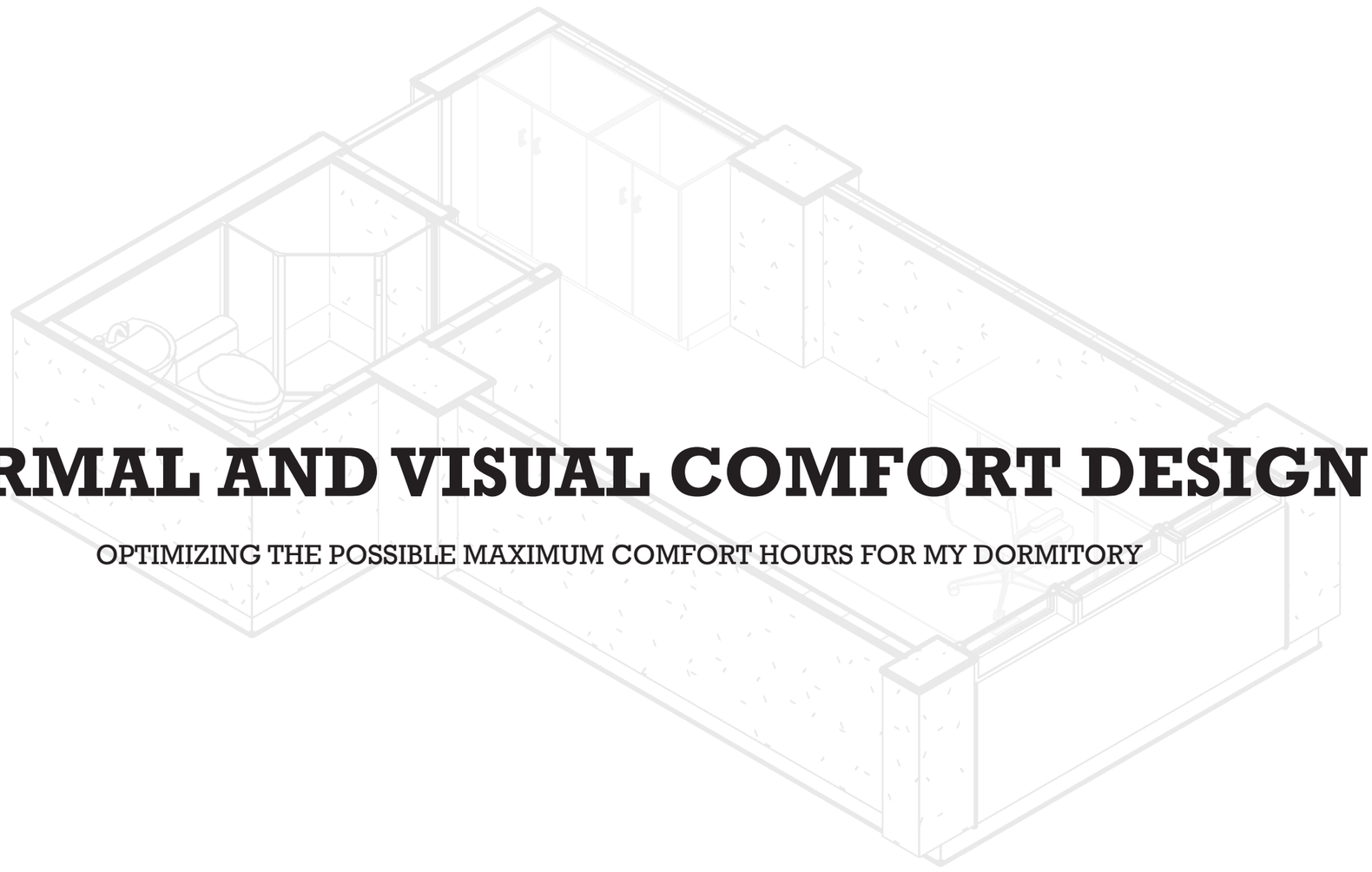


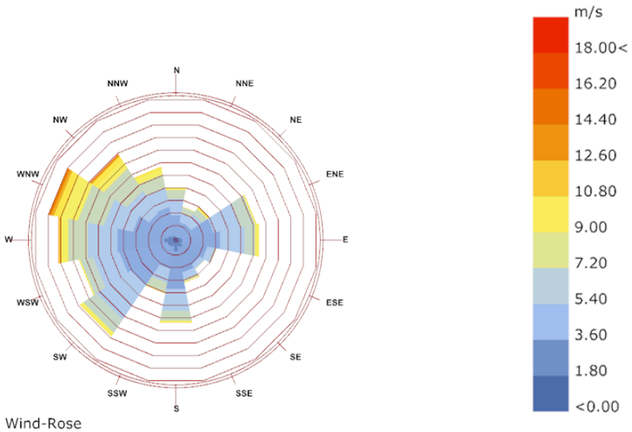
THERMAL AND VISUAL COMFORT DESIGN

OPTIMIZING THE POSSIBLE MAXIMUM COMFORT HOURS FOR MY DORMITORY

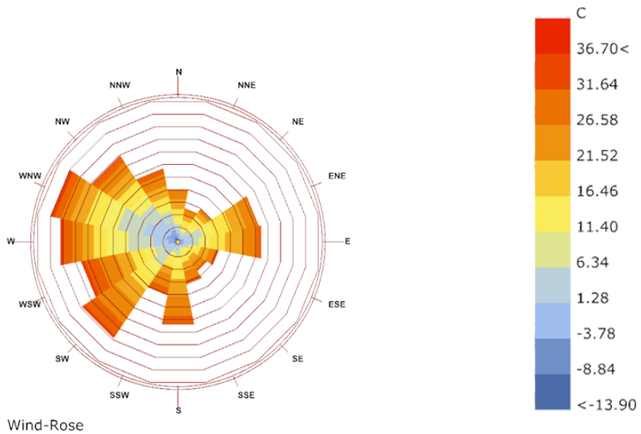
Yunzhongda Peng | MSD2017 Candidate
Arch 753 Building Performance Simulation
Instructor: Mostapha S. Roudsari
University of Pennsylvania
School of Design

Weather Data Analysis

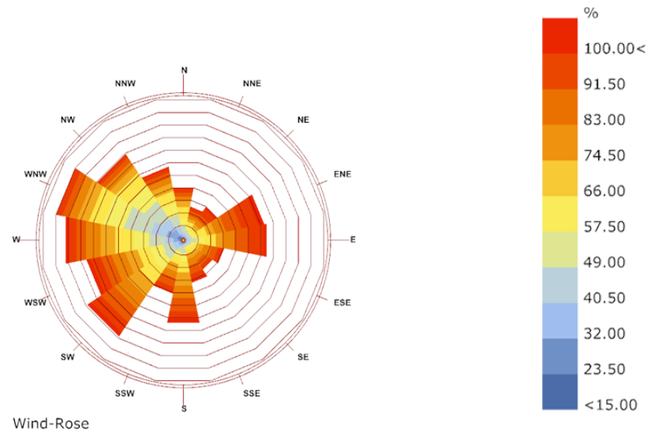
Original Windrose



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 1.0%. = 90 hours.

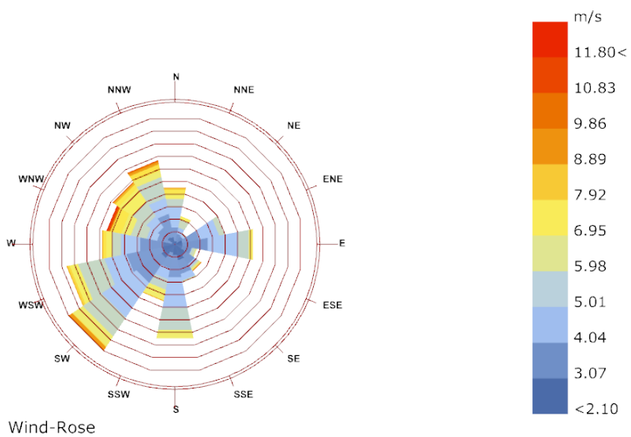


Wind-Rose
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00
Hourly Data: Dry Bulb Temperature (C)
Calm for 2.81% of the time = 246 hours.
Each closed polyline shows frequency of 1.0%. = 90 hours.

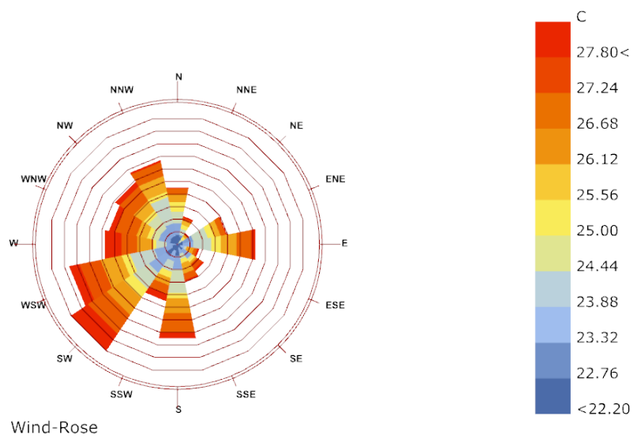


Wind-Rose
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00
Hourly Data: Relative Humidity (%)
Calm for 2.81% of the time = 246 hours.
Each closed polyline shows frequency of 1.0%. = 90 hours.

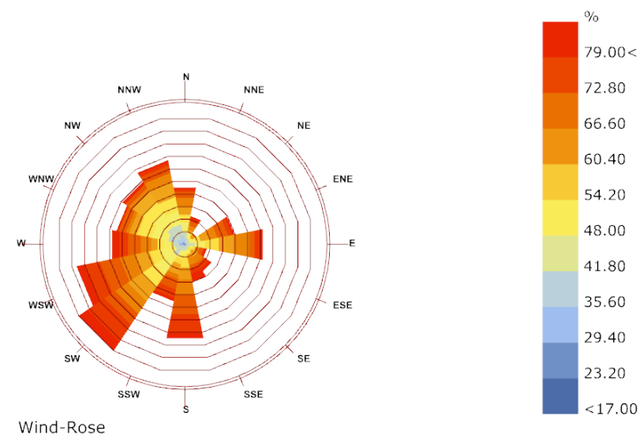
Windrose on Condition of Dry Bulb Temperature and Relative Humidity



Wind-Rose
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00
Hourly Data: Wind Speed (m/s)
Calm for 0.00% of the time = 0 hours.
Each closed polyline shows frequency of 0.1%. = 11 hours.
... ...
Conditional Selection Applied:
22 < Dry Bulb Temperature < 28
and Relative Humidity < 80
and Wind Speed > 2
951.0 hours of total 8760.0 hours (10.86%).



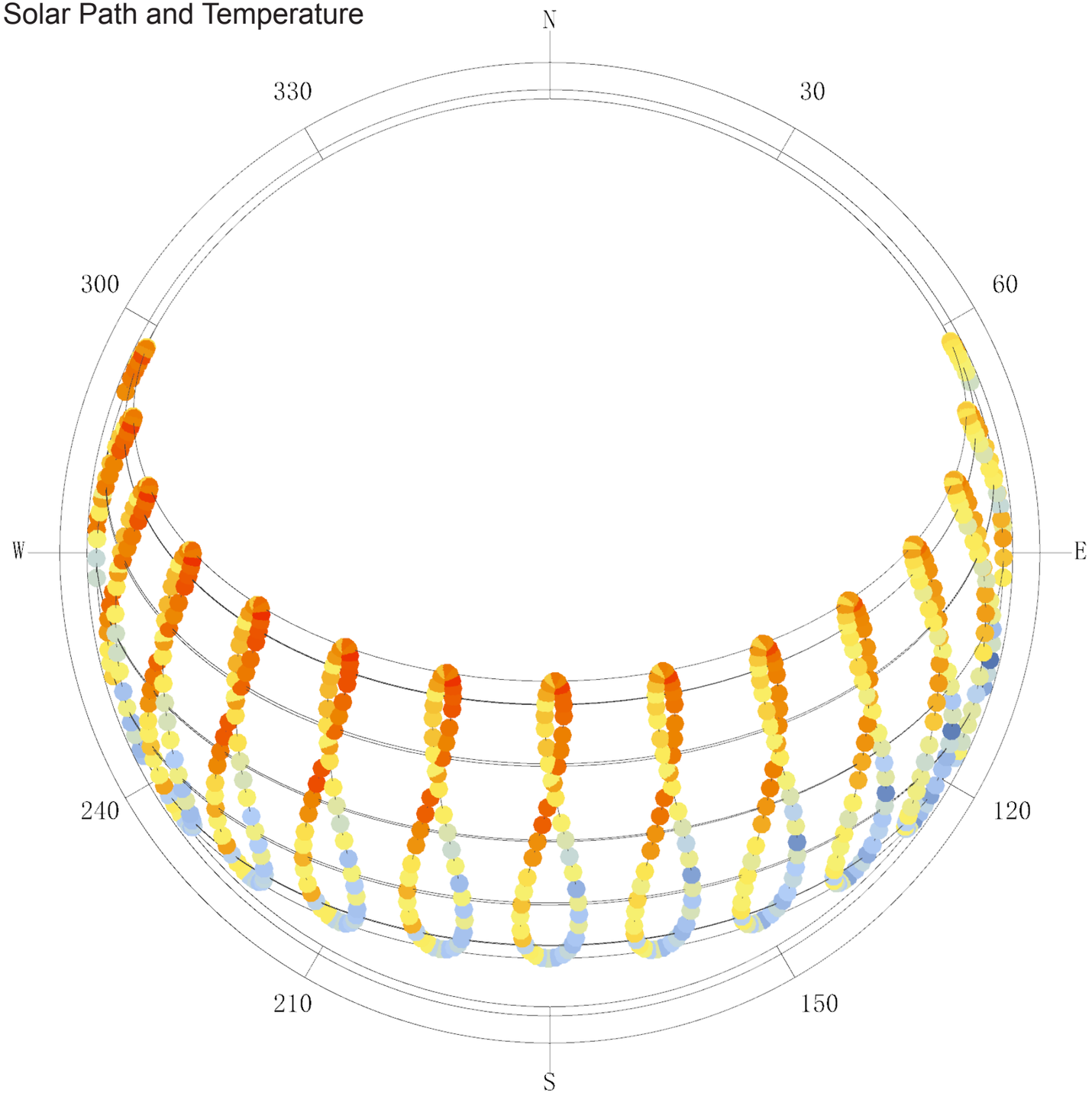
Wind-Rose
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00
Hourly Data: Dry Bulb Temperature (C)
Calm for 0.00% of the time = 0 hours.
Each closed polyline shows frequency of 0.1%. = 11 hours.
... ...
Conditional Selection Applied:
22 < Dry Bulb Temperature < 28
and Relative Humidity < 80
and Wind Speed > 2
951.0 hours of total 8760.0 hours (10.86%).

