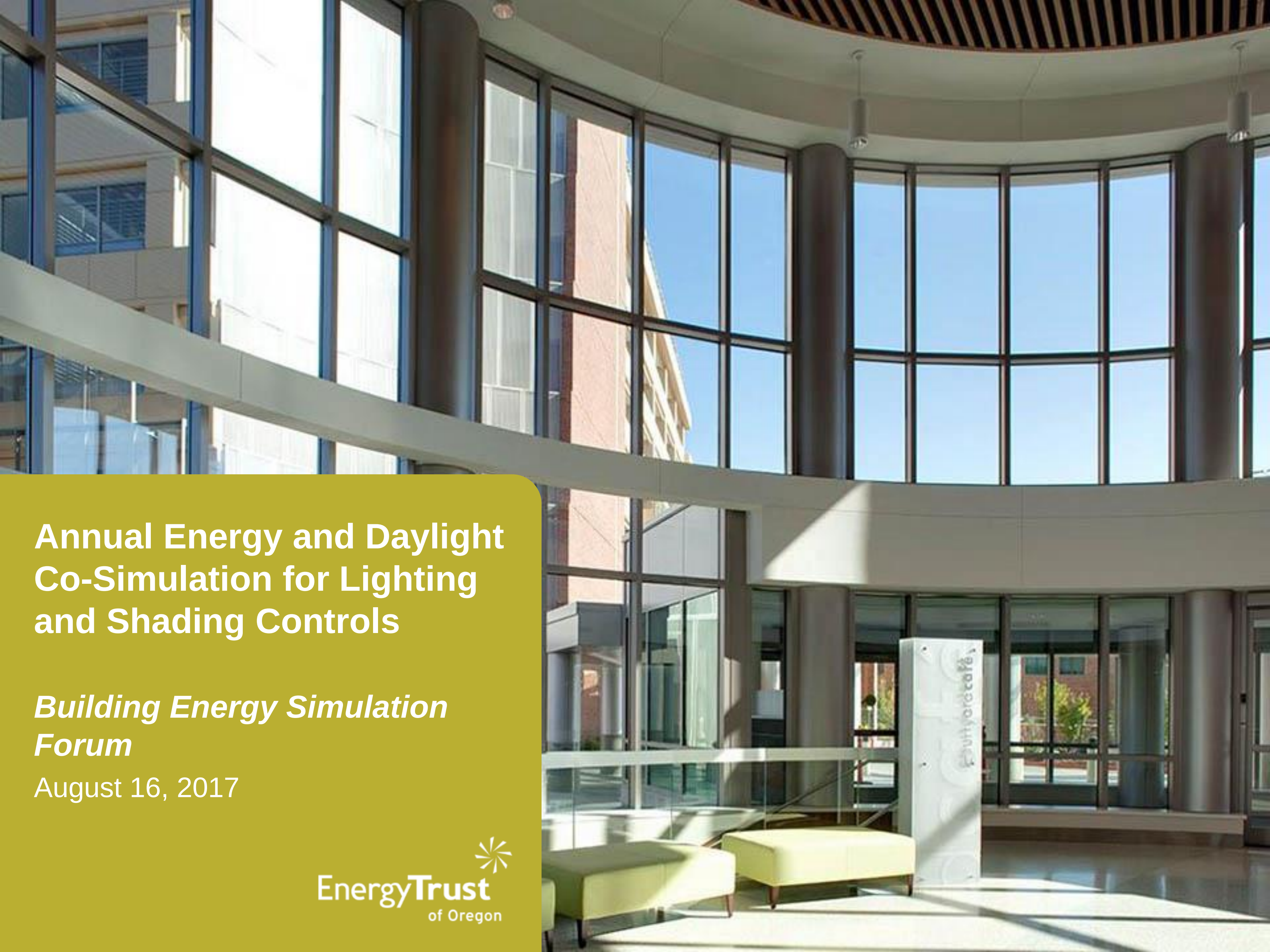


Annual Energy and Daylight Co-Simulation for Lighting and Shading Controls

Building Energy Simulation Forum

August 16, 2017

EnergyTrust of Oregon

Who we are

Energy Trust is an independent nonprofit dedicated to helping 1.5 million utility customers invest in energy efficiency and clean, renewable power.

We provide:

- Information
- Technical services
- Engineering studies
- Cash incentives
- Contractor connections

Energy Trust New Buildings

- New construction
- Major renovation
- Tenant build-out
- Additions or expansions

Energytrust.org/commercial

New Buildings Training & Education

Allies for Efficiency (AFE)

- Case study presentations on high-performance design and construction projects
- Take place 3-5 times per year in Portland + regionally

High Performance Design Trainings

- Advanced training events for designers, architects and/or engineers
- Take place 2 – 3 times per year
- Content is focused on specific techniques or technologies

Building Energy Simulation Forum (BESF)

- Advanced energy modeling presentations
- Topics relevant to energy modelers / analysts, and engineers
- Take place every other month

Upcoming Building Energy Simulation Forum Trainings

BESF usually takes place the third Wednesday of every other month at the Ecotrust Building at noon.

October 18, 2017:

Energy Management Information Systems

Presented by Hannah Kramer,
Lawrence Berkeley National Laboratory

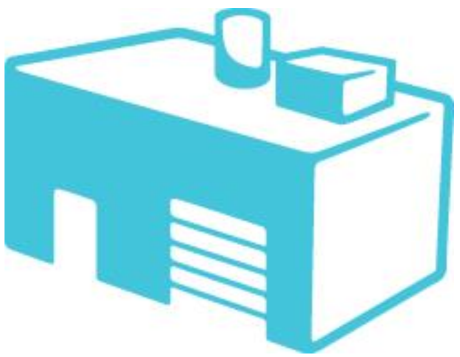
December 13, 2017:

Topic TBD

Upcoming Allies for Efficiency Trainings

September 15, 2017

Chemeketa Community College –
Applied Technology Building
Salem, Oregon



September 29, 2017

Bellevue Crossing – Bend Energy Week
Bend, Oregon

Training & Education Webpage

energytrust.org/commercial/commercial-training-events/

Boost your knowledge with Energy Trust's continuing education opportunities and special training events. Trainings include real-world examples, case studies, and detailed technical information presented by experts from the fields of architecture, engineering, construction and development, as well as specialists in a variety of building types and market sectors. Attendees may be eligible for continuing education units, CEUs.

Find Upcoming Trainings and Events

Questions?

Have questions about upcoming training and education opportunities *or* about becoming an Energy Trust New Buildings Ally?

Contact Kirsten.Vogel@clearesult.com

Thank You

Kirsten Vogel
Market Outreach Specialist
Kirsten.Vogel@clearesult.com

EnergyTrust
of Oregon

Building Energy Simulation Forum - Ecotrust Portland

Annual Energy and Daylight Co-Simulation for More Accurate Representation of Electric Lighting and Shading Controls in Buildings

Kevin Van Den Wymelenberg,
Alen Mahic,
Amir Nezamdoost.

University of Oregon, Energy Studies in Buildings Laboratory, Eugene & Portland, OR

Photo Credit: Craig F. Johnson PE, UCSD FD&C

Environmental Services Building, WA
The Miller Hull Partnership

E

W

E

W

IES LM-83-12 Approved Method:

Spatial Daylight Autonomy (sDA)

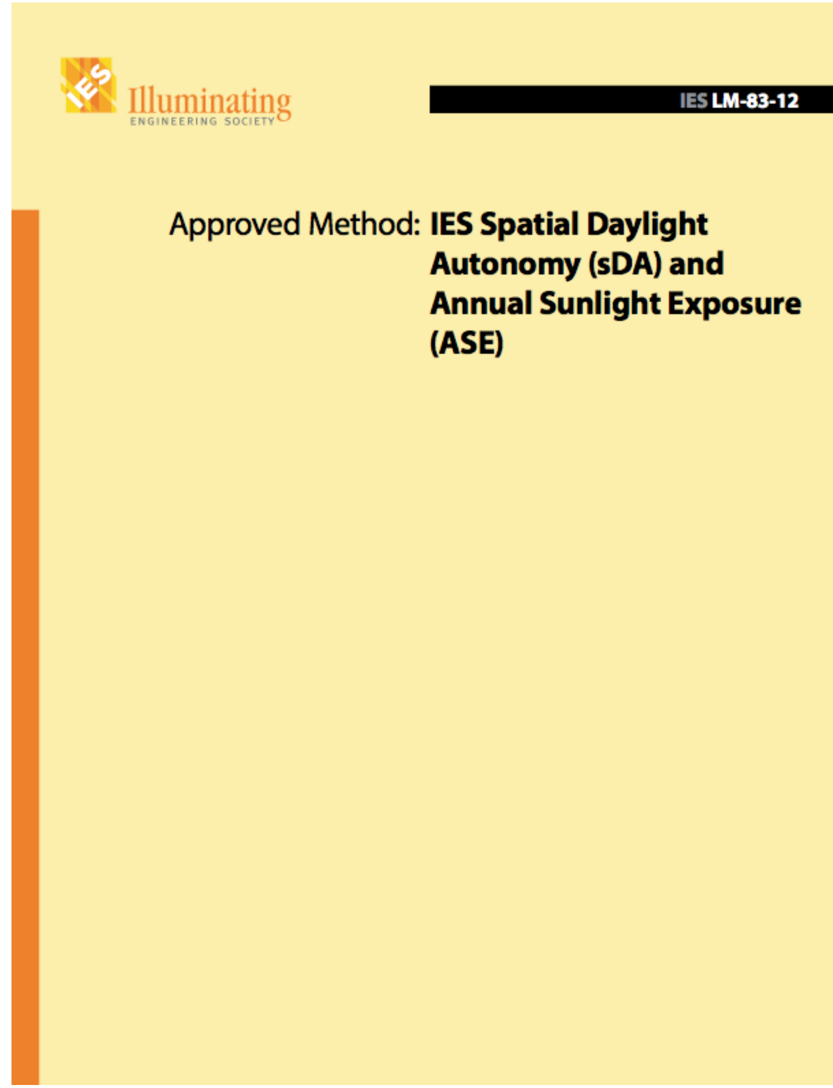
Is there enough daylight in the space? (measured using annual hourly illuminance):

- During analysis hours (8am-6pm)
- What % of floor area exceeds 300 lux for at least 50% of analysis hours?
- Exceed 55% of the floor area for “nominally acceptable daylight”
- Exceed 75% of the floor area for “preferred daylight”

Annual Sunlight Exposure (ASE)

Is there excessive daylight in the space (measured using annual hourly illuminance):

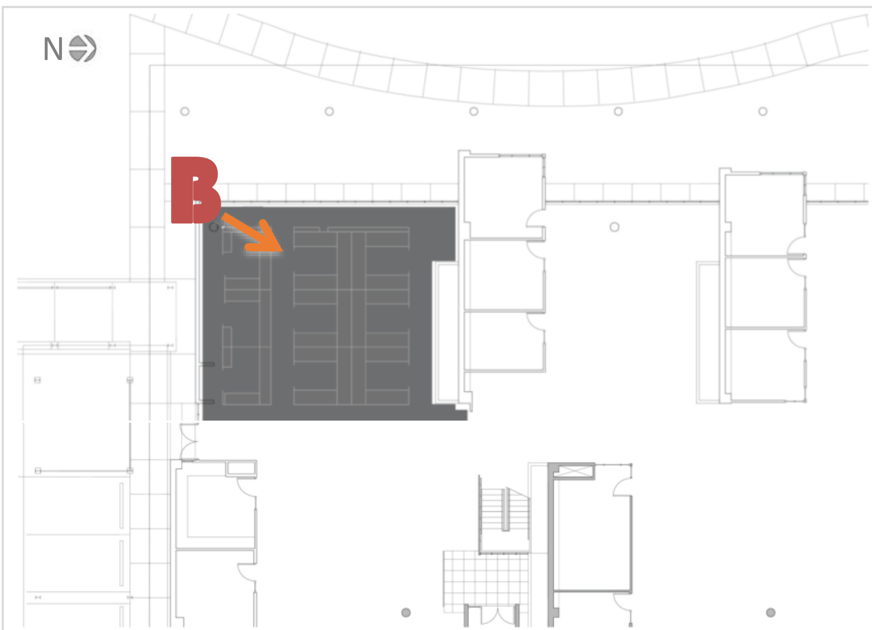
- During analysis hours (8am-6pm)
- What % of the floor area exceeds 1000 lux “computational direct sunlight” (sun spots) for more than 250 annual analysis hours?
- Below 10% of the floor area for less discomfort, lower is better
- Exceeding 20% of the floor area suggests need for automated blinds or additional fixed shading strategies


IES Illuminating ENGINEERING SOCIETY

IES LM-83-12

Approved Method: **IES Spatial Daylight Autonomy (sDA) and Annual Sunlight Exposure (ASE)**

