Integrating shading, lighting and glare and achieving reliable results for clients

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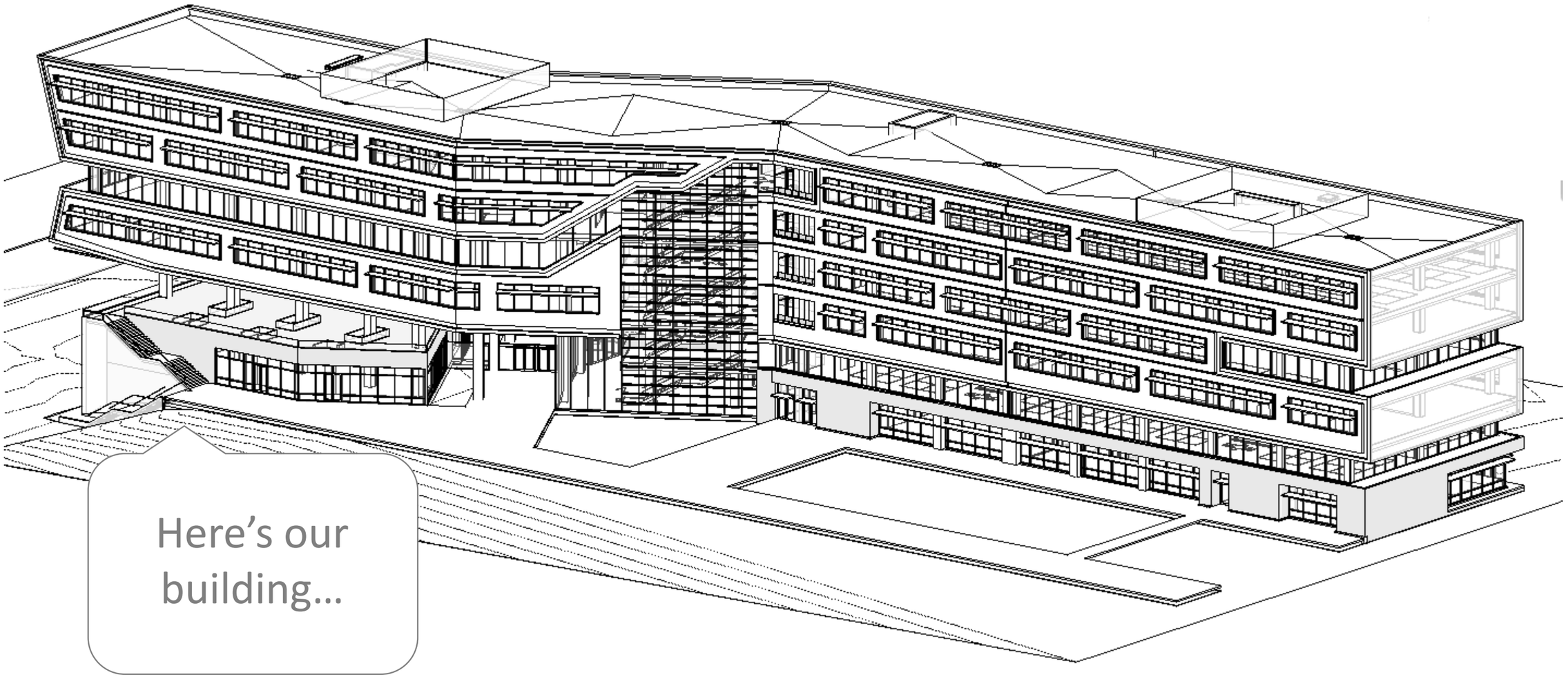
How it begins…

Architect:



Here’s our building…

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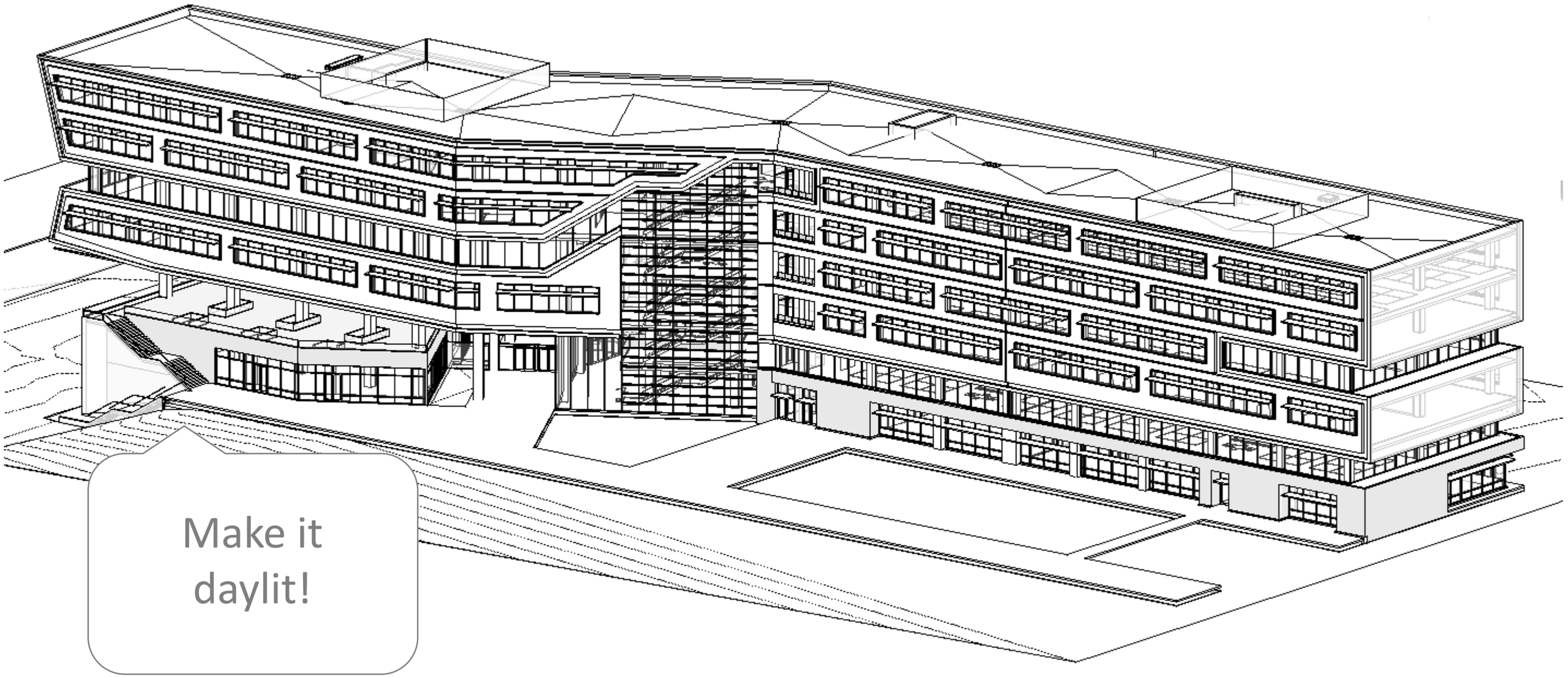
Architect:



Make it daylit!

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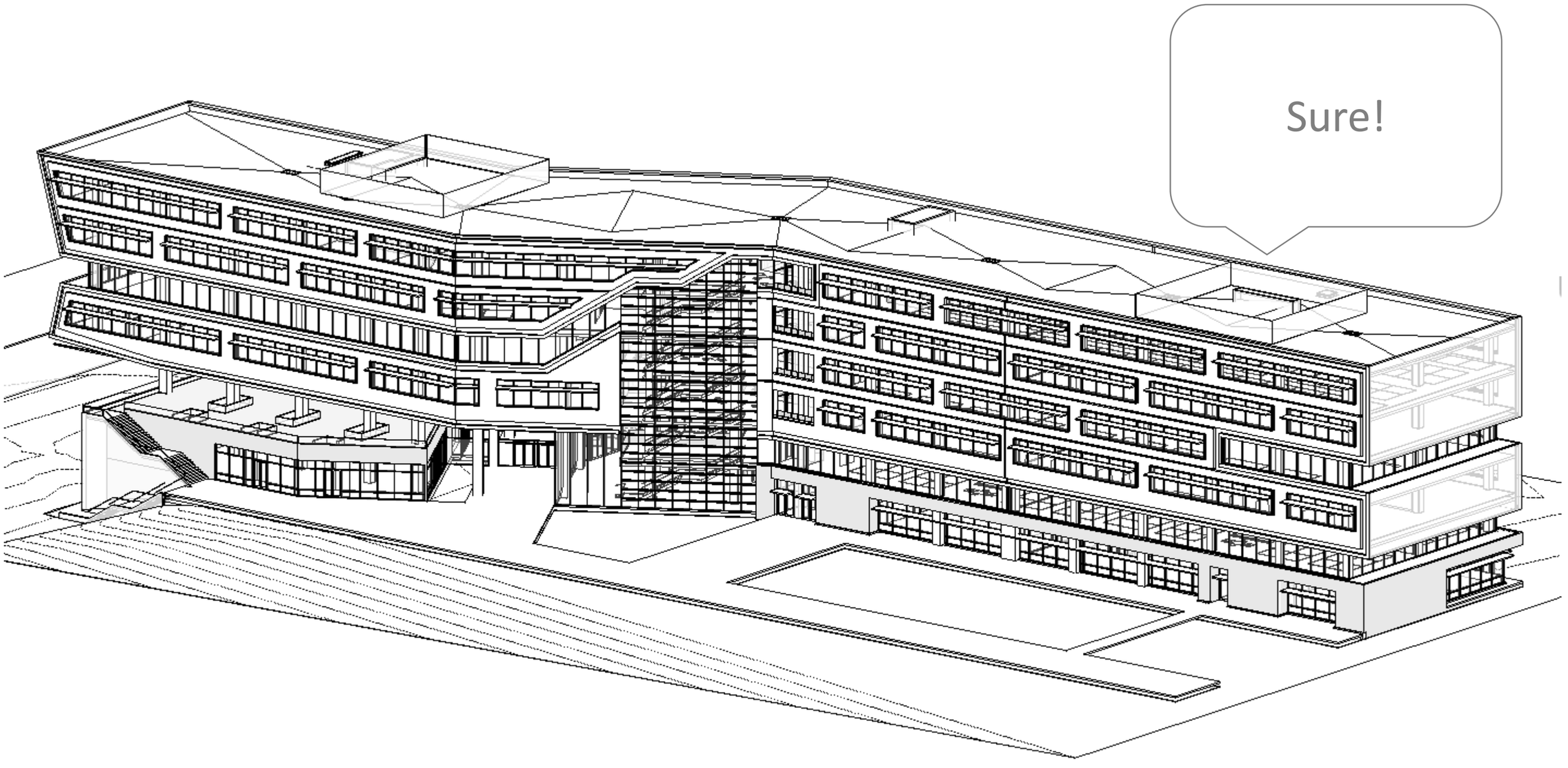
Consultant:



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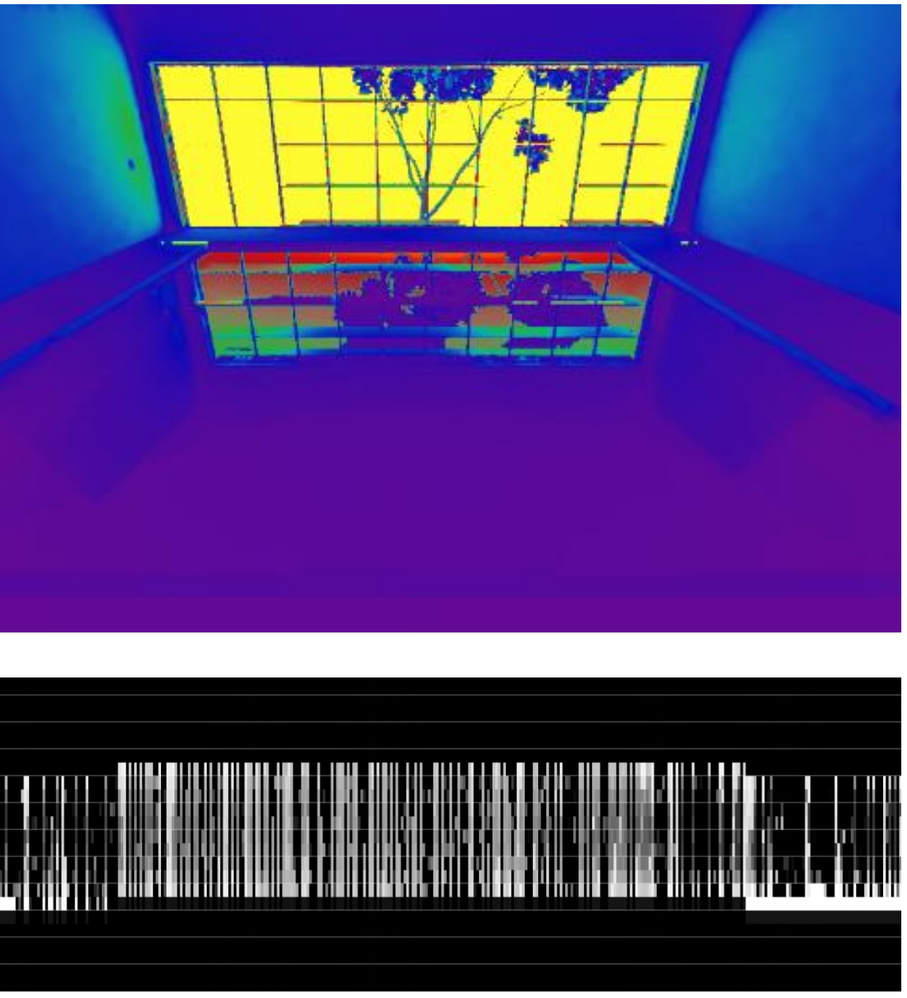
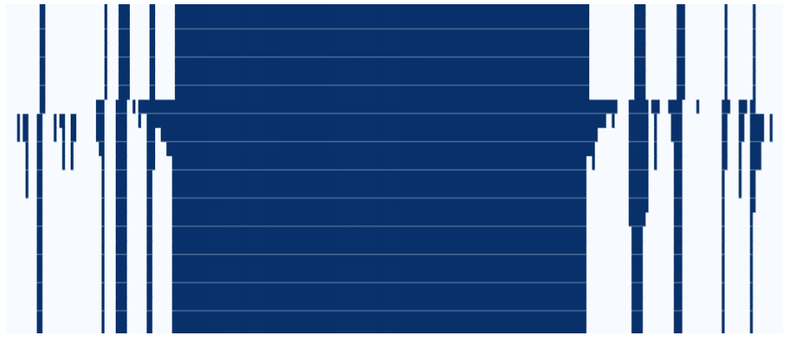
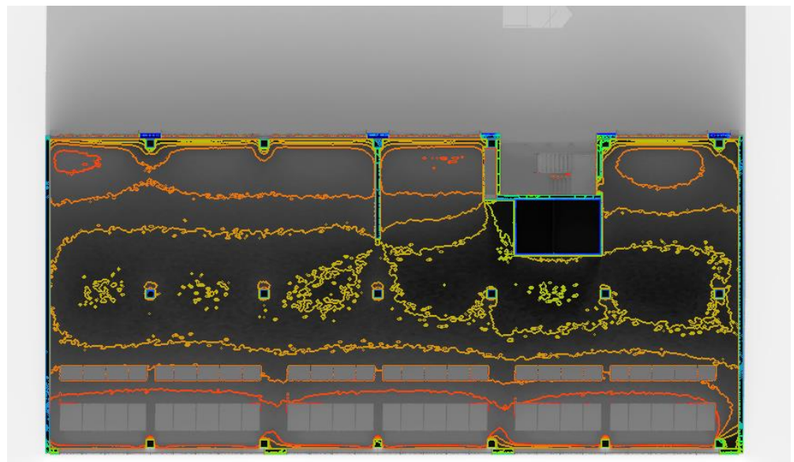
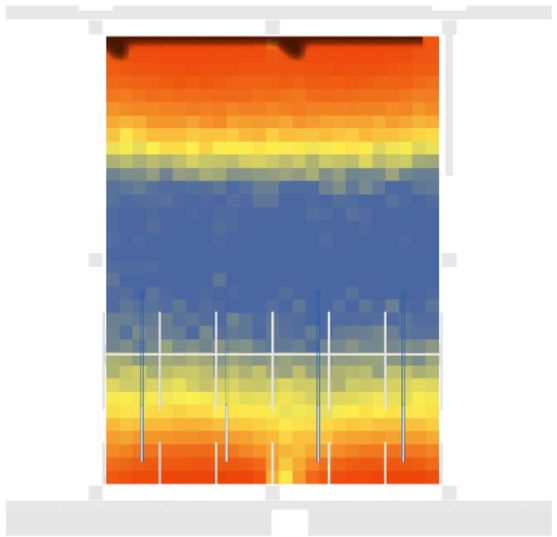
Consultant:

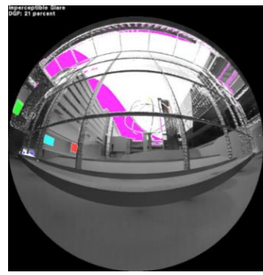
What we can test…

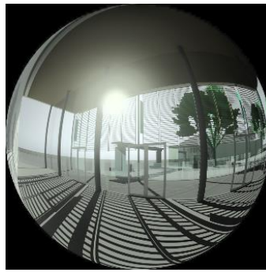


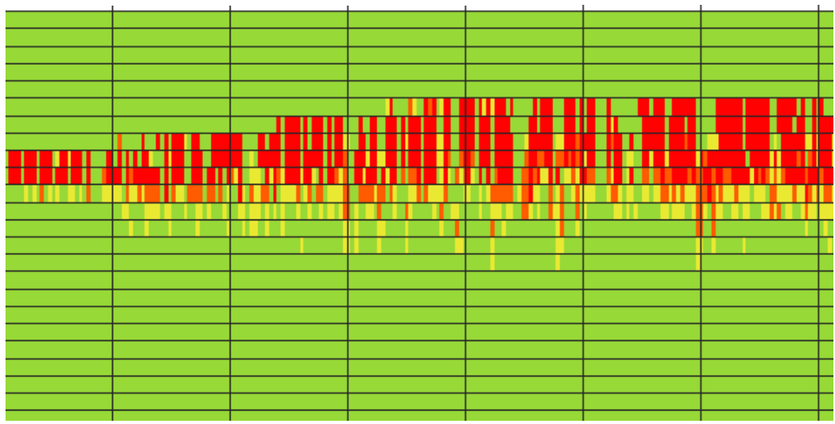












…but what should we test?

What does the client want to know?

1. How much does it cost?
2. How much energy will it save?
3. What does it look like?
4. How comfortable will it be for the occupants?
5. What is the perfect solution that is beautiful, energy efficient, and doesn't cost any more than a standard solution?

…what does that mean?

As a consultant, our job is to:

1. Faithfully describe the building performance conditions
2. Give the client useful information so they can make decisions
3. Not blow the entire fee running too many simulations
4. Convince the client of the “best” option

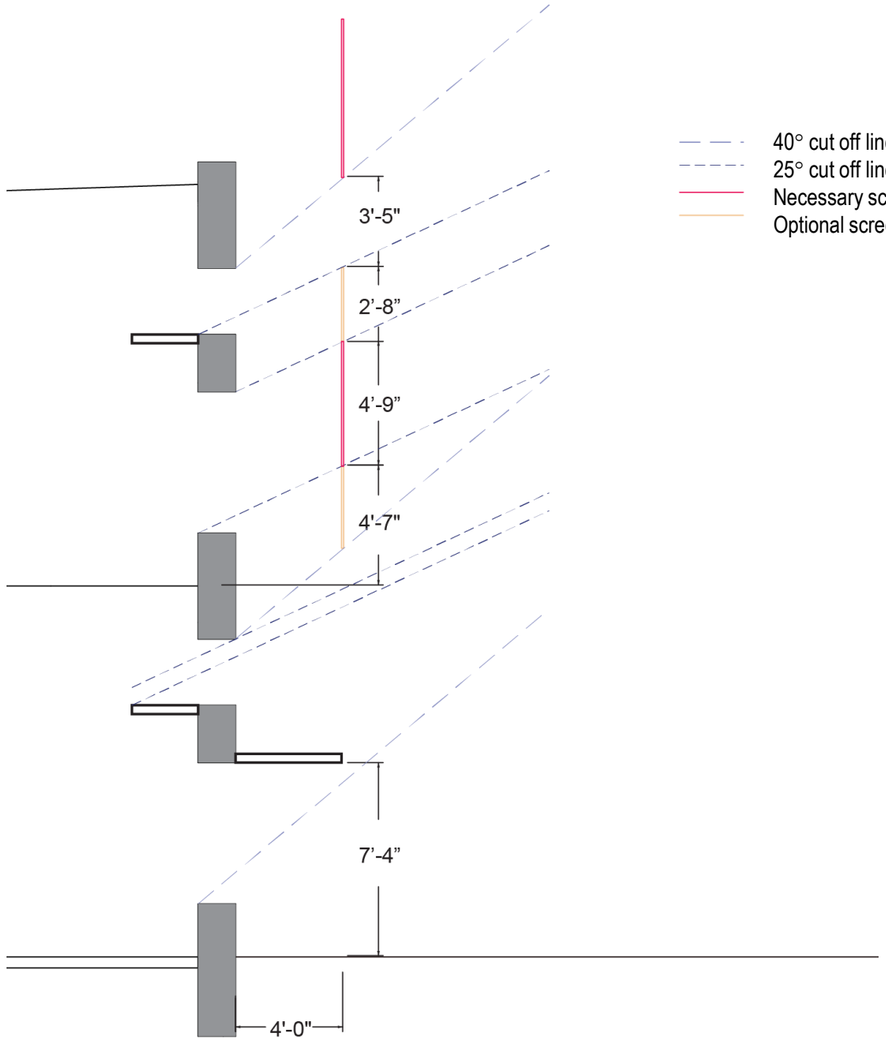
actionable information

Provide a actionable guidelines for the architect to build on or from

[e.g dimensions, angles, locations, colors, materials]

Example Recommendation for South Facade

Weighing options



40° cut off line
25° cut off line
Necessary screen area
Optional screen area

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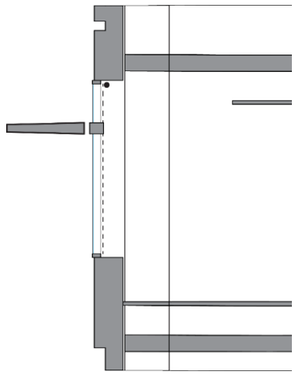
dynamic and temporal feedback

Convey the dynamic and temporal qualities of daylighting and lighting to the architect

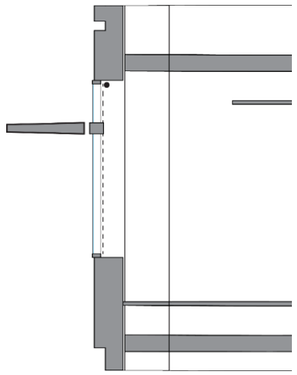
[e.g quanity over time over area]

