International Radiance Workshop 2012

Parametric Daylight Envelope: shading for maximum performance

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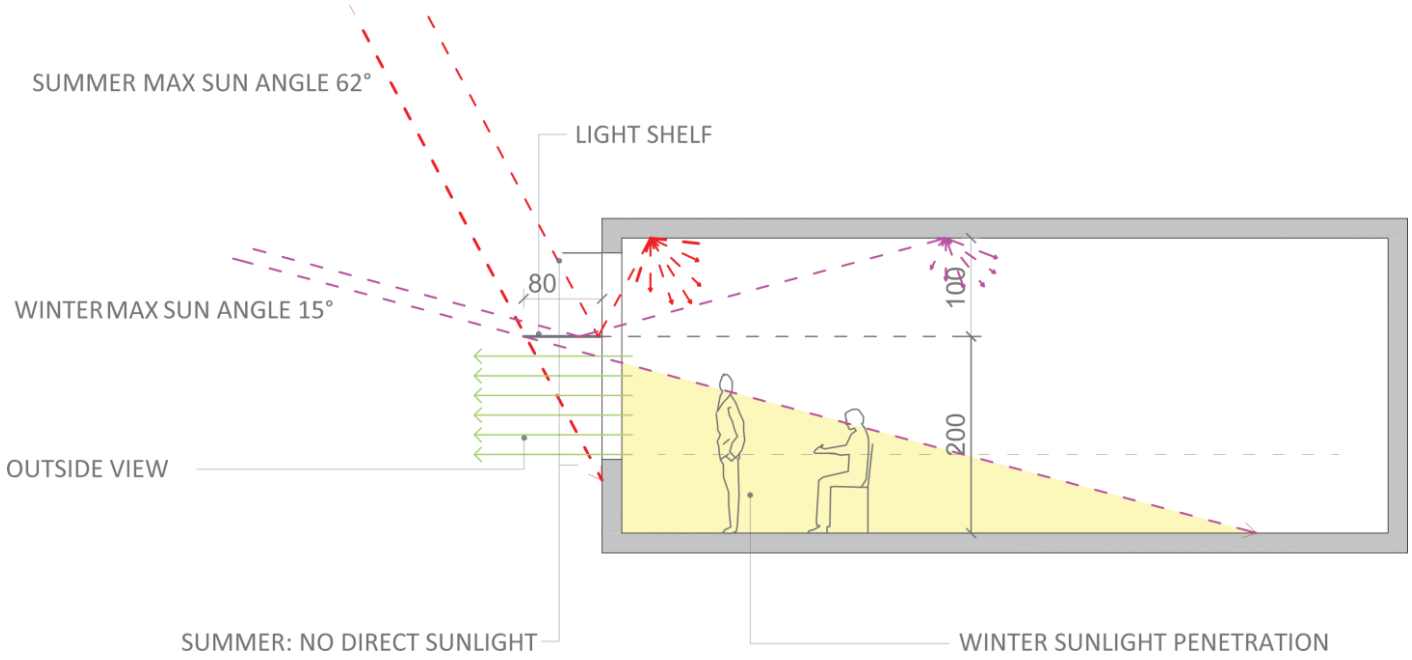
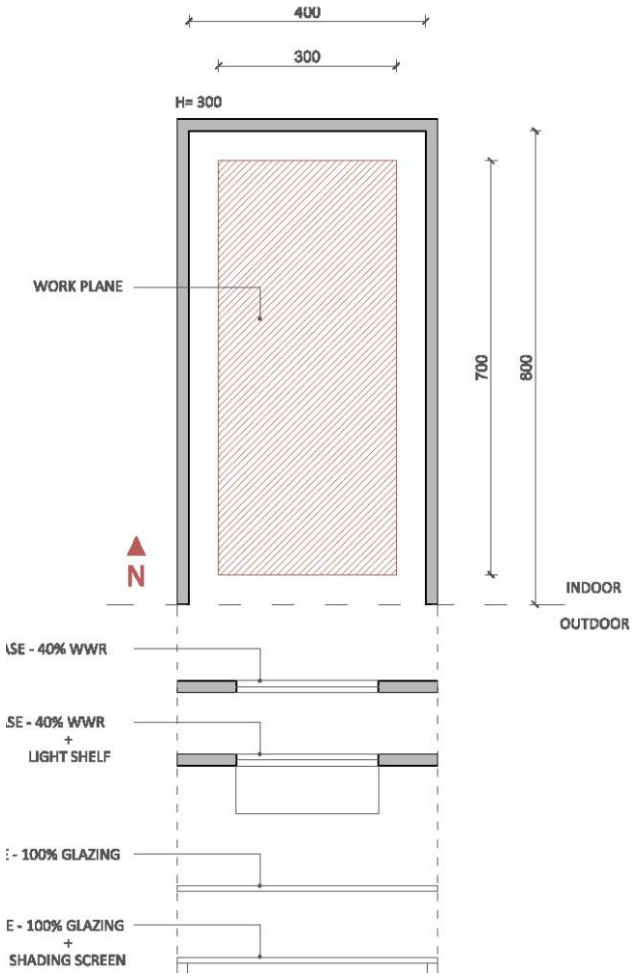
Summary

Introduction
Case study
Screen Geometry and Parametric Variation of the Depth
Daylight results
Thermal results
Conclusions

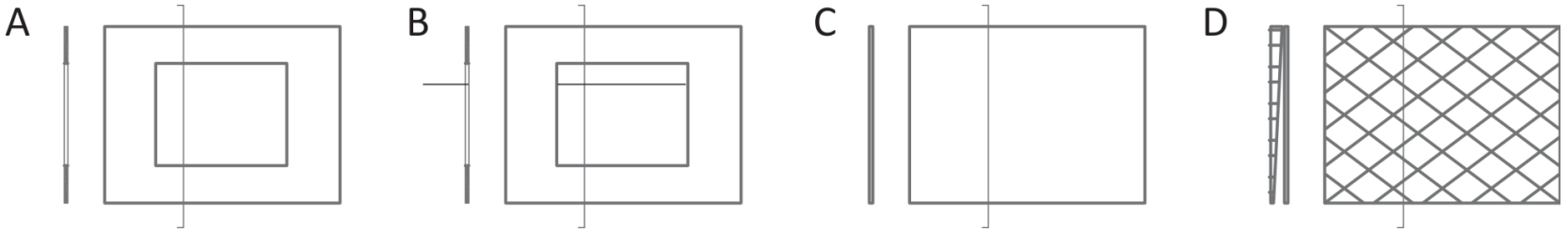


Case study

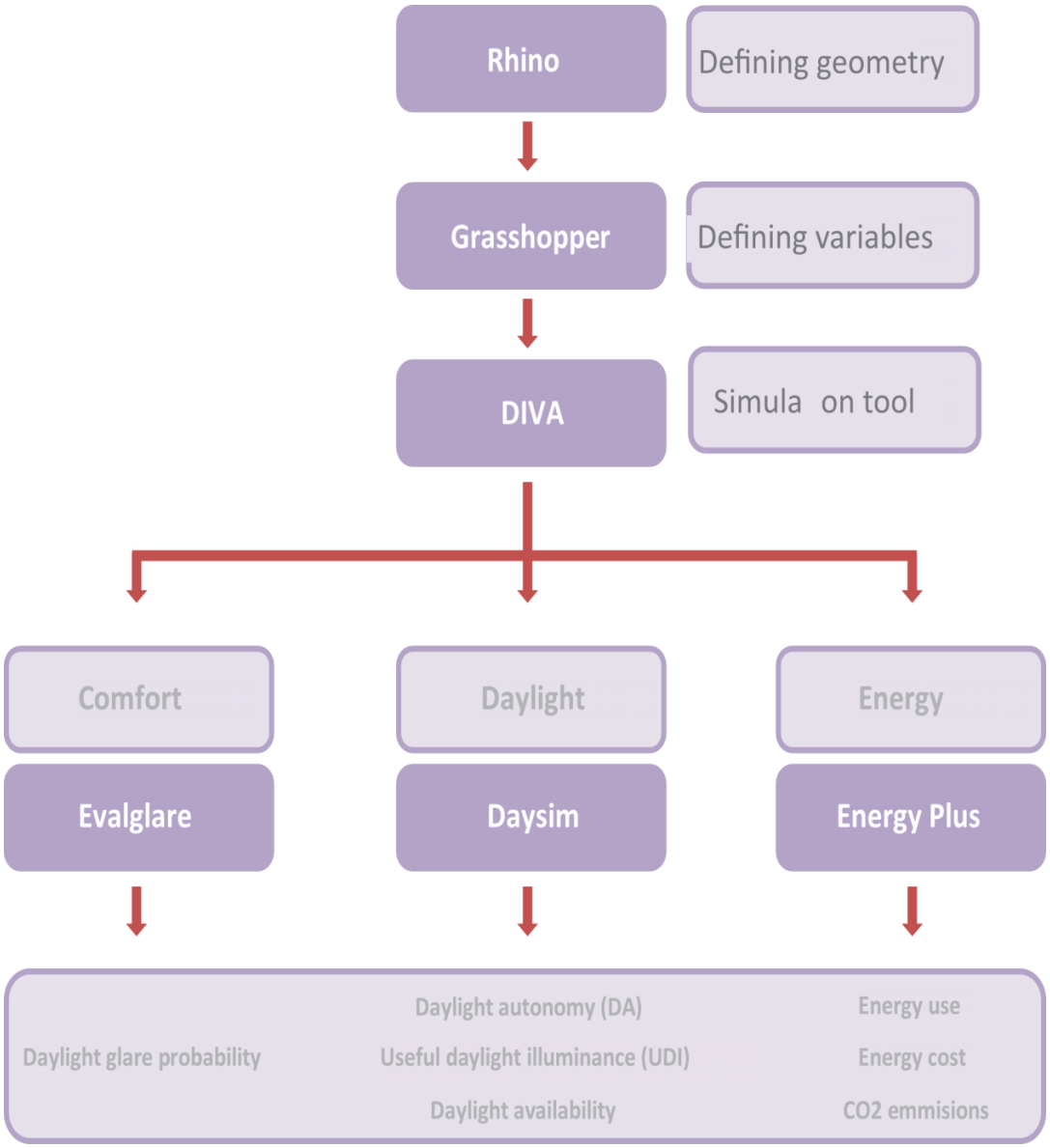


London (51 N, Long 0)

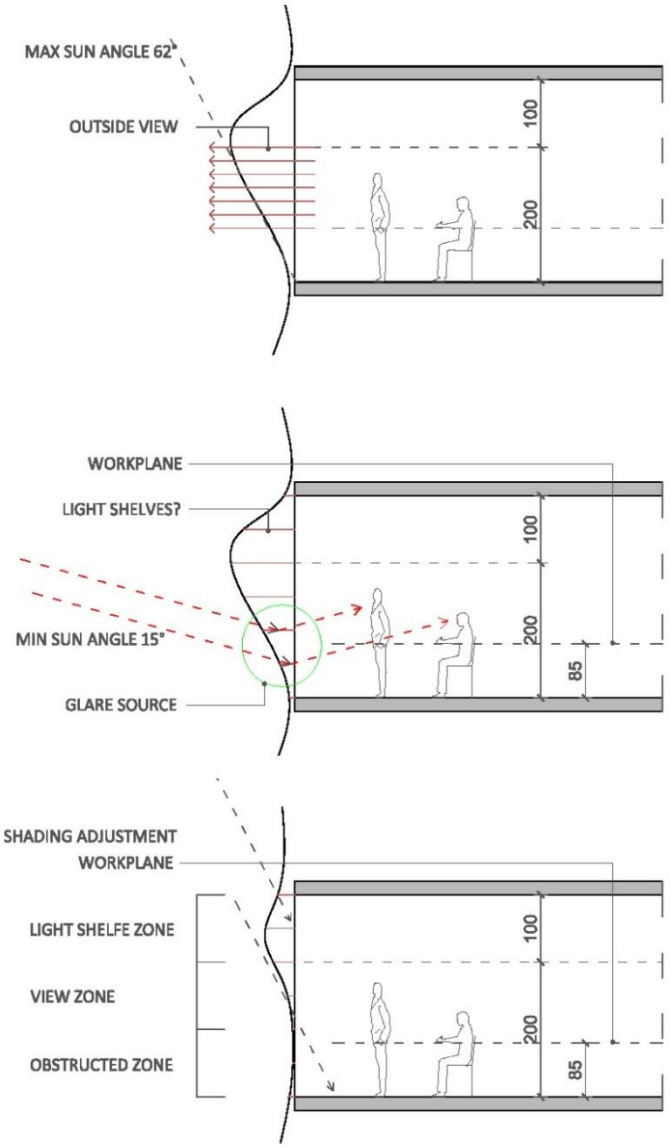
A. 40%WWR
B. 40%WWR + Light shelf (enhanced A case)
C. 100%WWR
D. 100%WWR + 3d parametrically designed ‘screen’ (enhanced C case)



