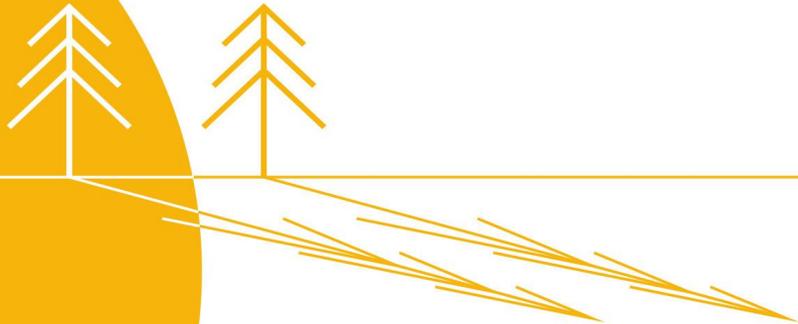


Spring Education Seminar: A Complete Picture of Daylight

Daniel Glaser, PhD Principal, LightStanza
Pacific Energy Center, San Francisco, June 9, 2016

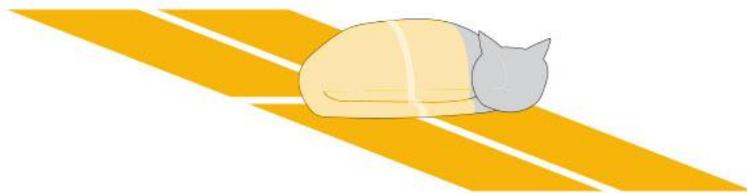


Agenda

1. Overview of major differences between LEED v2009 & LEED v4
2. LEED v4 Daylighting EQc7: Compliance Paths
3. Daylighting Metrics: How to Engage & Interpret
4. Going Beyond the Workplane
5. Advanced Topics
6. Daylight Metrics In-Class Exercise
7. Case Study/Demo
8. Q&A

How do you use daylighting?

- Architects? Consultants? Lighting Designers? Engineers? Students? Software Developers?
- Who has pursued the LEED v2009 daylight credit?
- Who has pursued the LEED v4 daylight credit?
- What specifically do you want to get from this talk?



LEED v2009 vs. LEED v4: Intent

To provide building occupants with a connection between indoor spaces and the outdoors through the introduction of daylight and views in the the regularly occupied areas of the building.

LEED v2009 IEQc8.1 - Daylight



To connect building occupants with the outdoors, **reinforce circadian rhythms**, and **reduce the use of electrical lighting** by introducing daylight into the space.

LEED v4 EQc7 - Daylight



LEED v2009 vs. LEED v4: Daylight Prevalence

Indoor Environmental Quality: 4/15



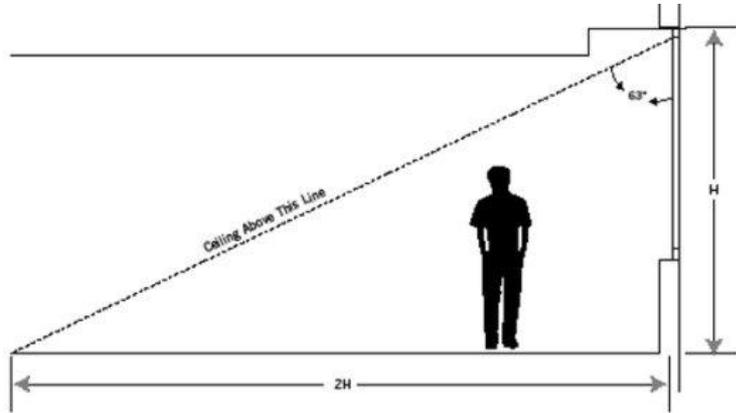
LEED v2009 IEQc8.1 - Daylight

Indoor Environmental Quality: 6/16



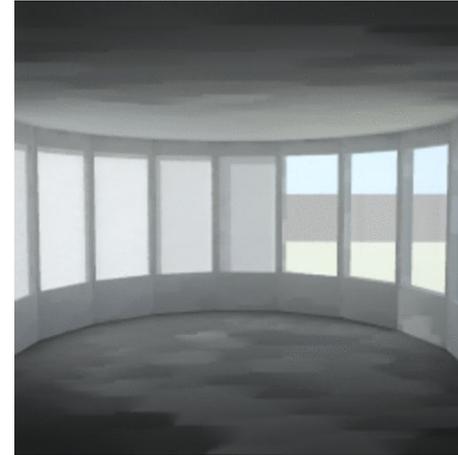
LEED v4 EQc7 - Daylight

LEED v2009 vs. LEED v4: Process



Allows simplified **prescriptive** path for full credit.

LEED v2009 IEQc8.1 - Daylight



March 21, 09:00 AM

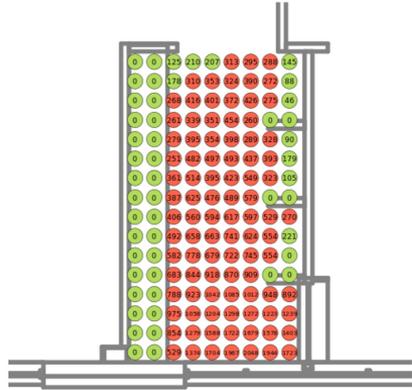
Requires robust **annual simulation** (ASE & sDA) for full credit.

LEED v4 EQc7 - Daylight

LEED v4 Daylighting EQc7: Compliance Paths

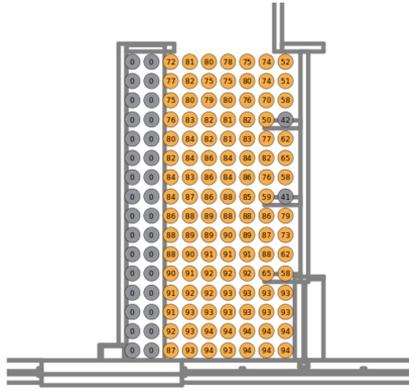
ASE

✗ 65.28 %



sDA

✓ 75.69 %



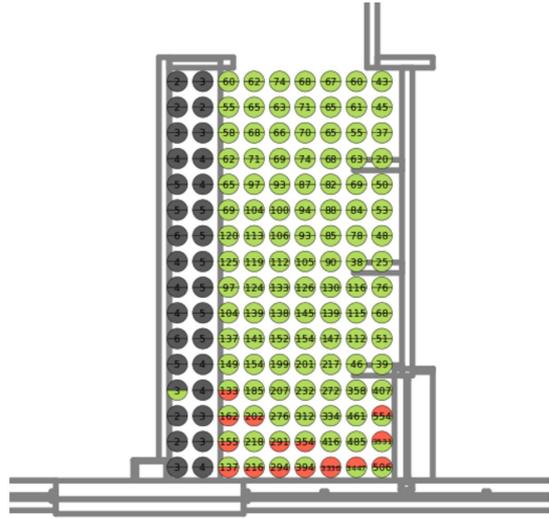
Option 1 (2-3 Points): Simulation: Spatial Daylight Autonomy (sDA) & Annual Sunlight Exposure (ASE)

1. Demonstrate through annual computer simulations that Spatial Daylight Autonomy_{300/50%} of at least 55%, 75%, or 90% is achieved. Use regularly occupied floor area.
2. Demonstrate through annual computer simulations that Annual Sunlight Exposure_{1000,250} of no more than 10% is achieved. Use regularly occupied floor area that is daylit per the sDA simulations.

A Complete Picture of Daylight, D. Glaser
Pacific Energy Center, 6/9/2016
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LEED v4 Daylighting EQc7: Compliance Paths

✗ 67.36% September 21, 9:00am & 3:00pm



Option 2 (1-2 Points): Simulation: Illuminance Calculations

1. Demonstrate through computer modeling that illuminance levels will be between 300 lux and 3,000 lux for 9 a.m. and 3 p.m., both on a clear-sky day at the equinox. Use regularly occupied floor area.

Daylighting Metrics: How to Engage & Interpret

How to Simulate for Daylight?



Varies by Sky Type



Varies by Season



Varies by Hour





Precedents: DA, cDA, & UDI

Daylight Autonomy (DA)

*The percentage of the time-in-use that a certain user-defined lux threshold is reached through the use of just **daylight**. DA is a useful metric for determining potential savings with an on/off dimming system.*



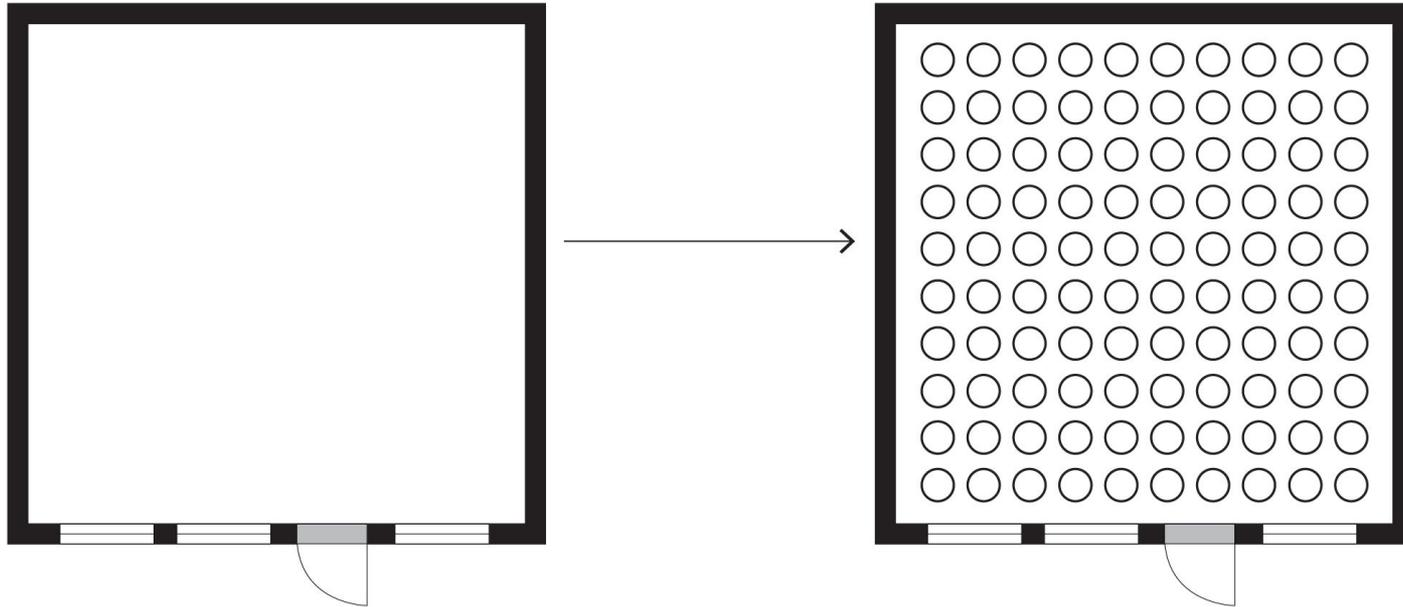
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Pacific Energy Center, 6/9/2016
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Daylight Autonomy (DA)

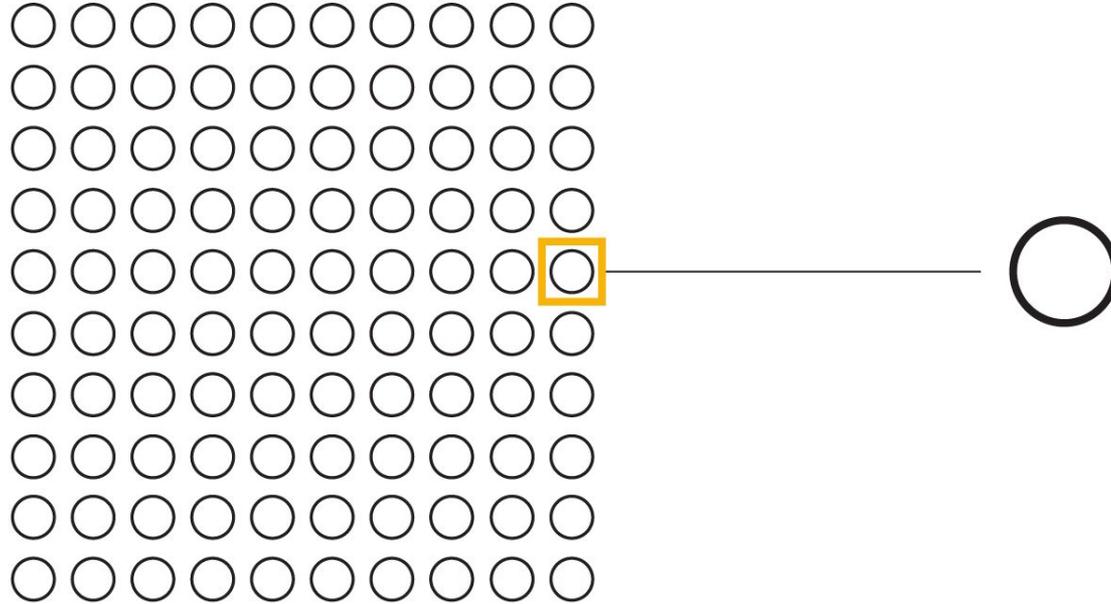
*The percentage of the time-in-use that a certain user-defined lux threshold is reached through the use of just **daylight**. DA is a useful metric for determining potential savings with an on/off dimming system.*