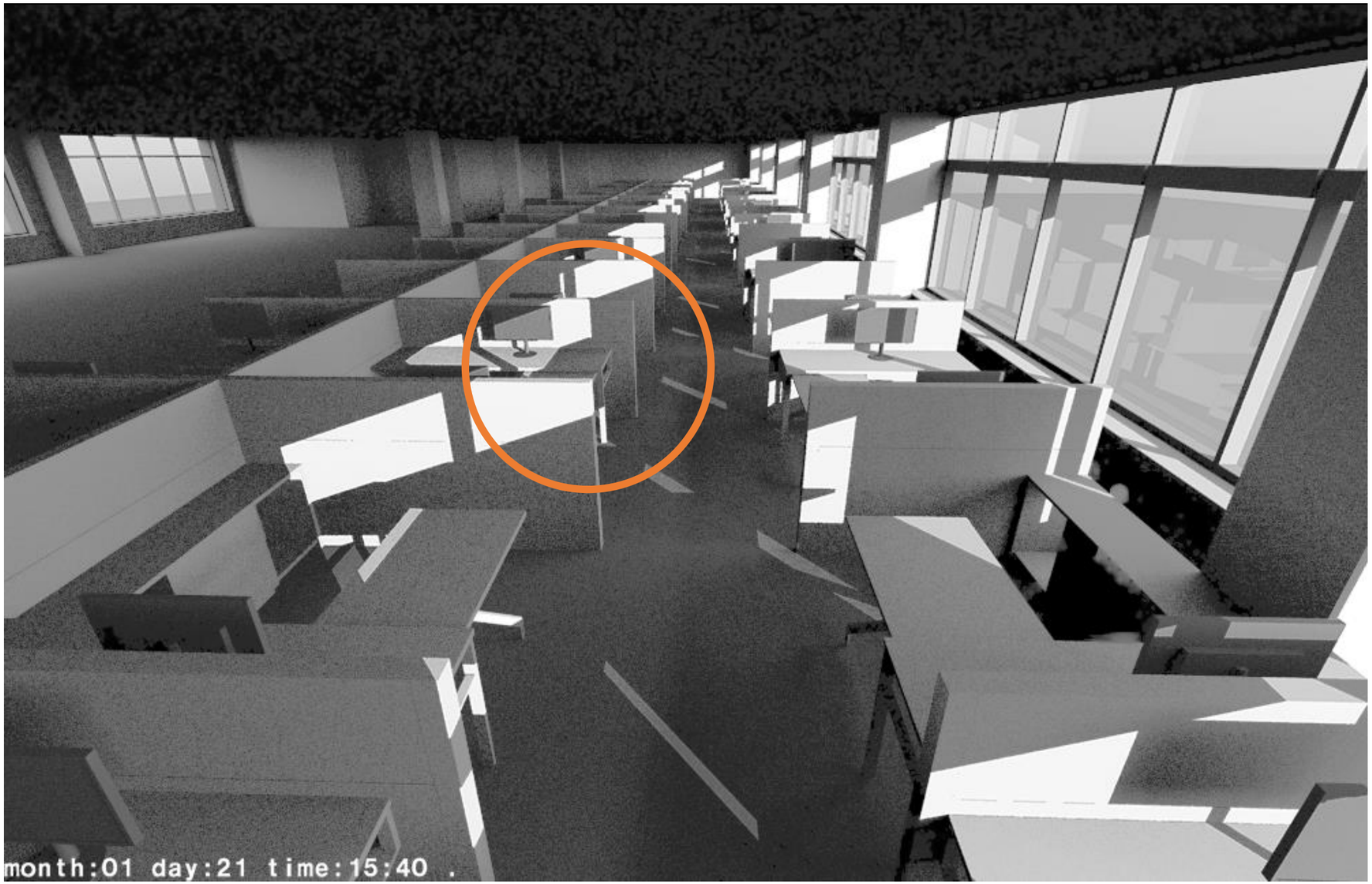
Animations



Animation showing direct solar beam on the 21st of each month

Animations





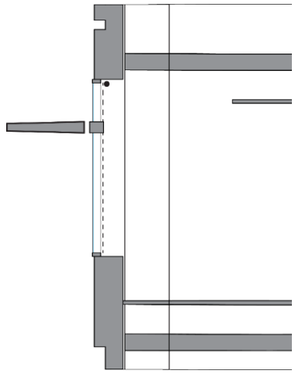
Animation showing direct solar beam on the 21st of each month

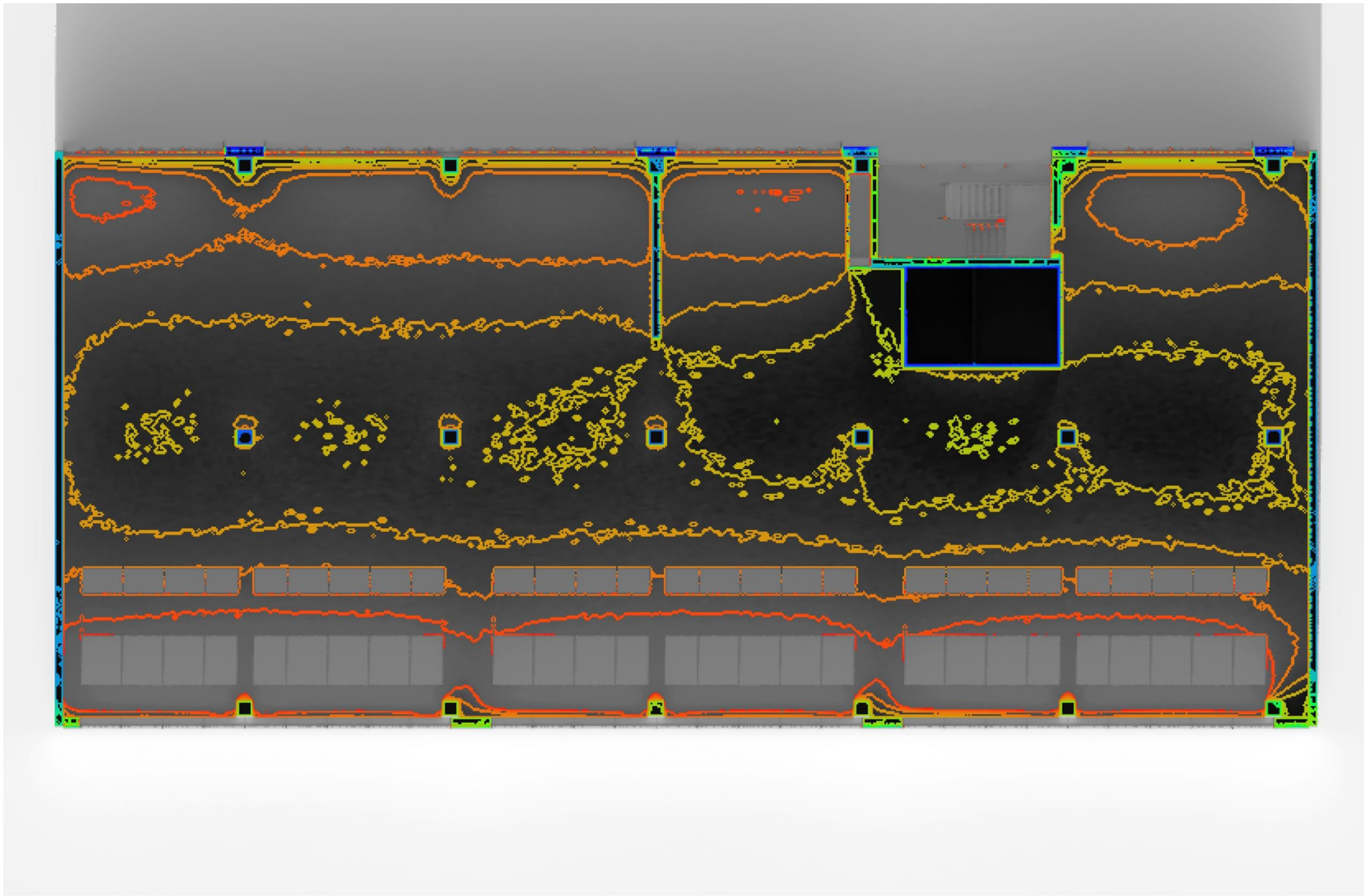
meaningful comparisons

Synthesize not just differences between strategies, but which differences are meaningful

[e.g how much of a change]

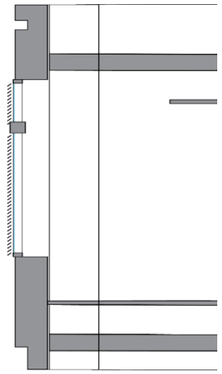
Point-in-time illuminance simulations

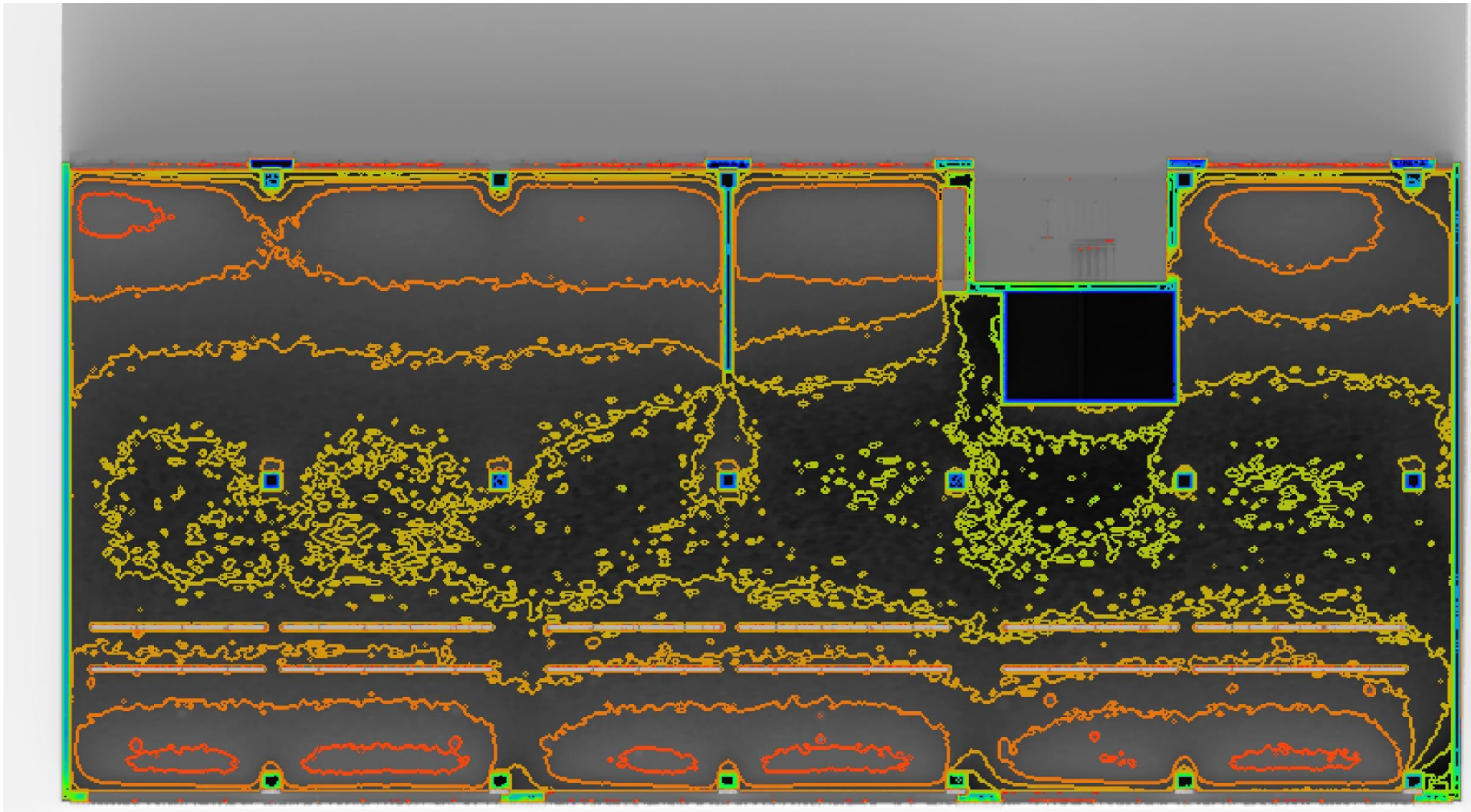




December 21, 12pm, Clear Sunny Sky with fabric shades

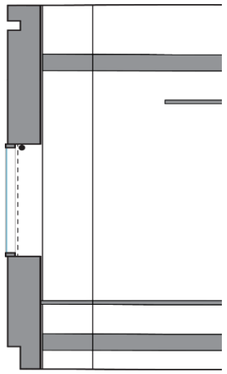
Point-in-time illuminance simulations

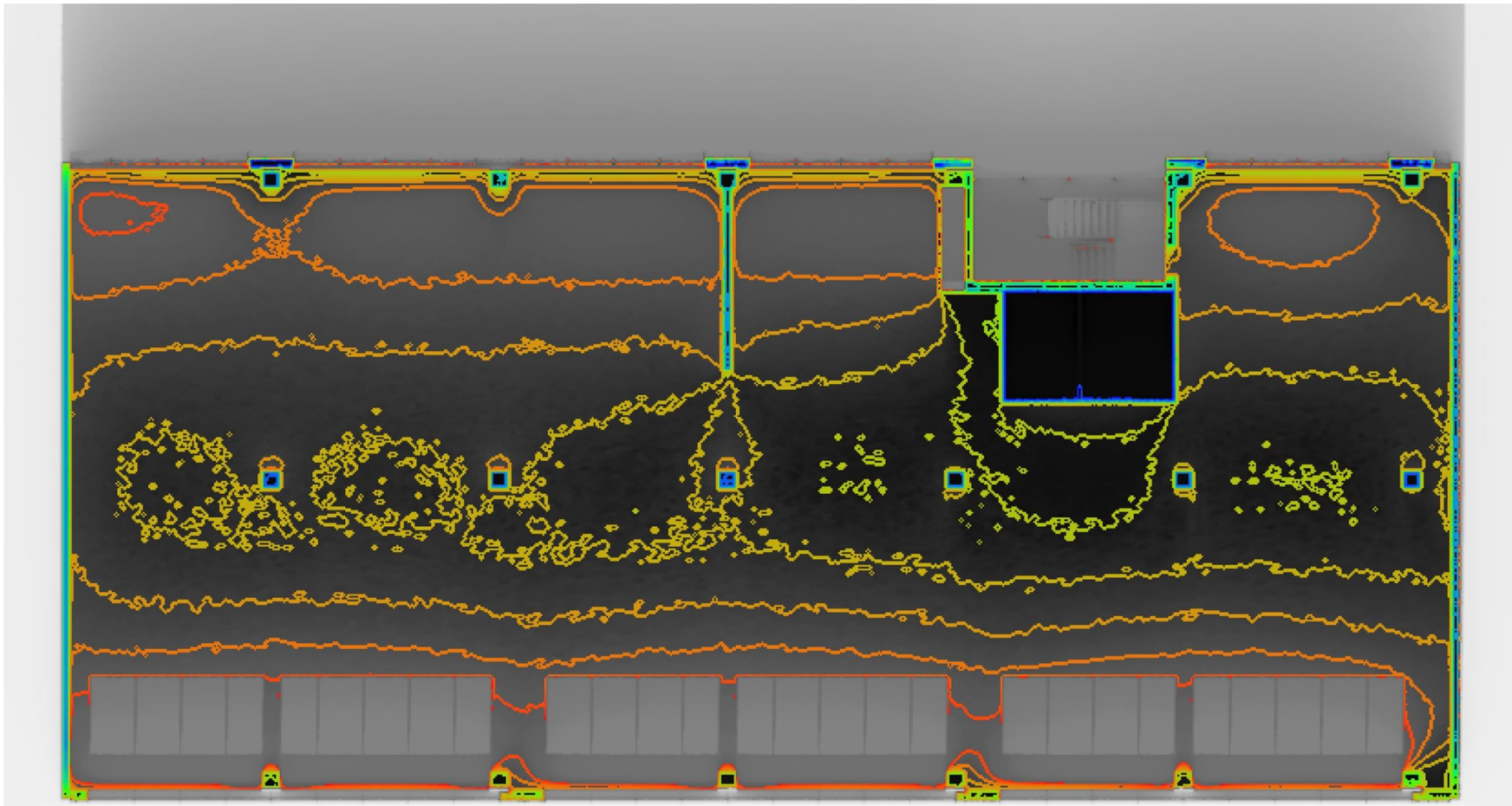




December 21, 12pm, Clear Sunny Sky with louvers at 37 degrees

Point-in-time illuminance simulations



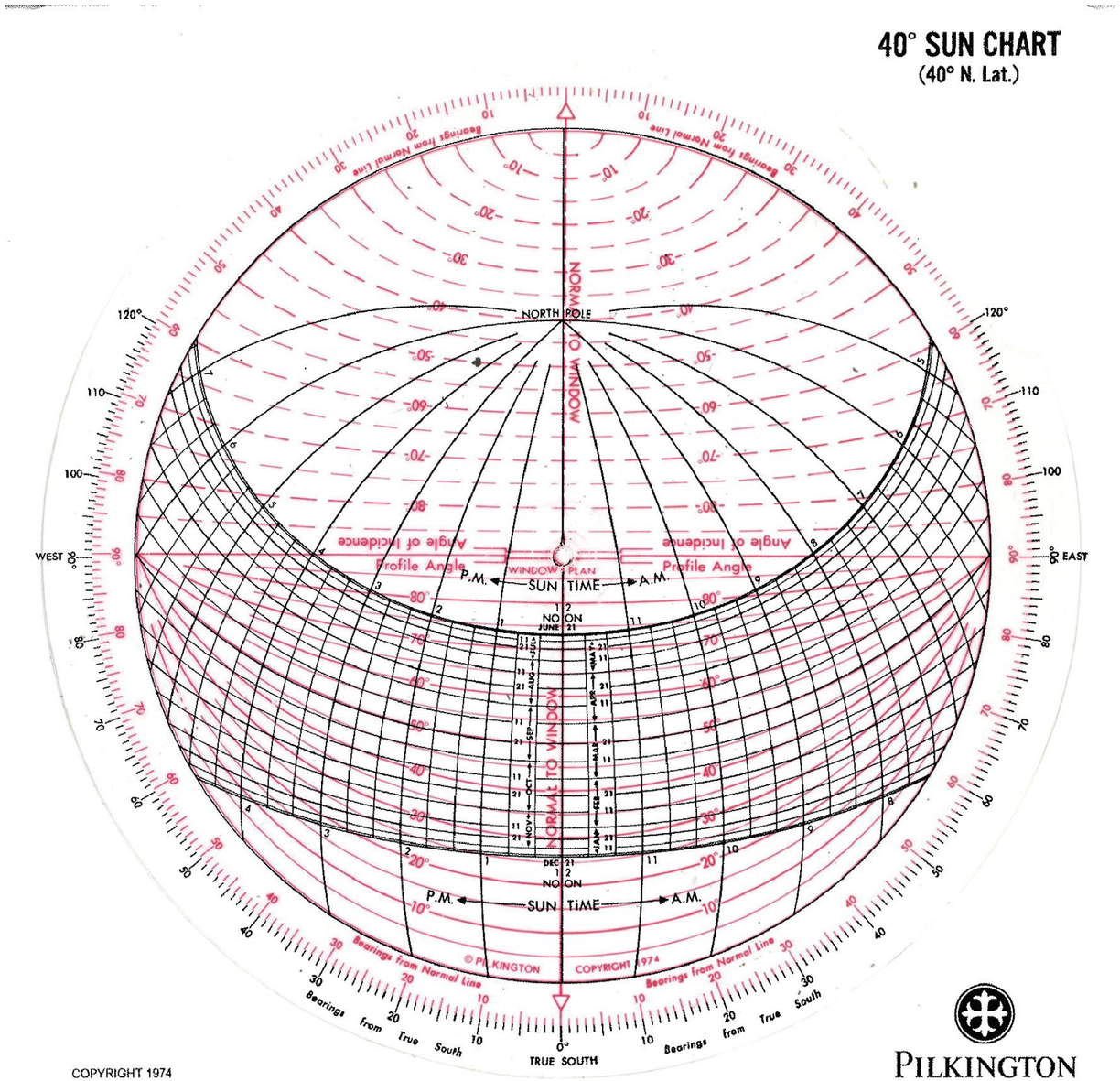


December 21, 12pm, Clear Sunny Sky with 40% WWR and fabric shades

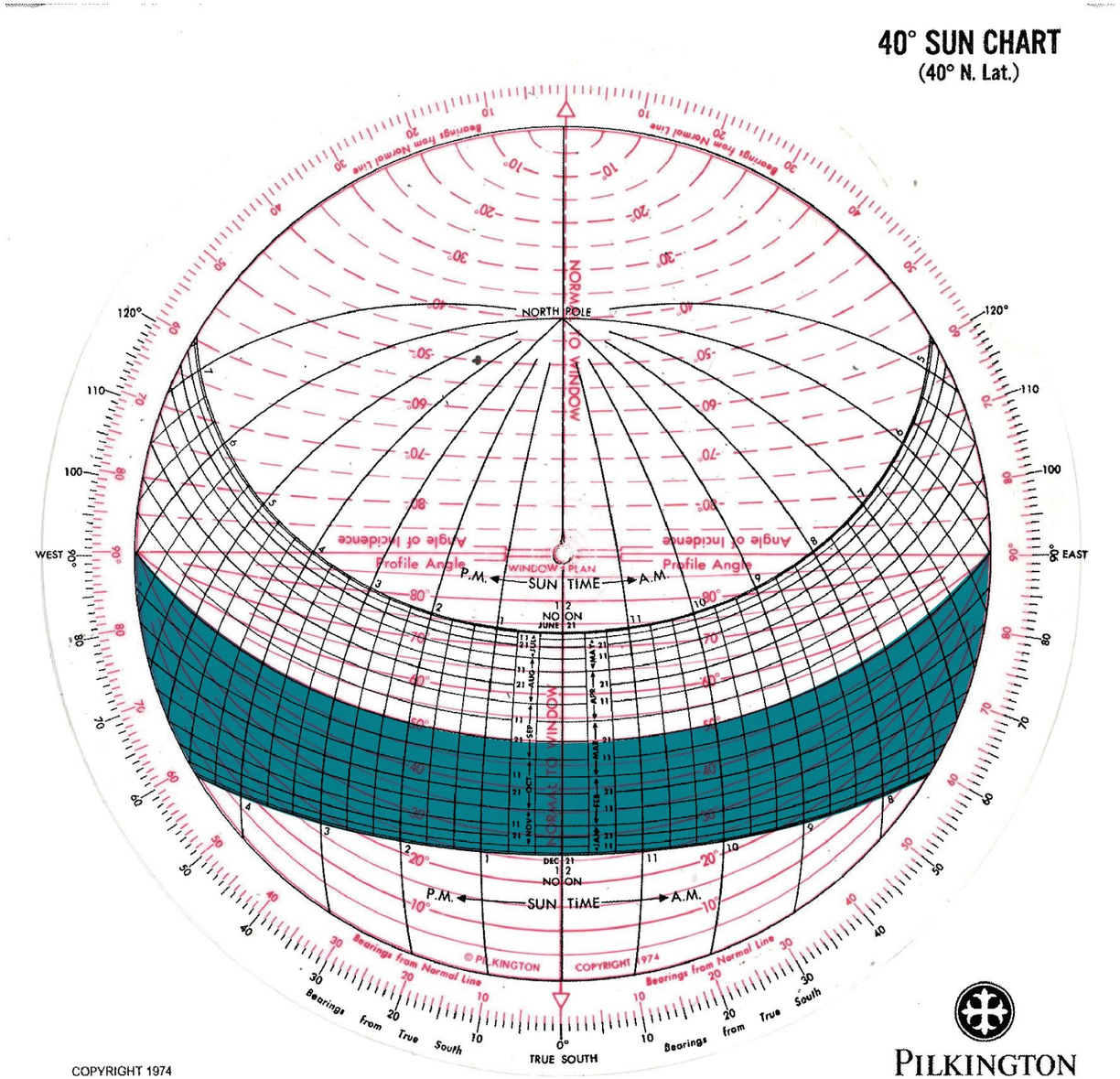
Actionable Information

A brief detour

Solar Geometry

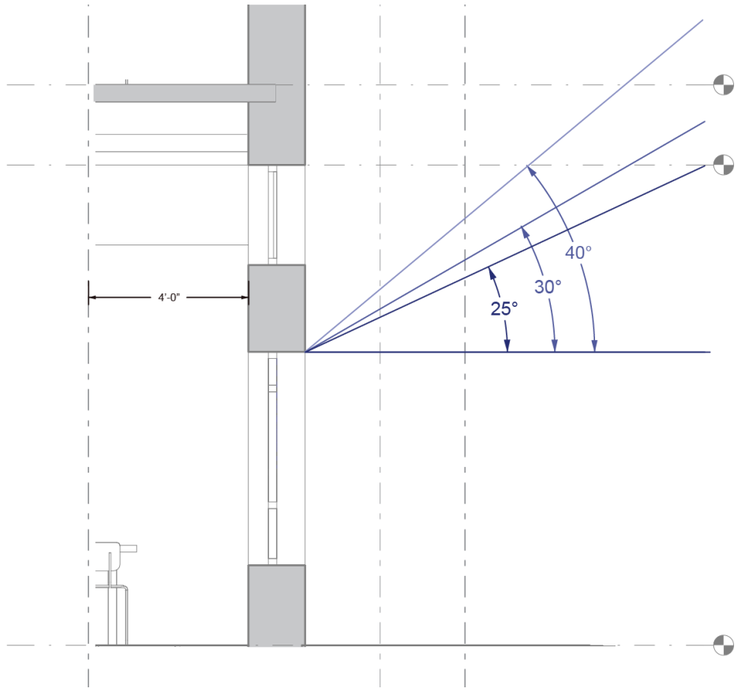


Profile Angles as Design Tool

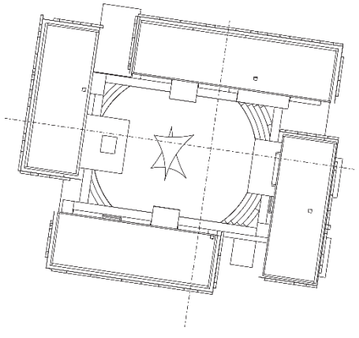


Direct Sun Shading Profile Angles

Using solar geometry to provide architects with useable dimensions

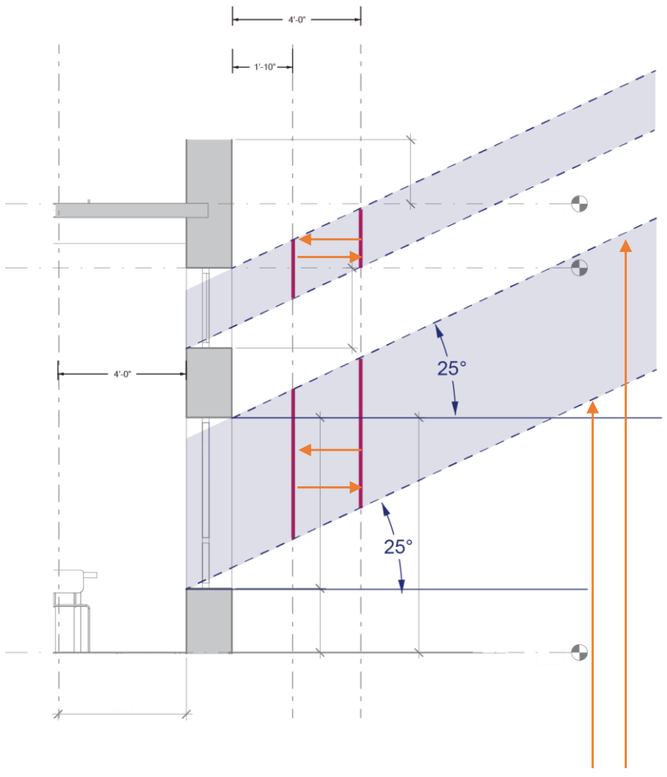


	EAST	SOUTH	WEST	NORTH
25°	Most of the year after 9am	Most of the year until 3pm	Entire year	
30°	Entire year after 10am	Feb 21-Oct 21 until 3pm	Jan 31-Nov 11 until 3pm	
40°	Entire year after 10:30am	Sep 30-Mar 11 until 3pm	Sep 21-Mar 21 until 3pm	
50°				Entire year until 7pm
60°				Most of the year until 7pm