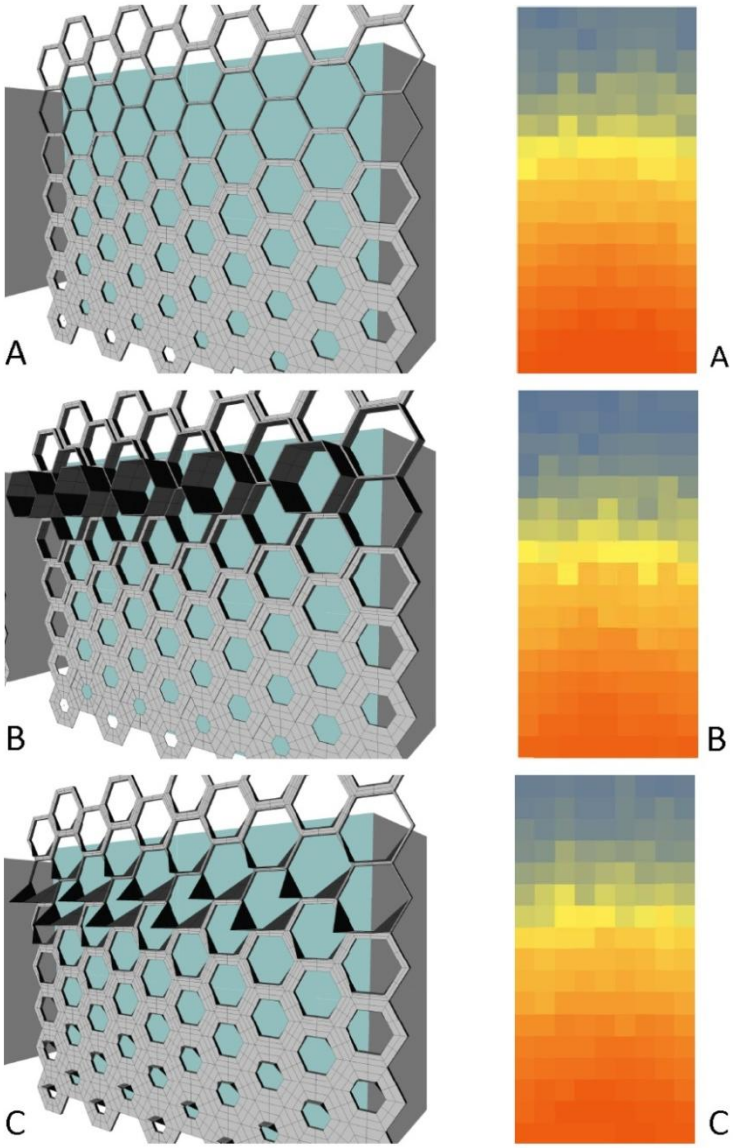
Scheme of software



Summary

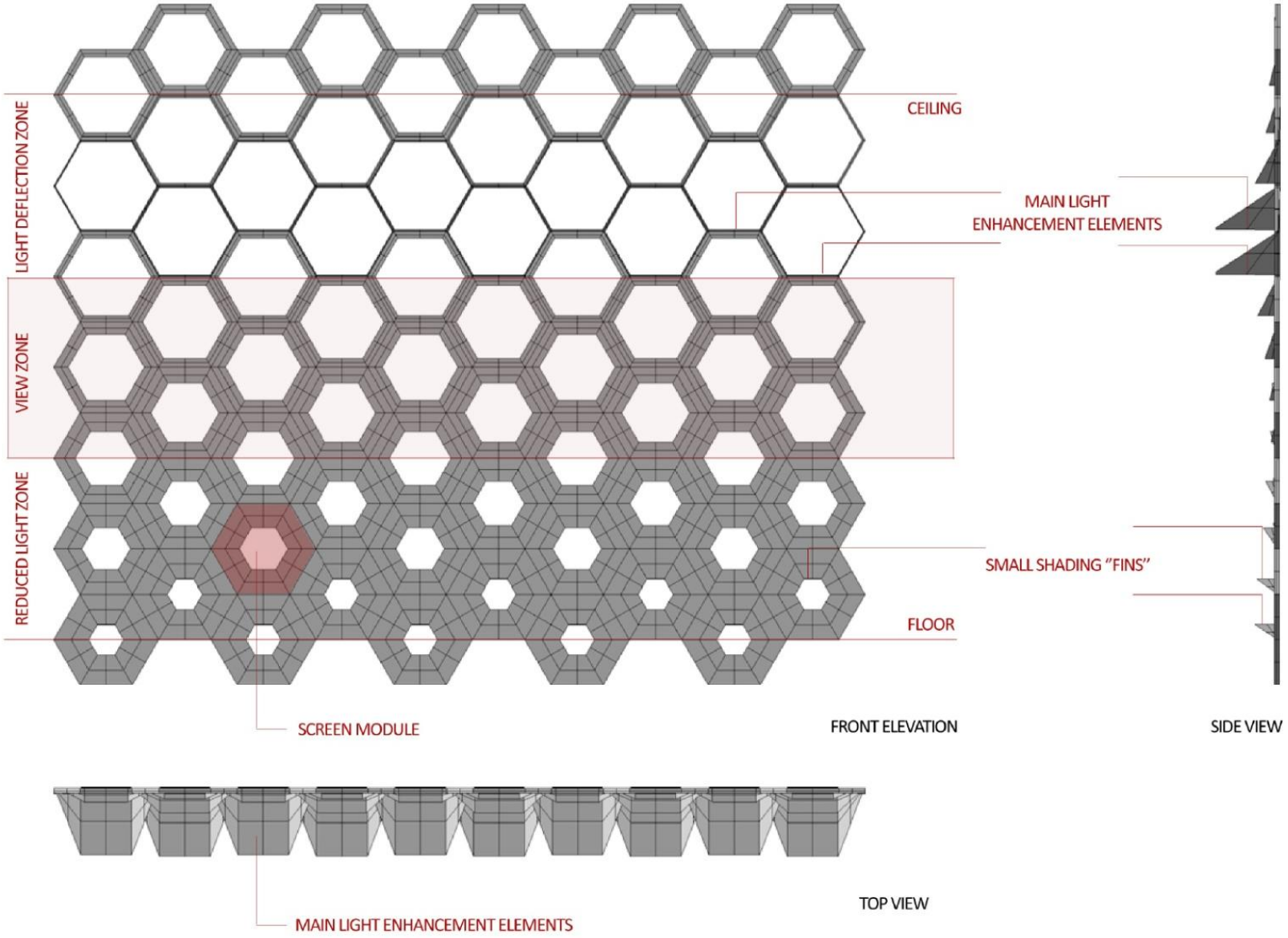


Conceptual CAD sketches

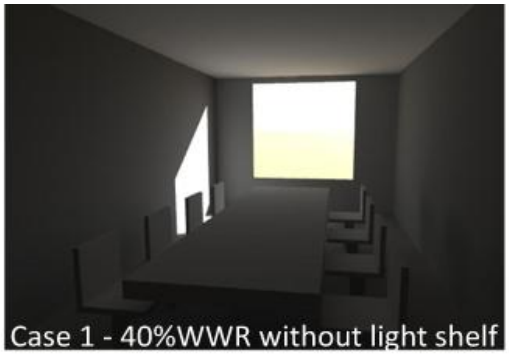


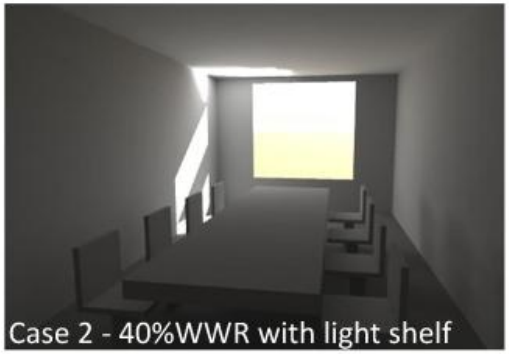
Daylight Autonomy comparison

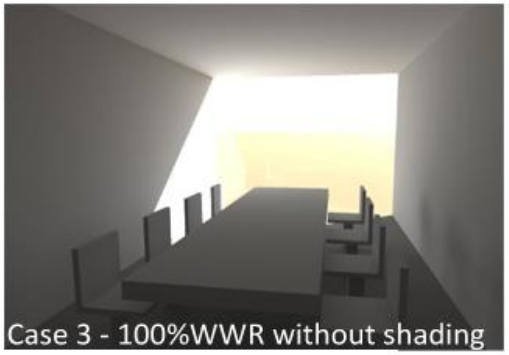
Summary


LIGHT DEFLECTION ZONE
VIEW ZONE
REDUCED LIGHT ZONE
CEILING
MAIN LIGHT
ENHANCEMENT ELEMENTS
SMALL SHADING "FINS"
FLOOR
SCREEN MODULE
FRONT ELEVATION
SIDE VIEW
MAIN LIGHT ENHANCEMENT ELEMENTS
TOP VIEW

Radiance parameters



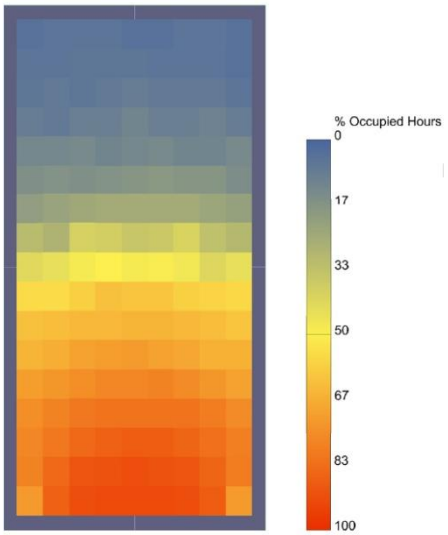




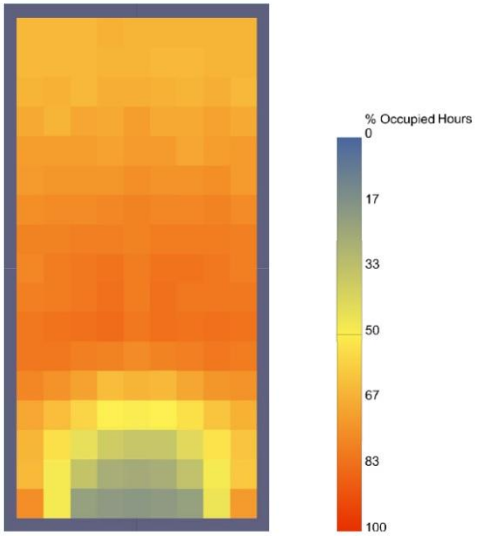
Ambient bounces	Ambient division	Ambient sampling	Ambient accuracy	Ambient resolution	Direct threshold
6	1024	512	0.1	128	0.05