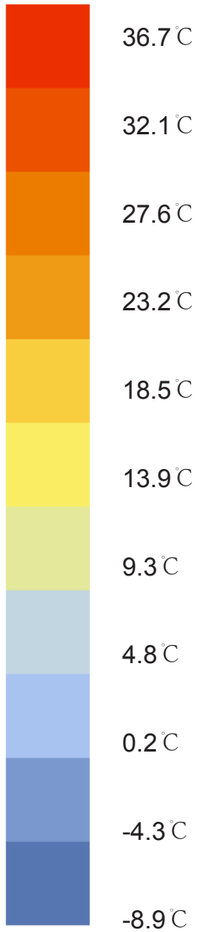


Wind-Rose
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00
Hourly Data: Relative Humidity (%)
Calm for 0.00% of the time = 0 hours.
Each closed polyline shows frequency of 0.1%. = 11 hours.
... ...
Conditional Selection Applied:
22 < Dry Bulb Temperature < 28
and Relative Humidity < 80
and Wind Speed > 2
951.0 hours of total 8760.0 hours (10.86%).

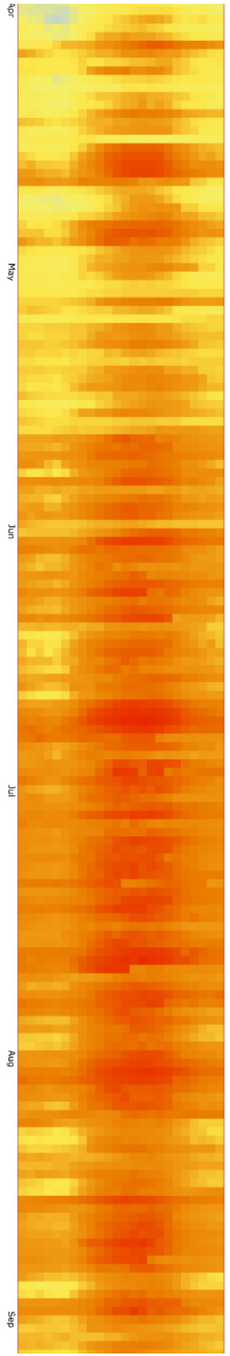
Weather Data Analysis

Solar Path and Temperature

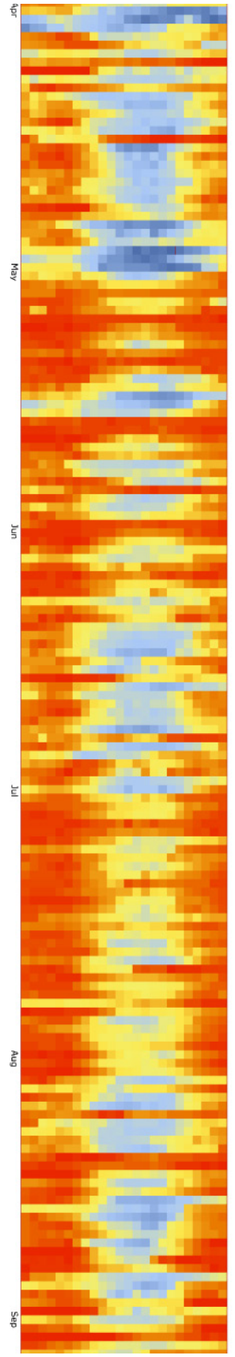




Air Temperature

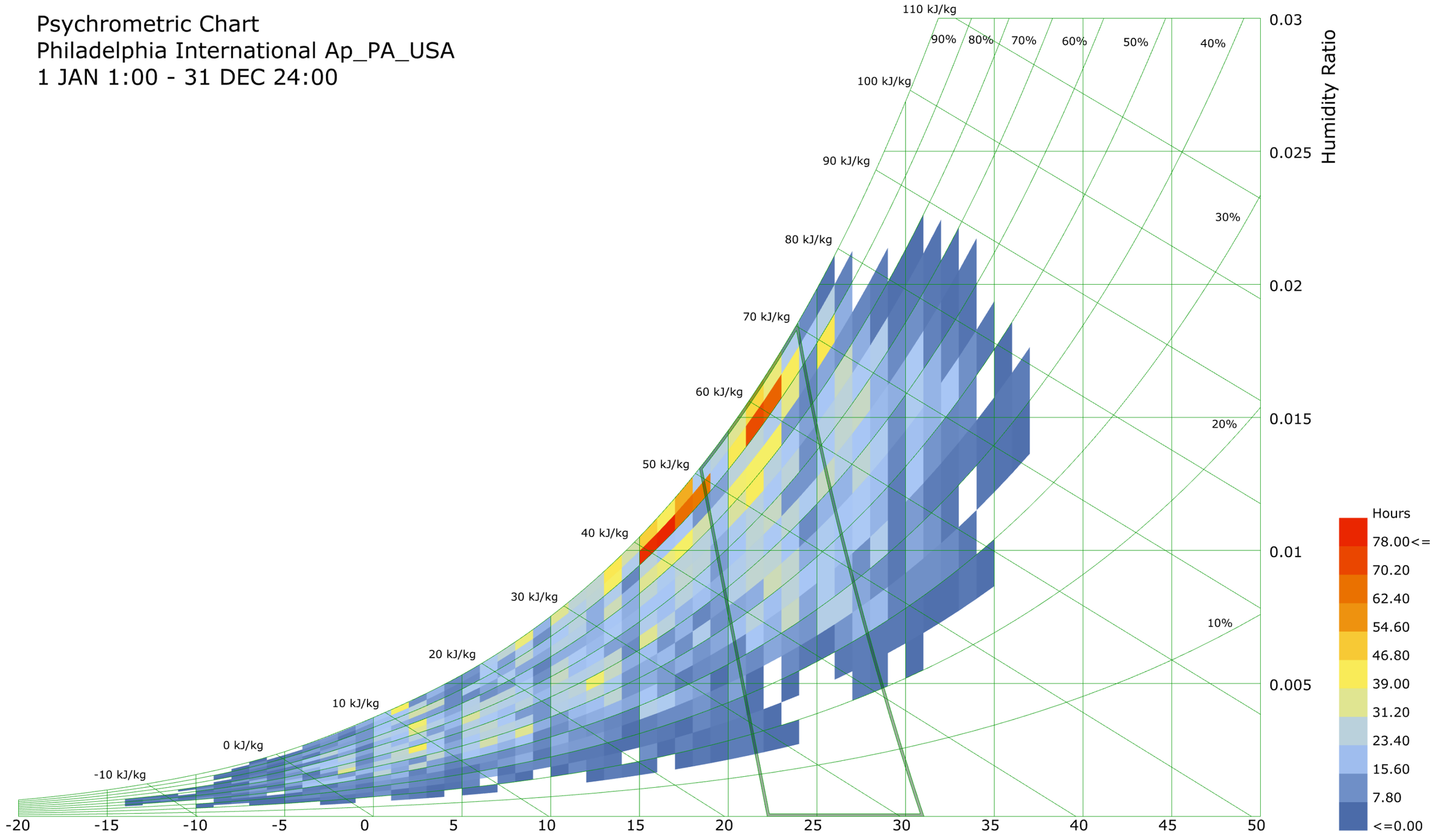


Relative Humidity

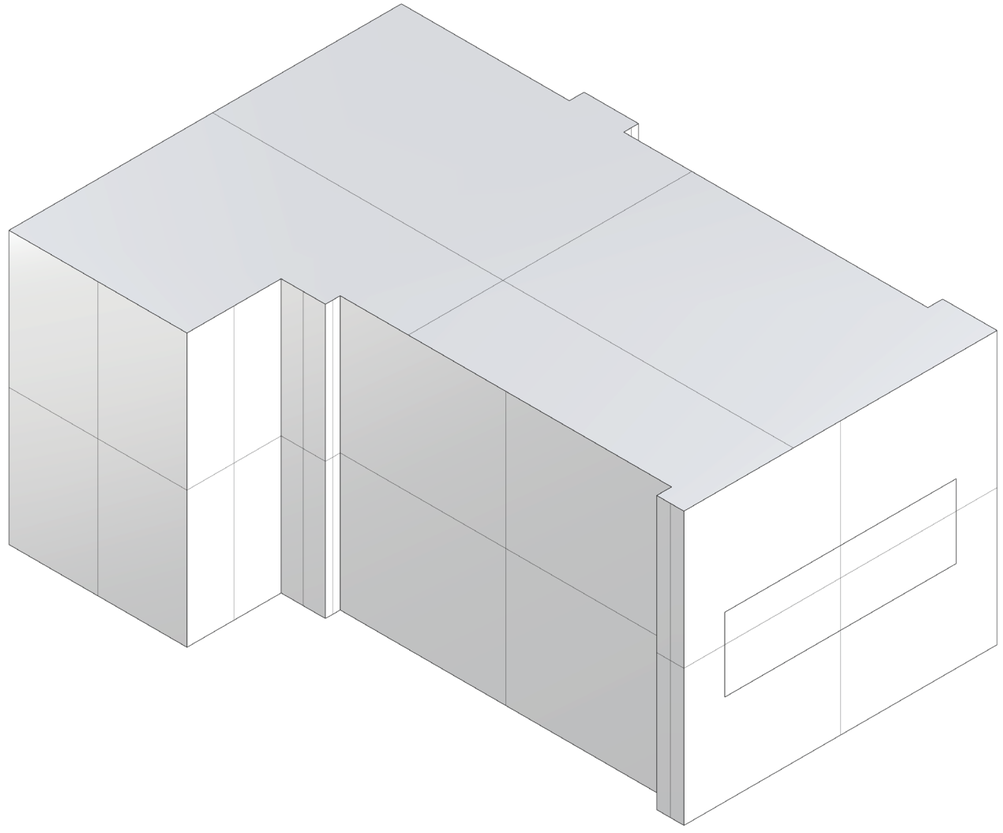


Weather Data Analysis

Psychrometric Chart
Philadelphia International Ap_PA_USA
1 JAN 1:00 - 31 DEC 24:00

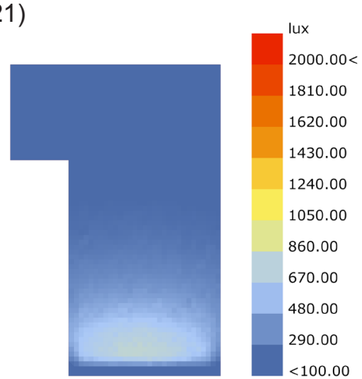


Original Room Analysis

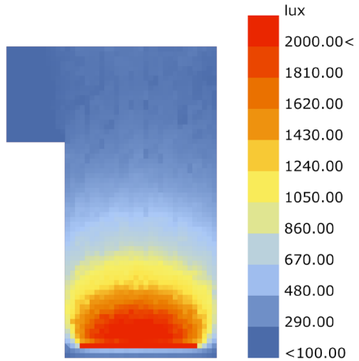


Point-based Daylight Analysis

Spring/Fall(3.21/9.21)



09:00



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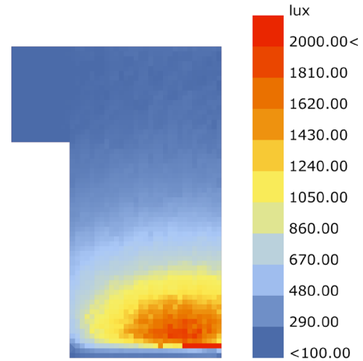
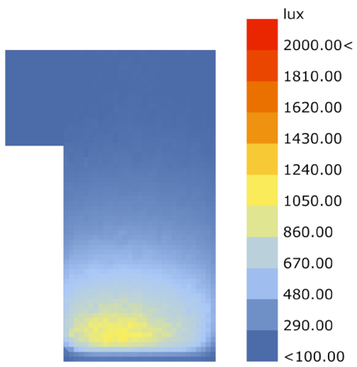


15:00

Summer(6.21)



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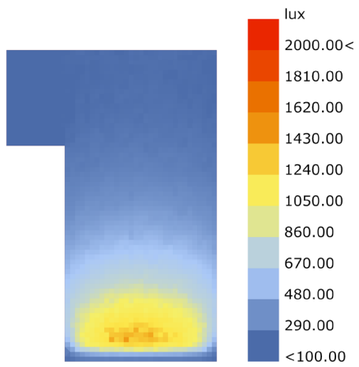

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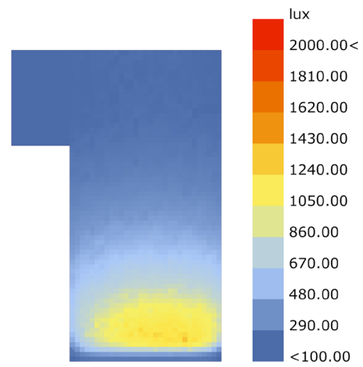
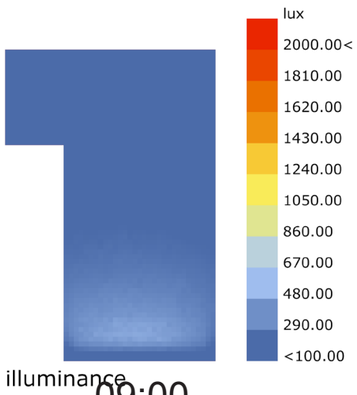


15:00

Winter(12.21)



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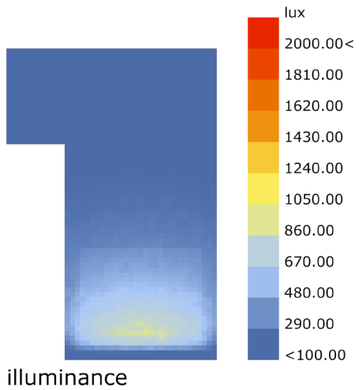

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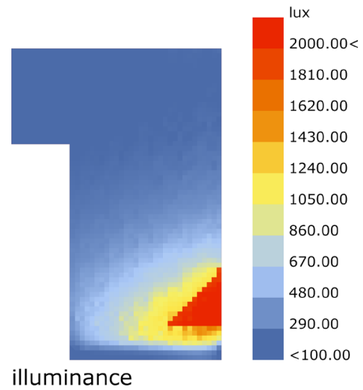


15:00

#In summer there is no major problem of overwhelming daylight. In spring /fall/winter the area near the window is higher than needed.
#Most area cannot get adequate daylight for activities, but is OK for resting.

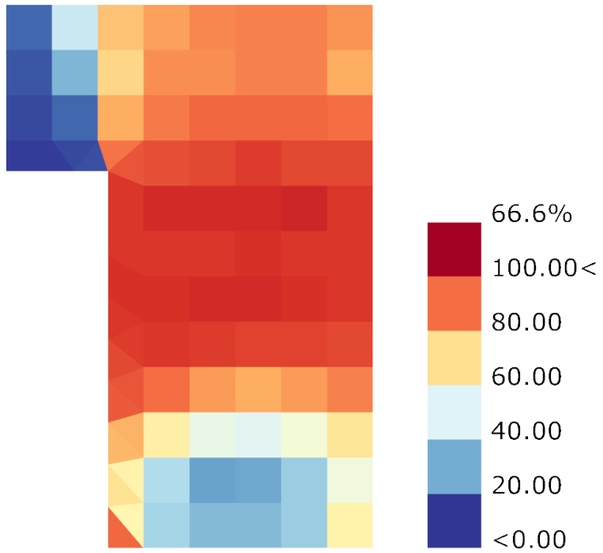
Glare Analysis

#Without shading there is no significant glare, but it is disturbing.