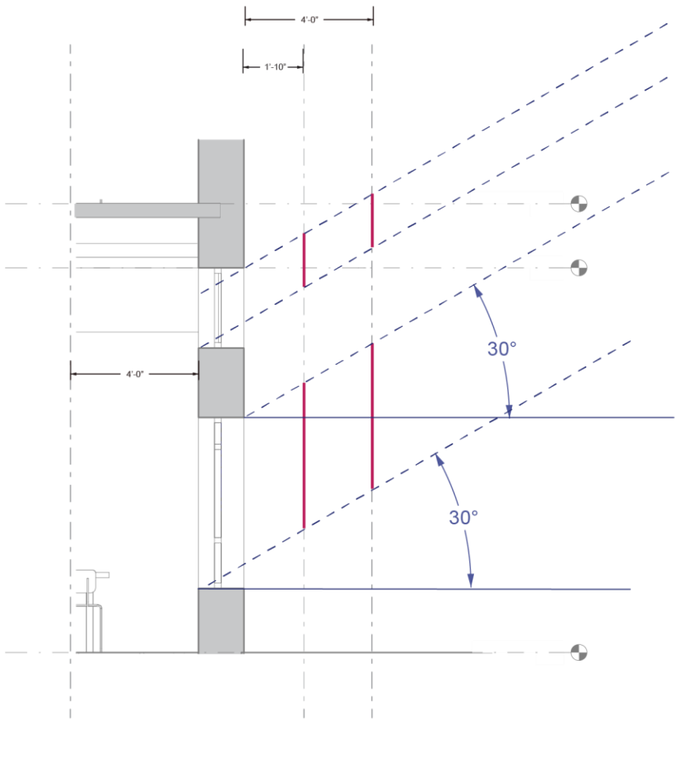


Screen Offset and Dimensions

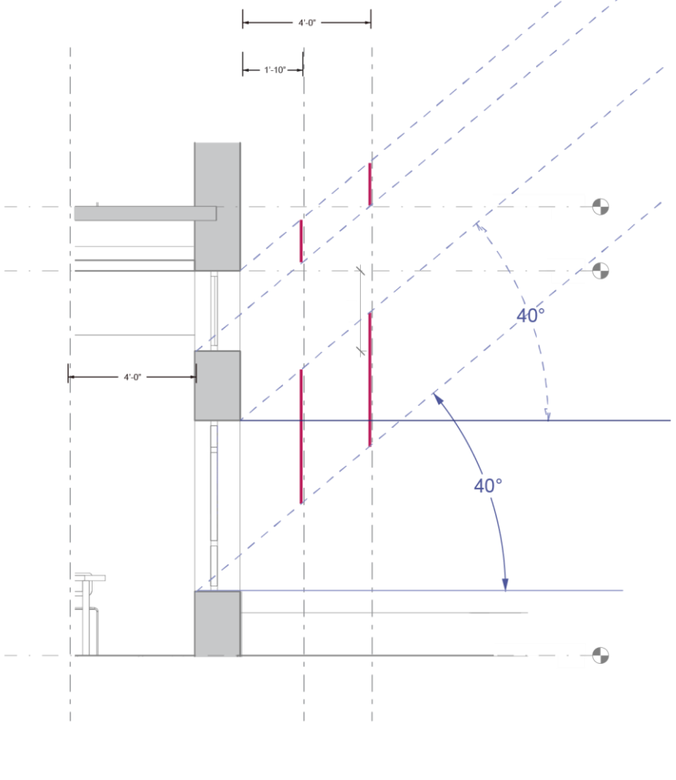
25° cut off angle (South, West or East)



30° cut off angle (South, West or East)



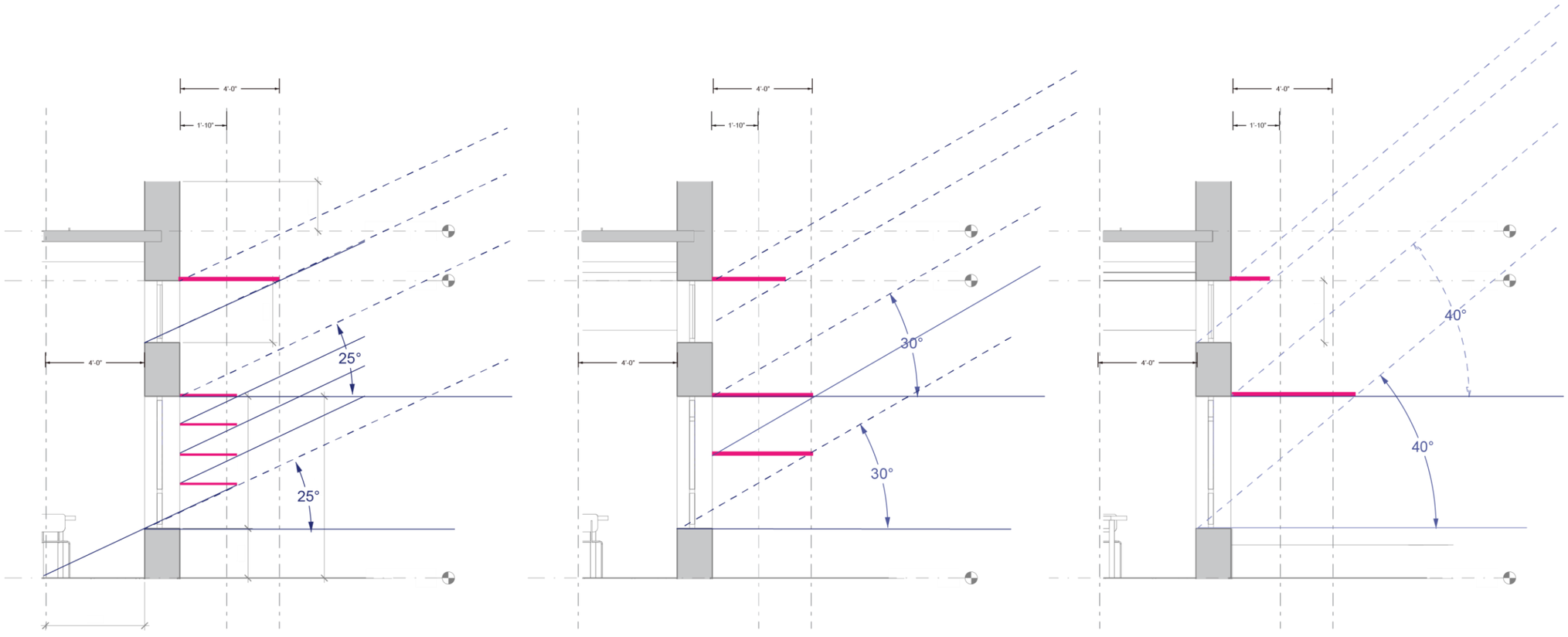
40° cut off angle (South, West or East)



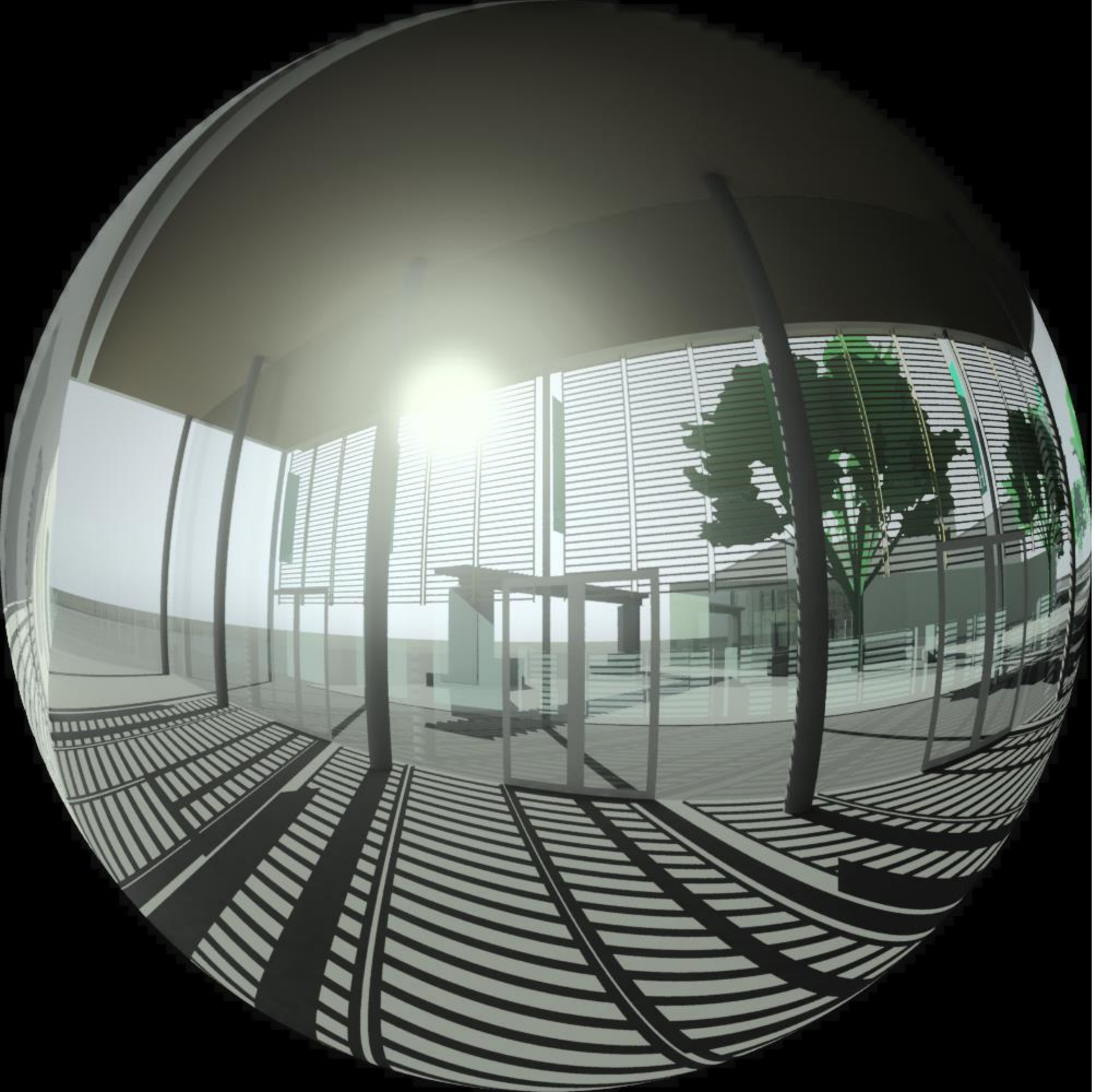
If you move the screens anywhere along the diagonal lines, cut off will be achieved for the respective time/facade. The further off of the façade the screen is, the more unobstructed view is available.

Overhangs for Shading

Achieving cutoff



If we wanted to use overhangs to solve the direct sun problem instead of screens, we could design overhangs as above. While the depths of these overhangs are perhaps more than achievable, these represent a “perfect” condition. Overhangs sized slightly smaller, will still achieve cut off during most of the specified time.



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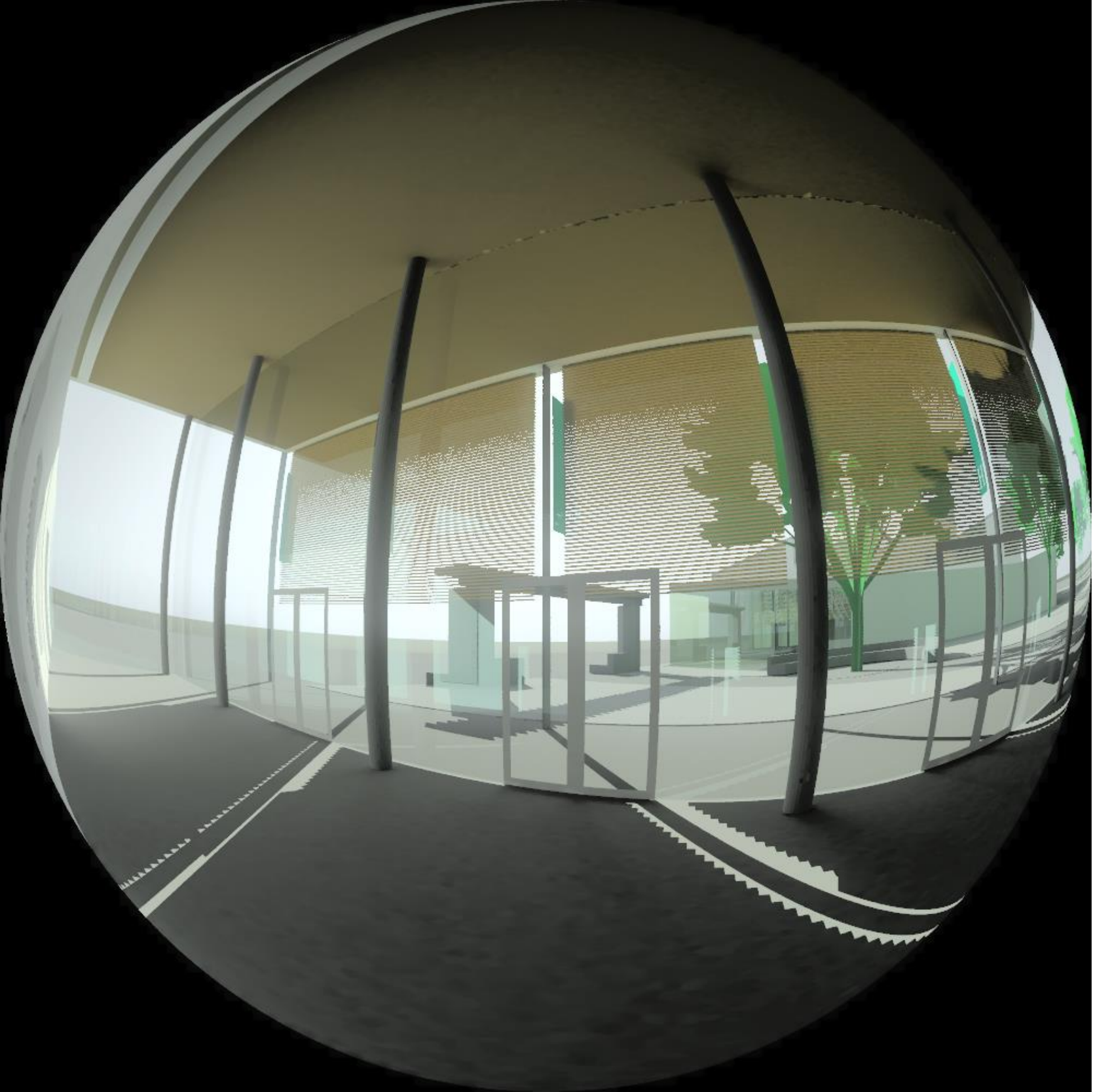

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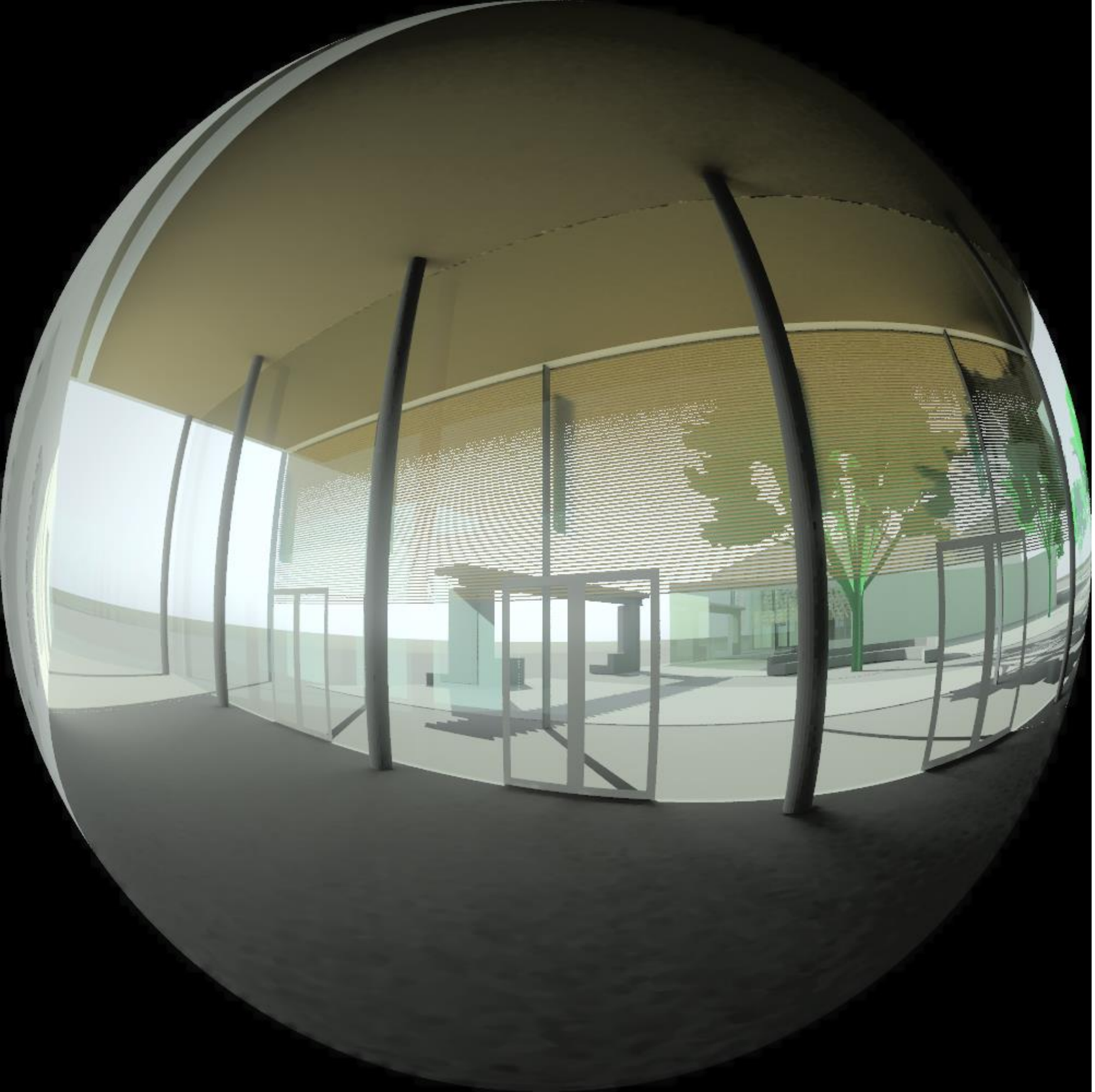

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Lighting, shading and glare in daylight analysis

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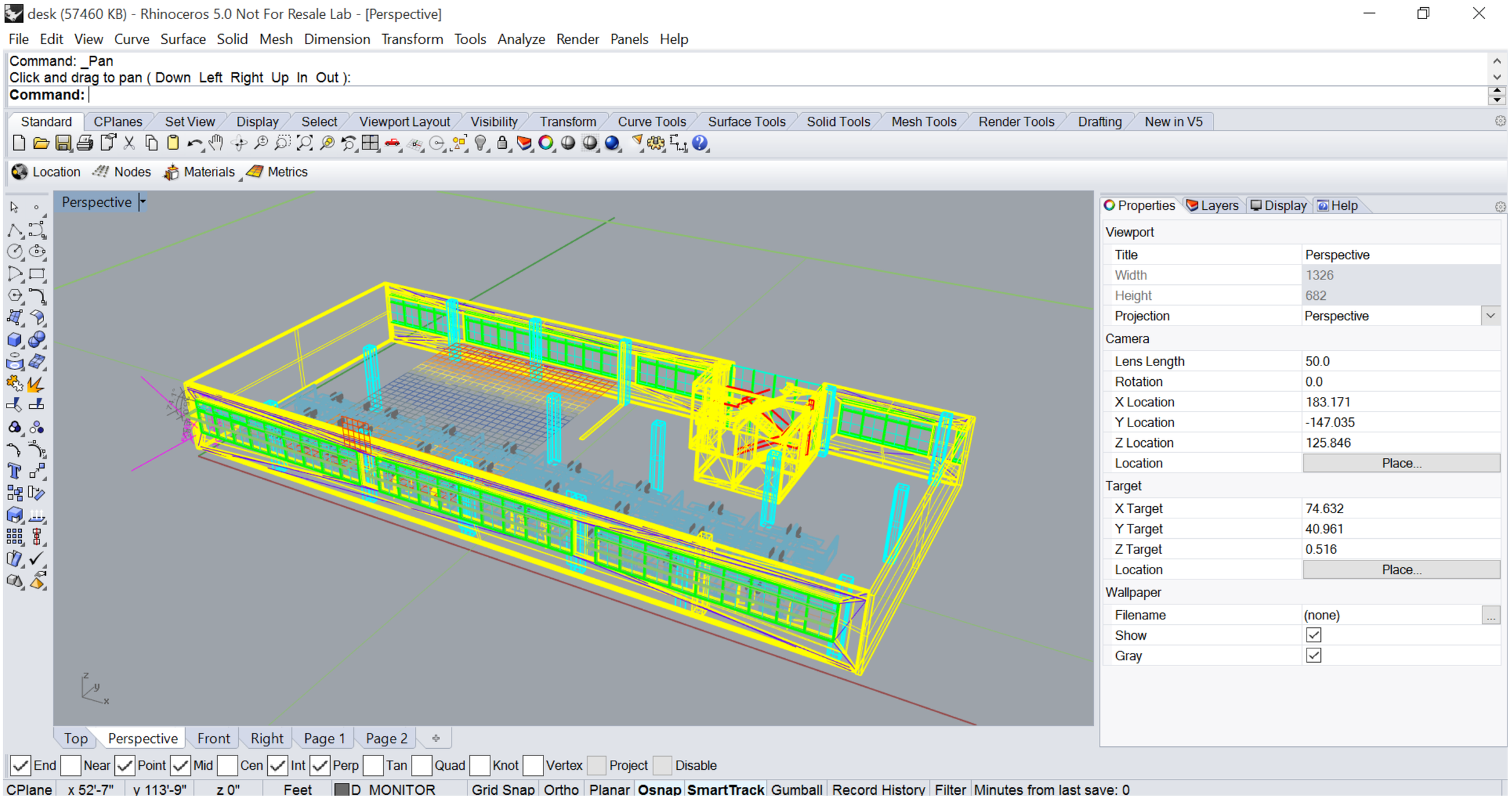
How do we achieve reliable results?