A



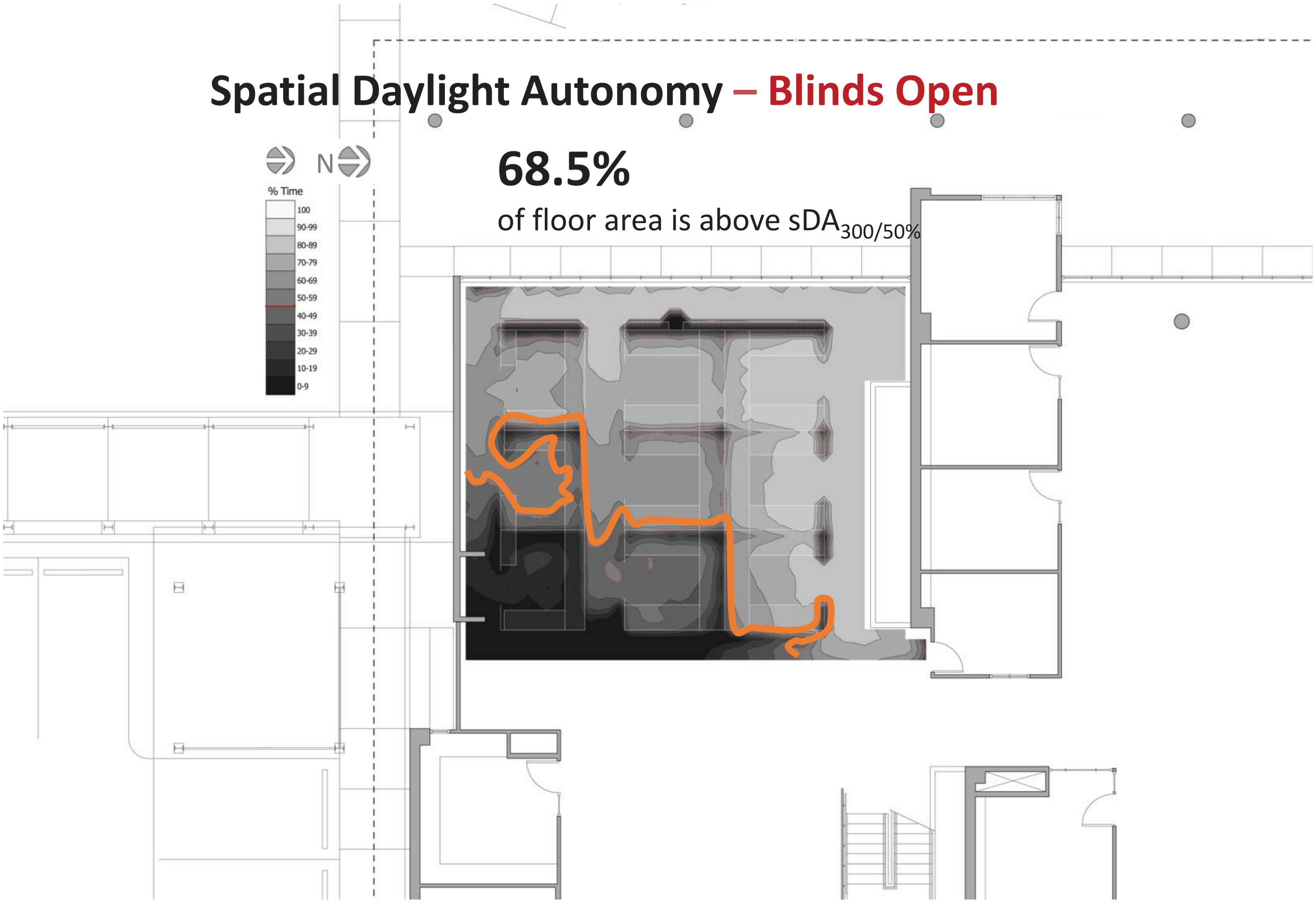
A

B

Spatial Daylight Autonomy – Blinds Open

68.5%

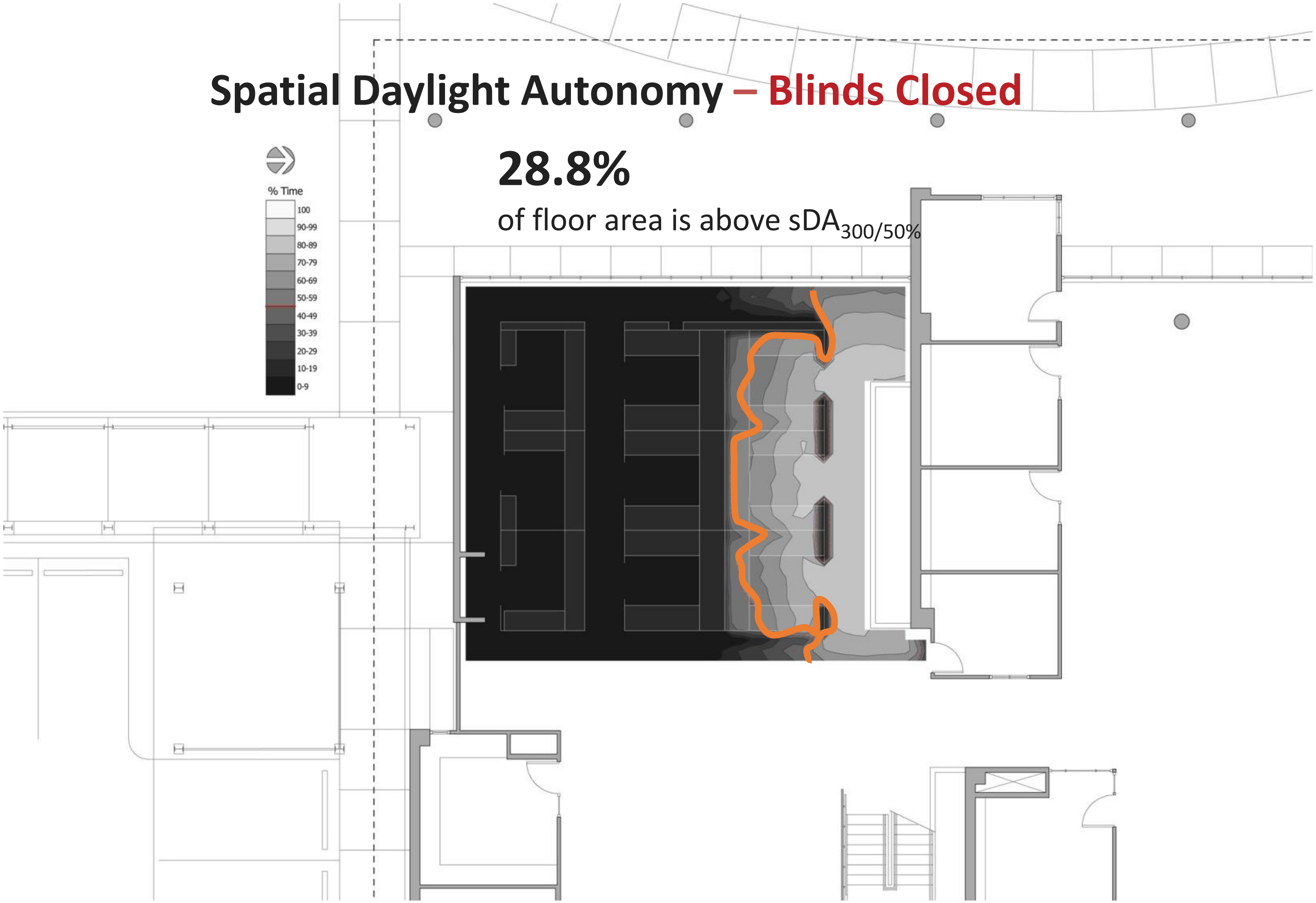
of floor area is above $sDA_{300/50\%}$



Spatial Daylight Autonomy – Blinds Closed

28.8%

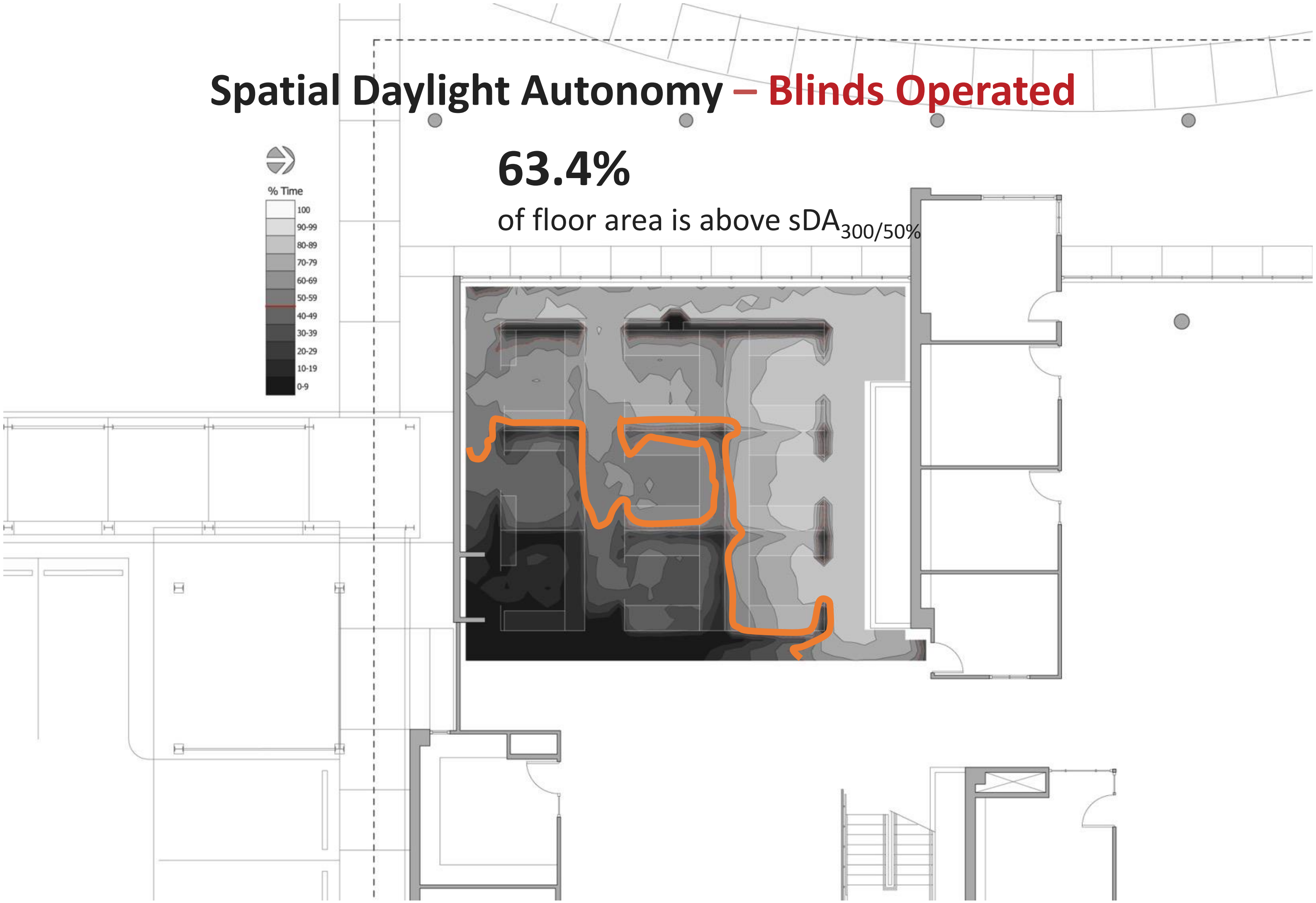
of floor area is above $sDA_{300/50\%}$



Spatial Daylight Autonomy – Blinds Operated

63.4%

of floor area is above $sDA_{300/50\%}$



Recommended Performance Criteria
75% of floor area - Preferred
55% of floor area- Nominally Accepted

Ash Creek Elementary
Monmouth, OR

BORA Architects

Photo: Nick Hubof
Rendering: Nick Hubof

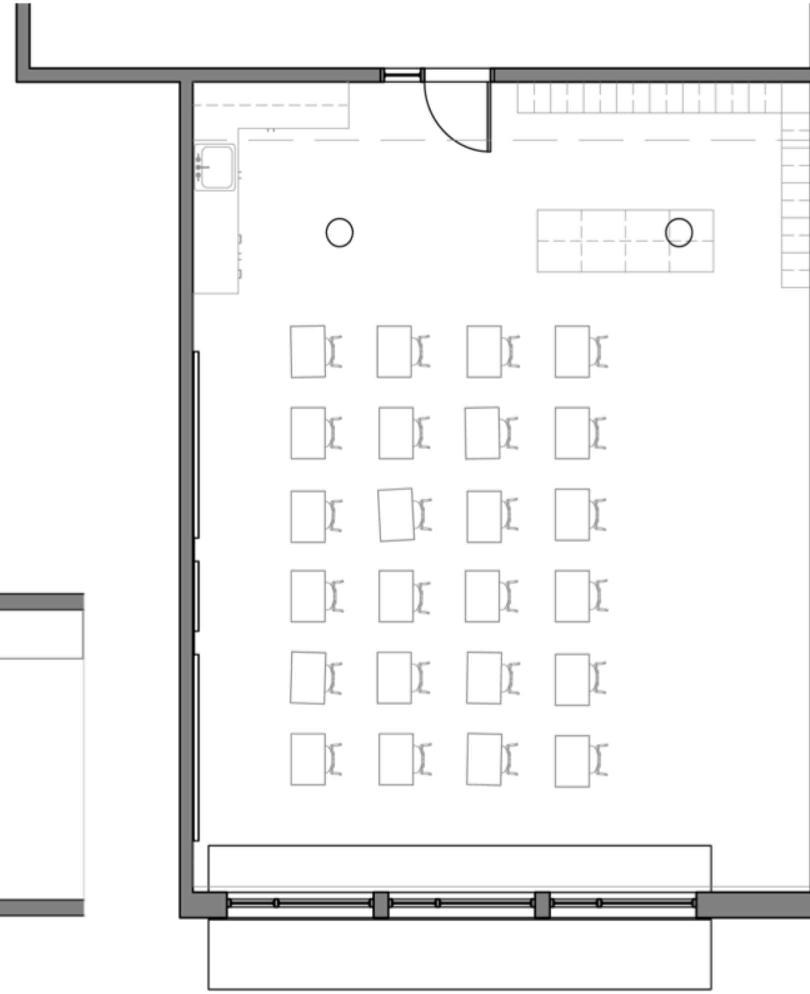
Annual metrics for a classroom model

South face.

- Run with varied number of window groups.

North re-light.

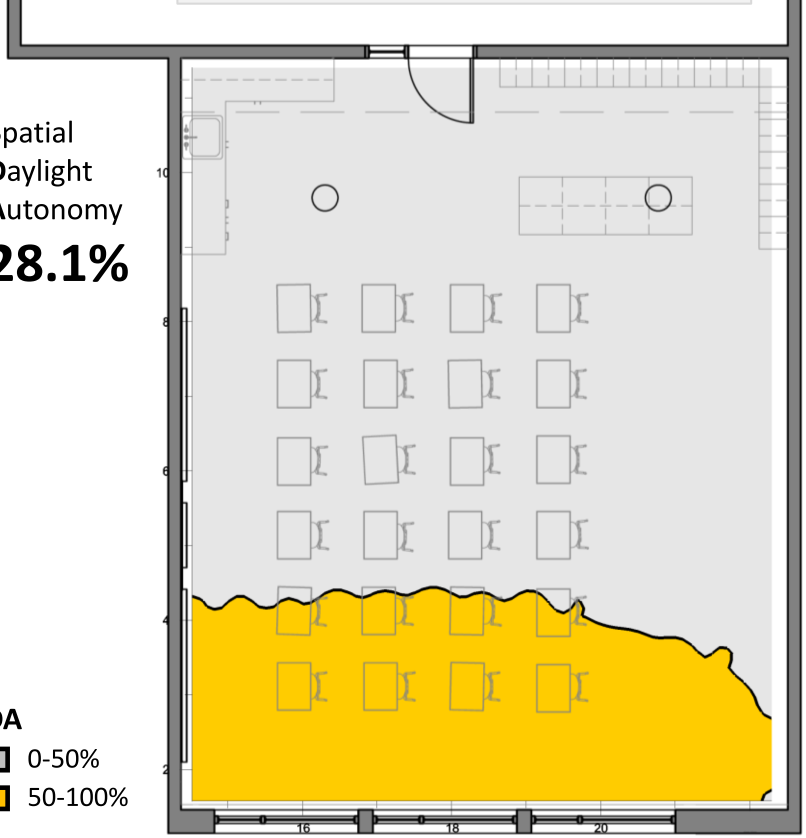
- Run as a single north-facing window group.



Recommended Performance Criteria
75% of floor area - Preferred
55% of floor area- Nominally Accepted

Spatial Daylight Autonomy

28.1%



DA
- 0-50%
- 50-100%

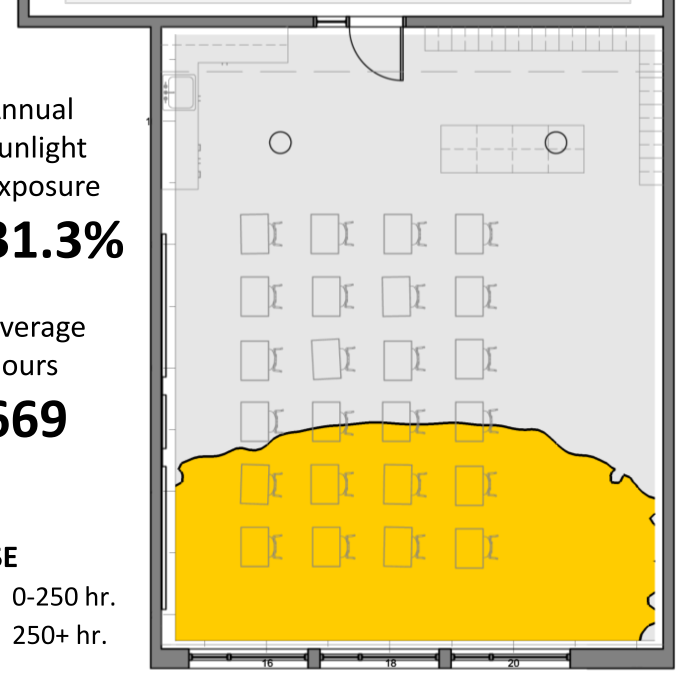
Recommended Performance Criteria
<10% of floor area - Nominally Accepted
>20% of floor area – Add Shading /Automation

Annual Sunlight Exposure

31.3%

Average Hours

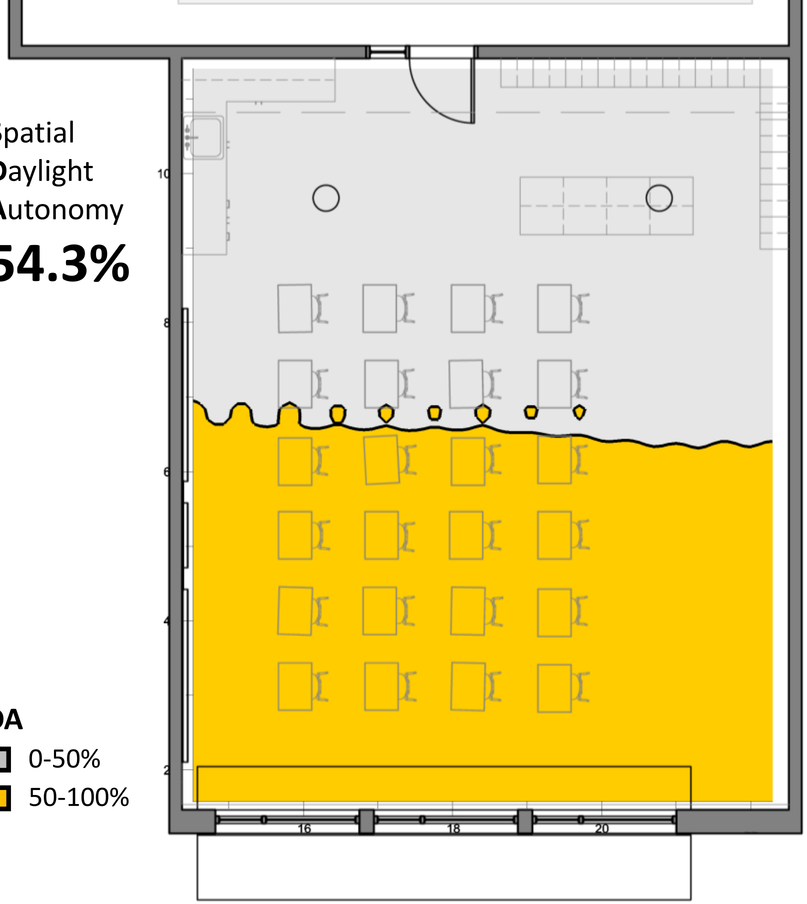
669



ASE
- 0-250 hr.
- 250+ hr.

Recommended Performance Criteria
75% of floor area - Preferred
55% of floor area- Nominally Accepted

Spatial
Daylight
Autonomy
54.3%

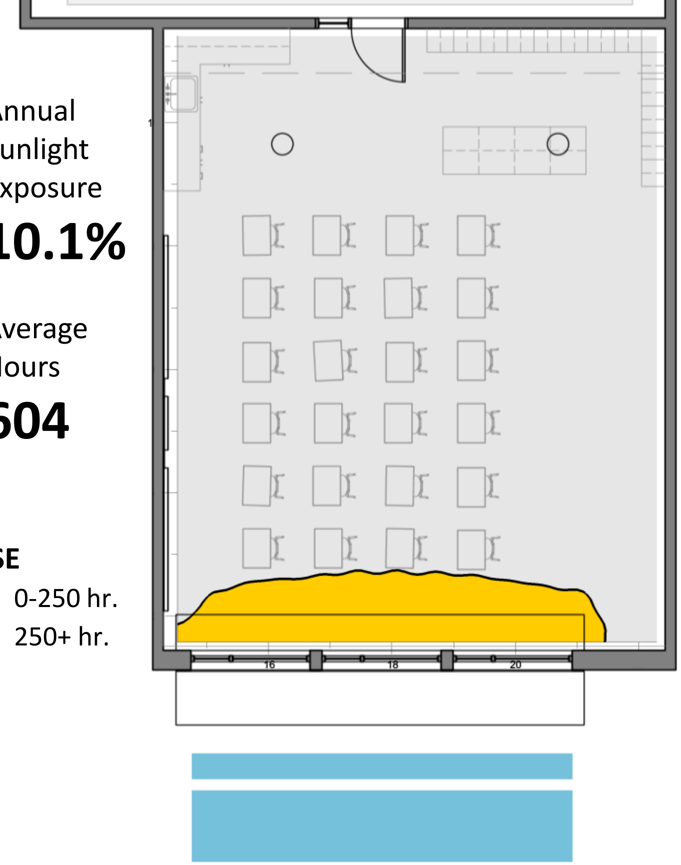


DA
- 0-50%
- 50-100%

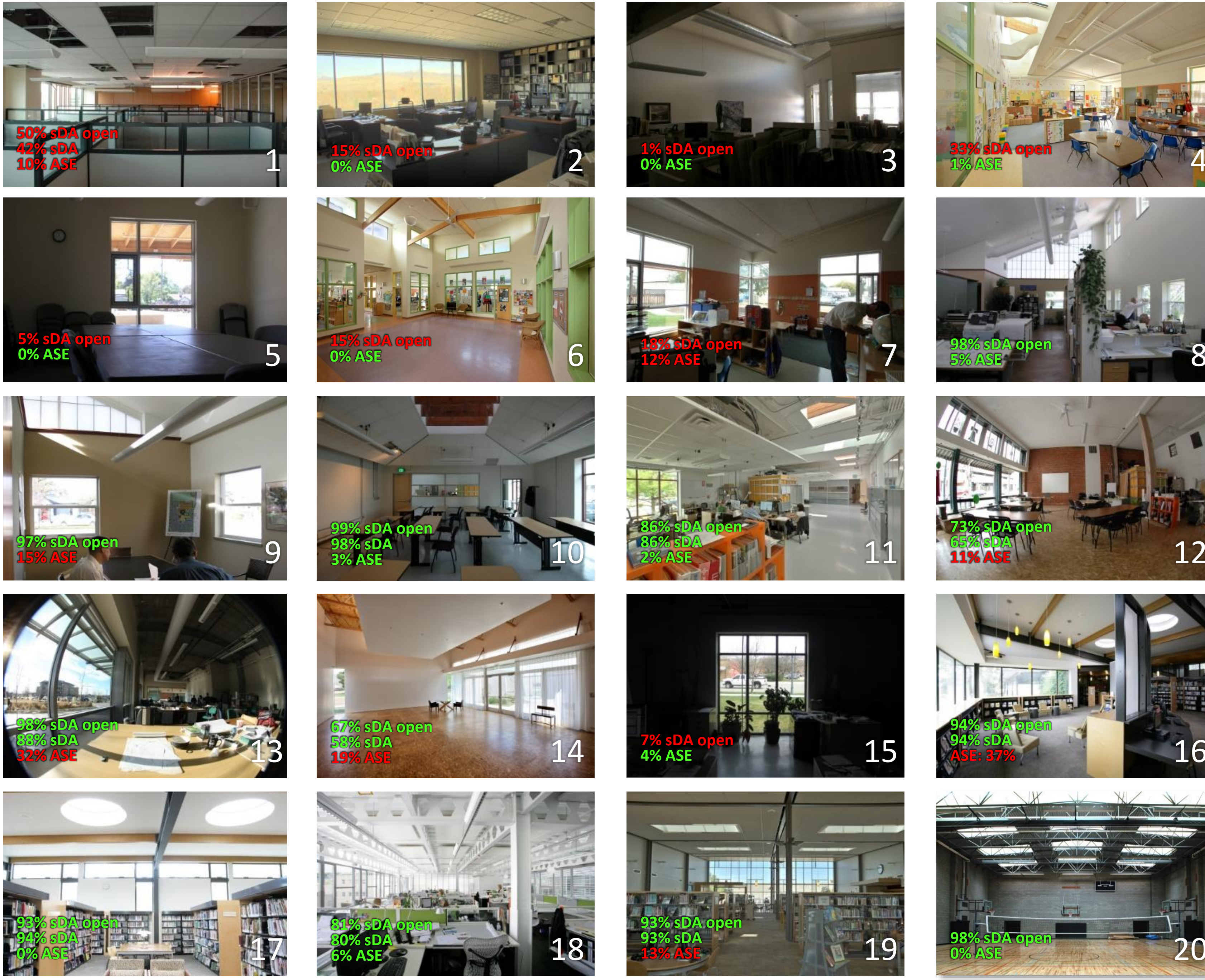
Recommended Performance Criteria
<10% of floor area - Nominally Accepted
>20% of floor area – Add Shading /Automation

Annual
Sunlight
Exposure
10.1%

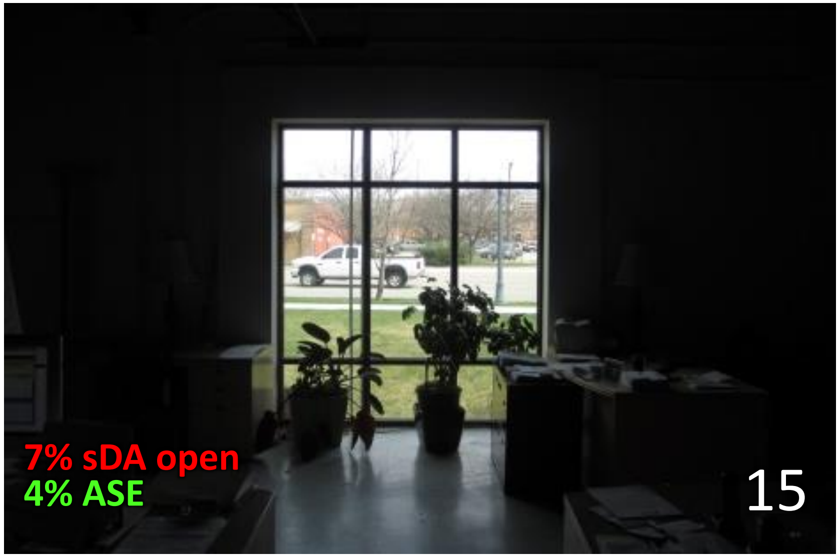
Average
Hours
604



ASE
- 0-250 hr.
- 250+ hr.