Radiance parameters used

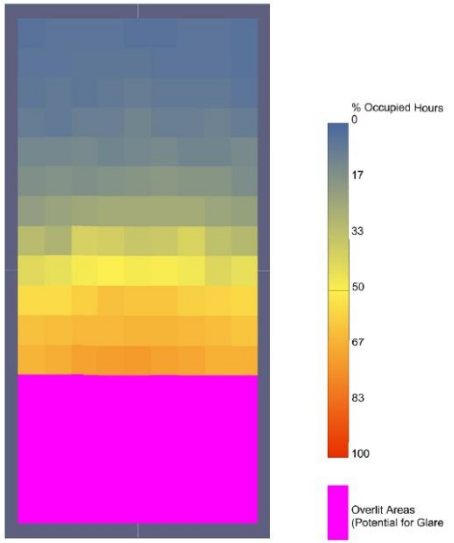
40% WWR without light shelf



DA (500lx)= 44.65%

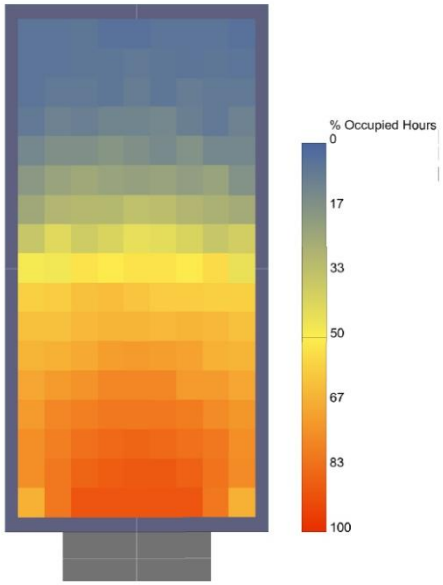


Useful Daylight Illuminance (UDI)
(100lux<UDI<2000lux)
UDI= 67.02%

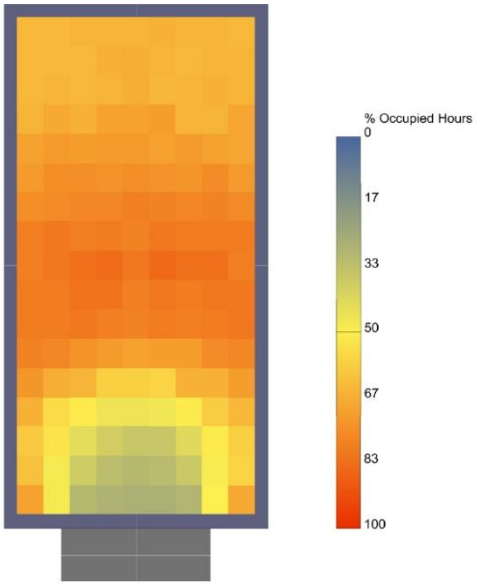


Oversupplied area

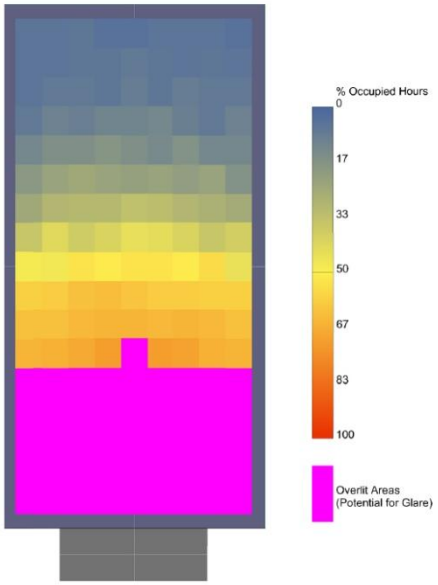
40% WWR with light shelf



DA (500 lux)= 45.33%

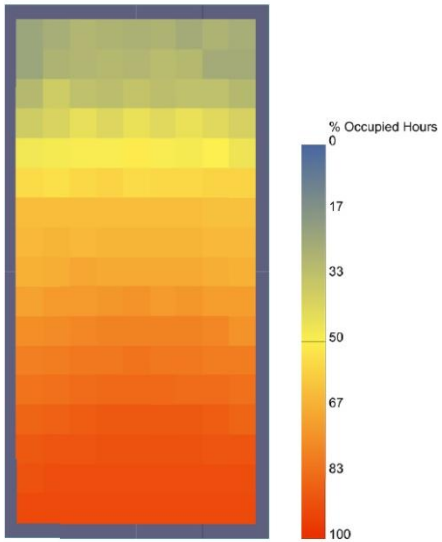


Useful Daylight Illuminance (UDI)
(100lux<UDI<2000lux)
UDI= 66.43%

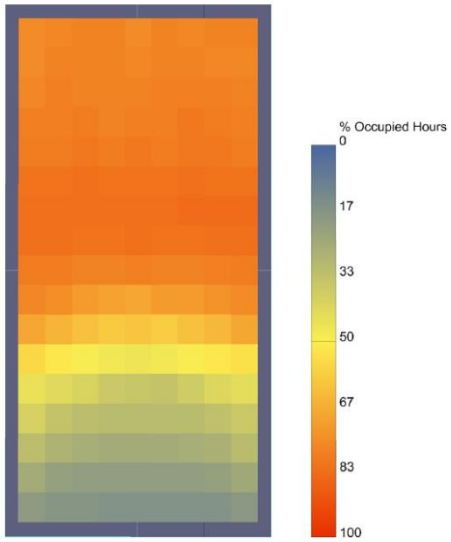


Oversupplied area

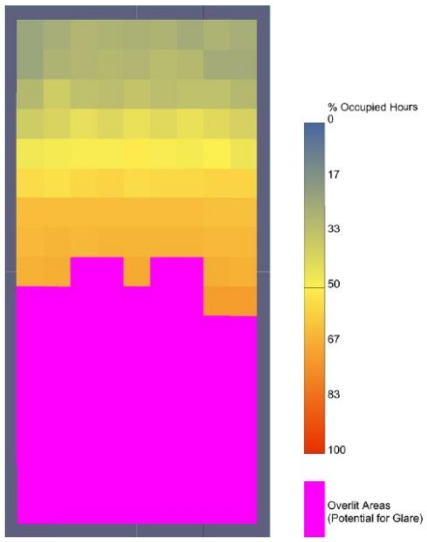
100% WWR without shading screen



DA (500 lux) = 64.96%

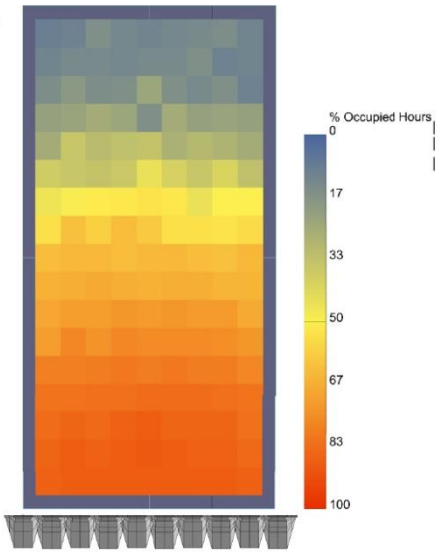


Useful Daylight Illuminance (UDI)
(100lux<UDI<2000lux)
UDI= 61.42%

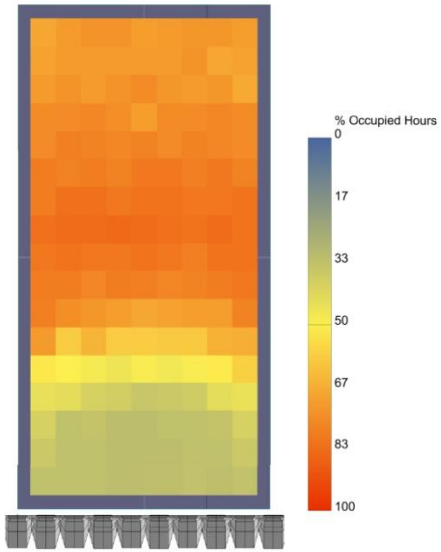


