, we can see that the overall uncomfortable wind and from south with a low velocity. In autumn, uncomfortable winds are mostly the strong wind, which come from northwest. In winter, the uncomfortable winds are also mostly from northeast, including the strong wind and slow wind.



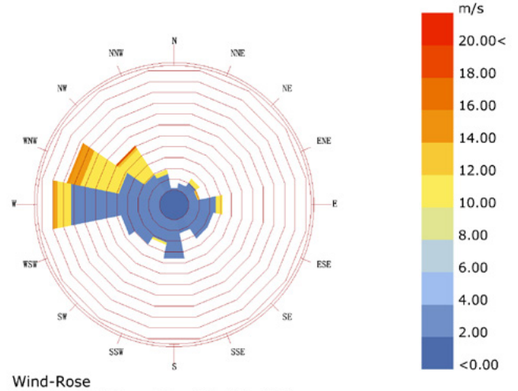
Wind-Rose
Philadelphia International Ap_PA_USA
21 MAR 1:00 - 22 JUN 24:00
Hourly Data: Wind Speed (m/s)
Calm for 2.53% of the time = 57 hours.
Each closed polyline shows frequency of 0.1%. = 2 hours.
... ...
Conditional Selection Applied:
Wind Speed < 2
or Wind Speed > 10
203.0 hours of total 8760.0 hours (2.32%).
203.0 hours of analysis period 2256.0 hours (9.00%).



Wind-Rose
Philadelphia International Ap_PA_USA
22 JUN 1:00 - 23 SEP 24:00
Hourly Data: Wind Speed (m/s)
Calm for 1.86% of the time = 42 hours.
Each closed polyline shows frequency of 0.1%. = 1 hours.
... ...
Conditional Selection Applied:
Wind Speed < 2
or Wind Speed > 10
144.0 hours of total 8760.0 hours (1.64%).
144.0 hours of analysis period 2256.0 hours (6.38%).



Wind-Rose
Philadelphia International Ap_PA_USA
23 SEP 1:00 - 22 DEC 24:00
Hourly Data: Wind Speed (m/s)
Calm for 2.06% of the time = 45 hours.
Each closed polyline shows frequency of 0.2%. = 3 hours.
... ...
Conditional Selection Applied:
Wind Speed < 2
or Wind Speed > 10
203.0 hours of total 8760.0 hours (2.32%).
203.0 hours of analysis period 2184.0 hours (9.29%).



Wind-Rose
Philadelphia International Ap_PA_USA
22 DEC 1:00 - 21 MAR 24:00
Hourly Data: Wind Speed (m/s)
Calm for 4.72% of the time = 102 hours.
Each closed polyline shows frequency of 0.2%. = 4 hours.
... ...
Conditional Selection Applied:
Wind Speed < 2
or Wind Speed > 10
341.0 hours of total 8760.0 hours (3.89%).
341.0 hours of analysis period 2160.0 hours (15.79%).

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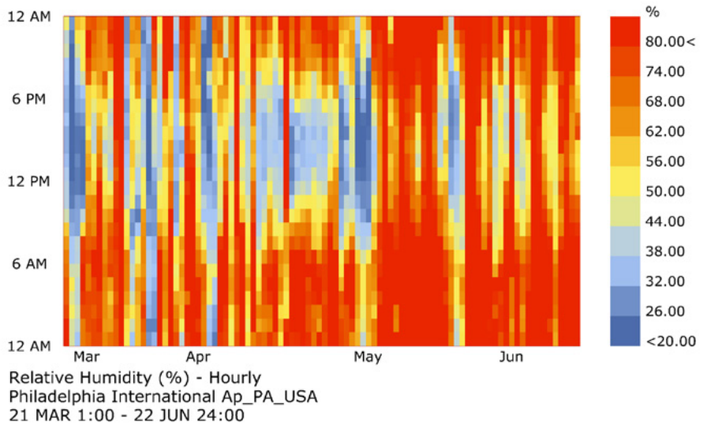
Overall Humidity Analysis