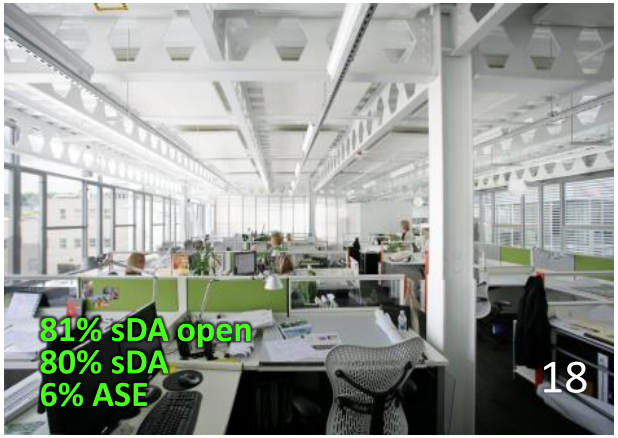

50% sDA open
42% sDA
10% ASE
1
15% sDA open
0% ASE
2
1% sDA open
0% ASE
3
33% sDA open
1% ASE
4
5% sDA open
0% ASE
5
15% sDA open
0% ASE
6
18% sDA open
12% ASE
7
98% sDA open
5% ASE
8
97% sDA open
15% ASE
9
99% sDA open
98% sDA
3% ASE
10
86% sDA open
86% sDA
2% ASE
11
73% sDA open
65% sDA
11% ASE
12
98% sDA open
88% sDA
32% ASE
13
67% sDA open
58% sDA
19% ASE
14
7% sDA open
4% ASE
15
94% sDA open
94% sDA
ASE: 37%
16
93% sDA open
94% sDA
0% ASE
17
81% sDA open
80% sDA
6% ASE
18
93% sDA open
93% sDA
13% ASE
19
98% sDA open
0% ASE
20

4 of 20 failed sDA & passed ASE

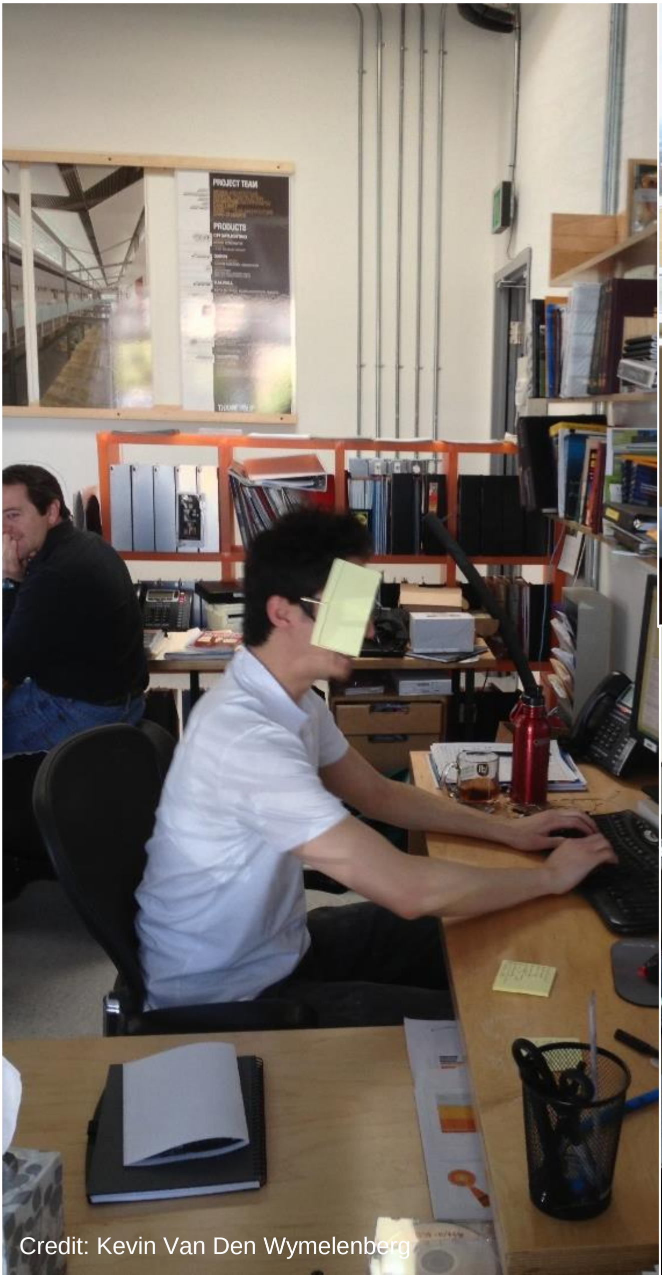


6 of 20 passed sDA & failed ASE

6 of 20 passed



SOLUTIONS?



Credit: Kevin Van Den Wymelenberg

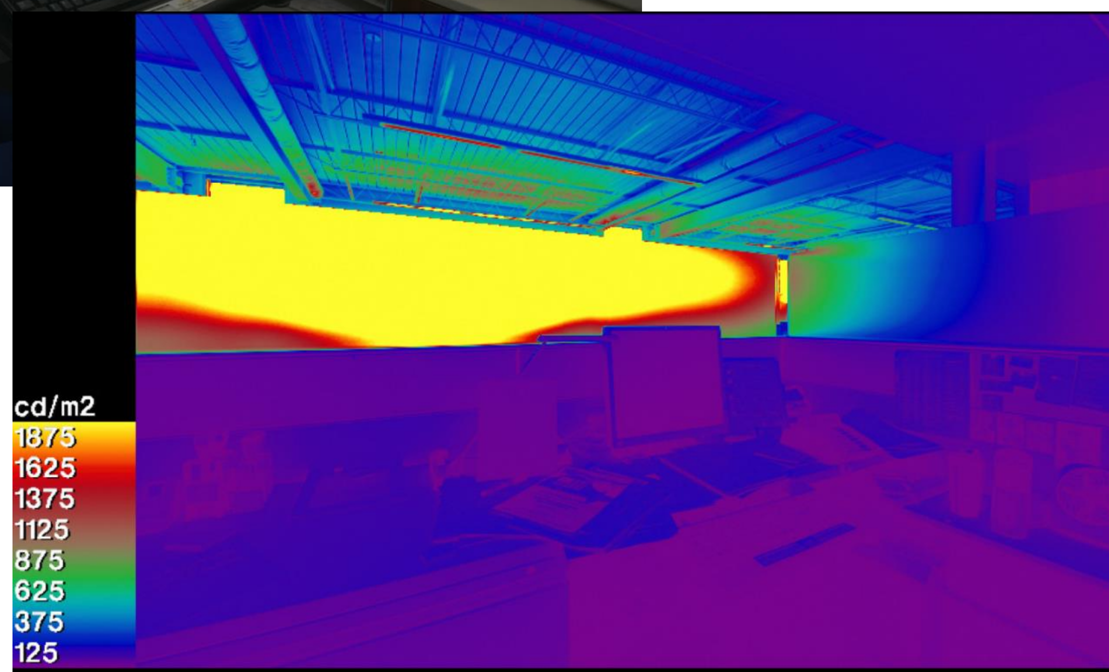
- Visual comfort is highly subjective
- Occupant behavior is unpredictable
- Undesirable to block natural light and views

→ Few adequate solutions!

Source: paradoxoff.com

Source: Adweek.com

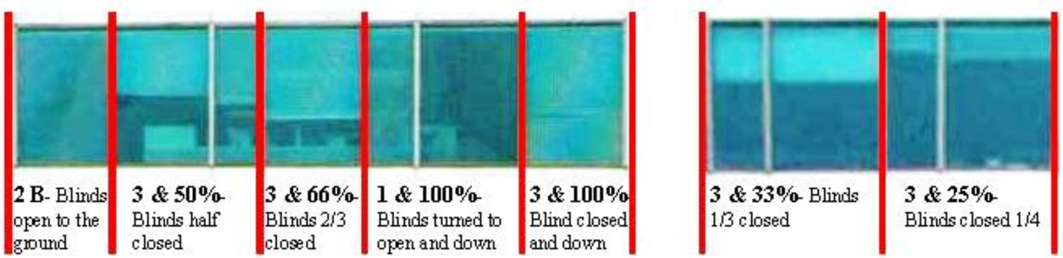
Location_19, 12:00



Human behavior

Human behavior

Six commercial case study buildings in Boise, Idaho

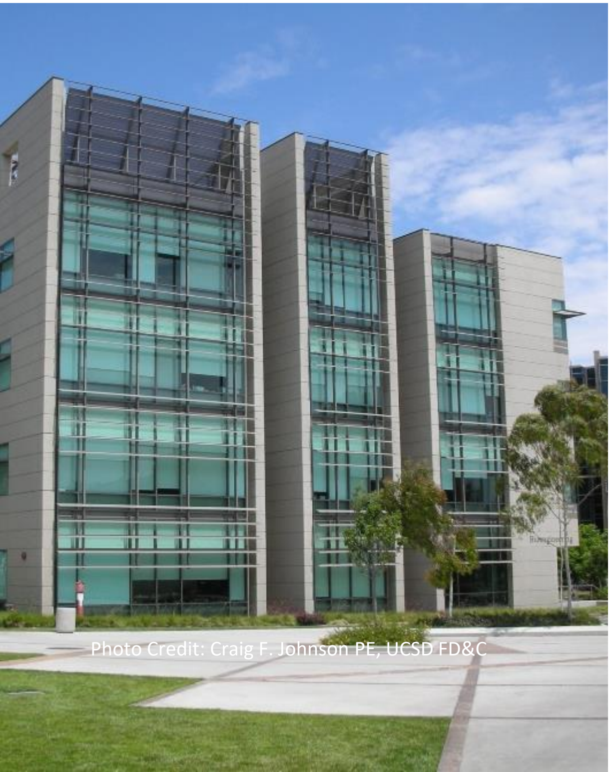


92,480

total blind position recordings



Manual blinds are quite common in spaces designed for daylighting





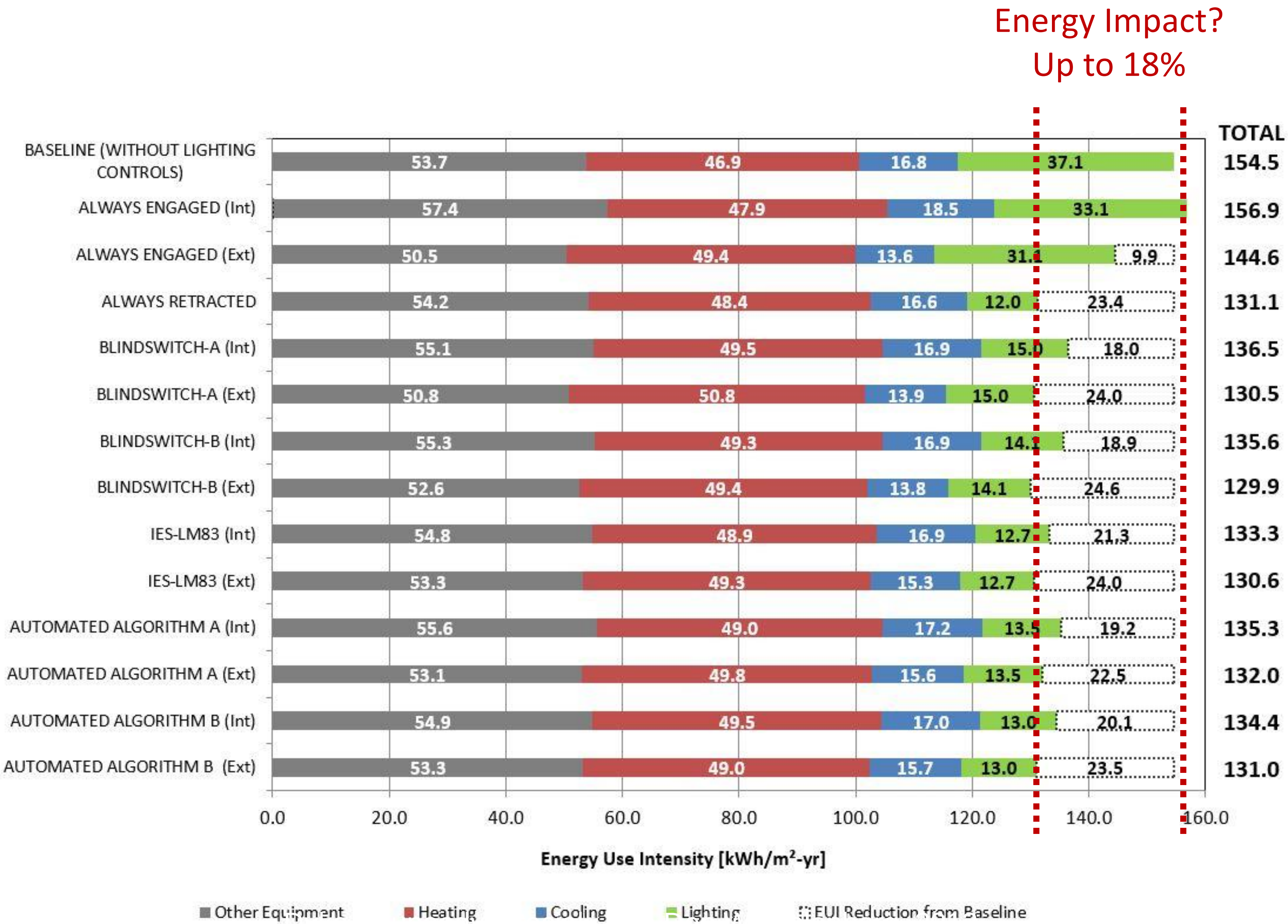

PARKING ONLY

PURPOSE / PROBLEM STATEMENT

Design Intent

Blinds open
Lights dim/off

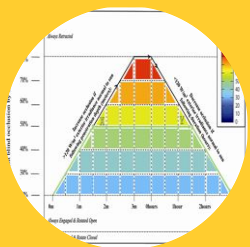
PURPOSE / PROBLEM STATEMENT



Energy Impact?
Up to 18%
TOTAL
BASELINE (WITHOUT LIGHTING CONTROLS) 53.7 46.9 16.8 37.1 154.5
ALWAYS ENGAGED (Int) 57.4 47.9 18.5 33.1 156.9
ALWAYS ENGAGED (Ext) 50.5 49.4 13.6 31.1 9.9 144.6
ALWAYS RETRACTED 54.2 48.4 16.6 12.0 23.4 131.1
BLINDSWITCH-A (Int) 55.1 49.5 16.9 15.0 18.0 136.5
BLINDSWITCH-A (Ext) 50.8 50.8 13.9 15.0 24.0 130.5
BLINDSWITCH-B (Int) 55.3 49.3 16.9 14.1 18.9 135.6
BLINDSWITCH-B (Ext) 52.6 49.4 13.8 14.1 24.6 129.9
IES-LM83 (Int) 54.8 48.9 16.9 12.7 21.3 133.3
IES-LM83 (Ext) 53.3 49.3 15.3 12.7 24.0 130.6
AUTOMATED ALGORITHM A (Int) 55.6 49.0 17.2 13.5 19.2 135.3
AUTOMATED ALGORITHM A (Ext) 53.1 49.8 15.6 13.5 22.5 132.0
AUTOMATED ALGORITHM B (Int) 54.9 49.5 17.0 13.0 20.1 134.4
AUTOMATED ALGORITHM B (Ext) 53.3 49.0 15.7 13.0 23.5 131.0
0.0 20.0 40.0 60.0 80.0 100.0 120.0 140.0 160.0
Energy Use Intensity [kWh/m²-yr]
Other Equipment
Heating
Cooling
Lighting
EUI Reduction from Baseline

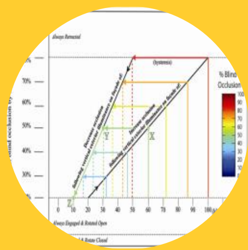
Manual Blind Control Algorithms

Therefore, we need to simulate blinds in our models.
HOW?



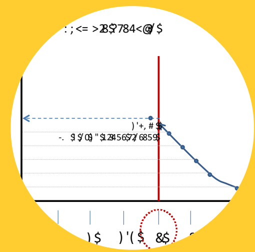
BLINDSWITCH - 2012 A

- Change the occlusion according to the penetration depth and irradiance > 120 W/m^2 exterior.



BLINDSWITCH - 2012 B

- Change the occlusion according to the change of vertical exterior illuminance on façade.