Daylight Autonomy

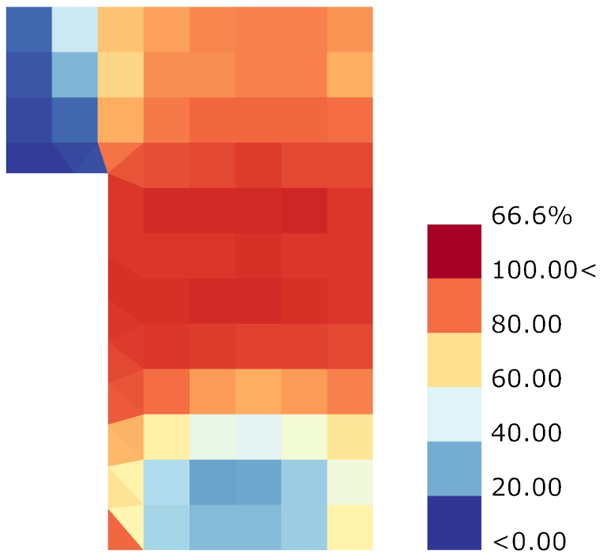
#The toilet is usually inadequate in daylight

Without Natural Ventilation



annual analysis

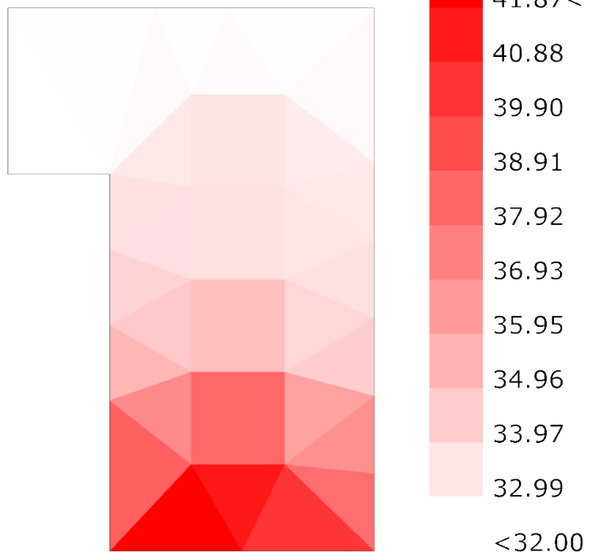
With Natural Ventilation



annual analysis

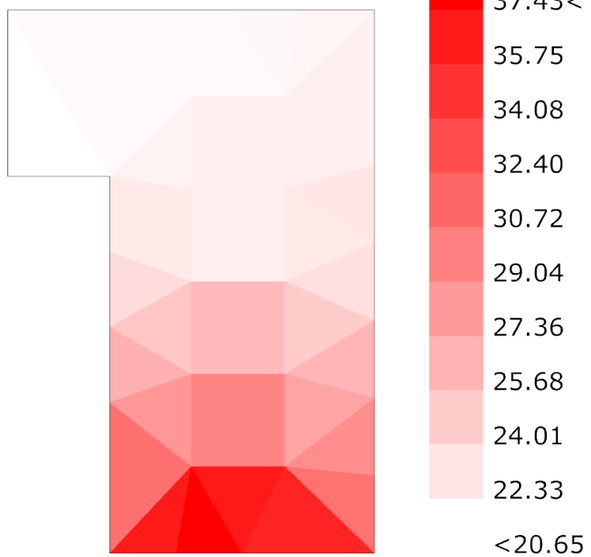
Thermal Autonomy

#Some area near the window may be overheated, but rarely under-heated

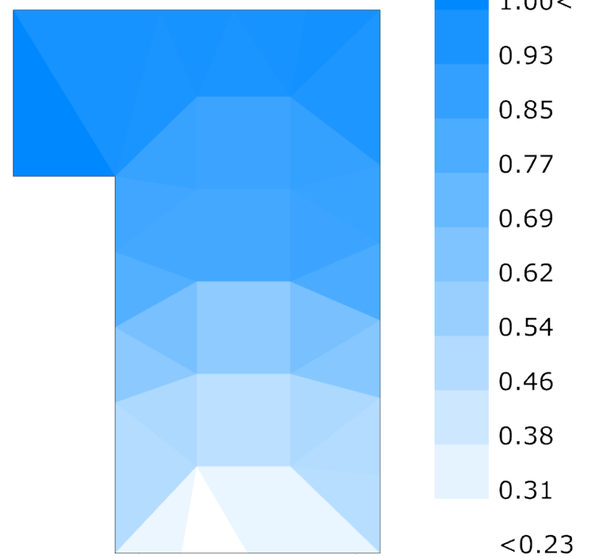


PMV Over-Heated Percent
Jan 1 1:00 - Dec 31 24:00

PMV Under-Heated Percent
Jan 1 1:00 - Dec 31 24:00

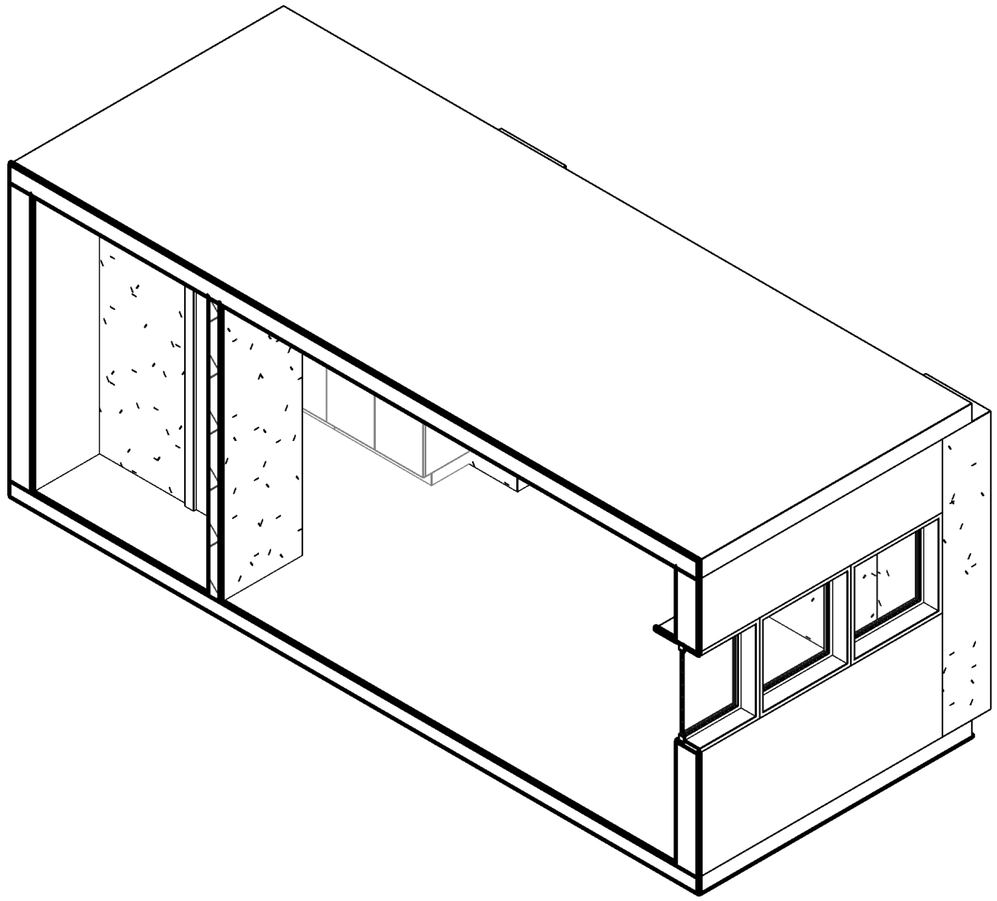


PMV Over-Heated Percent
Jan 1 1:00 - Dec 31 24:00

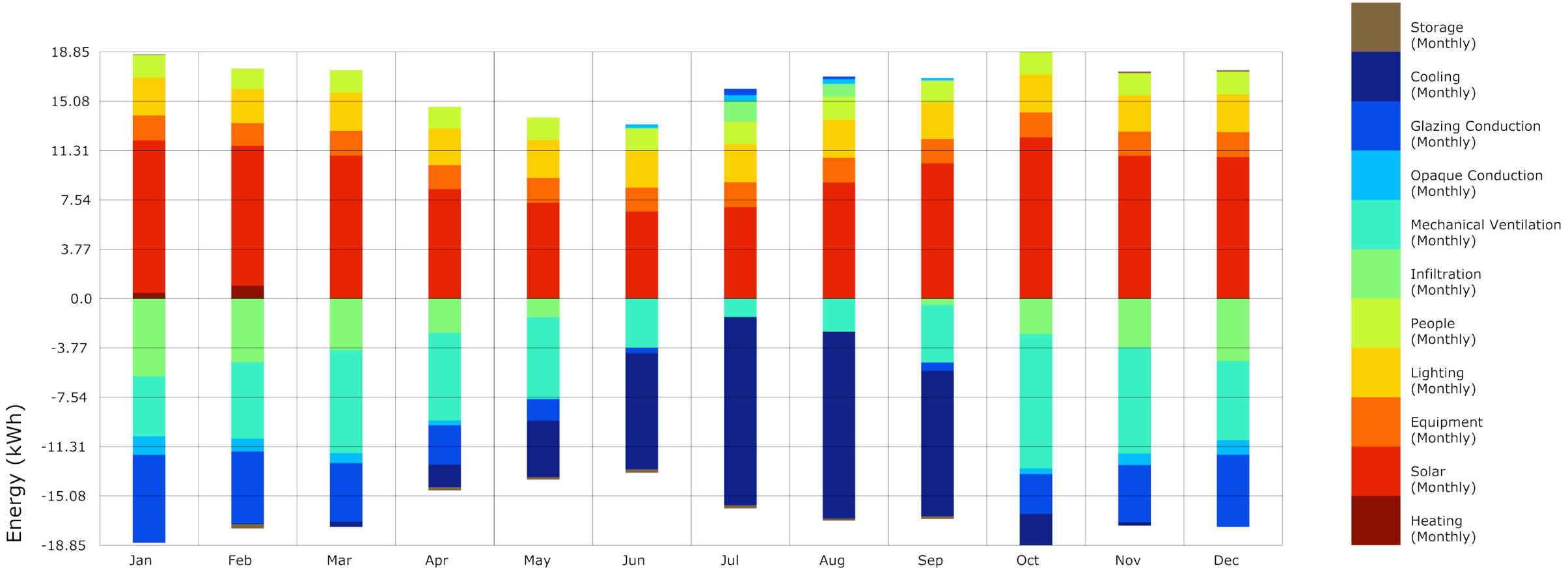


PMV Under-Heated Percent
Jan 1 1:00 - Dec 31 24:00

Construction



Default Energy Balance

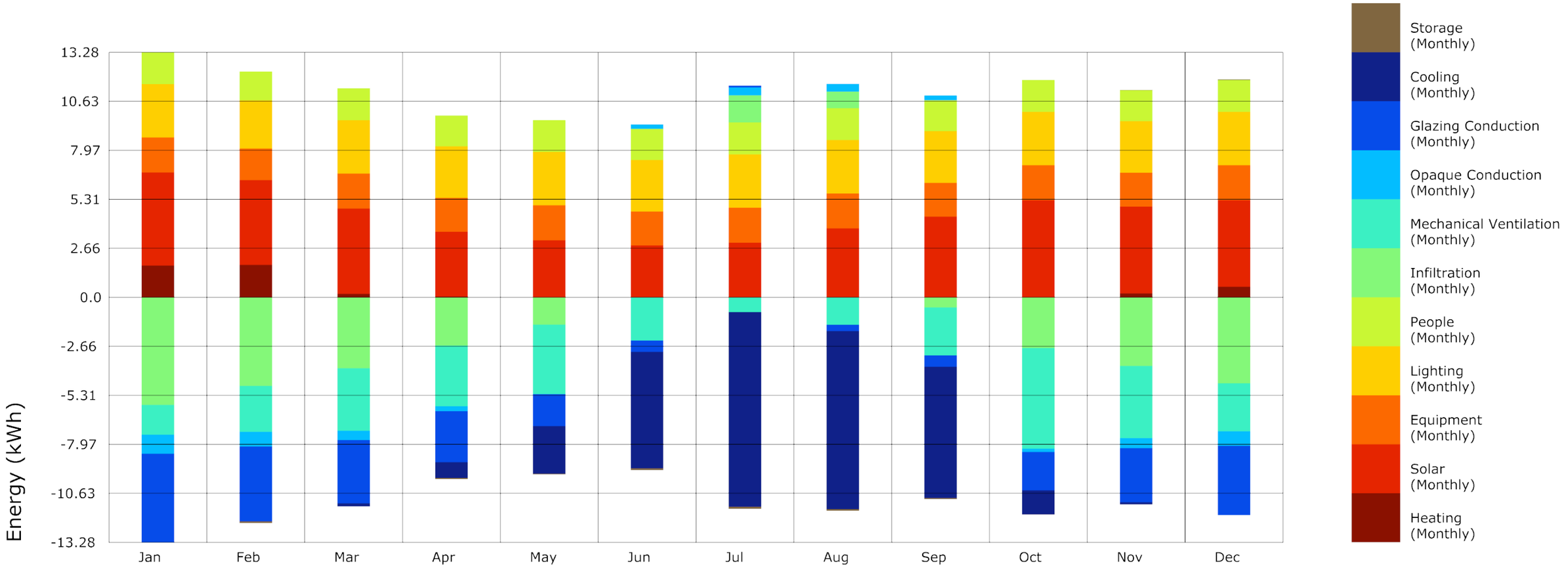


#The overall energy consumption is rather low in this room.

#There is some potential to reduce the glazing conduction and infiltration in winter, suggesting the possibilities of increasing the enclosure's R values.

#Cooling and solar energy intake constitute the most energy consumption in summer, natural ventilation may be deployed.