Oversupplied Area

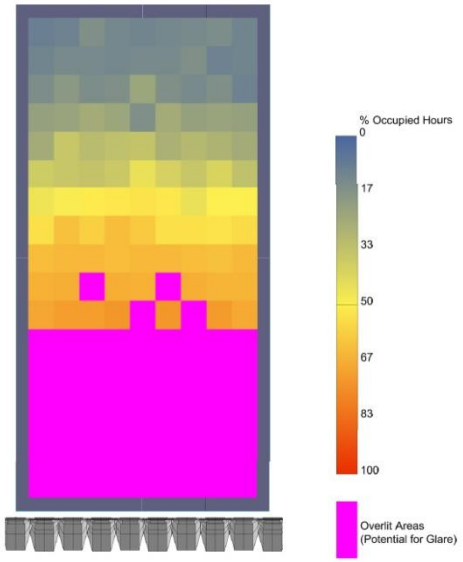
100% WWR with shading screen



Daylight Autonomy (500 lux)
DA= 54.95% of time occupied

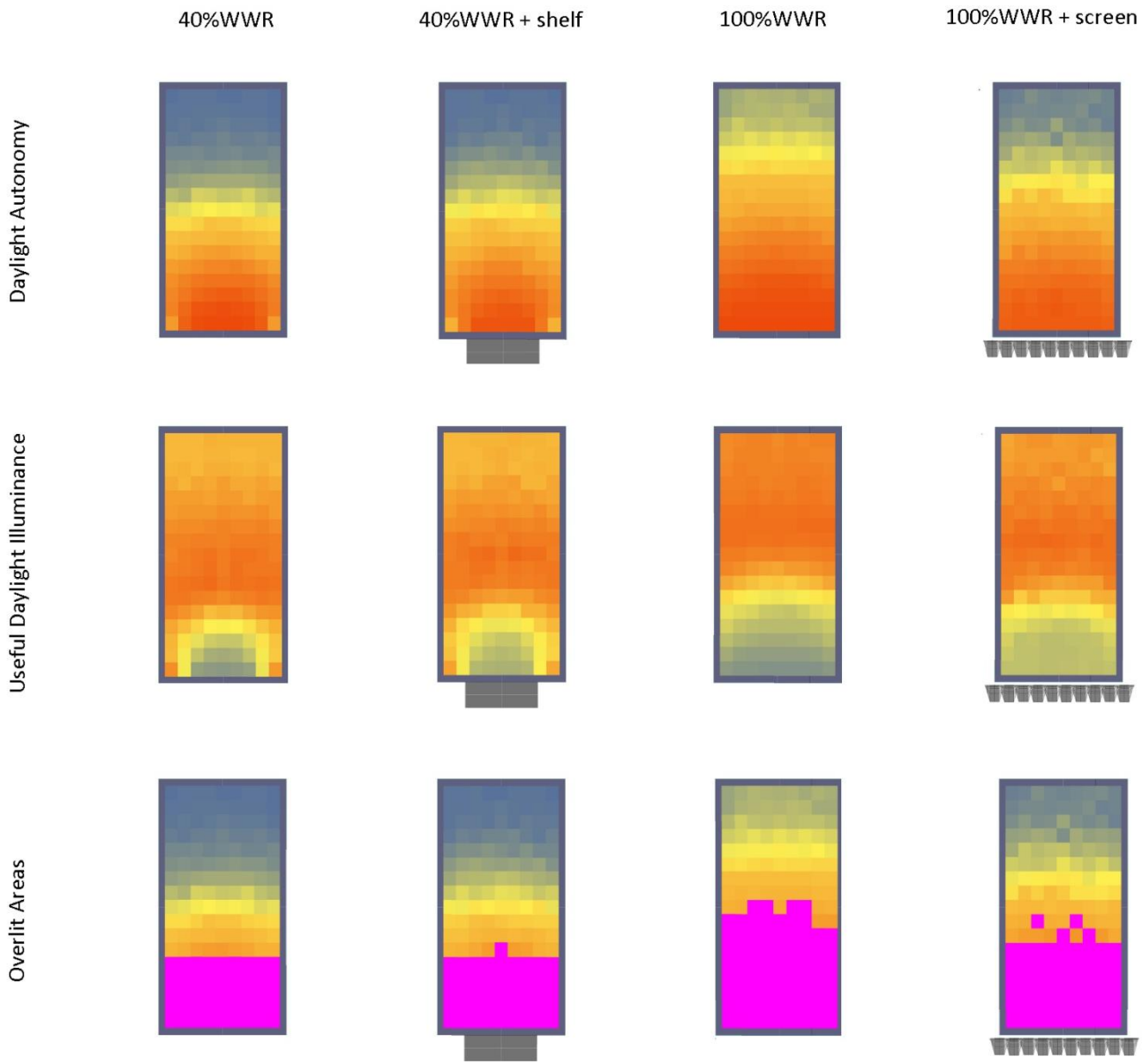


Useful Daylight Illuminance (UDI)
(100lux<UDI<2000lux)
UDI= 64.72%



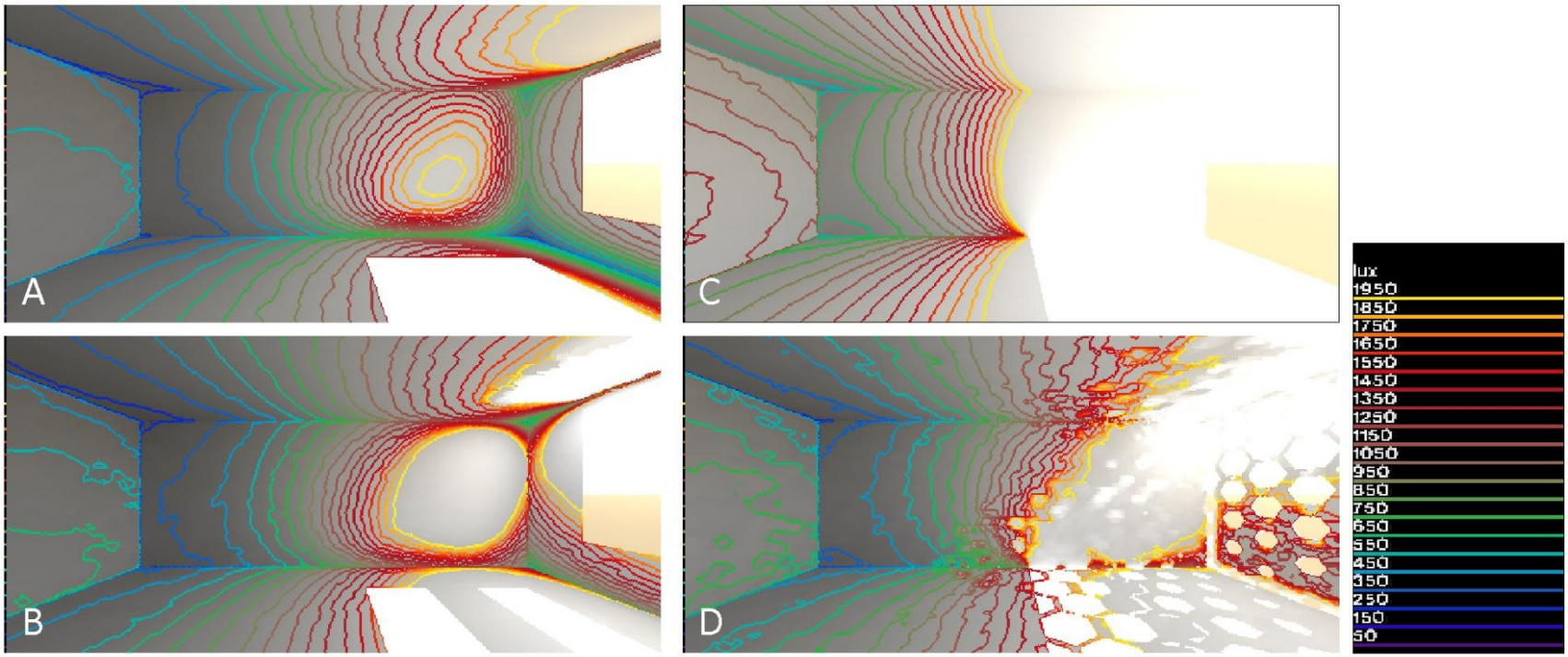
Oversupplied Area

Climate base metrics case comparison

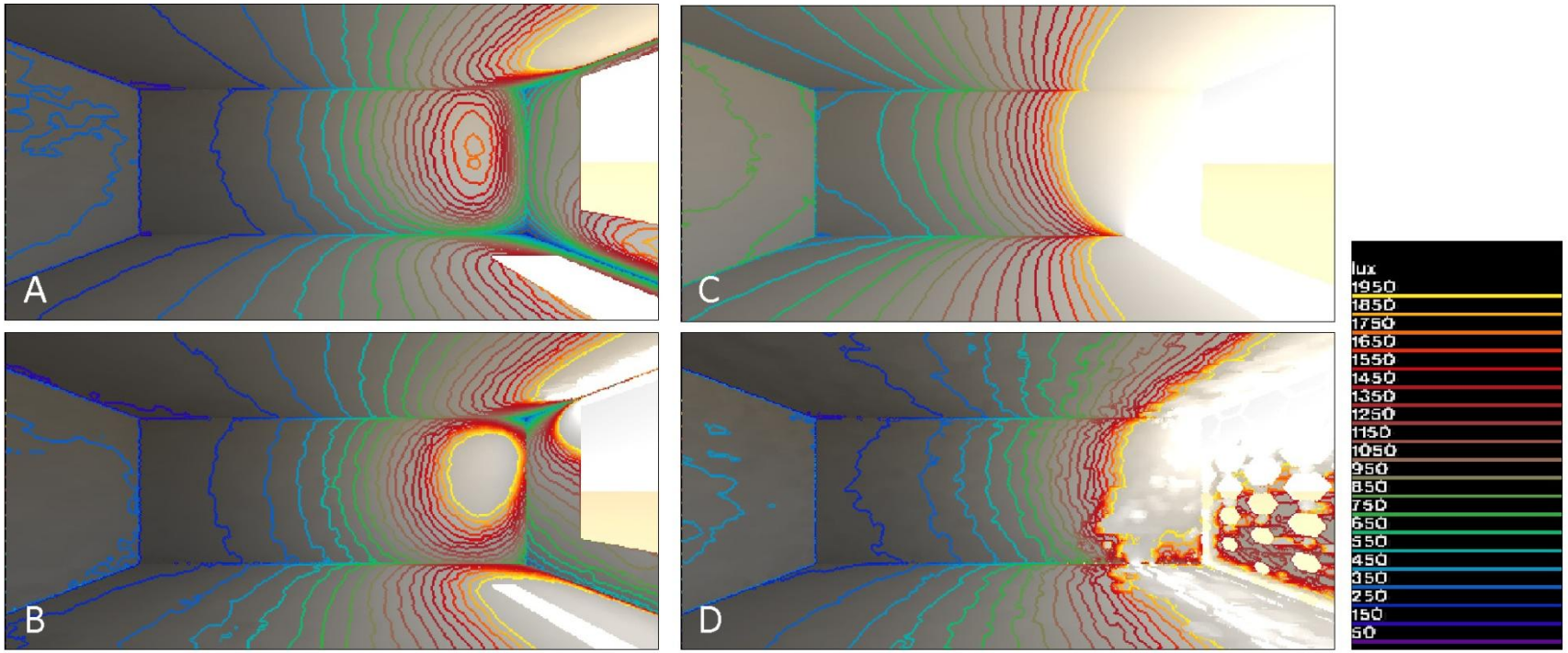


Equinox days - Clear sky - illuminance comparison

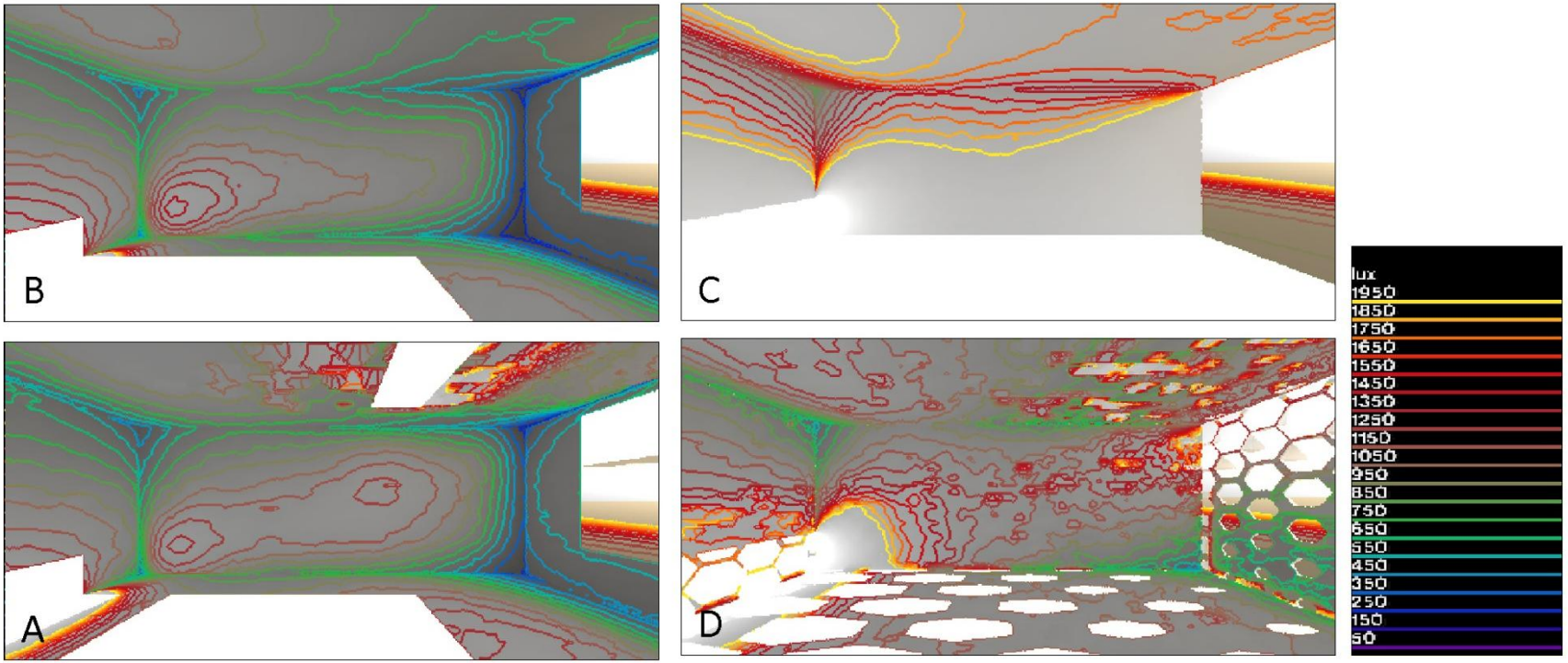
Analyses in Radiance have shown a slight increase of illuminance on a sunny equinox day in the back of the room after the light shelf is applied, while the screen resulted in an illuminance decrease.



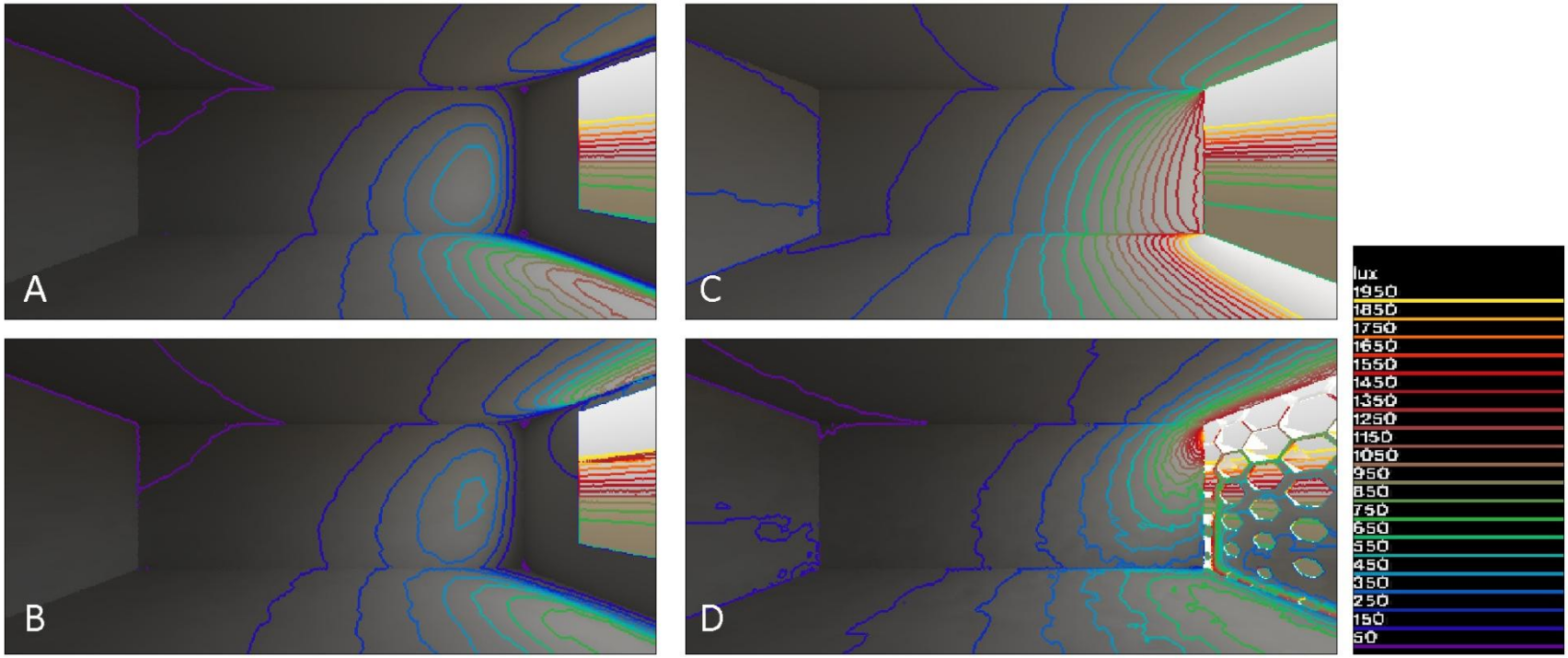
Summer Solstice- Clear sky - illuminance comparison