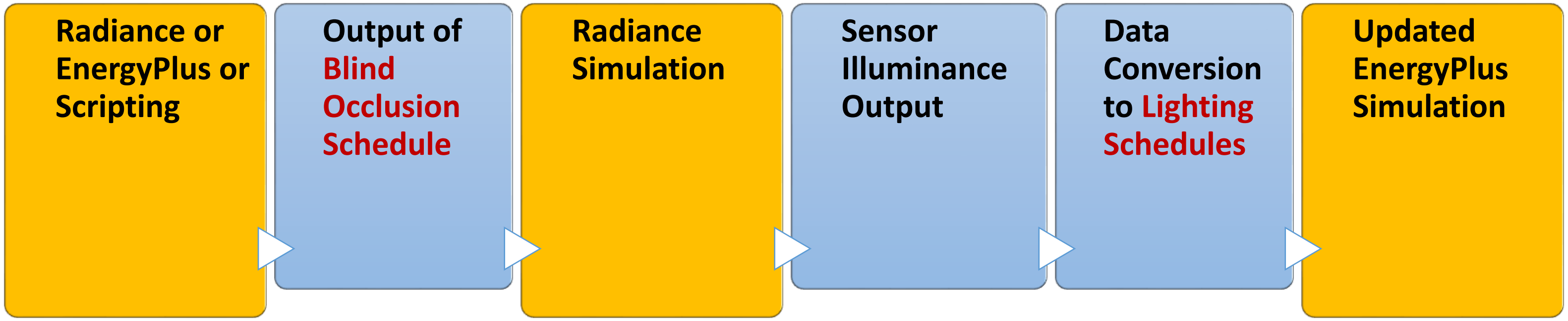


LM - 83

- Close the blinds whenever more than 2% of the sensors get 1,000 lux or more of direct beam sunlight with zero bounce.

WORKFLOW?

Each algorithm for manual or automated blinds/shades requires unique simulation pathway to conduct an energy and daylighting study. However, in all cases, a co-simulation between EnergyPlus and Radiance is required.



Blind Occlusion Schedule

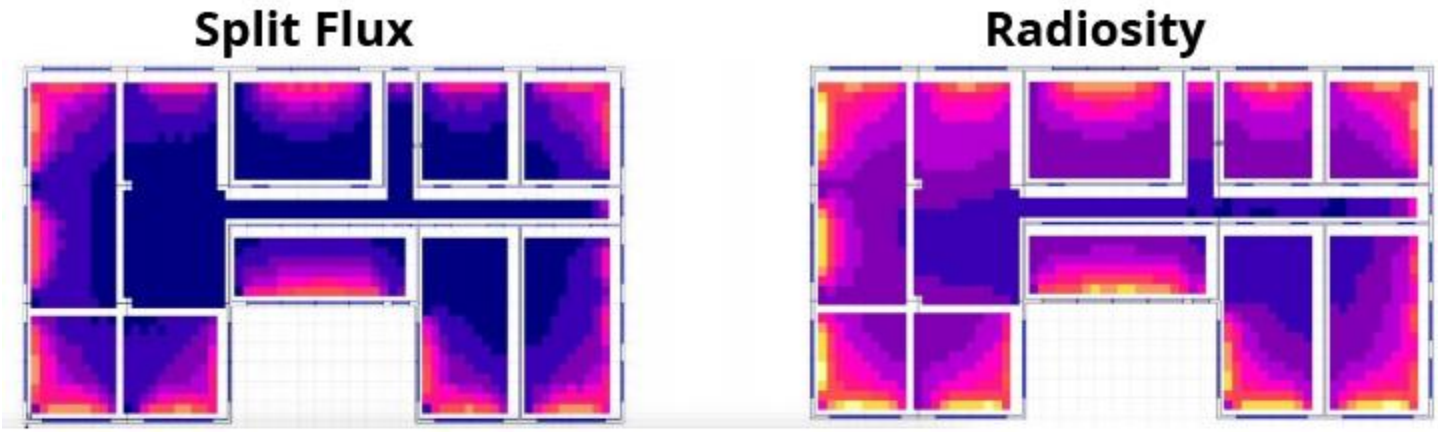
- Manual Calculation/Scripting
- EnergyPlus (Energy Management System)
- Radiance

Lighting Schedule

- **EnergyPlus**
- **Radiance**

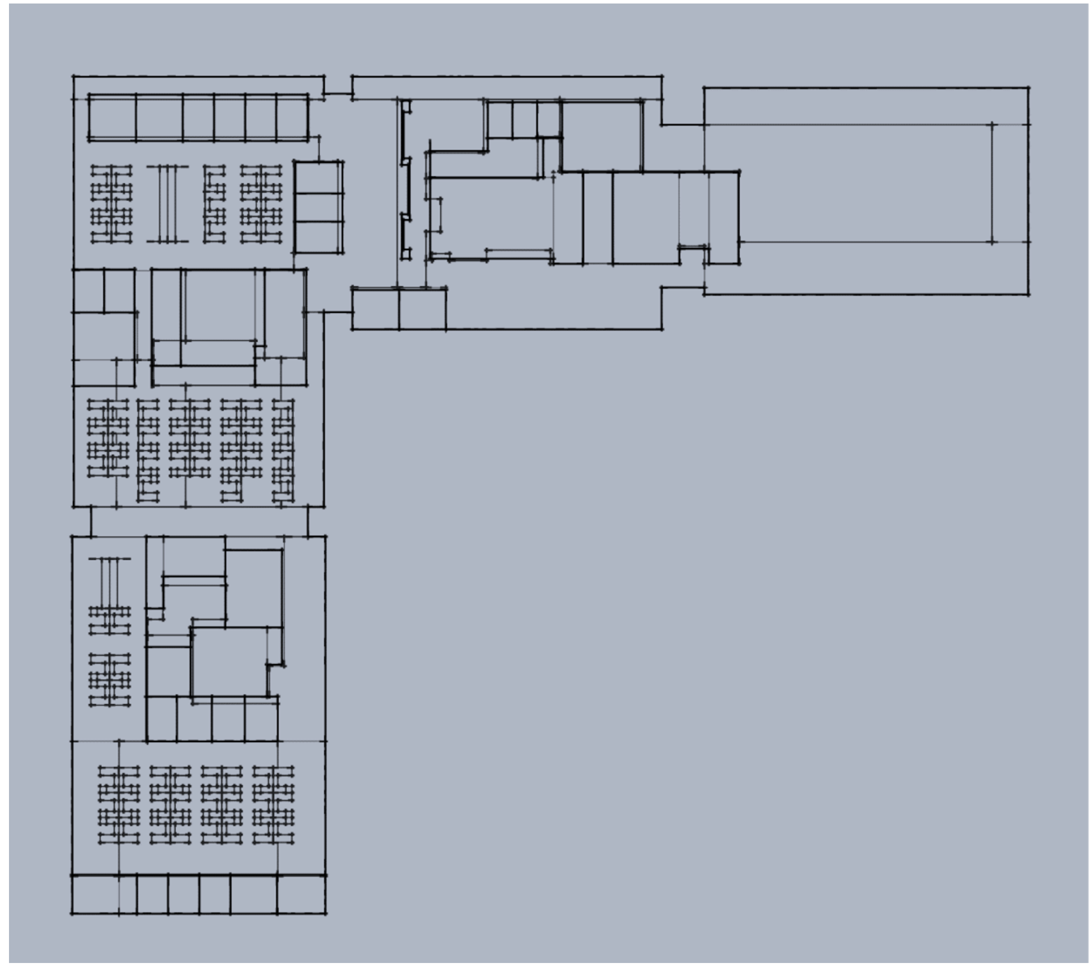
} **?**

EnergyPlus approaches this with the split-flux method while Radiance employs a more accurate ray-tracing technique.



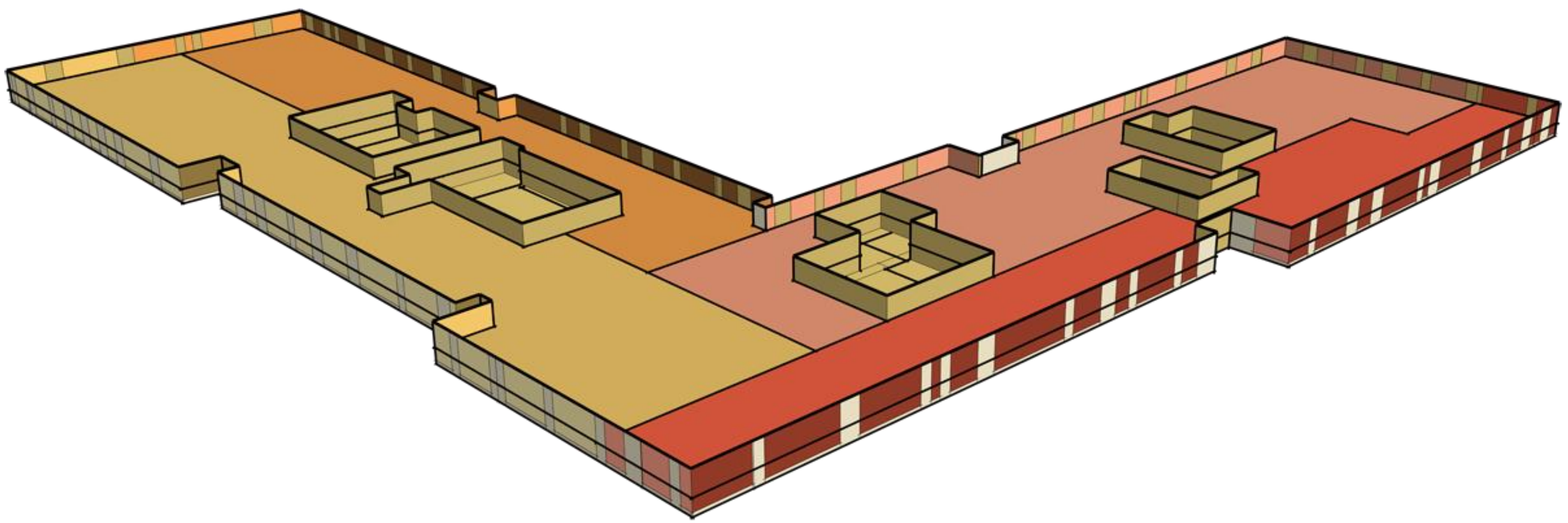
Modeling for Radiance & EnergyPlus

- Starting from OpenStudio energy model.
- Revit provides more detailed geometry, but also more potential for troubleshooting. Gaps between the various geometries causes light leaks in Radiance.
- Addition of furniture and wall partitions as needed.



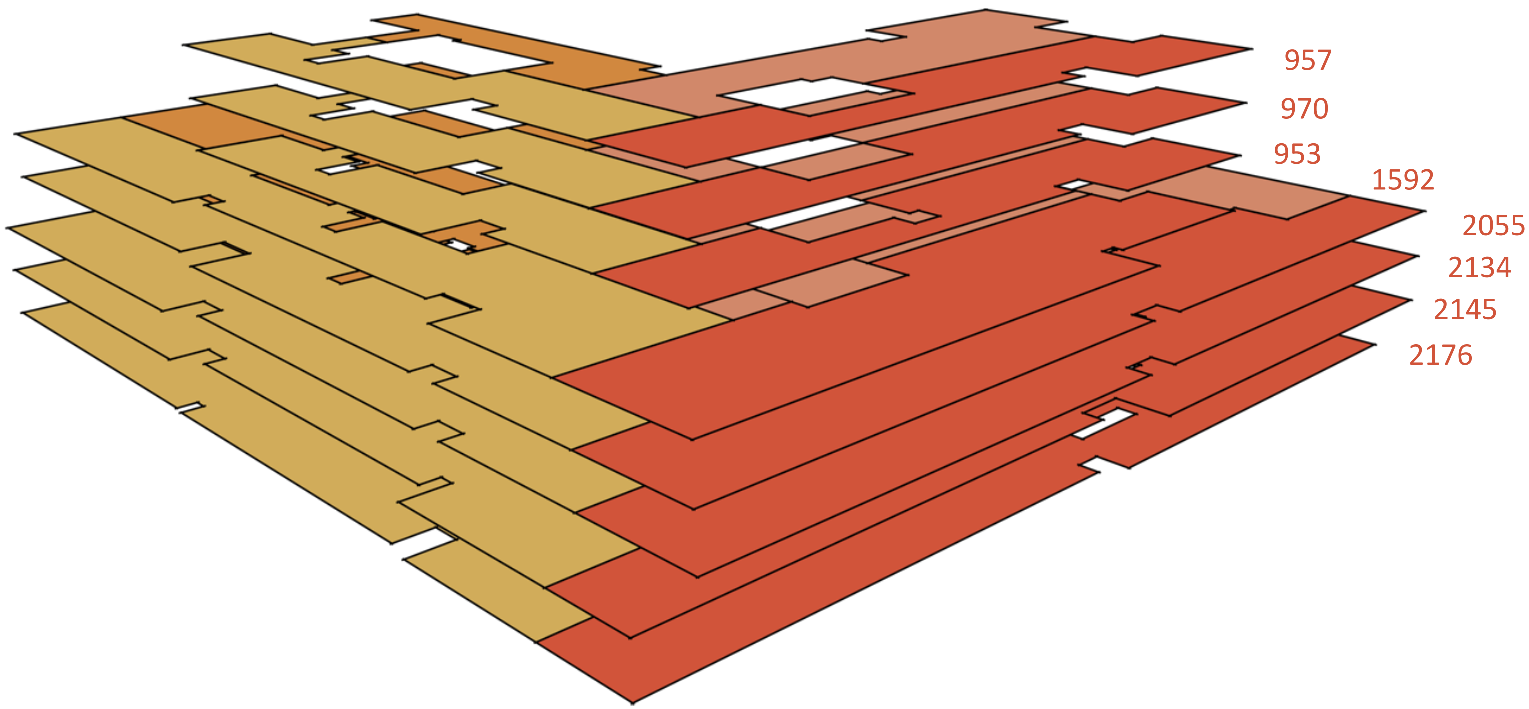
Modeling for Radiance

- Blinds operation based on zoning of spaces and window groups.
- Four spatial zones per floor.
- Windows grouped as designed and operated as part of each spatial zone.
- 4’x4’ analysis grid spacing.
- Cores excluded.



Modeling for Radiance

- 12,982 analysis points. (4’x4’ grids)

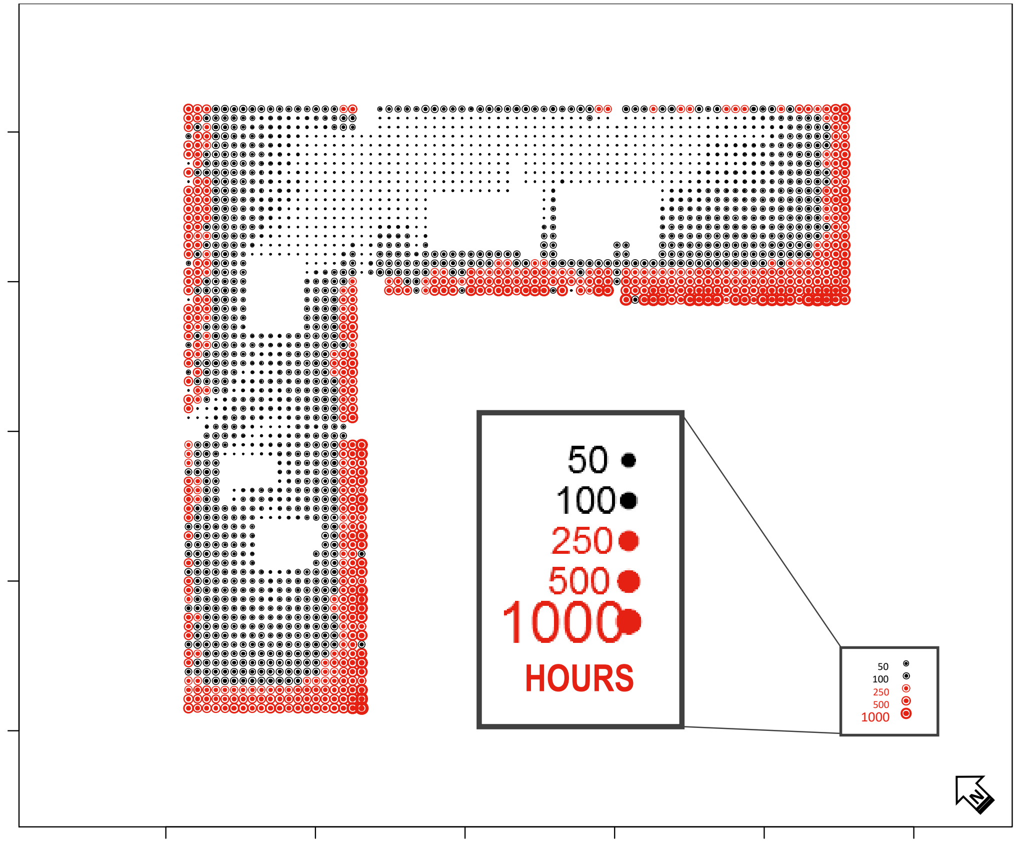


Modeling for Radiance

ASE based on single analysis grid

- Annual Sunlight Exposure

Floor		Zone	Time		ASE(%)
2nd		all	Annual		23.53
3rd		all	Annual		24.90
4th		all	Annual		24.88
5th		all	Annual		24.72
6th		all	Annual		28.52
7th		all	Annual		29.59
8th		all	Annual		32.08
9th		all	Annual		34.48



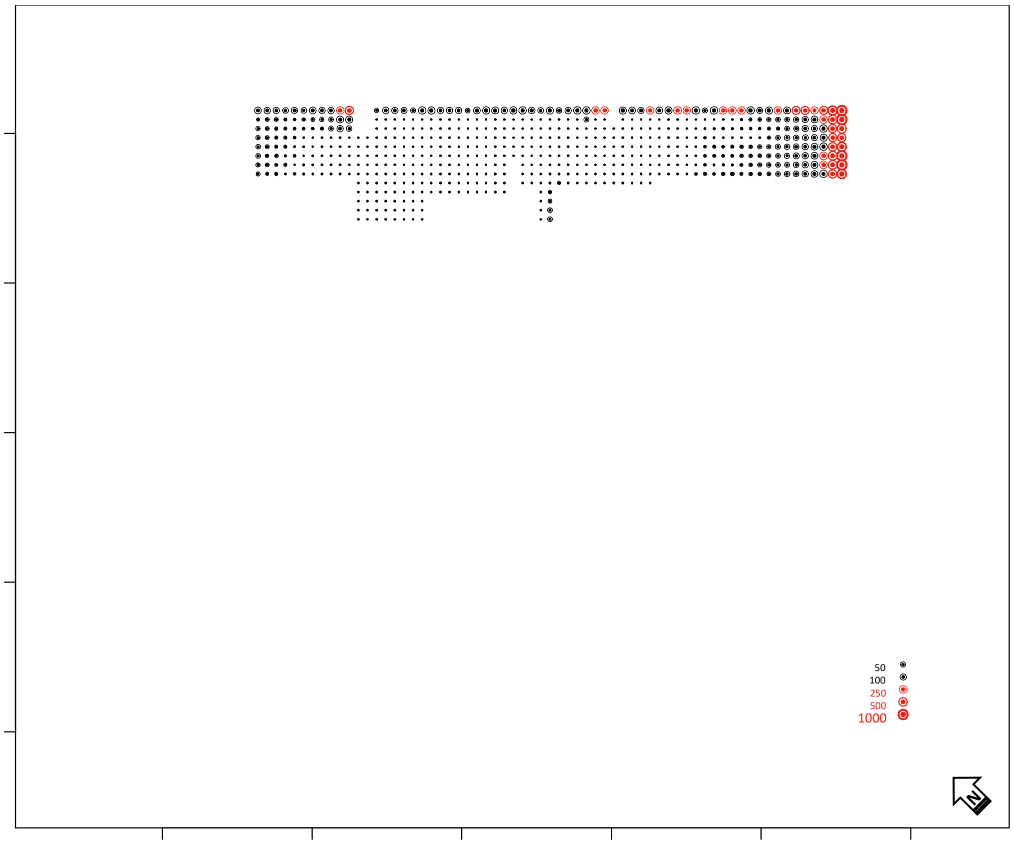
- **Annual Sunlight Exposure** (ASE/1000Lux/250hours) is an area-based metric which quantifies the percentage of floor area (analysis points) that is at or above 1000 Lux for at least 250 hours out of the occupied hours of the year.(8am to 6pm)