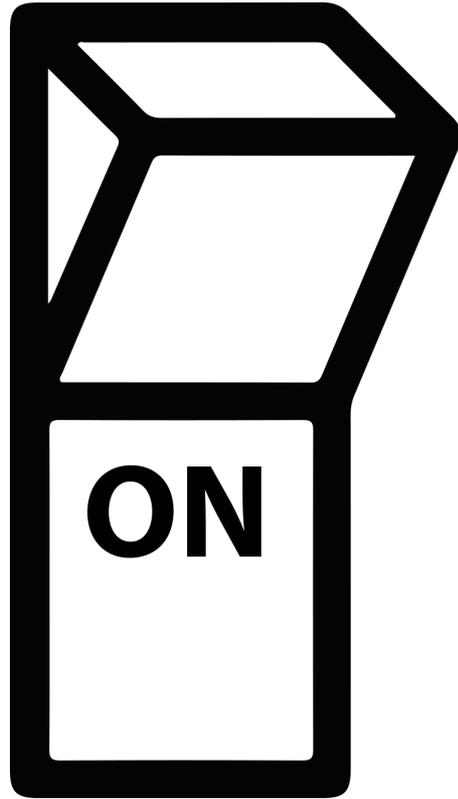
Create A Grid



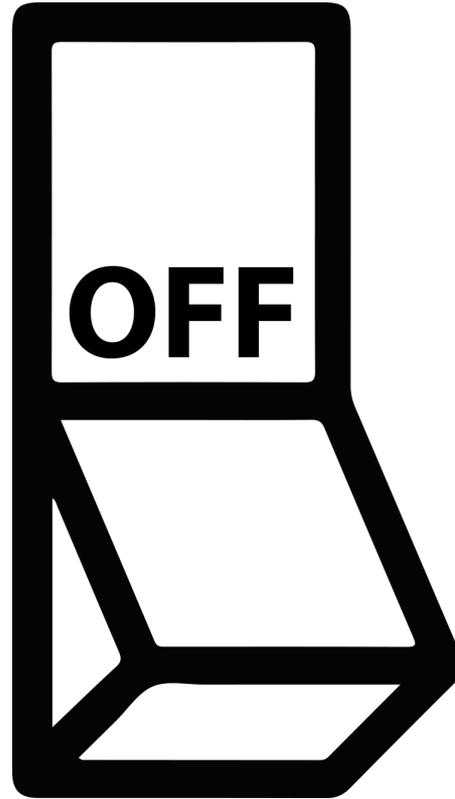
Start By Looking at a Single Point



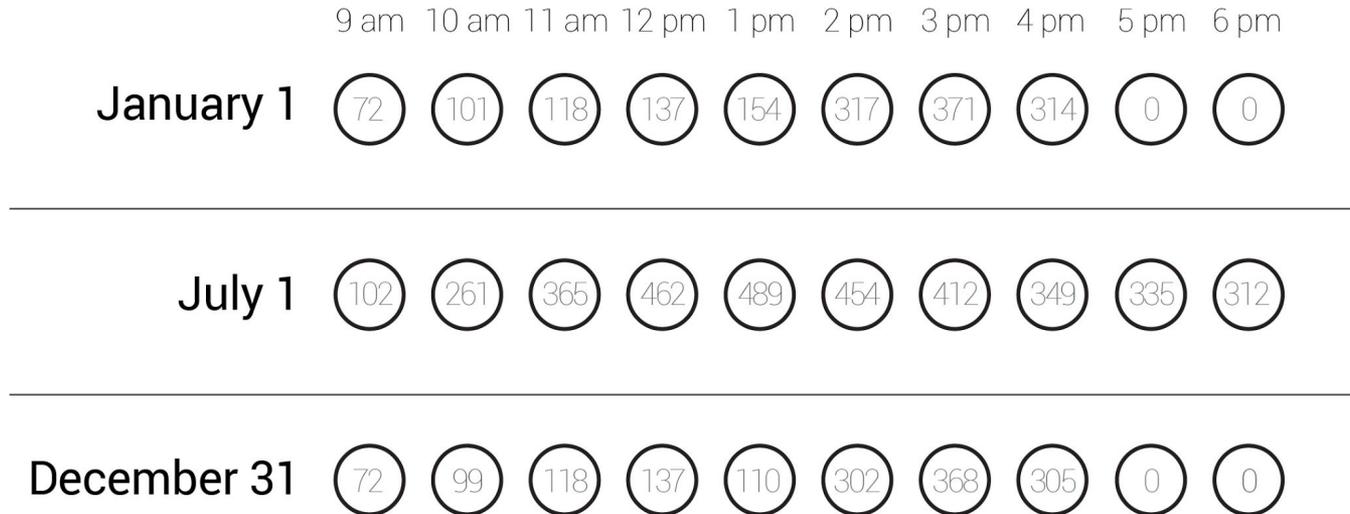
23



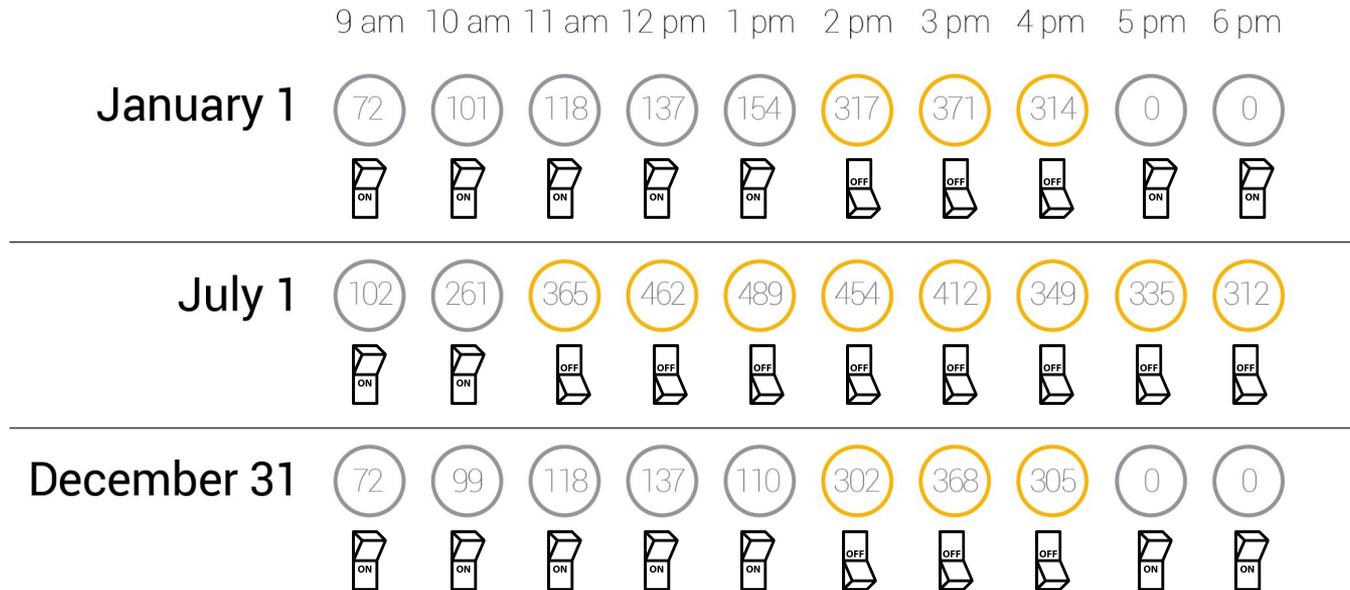
342



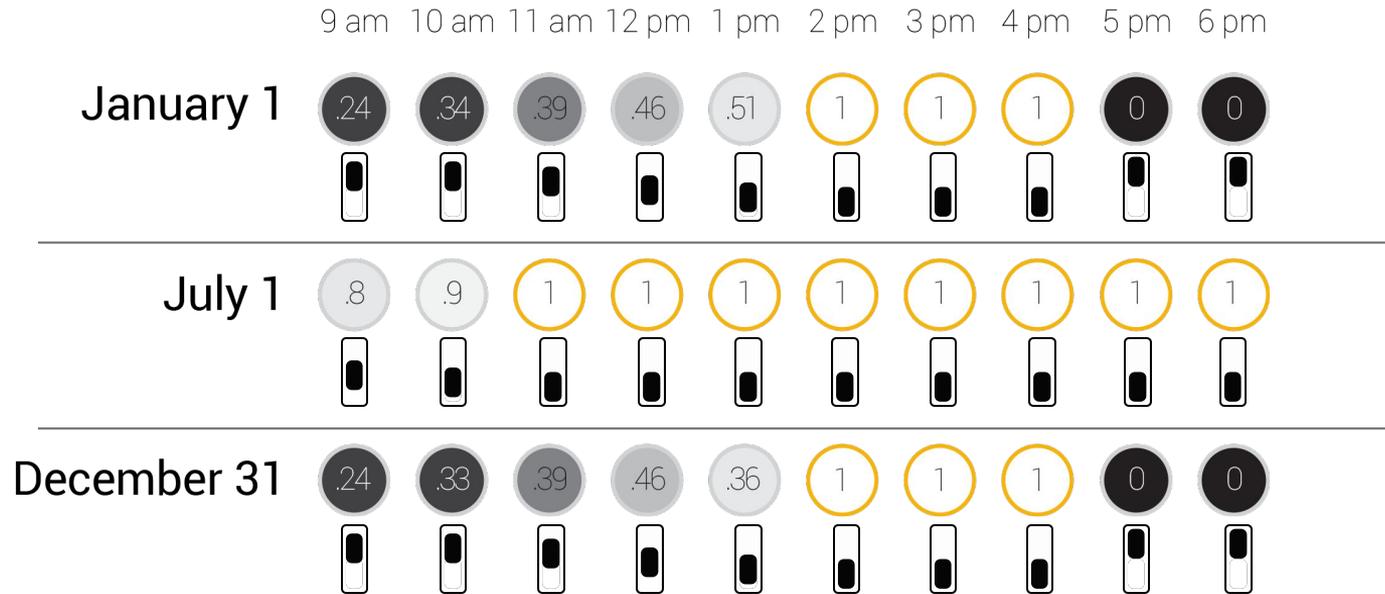
Measure Point's Illuminance Hourly



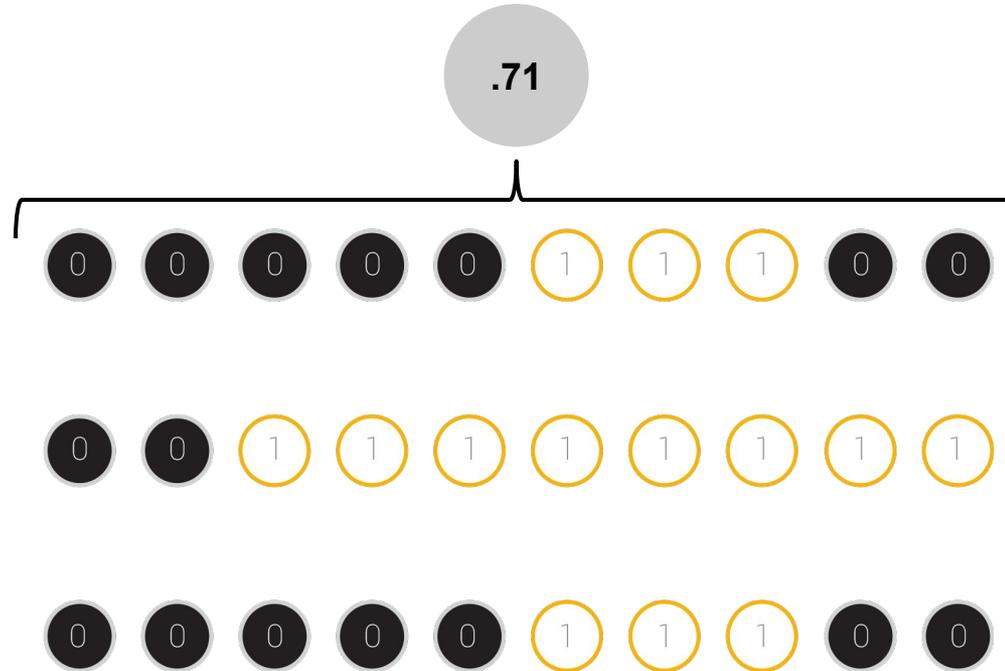
Determine if Point Meets Target Threshold (300 lux)