Winter Solstice - Clear sky - illuminance comparison

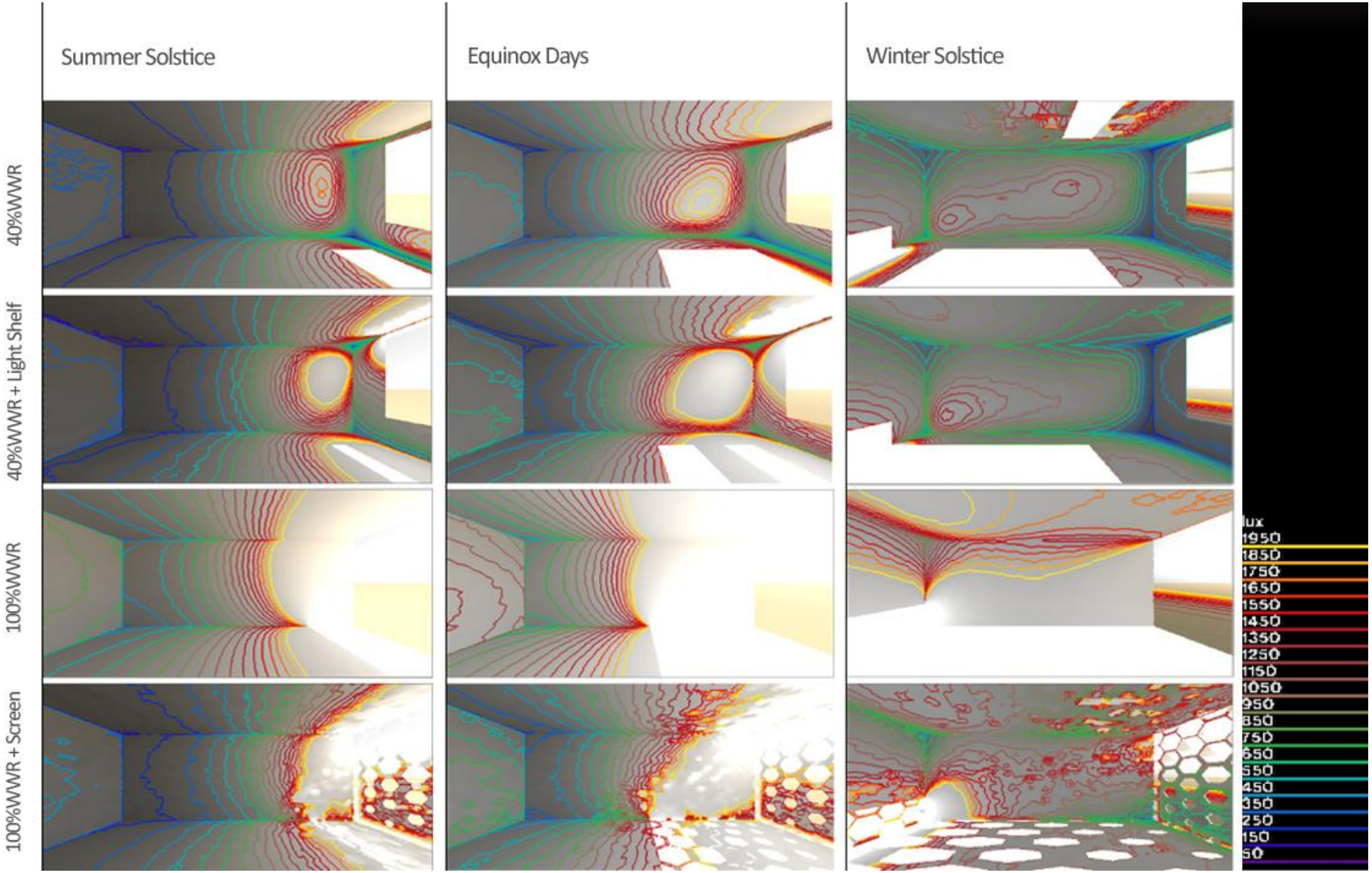


Overcast Sky – illuminance comparison

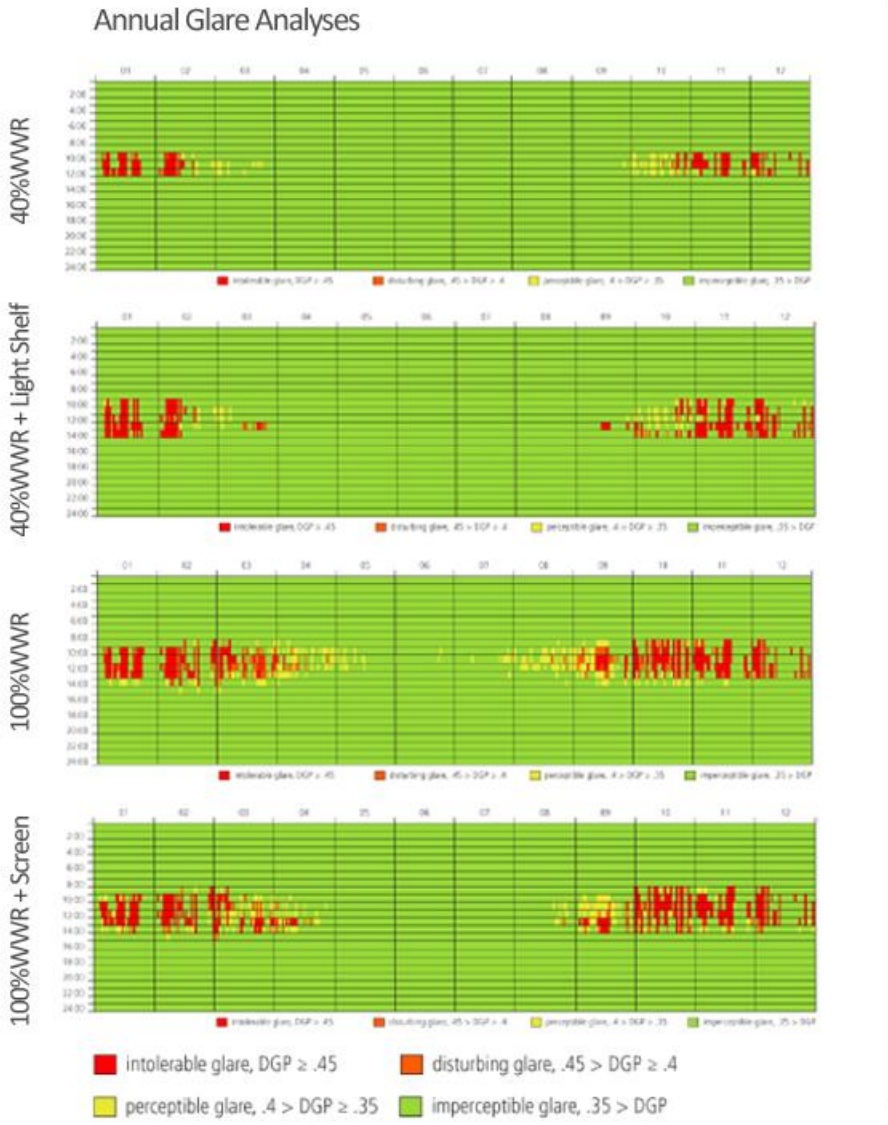


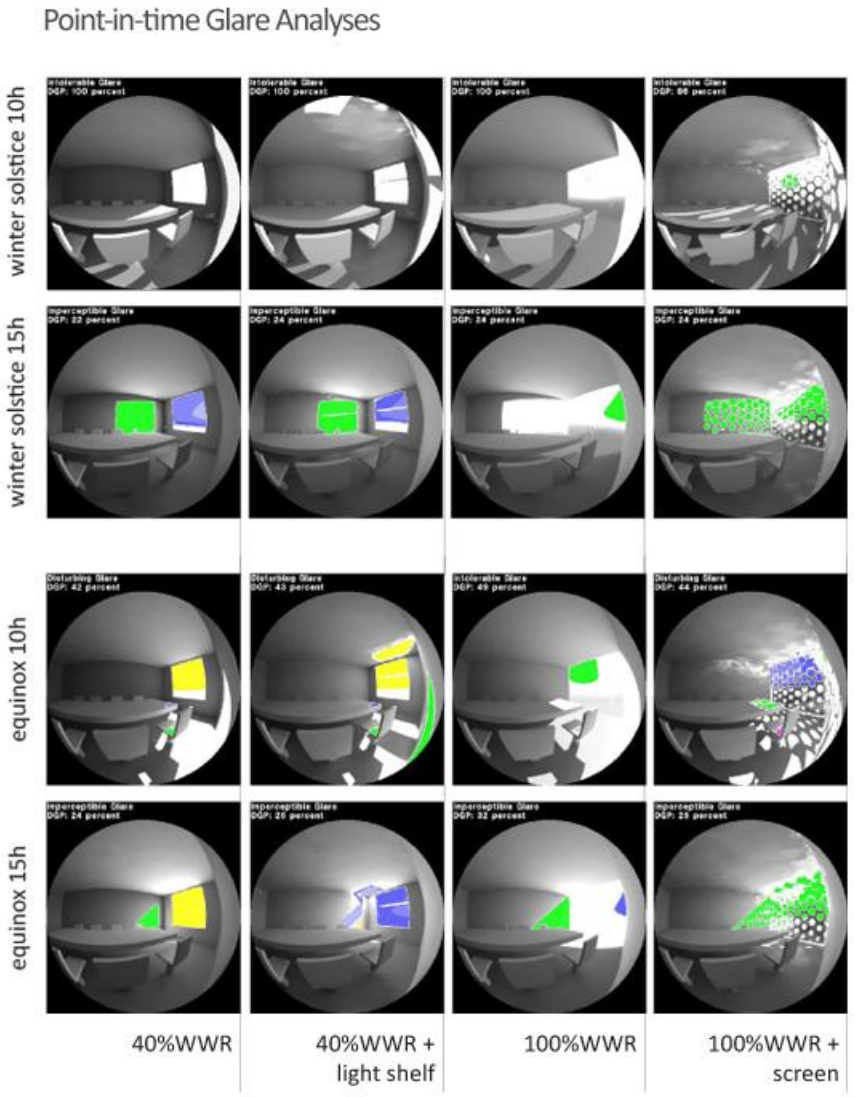
10,000 horizontal illuminance outdoors

RADIANCE illuminance comparison

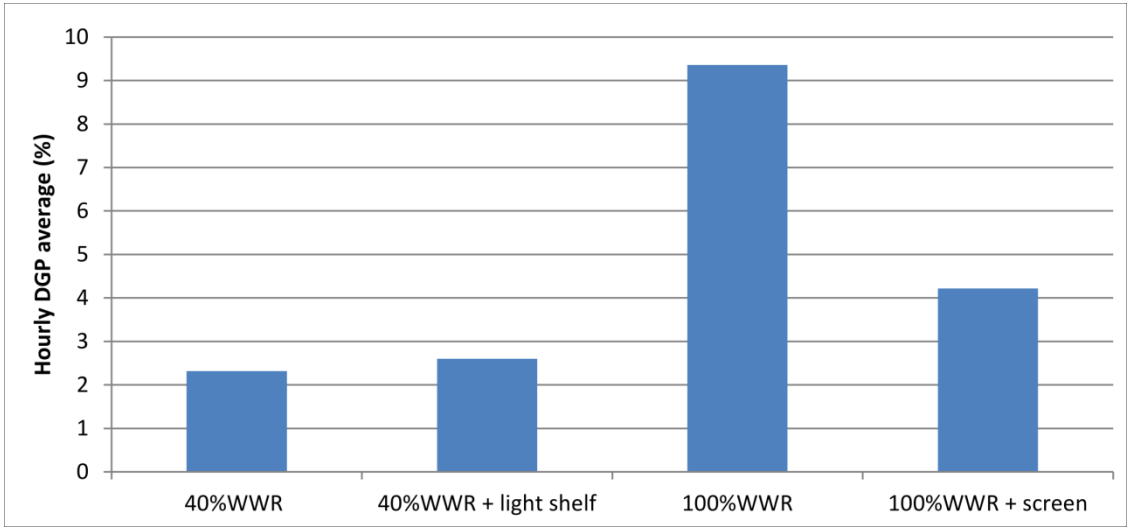


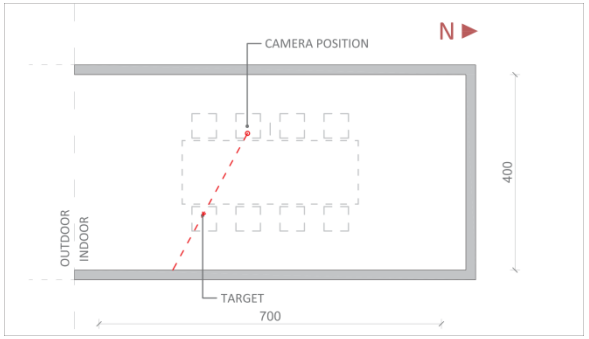
Glare analysis - point in time glare analysis





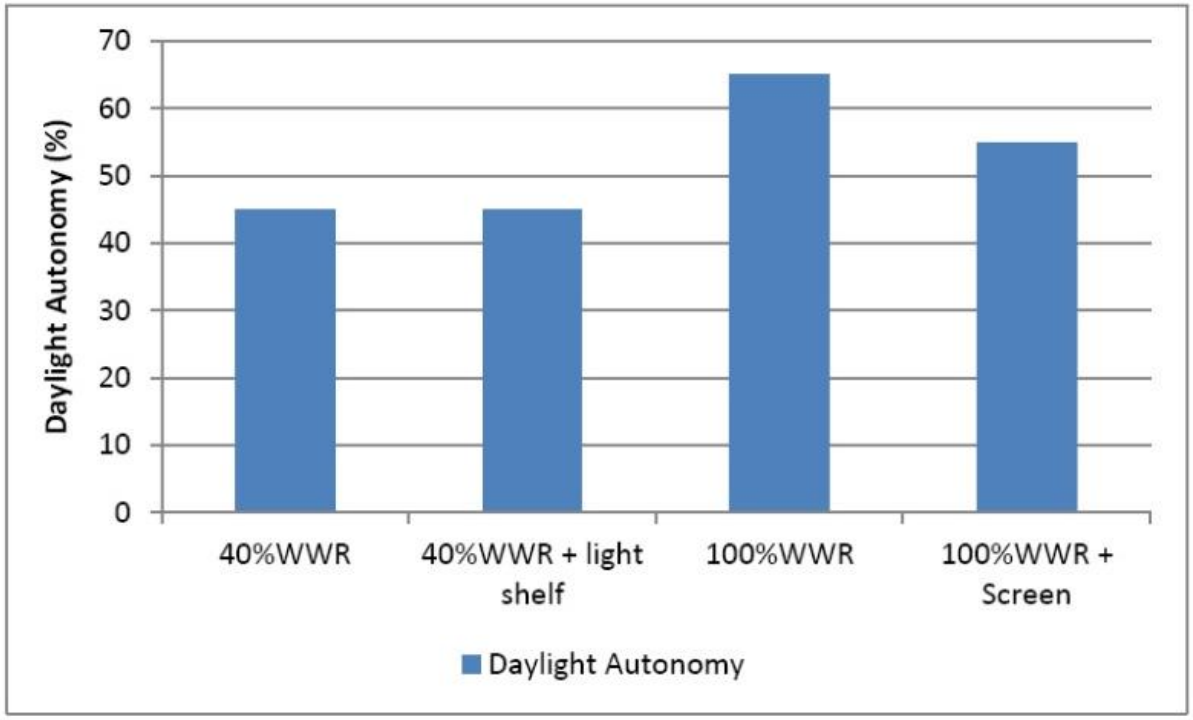
Average DGP Jan – Mar period





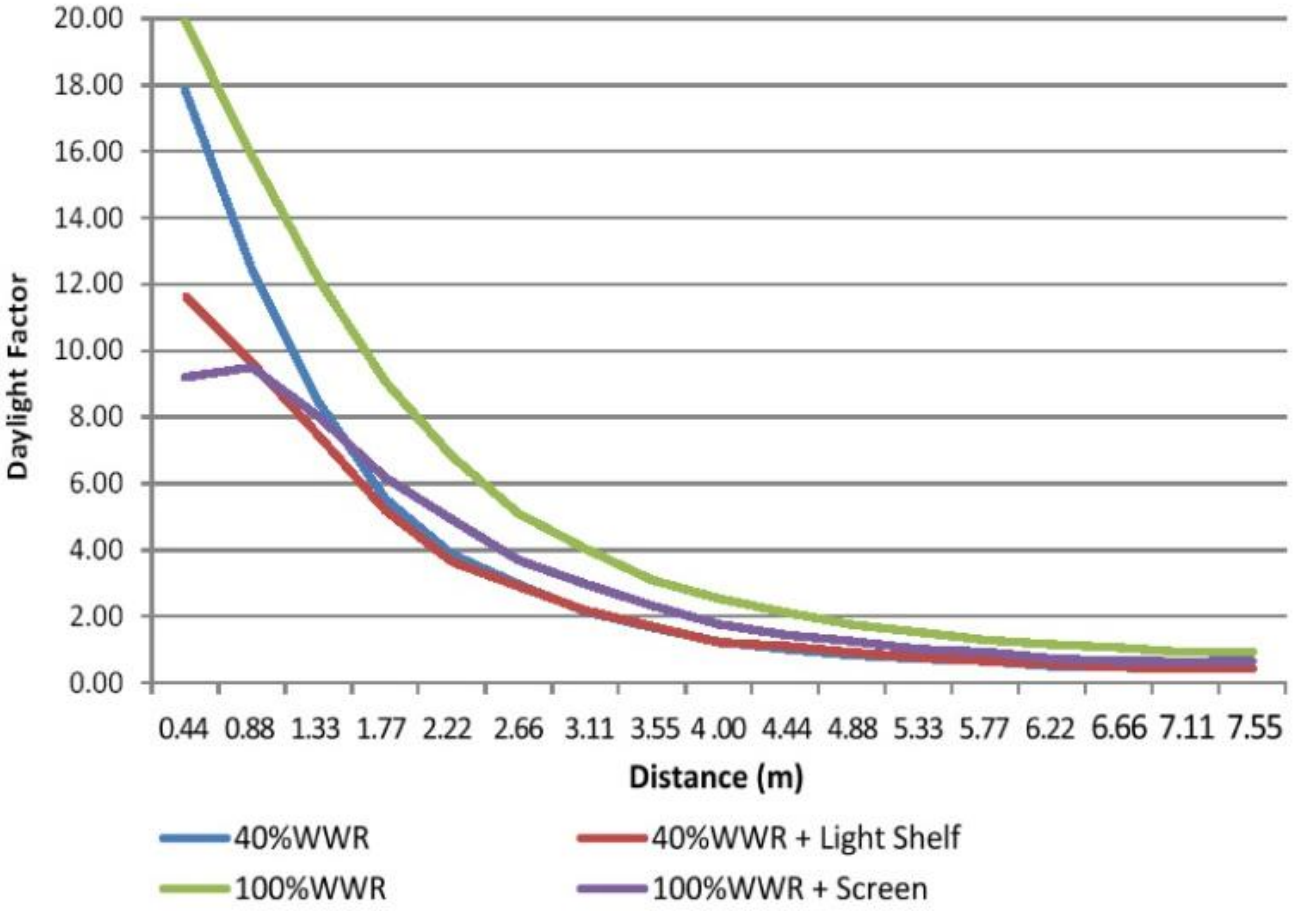
It is important to say that in these average values are included all the hours of the day (which resulted in lower DGP values that it is in reality). Nevertheless, the relative evaluation between cases is still valid.