DIVA-for-Rhino Background



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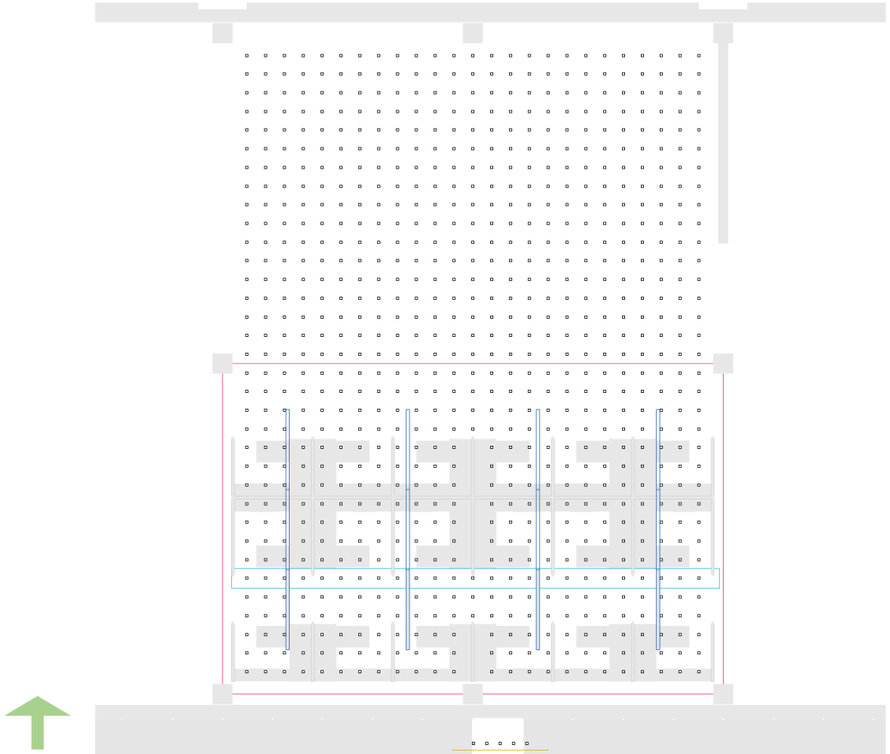
Objective

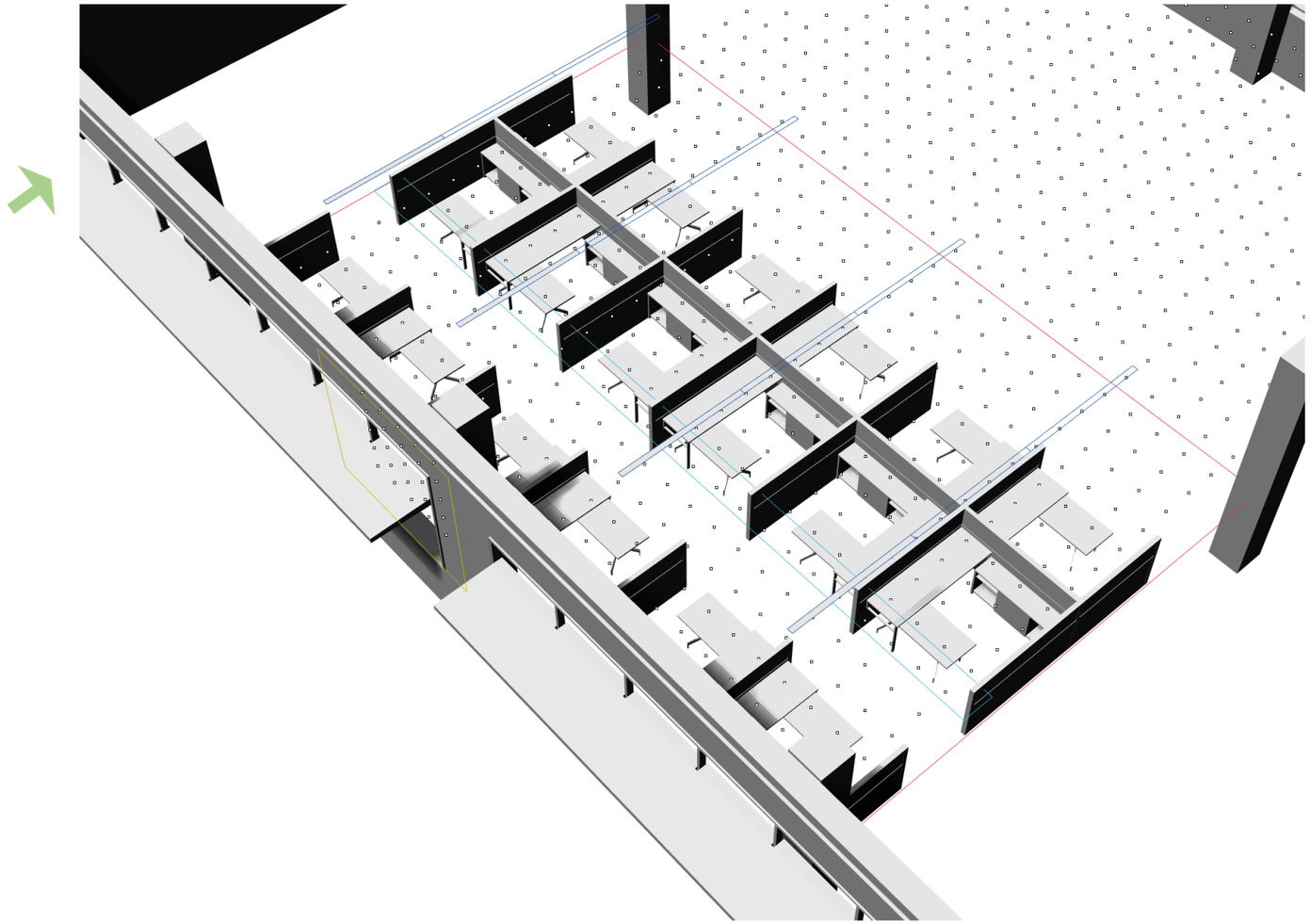
- To run a suite of simulations that will describe the behavior of a façade system including the lighting, shading and glare conditions.

Caveats

- This procedure does NOT use the Penn State Daysim
- This procedure uses DIVA-for-Rhino
- Control system algorithms are open loop systems

What are the steps?





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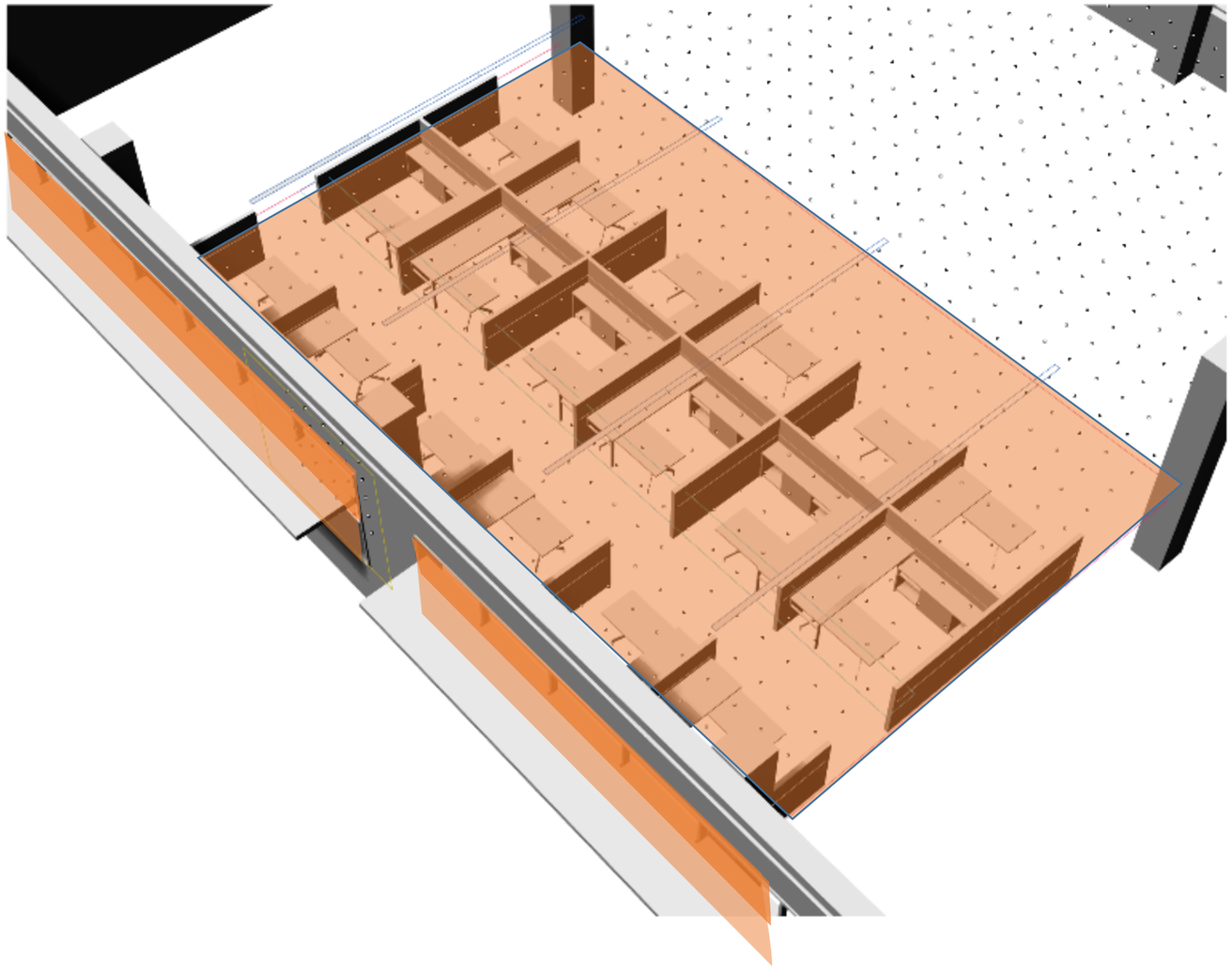
Shading module – Set Up

Critical inputs

- Modeling geometry
- Selecting a control algorithm
- Setting illumination set points
- Sensor node selection

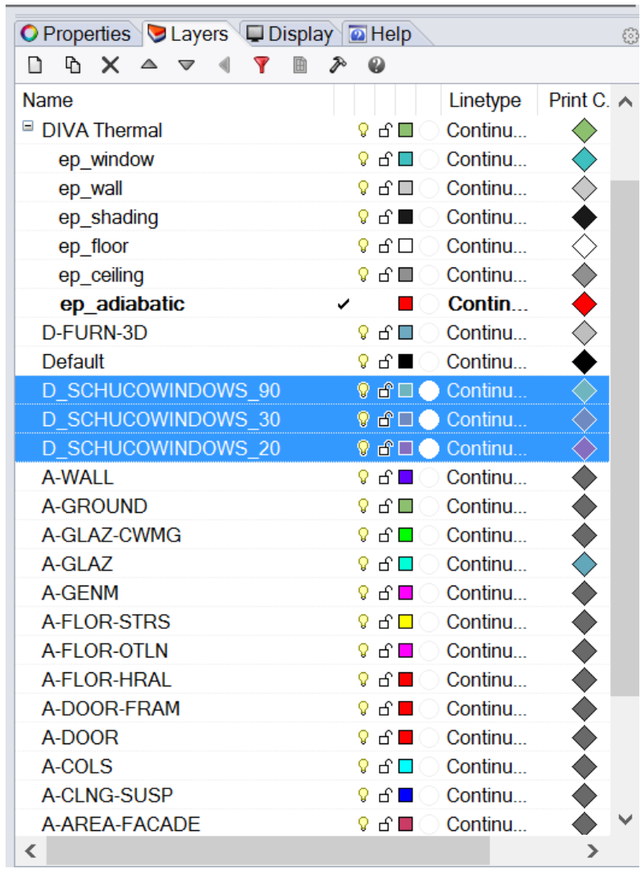


Shading module – Shading Geometry

1. Physically model each shading state on its own layer
2. Assign a material to that layer

If you want the shades to operate at all open, halfway down, and all the way down, model the shades halfway down, and all the way down on separate layers. If you want louvers at 90 degrees, 30 degrees and 20 degrees, you would model that geometry on 3 separate layers.

Note: you can leave all of the shading layers in the "on" state before running the simulations.



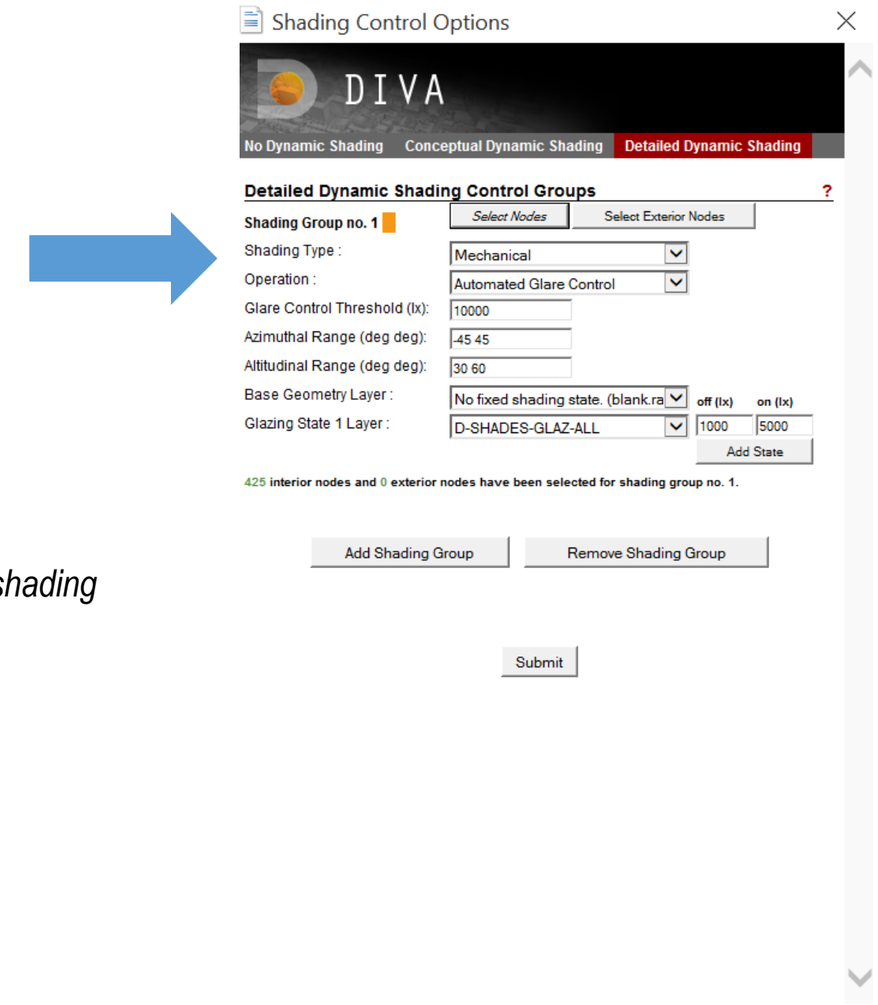
Shading module – Shading Control Type

3. Select from the available control algorithms, for each group:

Mechanical
- *Manual*
- *Automated Thermal Control*
- *Automated Thermal Control with Occupancy*
- *Automated Glare Control*
- *Automated Glare Control with Occupancy*

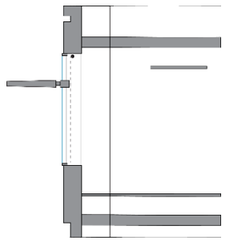
Electrochromics

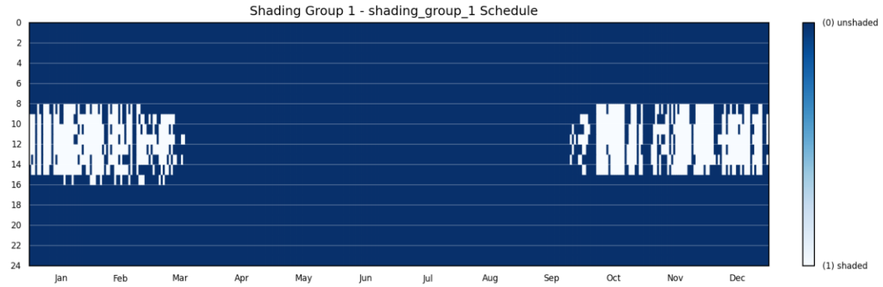
Note: The shading behavior in one shading group does not affect the shading behavior of a separate shading group.



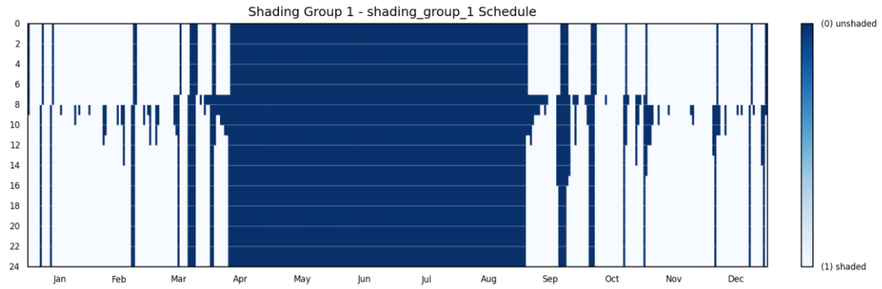
Manual shade control

Shading Schedule with automated blinds





Shading Schedule with manual control



This model assumes that the shades are "reset" once a day in the morning. In reality, without automation, the resetting is unlikely to happen. The algorithm may underestimate the amount of time the shades are down.

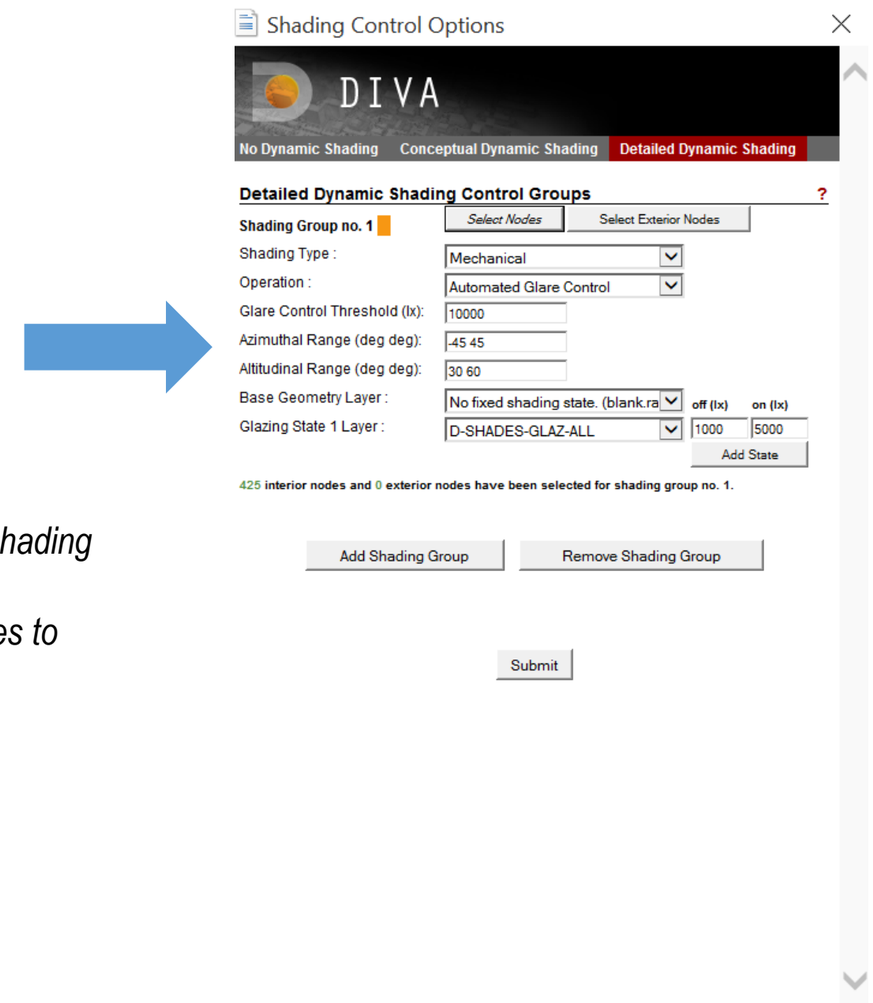
Automated Glare Control

Mechanical
- *Manual**
- *Automated Thermal Control*
- *Automated Thermal Control with Occupancy*
- *Automated Glare Control*
- *Automated Glare Control with Occupancy*

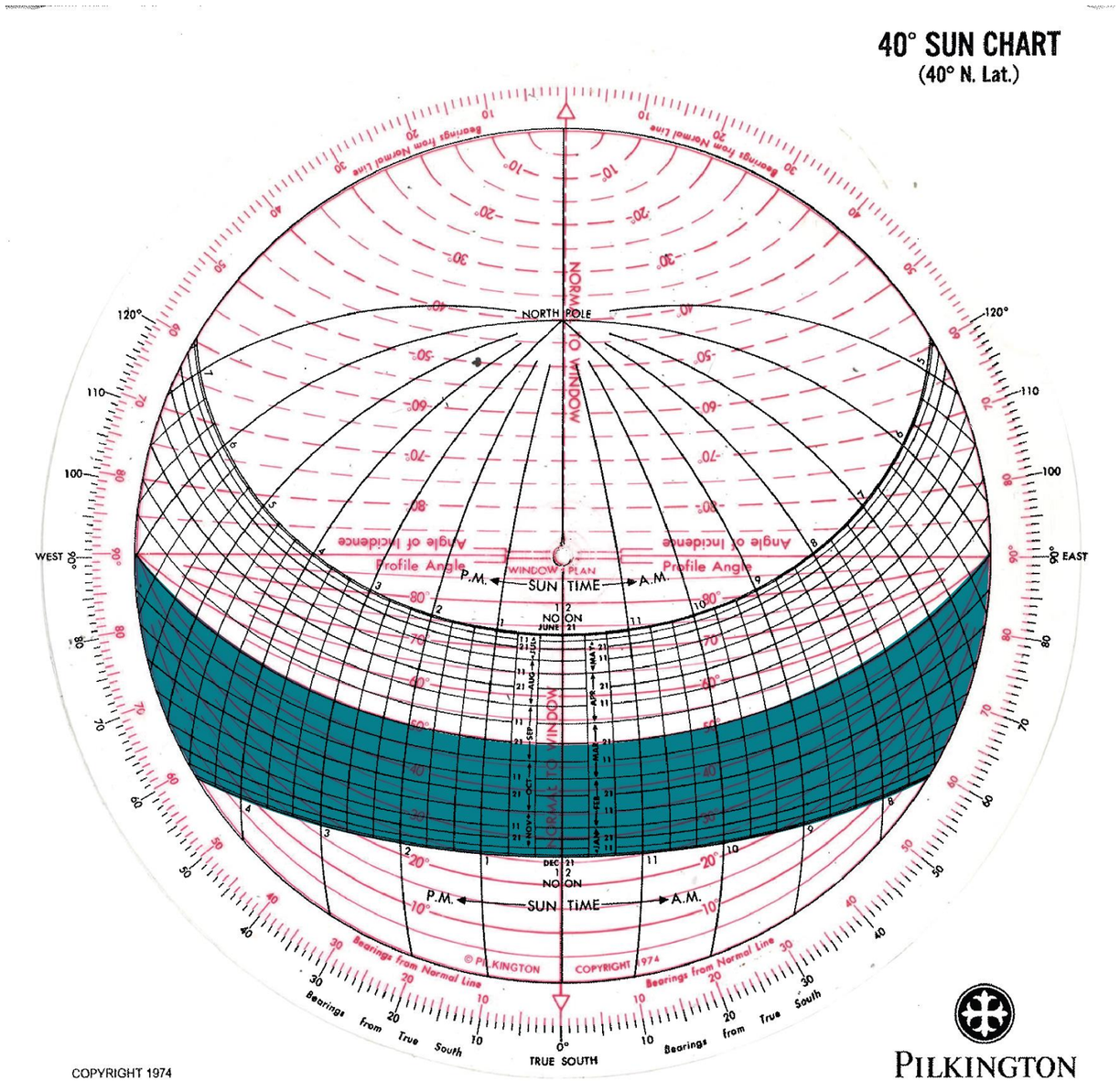
Electrochromics

Note: The shading behavior in one shading group does not affect the shading behavior of a separate shading group.