Continuous Daylight Autonomy (cDA) - Partial Credit

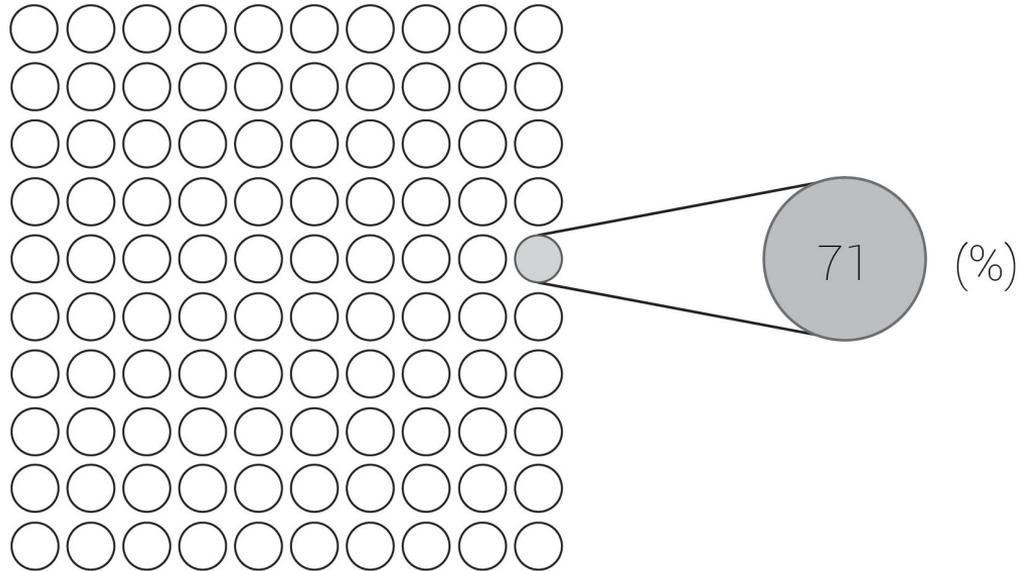


Average Across Year

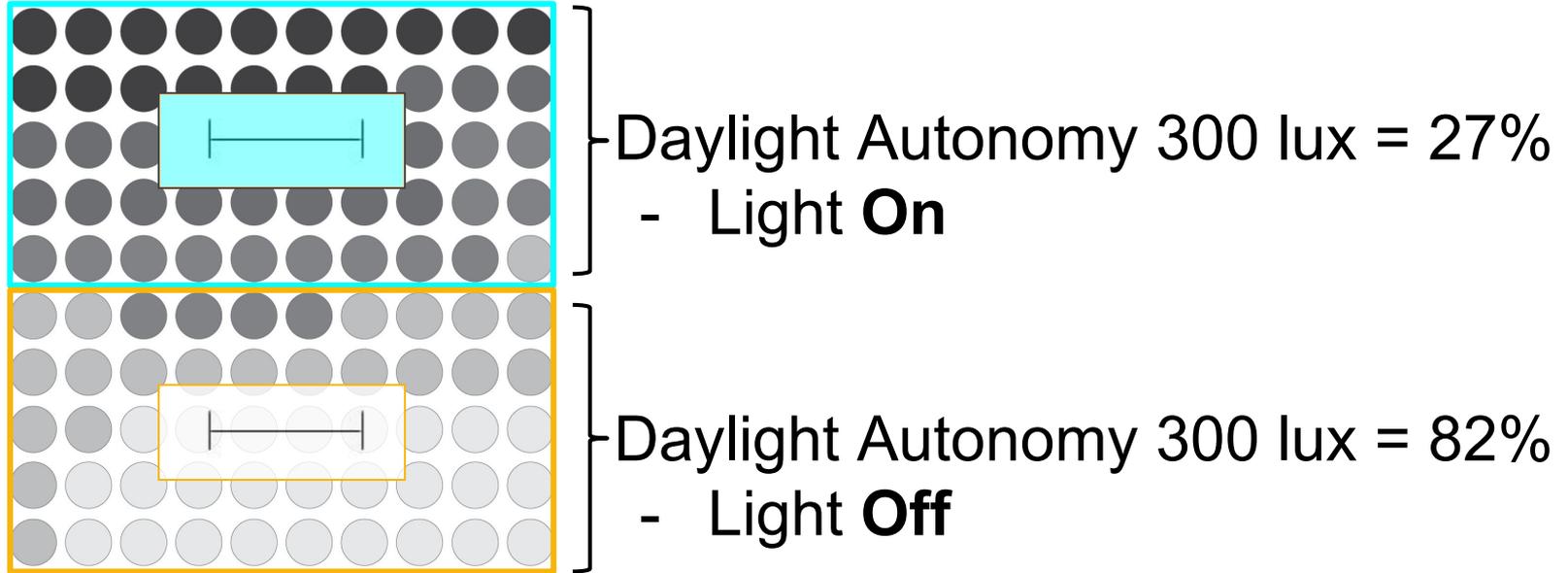


Score Each Point

Percent of time at or above illuminance threshold of 300 lux



Final Result

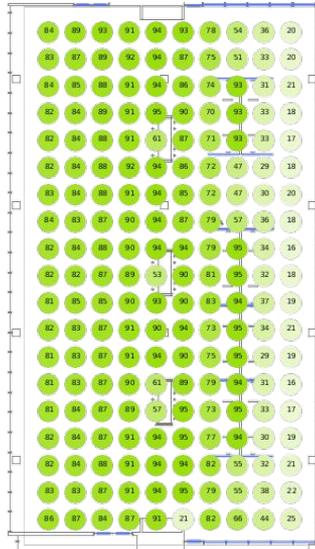


percent of time meeting target illuminance of 300 lux (with partial credit)



Useful Daylight Illuminance (UDI)

72.39 %



percent of time within target illuminance range (100 - 3000 lux)



The New LEED v4 Metrics: ASE & sDA

ASE 1000 250h



ASE_{1000, 250h}

Annual Sunlight Exposure



Annual Sunlight Exposure: First Measure Workplane



Workplane
30" off floor

A Complete Picture of Daylight, D. Glaser
Pacific Energy Center, 6/9/2016
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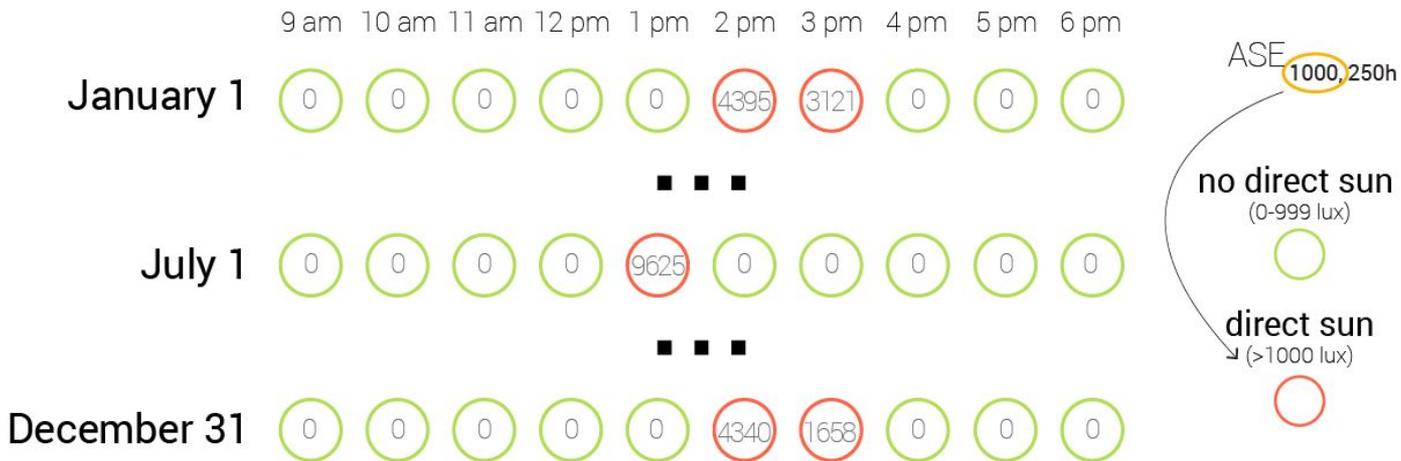
Evaluate Lighting Levels

3,438h 

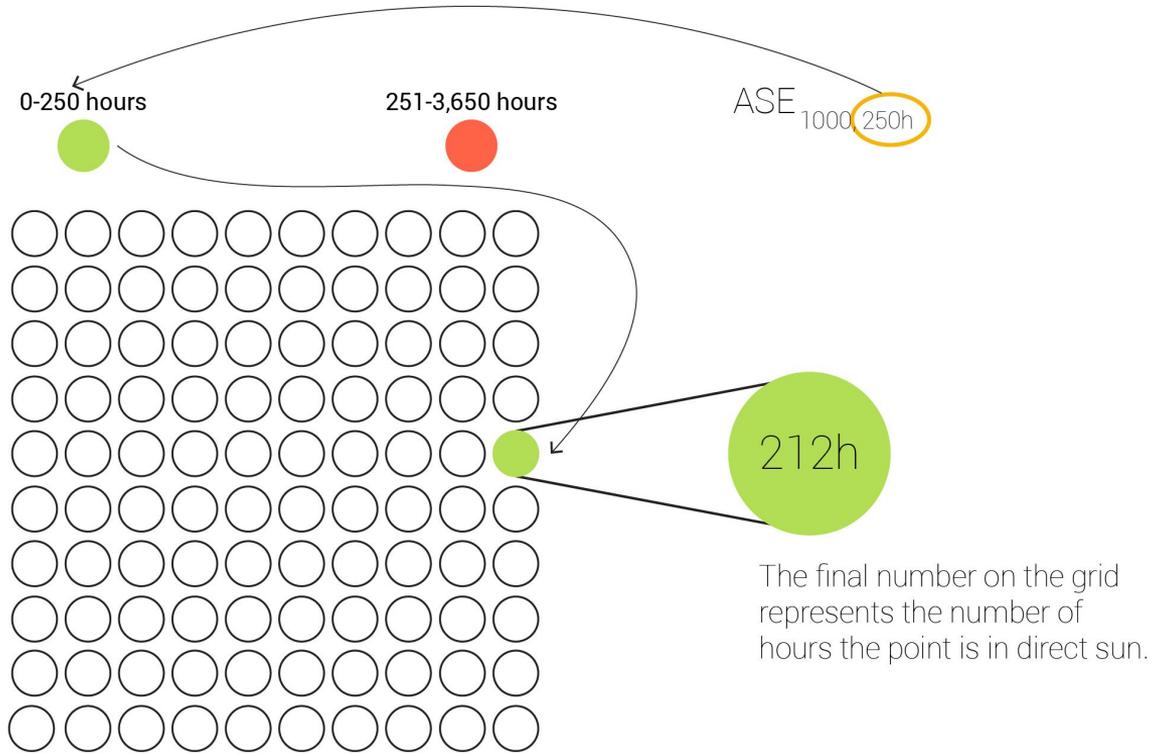
The point is not in direct sun for 3,438 hours.

 212h

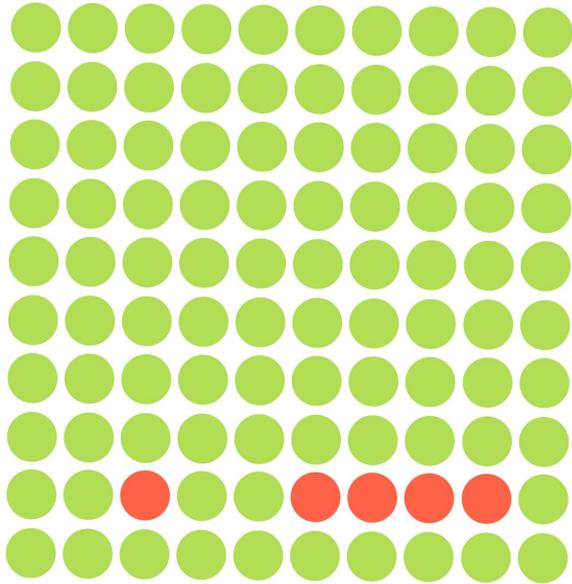
The point is in direct sun for 212 hours.



Score Each Point



Final Result



0-10% - acceptable

10.01-100% - unacceptable

95



Points on the grid that
are in direct sun for
less than 250 hours.

5

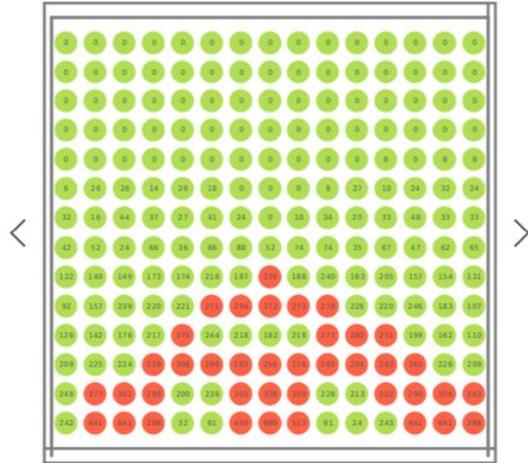


Points on the grid that
are in direct sun for
more than 250 hours.

