FINAL ANALYSIS RESULTS COMPILATION

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ARCH 753, BUILDING PERFORMANCE SIMULATION

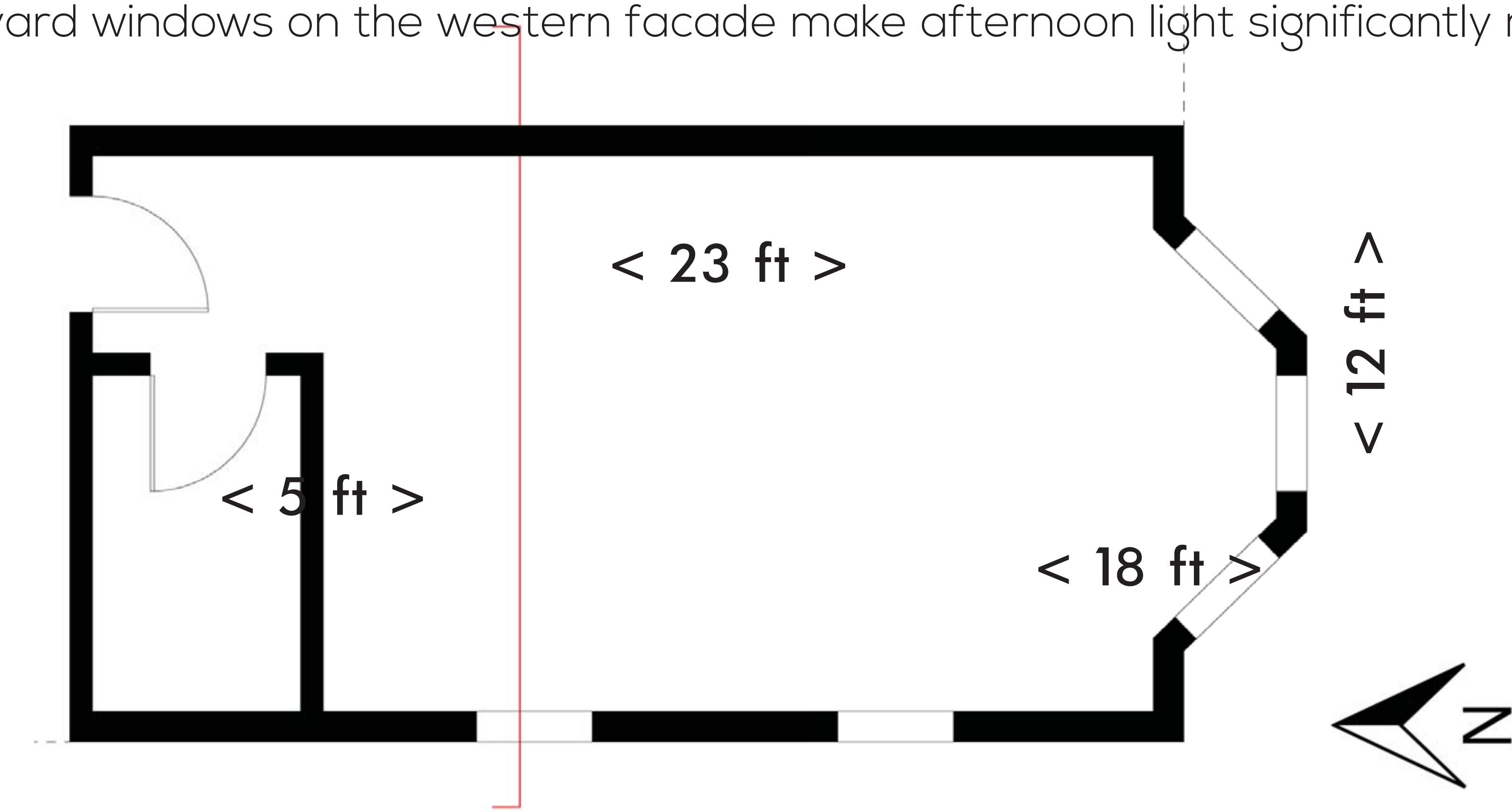
MOSTAPHA SADEGHIPOUR ROUDSARI

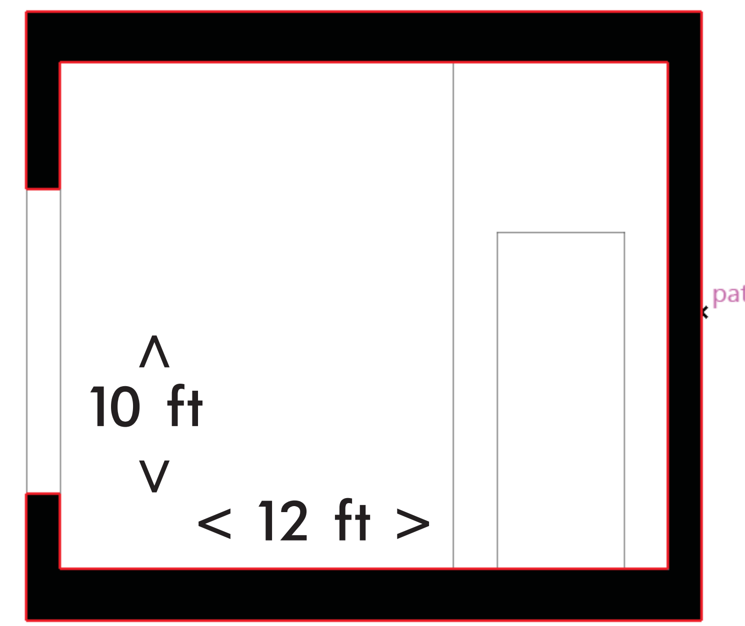
DECEMBER 11, 2017

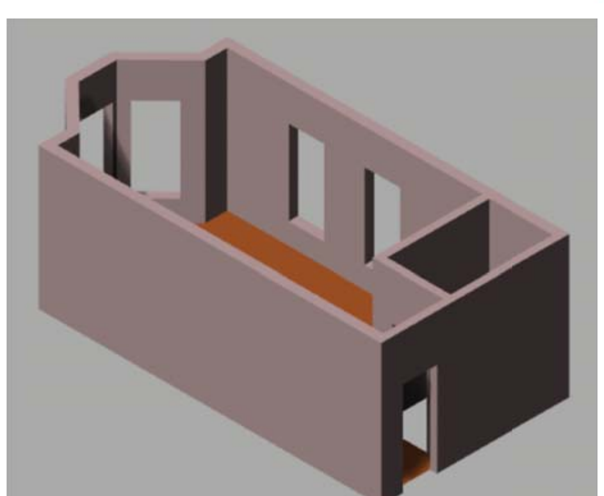
ROOM CONTEXT

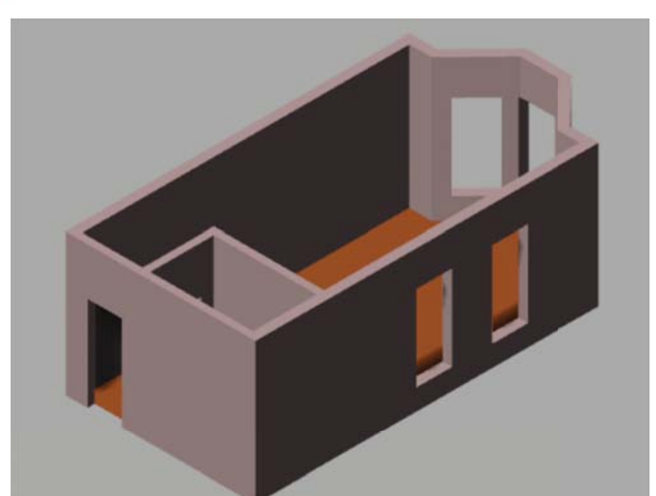
OVERVIEW OF SPACE IN QUESTION

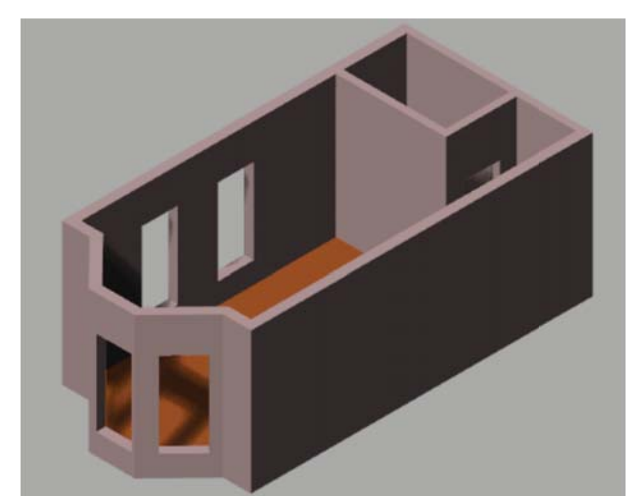
The space for which a comprehensive environmental analysis will be performed is a bedroom on the second floor of a 1915 Row House in Philadelphia, PA. The structure has brick masonry exterior walls and wood-framing on the interior. Because it is a row home, the room's floor, ceiling, eastern and northern walls are all adiabatic. Additionally, the space has a bay window that projects out from the masonry opening on the southern facade. As this window makes light from the east and west seem direct on the southern face, the bay is a significant factor in examining daylight performance. Furthermore, the side-yard windows on the western facade make afternoon light significantly more effective and relevant for the space.