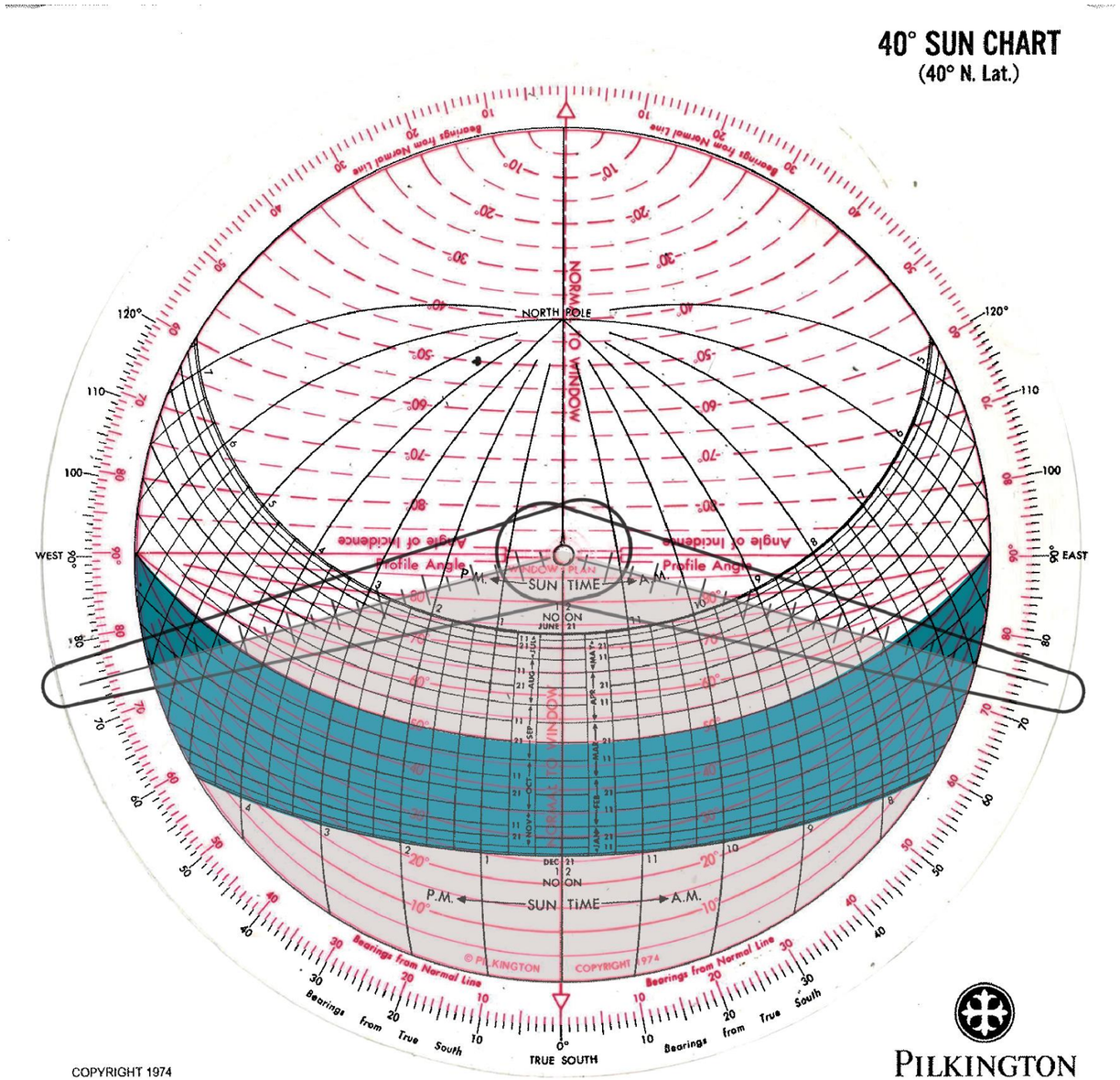
** Annual glare schedules are not used to control the operation of the shades. To use the DGP schedules to control the shades, select Manual control and in the climate-based metrics menu, select "Use DGP Schedules".*



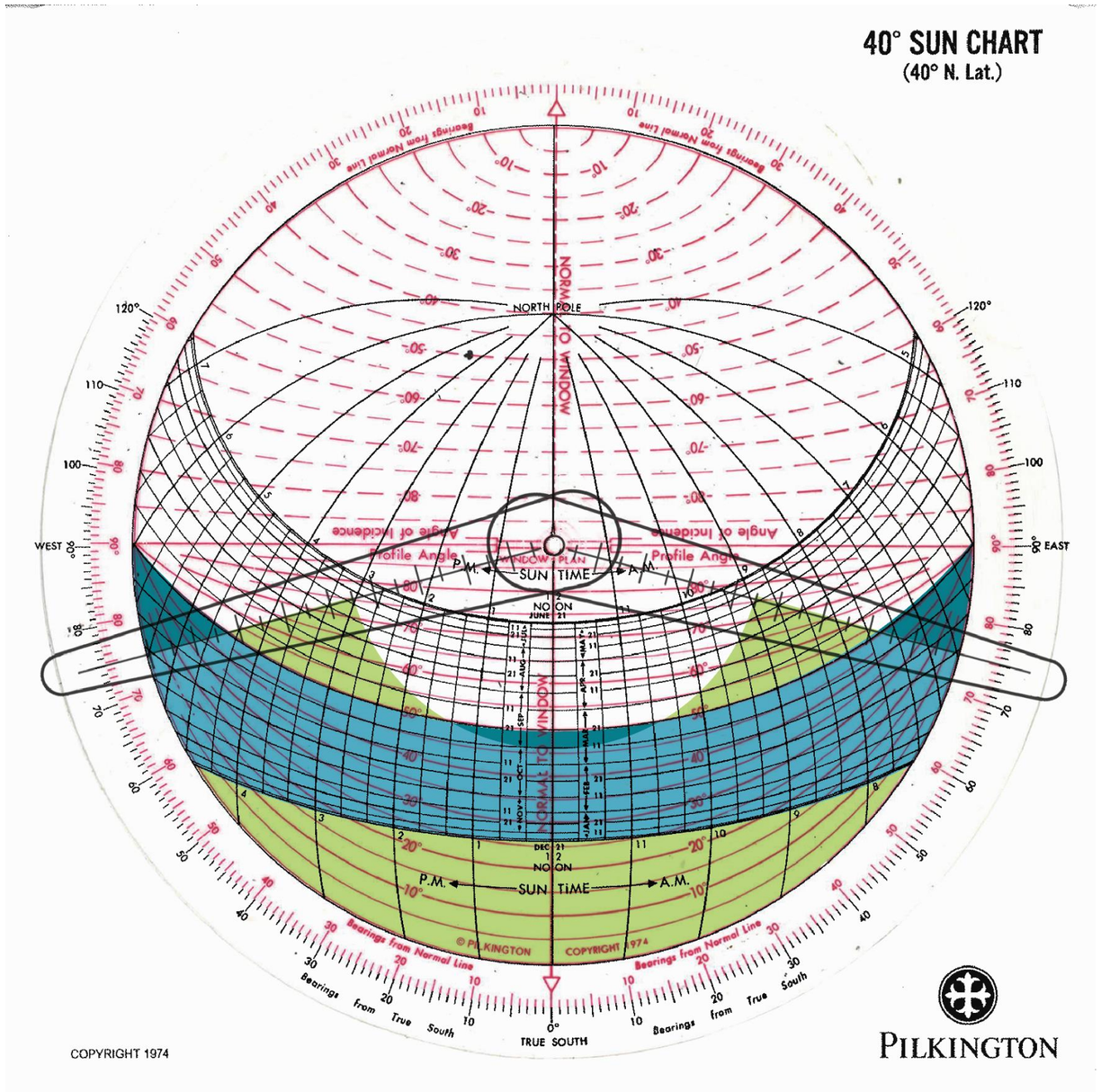
Automated Glare Control



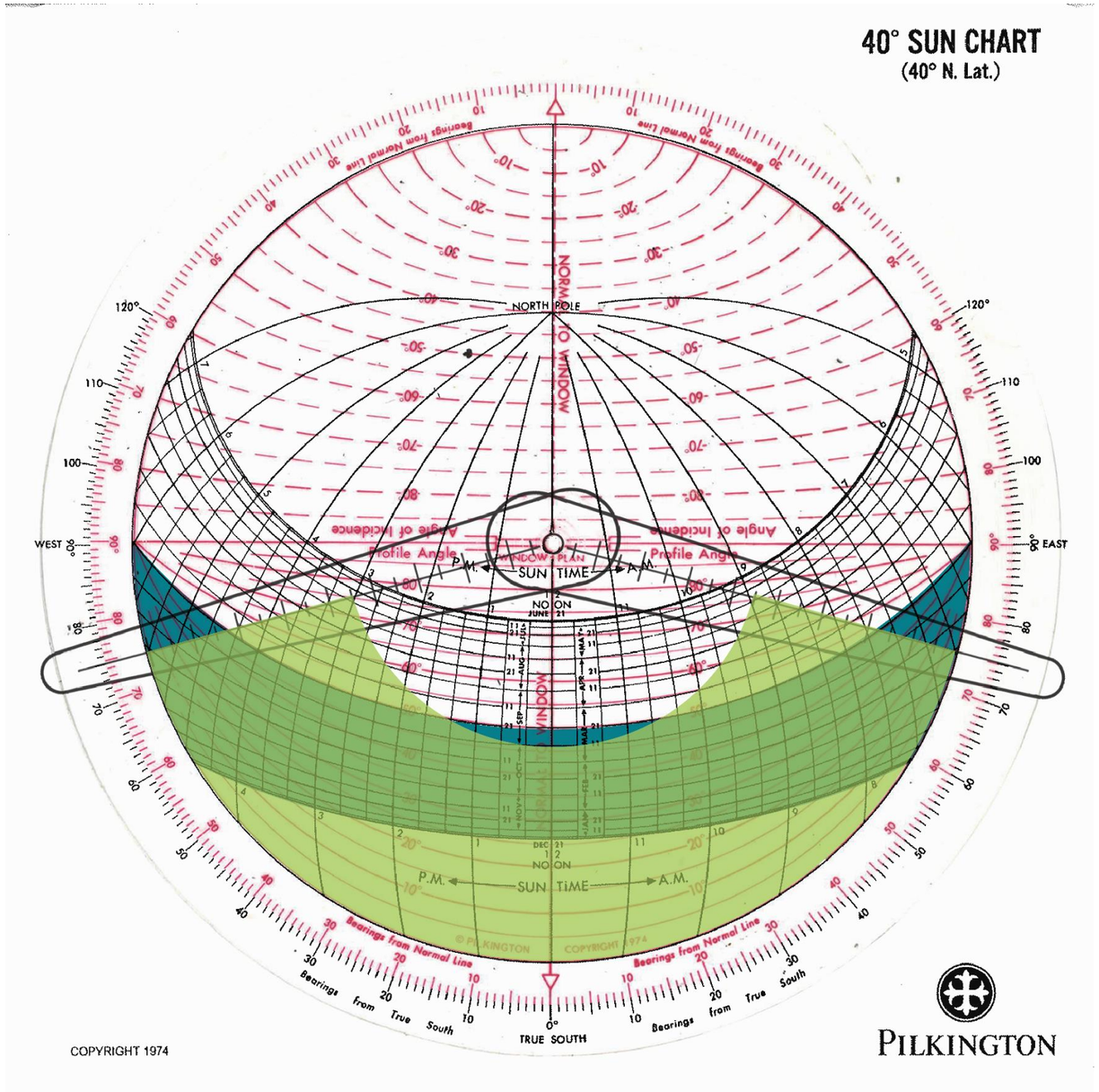
Automated Glare Control



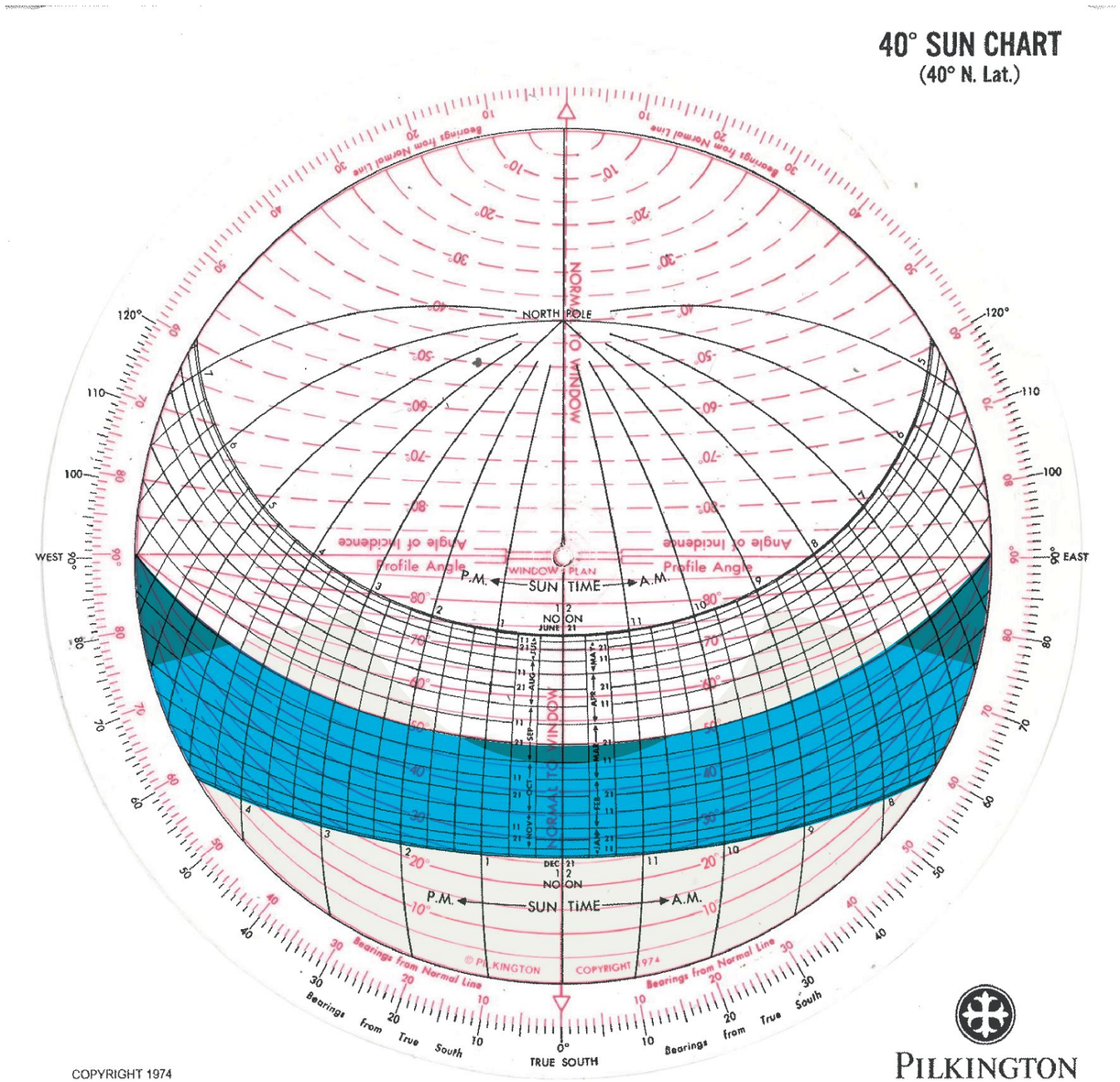
Automated Glare Control



Automated Glare Control



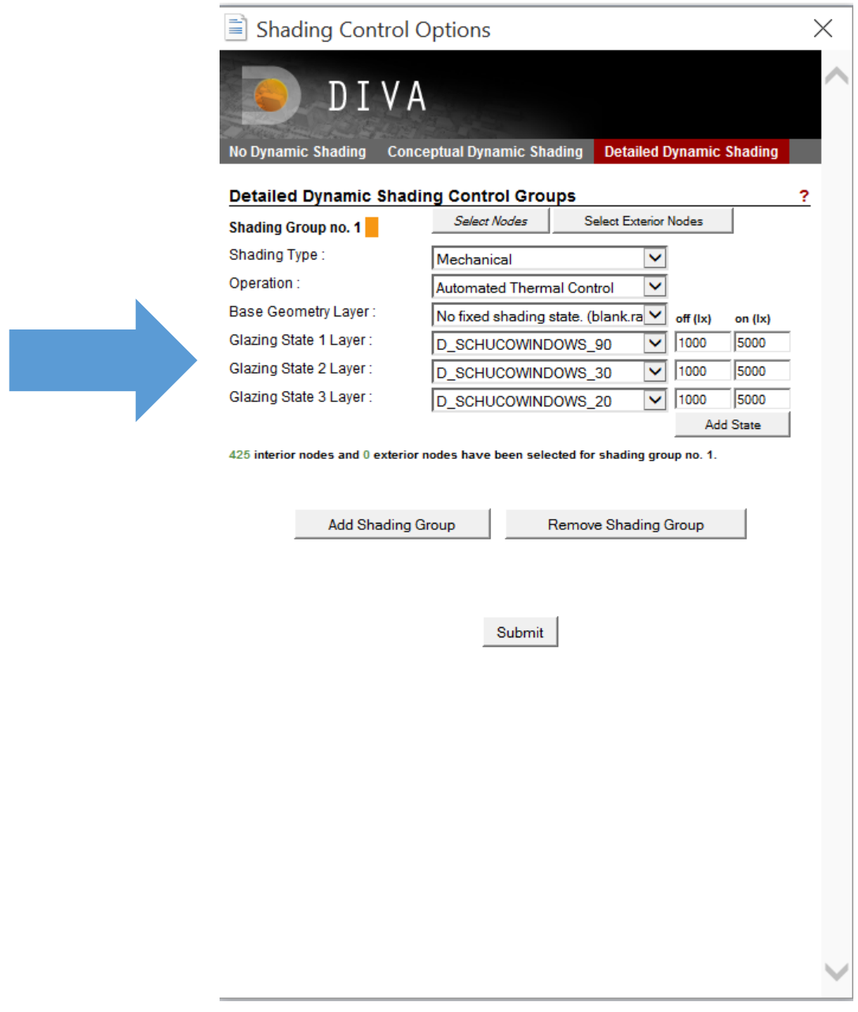
Automated Glare Control



Shading module – Shading States

4. Set up the shading states

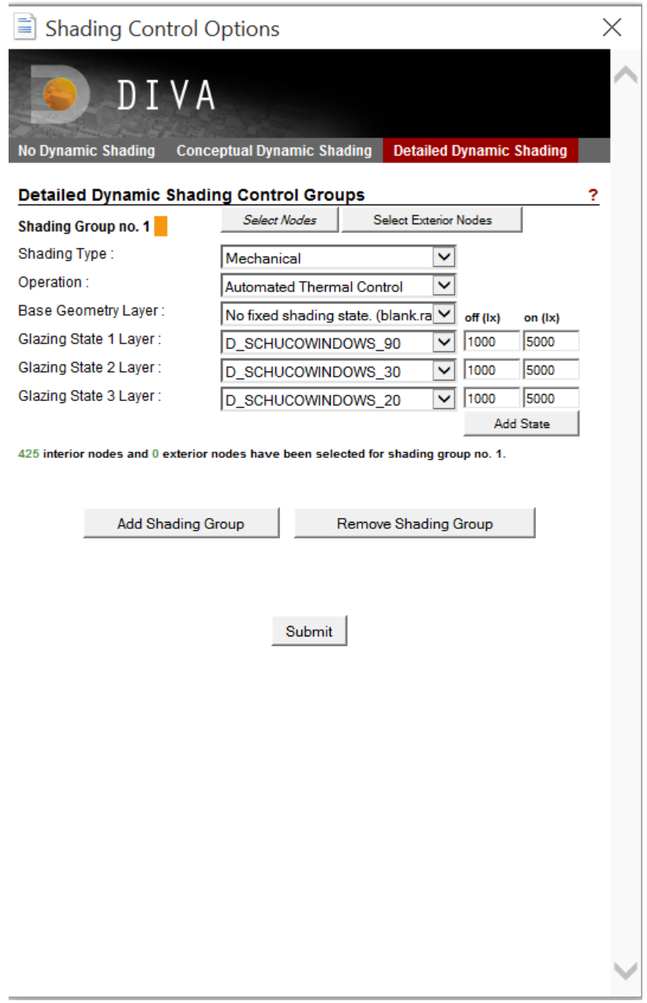
The "Base Geometry Layer" is the default shading state. If that means "shades all the way up", then select "No fixed shading state." The case shown here is louvers that start as fully retracted, then can be fully down at 90, 30 or 20 degree rotation angles.



Shading module – State Thresholds

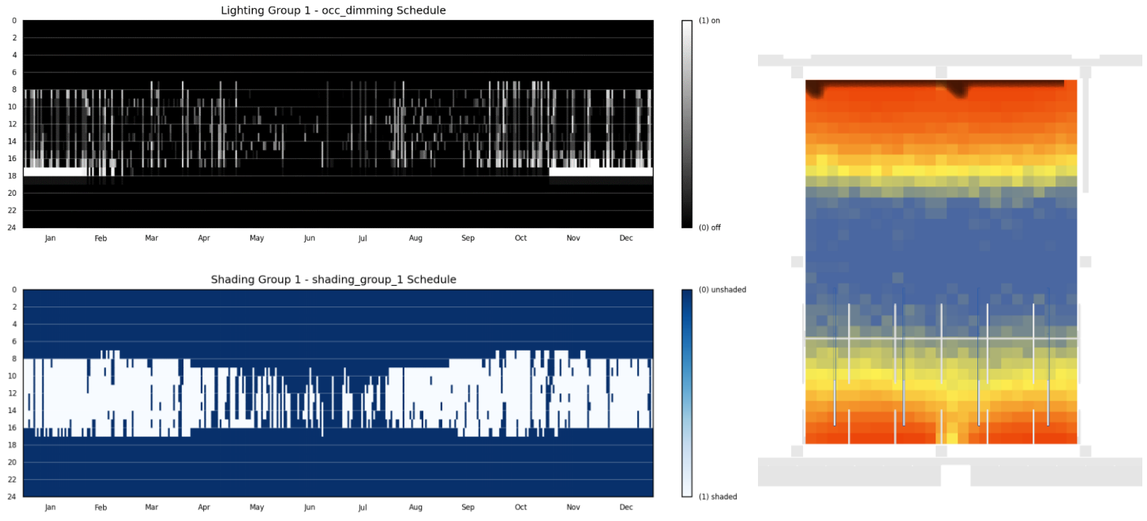
5. Set up the shading thresholds

The shading thresholds are the value (in lux) which control when the system moves from one state to another. In the example to the right, the shading starts as fully open, if the daylight levels on any of the sensors rises above 5000 lux, the program sets the shading position to the next level down (90 degree louver, in this case). If at the next timestep, the light levels are still over 5000 lux, the program proceeds to the next lowest shading level. If, on the other hand, the light levels fall below 1000 lux at the next time step, then the shading reverts to the next highest level.



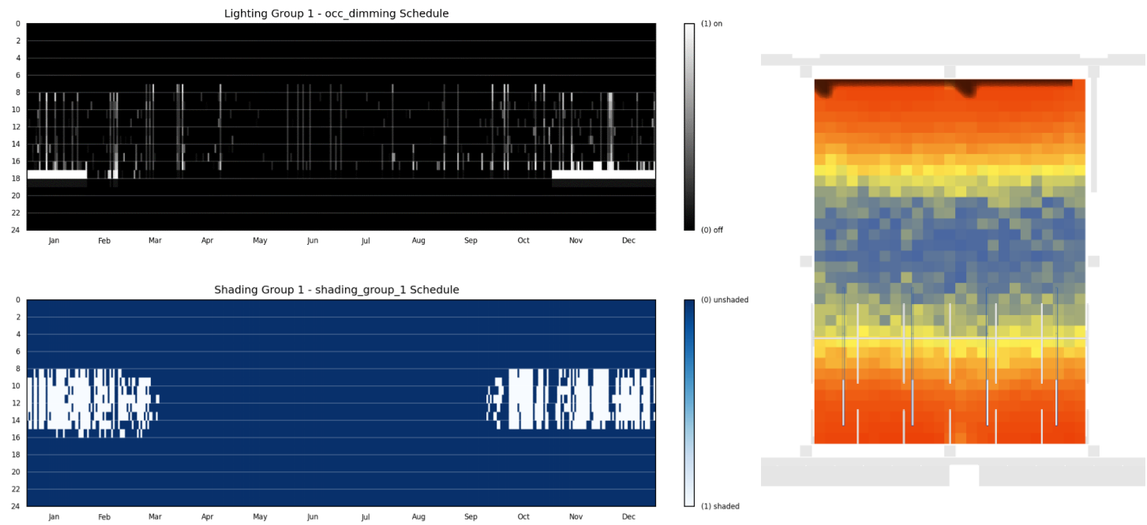
Shading module – State Thresholds

Off (lx) On (lx)
300 2500 lux



SDa (300lx 50%): ***40%***
Shading Open: ***39%***
Electric Lighting Use Reduction : ***85.1%***

Off (lx) On (lx)
1000 5000 lux



SDa (300lx 50%): ***55%***
Shading Open: ***78%***
Electric Lighting Use Reduction: ***92.1%***

INTEGRAL GROUP

Setting sensor thresholds

423 fc

1650 fc

1996 fc

1986 fc

1573 fc

1843 fc

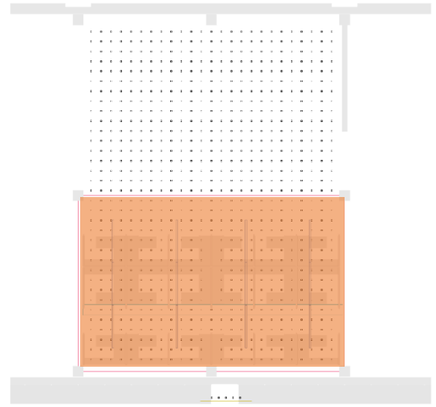
INTEGRAL GROUP

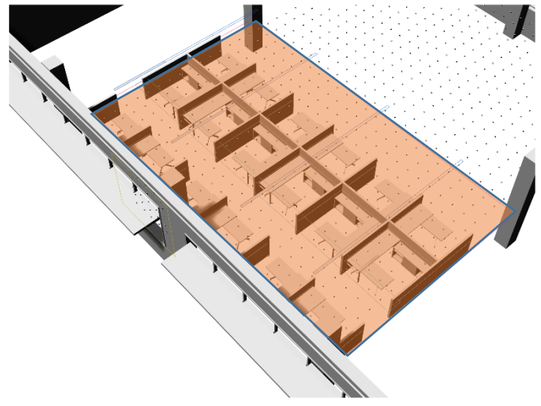
Shading module – Node selection

6. Select interior nodes (and exterior nodes) for each shading group

It is up to you how many sensors you select to drive your shades. You can select just one or all of the sensor nodes. (If you do not select any nodes, the program will use all of them).