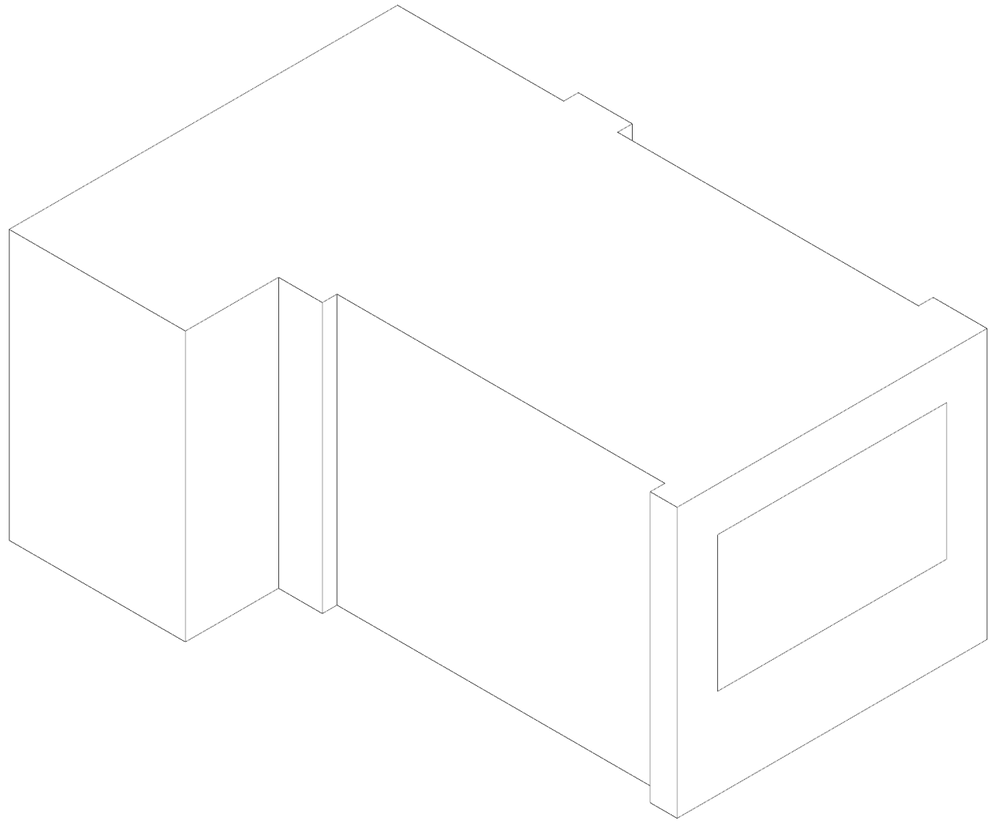
Improving R values in construction materials



#Construction for walls, windows, ceiling and floor sorted according to their R values, and will employ the ones with the highest, namely ASHRAE 90.1-2010 EXTWINDOW NONMETAL CLIMATEZONE 4 and ASHRAE 90.1-2010 EXTWALL STEELFRAME CLIMATEZONE ALT-RES 2-6.

#Infiltration in winter dropped after material change
however the glazing infiltration doesn't seem to decrease.

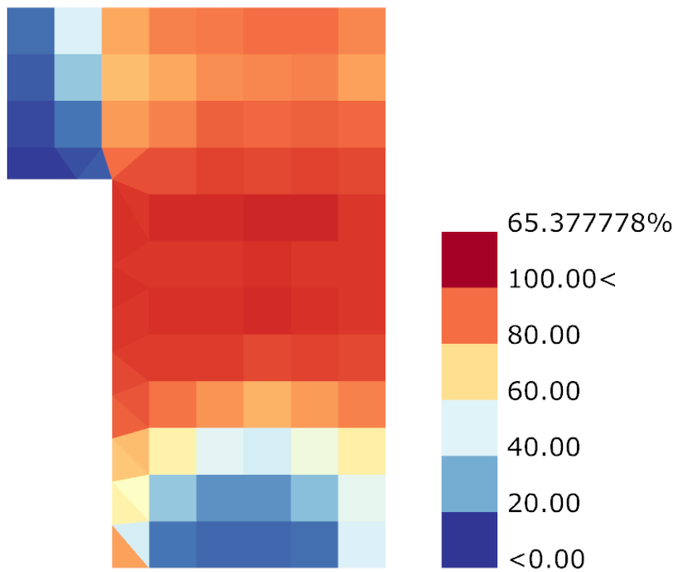
Window Size



Daylight Autonomy

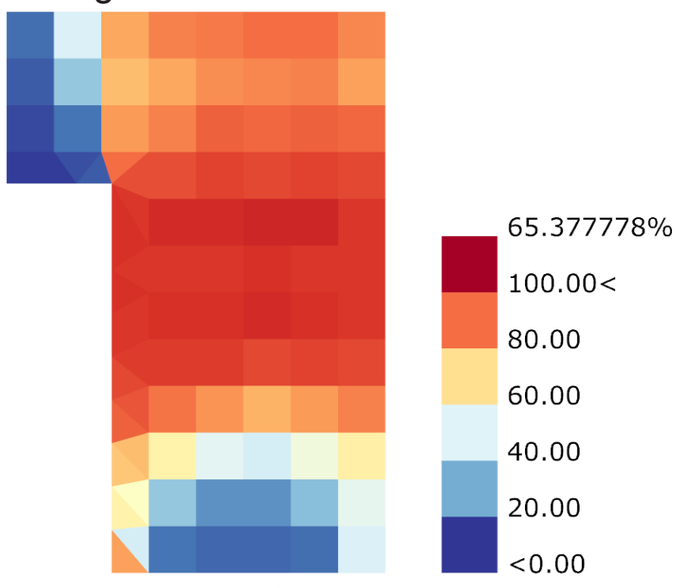
#Enlarged window size does not increase UDI

Window enlarged to 2.1m high



annual analysis

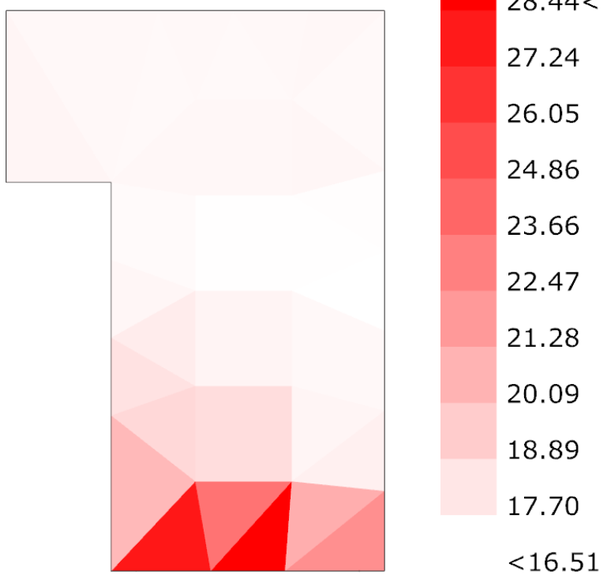
Shading added to the window



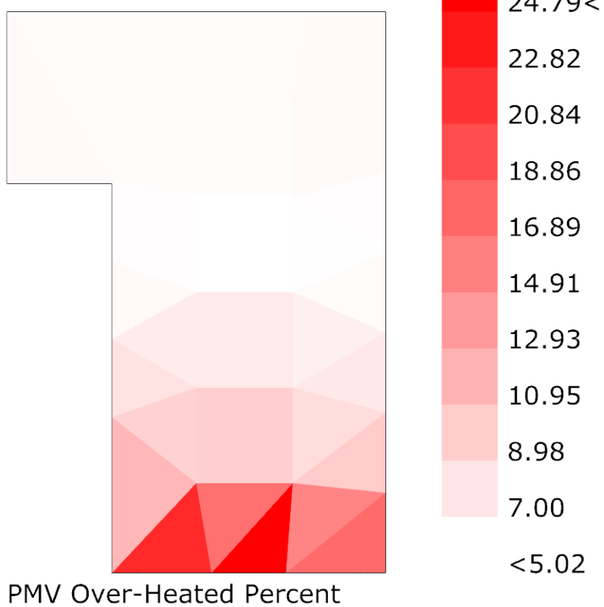
annual analysis

Thermal Autonomy

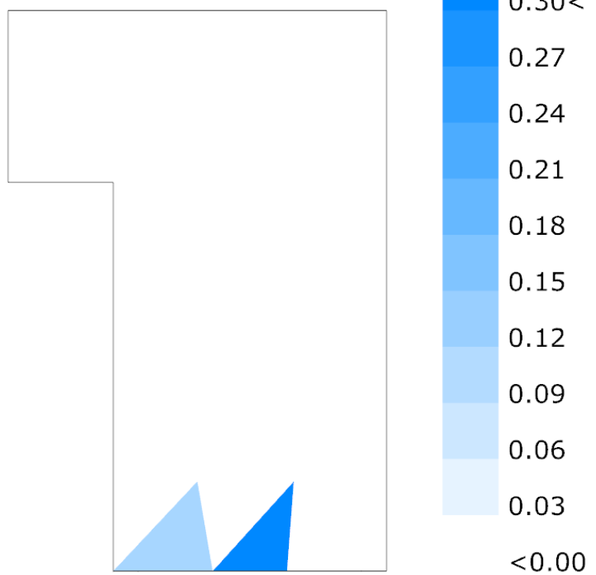
#Enlarged window size will decrease overheated area.



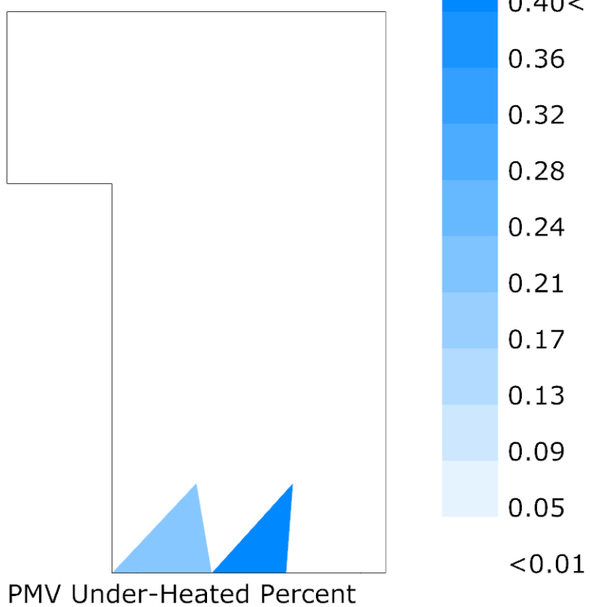
PMV Over-Heated Percent
Jan 1 1:00 - Dec 31 24:00



PMV Over-Heated Percent
Jan 1 1:00 - Dec 31 24:00



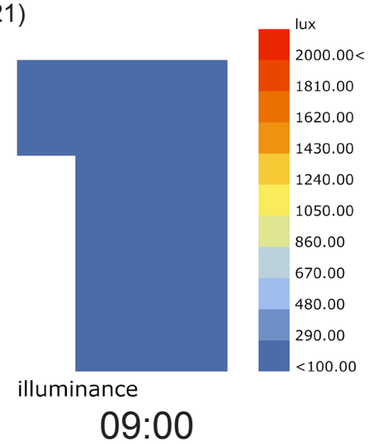
PMV Under-Heated Percent
Jan 1 1:00 - Dec 31 24:00



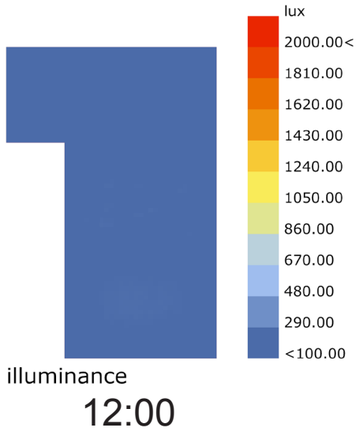
PMV Under-Heated Percent
Jan 1 1:00 - Dec 31 24:00

Window Decreased to 0.6m High

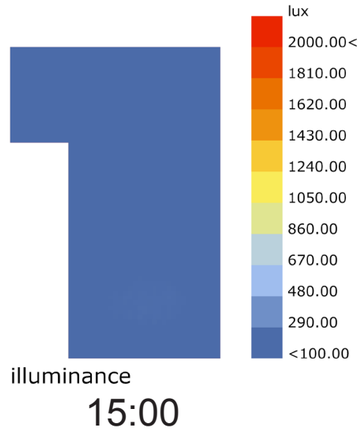
Spring/Fall(3.21/9.21)



09:00

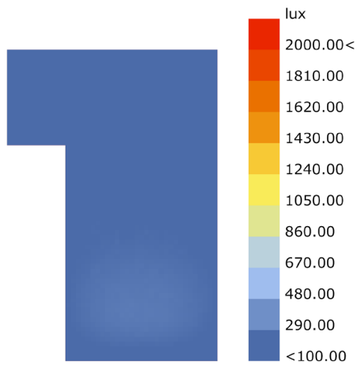


12:00



15:00

Summer(6.21)



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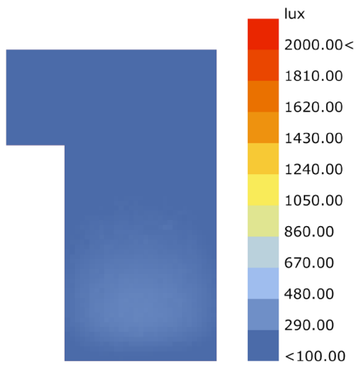

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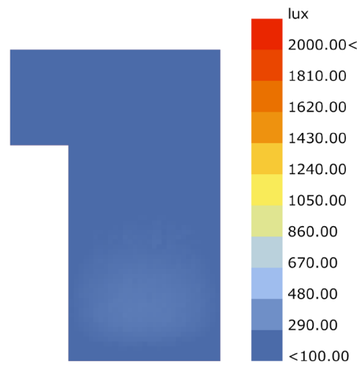
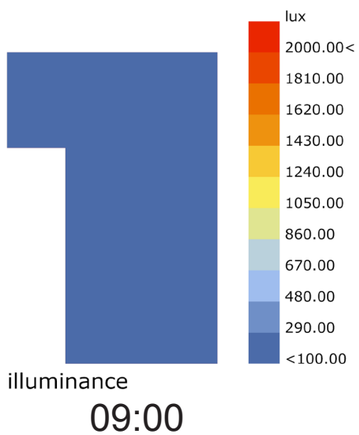


15:00

Winter(12.21)



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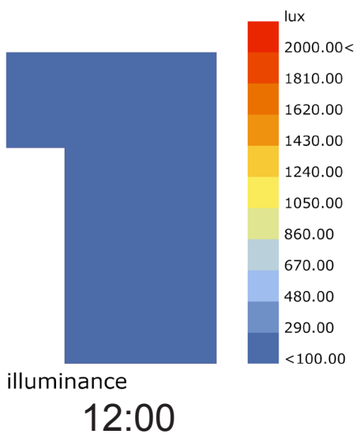

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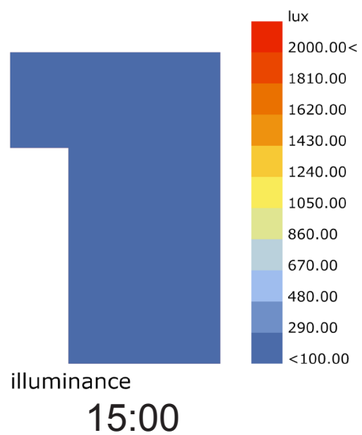
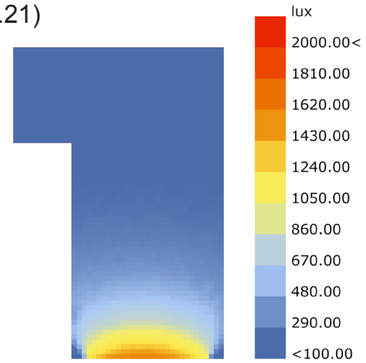


15:00

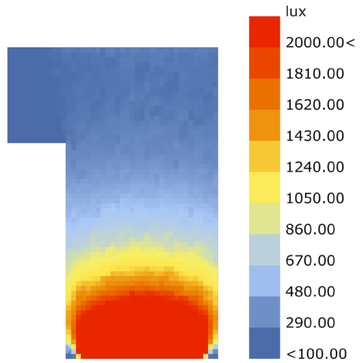
#The daylight illuminance is inadequate throughout the year, even in summer noons.