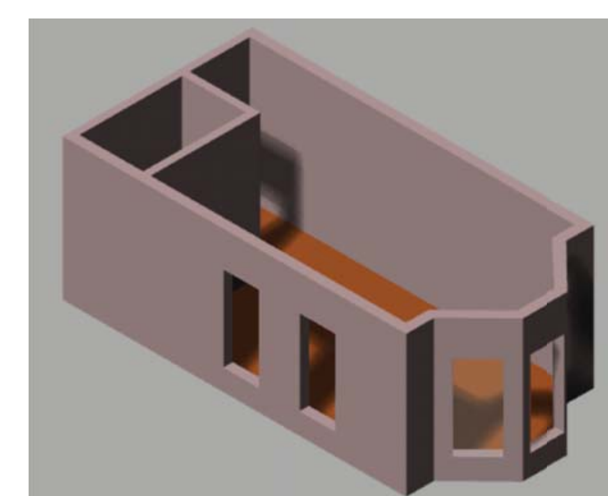










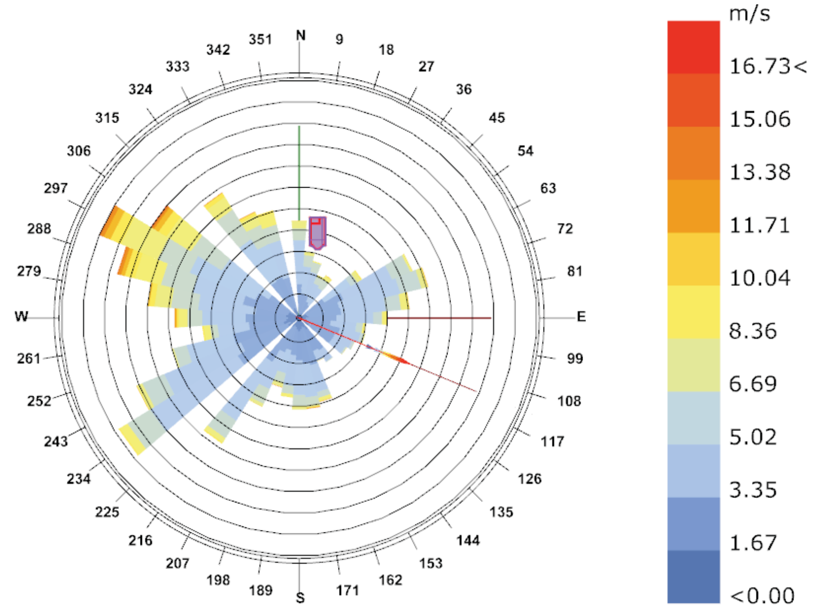


ENVIRONMENT CONTEXT

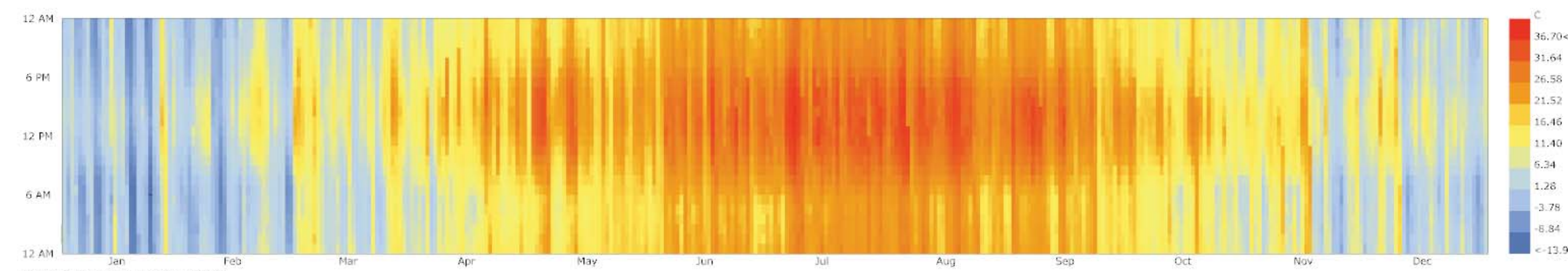
WIND PATTERNS, DEW POINT, DRY BULB, & SUN PATH

In order to do a comprehensive analysis of the space in question, it is necessary to have a comprehensive body of information showing the environmental context of the site in Philadelphia. These include a Wind Rose showing the prevailing winds in the area and the annual wind speeds, the annual adaptive comfort zone, the annual dry bulb temperatures and dew point temperatures, as well as the sun paths over the city.

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



Wind-Rose
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00
Hourly Data: Wind Speed (m/s)
Calm for 2.81% of the time = 246 hours.
Each closed polyline shows frequency of 0.6%. = 48 hours.



Dry Bulb Temperature (C) - Hourly
Philadelphia International Ap_PA_USA
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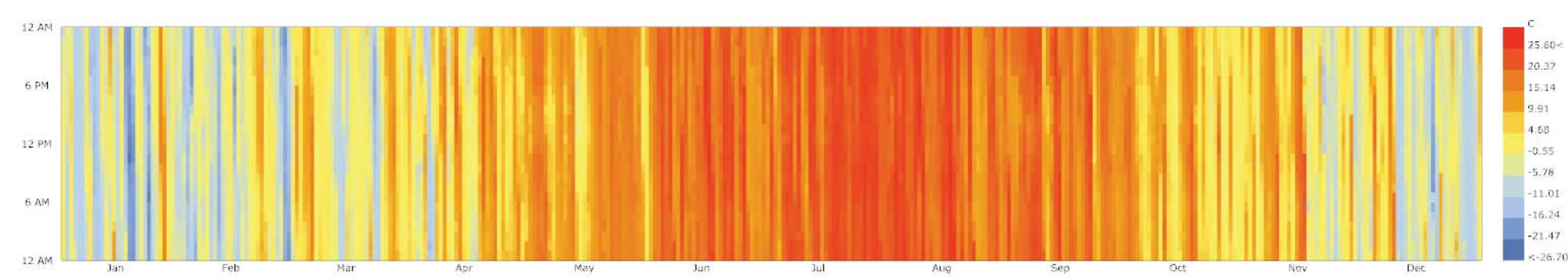

Dew Point Temperature (C) - Hourly
Philadelphia International Ap_PA_USA
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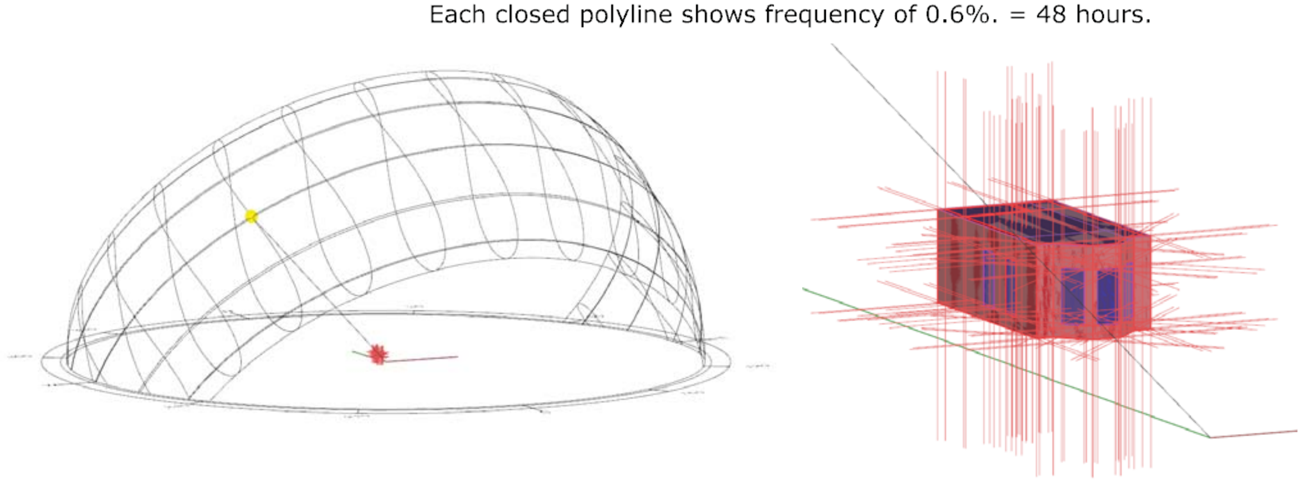
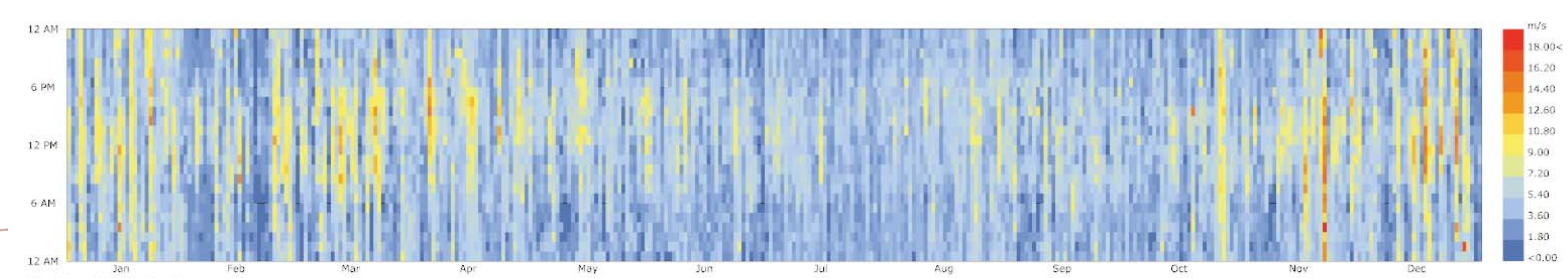