Modeling for Radiance

ASE based on zoned analysis grid

- Annual Sunlight Exposure

Floor		Zone	Time		ASE(%)
2nd		ne	Annual		5.75
3rd		ne	Annual		8.60
4th		ne	Annual		3.17
5th		ne	Annual		5.76
6th		ne	Annual		7.98
7th		ne	Annual		3.39
8th		ne	Annual		5.50
9th		ne	Annual		6.78

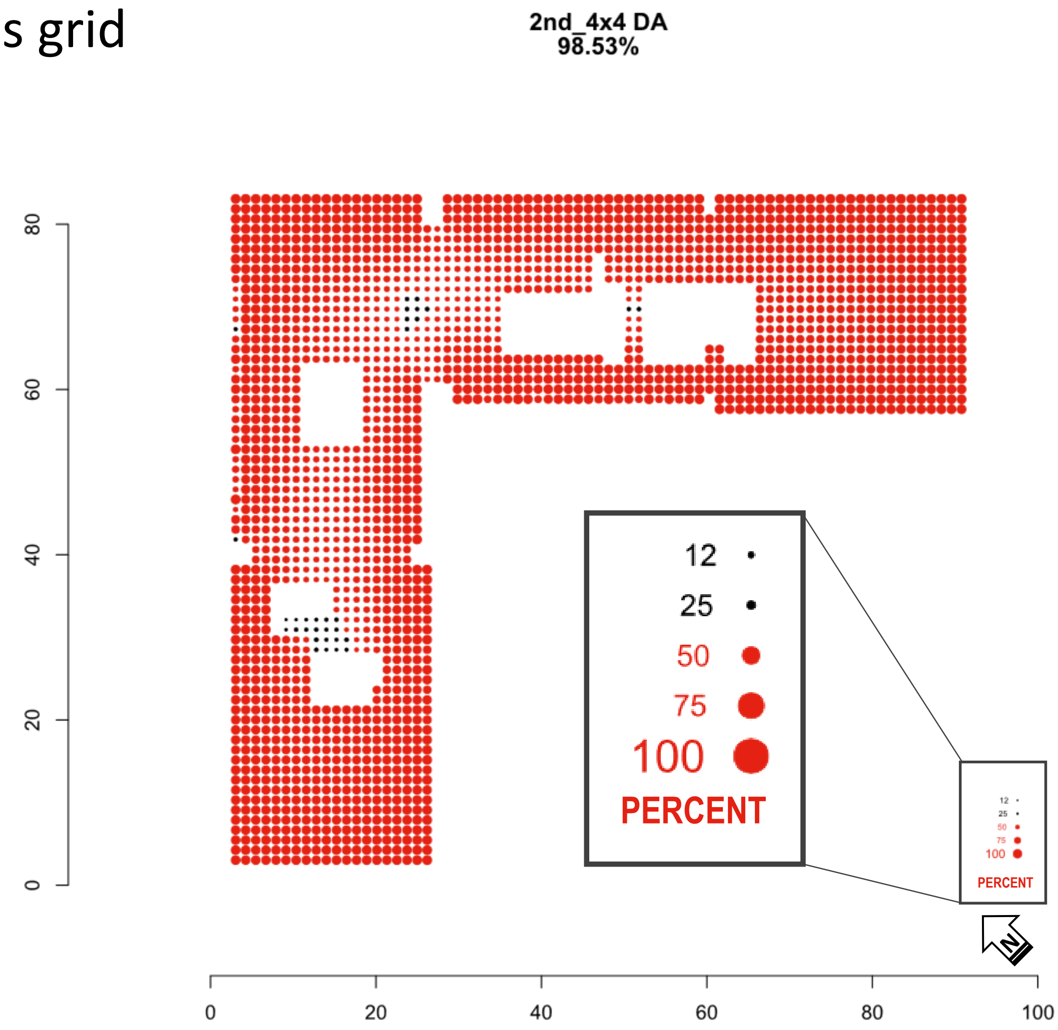


- **Annual Sunlight Exposure** (ASE/1000Lux/250hours) is an area-based metric which quantifies the percentage of floor area (analysis points) that is at or above 1000 Lux for at least 250 hours out of the occupied hours of the year.(8am to 6pm)

Modeling for Radiance

sDA based on single analysis grid

Floor		Zone	Time		sDA(%)
2nd		all	Annual		98.5
3rd		all	Annual		97.3
4th		all	Annual		99.2
5th		all	Annual		99.8
6th		all	Annual		100.0
7th		all	Annual		99.6
8th		all	Annual		99.4
9th		all	Annual		99.1

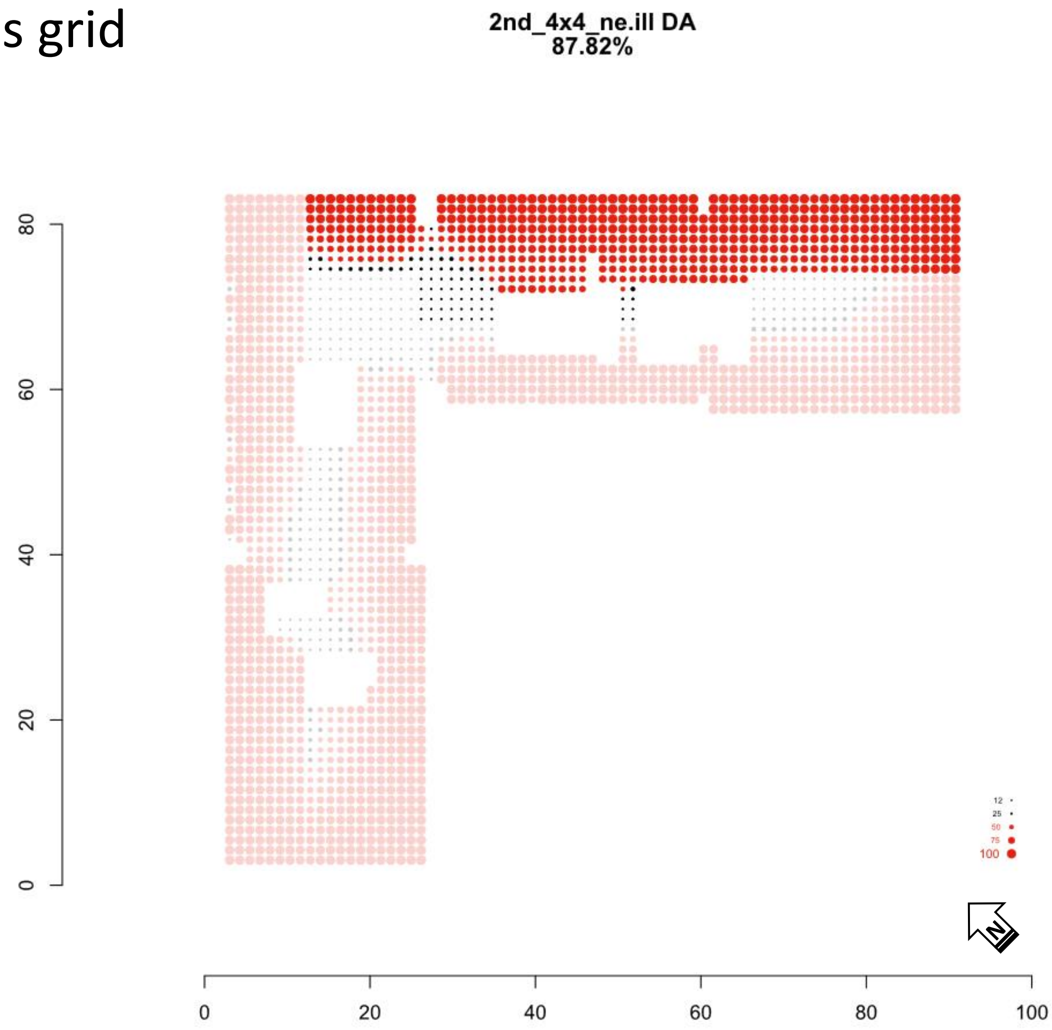


- **Daylight Autonomy** (DA/300Lux) is a **time**-based metric which quantifies the percent of occupied hours of the year (8am to 6pm) during which a single analysis point is above 300 Lux.

Modeling for Radiance

sDA based on zoned analysis grid

Floor		Zone	Time		DA(%)
2nd		ne	Annual		87.8
2nd		nw	Annual		94.1
2nd		se	Annual		69.4
2nd		sw	Annual		80.7
2nd		all	Annual		82.7

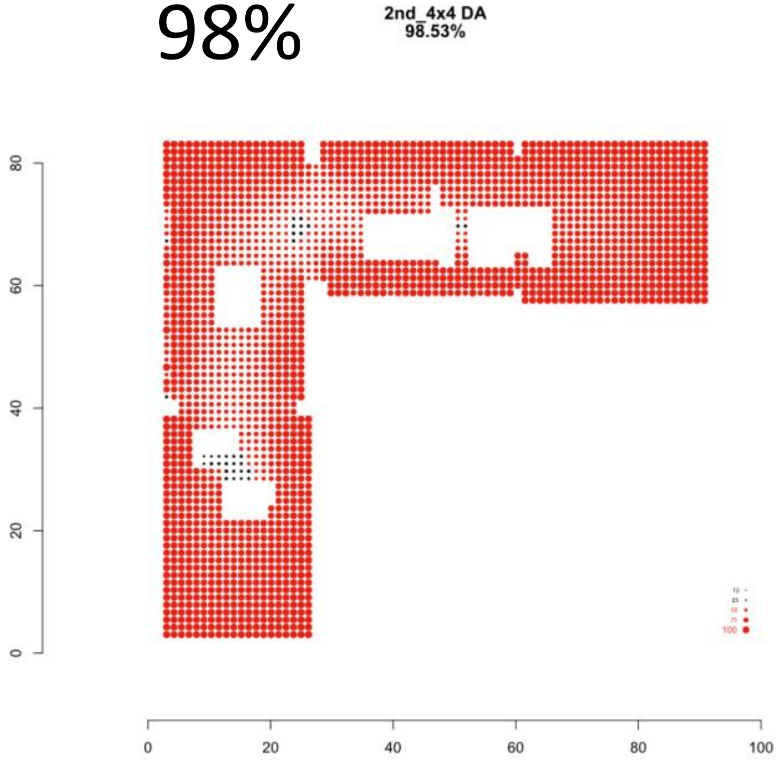


- **Daylight Autonomy** (DA/300Lux) is a **time**-based metric which quantifies the percent of occupied hours of the year (8am to 6pm) during which a single analysis point is above 300 Lux.

Modeling for Radiance

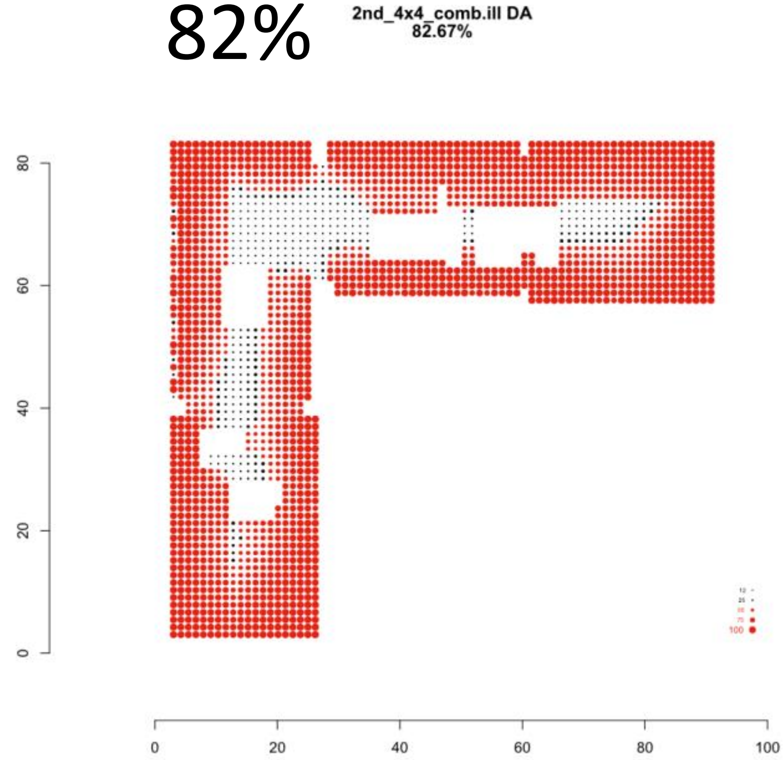
Different interpretation and application can sway outputs