Window Enlarged to 2.1m High

Spring/Fall(3.21/9.21)



09:00



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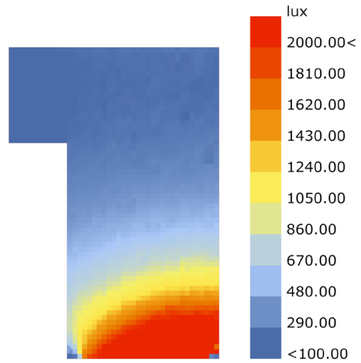
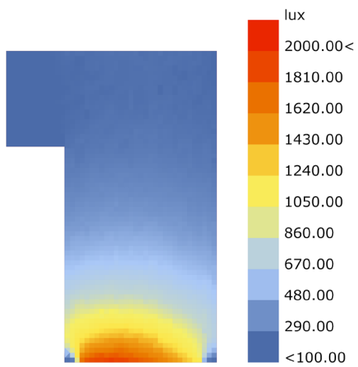
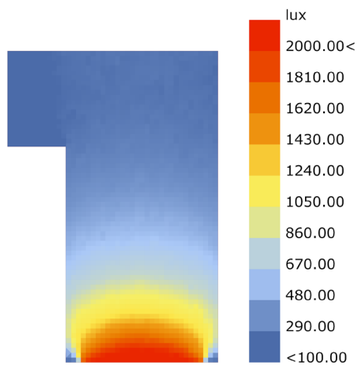


15:00

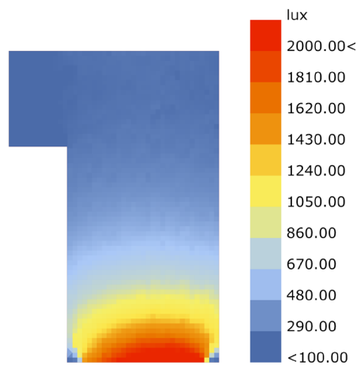
Summer(6.21)



09:00

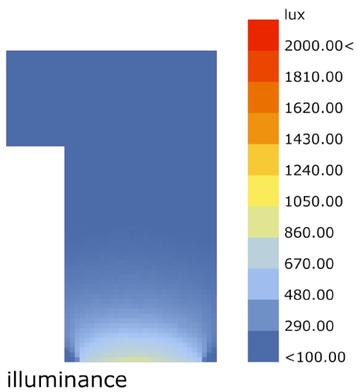


12:00

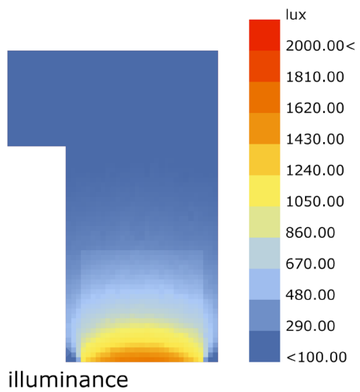


15:00

Winter(12.21)



09:00



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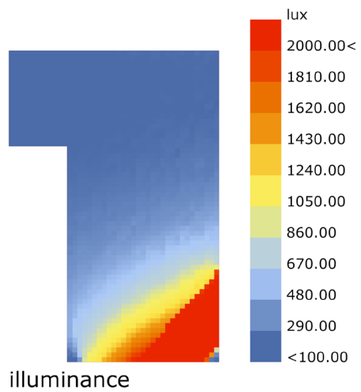
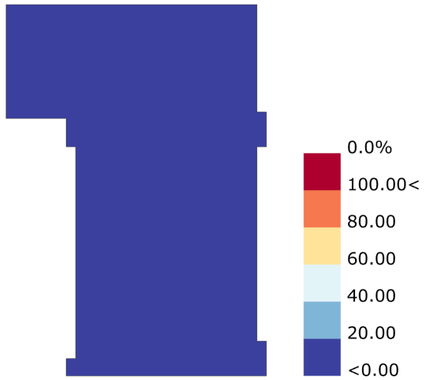


15:00

#There is much more overwhelming daylight for the area near the window than default.

Window to Wall Ratio and Annual UDI



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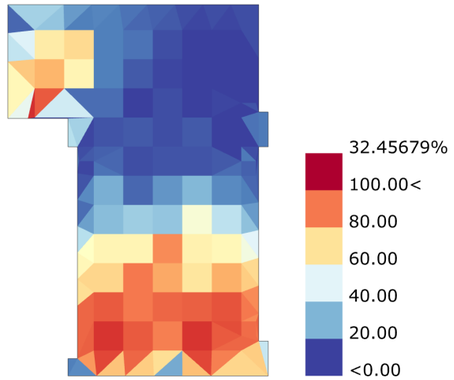

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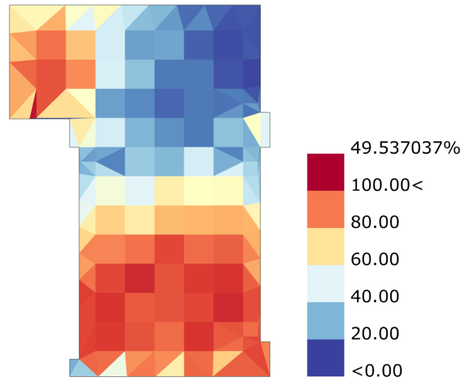

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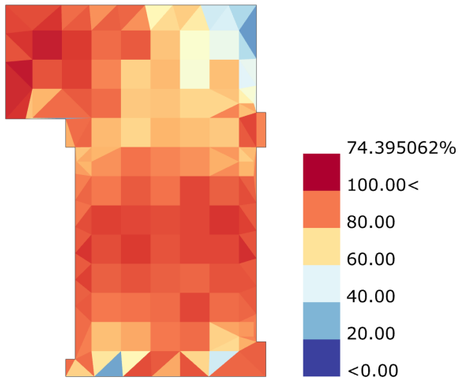

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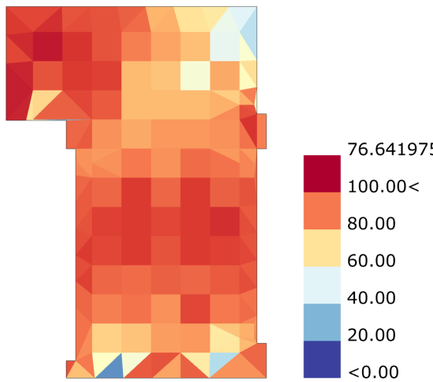

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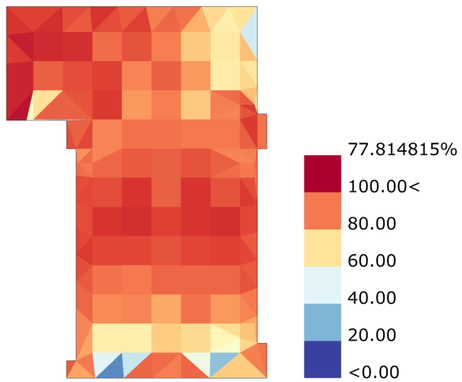

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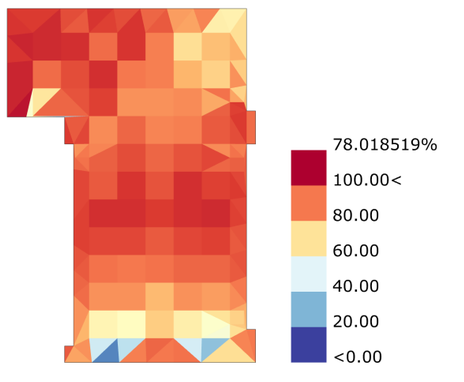

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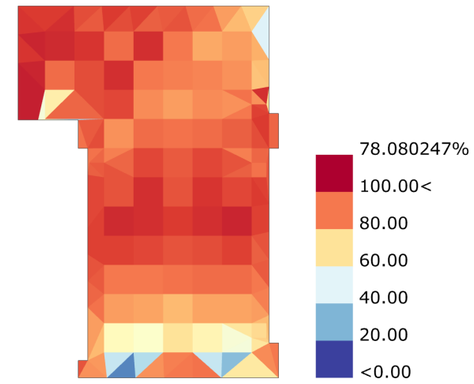

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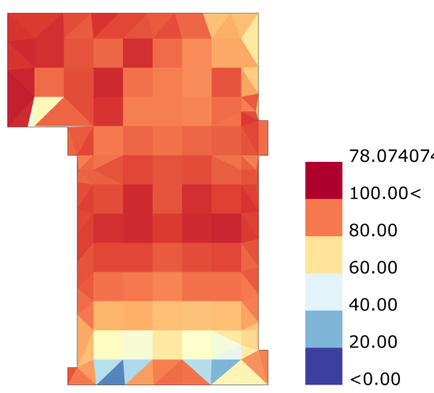

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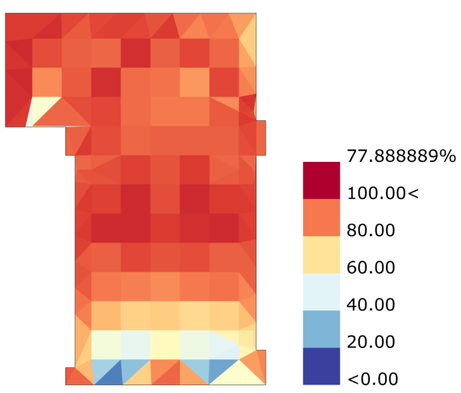

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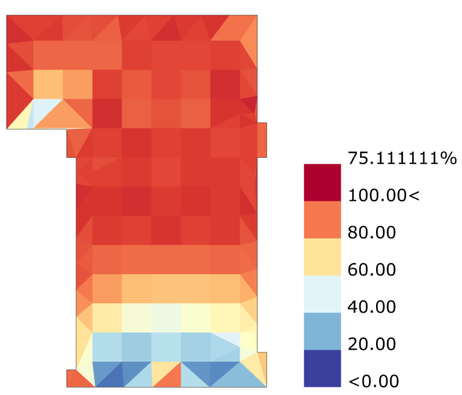

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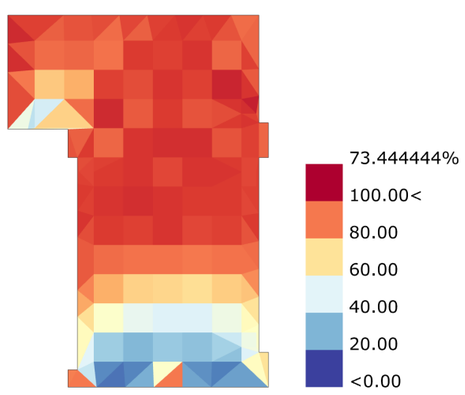

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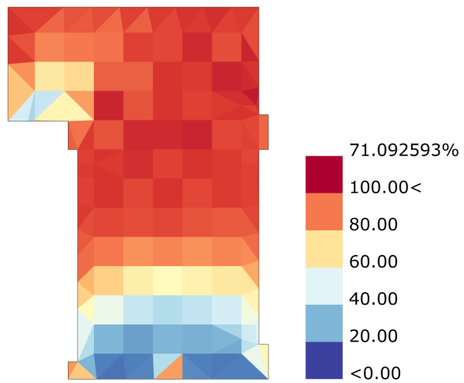

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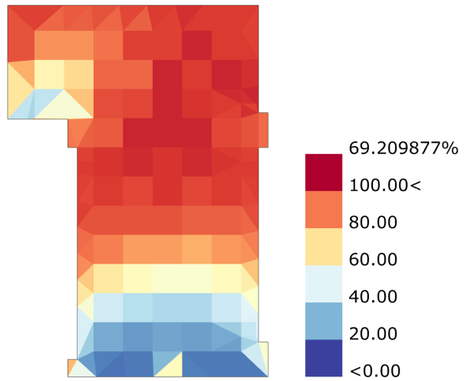

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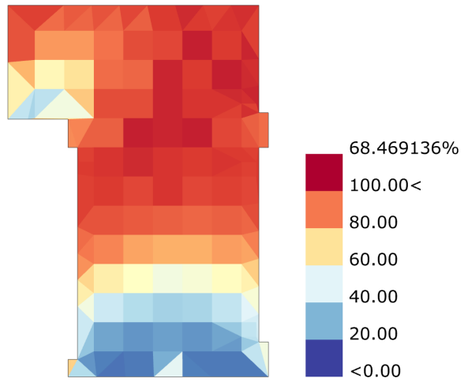

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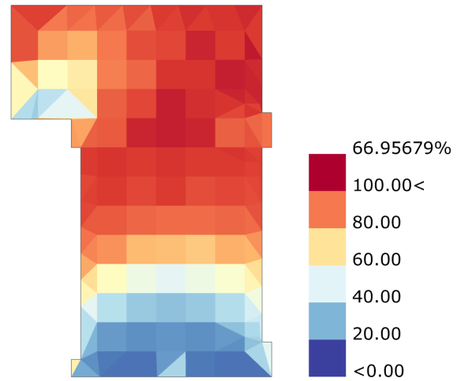

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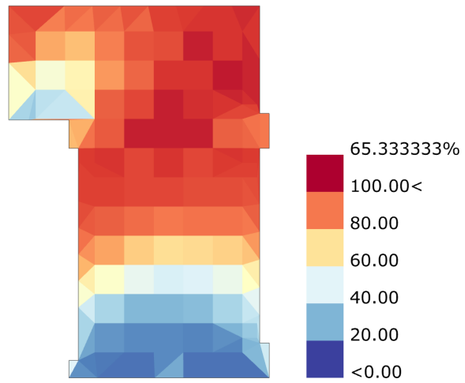

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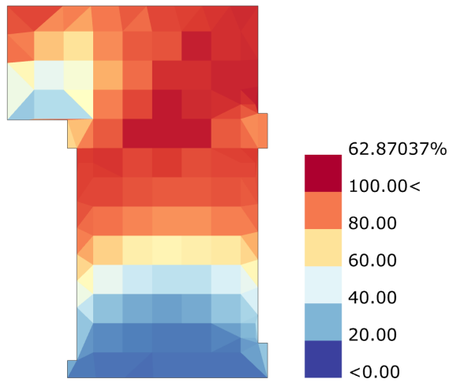

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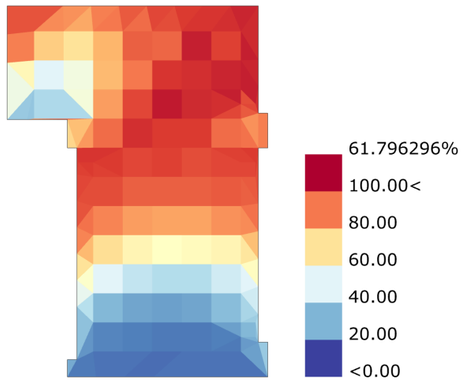