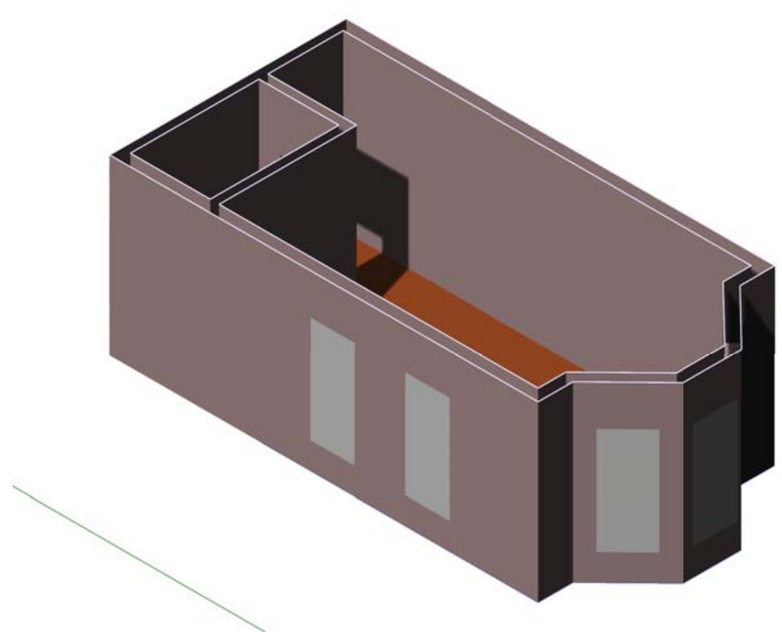


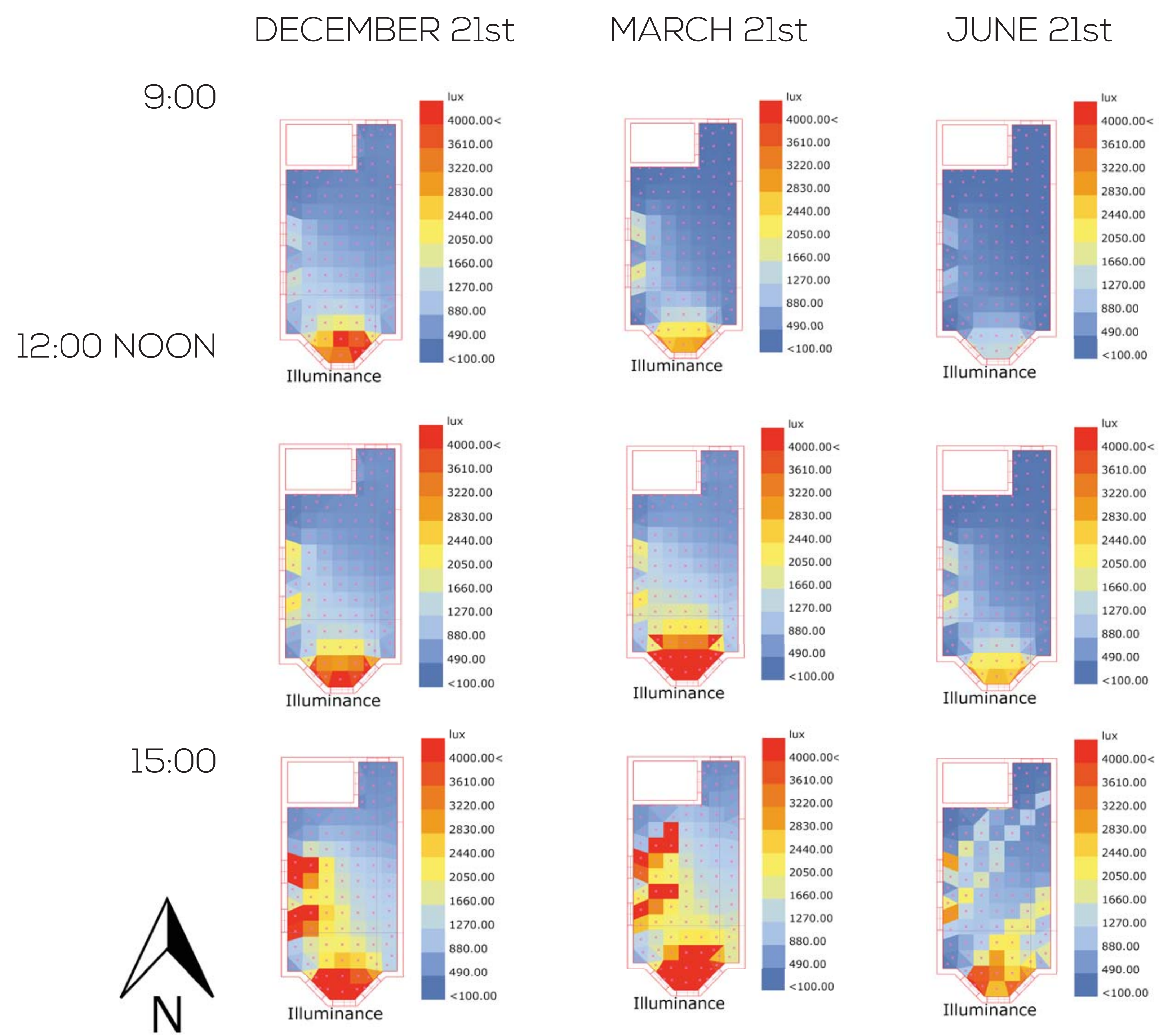
Wind Speed (m/s) - Hourly
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00

Sun paths relative to the space, 15:00 on Vernal Equinox.

GENERAL DAYLIGHT ANALYSIS
EXISTING CONDITIONS, SOLSTICES & VERNAL EQUINOX

This analysis looks at the basic levels of daylight that enter this space at various times during the day and various points in the year. These are at 9:00, 12:00, and 15:00, and at the Summer and Winter Solstices as well as the Vernal Equinox. The room actually receives the deepest light penetration with the least amount of glare at 15:00 on the Summer Solstice, due to the intensity of the solar radiation. The highest amounts of glare occur at 15:00 on the Vernal Equinox and to a lesser extent on the Winter Solstice.





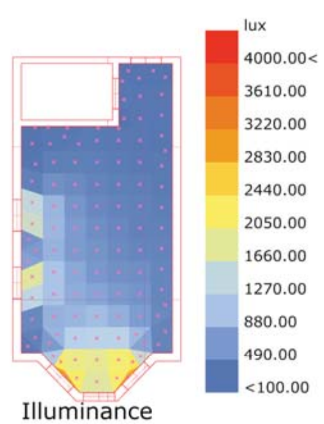
DAYLIGHT ANALYSIS

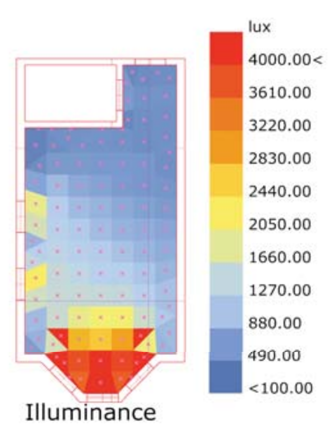
DIRECTLY SOUTH-FACING WINDOW BLOCKED

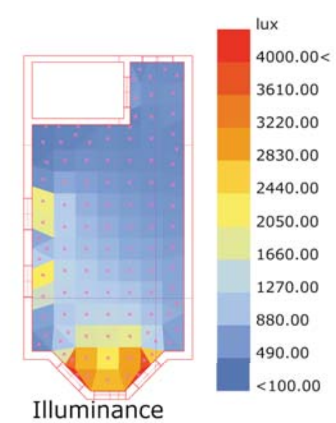
Building off of the earlier observations of daylight in the room, this analysis looks to see what the overall effects on the space will be if the central pane in the bay window -the only window in the space facing directly south- is obscured. If the room still received sufficient daylight from the SW, SE, and western windows then obscuring the central window could be a viable glare mitigation strategy. This analysis concluded that while glare from direct-south is reduced, there is no substantial change in glare from west, making it an incomplete solution.

DECEMBER 21st MARCH 21st JUNE 21st

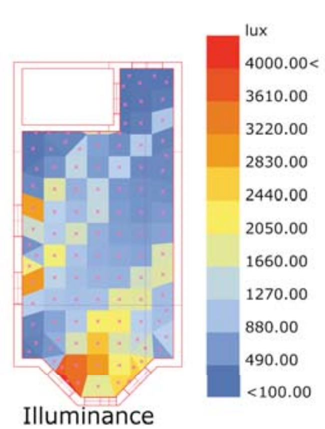
12:00 NOON

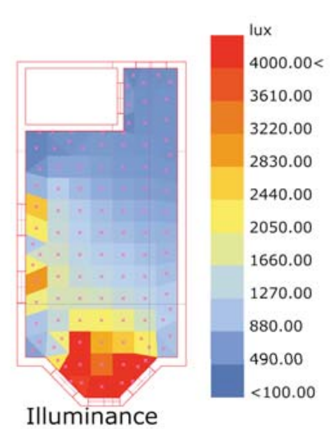


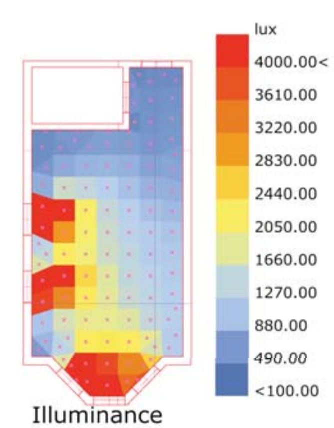




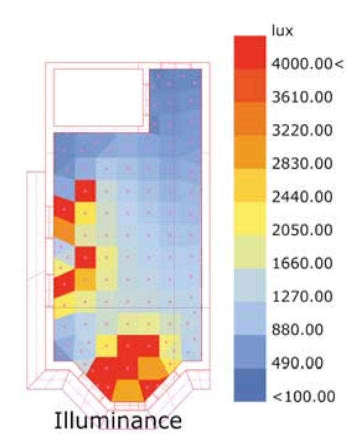
15:00



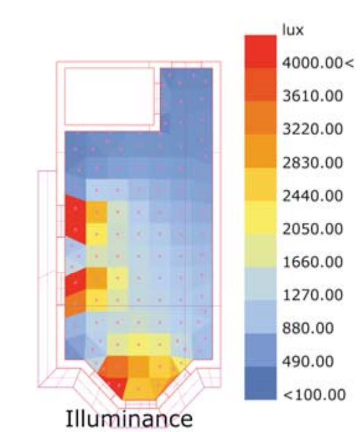




MARCH 21st



JUNE 21st



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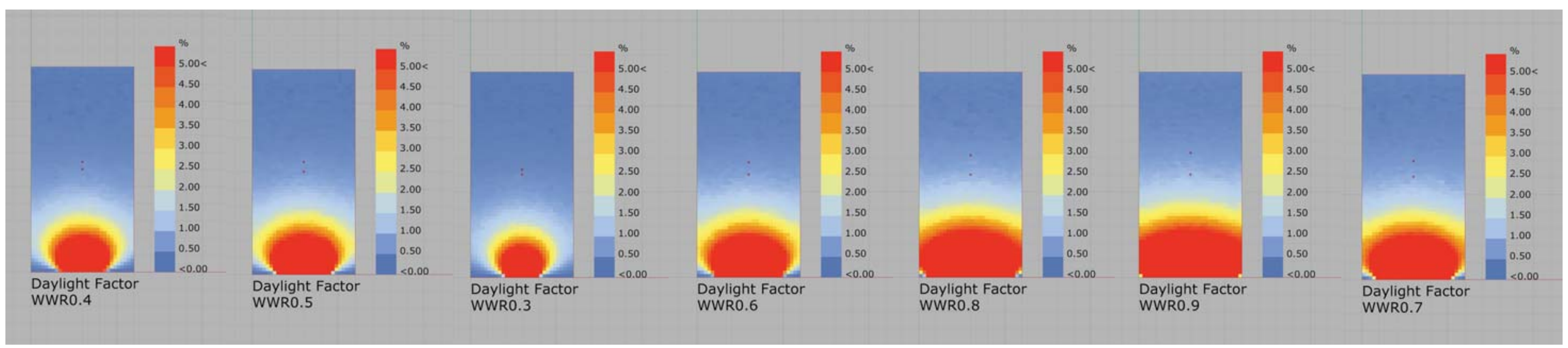
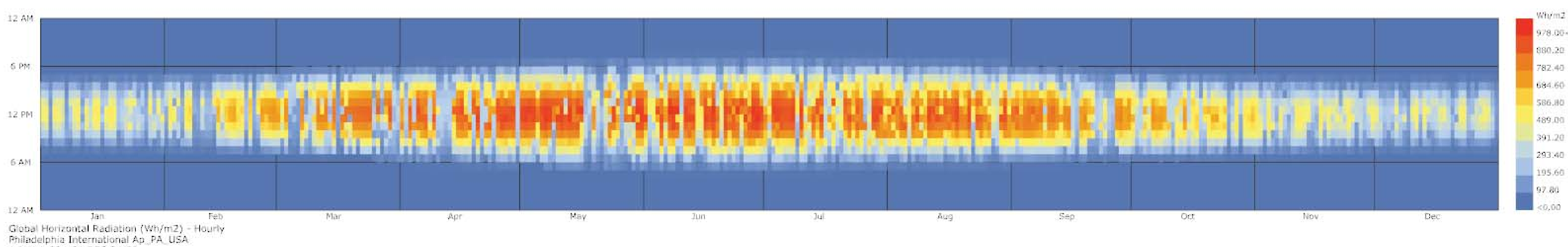
DAYLIGHT FACTOR

ANALYSIS OF EXPOSURE / OPENING SIZE, ILLUMINANCE & RADIATION

The space's Daylight factor is furthermore of concern as the Daylight Factor is necesscary for understanding the potential for Daylihgt Autonomy. This study used a simplified diagram of the south-facing room to observe how significant the Daylight Factor would be with glazing openings of various sizes. Also it is important in this context to look at Illuminance versus Radiation. In this space the Direct Normal Illuminance of 95.30 to 953.00 is highest in June & August, and more consistent with seasonal change. The Direct Normal Radiation of 9550.00 to 95500.00 is highest in June, July, & August, and lowest in February & March.