98%



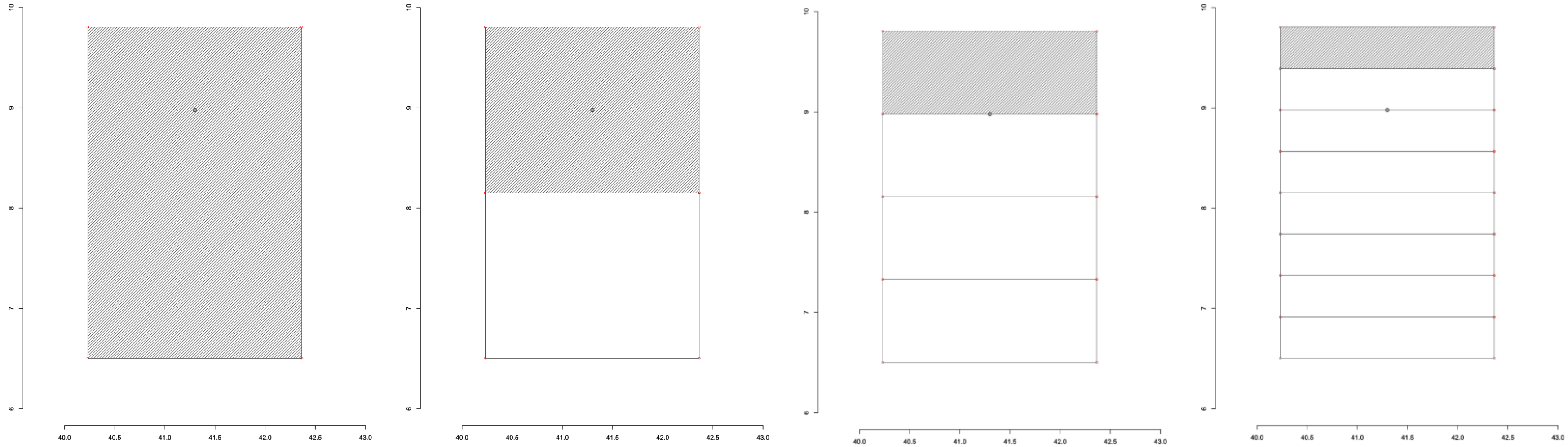
Full floor plate ASE+sDA

82%



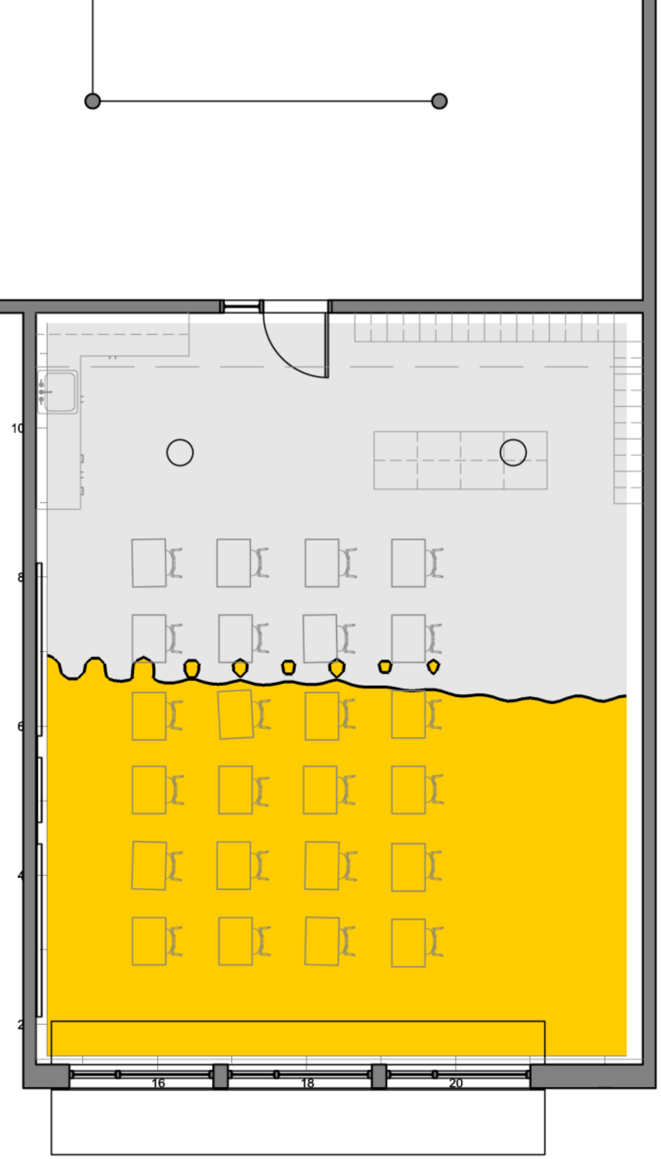
Zoned ASE+sDA

Window grouping granularity



Window grouping granularity

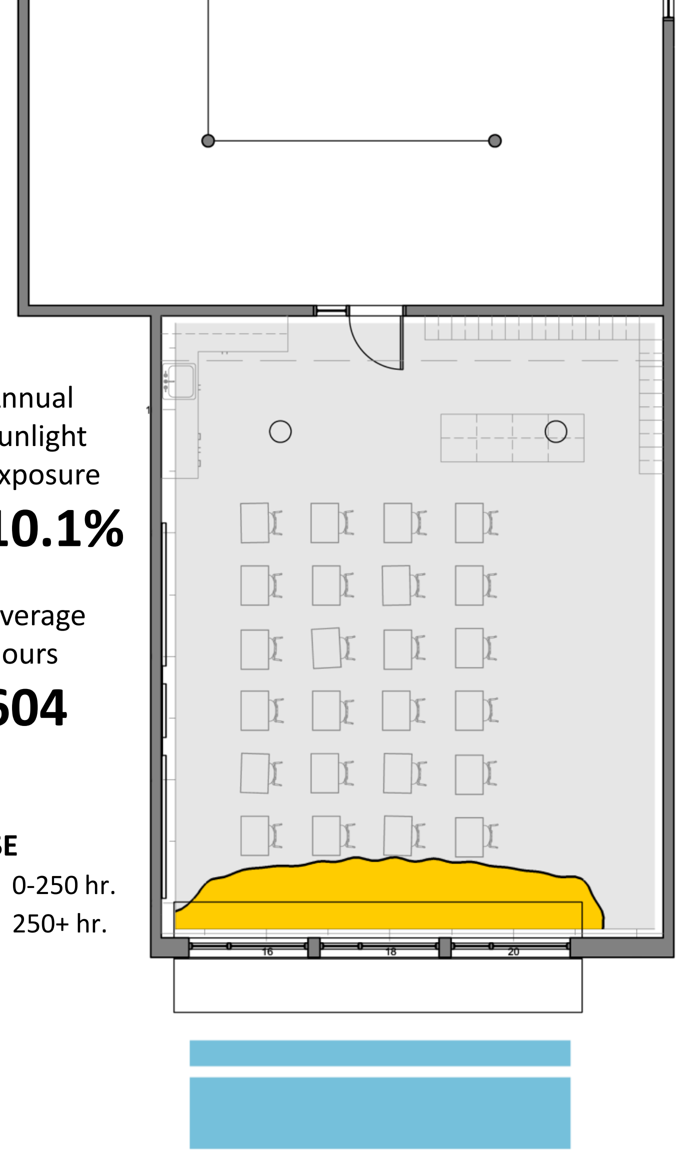
Spatial
Daylight
Autonomy
54.3%



DA
0-50%
50-100%

Annual
Sunlight
Exposure
10.1%

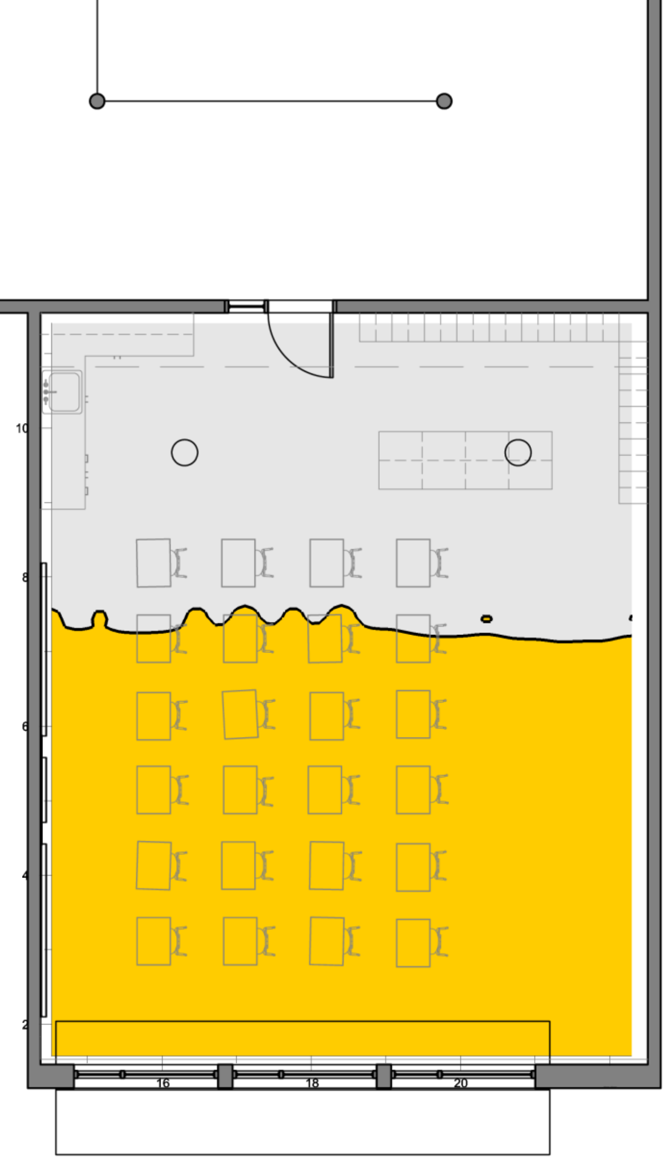
Average
Hours
604



ASE
0-250 hr.
250+ hr.

Shading + light shelf | 2 south window groups

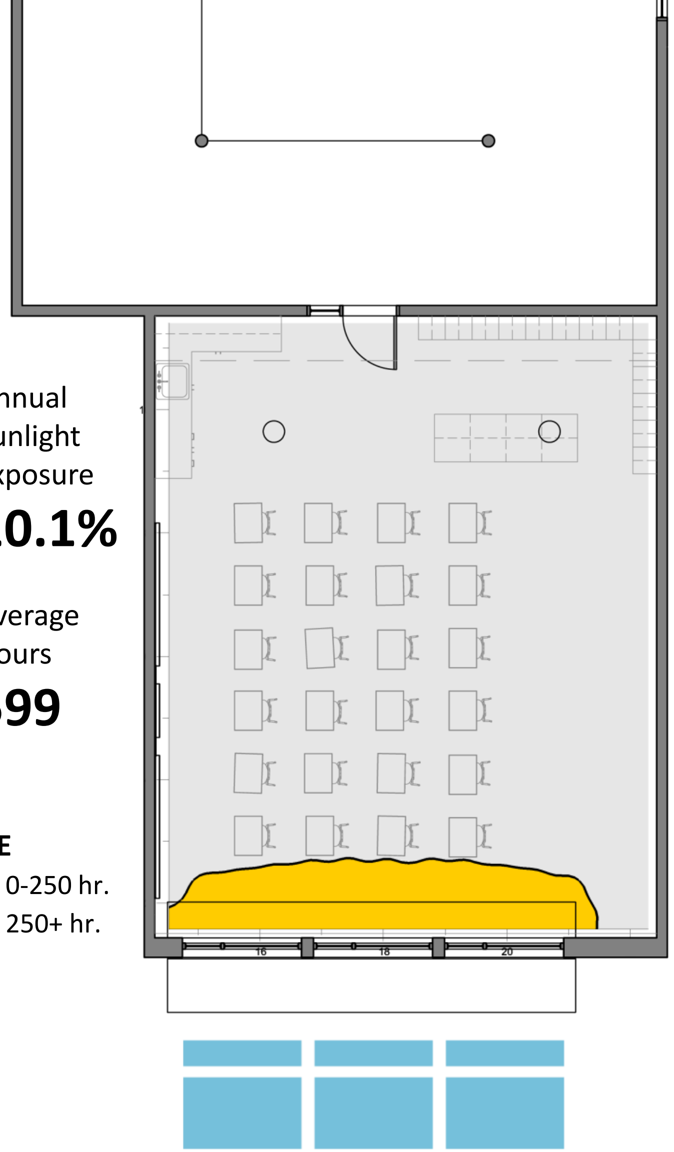
Spatial Daylight Autonomy
60.5%



DA
0-50%
50-100%

Annual Sunlight Exposure
10.1%

Average Hours
599



ASE
0-250 hr.
250+ hr.

Shading + light shelf | 6 south window groups

Modeling for Radiance

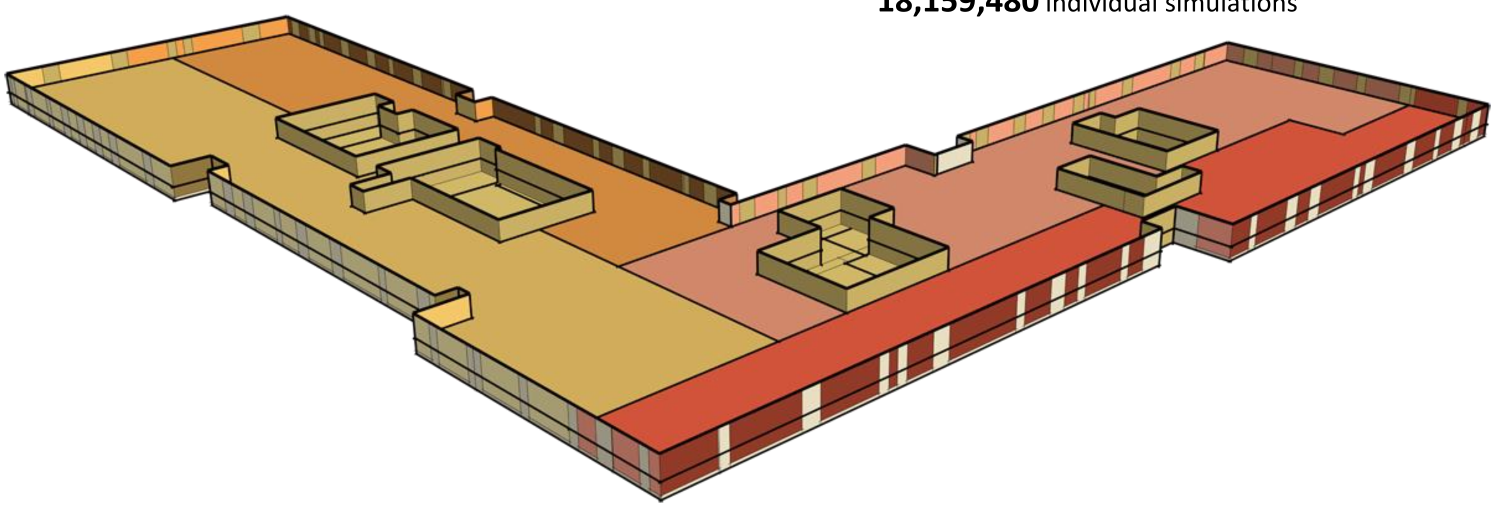
Model organization

- LM-83 Radiance model structure
  - Generation of blinds operation schedules per spatial zone:
    - North-East Zone
    - North-West Zone
    - South-East Zone
    - South-West Zone

    } 691 window groups } Direct solar simulations (1)
  - Application of blinds schedule to entire floor plate:
    - Whole floor } 691 window groups } Ambient simulations per blind condition (2)

(1) and (2) } 8760 hours

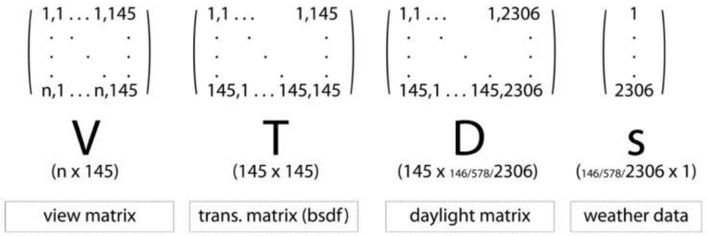
18,159,480 individual simulations



Modeling for Radiance

$i=V*T*D*s$

Radiance three-phase method



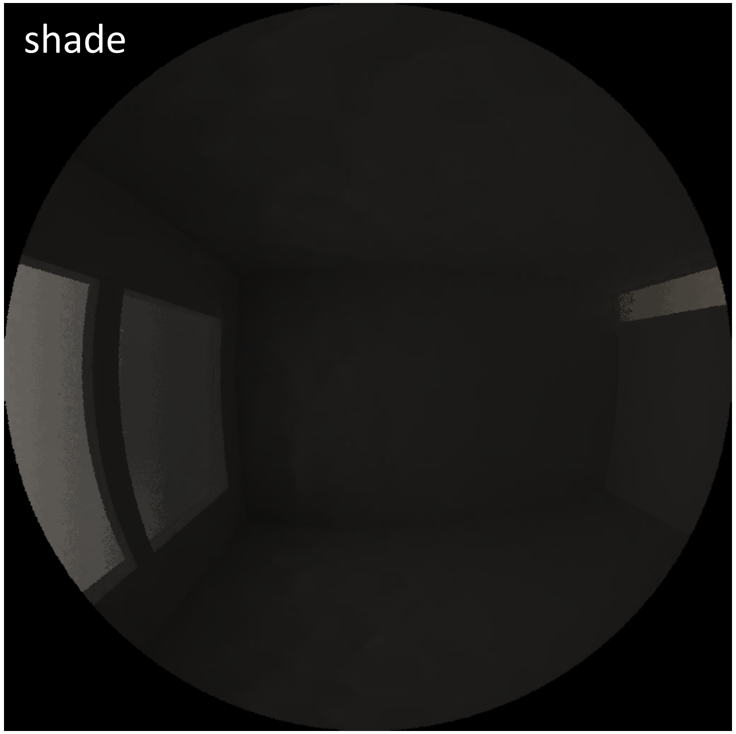
- A means to perform annual simulation of dynamic and complex fenestration systems.
- Each phase results in a matrix of normalized coefficients which can be multiplied by an input, namely sky luminance values.
- Breaks down into three, independently simulated phases:
  - Sky to exterior of fenestration.
  - Transmission through the fenestration.
  - Interior of fenestration to the point(s) of observation.

Modeling for Radiance

$i = V * T * D * s$

View matrix

- Describes the interaction between the interior of the glazing surface (as a BSDF) and the points of observation of the space interior such as a render view or a series of analysis point coordinates.

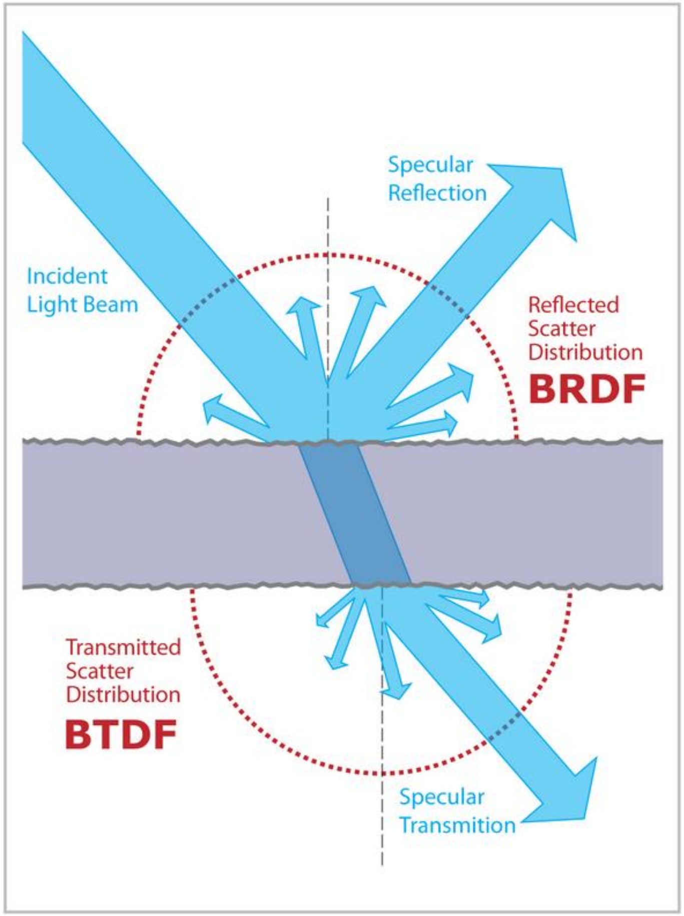


Modeling for Radiance

i=V*T*D*s

Transmission matrix

- Describes the way in which light passes through and is reflected off of a complex fenestration system.
- Window7 xml format file which contains transmission(BTDF) and reflection(BRDF) data for the front and back of a system. Radiance only uses the front transmission data.

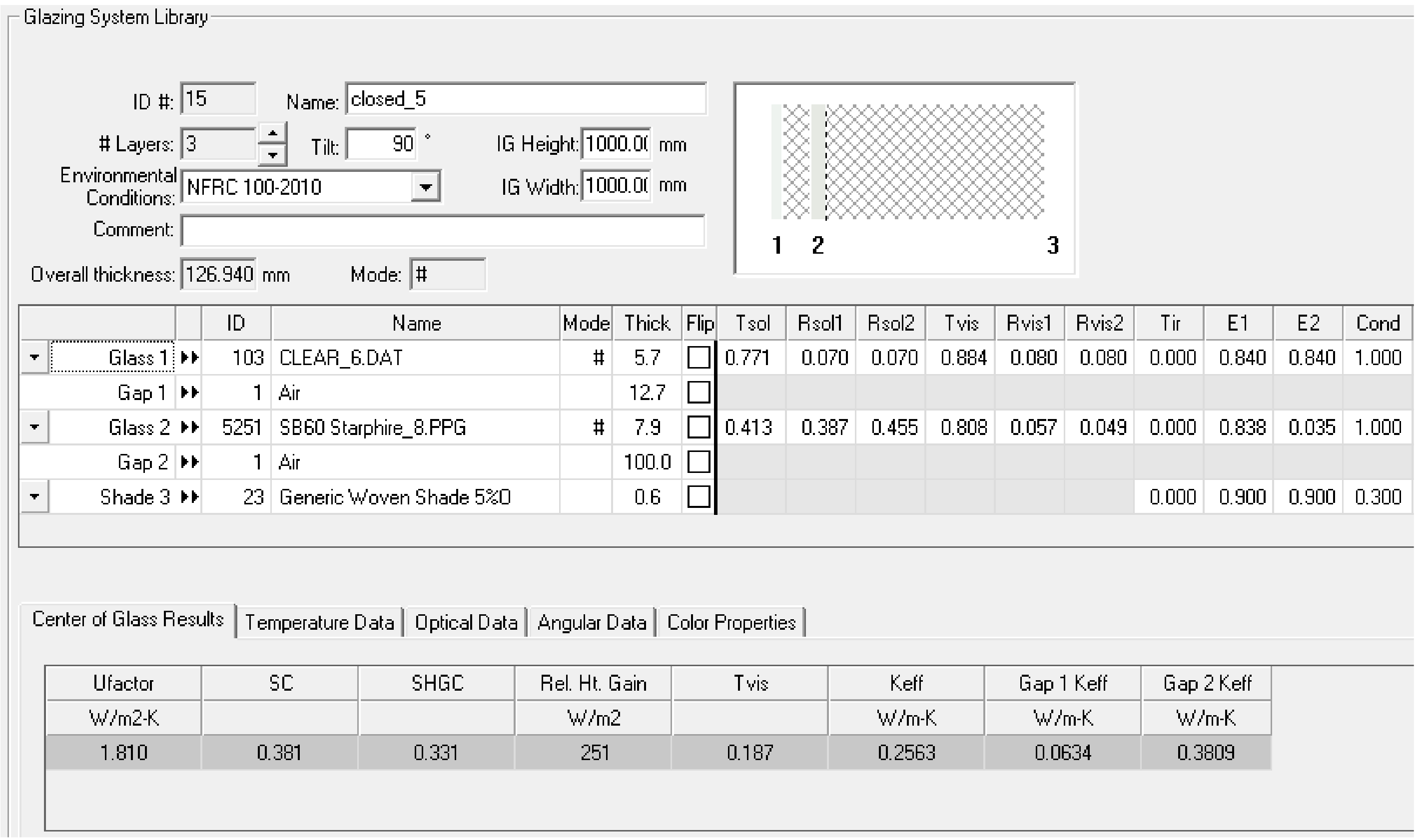


Modeling for Radiance

i=V*T*D*s

Transmission matrix

- LBNL Window7 BSDF calculation



Glazing System Library

ID #: 15 Name: closed_5

Layers: 3 Tilt: 90 ° IG Height: 1000.0(mm

Environmental Conditions: NFRC 100-2010 IG Width: 1000.0(mm

Comment:

Overall thickness: 126.940 mm Mode: #

		ID	Name	Mode	Thick	Flip	Tsol	Rsol1	Rsol2	Tvis	Rvis1	Rvis2	Tir	E1	E2	Cond
Glass 1	▸▸	103	CLEAR_6.DAT	#	5.7	☐	0.771	0.070	0.070	0.884	0.080	0.080	0.000	0.840	0.840	1.000
Gap 1	▸▸	1	Air		12.7	☐										
Glass 2	▸▸	5251	SB60 Starphire_8.PPG	#	7.9	☐	0.413	0.387	0.455	0.808	0.057	0.049	0.000	0.838	0.035	1.000
Gap 2	▸▸	1	Air		100.0	☐										
Shade 3	▸▸	23	Generic Woven Shade 5%O		0.6	☐							0.000	0.900	0.900	0.300

Center of Glass Results | Temperature Data | Optical Data | Angular Data | Color Properties