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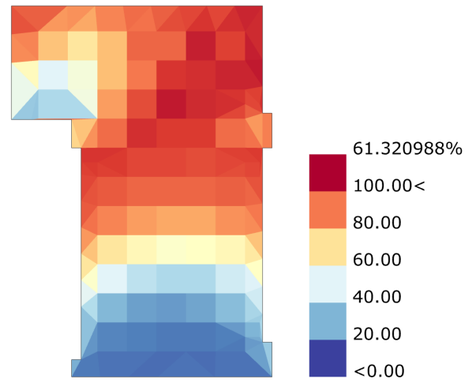

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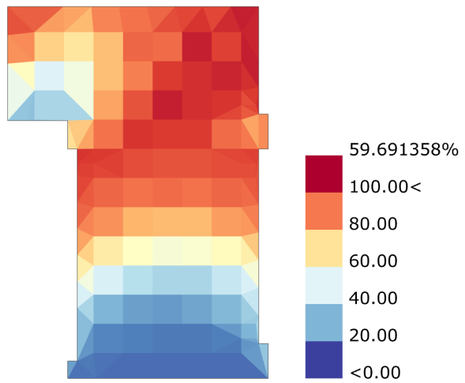

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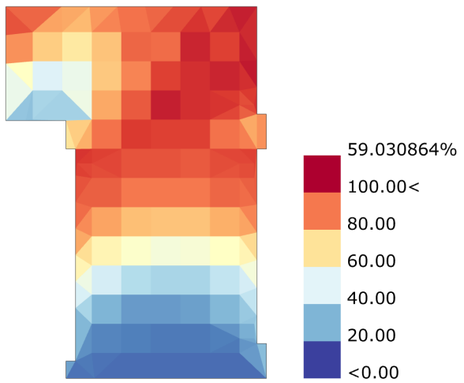

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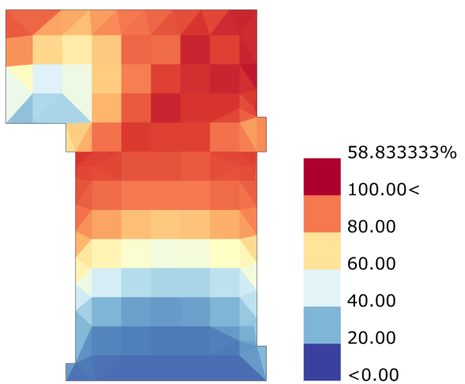

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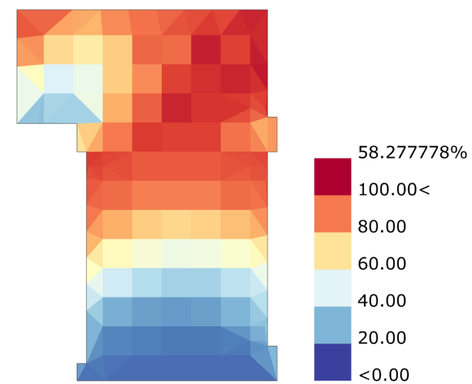
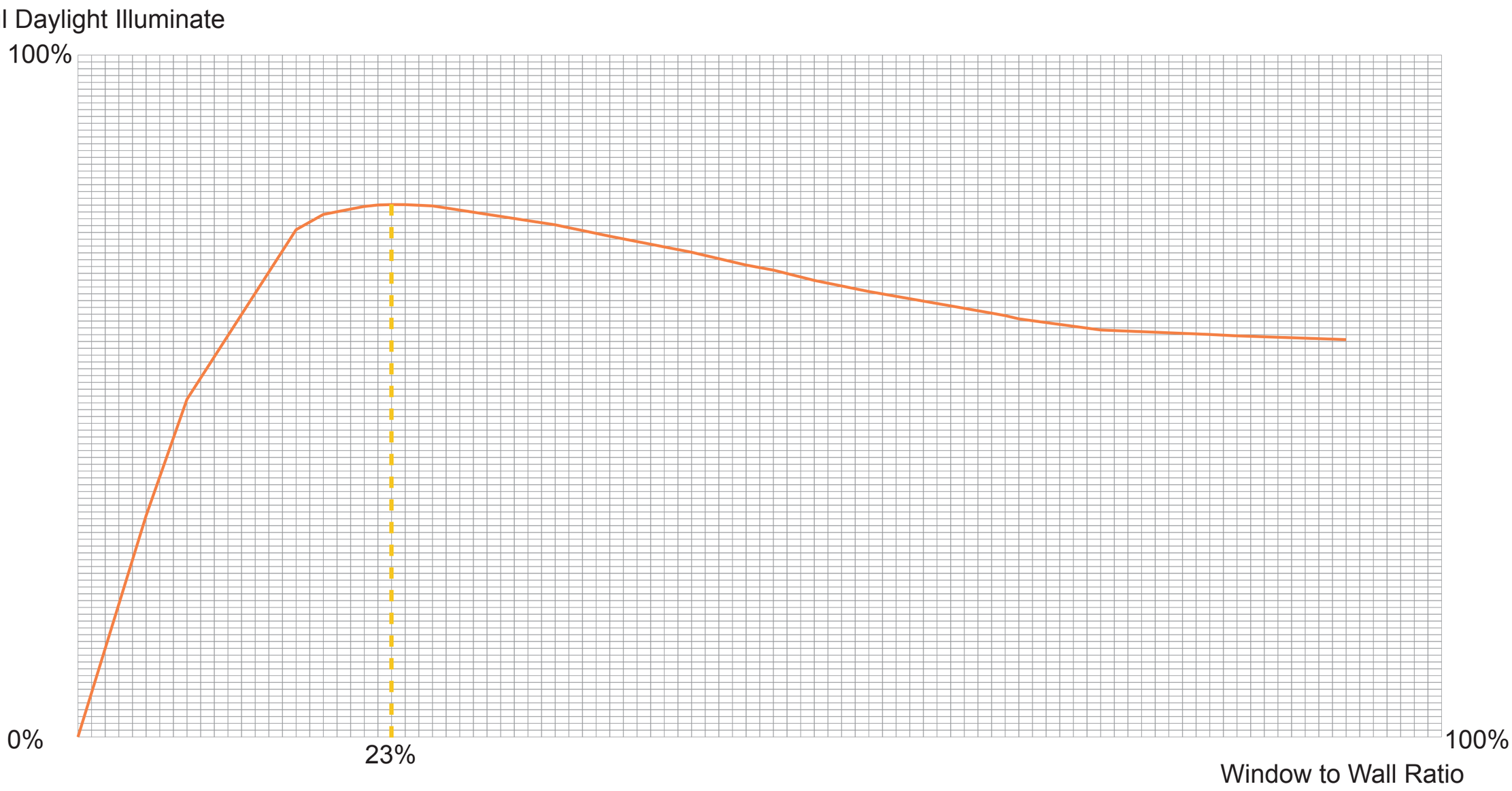


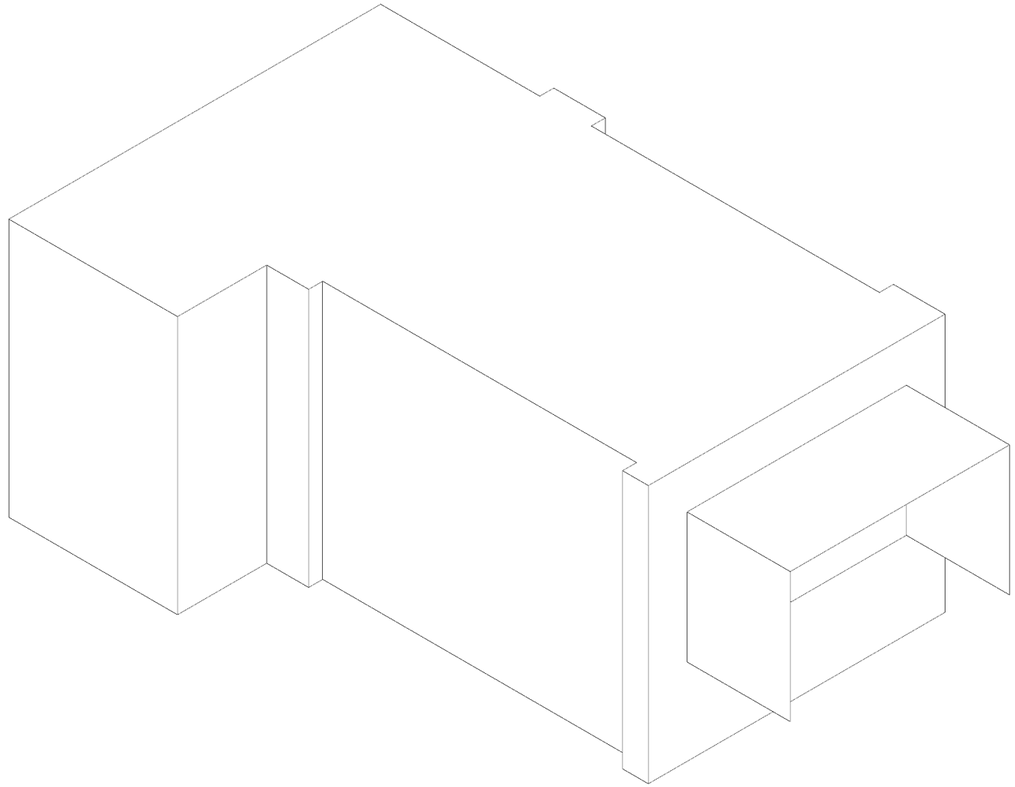
0.93

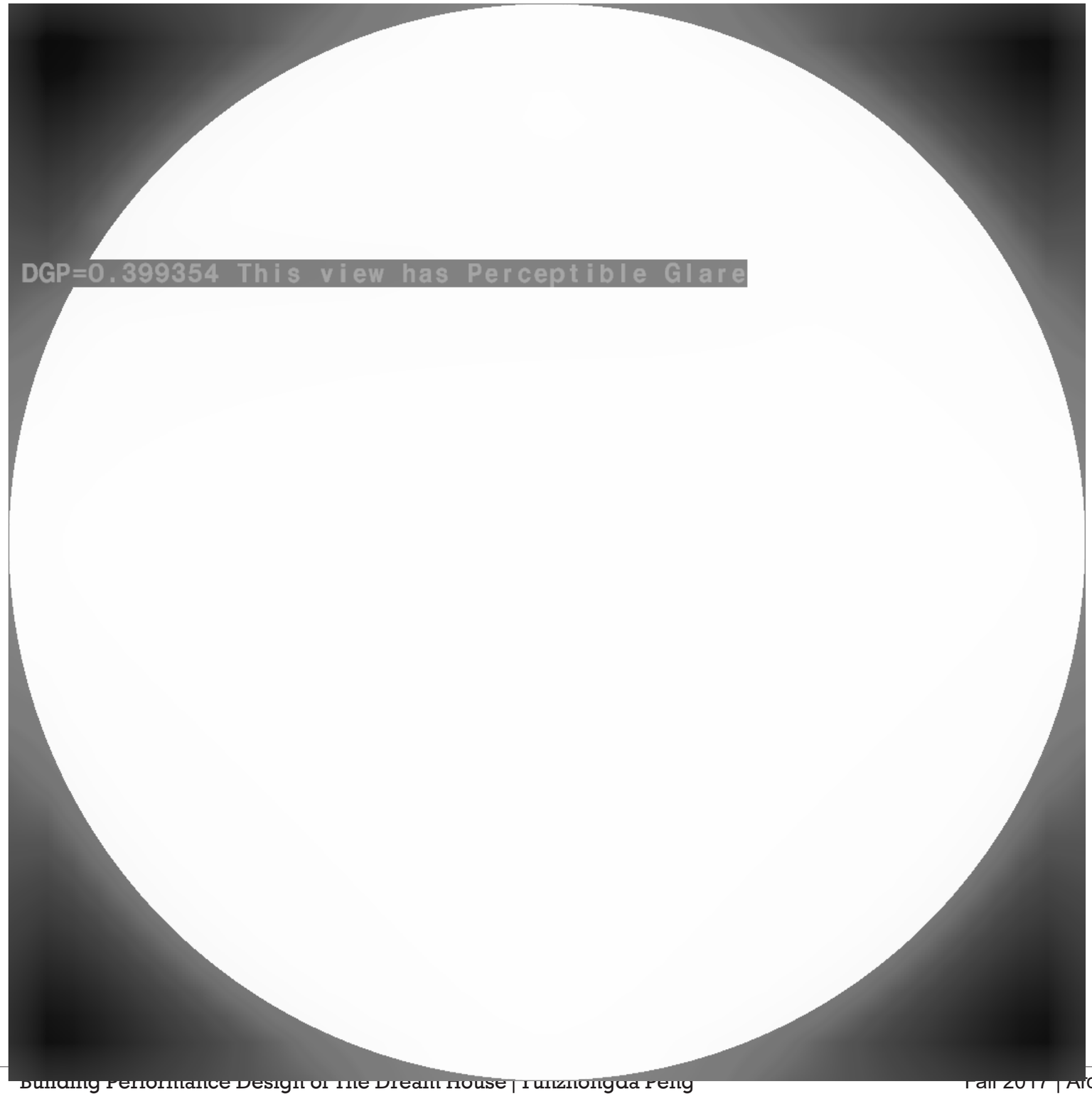
Window to Wall Ratio and Annual UDI



#The useful daylight illuminance will be maximized under the window to wall ratio which is around 0.23.

Shading



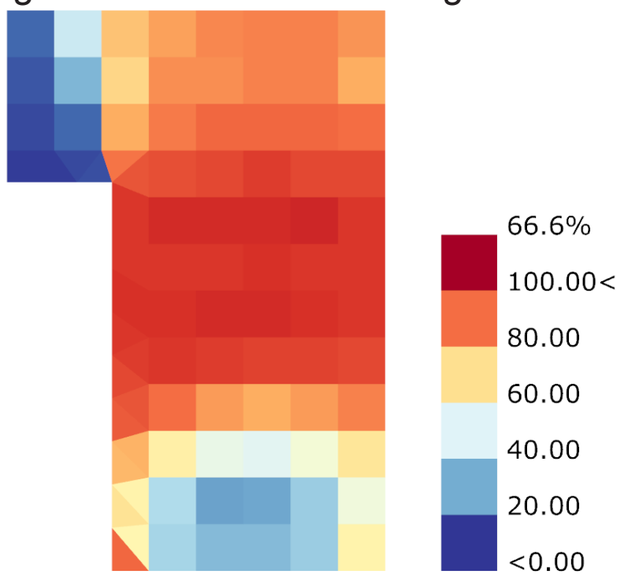


#Shading slightly reduced the glare intensity, so it is now perceptible, but not disturbing.