Daylight Autonomy comparison



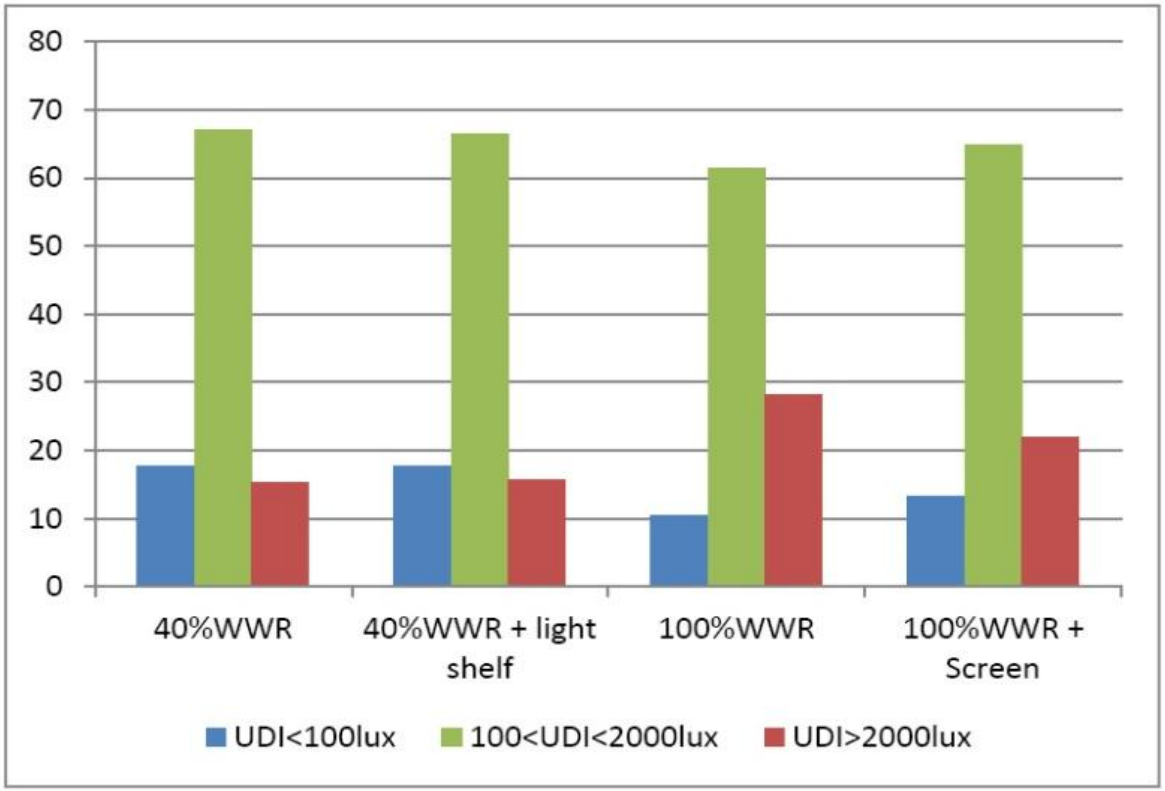
High percentage of DA for the 100%WWR in comparison to the 40%WWR can result in healthier environments for the occupants. When the enhanced solutions are compared, 100%WWR with the screen performs better than the 40%WWR + light shelf in terms of DA (55% and 45%, respectively).

DF comparison



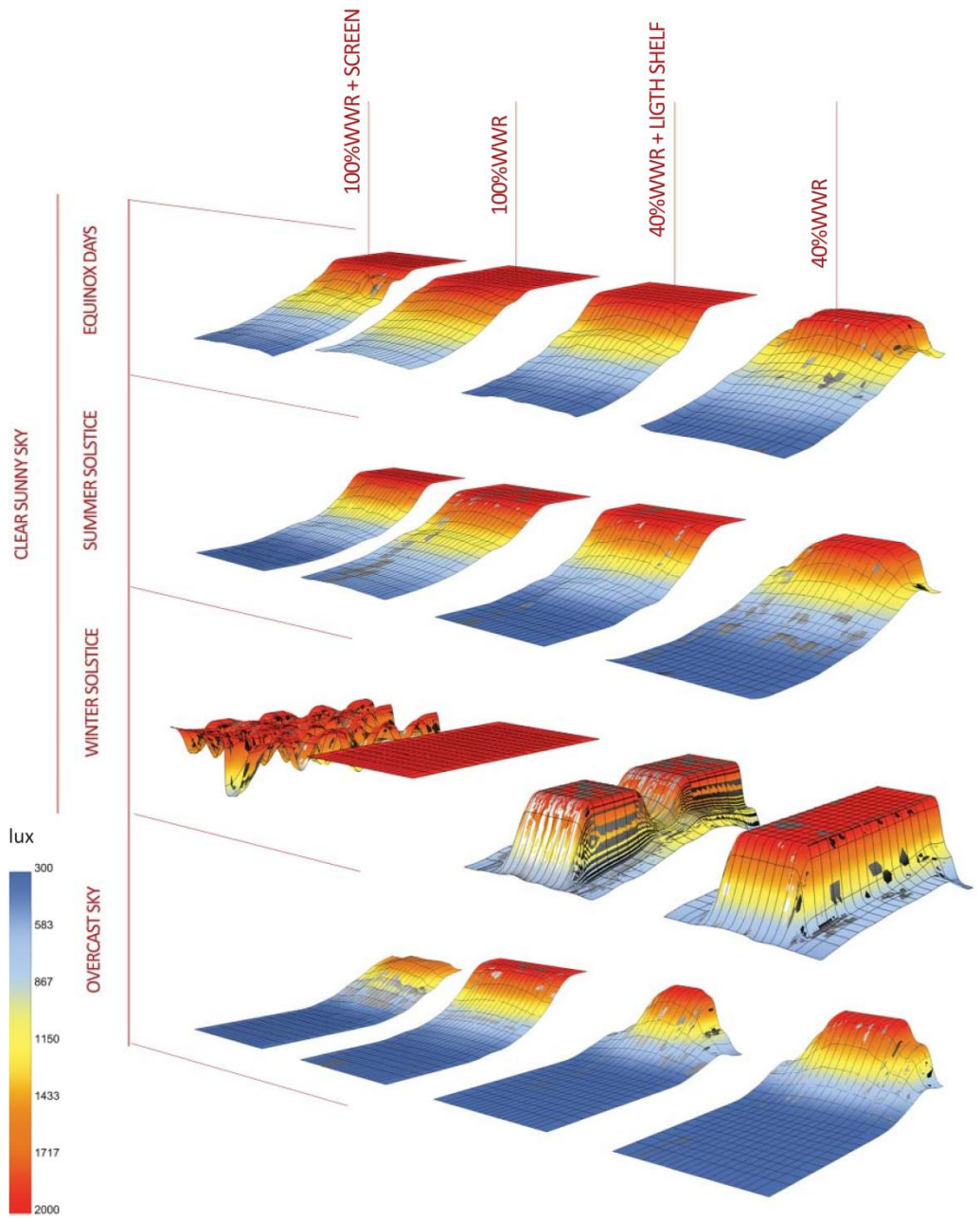
Under overcast conditions enhancement systems will significantly reduce daylight in areas close to the window.

UDI comparison



The screen reduces the 'exceeded' (>2,000lux) illuminance in the area close to the window from 28% down to 22%.
The UDI in that range is similar (around 15%) for the 40% WWR with and without the light shelf.
Overall, the daylight uniformity in the 'screen case is the best since the ratio of the maximum illuminance to the minimum value is lower.

Overall comparison



40%WWR with light shelf and 100%WWR with Screen have a similar performance, with the exception of winter solstice day where all the cases have different light distributions.

In winter time, on a sunny day, most of the workplane has the illuminance above 500lux. Conversely, on an overcast day (10,000lx) less than a third of the workplane area is above that threshold.

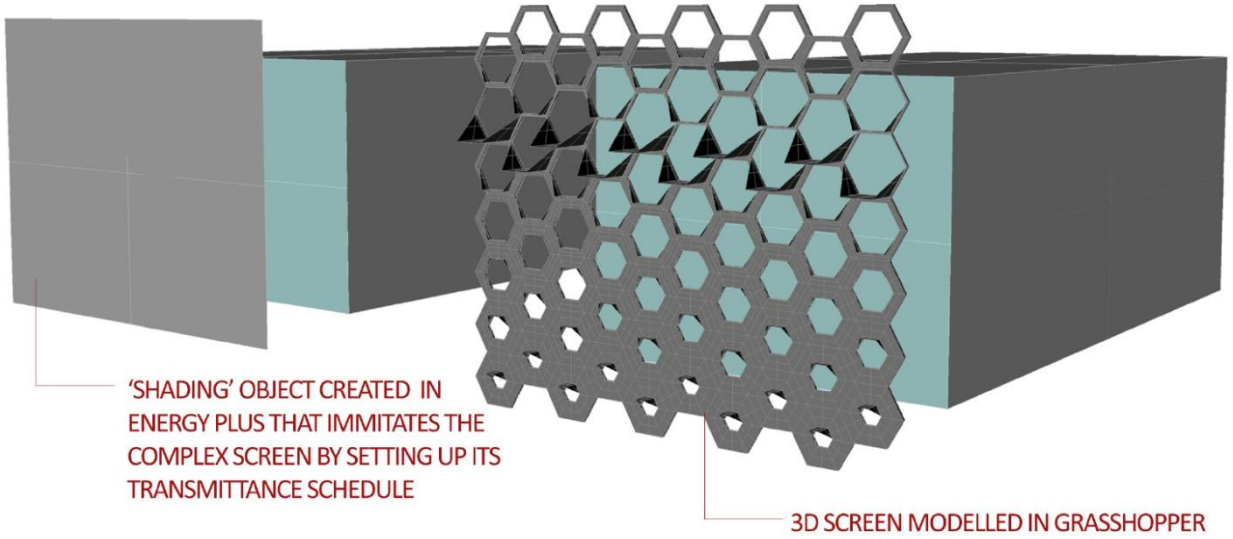
On the other hand, the 100%WWR model has the greatest workplane area with illuminance above 2,000lux for the summer solstice.

Thermal analysis shading simplification

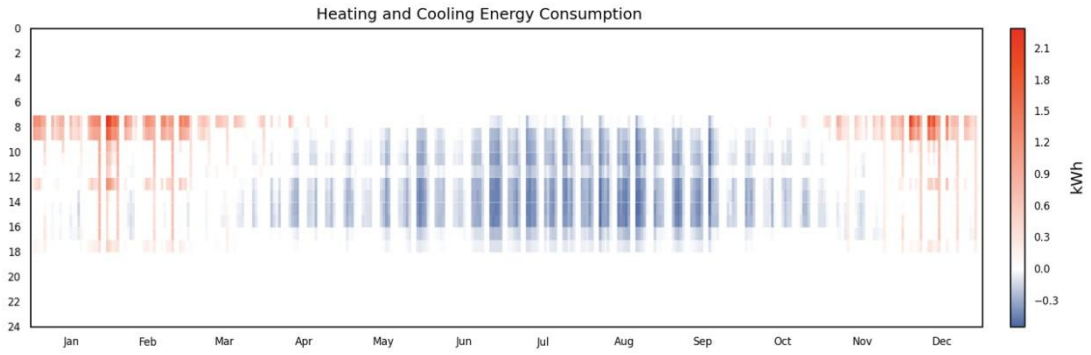
E+ only works with planar surfaces

The shading coefficient schedule is the hourly illuminance ratio on the vertical surface with and without the complex shading modelled in Grasshopper. It is averaged over the surface.

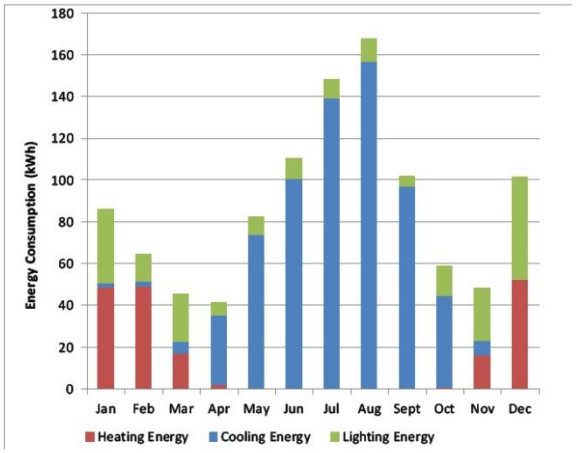
Complex shading E+ simplification



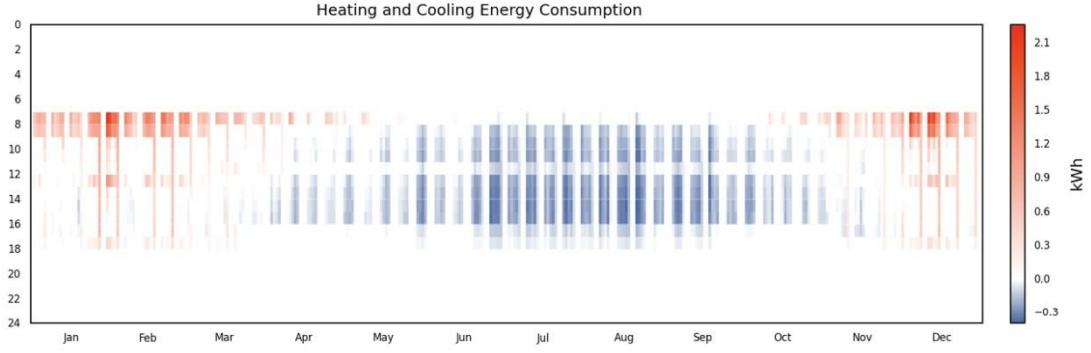
Energy Consumption 40%WWR with and without shelf