5% - *acceptable*

Classroom Example: No Overhangs or Shelves

✗ 18.57 %

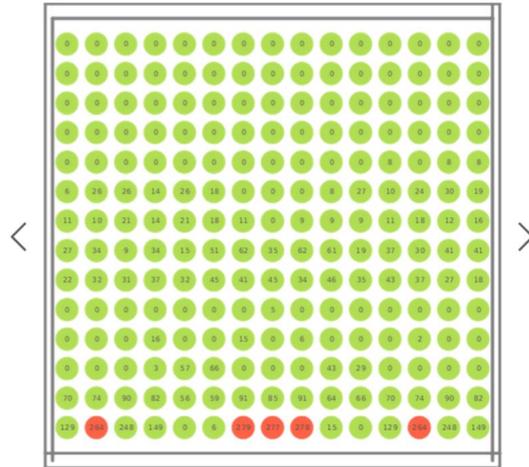


Hours of direct sun/year



Classroom Example: With Overhangs and Shelves

✓ 2.38 %



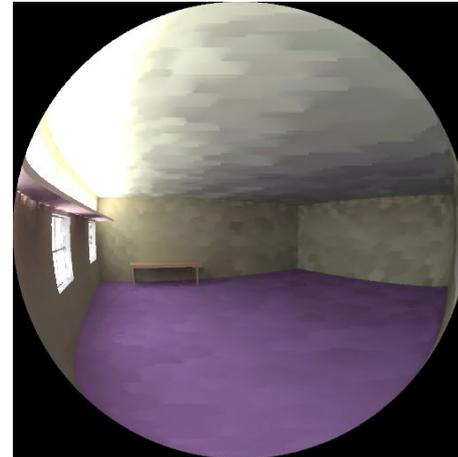
Hours of direct sun/year



<250h



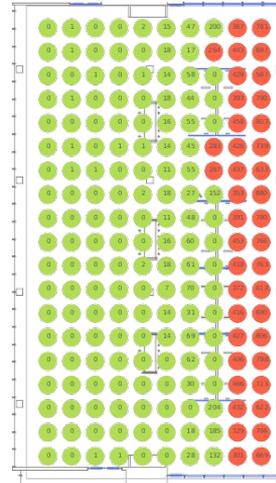
>250h



Office Example

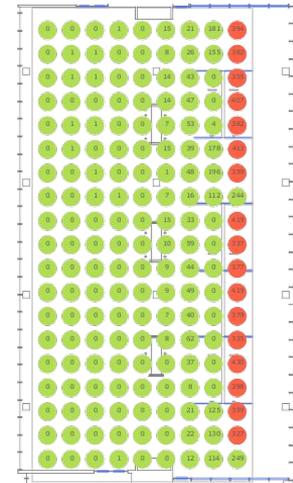


ASE = 21.5% ✗



Removal of
Circulation Area:

ASE=9.5% ✓



Hours of direct sun/year

<250h

>250h

Institutional Example



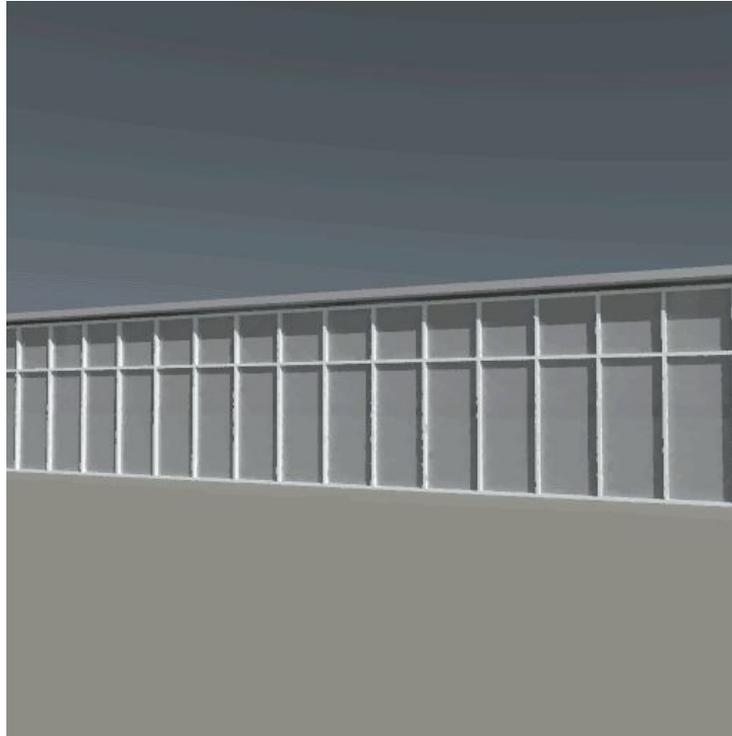
SDA_{300/50%}



Blinds Operation Informs Electricity Use



Blinds Operation: Human Aspect

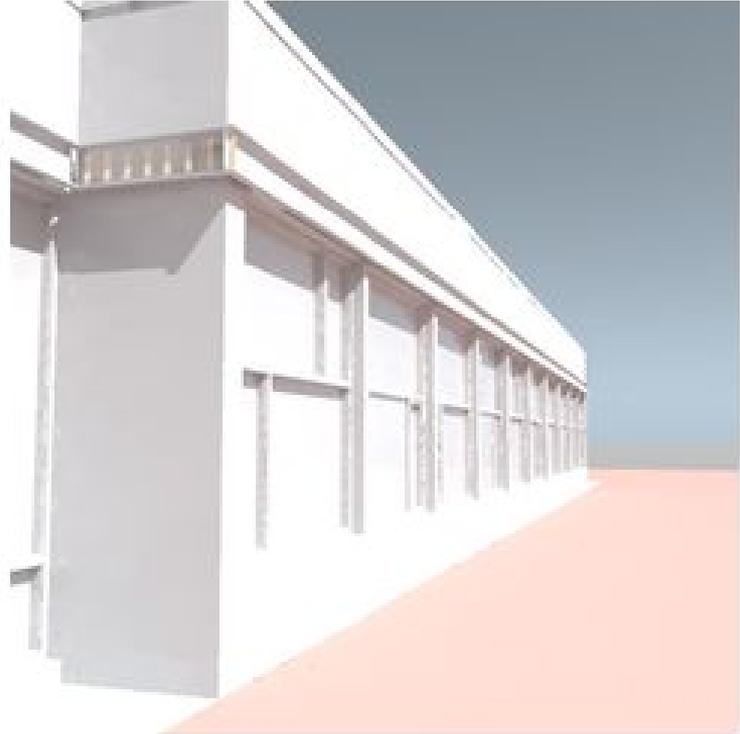


March 21, 09:00 AM



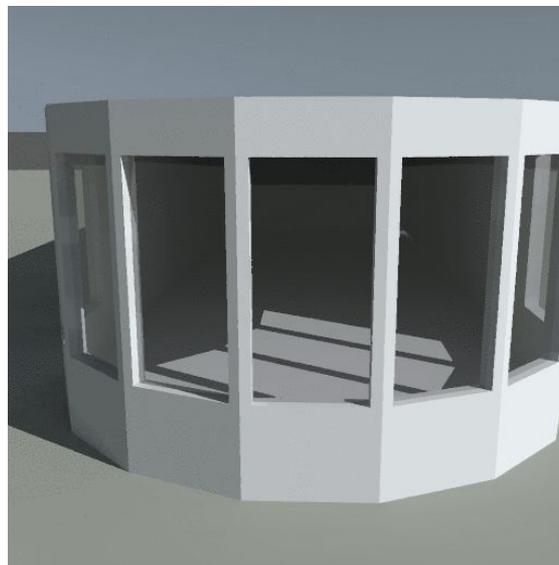
March 21, 09:00 AM

sDA Measures Realistic Daylight Availability



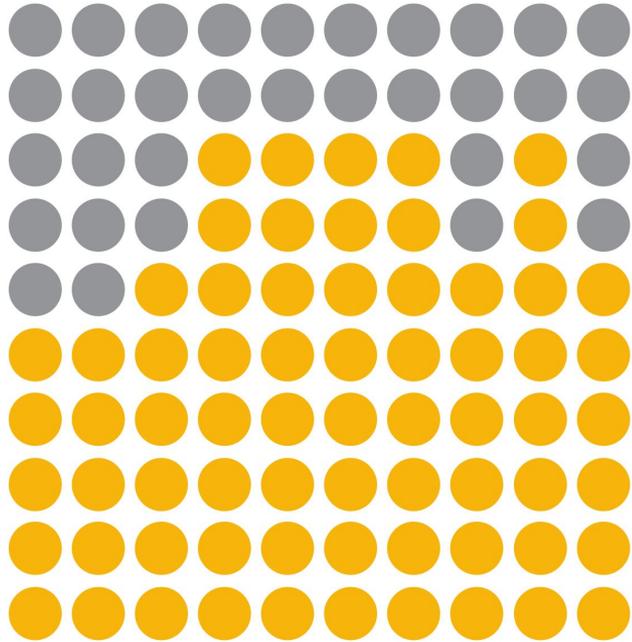


March 21, 09:00 AM
40.015, -105.271
Blinds sDA Specification



March 21, 09:00 AM
40.015, -105.271
Blinds sDA Specification

sDA_{300/50%} Sample Space



68



Points on the grid meet the threshold for at least 50% of the time.

32



Points on the grid do not meet the threshold for at least 50% of the time.

68% - *nominally acceptable*

0-54.99% - unacceptable

55-74.99% - nominally acceptable (2 points)

75-100% - preferred (3 points)

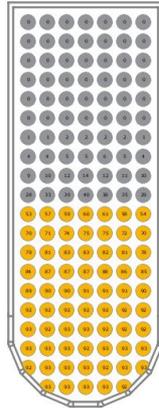
Over Predicting Daylight Availability

WITH BLINDS

Spatial Daylight Autonomy_{300,50%} (SDA)
Workplane



✗ 49.28 %



% of time at minimum illuminance threshold



(0-1,824 hours)



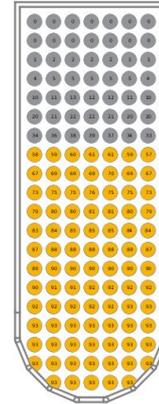
(1,825-3,650 hours)

WITHOUT BLINDS

Spatial Daylight Autonomy_{300,50%} (SDA)
Workplane



✓ 64.49 %



% of time at minimum illuminance threshold

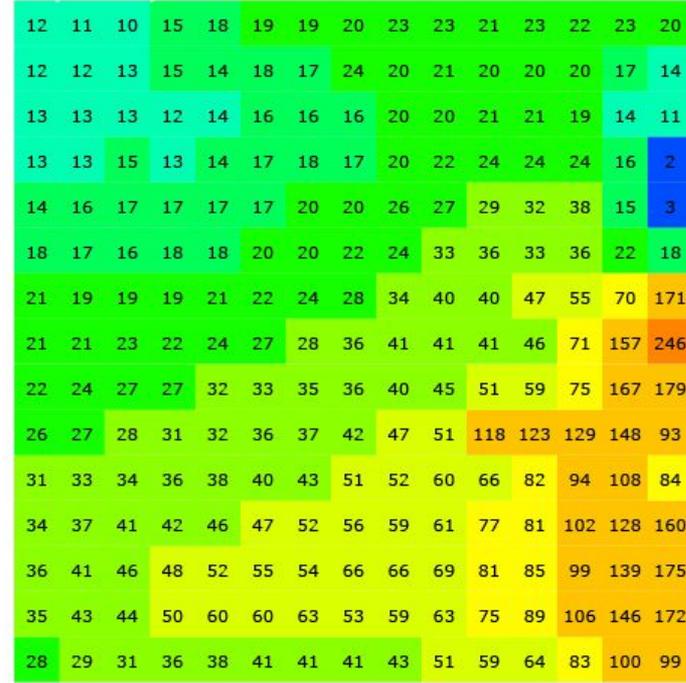


(0-1,824 hours)



(1,825-3,650 hours)

Workplane Limitations



Going Beyond the Workplane

New Standards Like WELL™ Focus on Occupant Comfort

1. Lack of exposure to natural light has harmful effects on quality of sleep, level of alertness, emotional state, and overall wellbeing.
2. Up and coming protocols to help the body maintain circadian alignment and achieve:
 - a. ideal lighting levels for various tasks
 - b. reduced eye-strain and glare
 - c. increased alertness
 - d. improved quality of sleep
 - e. decreased seasonal affective disorder
 - f. Vitamin D synthesis



*CBRE Headquarters, Los Angeles, CA
First WELL Certified™ Office*

Qualitative Measurements for Occupant Comfort

June 21, 12:00 pm



34,833.4 max 0.0 min 650.9 avg 0.0 avg/min 53.5 max/avg 0.0 max/min

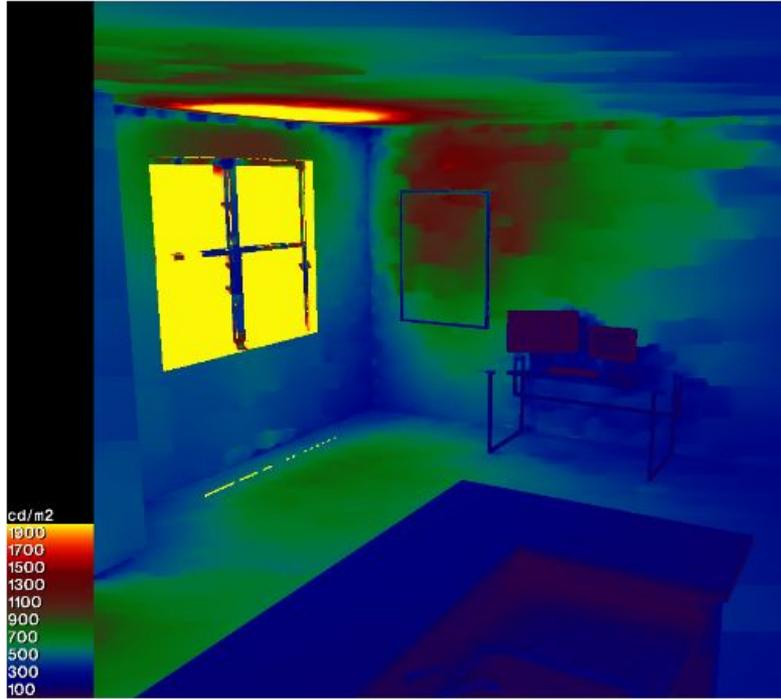
December 21, 12:00 pm



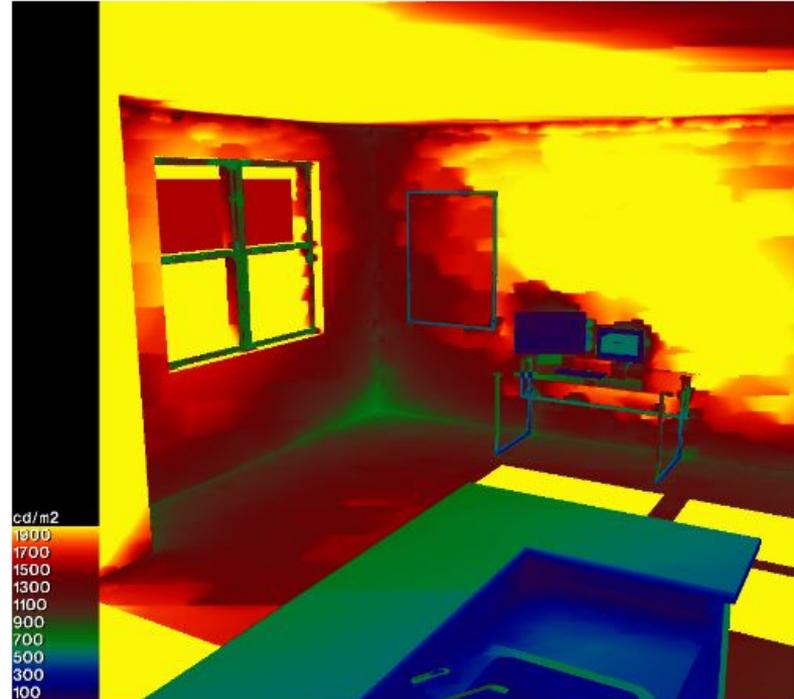
10,997.8 max 0.0 min 1,455.7 avg 0.0 avg/min 7.6 max/avg 0.0 max/min