Daylight Autonomy

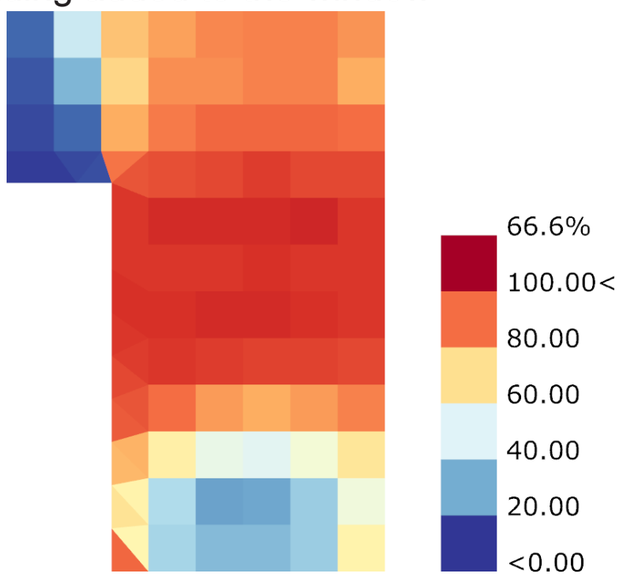
#Shading does not effect UDI.

Original room without shading



annual analysis

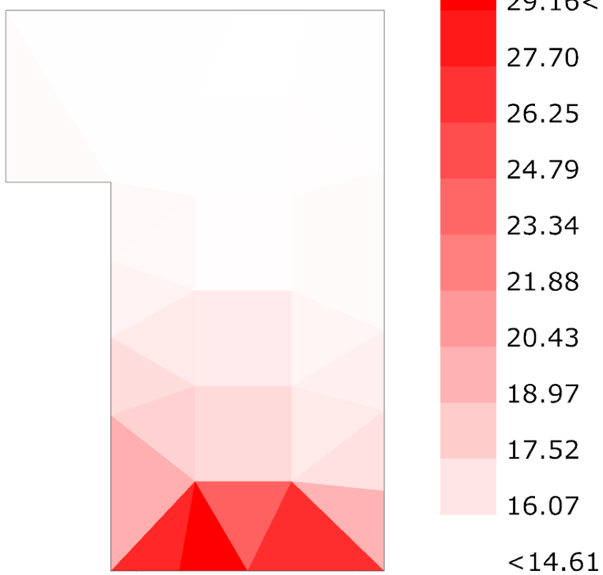
Shading added to the window



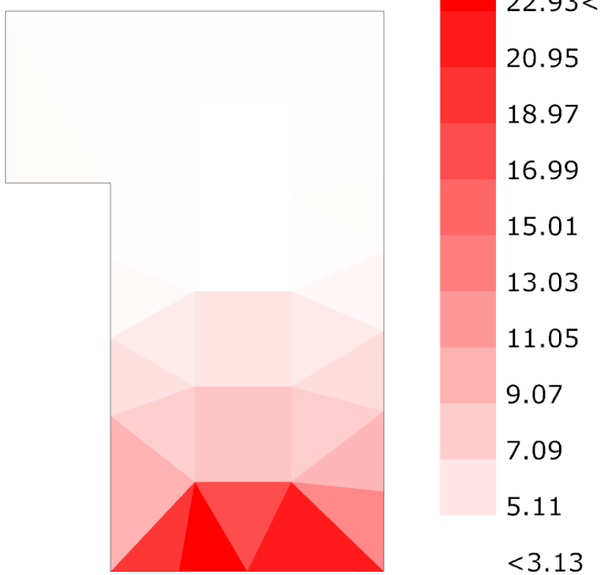
annual analysis

Thermal Autonomy

#Shading will make PMV values slightly better.

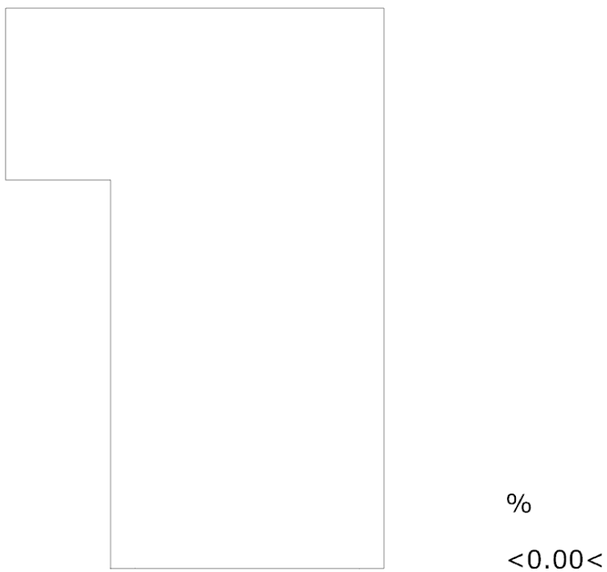


PMV Over-Heated Percent
Jan 1 1:00 - Dec 31 24:00



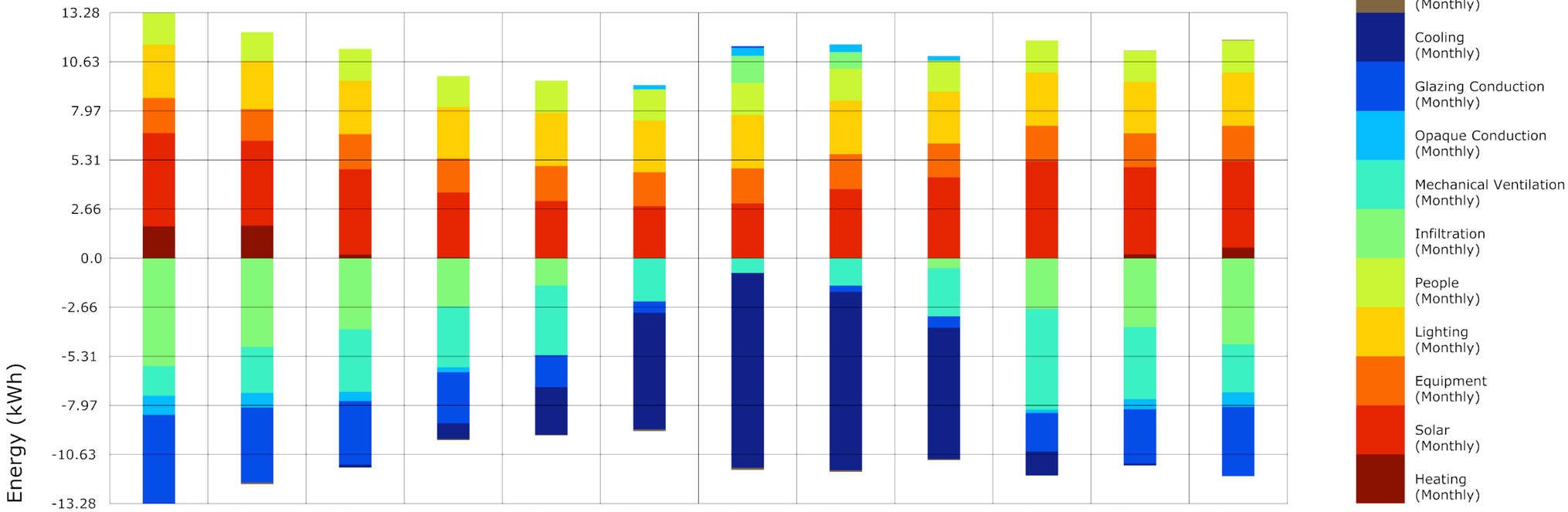
PMV Over-Heated Percent
Jan 1 1:00 - Dec 31 24:00

PMV Under-Heated Percent
Jan 1 1:00 - Dec 31 24:00



PMV Under-Heated Percent
Jan 1 1:00 - Dec 31 24:00

Default Energy Balance

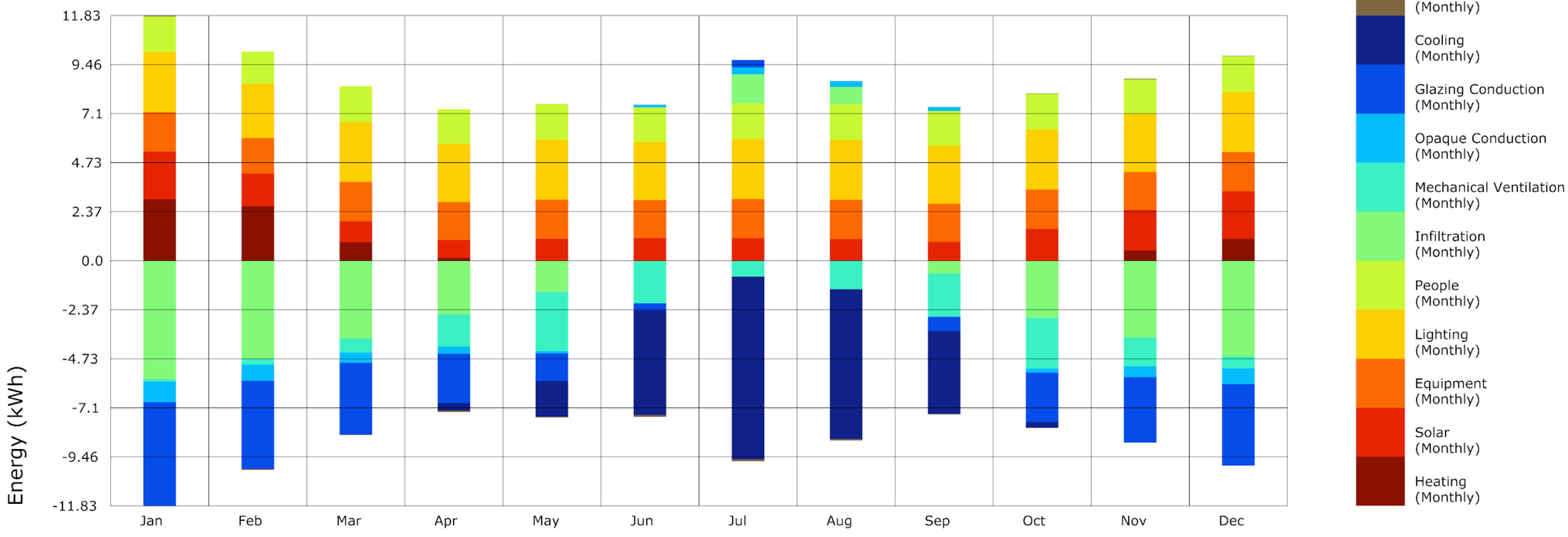


Energy Balance with Shading

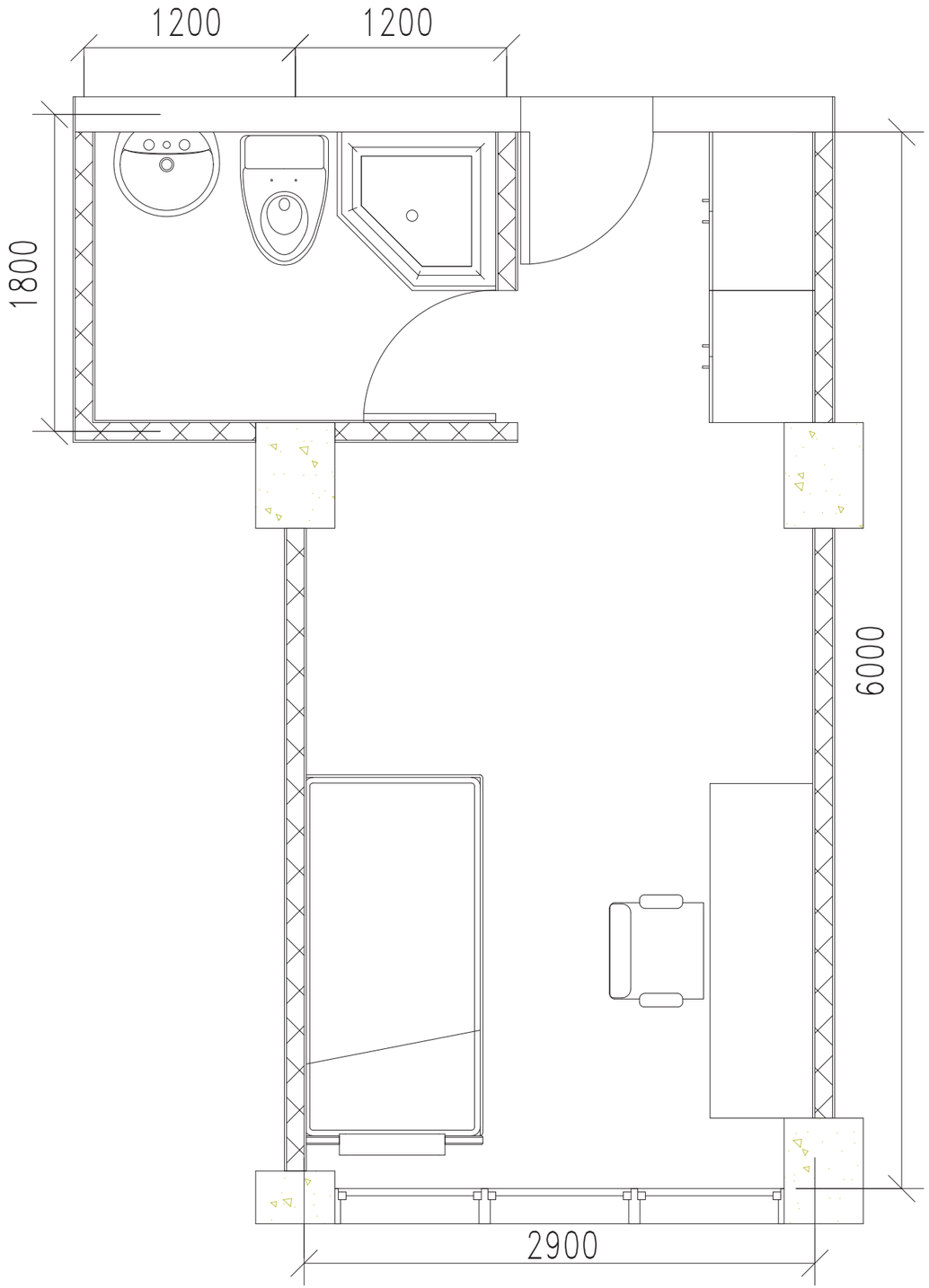
#The overall energy consumption decreases with shading.

#Shading mainly decreases the solar radiance.

#Cooling conduction in summer seems to increase with shading.