In the example to the right, all nodes on the south side of the building are selected. If light levels on any node reach above 5000 lux, the shades will deploy to their next lowest level. If all of the nodes fall below 1000 lux, at the next timestep, the shades will rise to the next highest level.





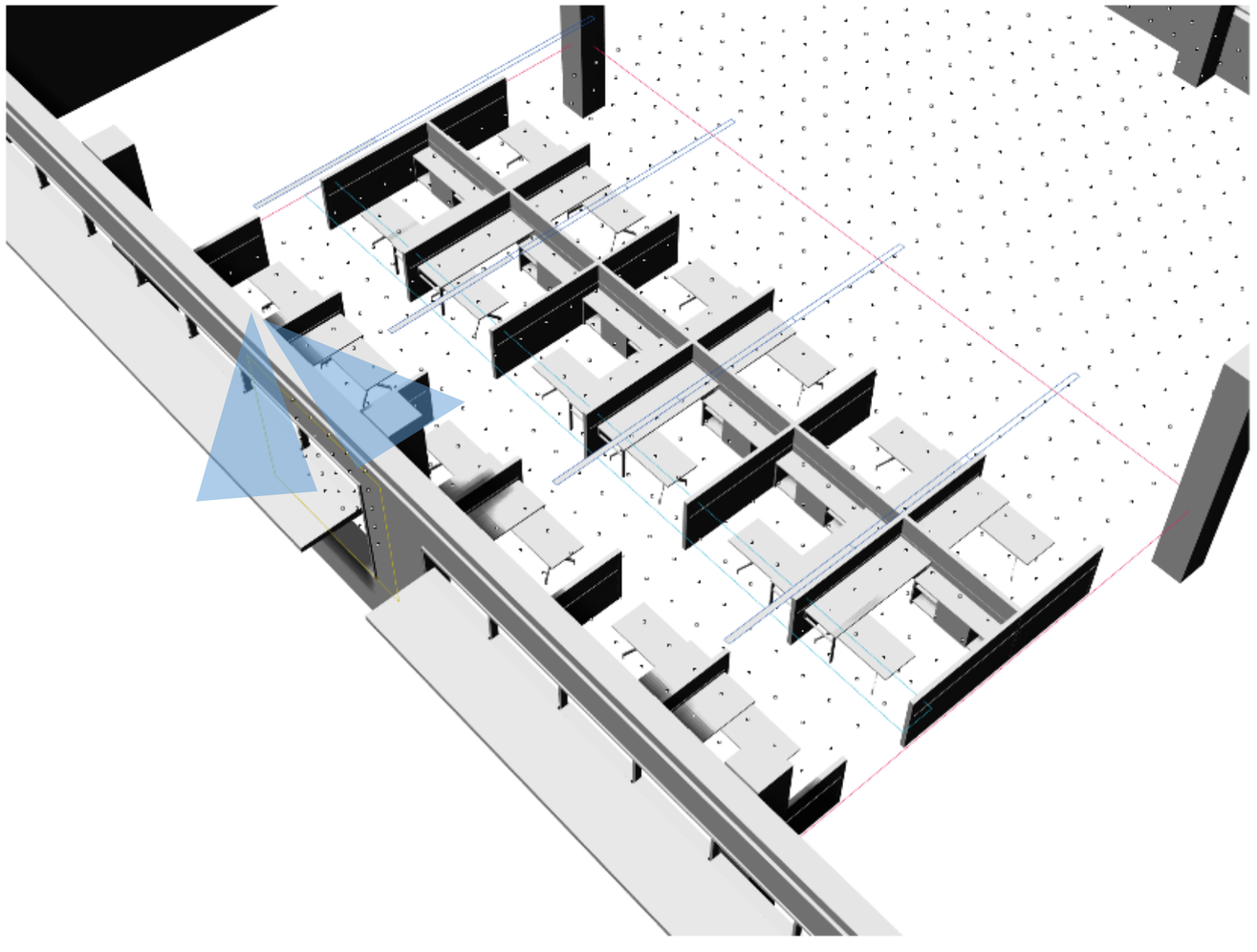
Annual Glare Module

INTEGRAL GROUP

Annual Glare Module – Set Up

Critical inputs

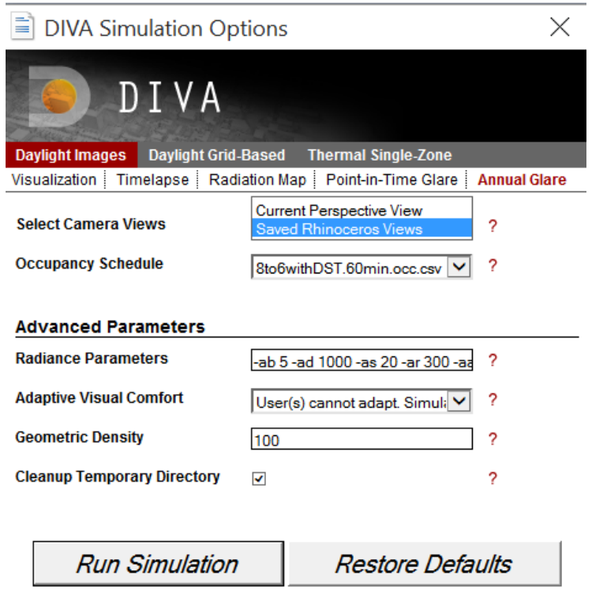
- Set up viewpoints
- User (occupant) adaptability

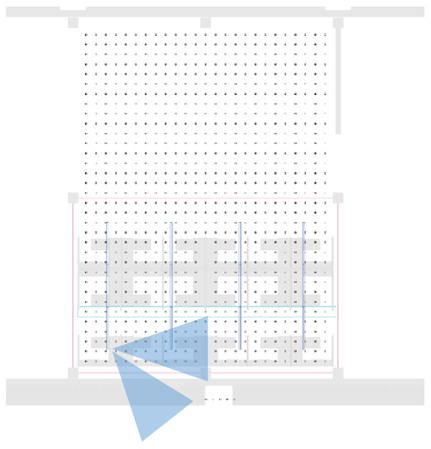


Annual glare module – Set Up

1. Save the Rhinoceros views you wish to test

Save more than one view if you want to test multiple views, and if you want to give the occupant the ability to adapt based on glare conditions.

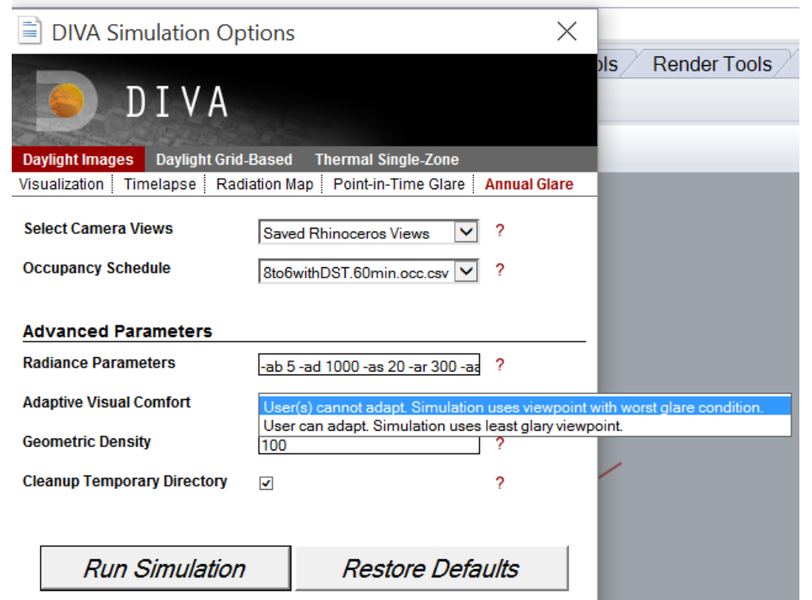




Annual glare module – Set Up

2. Select Adaptive Visual Comfort

Select whether or not the user can adapt – that is choose to look in a different direction given the glare conditions.



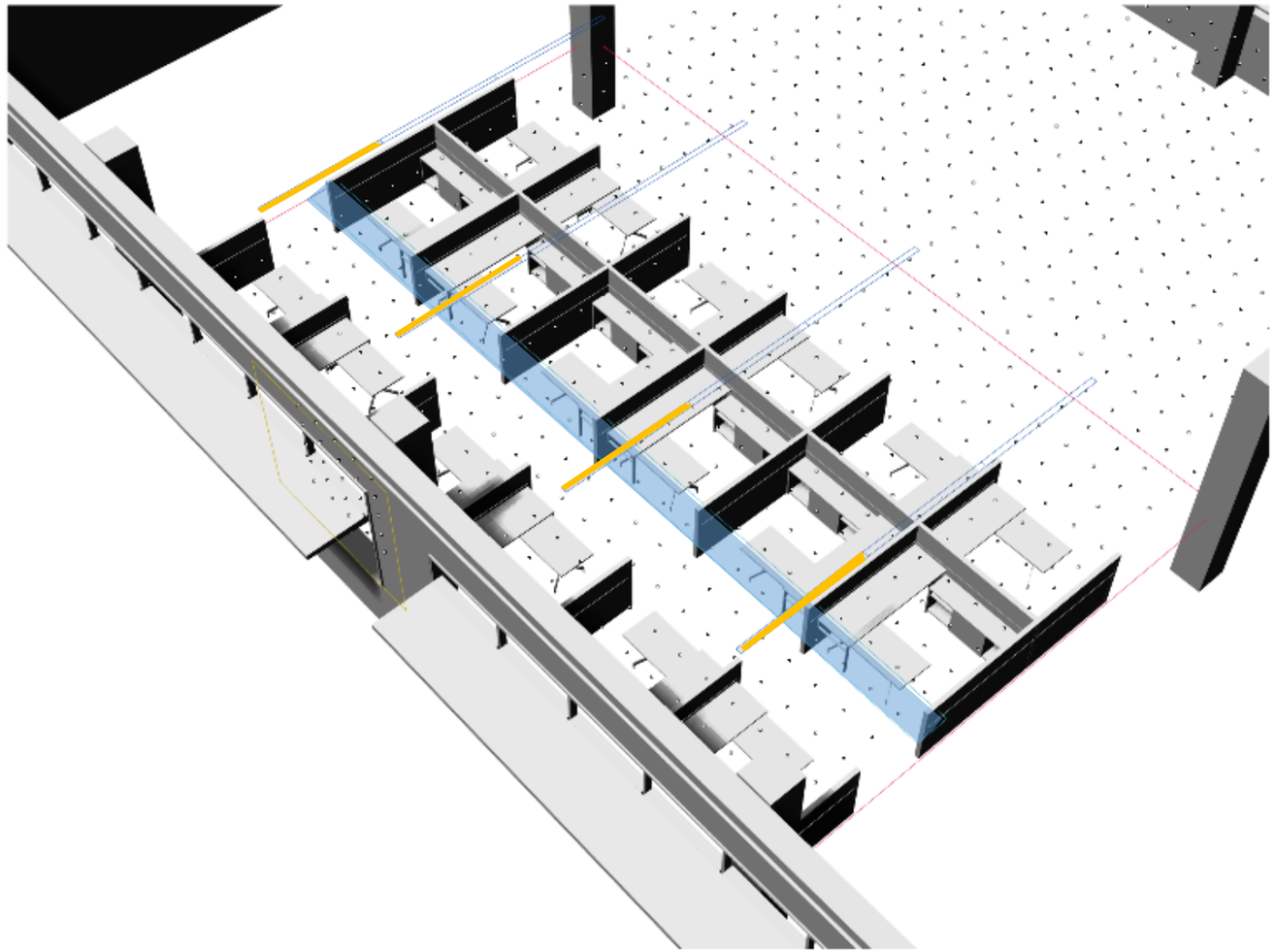
Lighting and Dimming Module

INTEGRAL GROUP

Lighting Module – Set Up

Critical inputs

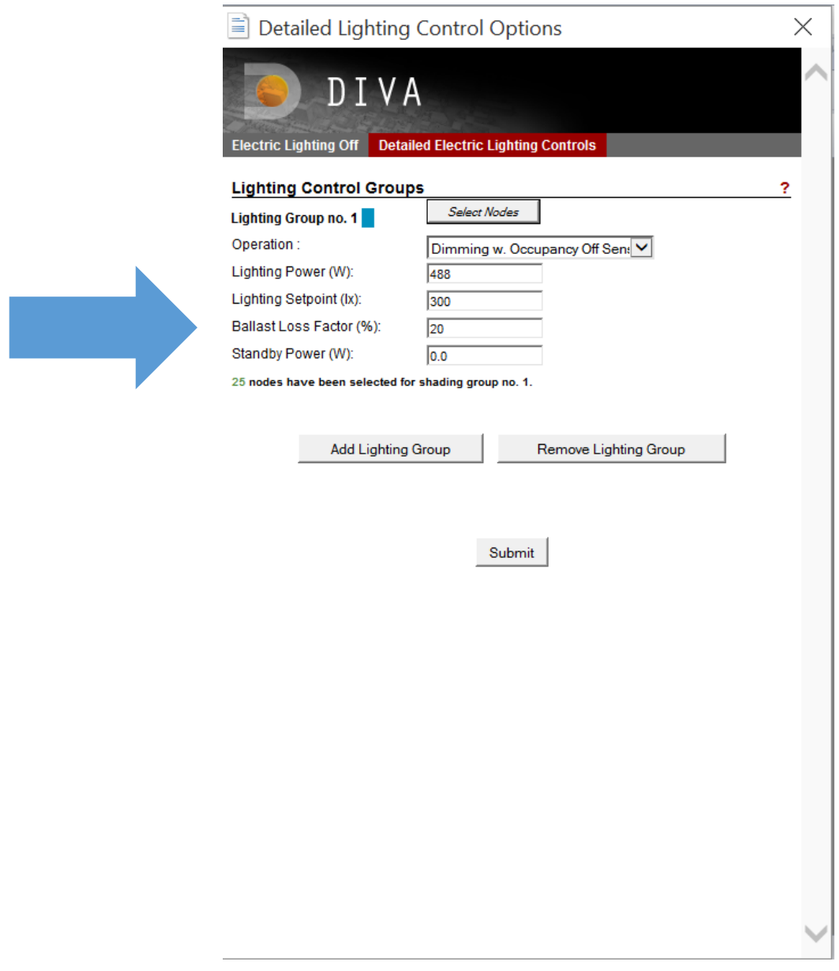
- Lighting system power
- Lighting control algorithm
- Sensor node selection



Lighting module - Set up

1. Enter lighting system information

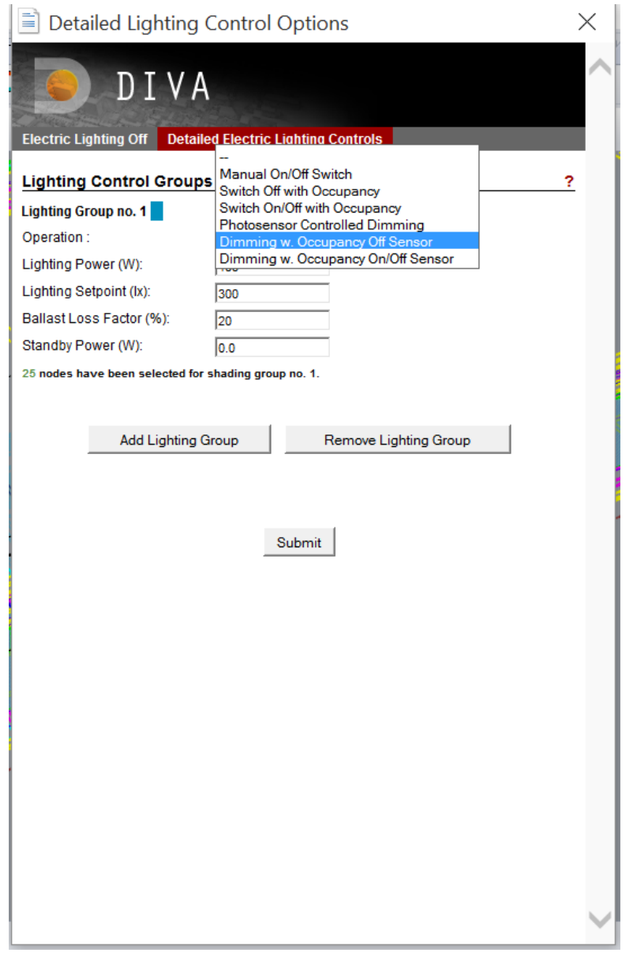
Lighting Power (W): total lighting power for the group of light fixtures being controlled
Ballast Loss Factor (%): percent of lighting power increased or decreased by the ballast (mostly an issue with fluorescents)
Standby Power (W): any power used when the system is either fully dimmed or off



Lighting module - Set up

2. Select the lighting control algorithm

None
Manual
Switch off with Occupancy
Switch on/off with Occupancy
(Photosensor Controlled) Dimming w. Occupancy Off Sensor
(Photosensor Controlled) Dimming w. Occupancy On/Off Sensor

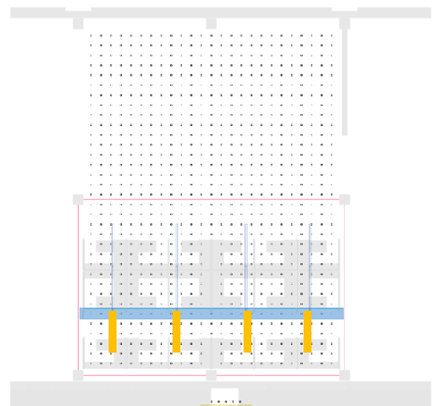


Lighting module - Set up

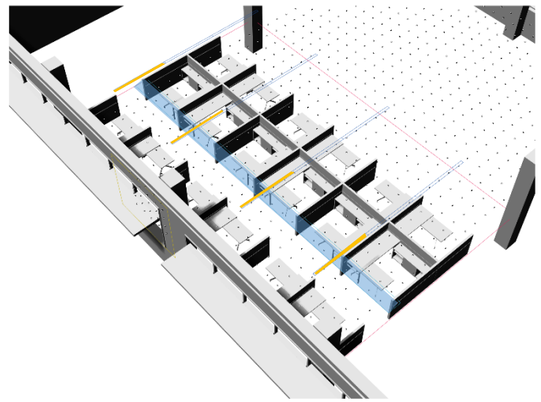
3. Select sensor nodes

Similarly to the shading nodes, it is up to you to decide how many nodes you will select as triggers, and where those sensors should be.

Mistrick and Casey suggested selecting nodes as follows, “The critical work plane point is usually located between the dimmed lighting zone and the non-dimmed lighting zone where the required output from the controlled group of luminaires is greatest when considering the presence of daylight.”



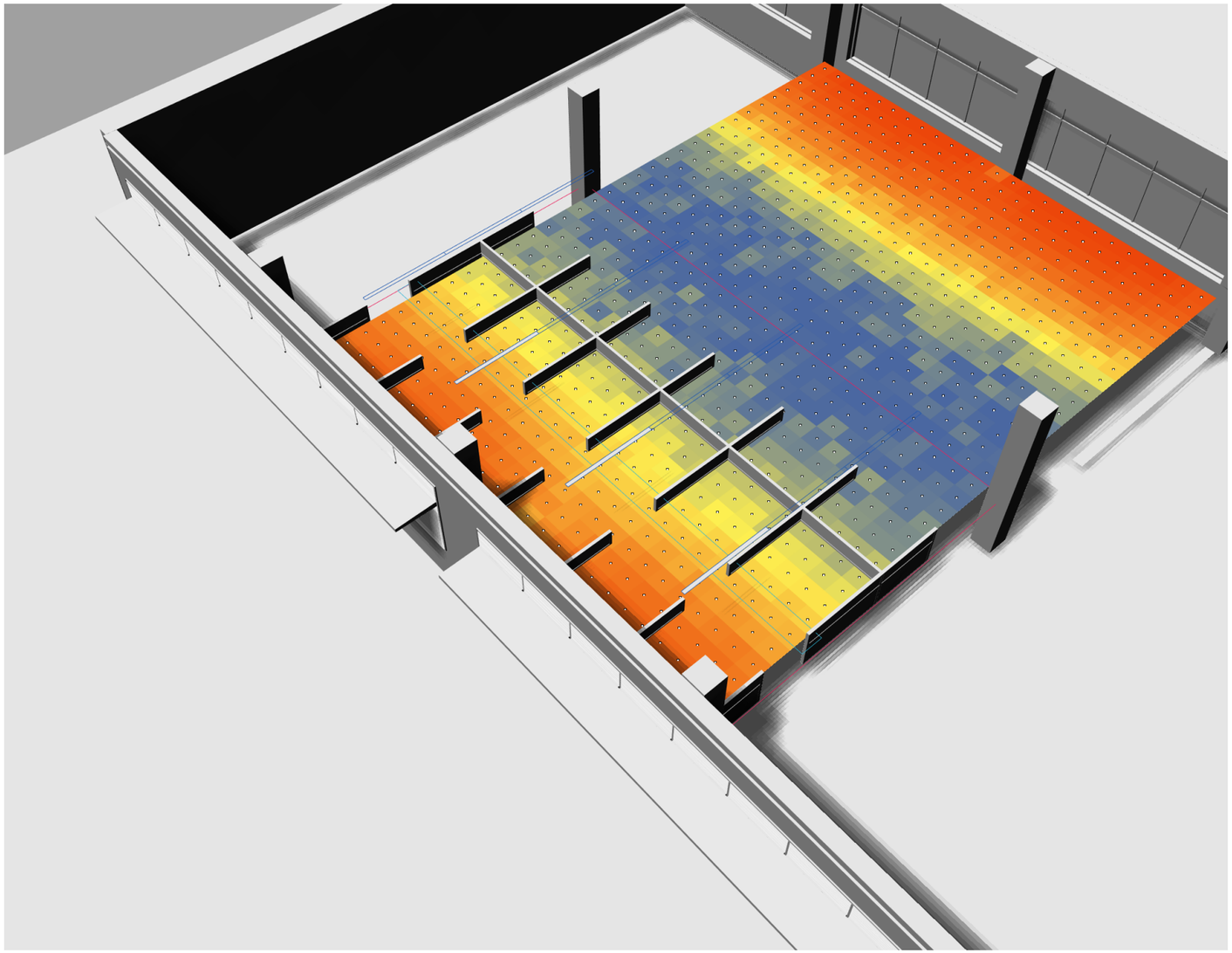
Reference: Mistrick and Casey, “Performance modeling of daylight integrated photosensor controlled lighting systems.” Proceedings of the 2011 Winter Simulation Conference.