Qualitative Measurements for Occupant Comfort

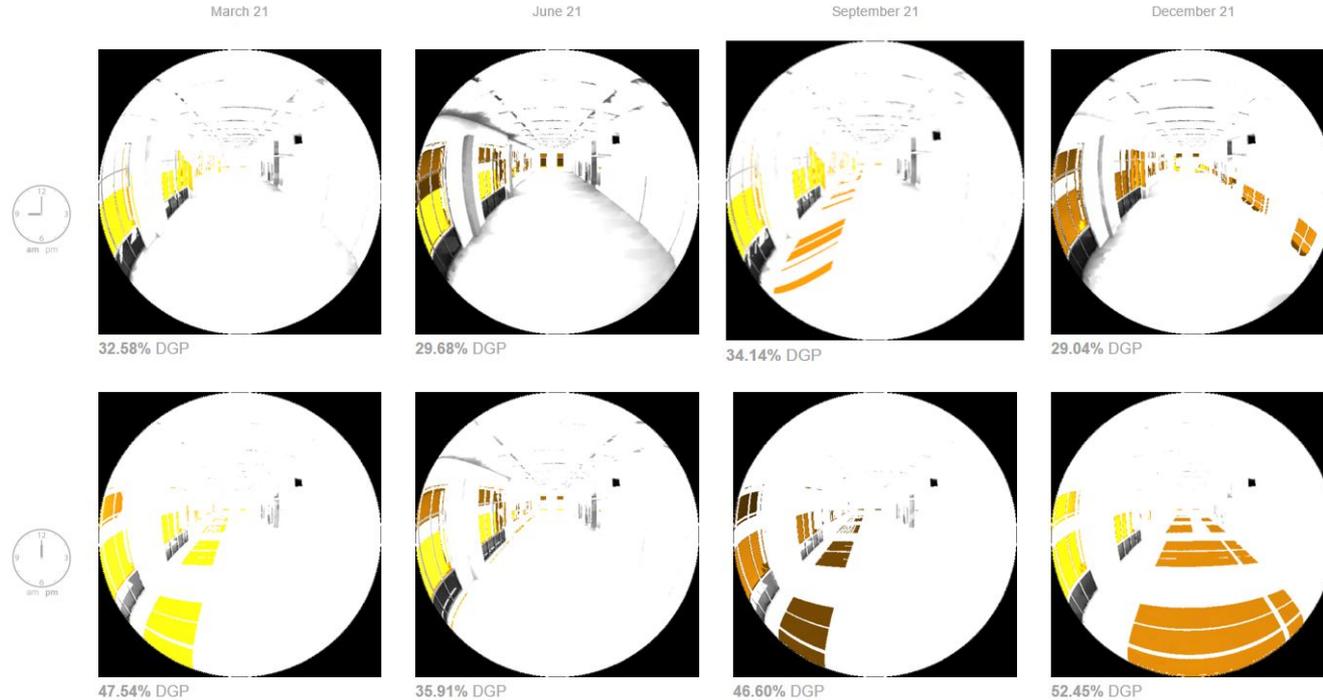
June 21, 12:00 pm



December 21, 12:00 pm



Daylight Glare Probability



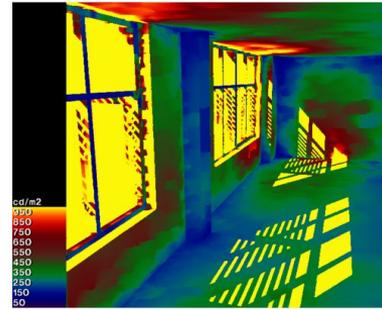
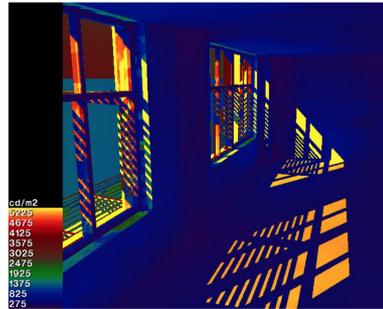
0-35% Imperceptible, 35-40% Perceptible, 40-45% Disturbing, 45-100% Intolerable

Iterations of Glazing Properties

40% Window Transmittance (VLT)



60% Window Transmittance (VLT)



Model Design by RNL Design

Experiment with Different Products

80% VT



December 21, 12:00 PM

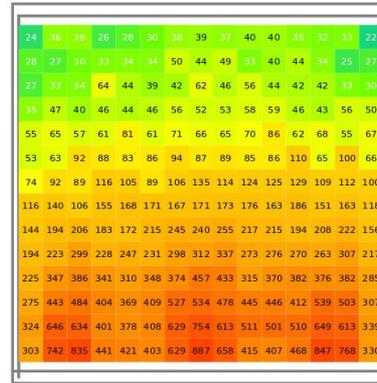


December 21, 12:00 PM

Redirecting Film 1

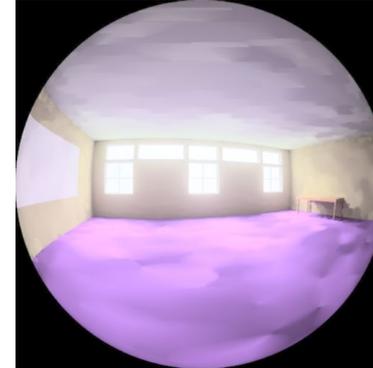


December 21, 12:00 PM

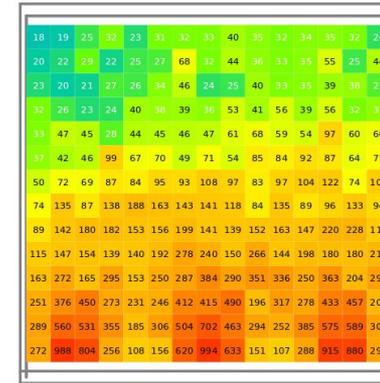


December 21, 12:00 PM

Redirecting Film 2



December 21, 12:00 PM



December 21, 12:00 PM

Iterations of Glazing Properties

Open Office 123 windows at **60% VT**



ASE score **15.07%**

Open Office 123 windows at **40% VT**



ASE score **10.96%**

Case Study: Focus on Details

LightStanza [Home](#) [Projects](#) [More](#)

Projects > Green Schools > K8 School2 expl 13 no vertical > aspen No trellis : Analyze **Model Setup**

aspen No trellis simple advanced Load settings from Cancel Save As

Materials Window Groups Site Layers Illuminance Grids Viewpoints

- Translucent_Glass_Tinted 91.8%
- [Translucent_Glass_Tinted]1 91.8%
- [Translucent_Glass_Tinted]1 91.8%

Translucent

Material	Properties
	DT ST DR SR A RA
<input type="checkbox"/> Google Earth Snapshot	30.8%
<input type="checkbox"/> Google Earth Snapshot#1	32.4%
<input type="checkbox"/> Google Earth Snapshot#2	28.3%
<input type="checkbox"/> ground plane	31.8%
<input type="checkbox"/> metal locker	74.8%
<input type="checkbox"/> Metal_Aluminum_Anodized	81.7%
<input type="checkbox"/> SketchUp Default	50.2%
<input type="checkbox"/> Sophie_Skin	60.5%
<input type="checkbox"/> wood	60.5%
<input type="checkbox"/> Wood_Board_Cork	77.6%

Opaque

Material	Color	Ref.
<input type="checkbox"/> Google Earth Snapshot		30.8%
<input type="checkbox"/> Google Earth Snapshot#1		32.4%
<input type="checkbox"/> Google Earth Snapshot#2		28.3%
<input type="checkbox"/> ground plane		31.8%
<input type="checkbox"/> metal locker		74.8%
<input type="checkbox"/> Metal_Aluminum_Anodized		81.7%
<input type="checkbox"/> SketchUp Default		50.2%
<input type="checkbox"/> Sophie_Skin		60.5%
<input type="checkbox"/> wood		60.5%
<input type="checkbox"/> Wood_Board_Cork		77.6%

Daylight Product

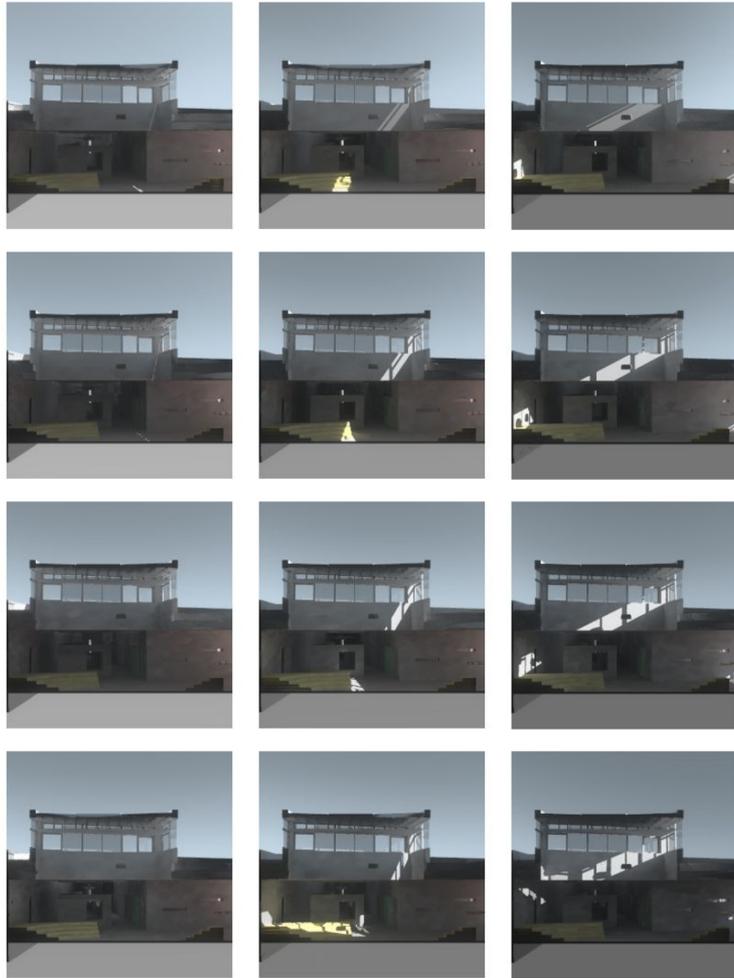
Material **Properties**

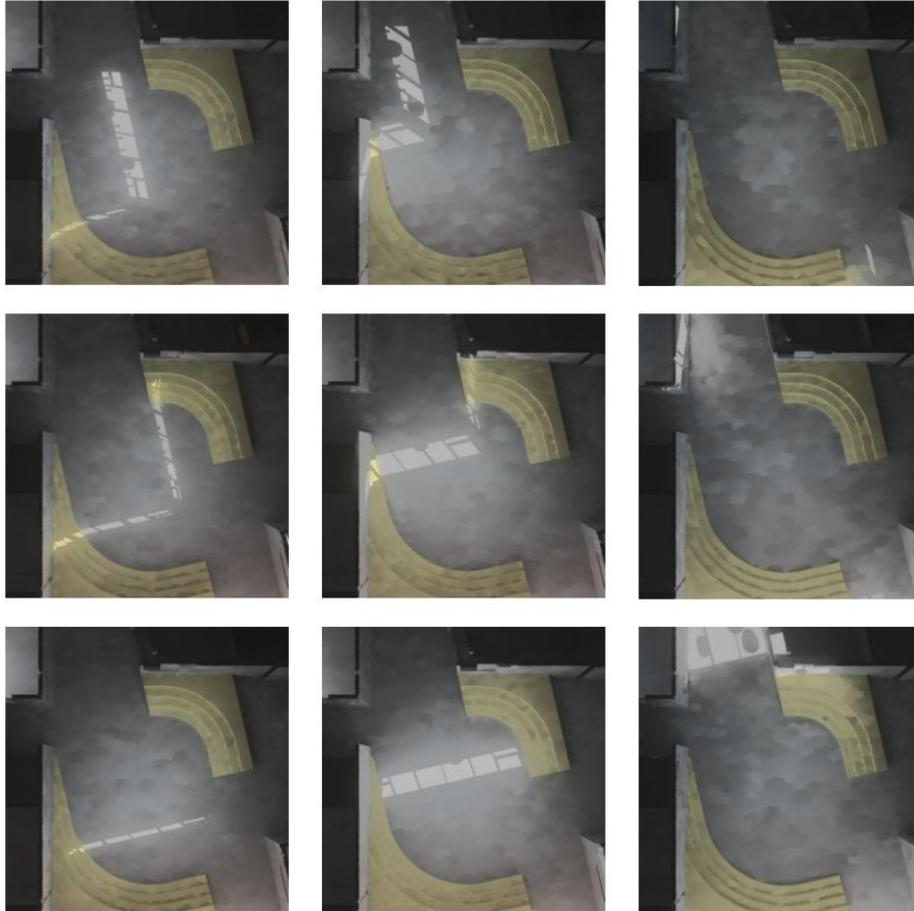
[+ Create material from scratch](#)