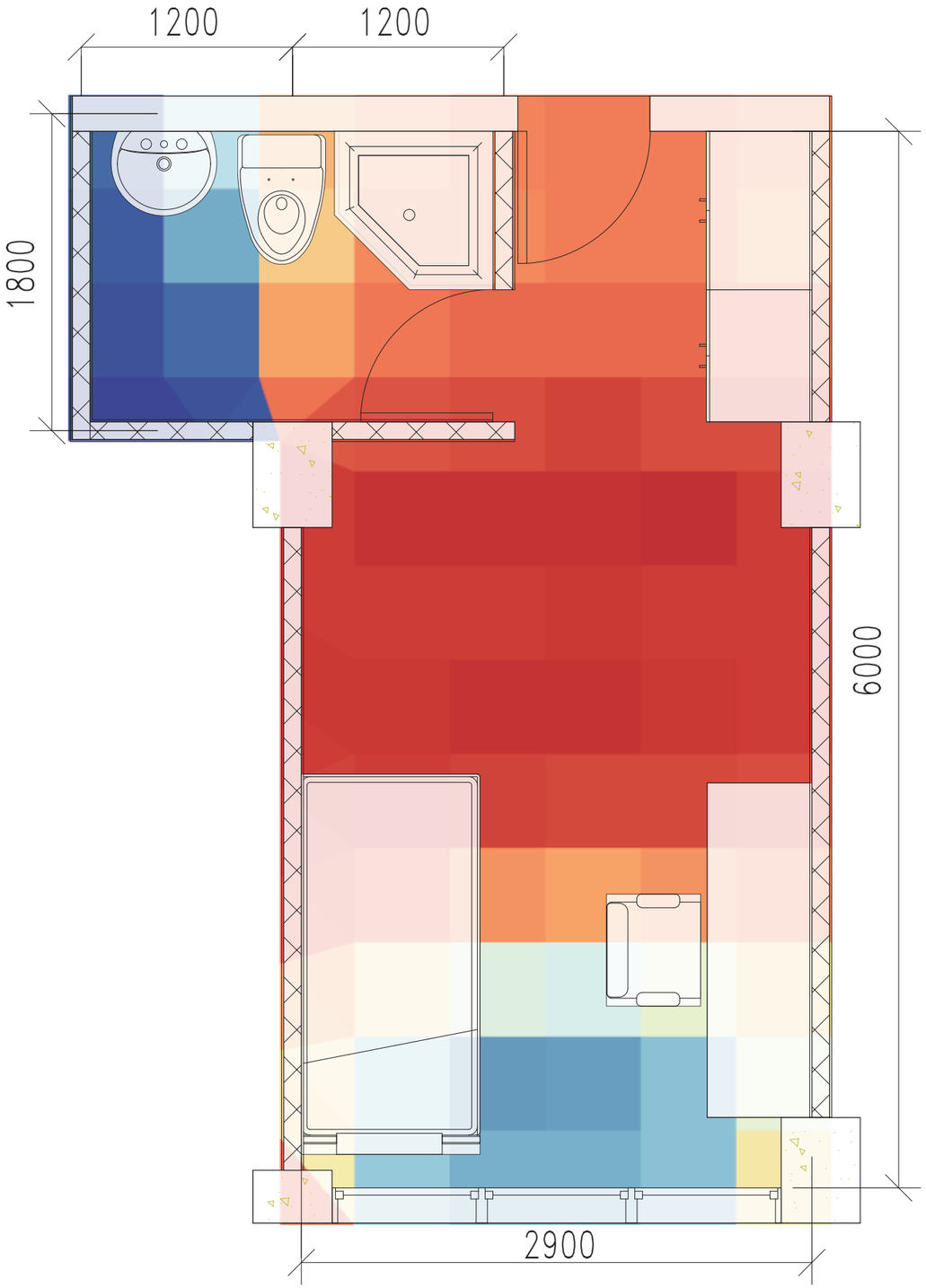
Conclusions



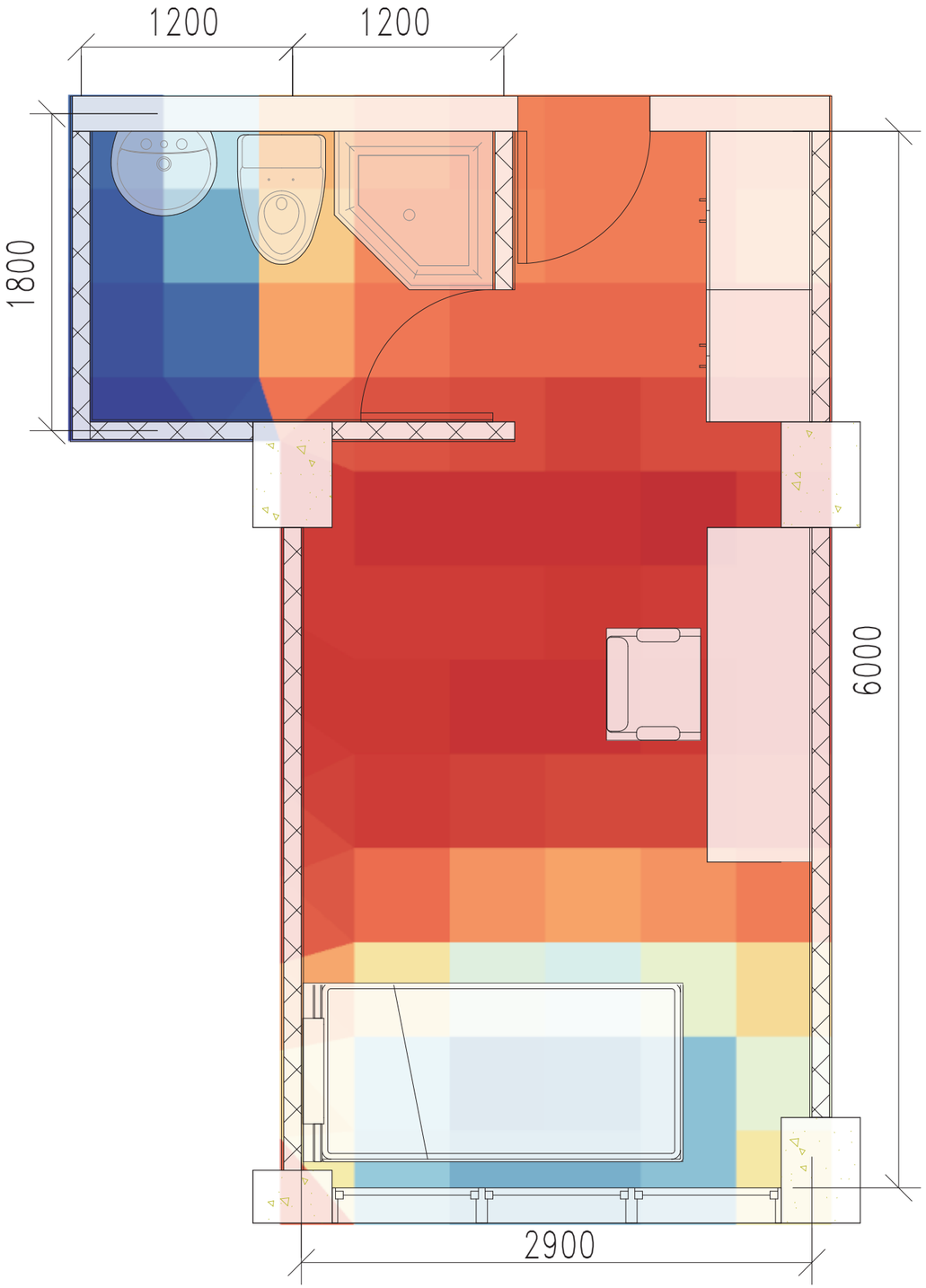
#As the measures to improve daylight and thermal comfort conditions, it is suggested to make the window to wall ratio around 0.23, and to install vertical and horizontal shades around the window.

#For saving energy consumption, it is suggested to employ building materials with high R values, such as non-metal exterior windows.

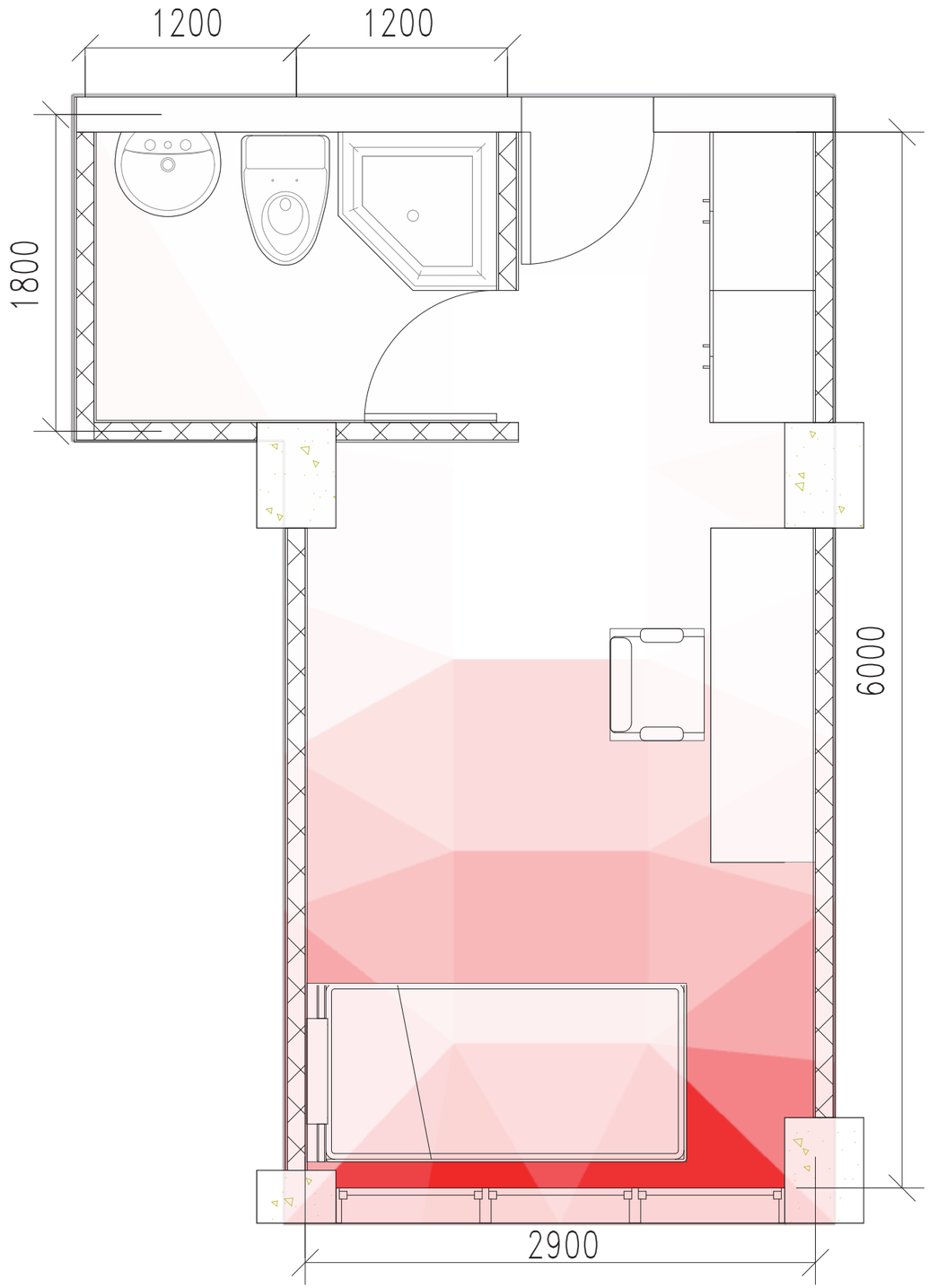
#Considering the glazing conduction consumption, further design of the window construction could be made such as insulating glass.



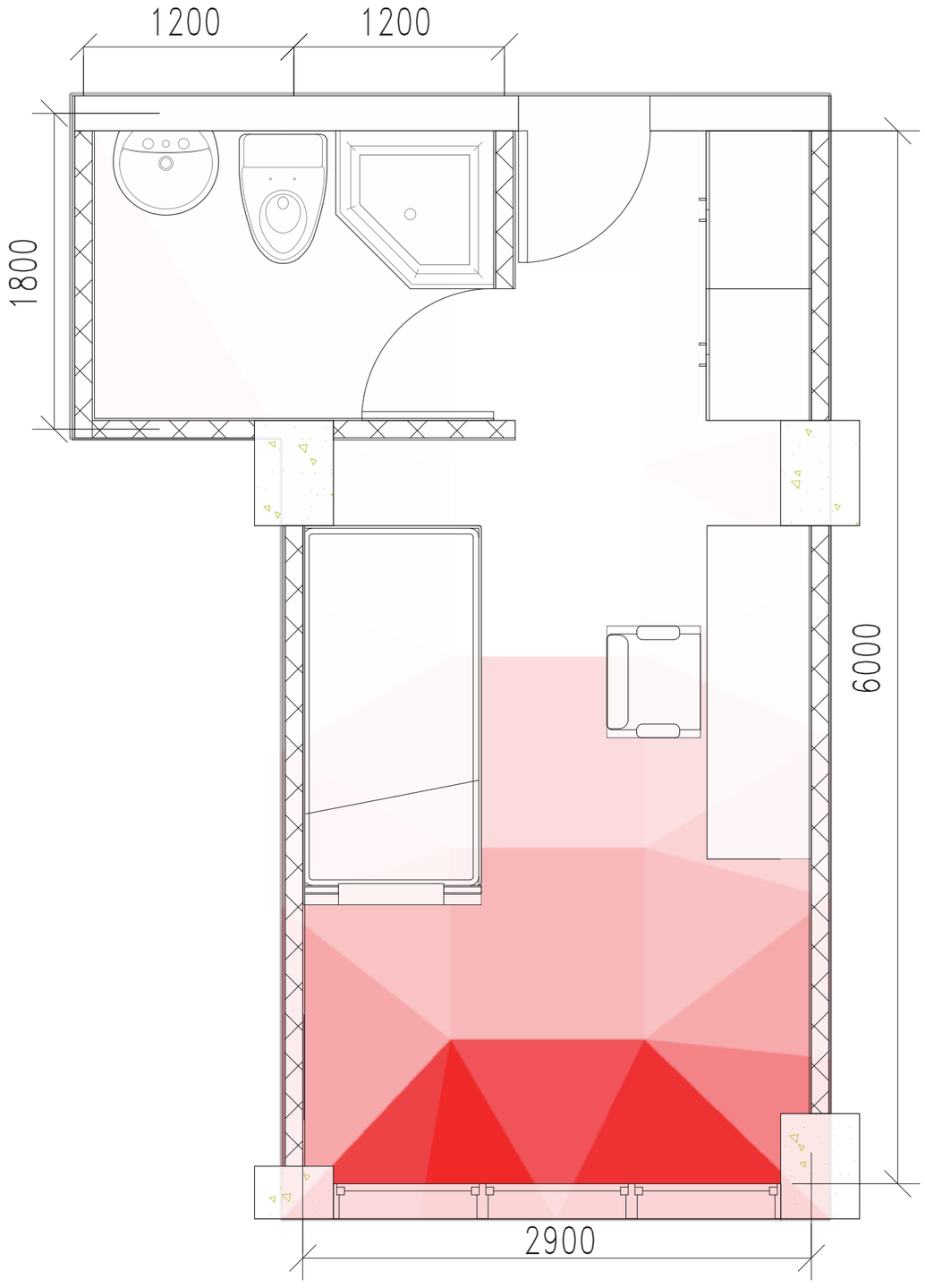
#According to UDI metrics of the room, the area near the window is lacking useful daylight illuminance, the original furniture layout is therefore not very suitable for activities such as reading.



#The desk and chair are moved toward the door to get better day-light illuminance. The bed could be put near the window to utilize the space without adequate UDI.



#According to the thermal comfort metrics, the bed is exposed to the hazard of being overheated provided there is no mechanical cooling. The new position for the desk is acceptable.



#Final layout of the room and furnitures.