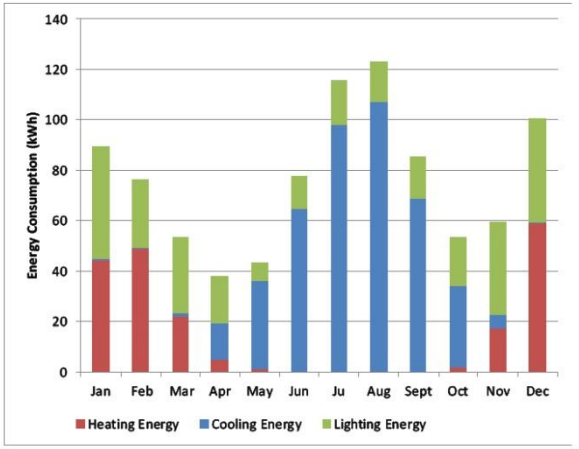
Case 1 - 40%WWR without light shelf



Case 1 - 40%WWR without light shelf

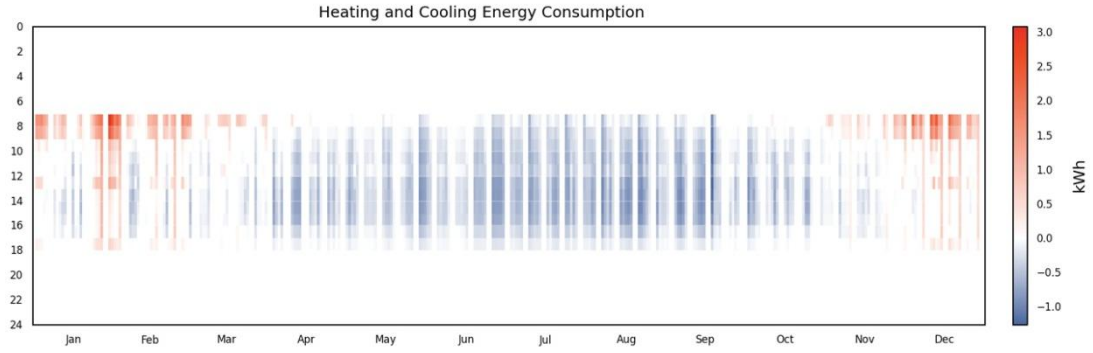


Case 2 - 40%WWR with light shelf

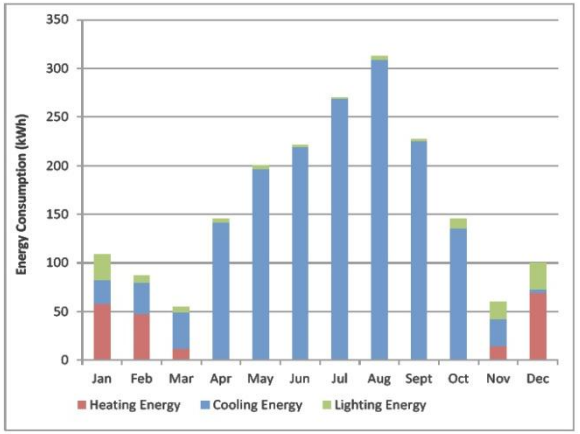


Case 2 - 40%WWR with light shelf

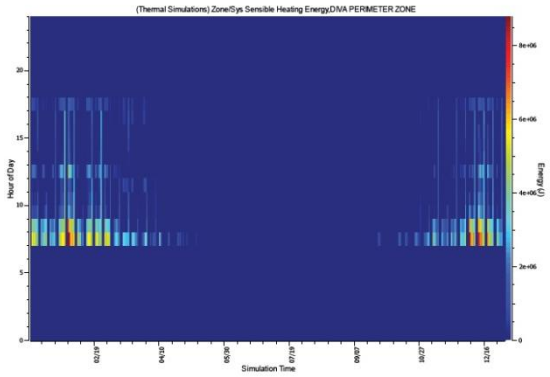
Energy Consumption 10%WWR with and without screen



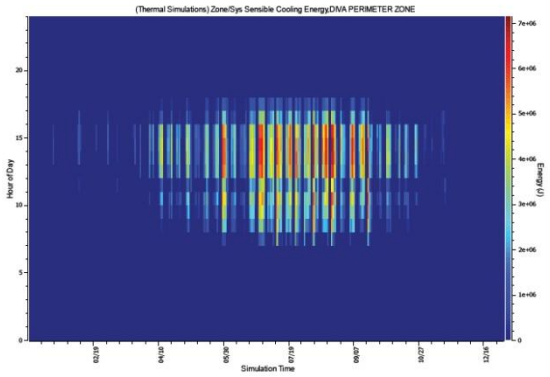
Case 3 - 100%WWR without screen



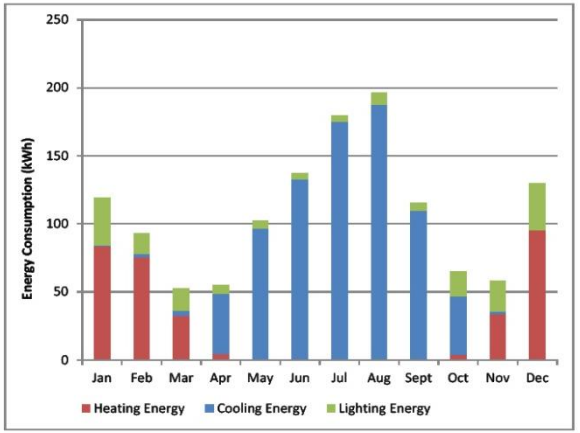
Case 3 - 100%WWR without screen



Case 4 - 100%WWR with screen - heating



Case 4 - 100%WWR with screen - cooling

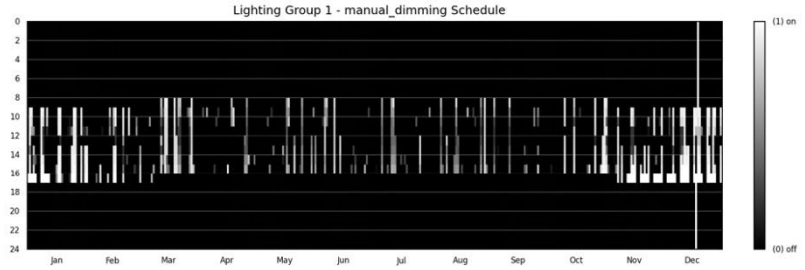


Case - 100%WWR with screen

Lighting usage – temporal maps

The introduction of additional elements has affected the daylight levels in the back of the room, so supplemental artificial light is necessary to achieve the desired lux levels. Enhanced 40% and 100%WWR consume 21% and 61% more energy for lighting than the base cases, respectively.

Case 1 - 40%WWR without light shelf

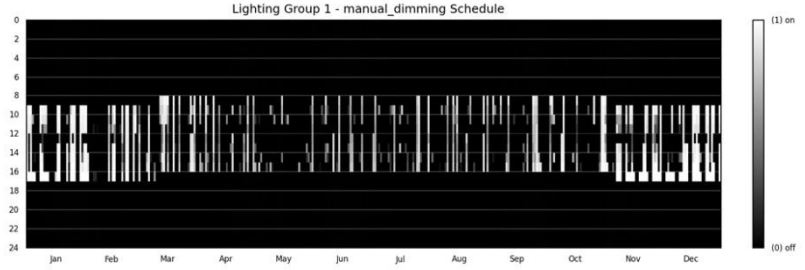


The predicted annual electric lighting energy use is: 237.1 kWh

Case 3 - 100%WWR without shading

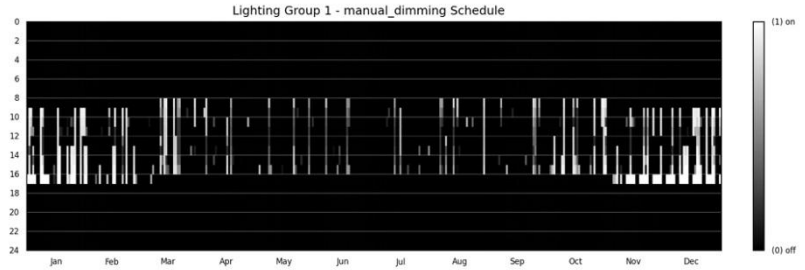
The predicted annual electric lighting energy use is: 108.1 kWh

Case 2 - 40%WWR with light shelf



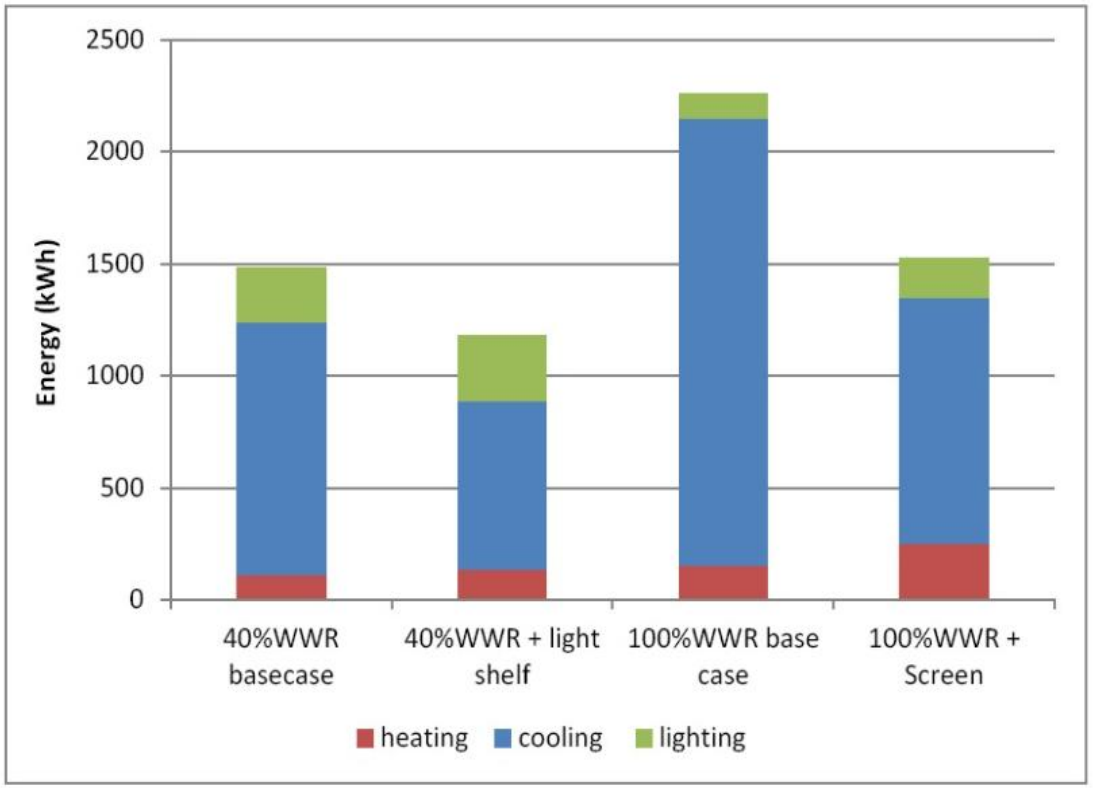
The predicted annual electric lighting energy use is: 286.0 kWh

Case 4 - 100%WWR with shading screen



The predicted annual electric lighting energy use is: 175.1 kWh

Energy consumption comparison

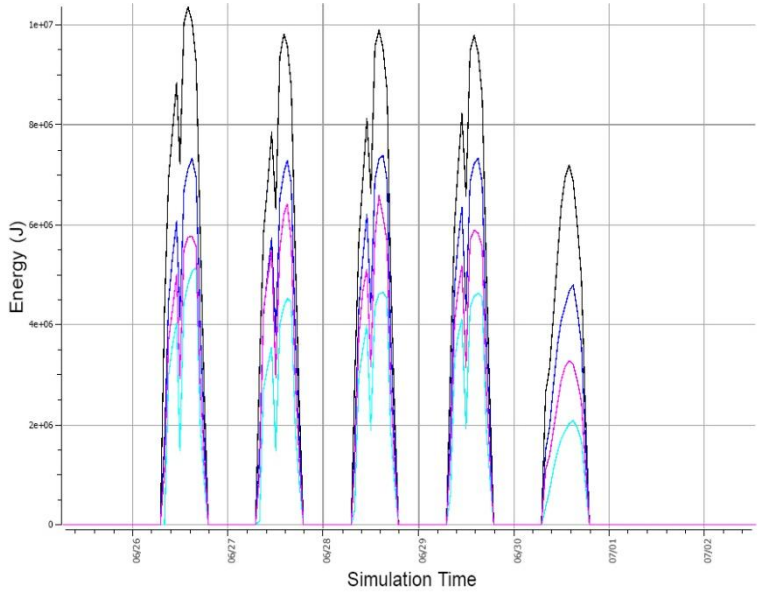


	40%WWR basecase	40%WWR + light shelf	100%WWR base case	100%WWR + Screen
Energy per total building area (kWh/m^2)	85.23	70.44	105.79	81.28
Total energy (kWh)	2727.5	2254	3385.37	2601.06

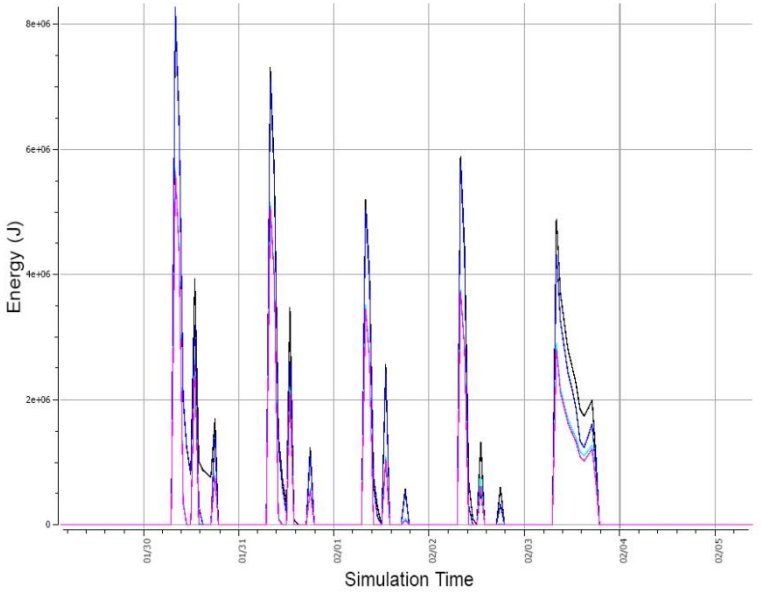
Total energy consumption

When enhanced systems (light shelf and screen) are applied, each of the cases (40% and 100%WWR base case) experience significant changes in energy consumption.
For instance, 40% WWR with light shelf consumes 19% more energy for heating and 66% less energy for cooling.
In case of 100% WWR, the enhanced solution consumes 62% more energy for heating and 54% less energy for cooling.