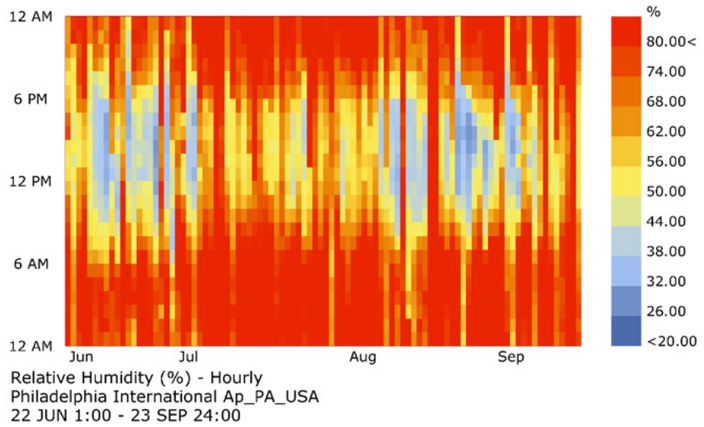
From the seasonal humidity chart, we can find that most of time, Philadelphia is in a high humidity condition. Especially in summer and autumn, the humidity can reach above 80%. Winter and spring have a relatively low humidity level.

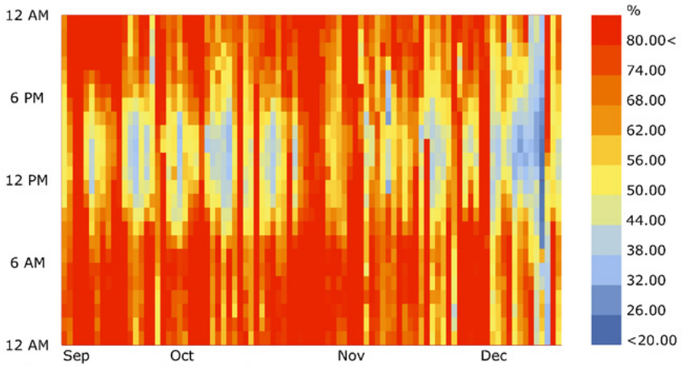
The chart at the bottom shows the humidity distribution throughout the whole year which is higher than 80% or lower than 20%, which is outside the comfort zone. We can find that Philadelphia is more likely to influenced by a high humidity level. When the sun sets, the humidity level tends to go up.

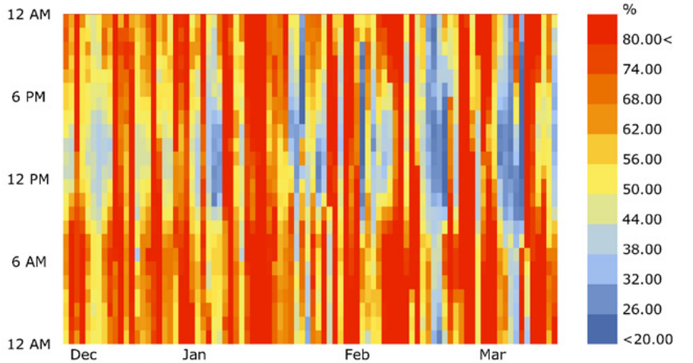
Now, we can calculate the percentage of over humidity level (more than 80%) according to seasons, and the result are shown as follows:
Spring: 26.6%
Summer: 34.2%
Fall: 30.0%
Winter: 26.4%