Cunningham Group, Architect of Record

A Complete Picture of Daylight, D. Glaser
Pacific Energy Center, 6/9/2016
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Untitled

simple advanced Cancel Save

Materials Window Groups Site Layers Illuminance Grids Viewpoints

Glazing Blinds Details

Multiple materials Properties Generic Custom Manufacturer

Glass Translucent Opaque

Cancel Okay

<input type="checkbox"/>	workplane E 90.0 2.4 m	[Translucent_Glass_Tinted]1	3% Shade Pewter	Dynamic
<input type="checkbox"/>	workplane E 90.0 3.0 m	Translucent_Glass_Tinted	3% Shade Pewter	Dynamic
<input type="checkbox"/>	workplane E 90.0 3.4 m	[Translucent_Glass_Tinted]1	3% Shade Pewter	Dynamic
<input type="checkbox"/>	workplane N 0.0 2.4 m	[Translucent_Glass_Tinted]1	3% Shade Pewter	Dynamic
<input type="checkbox"/>	workplane N 0.0 3.4 m	Translucent_Glass_Tinted	3% Shade Pewter	Dynamic
<input type="checkbox"/>	workplane N 0.0 4.1 m	[Translucent_Glass_Tinted]1	3% Shade Pewter	Dynamic
<input type="checkbox"/>	workplane N 0.0 6.7 m	Translucent_Glass_Tinted	3% Shade Pewter	Dynamic
<input checked="" type="checkbox"/>	workplane N 0.0 6.8 m	Polycarbonate 40% translucent	3% Shade Pewter	Dynamic
<input checked="" type="checkbox"/>	workplane N 0.0 7.0 m	Polycarbonate 40% translucent	3% Shade Pewter	Dynamic
<input type="checkbox"/>	workplane N 0.0 7.8 m	side monitor	3% Shade Pewter	Dynamic
<input type="checkbox"/>	workplane N 347.0 7.0 m	side monitor	3% Shade Pewter	Dynamic
<input type="checkbox"/>	workplane S 167.0 1.7 m	[Translucent_Glass_Tinted]1	3% Shade Pewter	Dynamic
<input type="checkbox"/>	workplane S 167.0 2.6 m	[Translucent_Glass_Tinted]1	3% Shade Pewter	Dynamic
<input type="checkbox"/>	workplane S 167.0 3.2 m	Translucent_Glass_Tinted	3% Shade Pewter	Dynamic
<input type="checkbox"/>	workplane S 167.0 3.9 m	[Translucent_Glass_Tinted]1	3% Shade Pewter	Dynamic
<input type="checkbox"/>	workplane S 167.0 6.5 m	Translucent_Glass_Tinted	3% Shade Pewter	Dynamic
<input type="checkbox"/>	workplane S 167.0 6.8 m	south monitor	3% Shade Pewter	Dynamic
<input checked="" type="checkbox"/>	workplane S 167.0 7.0 m	Polycarbonate 40% translucent	3% Shade Pewter	Dynamic
<input type="checkbox"/>	workplane S 180.0 2.1 m	[Translucent_Glass_Tinted]1	3% Shade Pewter	Dynamic
<input type="checkbox"/>	workplane S 180.0 3.3 m	Translucent_Glass_Tinted	3% Shade Pewter	Dynamic
<input type="checkbox"/>	workplane S 180.0 6.8 m	[Translucent_Glass_Tinted]1	3% Shade Pewter	Dynamic
<input type="checkbox"/>	workplane S 180.0 7.1 m	Translucent_Glass_Tinted	3% Shade Pewter	Dynamic
<input type="checkbox"/>	workplane W 270.0 2.1 m	[Translucent_Glass_Tinted]1	3% Shade Pewter	Dynamic
<input type="checkbox"/>	workplane W 270.0 2.4 m	[Translucent_Glass_Tinted]1	3% Shade Pewter	Dynamic
<input type="checkbox"/>	workplane W 270.0 3.9 m	[Translucent_Glass_Tinted]1	3% Shade Pewter	Dynamic
<input checked="" type="checkbox"/>	workplane W 270.0 6.8 m	Polycarbonate 40% translucent	3% Shade Pewter	Dynamic
<input checked="" type="checkbox"/>	workplane W 270.0 7.0 m	Polycarbonate 40% translucent	3% Shade Pewter	Dynamic
<input type="checkbox"/>	workplane W 275.0 1.6 m	[Translucent_Glass_Tinted]1	3% Shade Pewter	Dynamic
<input type="checkbox"/>	workplane W 275.0 2.1 m	[Translucent_Glass_Tinted]1	3% Shade Pewter	Dynamic
<input type="checkbox"/>	workplane W 275.0 2.8 m	[Translucent_Glass_Tinted]1	3% Shade Pewter	Dynamic
<input type="checkbox"/>	workplane W 275.0 3.3 m	Translucent_Glass_Tinted	3% Shade Pewter	Dynamic

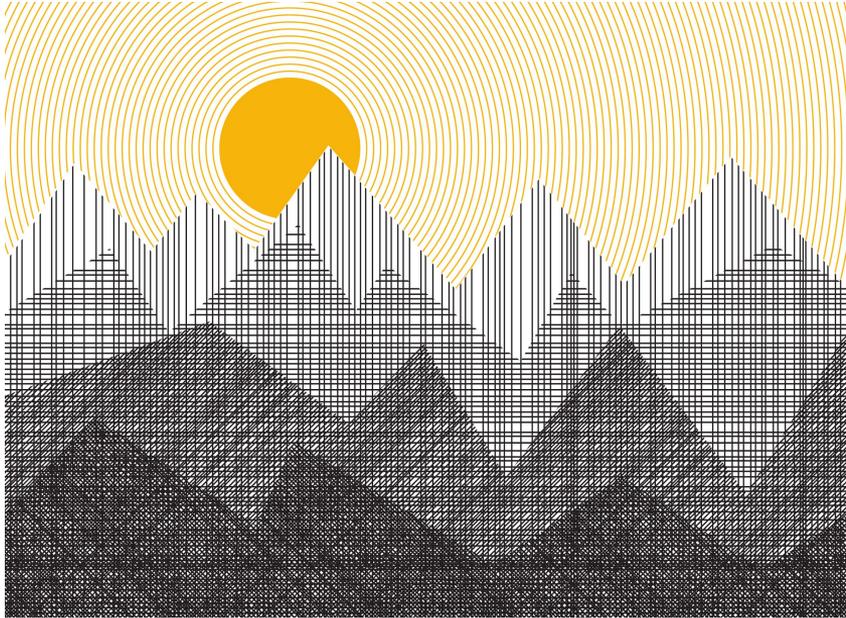


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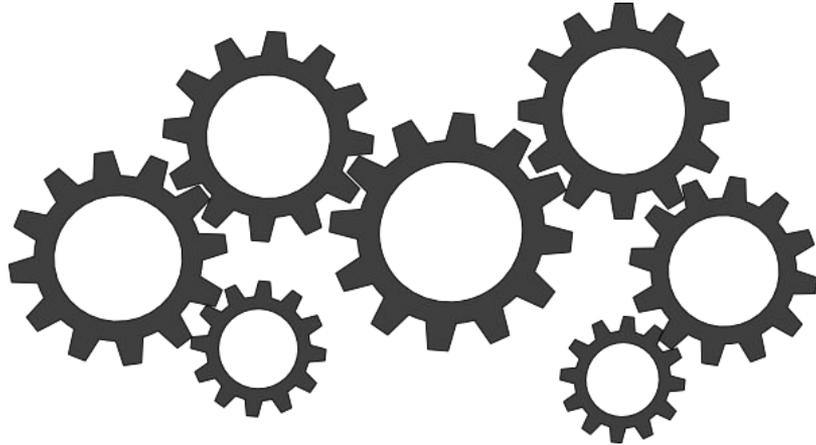
Cunningham Group, Architect of Record

Summary



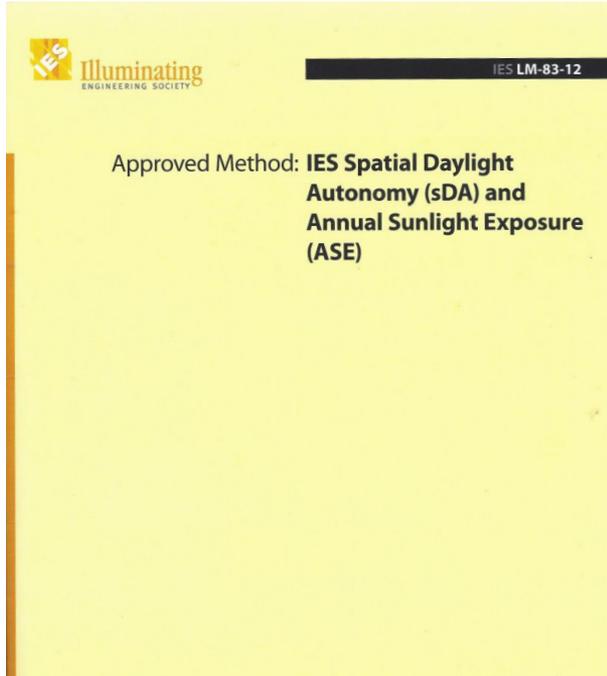
- LEED v2009 vs. LEED v4
- Daylight metrics are complicated, important for LEED v4 Credit
 - ASE, sDA
 - Think beyond the workplane
- Go beyond the workplane!
 - Occupant well-being
 - Point-in-time analysis; false color
 - Glazing, wall thickness, etc.
 - Climate variability

Advanced (But important!)



- Modeling Details
- Grid spacing
- Occupied Spaces
- Window Groups
- 2% Rule

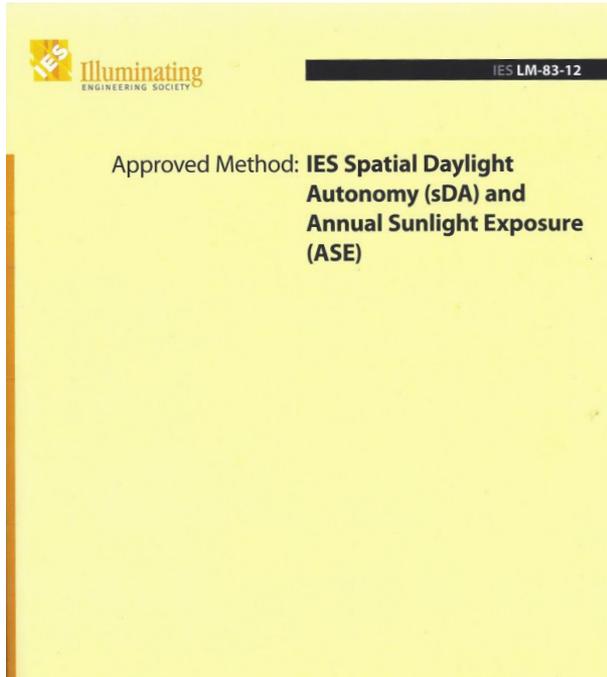
Modeling Details (IES LM-83-12 Excerpts)



2.2.8 Exterior Obstructions Exterior obstructions shall be modeled using at least the minimum level of detail described below.

1. Model all buildings and opaque structures within at least 100' of the spaces under study, including any surfaces of the modeled building itself. Such exterior obstructions shall be modeled with at least a resolution of 10' increments in dimensions.
2. Model trees as appropriately sized cones, spheres, or cylinders with 20% reflective component. More accurate shapes are allowable.

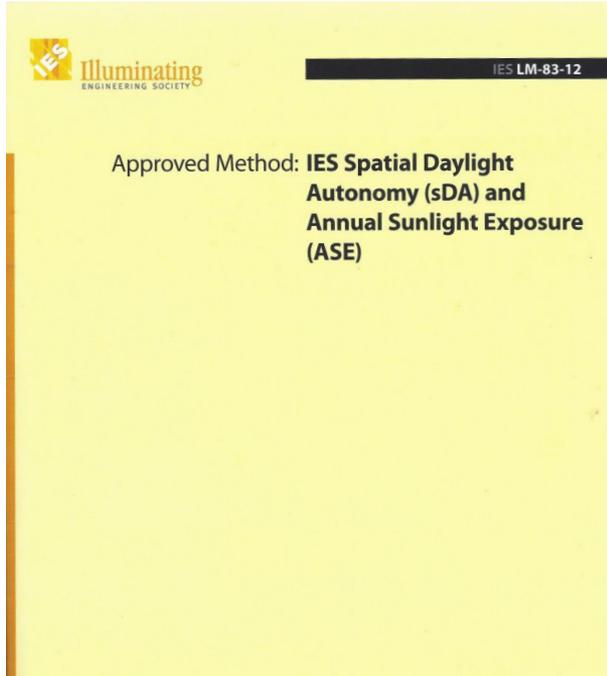
Modeling Details (IES LM-83-12 Excerpts)



2.2.9 Window openings should be modeled in three dimensions, per below.

2. Any window detail (sills, jambs, mullions, etc) greater than 2" in any dimension shall be modeled as such.

Modeling Details (IES LM-83-12 Excerpts)

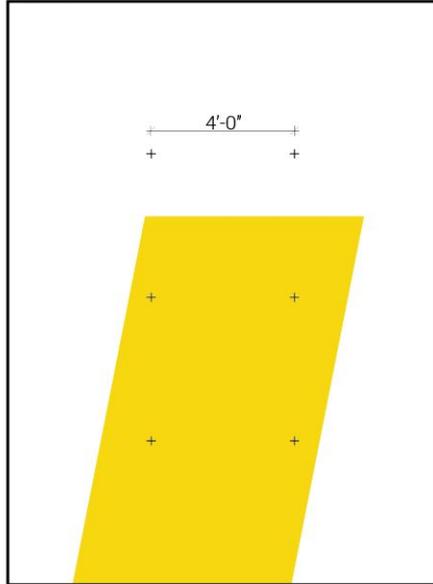


2.2.11 Furniture and Partitions Furniture and opaque interior partitions shall be modeled.

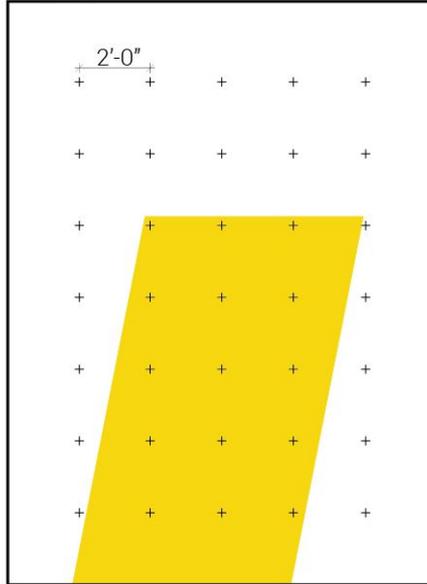
1. Any partition or furniture element extending 36" above the floor or more shall be modeled to within 6" accuracy.