Annual Simulation Runs

Critical inputs

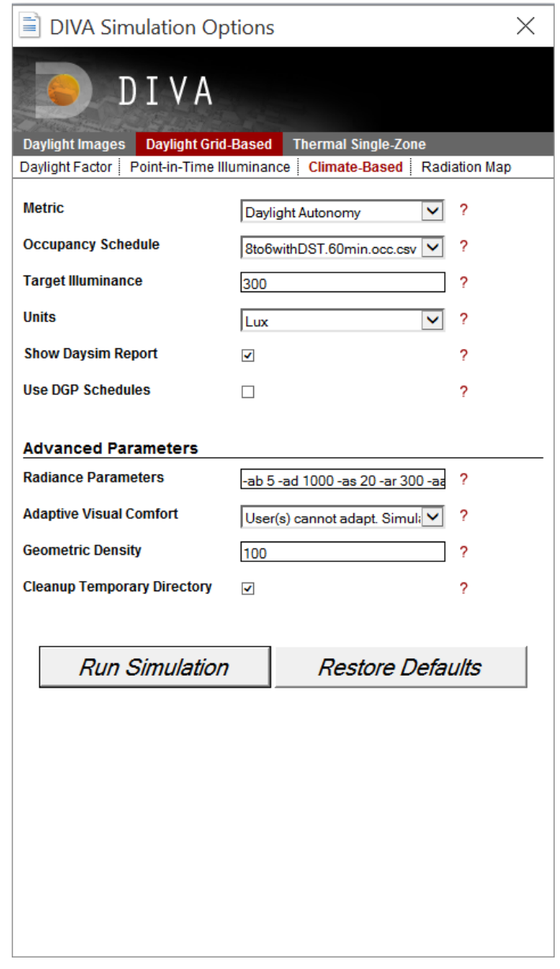
- Lighting system power
- Lighting control algorithm
- Sensor node selection



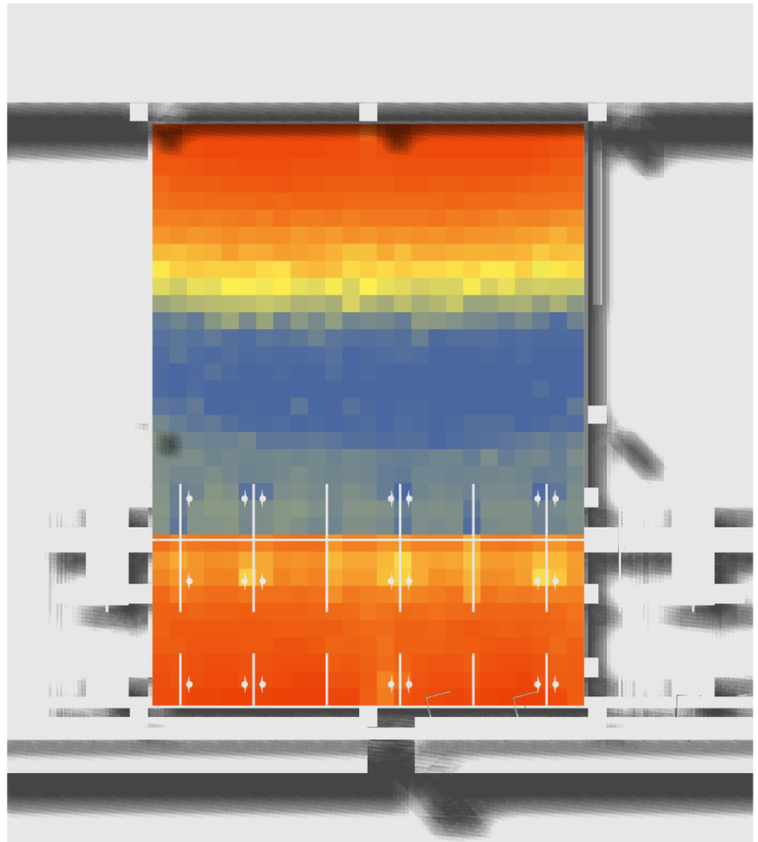
Annual Simulation Runs

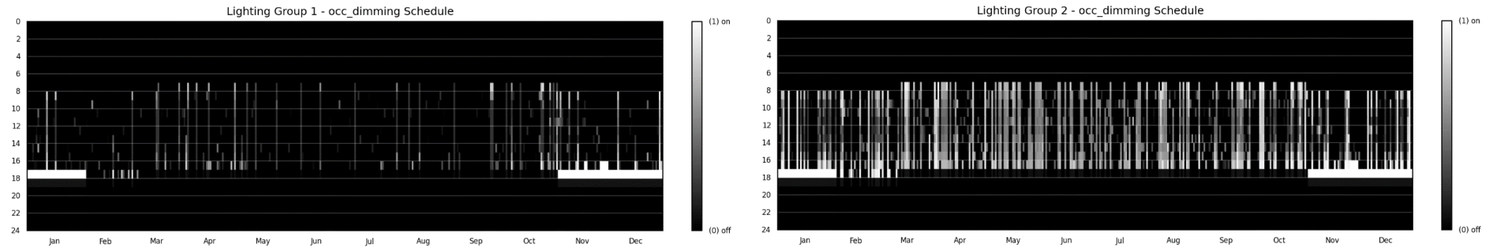
Critical inputs

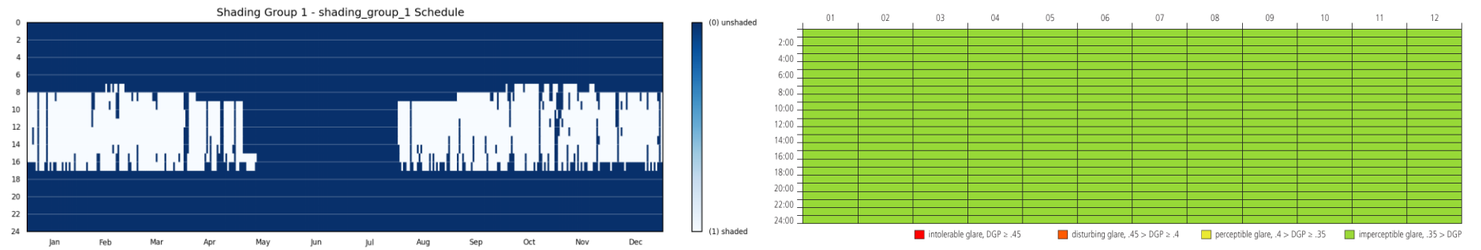
- Simulations to run
- Simulation settings
- Use DGP Schedules, Use Adaptive Comfort



Annual simulations combining glare, shading and lighting



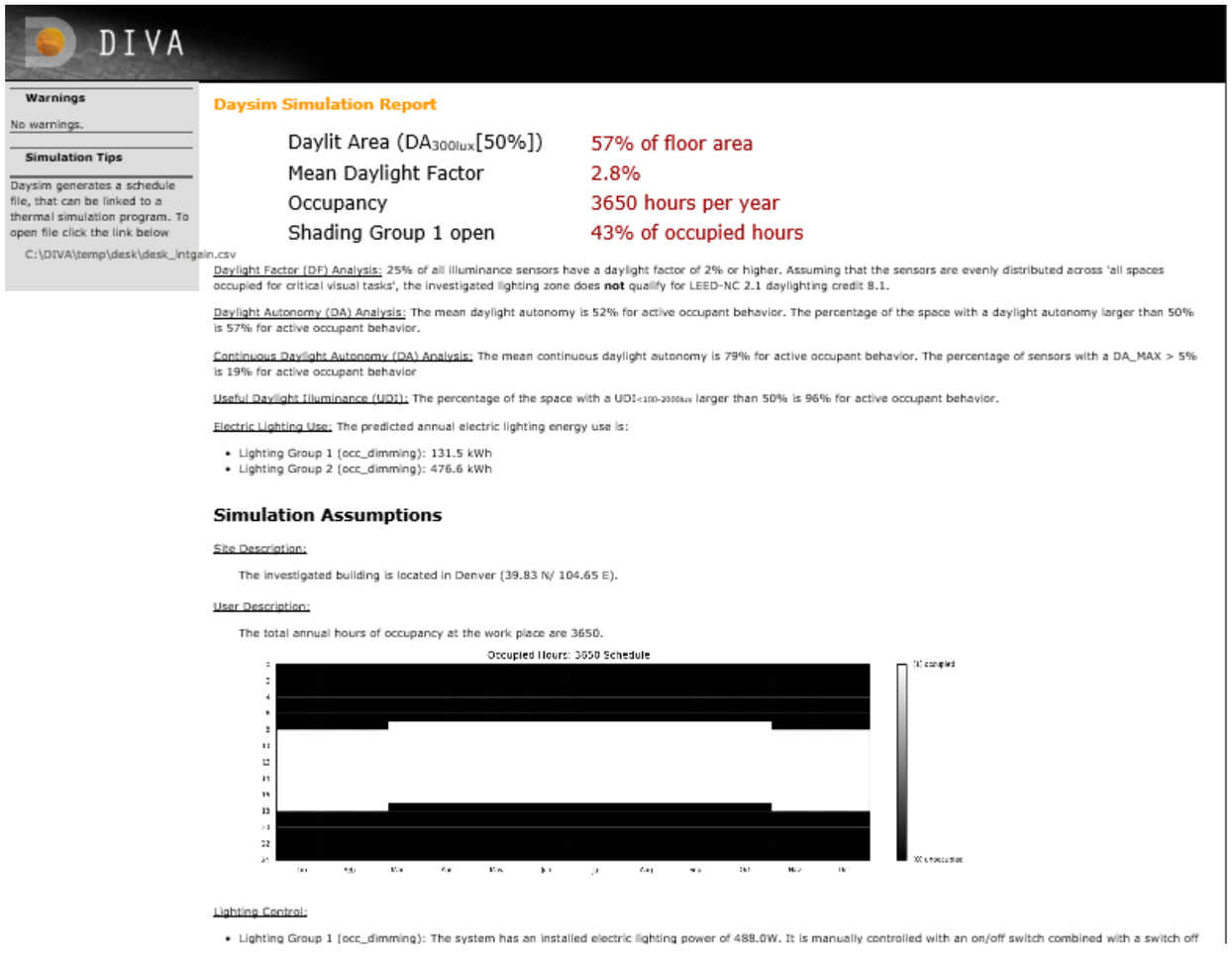




Results of a full Climate-Based Metrics run including (2) lighting/dimming groups and one shading group with outputs: Daylight Autonomy falsecolor grid, dimming and shading schedules, and annual glare simulation (with shade operation).
The occupancy, lighting and shading schedules are also output as a .csv file which can be used in energy simulations to for more accurate evaluations of the lighting performance.

INTEGRAL GROUP

Annual simulations combining glare, shading and lighting



DIVA

Warnings

No warnings.

Simulation Tips

Daysim generates a schedule file, that can be linked to a thermal simulation program. To open file click the link below

C:\DIVA\temp\desk\desk_intgain.csv

Daysim Simulation Report

Daylit Area (DA$_{300lux}$[50%])	57% of floor area
Mean Daylight Factor	2.8%
Occupancy	3650 hours per year
Shading Group 1 open	43% of occupied hours

Daylight Factor (DF) Analysis: 25% of all illuminance sensors have a daylight factor of 2% or higher. Assuming that the sensors are evenly distributed across 'all spaces occupied for critical visual tasks', the investigated lighting zone does **not** qualify for LEED-NC 2.1 daylighting credit 8.1.

Daylight Autonomy (DA) Analysis: The mean daylight autonomy is 52% for active occupant behavior. The percentage of the space with a daylight autonomy larger than 50% is 57% for active occupant behavior.

Continuous Daylight Autonomy (DA) Analysis: The mean continuous daylight autonomy is 79% for active occupant behavior. The percentage of sensors with a DA_MAX > 5% is 19% for active occupant behavior

Useful Daylight Illuminance (UDI): The percentage of the space with a UDI$_{<100\text{-}2000lux}$ larger than 50% is 96% for active occupant behavior.

Electric Lighting Use: The predicted annual electric lighting energy use is:

- Lighting Group 1 (occ_dimming): 131.5 kWh
- Lighting Group 2 (occ_dimming): 476.6 kWh

Simulation Assumptions

Site Description:

The investigated building is located in Denver (39.83 N/ 104.65 E).

User Description:

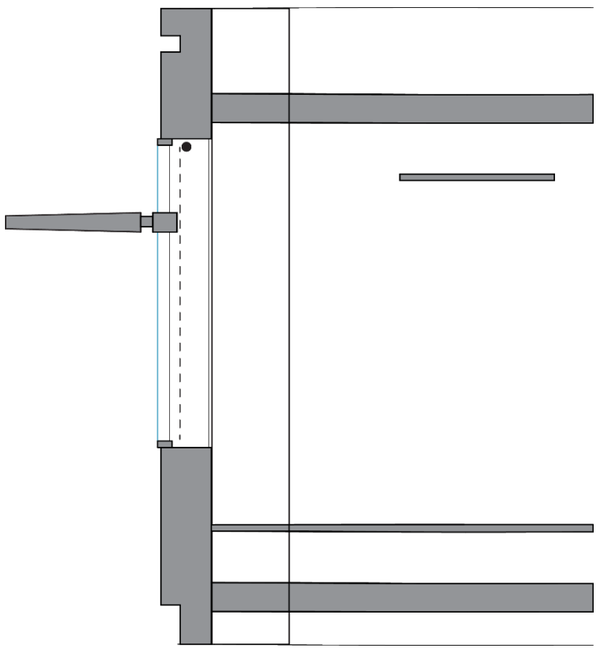
The total annual hours of occupancy at the work place are 3650.

Lighting Control:

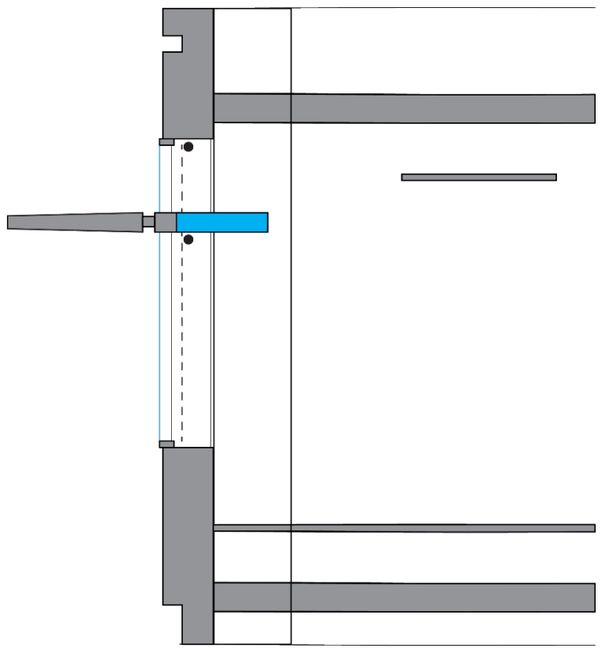
- Lighting Group 1 (occ_dimming): The system has an installed electric lighting power of 488.0W. It is manually controlled with an on/off switch combined with a switch off

Additional information can be found in the report output at the end of the DIVA simulation.

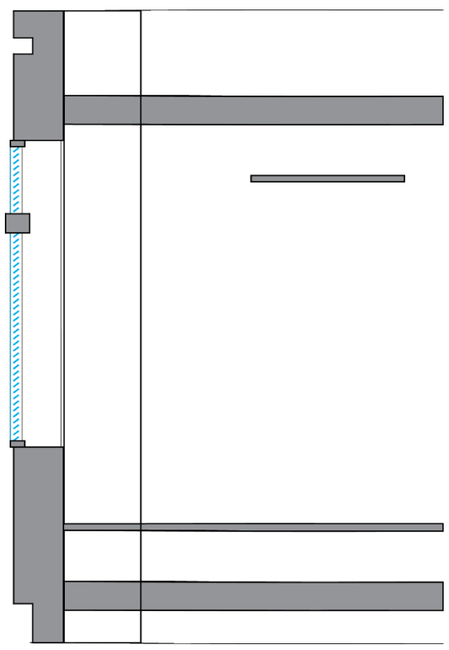
Meaningful Comparisons



A
Overhang with automated interior roller shades

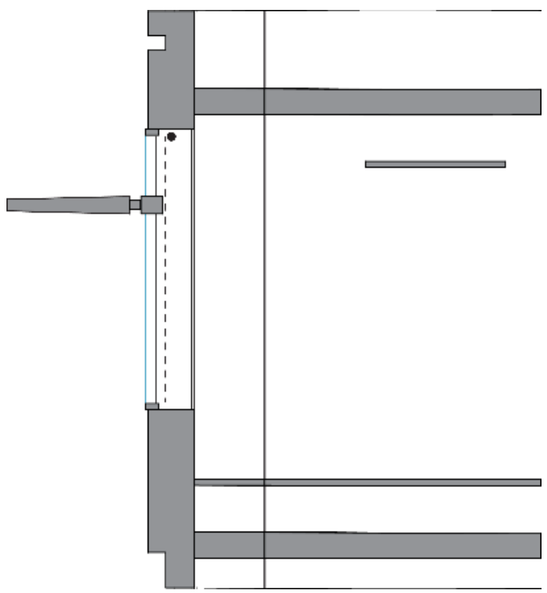


B
Overhang, with interior light shelf, with automated interior roller shades above and below the glazing

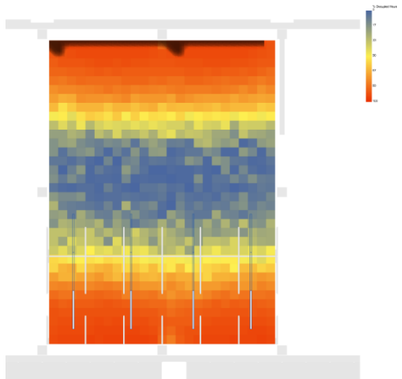


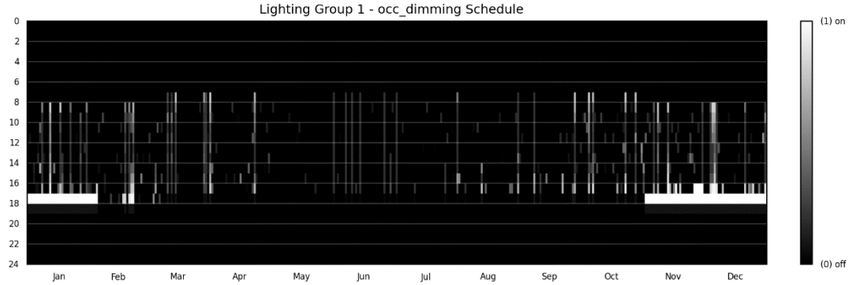
C
Captured sandwich venetian blind glazing assembly with no external overhang or internal lightshelf

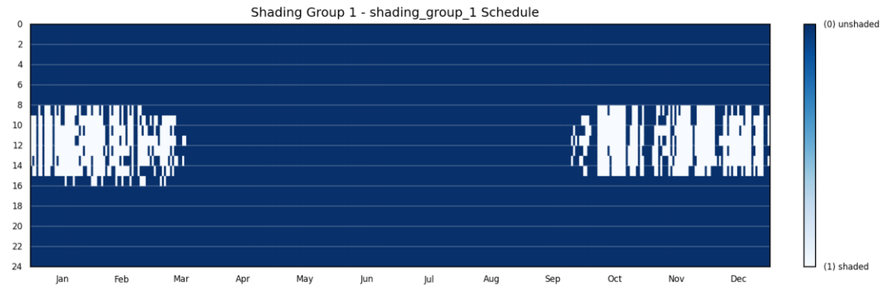
A Overhang



Spatial Daylit Autonomy (300lx 50%):	*55%*
Shades Open:	*78%*
Electric Lighting Use Reduction for daylit zone:	*92.1%*

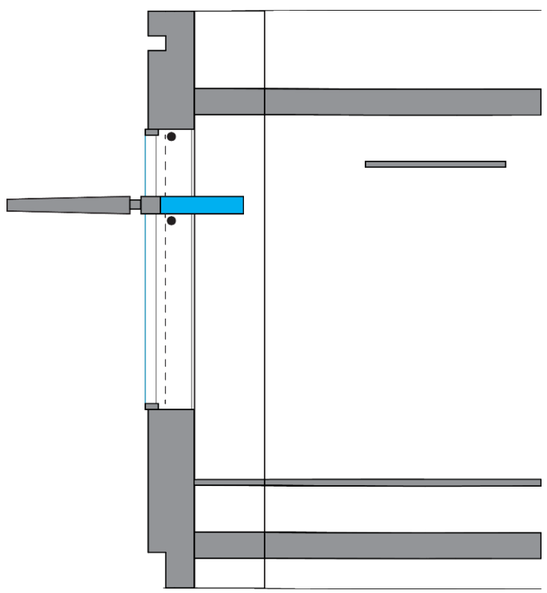




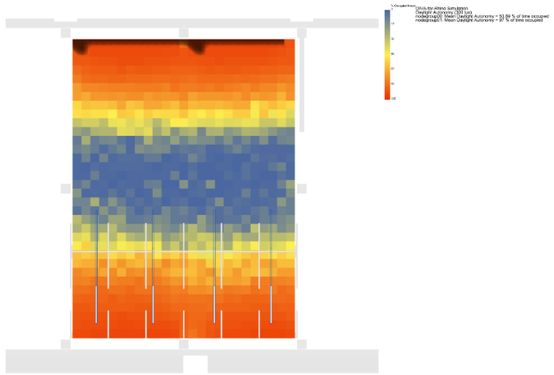


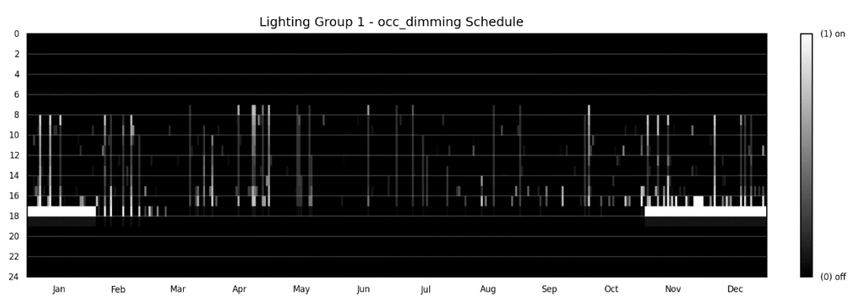
INTEGRAL GROUP

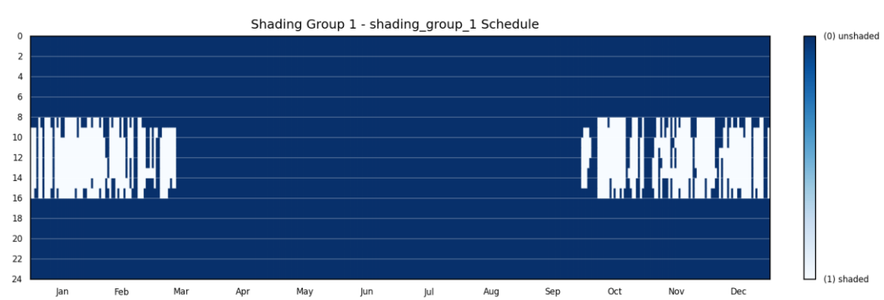
B Overhang with Light Shelf



Spatial Daylit Autonomy (300lx 50%):	*57%*
Shades Open:	*75%*
Electric Lighting Use Reduction for daylit zone:	*92.7%*

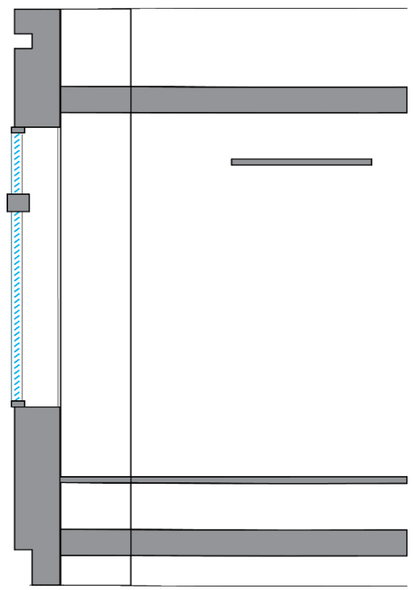




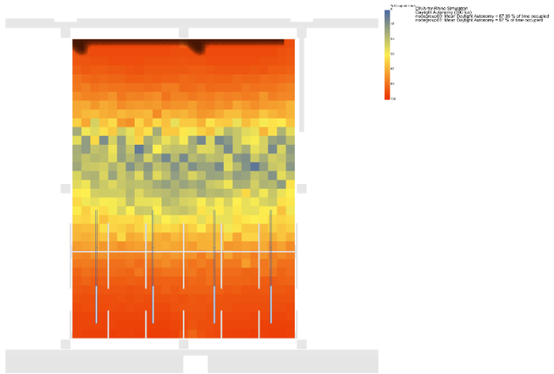


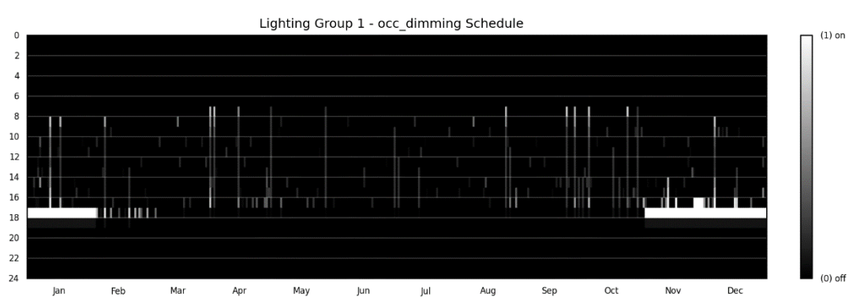
INTEGRAL GROUP

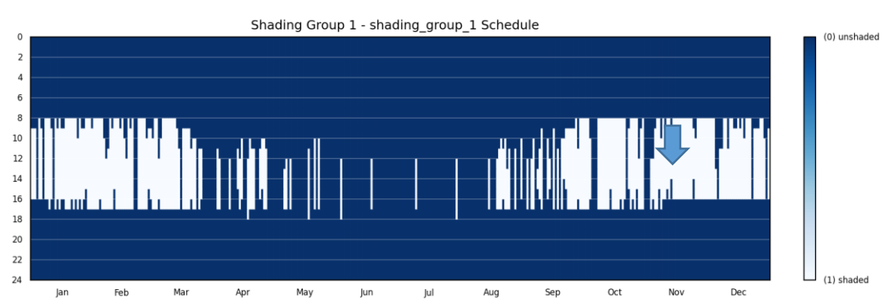
C Venetian Blinds Glazing Unit



Spatial Daylit Autonomy (300lx 50%):	*73%*
Shades Open:	*57%*
Electric Lighting Use Reduction for daylit zone:	*92.7%*