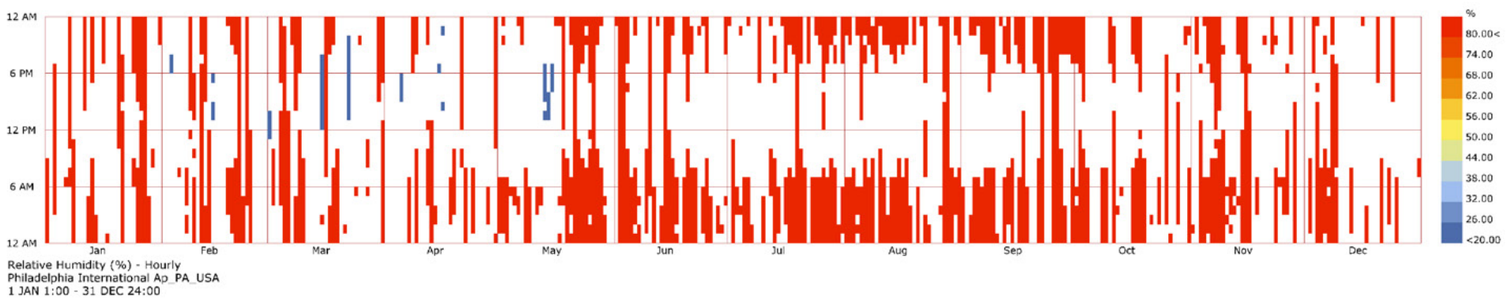
Now, we can conclude that the building should response to humidity to improve the interior experience.











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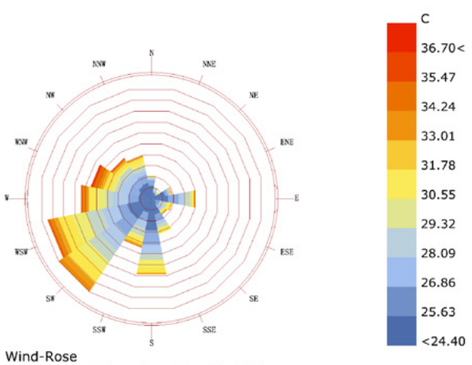
Passive Strategies to Improve Interior Satisfaction

The passive strategies can be applied to improve the interior environment condition according to three factors: dry bulb temperature, natural ventilation and humidity. We can set a ideal interior condition as follows:
18 < temperature < 24 degree
2m/s < wind vilocity < 10m/s
20% < humidity < 80%

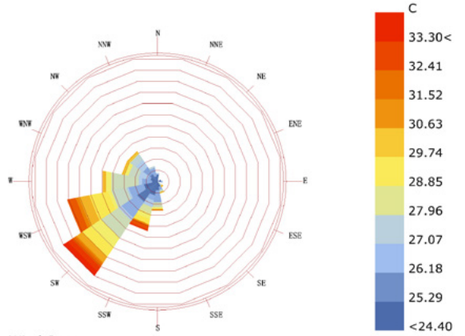
A) About Interior Overheat
Natural ventilation is an efficient way to reduce interior overheat. When we overlay the overheat condition with wind rose diagram, we can find that when the temperature is high, the winds are mostly come from southwest. As a result, introducing natural ventilation from southwest is an efficient way to reduce interior overheat.

B) Strategies for Ventilation
From A, we can conclude that during the summer, we can introduce natural ventilation from southwest to cool interior down. During the winter, from the wind rose chart below, we can see that when the temperature is below 18 degree, the wind are mostly come from northwest and northeast. To avoid heat lose, we should block the wind from these two directions.

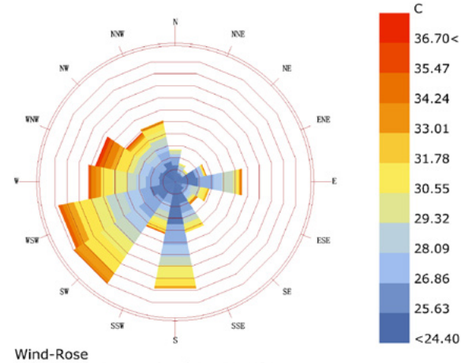
C) Avoid High Humidity
From the previous analysis, we can find that philadelphia is more easily to suffer from high humidity during summer and fall night. To solve this problem, we can cool down the interior temperature below the air's dewpoint, then use desiccants that adsorb or absorb water.