Daylight Factor vs South-Facing Glazing



DAYLIGHT ANALYSIS

CUSTOM JAGGED OVERHANG SHADING

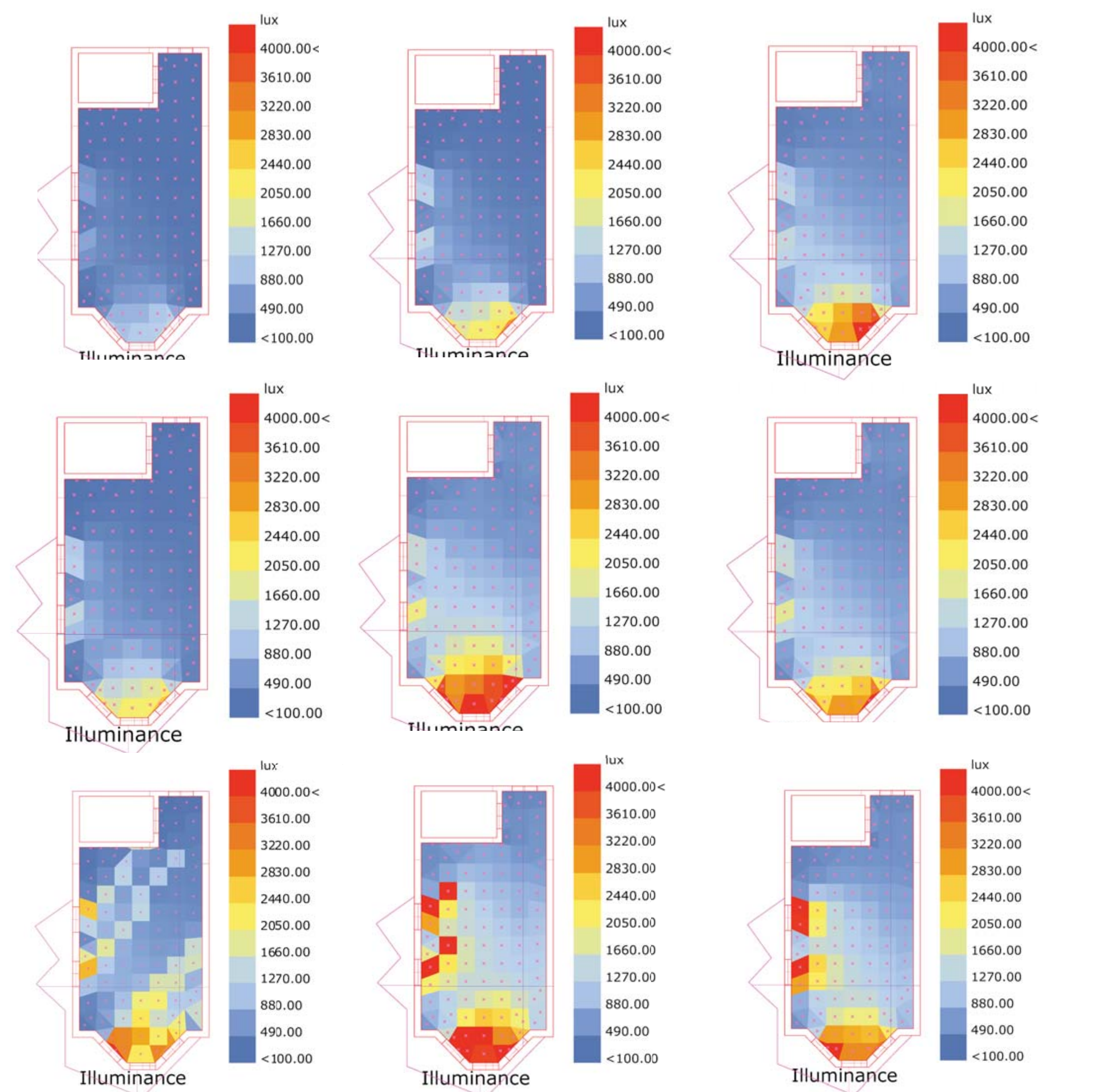
After analyzing how this room is affected by daylight, this analysis seeks to build off of those observations by testing the effects of a custom solar shade. This shade is flush with the top of the window's masonry opening, and is angled to the southwest, in order to intersect the most solar radiation vectors. This analysis demonstrated that this type of shading is most effective at the Summer Solstice when the sun is high, however at the Vernal Equinox the solar angle is still too low to be greatly impacted by a shade above the windows.

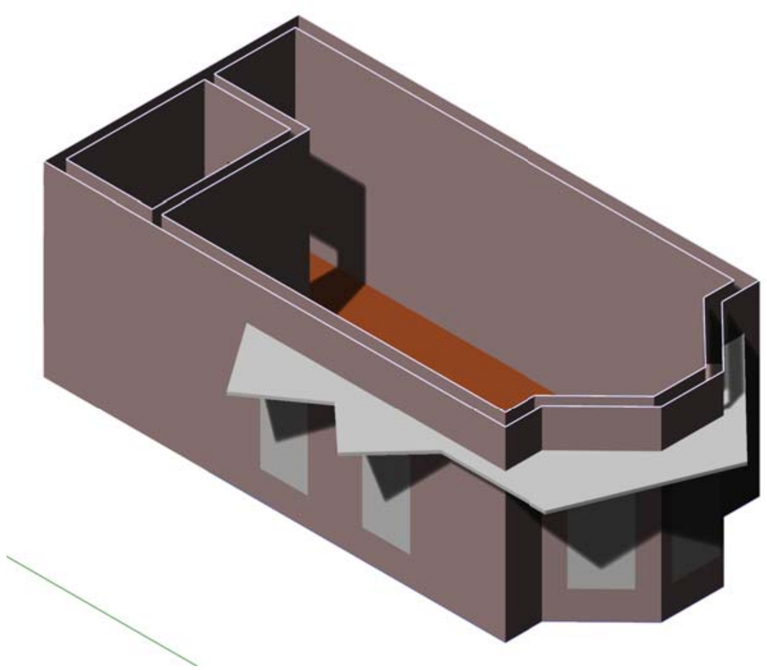
DECEMBER 21st MARCH 21st JUNE 2

9:00

12:00 NOON

15:00



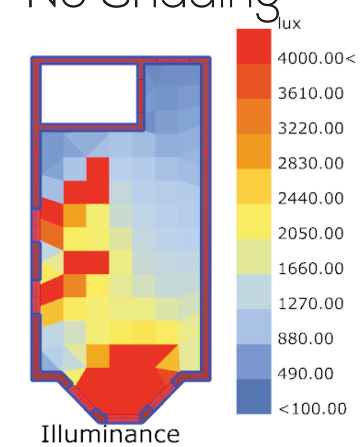


DAYLIGHT ANALYSIS

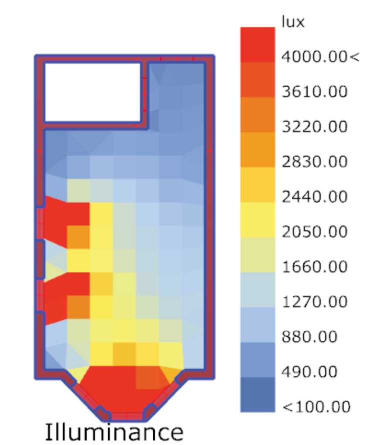
VARIOUS SHADING SCHEMES, GLARE MITIGATION

Building off the general analysis of how this room is affected by daylight, this analysis first determines at what time of year the most severe occurs. This is around the vernal equinox at 3:00 PM, when the sun is moderately intense, however still low enough in the sky to penetrate the space. A series of potential shading deployments then followed in order to ascertain the optimal shape and method for blocking glare. The most successful involved custom sail-shaped shades positioned southwest of the window, however this would result in substantial view reduction as well.