Grid Spacing Matters!

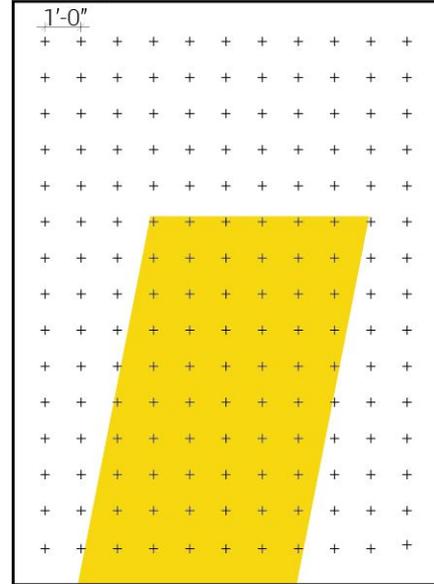
4'-0" point spacing
6 grid points



2'-0" point spacing
35 grid points



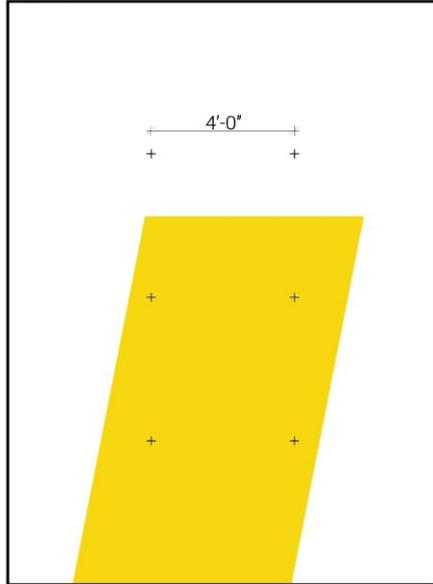
1'-0" point spacing
165 grid points



Grid Spacing Matters!

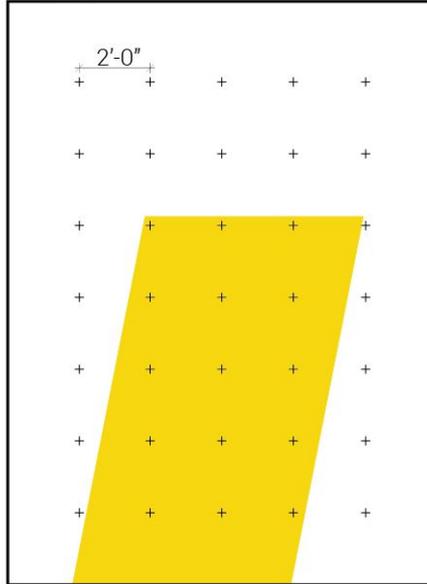
4'-0" point spacing
6 grid points

67%



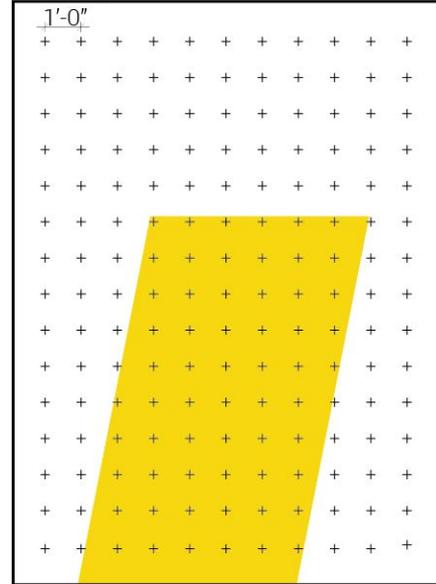
2'-0" point spacing
35 grid points

42%



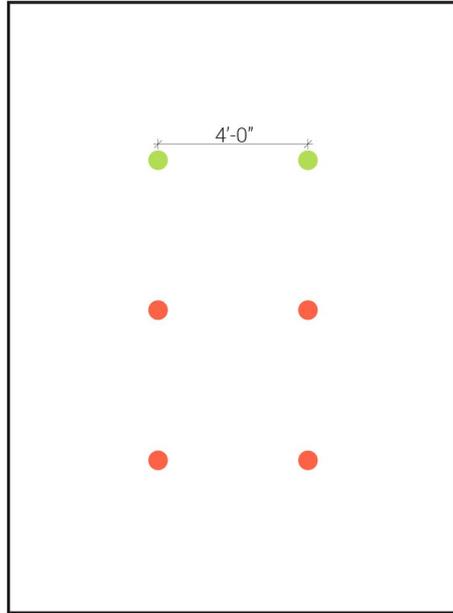
1'-0" point spacing
165 grid points

33%

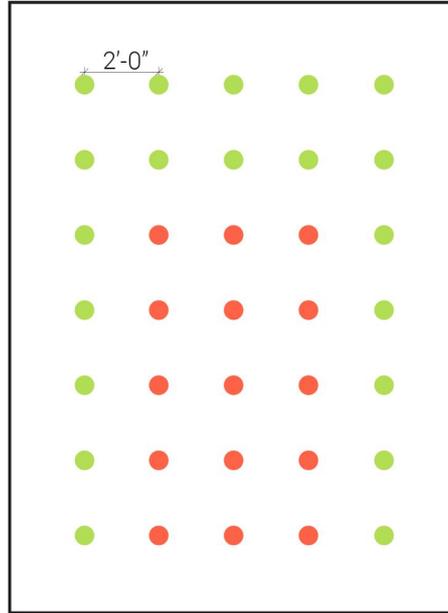


Grid Spacing Matters!

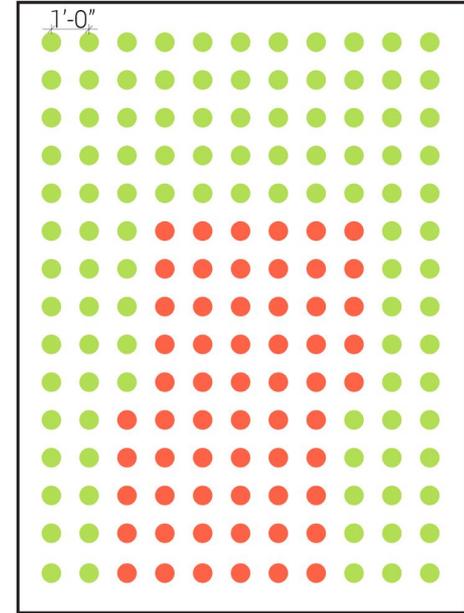
4'-0" point spacing
6 grid points



2'-0" point spacing
35 grid points



1'-0" point spacing
165 grid points

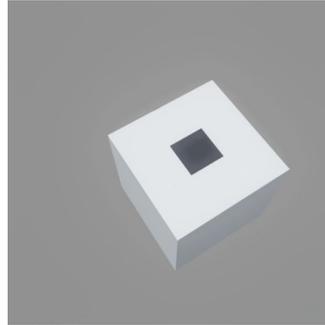


Focus on Workplane in Occupied Spaces

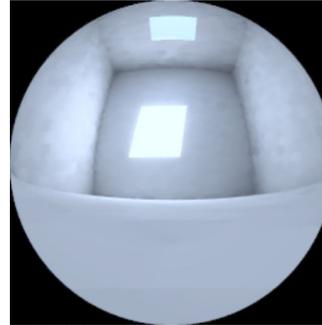


Wall/Ceiling Thickness, Skylights

< 1in ceiling thickness
3x3 foot skylight



June 21, 03:00 PM

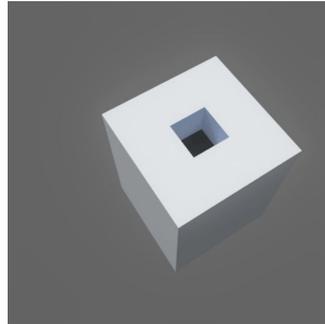


June 21, 03:00 PM

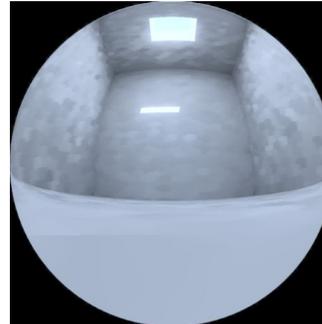


June 21, 03:00 PM

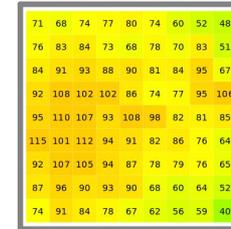
3ft ceiling thickness
3x3 foot skylight



June 21, 03:00 PM



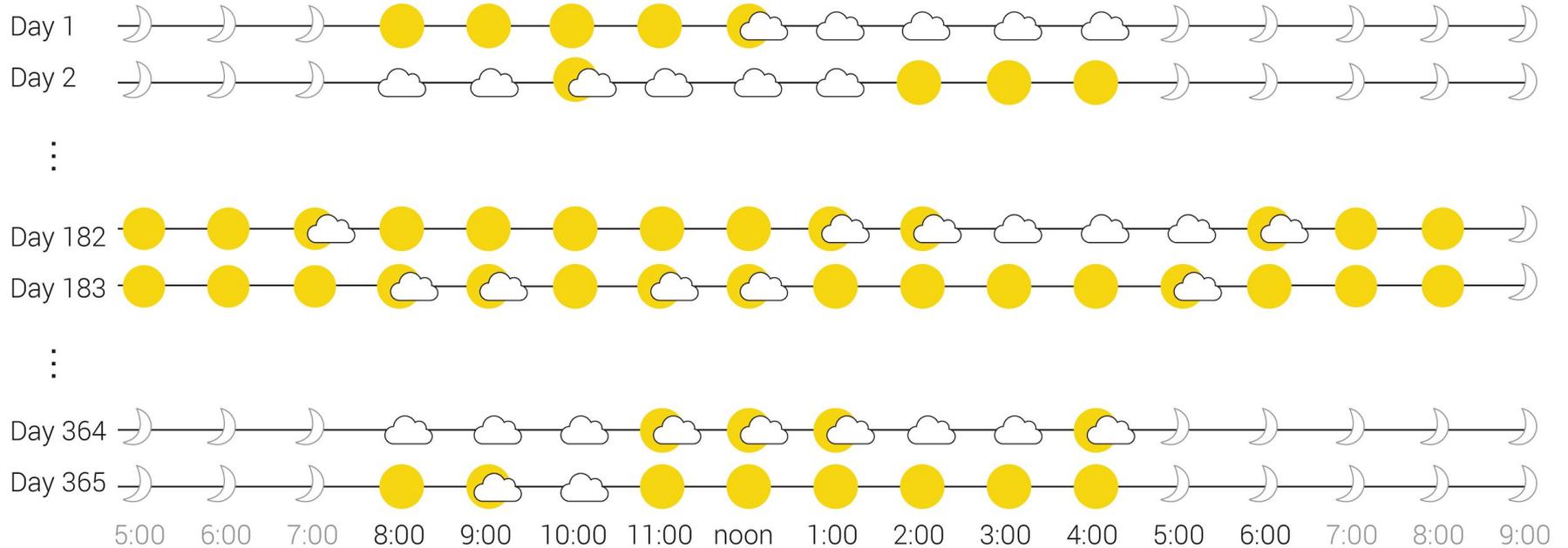
June 21, 03:00 PM



June 21, 03:00 PM

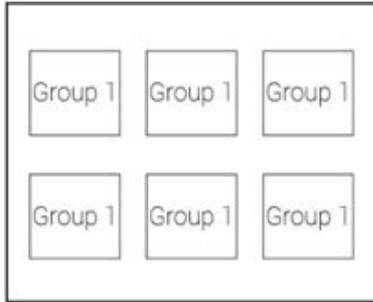
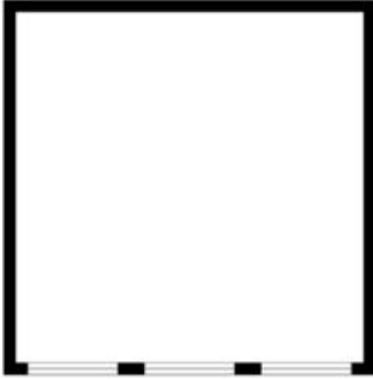
A Complete Picture of Daylight, D. Glaser
Pacific Energy Center, 6/9/2016
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Climate Variability