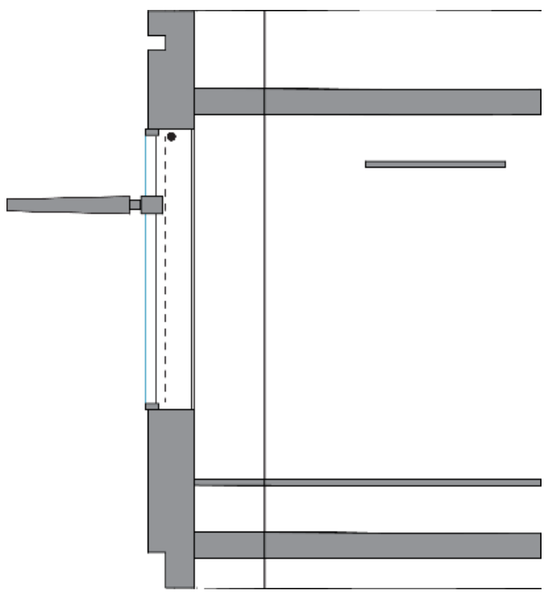




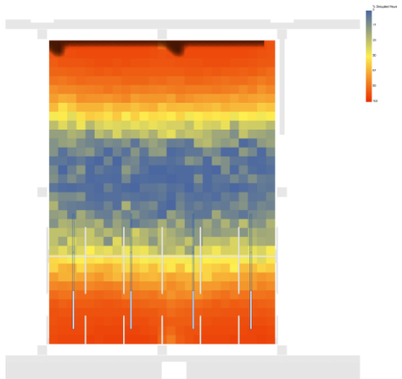


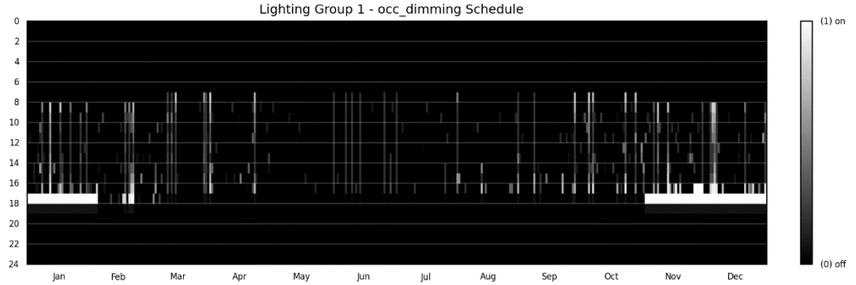
INTEGRAL GROUP

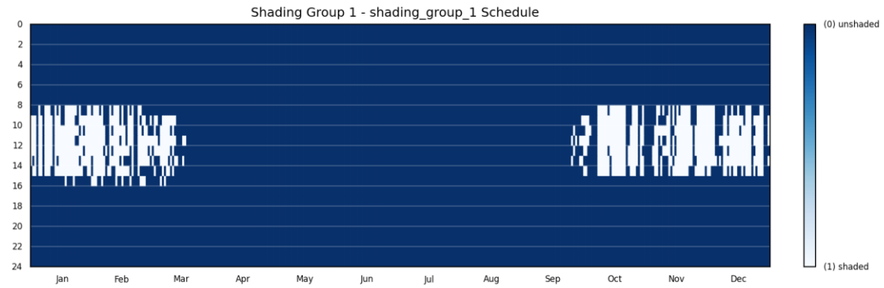
A1 Overhang - Automatic Shades (Glare Control)



Spatial Daylit Autonomy (300lx 50%):	*55%*
Shades Open:	*78%*
Electric Lighting Use Reduction for daylit zone:	*92.1%*

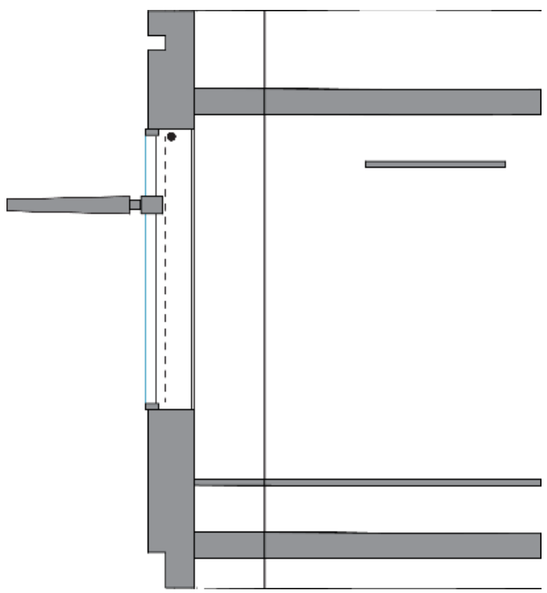




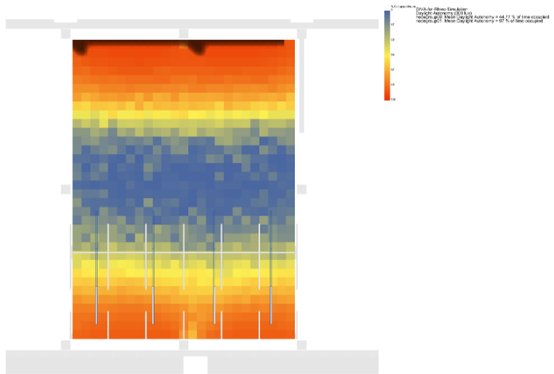


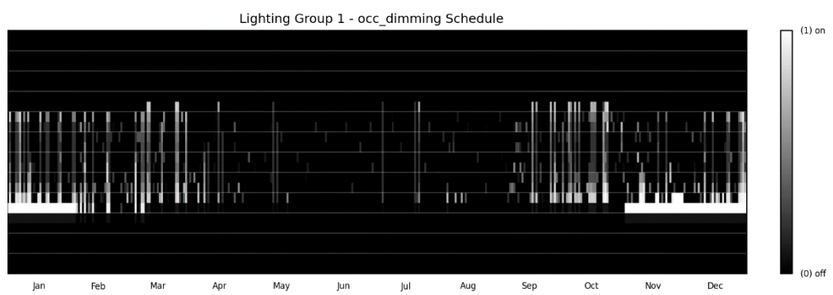
INTEGRAL GROUP

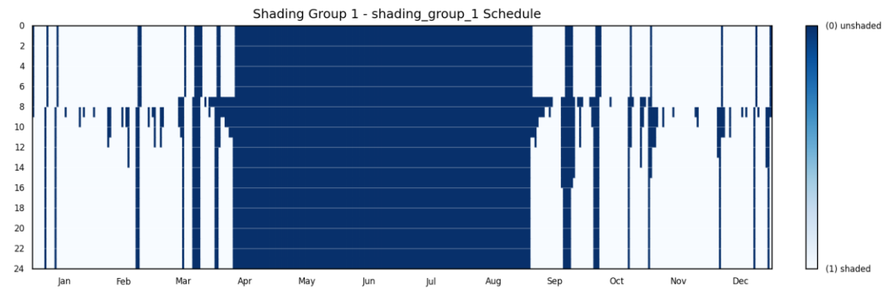
A2 Overhang – Manually Controlled Shades



Spatial Daylit Autonomy (300lx 50%):	*48%*
Shades Open:	*52%*
Electric Lighting Use Reduction for daylit zone:	*88.2%*

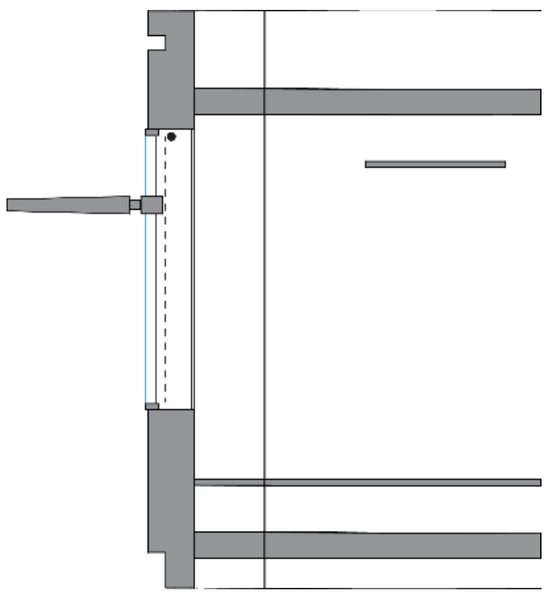




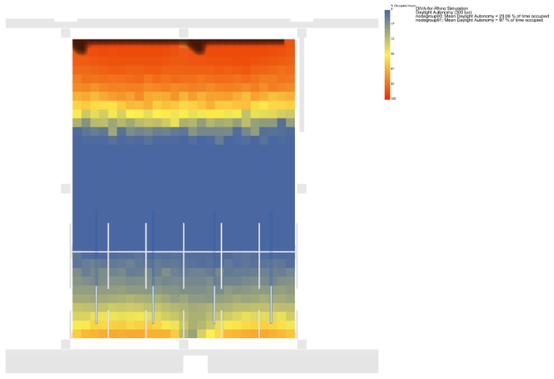


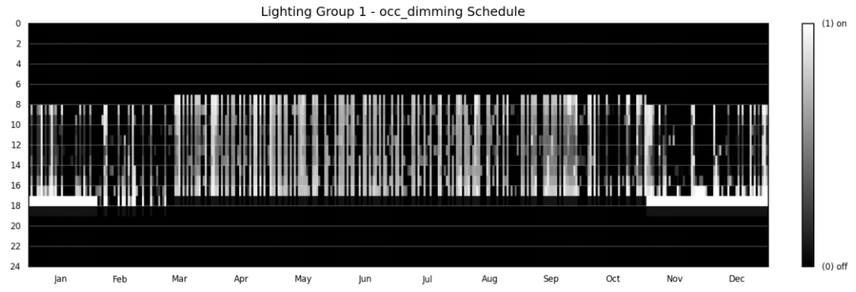
INTEGRAL GROUP

A3 Overhang – Assume shades down always

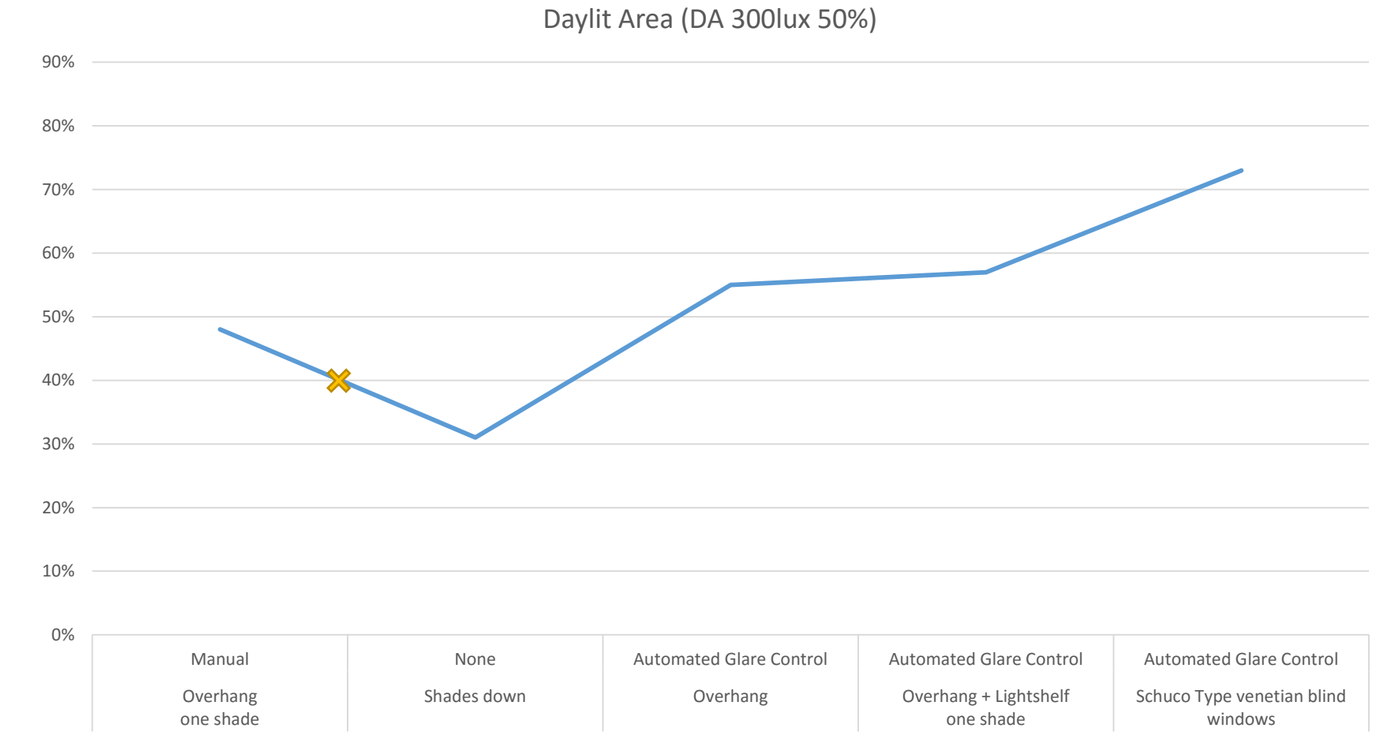


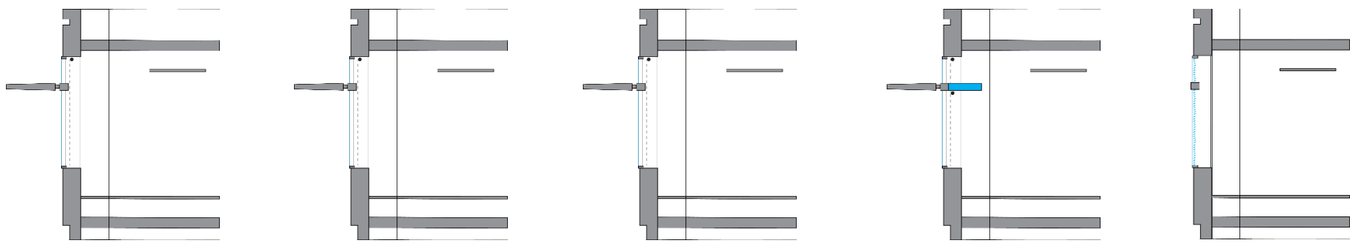
Spatial Daylit Autonomy (300lx 50%):	*31%*
Shades Open:	*0%*
Electric Lighting Use Reduction for daylit zone:	*66.6%*





Comparing Strategies – Daylit Area

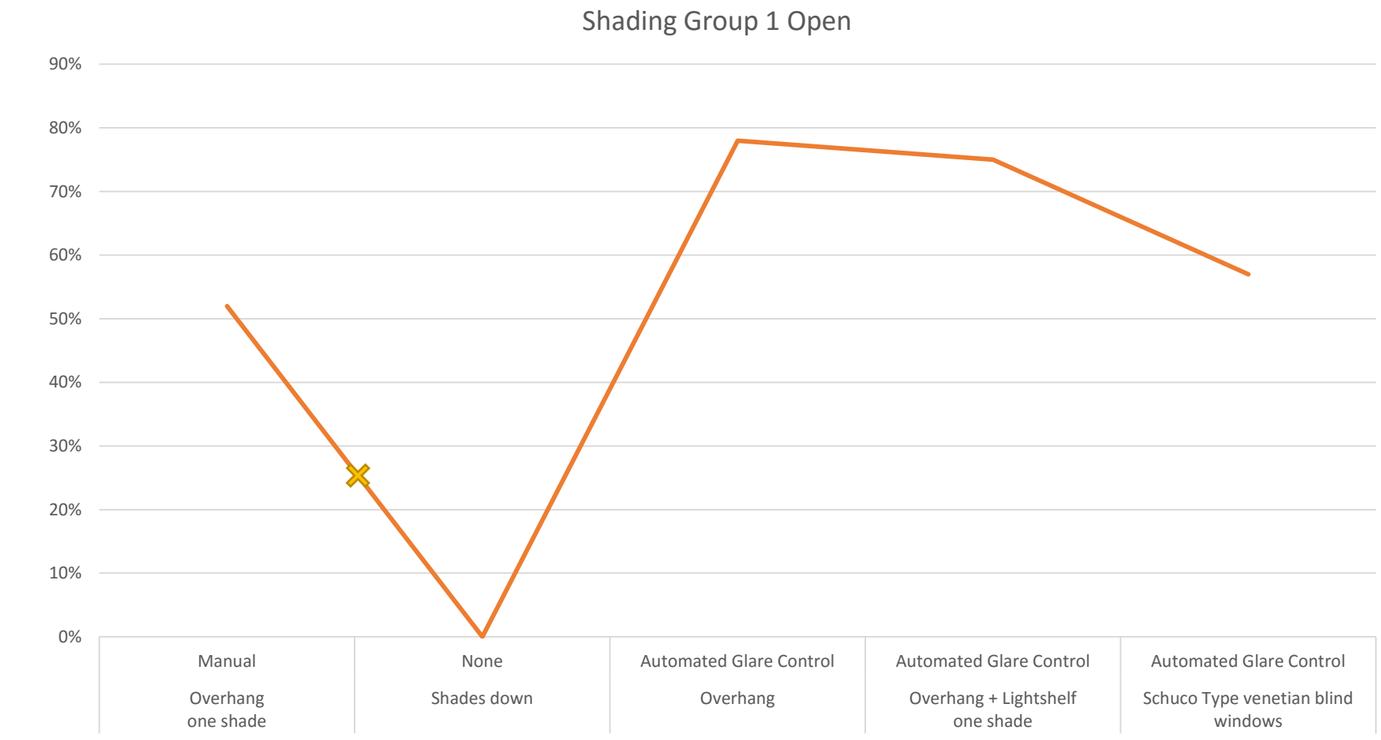


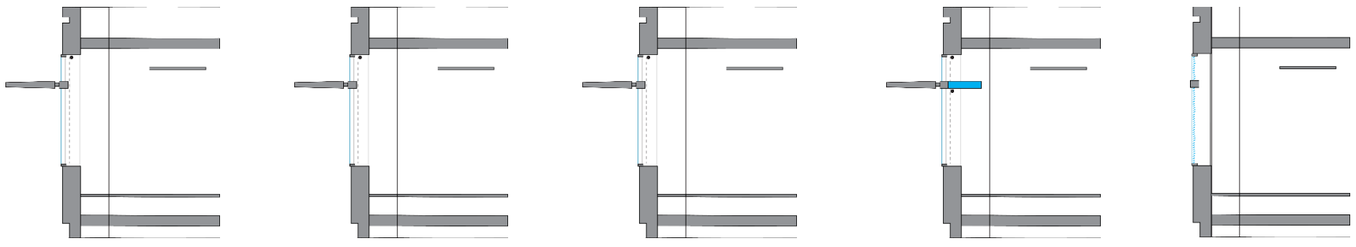


✖ *This marker indicates the likely performance between manual operation in which the shades are faithfully opened by the occupants, and the condition in which the shades are always left down.*

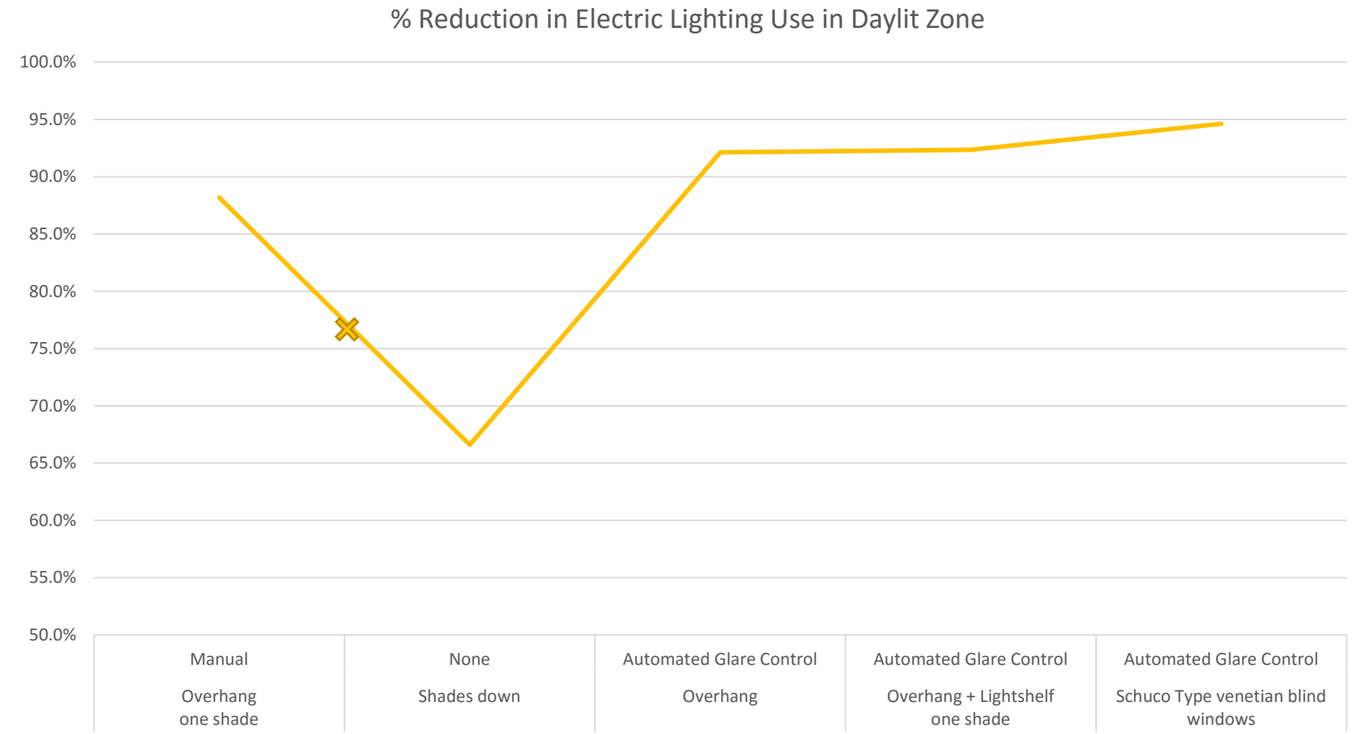
INTEGRAL GROUP

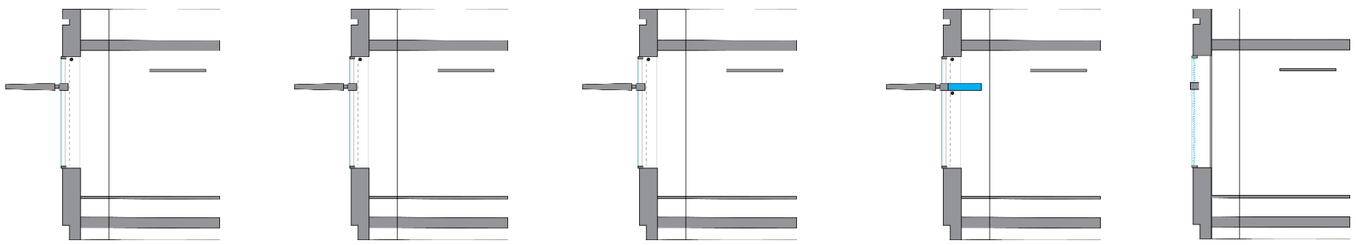
Comparing Strategies – Shading Group Open





Comparing Strategies – Reduction in Electric Lighting Use





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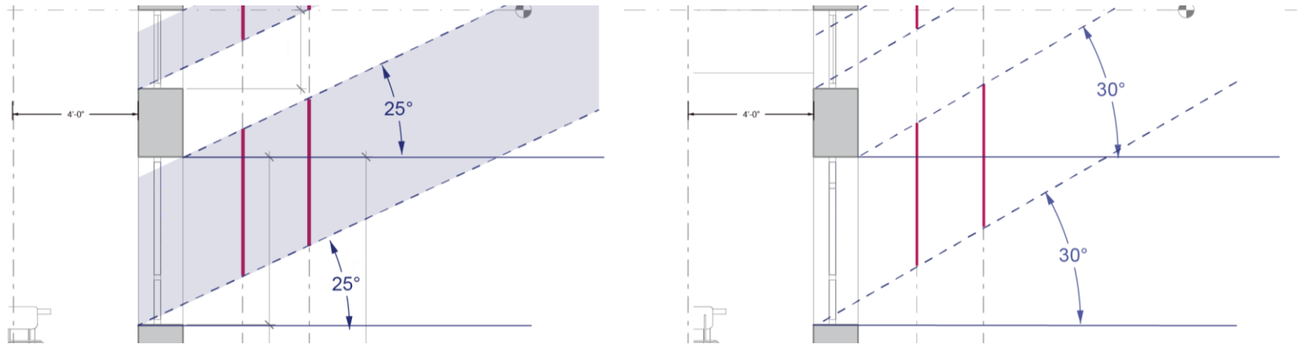
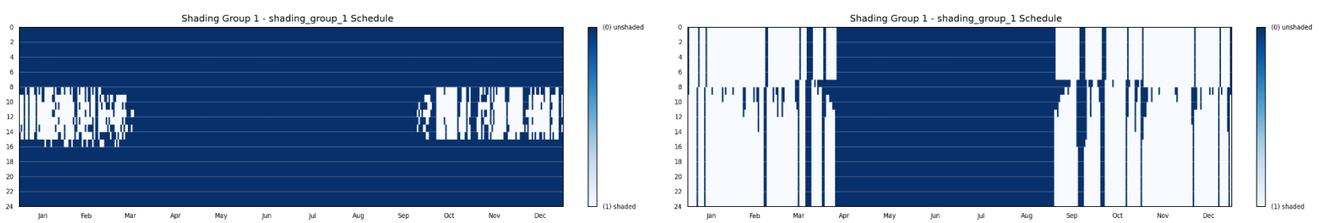
actionable information



dynamic and temporal feedback

meaningful comparisons



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Thank you

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