Heating & Cooling



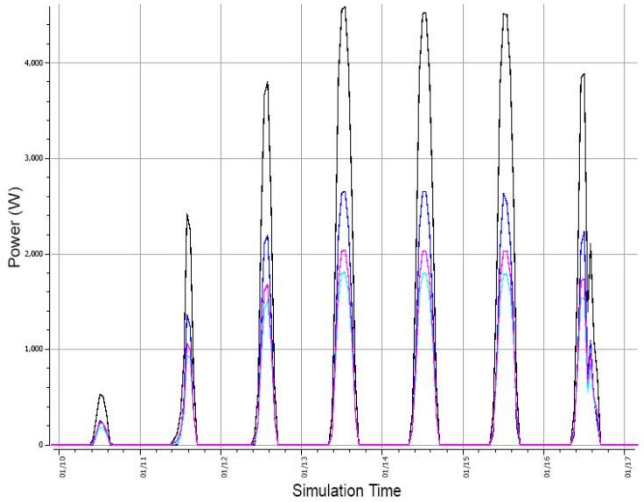
Cooling Energy (26.06 - 02.07)



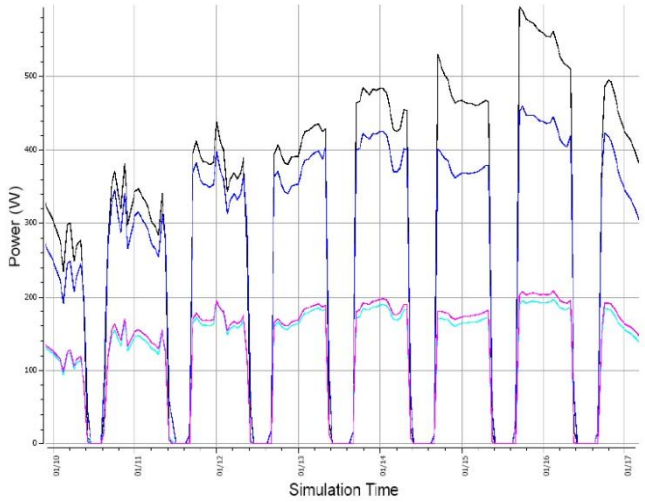
Heating Energy (30.01 - 05.02)

100%WWR
100%WWR + Screen
40%WWR
40%WWR + light shelf

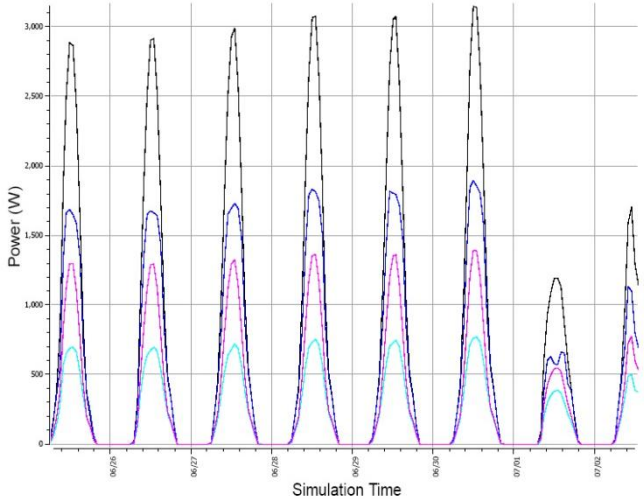
Glazing thermal performance



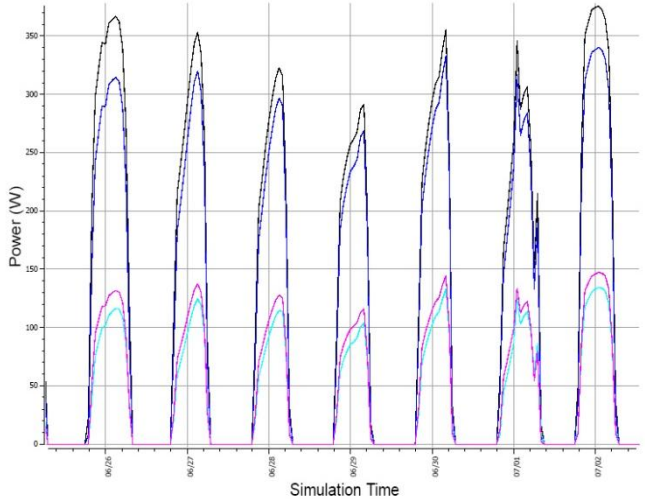
Window Heat Gain, Winter (10.01 - 17.001)



Window Heat Loss, Winter (10.01 - 17.01)



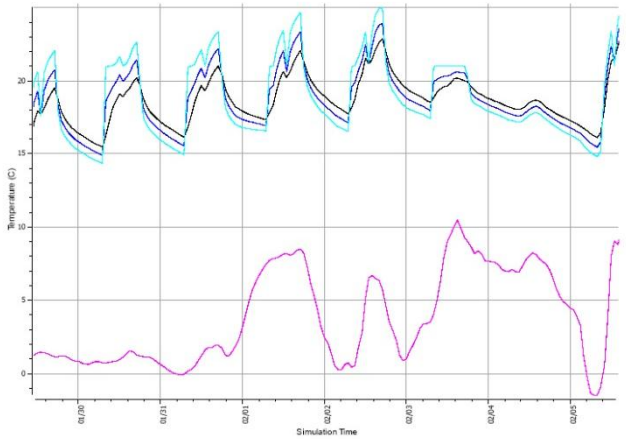
Window Heat Gain, Summer (26.06 - 02.07)



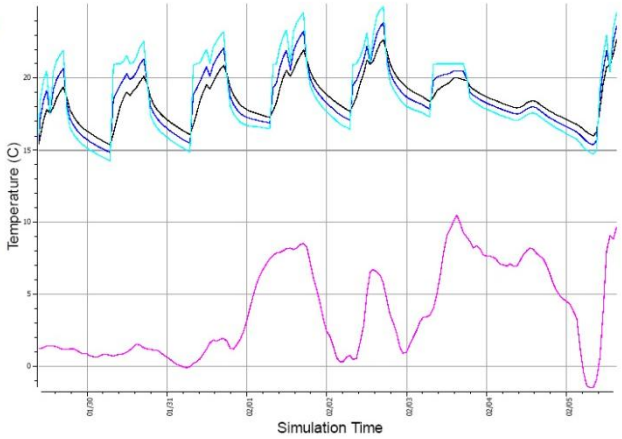
Window Heat Loss, Summer (26.06 - 02.07)

40%WWR
40%WWR + light shelf
100%WWR
100%WWR + Screen

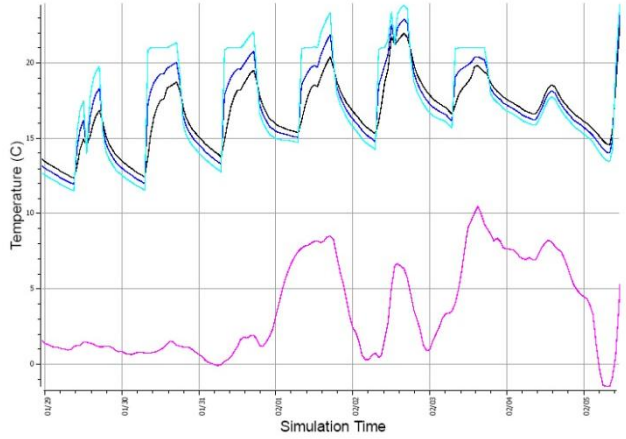
Winter temperature comparison



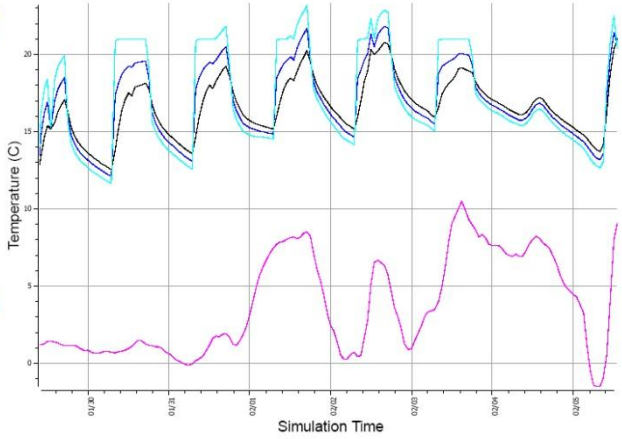
40%WWR temperatures, Winter (30.01 - 05.02)



40%WWR + light shelf temperatures, Winter (30.01 - 05.02)

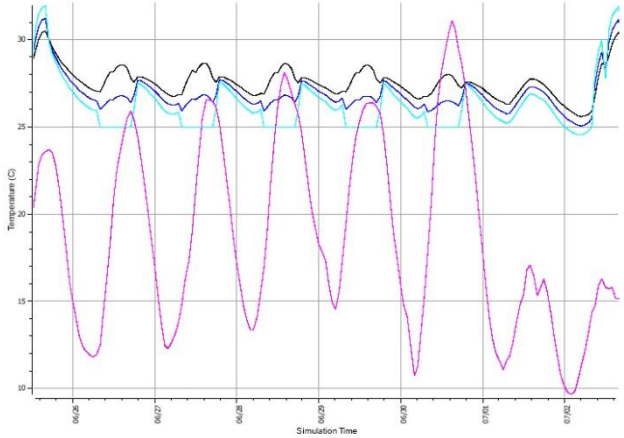


100%WWR temperatures, Winter (30.01 - 05.02)

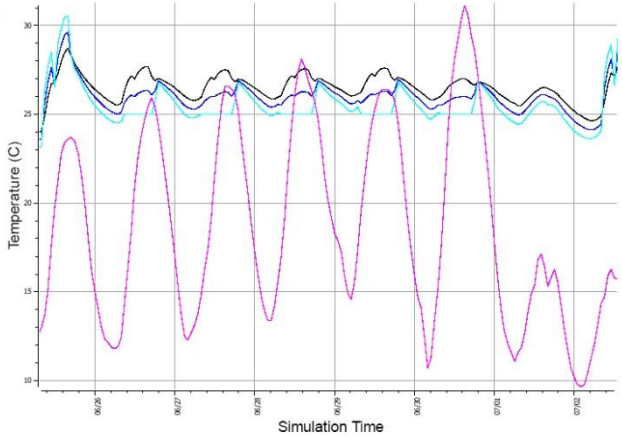


100%WWR + screen temperatures, Winter (30.01 - 05.02)

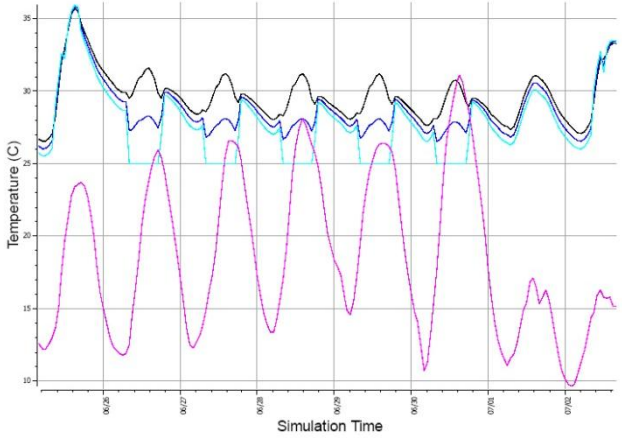
Summer temperature comparison



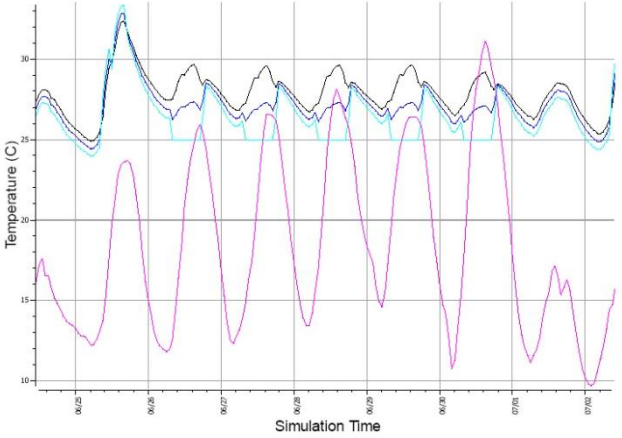
40%WWR temperatures, Summer (26.06 - 02.07)



40%WWR + light shelf temperatures Summer (26.06 - 02.07)



100%WWR temperatures, Summer (26.06 - 02.07)



100%WWR + screen temperatures, Summer (26.06 - 02.07)

Conclusions

Daylight enhancement systems such as light shelves do not improve significantly the daylight levels in London due to a high percentage of overcast skies in the city. However, major advantage of the light shelf is to provide shading to the lower part of the windows and therefore reducing the cooling loads in summer without compromising the advantage of solar gains during winter.

It has been seen that some of the tested cases perform better in terms of daylight than in energy performance or vice versa. Consequently, a compromise has to be made, or a particular issue has to be assumed as a priority.

If an equal significance was given to both daylight quality and energy consumption, the light shelf would be assumed as the better solution from the 4 cases analysed.

In individual assessments the Screen is the better solution in terms of daylight and the light shelf in its energy performance.

Thank you

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