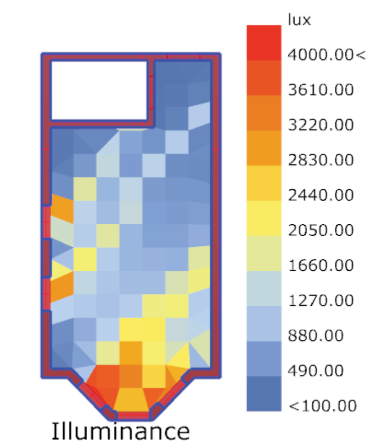
No Shading



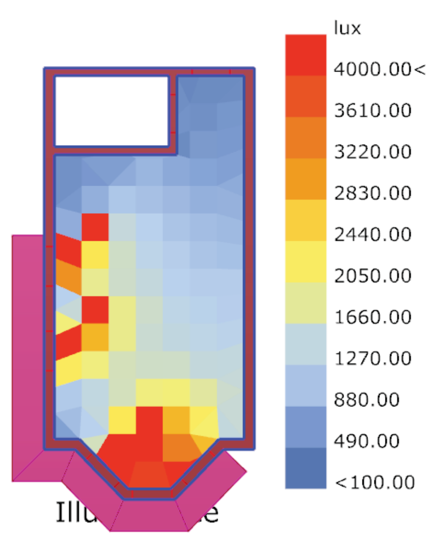
Vernal Equinox



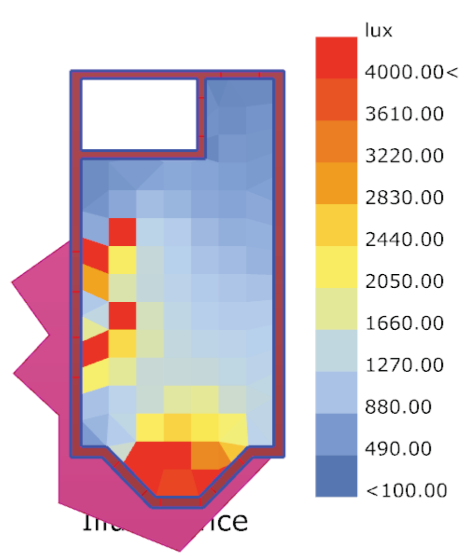
Summer Solstice



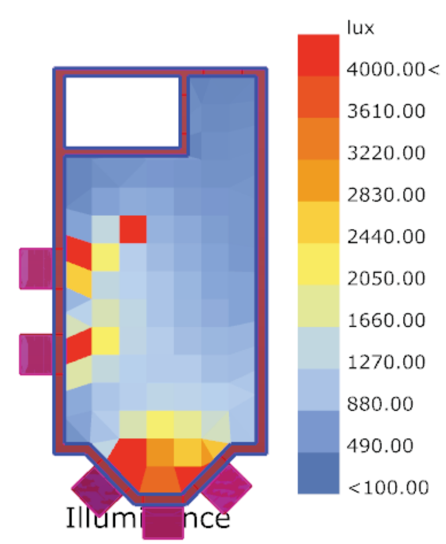
Winter Solstice



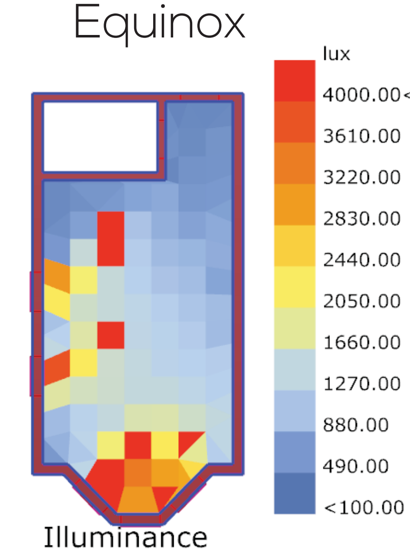
1M Offset Shade



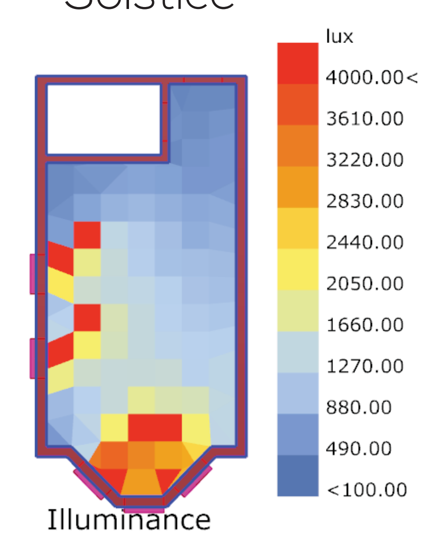
Jagged Vector-Based Shade



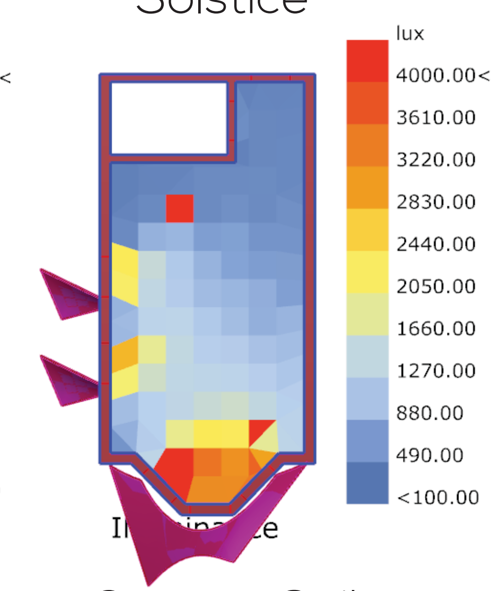
Angled Awnings



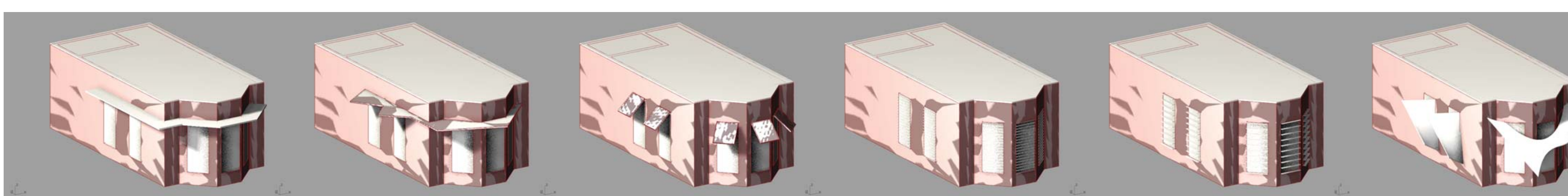
Short & Close Window Ribs



Wide & Far Window Ribs



Custom Sails

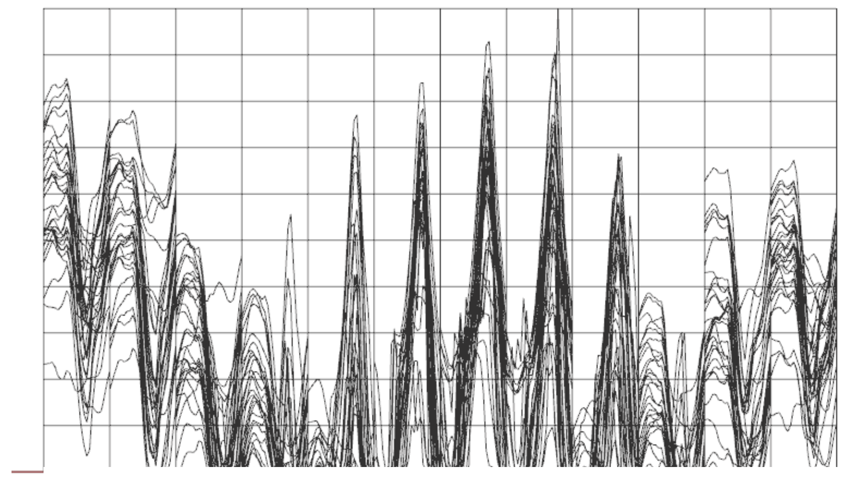


ENERGY USAGE

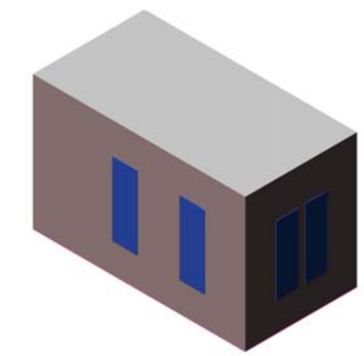
TOTAL YEARLY KWH WITH RESPECT TO CONTEXT AND SHADING

This analysis seeks to determine the effects of adjacent structures and shading interventions on the annual heating and cooling loads of the room in question. Basically to determine if the adjacent row house- with an adiabatic parti wall is a help or a hindrance, and how much of an effect the addition of a simple 1M solar shade will have on annual energy usage.

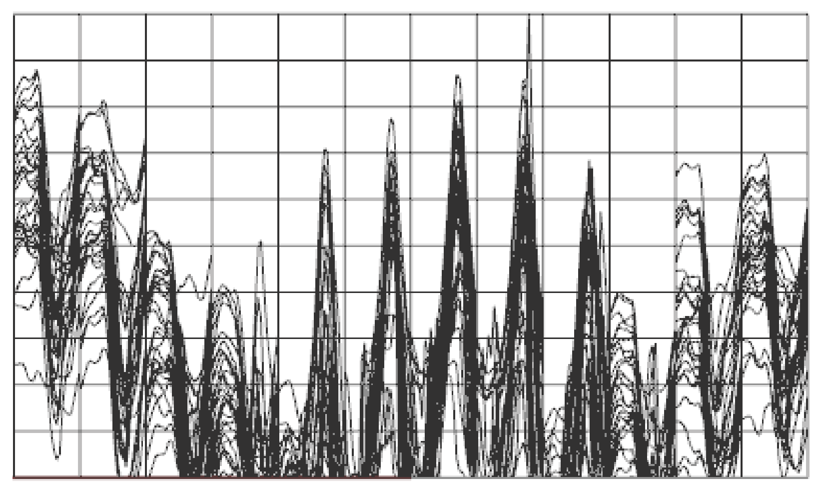
Without adjacent row-house.



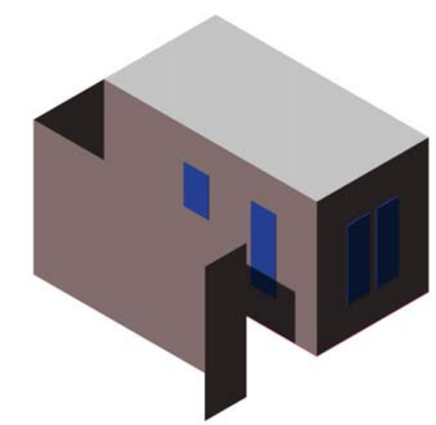
Total Cooling: 2643.897 kWh
Total Heating: 5793.826 kWh



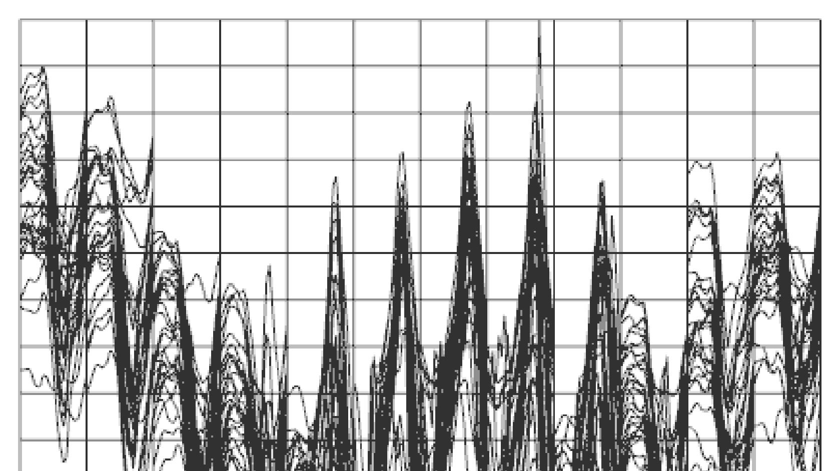
With adjacent row-house/ side-yard.