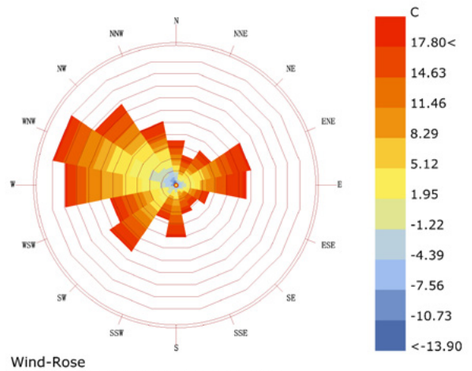
Wind-Rose
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00
Hourly Data: Dry Bulb Temperature (C)
Calm for 0.06% of the time = 5 hours.
Each closed polyline shows frequency of 0.2%. = 18 hours.
...
Conditional Selection Applied:
Dry Bulb Temperature > 24
1255.0 hours of total 8760.0 hours (14.33%).



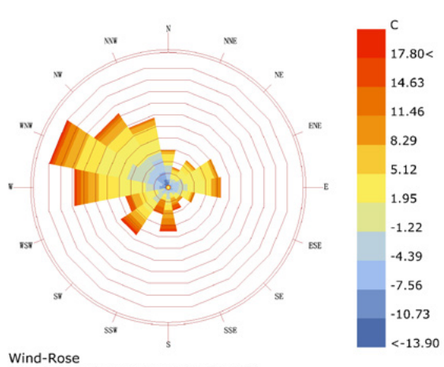
Wind-Rose
Philadelphia International Ap_PA_USA
21 MAR 1:00 - 22 JUN 24:00
Hourly Data: Dry Bulb Temperature (C)
Calm for 0.04% of the time = 1 hours.
Each closed polyline shows frequency of 0.3%. = 6 hours.
...
Conditional Selection Applied:
Dry Bulb Temperature > 24
270.0 hours of total 8760.0 hours (3.08%).
270.0 hours of analysis period 2256.0 hours (11.97%).



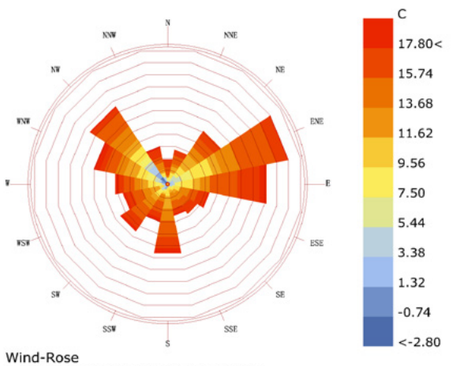
Wind-Rose
Philadelphia International Ap_PA_USA
22 JUN 1:00 - 23 SEP 24:00
Hourly Data: Dry Bulb Temperature (C)
Calm for 0.18% of the time = 4 hours.
Each closed polyline shows frequency of 0.5%. = 12 hours.
...
Conditional Selection Applied:
Dry Bulb Temperature > 24
984.0 hours of total 8760.0 hours (11.23%).
984.0 hours of analysis period 2256.0 hours (43.62%).



Wind-Rose
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00
Hourly Data: Dry Bulb Temperature (C)
Calm for 2.32% of the time = 203 hours.
Each closed polyline shows frequency of 0.8%. = 68 hours.
...
Conditional Selection Applied:
Dry Bulb Temperature < 18
5540.0 hours of total 8760.0 hours (63.24%).



Wind-Rose
Philadelphia International Ap_PA_USA
22 DEC 1:00 - 21 MAR 24:00
Hourly Data: Dry Bulb Temperature (C)
Calm for 4.68% of the time = 101 hours.
Each closed polyline shows frequency of 1.4%. = 30 hours.
...
Conditional Selection Applied:
Dry Bulb Temperature < 18
2087.0 hours of total 8760.0 hours (23.82%).
2087.0 hours of analysis period 2160.0 hours (96.62%).



Wind-Rose
Philadelphia International Ap_PA_USA
21 MAR 1:00 - 22 JUN 24:00
Hourly Data: Dry Bulb Temperature (C)
Calm for 2.08% of the time = 47 hours.
Each closed polyline shows frequency of 0.8%. = 17 hours.
...
Conditional Selection Applied:
Dry Bulb Temperature < 18
1324.0 hours of total 8760.0 hours (15.11%).
1324.0 hours of analysis period 2256.0 hours (58.69%).

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