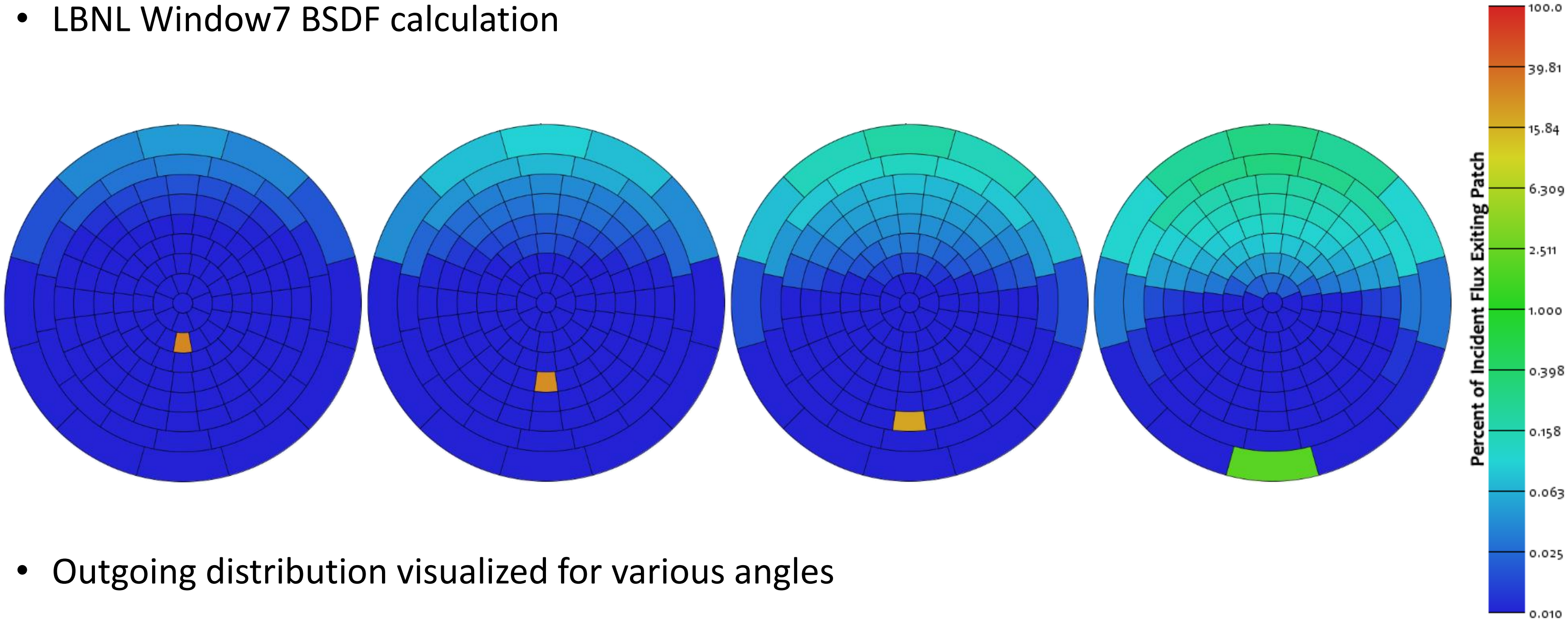
Ufactor	SC	SHGC	Rel. Ht. Gain	Tvis	Keff	Gap 1 Keff	Gap 2 Keff
W/m2-K			W/m2		W/m-K	W/m-K	W/m-K
1.810	0.381	0.331	251	0.187	0.2563	0.0634	0.3809

Modeling for Radiance

i=V*T*D*s

Transmission matrix

- LBNL Window7 BSDF calculation

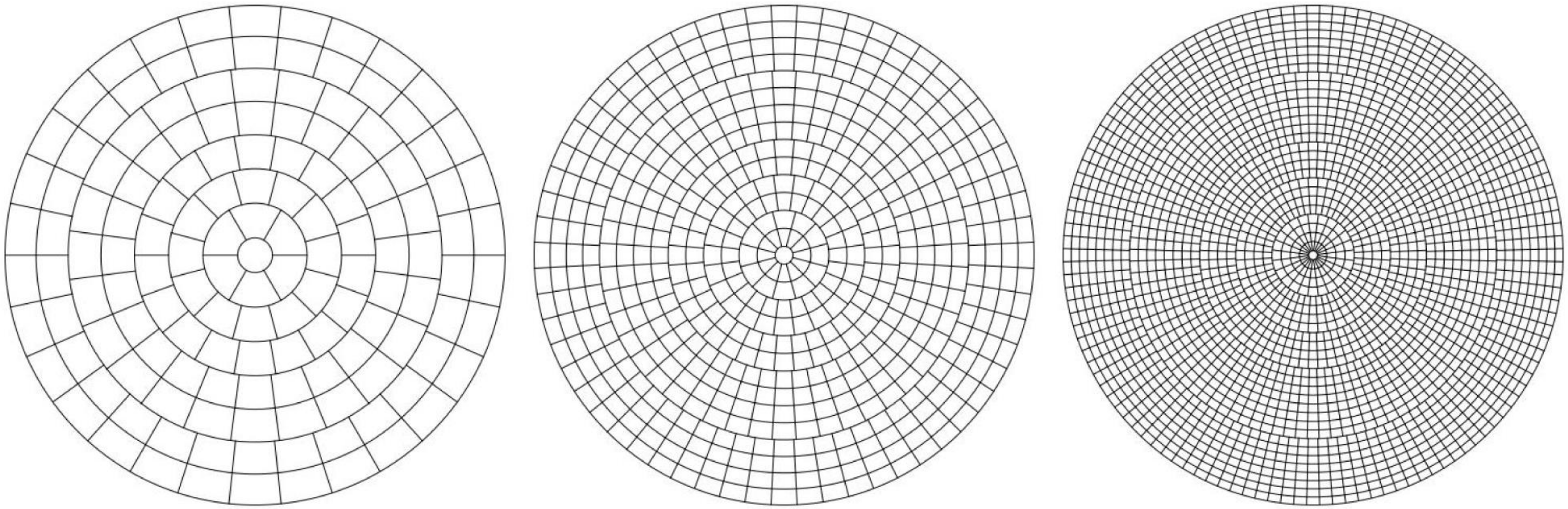


- Outgoing distribution visualized for various angles

Modeling for Radiance

i=V*T*D*s

Tregenza/Reinhart sky divisions



Tregenza/Reinhart MF:1
145 divisions

Reinhart MF:2
577 divisions

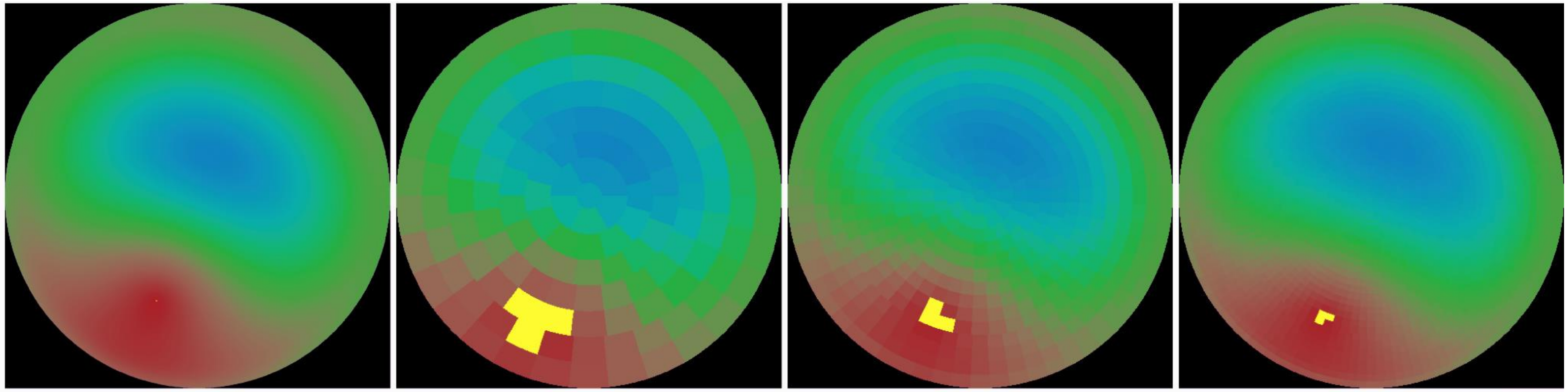
Reinhart MF:4
2305 divisions

- Average brightness values are taken for each discretized patch of the sky to construct a sky vector which can then be applied to a daylight matrix for the classic single-phase rcontrib simulation or the i=VTDs three-phase method.

Modeling for Radiance

i=V*T*D*s

Daylight matrix



Continuous sky

Tregenza/Reinhart MF:1
145 divisions

Reinhart MF:2
577 divisions

Reinhart MF:4
2305 divisions

- The sun disc is distributed among the three nearest sky patches, which means the full intensity of the sun is reduced.
- The higher the “resolution” of our sky, the smaller, more intense, and more accurate our representation of the sun.

Modeling for Radiance

Simulation outputs

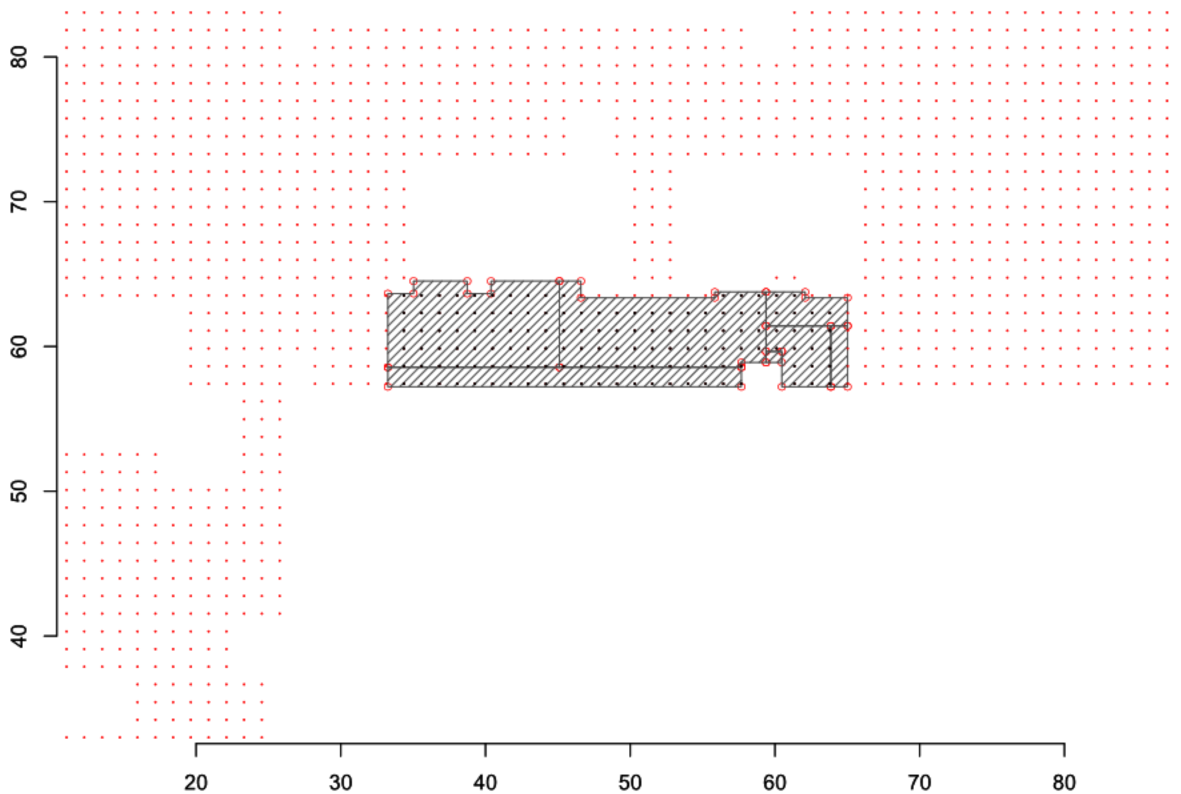
- Series of Lux matrices with dimensions of 8760 rows by the number of analysis points in the analysis grid.
- These matrices can represent the contribution of a single window group or combinations of window groups, with various blinds conditions for each.
- Different operation algorithms can then be applied to drive the combinations of these matrices which produce the final operated outputs.
    - The operated results can then be used to generate fractional lighting schedules for EnergyPlus based on the Lux threshold desired at the analysis grid and the Lux output of the lighting fixture at dimming levels.

Modeling for Radiance

Simulation outputs

Overlay of EnergyPlus thermal zones onto the Radiance analysis grid in order to isolate the points that are inside the zone.

These can be averaged, or a single point specified to generate the fractional lighting schedule.



Updated EnergyPlus

based on generated blind schedule and fractional lighting schedule

- Define shade material and shade construction in EnergyPlus
- Assigning shade to a window
- Define shading control

- Lighting schedules

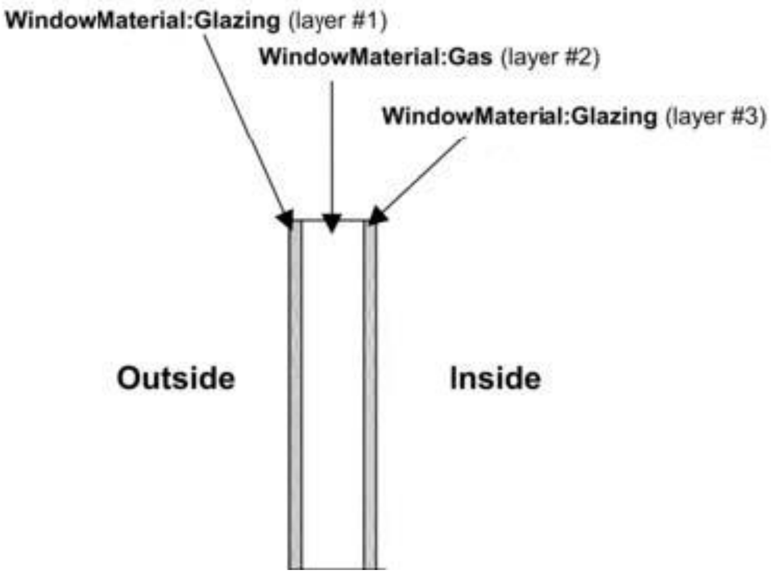
EnergyPlus

There are two methods of assigning a shade to a window:

Method 1:

1) **Define the construction of the window without the shade, the so-called "bare" construction.**
2) Reference the bare construction in the FenestrationSurface:Detailed for the window.
3) Define the WindowMaterial:Shade.
4) Define a WindowProperty:ShadingControl for the window in which you (a) specify that this WindowMaterial:Shade is the window's shading device and (b) specify how the shade is controlled.

```
Construction,
DOUBLE PANE WITHOUT SHADE,        !- Name
GLASS - CLEAR SHEET 1,            !- Outside Layer
WinAirB1 - AIRSPACE RESISTANCE,   !- Layer #2
GLASS - CLEAR SHEET 2;            !- Layer #3
```



Bare Construction

There are two methods of assigning a shade to a window:

Method 1:

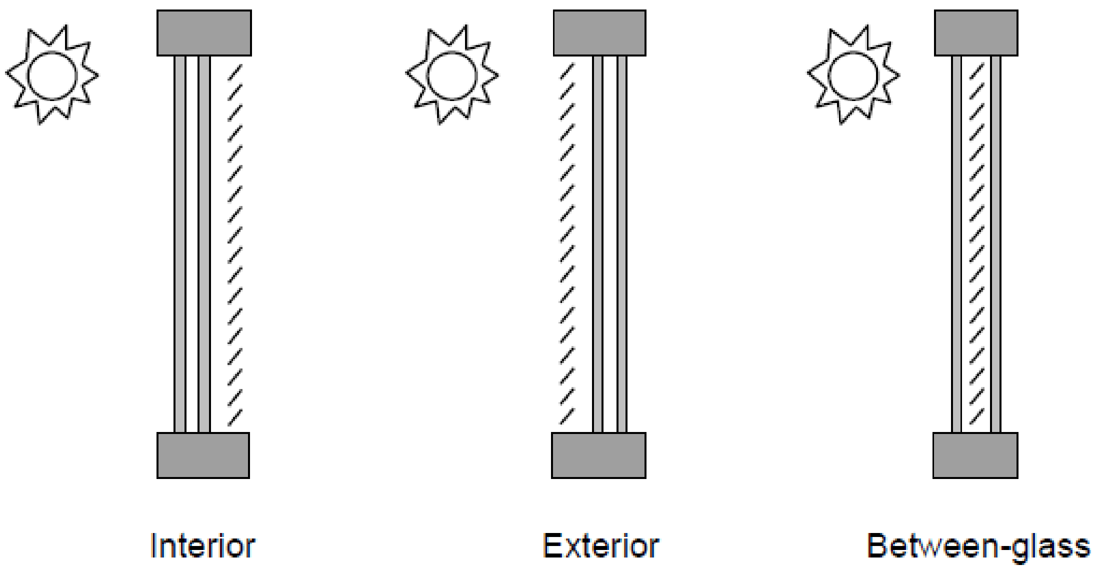
1) Define the construction of the window without the shade, the so-called “bare” construction.
2) Reference the bare construction in the FenestrationSurface:Detailed for the window.
3) Define the WindowMaterial:Shade.
4) Define a WindowProperty:ShadingControl for the window in which you (a) specify that this WindowMaterial:Shade is the window’s shading device and (b) specify how the shade is controlled.

```
FenestrationSurface:Detailed ,
Zn001:Wall001:Win001 ,                  !- SubSurface Name
DOUBLE PANE WITHOUT SHADE,              !- Class and Construction Name
Zn001:Wall001,                          !- Base Surface Name and Target (if applicable)
0.5000000 ,                             !- VF to Ground
CONTROL ON INCIDENT SOLAR,              !- Window Shading Control
TestFrameAndDivider ,                   !- Frame/Divider name
5,                                      !- Multiplier
4,                                      !- Rectangle (number of sides)
1.524000 ,   0.1520000 , 2.743000 ,
1.524000 ,   0.1520000 , 0.3050000 ,
4.572000 ,   0.1520000 , 0.3050000 ,
4.572000 ,   0.1520000 , 2.743000 ;
```

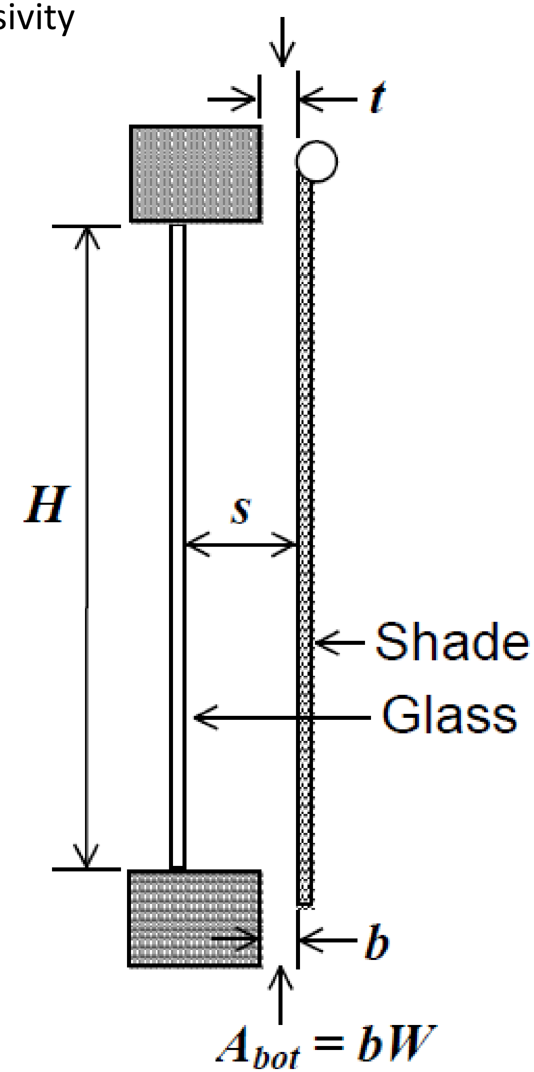
There are two methods of assigning a shade to a window:

Method 1:

1) Define the construction of the window without the shade, the so-called "bare" construction.
2) Reference the bare construction in the FenestrationSurface:Detailed for the window.
3) **Define the WindowMaterial:Shade.**
4) Define a WindowProperty:ShadingControl for the window in which you (a) specify that this WindowMaterial:Shade is the window's shading device and (b) specify how the shade is controlled.



```
WindowMaterial:Shade,
CLOSE WEAVE MEDIUM,          !- Name
0.05,                        !- Solar transmittance
0.3000000,                   !- Solar Reflectance
0.05,                        !- Visible transmittance
0.3000000,                   !- Visible reflectance
0.9000000,                   !- Thermal Hemispherical Emissivity
0.0,                         !- Thermal Transmittance
0.003,                       !- Thickness {m}
0.1,                         !- Conductivity {W/m-K}
0.050,                       !- Shade to glass distance {m}
0.6,                         !- Top opening multiplier
0.6,                         !- Bottom opening multiplier
0.4,                         !- Left-side opening multiplier
0.4,                         !- Right-side opening multiplier
0.01;                        !- Air flow permeability
```



There are two methods of assigning a shade to a window:

Method 1:

1) Define the construction of the window without the shade, the so-called “bare” construction.
2) Reference the bare construction in the FenestrationSurface:Detailed for the window.
3) Define the WindowMaterial:Shade.
4) **Define a WindowProperty:ShadingControl for the window in which you (a) specify that this WindowMaterial:Shade is the window’s shading device and (b) specify how the shade is controlled.**

```
WindowProperty:ShadingControl,
CONTROL ON INCIDENT SOLAR,      !- Name of Shading Control
InteriorShade,                  !- Shading Type
,                               !- Name of shaded construction
OnIfHighSolarOnWindow,          !- Shading Control Type
,                               !- Schedule name
50.0,                           !- Setpoint {W/m2}
NO,                             !- Shading Control Is Scheduled
NO,                             !- Glare Control Is Active
CLOSE WEAVE MEDIUM,             !- Material Name of Shading Device
,                               !- Type of Slat Angle Control for Blinds
;                               !- Slat Angle Schedule Name
```

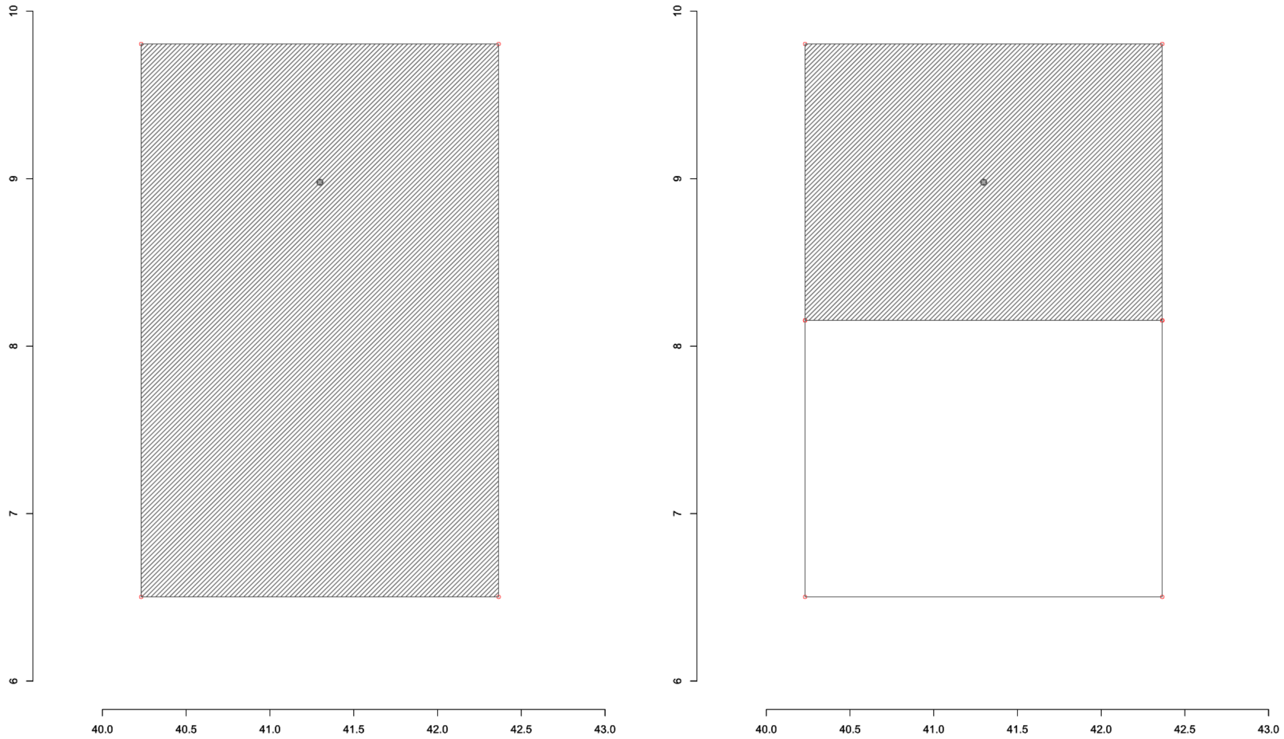
```
WindowProperty:ShadingControl,
CONTROL ON INCIDENT SOLAR,                  !- Name of Shading Control
InteriorShade,                              !- Shading Type
,                                           !- Name of shaded construction
OnIfHighSolarOnWindow,                      !- Shading Control Type
,                                           !- Schedule name
50.0,                                       !- Setpoint {W/m2}
NO,                                         !- Shading Control Is Scheduled
NO,                                         !- Glare Control Is Active
CLOSE WEAVE MEDIUM,                         !- Material Name of Shading Device
,                                           !- Type of Slat Angle Control for Blinds
;                                           !- Slat Angle Schedule Name
```

Update "Window Shading Control" for all windows with operable shade

```
FenestrationSurface:Detailed ,
Zn001:Wall001:Win001 ,                      !- SubSurface Name
DOUBLE PANE WITHOUT SHADE,                  !- Class and Construction Name
Zn001:Wall001,                              !- Base Surface Name and Target (if applicable)
0.5000000 ,                                 !- VF to Ground
CONTROL ON INCIDENT SOLAR,                  !- Window Shading Control
TestFrameAndDivider ,                       !- Frame/Divider name
5,                                          !- Multiplier
4,                                          !- Rectangle (number of sides)
1.524000 ,   0.1520000 , 2.743000 ,
1.524000 ,   0.1520000 , 0.3050000 ,
4.572000 ,   0.1520000 , 0.3050000 ,
4.572000 ,   0.1520000 , 2.743000 ;
```

WindowProperty:ShadingControl

To model a case in which the shading device, when activated, covers **only part of the window** you will have to divide the window into two separate windows, one with the shading device and one without the shading device.

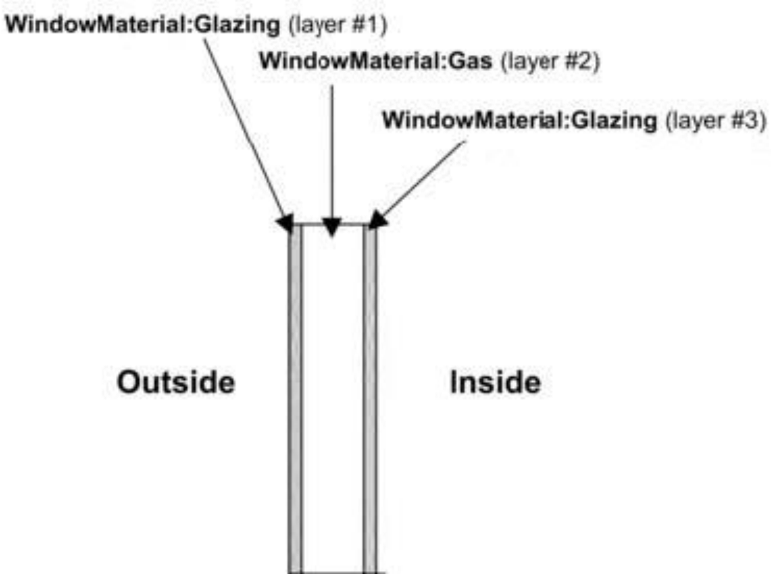


There are two methods of assigning a shade to a window:

Method 2:

1) Define the Construction of the window without the shade, the so-called "bare" construction.
2) Reference the bare construction in the FenestrationSurface:Detailed for the window.
3) Define the WindowMaterial:Shade.
4) Define another Construction, called the "shaded construction," that includes the WindowMaterial:Shade.
5) Define a WindowProperty:ShadingControl for the window in which you (a) reference the shaded construction and (b) specify how the shade is controlled.

```
Construction,
DOUBLE PANE WITHOUT SHADE,        !- Name
GLASS - CLEAR SHEET 1,            !- Outside Layer
WinAirB1 - AIRSPACE RESISTANCE,   !- Layer #2
GLASS - CLEAR SHEET 2;            !- Layer #3
```



Bare Construction

There are two methods of assigning a shade to a window:

Method 2:

1) Define the Construction of the window without the shade, the so-called "bare" construction.
2) Reference the bare construction in the FenestrationSurface:Detailed for the window.
3) Define the WindowMaterial:Shade.
4) Define another Construction, called the "shaded construction," that includes the WindowMaterial:Shade.
5) Define a WindowProperty:ShadingControl for the window in which you (a) reference the shaded construction and (b) specify how the shade is controlled.

```
FenestrationSurface:Detailed ,
Zn001:Wall001:Win001 ,                          !- SubSurface Name
DOUBLE PANE WITHOUT SHADE,                      !- Class and Construction Name
Zn001:Wall001,                                  !- Base Surface Name and Target (if applicable)
0.5000000 ,                                     !- VF to Ground
CONTROL ON INCIDENT SOLAR,                      !- Window Shading Control
TestFrameAndDivider ,                           !- Frame/Divider name
5,                                              !- Multiplier
4,                                              !- Rectangle (number of sides)
1.524000 ,   0.1520000 , 2.743000 ,
1.524000 ,   0.1520000 , 0.3050000 ,
4.572000 ,   0.1520000 , 0.3050000 ,
4.572000 ,   0.1520000 , 2.743000 ;
```

There are two methods of assigning a shade to a window:

Method 2:

1) Define the Construction of the window without the shade, the so-called "bare" construction.
2) Reference the bare construction in the FenestrationSurface:Detailed for the window.
3) Define the WindowMaterial:Shade.
4) Define another Construction, called the "shaded construction," that includes the WindowMaterial:Shade.
5) Define a WindowProperty:ShadingControl for the window in which you (a) reference the shaded construction and (b) specify how the shade is controlled.

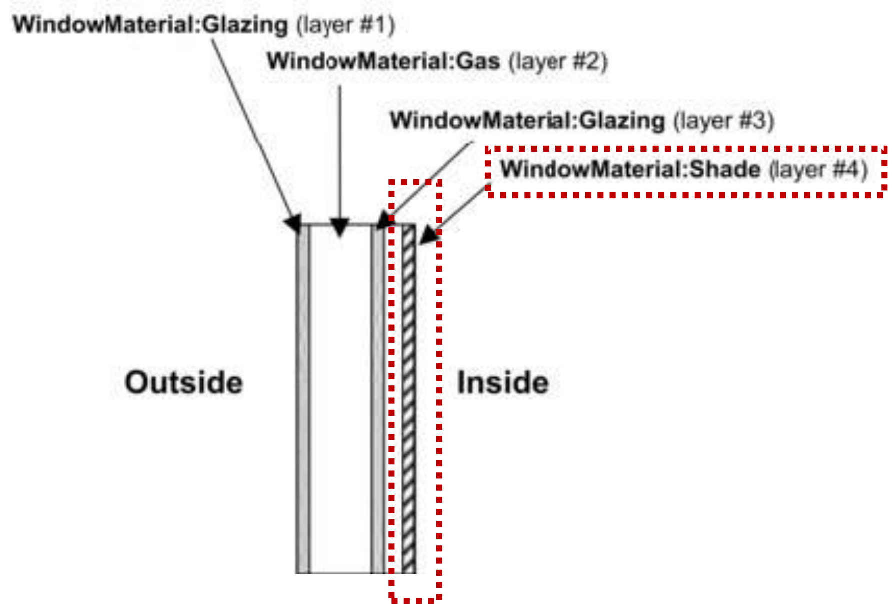
```
WindowMaterial:Shade,
CLOSE WEAVE MEDIUM,          !- Name
0.05,                        !- Solar transmittance
0.3000000,                   !- Solar Reflectance
0.05,                        !- Visible transmittance
0.3000000,                   !- Visible reflectance
0.9000000,                   !- Thermal Hemispherical Emissivity
0.0,                         !- Thermal Transmittance
0.003,                       !- Thickness {m}
0.1,                         !- Conductivity {W/m-K}
0.050,                       !- Shade to glass distance {m}
0.6,                         !- Top opening multiplier
0.6,                         !- Bottom opening multiplier
0.4,                         !- Left-side opening multiplier
0.4,                         !- Right-side opening multiplier
0.01;                        !- Air flow permeability
```

There are two methods of assigning a shade to a window:

Method 2:

1) Define the Construction of the window without the shade, the so-called “bare” construction.
2) Reference the bare construction in the FenestrationSurface:Detailed for the window.
3) Define the WindowMaterial:Shade.
4) Define another Construction, called the “shaded construction,” that includes the WindowMaterial:Shade.
5) Define a WindowProperty:ShadingControl for the window in which you (a) reference the shaded construction and (b) specify how the shade is controlled.

```
Construction,
DOUBLE PANE_SHADED,                !- Name
GLASS - CLEAR SHEET 1,             !- Outside Layer
WinAirB1 - AIRSPACE RESISTANCE,    !- Layer #2
GLASS - CLEAR SHEET 2,             !- Layer #3
CLOSE WEAVE MEDIUM;                !- Layer #4
```



Shaded Construction

There are two methods of assigning a shade to a window:

Method 2:

1) Define the Construction of the window without the shade, the so-called “bare” construction.
2) Reference the bare construction in the FenestrationSurface:Detailed for the window.
3) Define the WindowMaterial:Shade.
4) Define another Construction, called the “shaded construction,” that includes the WindowMaterial:Shade.
5) **Define a WindowProperty:ShadingControl for the window in which you (a) reference the shaded construction and (b) specify how the shade is controlled.**

```
WINDOWPROPERTY:SHADINGCONTROL,
CONTROL ON INCIDENT SOLAR,        !- Name of Shading Control
InteriorShade,                    !- Shading Type
DOUBLE PANE_SHADED,               !- Name of shaded construction
OnIfHighSolarOnWindow,            !- Shading Control Type
,                                 !- Schedule name
50.0,                             !- Setpoint {W/m2}
NO,                               !- Shading Control Is Scheduled
NO,                               !- Glare Control Is Active
,                                 !- Material Name of Shading Device
,                                 !- Type of Slat Angle Control for Blinds
;                                 !- Slat Angle Schedule Name
```

```
WINDOWPROPERTY:SHADINGCONTROL,
CONTROL ON INCIDENT SOLAR,                 !- Name of Shading Control
InteriorShade,                             !- Shading Type
DOUBLE PANE_SHADED,                        !- Name of shaded construction
OnIfHighSolarOnWindow,                     !- Shading Control Type
,                                          !- Schedule name
50.0,                                      !- Setpoint {W/m2}
NO,                                        !- Shading Control Is Scheduled
NO,                                        !- Glare Control Is Active
,                                          !- Material Name of Shading Device
,                                          !- Type of Slat Angle Control for Blinds
;                                          !- Slat Angle Schedule Name
```

Update "Window Shading Control" for all windows with operable shade

```
FenestrationSurface:Detailed ,
Zn001:Wall001:Win001 ,                     !- SubSurface Name
DOUBLE PANE WITHOUT SHADE,                 !- Class and Construction Name
Zn001:Wall001,                             !- Base Surface Name and Target (if applicable)
0.5000000 ,                                !- VF to Ground
CONTROL ON INCIDENT SOLAR,                 !- Window Shading Control
TestFrameAndDivider ,                      !- Frame/Divider name
5,                                         !- Multiplier
4,                                         !- Rectangle (number of sides)
1.524000 ,   0.1520000 , 2.743000 ,
1.524000 ,   0.1520000 , 0.3050000 ,
4.572000 ,   0.1520000 , 0.3050000 ,
4.572000 ,   0.1520000 , 2.743000 ;
```

Lighting schedules in E+

1

```
Schedule:File,
sched_201_SE_Private,          !- Name
Any Number,                    !- Schedule Type Limits Name
sched_final_keys.csv,          !- File Name
24,                            !- Column Number
1,                             !- Rows to Skip at Top
8760,                          !- Number of Hours of Data
Comma,                         !- Column Separator
Yes;                           !- Interpolate to Timestep
```

2

```
Lights,
lights_201_SE_Private,         !- Name
201_SE_Private,                !- Zone or ZoneList Name
sched_201_SE_Private,          !- Schedule Name
Watts/Area,                    !- Design Level Calculation Method
,                              !- Lighting Level {W}
11.64,                         !- Watts per Zone Floor Area {W/m2}
,                              !- Watts per Person {W/person}
0,                             !- Return Air Fraction
0.7,                           !- Fraction Radiant
0.2;                           !- Fraction Visible
```

OpenStudio?

OpenStudio only offers 4 shading control types while EnergyPlus has 18.

OpenStudio offers:
Always On
Always Off
OnIfScheduleAllows
OnIfHighSolarOnWindow

OpenStudio

EnergyPlus offers:
Always On
Always Off
OnIfScheduleAllows
OnIfHighSolarOnWindow
OnIfHighHorizontalSolar
OnIfHighOutdoorAirTemperature
OnIfHighZoneAirTemperature
OnIfHighZoneCooling
OnIfHighGlare
MeetDaylightIlluminanceSetpoint
OnNightIfLowOutdoorTempAndOffDay
OnNightIfLowInsideTempAndOffDay
OnNightIfHeatingAndOffDay
OnNightIfLowOutdoorTempAndOnDayIfCooling
OnNightIfHeatingAndOnDayIfCooling
OffNightAndOnDayIfCoolingAndHighSolarOnWindow
OnNightAndOnDayIfCoolingAndHighSolarOnWindow
OnIfHighOutdoorAirTempAndHighSolarOnWindow
OnIfHighOutdoorAirTempAndHighHorizontalSolar

EnergyPlus

"If a window of opportunity appears, don't pull down the shade."

Tom Peters

THANK YOU!

Kevin Van Den Wymelenberg (kevinvdw@uoregon.edu)
Alen Mahic (alen@uoregon.edu)
Amir Nezamdoost (amirn@uoregon.edu)

University of Oregon, Energy Studies in Buildings Laboratory, Eugene & Portland, OR


2017 INTERNATIONAL
RADIANCE WORKSHOP
AUGUST 21-25
PORTLAND OREGON
HOSTED BY THE UNIVERSITY OF OREGON
ENERGY STUDIES IN BUILDINGS LABORATORY
EVENT INFORMATION AND REGISTRATION:
radiance.uoregon.edu
UNIVERSITY OF OREGON