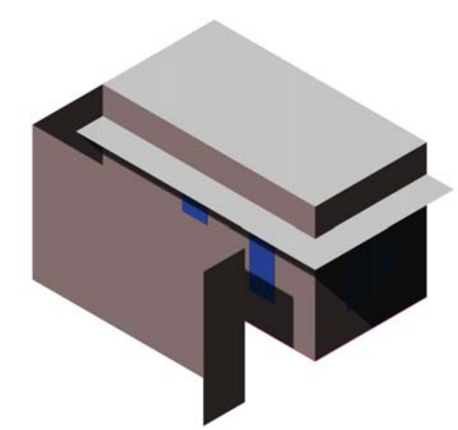
Total Cooling: 2391.082 kWh
Total Heating: 5887.804 kWh



With the addition of a hypothetical 1M sun-shade.



Total Cooling: 2153.921 kWh
Total Heating: 6036.145 kWh



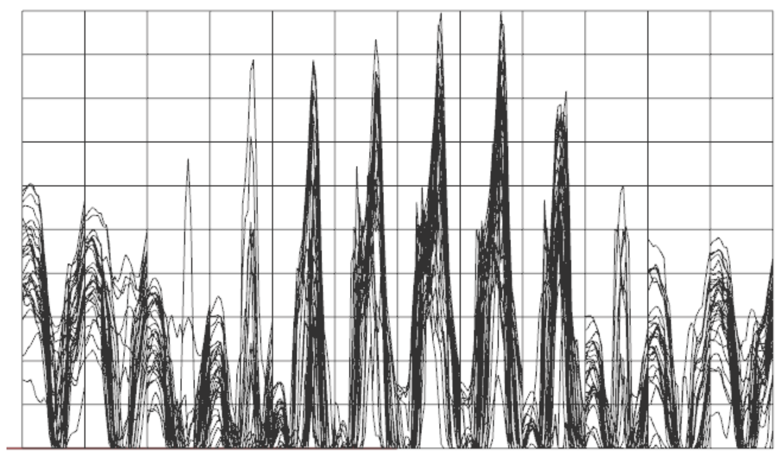
ENERGY USAGE

TOTAL YEARLY KWH WITH RESPECT TO INSULATION

Building off the general analysis of annual heating and cooling loads, the insulating capacity of a building's envelope, and the transmissive properties of its glazing, have a significant impact on said building's energy usage. In this analysis, a comparative study is done with the R-Value of the room's walls and the U-Value, Solar Heat Gain Coefficient, and Visual Transmittance of its glazing.

R-Value:

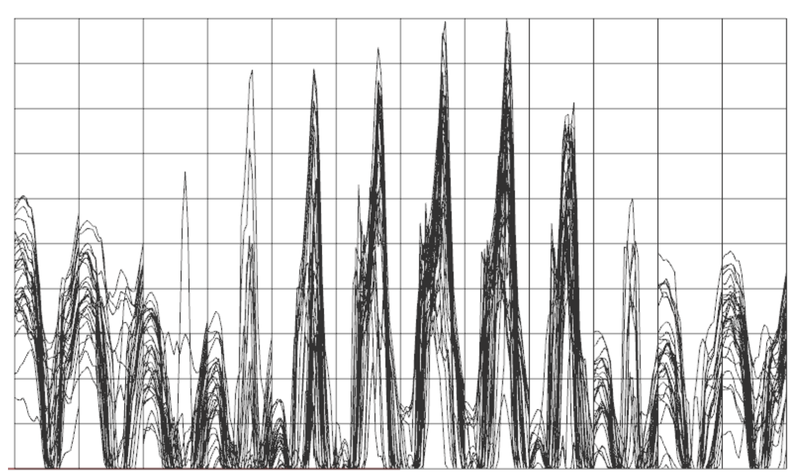
Roof: 45
Walls: 17
Floor: 40



Total Cooling: 2589.97 kWh
Total Heating: 2848.71 kWh

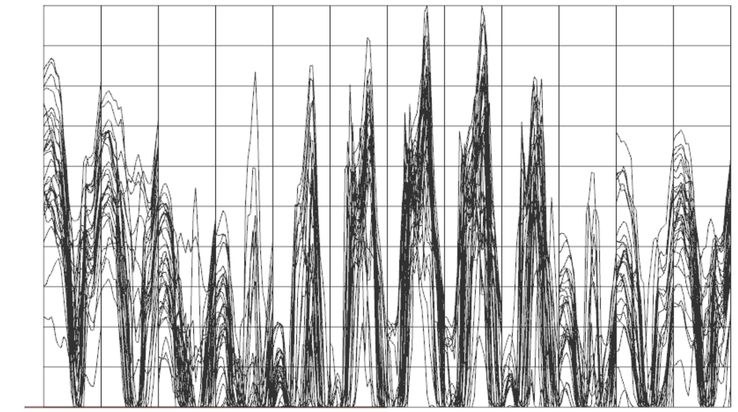
R-Value:

Roof: 30
Walls: 20
Floor: 30



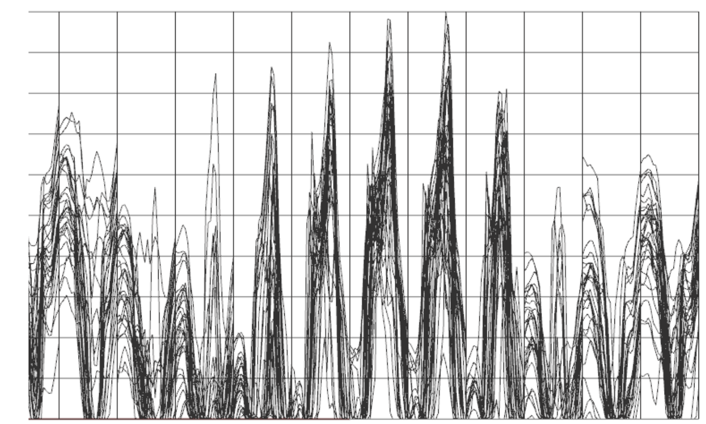
Total Cooling: 2597.2 kWh
Total Heating: 2908.2 kWh

U-Value: .25
SHGC: .35
Vis Tran: .55



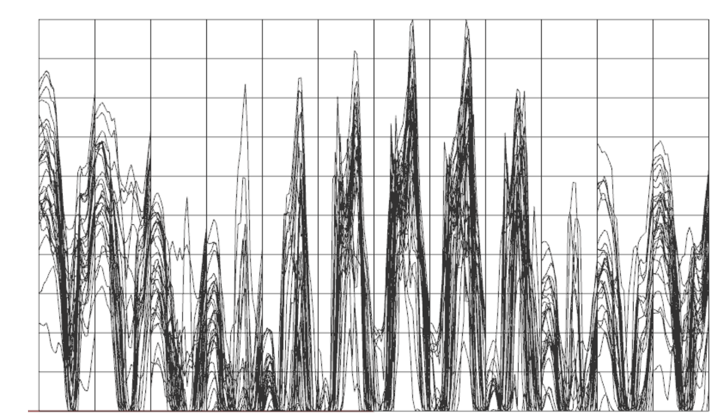
Total Cooling: 1831.57 kWh
Total Heating: 2632.54 kWh

U-Value: .35
SHGC: .45
Vis Tran: .75



Total Cooling: 1928.4 kWh
Total Heating: 2817.7 kWh

U-Value: .65
SHGC: .55
Vis Tran: .6



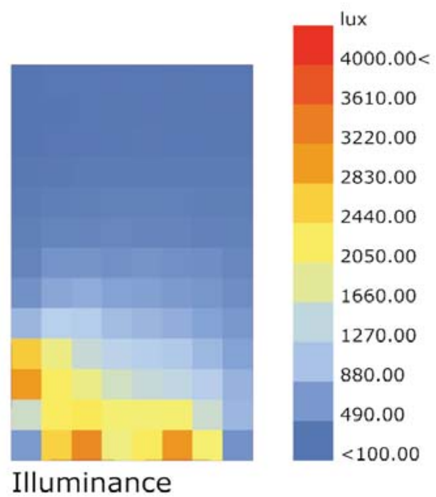
Total Cooling: 2153.78 kWh
Total Heating: 3346.00 kWh

USEFULL ILLUMINANCE

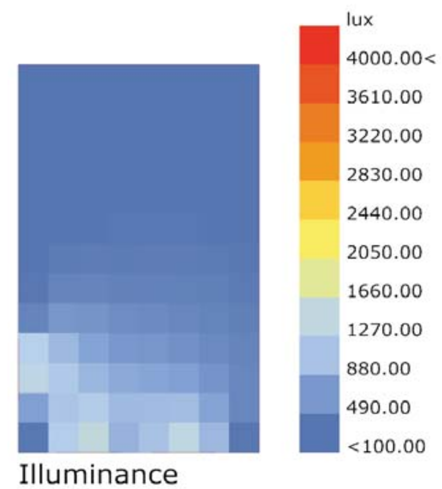
THE EFFECT OF FINISH MATERIALS ON UDI

Analysing Usefull Daylight Illuminance is vital in order to be able to understand how daylight will be reflected off finish materials into a space, This includes the transmissivity of the glass itself, as well as the reflectance of the floor onto which the light first makes contat. In this analysis, the aforementioned transmittance and reflectance were observed for maximum daylight distribution on the Summer and Winter Solstices.

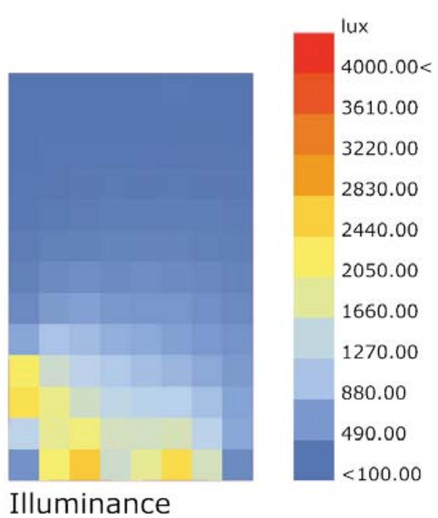
Winter Solstice 12/21



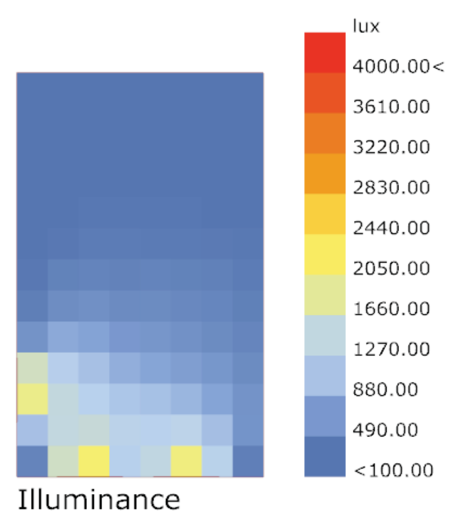
12:00 PM
Floor Reflectance: .2
Glass Transmittance: .6



12:00 PM
Floor Reflectance: .2
Glass Transmittance: .3

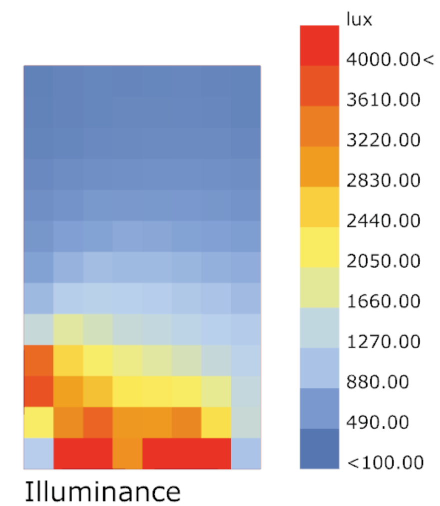


12:00 PM
Floor Reflectance: .4
Glass Transmittance: .5

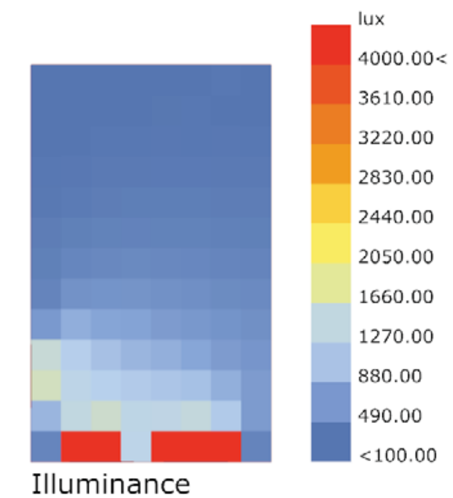


12:00 PM
Floor Reflectance: .6
Glass Transmittance: .4

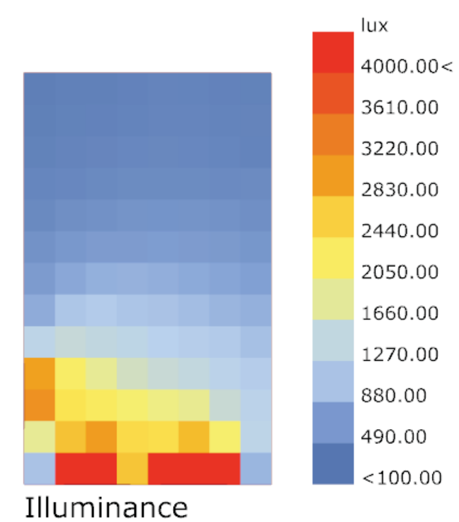
Summer Solstice 06/21



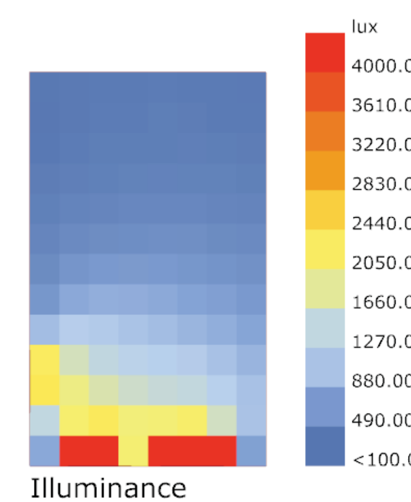
12:00 PM
Floor Reflectance: .2
Glass Transmittance: .6



12:00 PM
Floor Reflectance: .2
Glass Transmittance: .3



12:00 PM
Floor Reflectance: .4
Glass Transmittance: .5



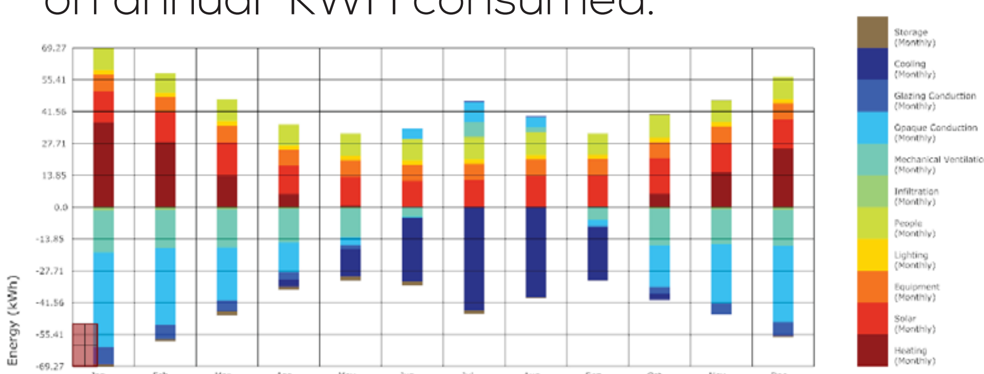
12:00 PM
Floor Reflectance: .6
Glass Transmittance: .4

ENERGY BALANCE

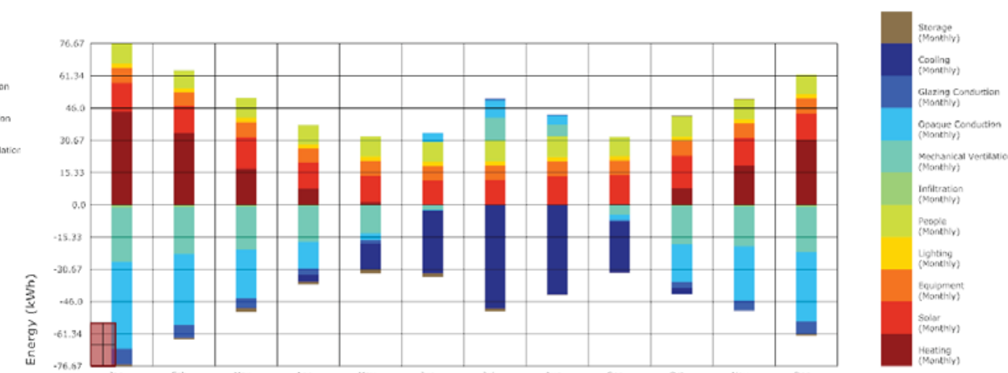
ENERGY BALANCE, AIR CHANGE & OCCUPANT LOAD

It is of significant importance to determine the primary factors affecting the overall environmental performance of this south-facing room in a 1915 Philadelphia row-house. These effects can be seen in the associated Energy Balance charts, and the variations due to certain factors. In this case, the Energy Balance relative to air changes per hour, number of occupants per square meter, U-Value of the windows, and R-Value of the exterior walls are of particular importance. The charts make it apparent how the space's environmental performance is improved with a reduction in the rate of air exchange and an increase in the number of persons per square meter.

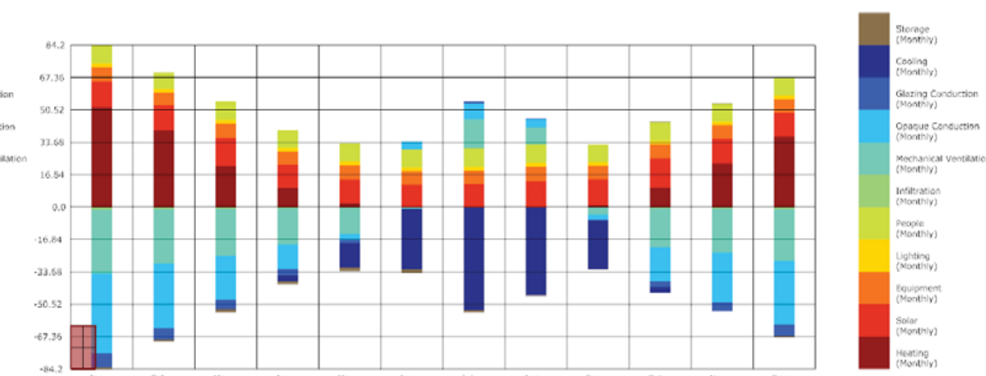
Effects of Air Changes per hour on annual KWH consumed.



1 Air Change / Hour

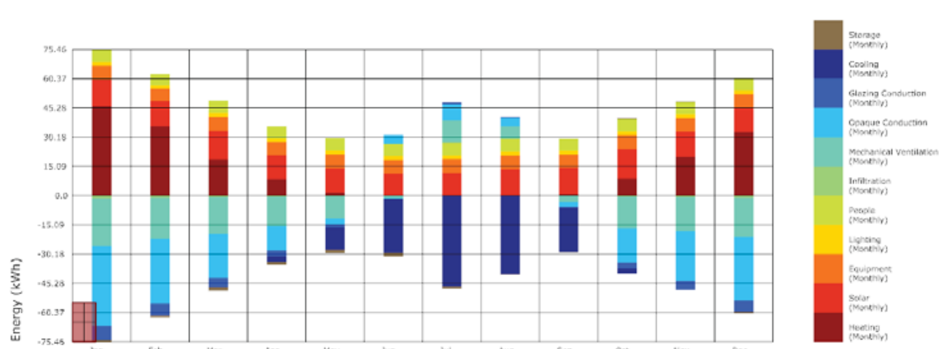


1.5 Air Change / Hour

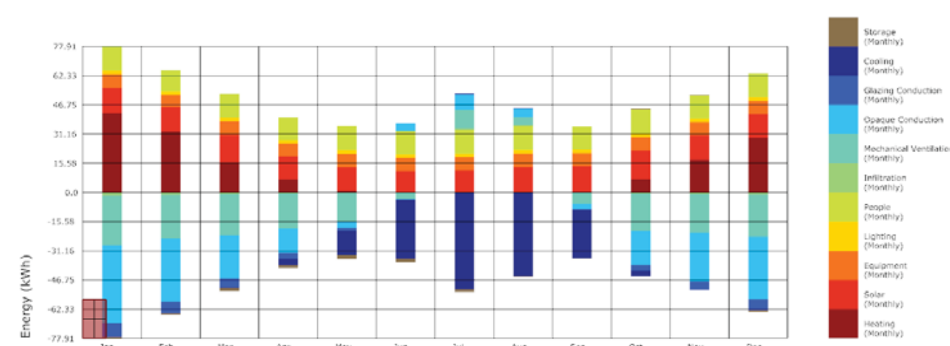


2 Air Change /

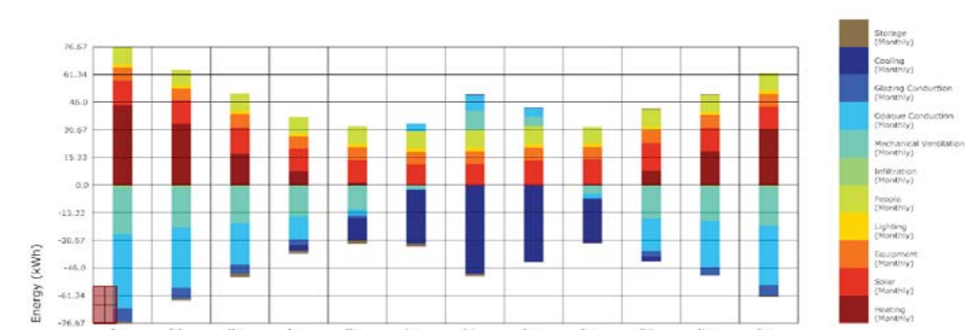
Effects of Persons per square meter on annual KWH consumed.



.1 Person/Meter



.2 Person/Meter



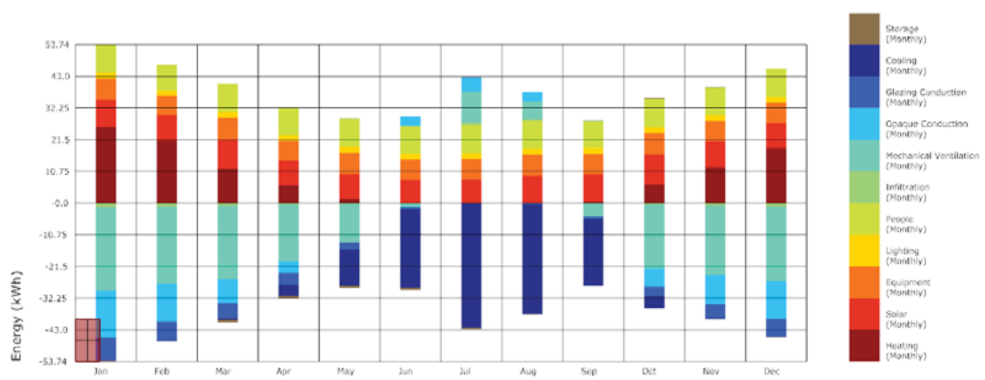
.15 Person/Meter

ENERGY BALANCE

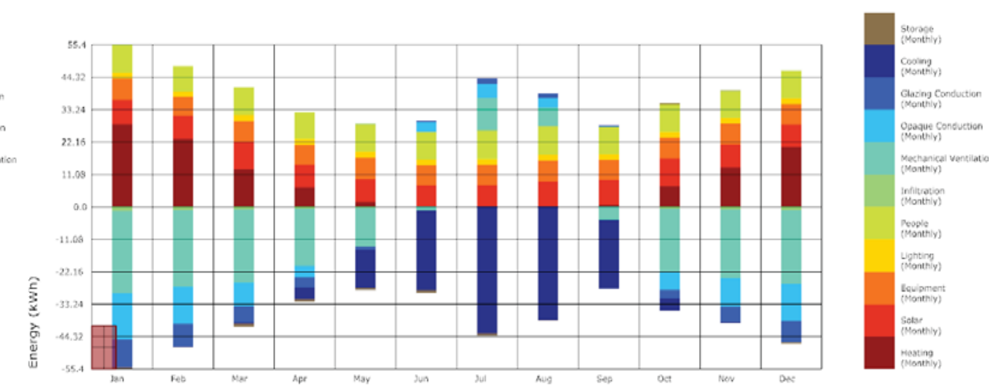
EFFECTS OF WALL TYPE AND INSULATION

Observing the changes in the room's energy balance due to different levels of wall insulation, Glazing U-Value, and SHGC. TOTAL ANNUAL KWH WITH RESPECT TO WINDOWS Observing the changes in the room’s energy consumption due to the U-Values, SHGC, and Visual Transmittance of its windows.

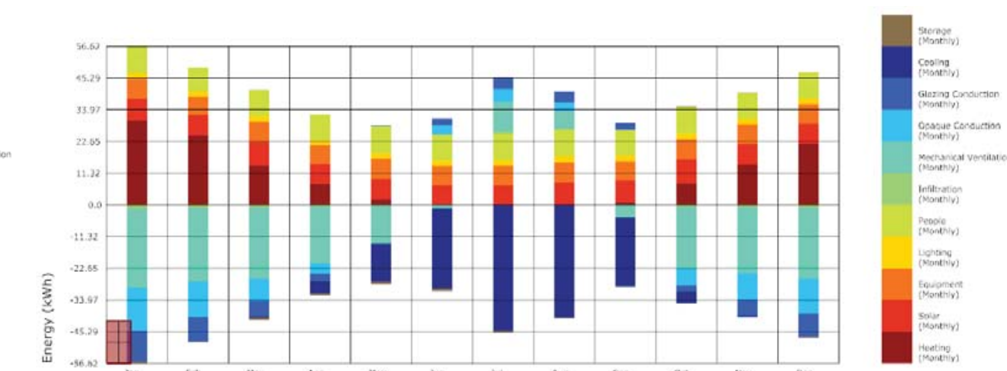
With:
Wall R-Value, 25
SHGC, .55
Visual Transmittance, .6



Window U-Value, .45

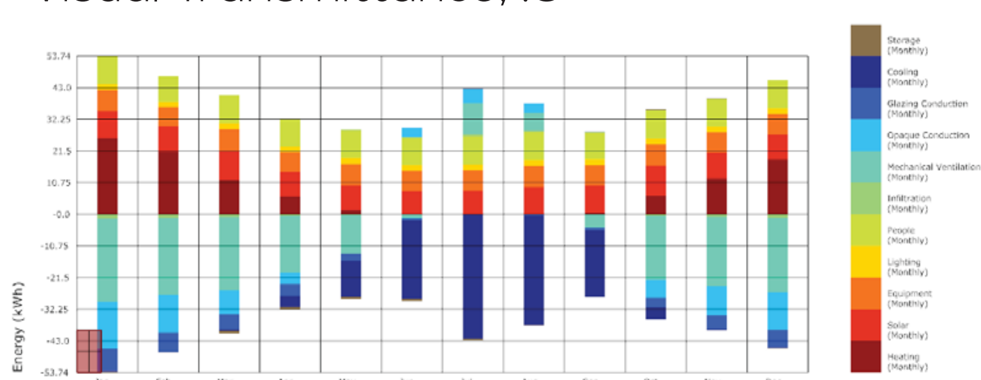


Window U-Value, .7

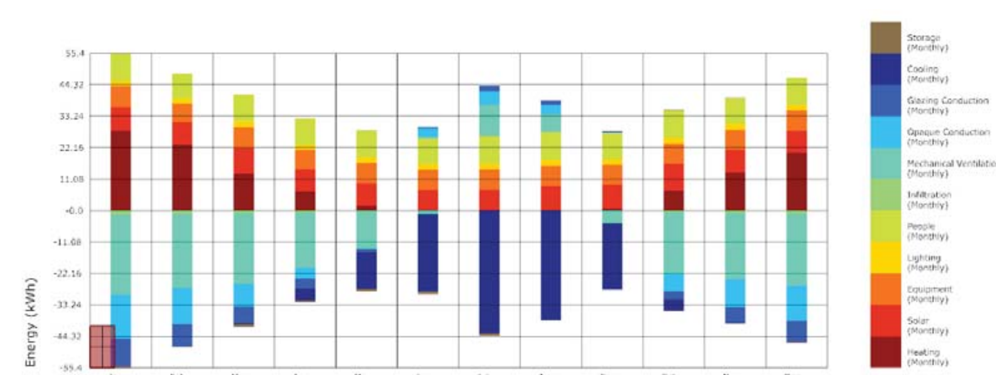


Window U-Value, .95

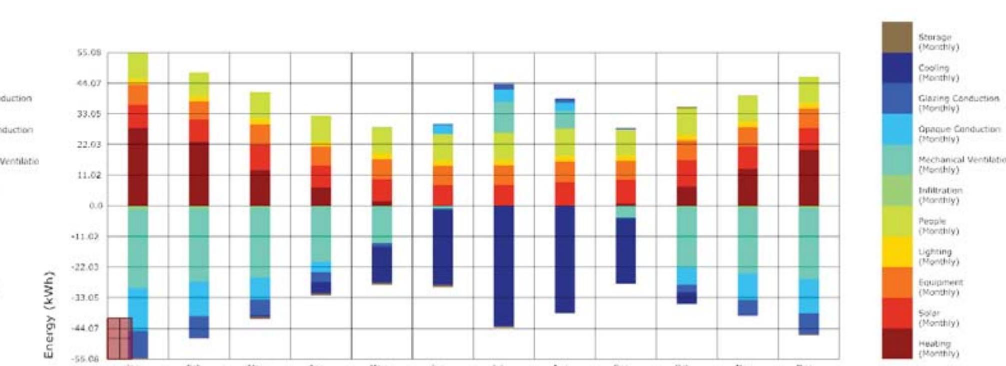
With:
Window U-Value, .65
SHGC, .55
Visual Transmittance, .6



Wall R-Value, 20



Wall R-Value, 25



Wall R-Value, 30

CONCLUSIONS

POTENTIAL STRATEGIES

Several results and conclusions became apparent after performing the preceding analysis. Firstly, this room benefits from significant daylight during midday and for most of the afternoon, resulting in high daylight autonomy. However, this also results in the need for a strategy to reduce glare. Louvers are one such option, as the custom sails would obscure far more of the view. This is especially apparent at the hour of 15:00 as during this time the room consistently receives the most daylight. Furthermore, the adiabatic nature of several of the building's walls results in manageable energy consumption, however it is apparent that improving the U-Value of the windows would significantly improve environmental performance. Also, this space is currently inhabited by just one person, resulting in higher energy usage due to the low number of people per square meter. Furthermore increasing the R-Values of the non-adiabatic walls would also significantly improve performance. In conclusion, the nature of this space does provide several distinct advantages, however this analysis has shown clear issues that ought to be addressed and manifested areas where the space's environmental performance may be improved.