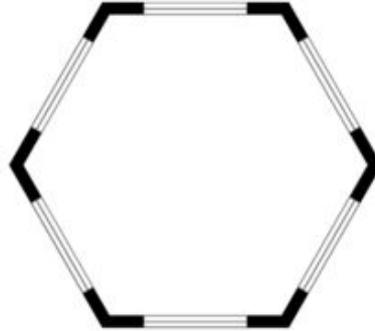


Window Groups

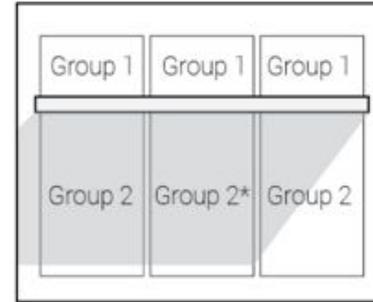
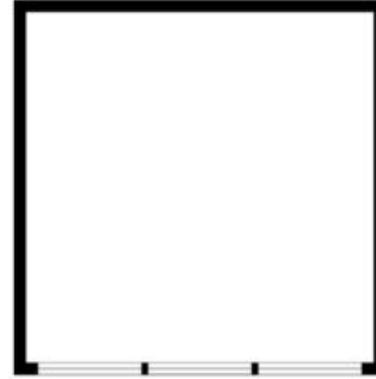
A



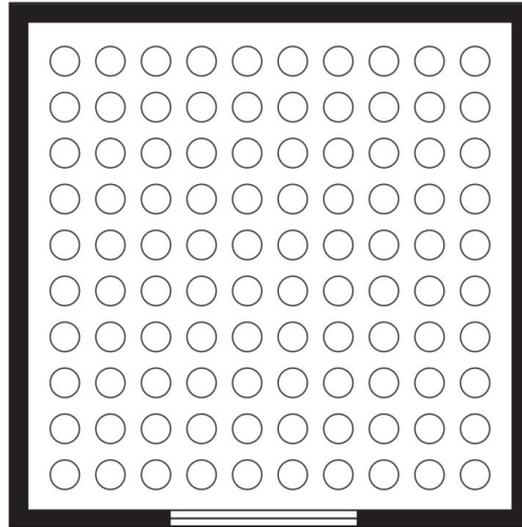
B



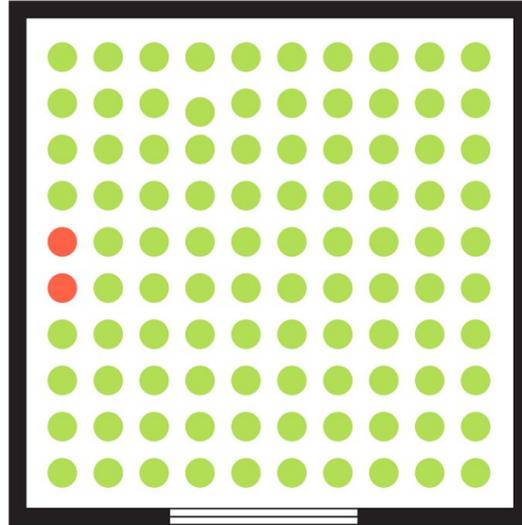
C



Example: Illuminance Grid with 100 Grid Points and 1 Window



2% Rule: Blinds Stay Open

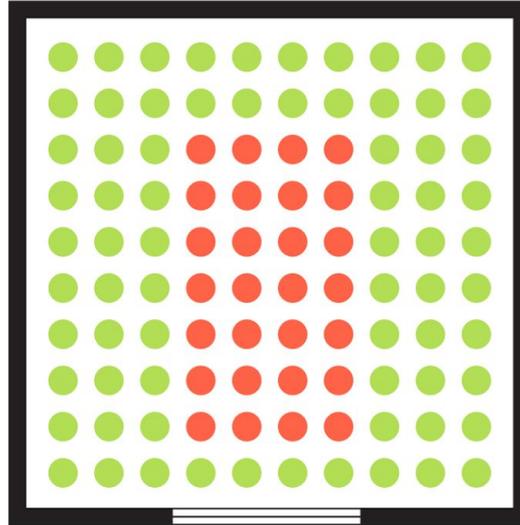


Dec 21st at 10:00 a.m.

Blinds open

2%

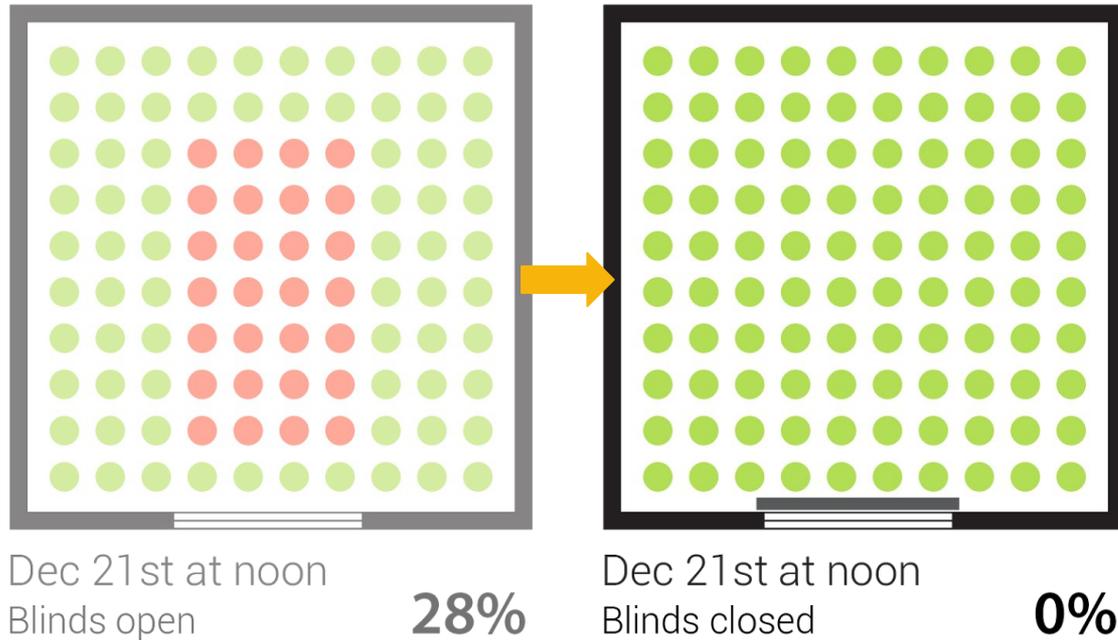
2% Rule: Exceeding 2% Direct Sunlight Before Blinds Operate



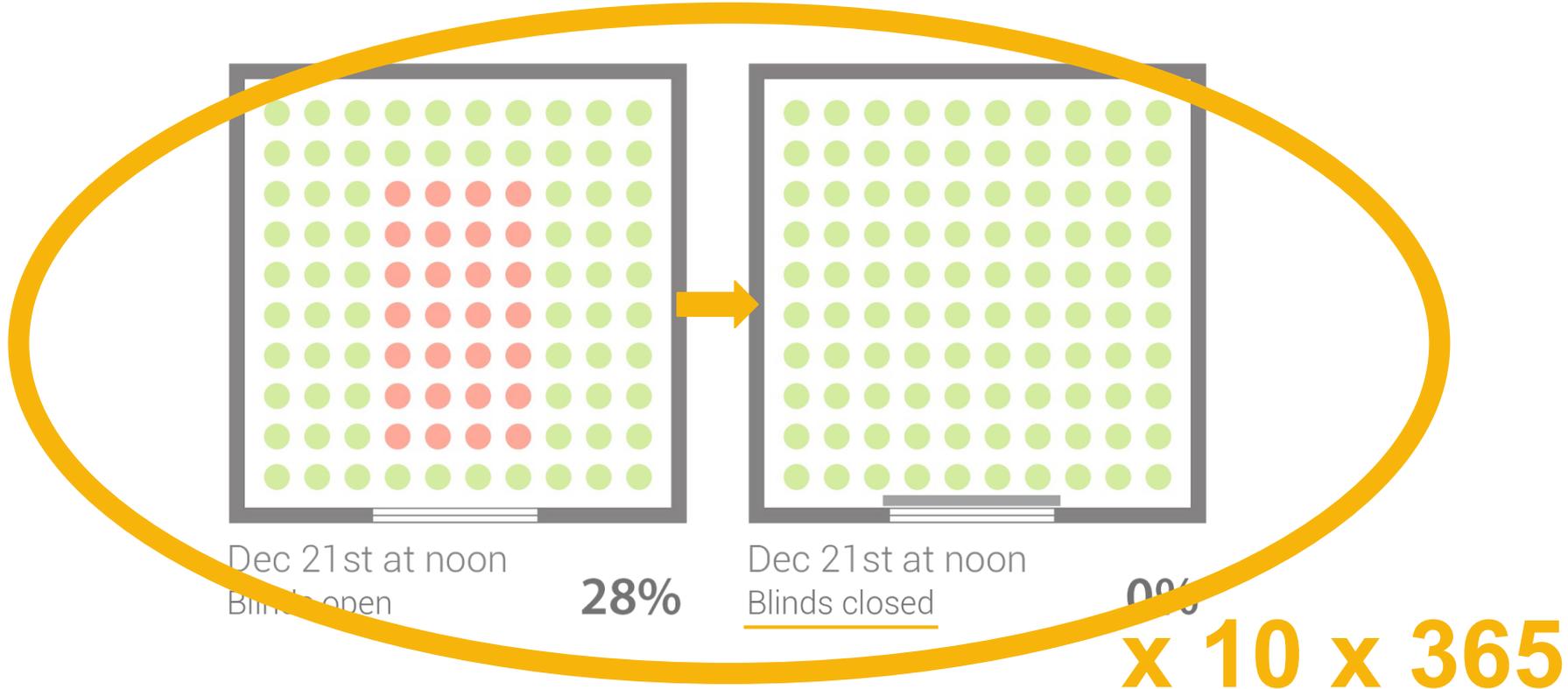
Dec 21 st at noon
Blinds open

28%

2% Rule: Blinds Close

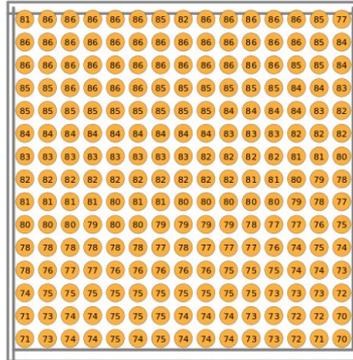


Blinds Operate for 1 Year



Daylight Metrics In-Class Exercise

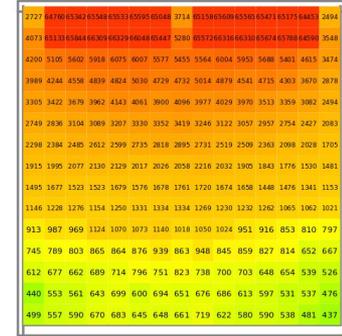
Classroom Model with
Blinds NOT Operating:



sDA: 100.00%

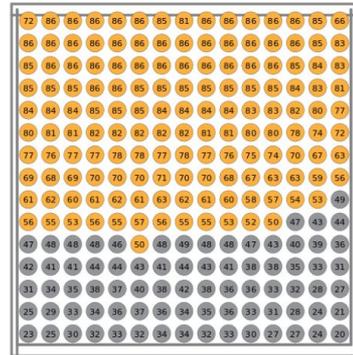


September 21, 12:00 PM



September 21, 12:00 PM

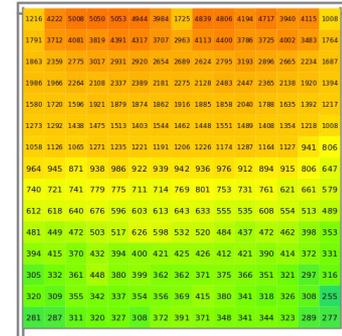
Classroom Model with
Blinds Operating:



sDA: 64.89%



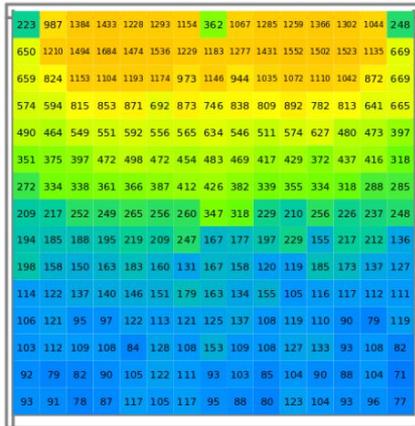
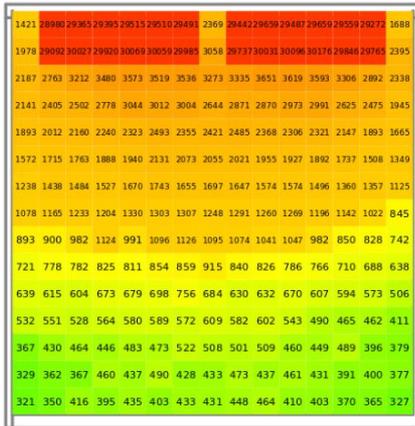
September 21, 12:00 PM



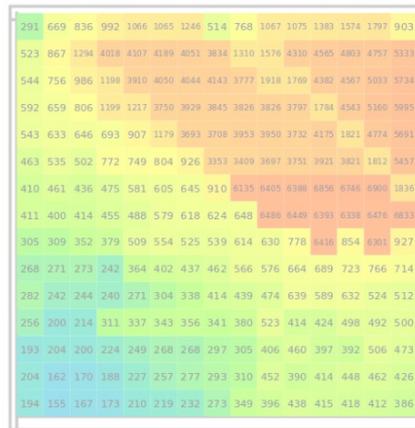
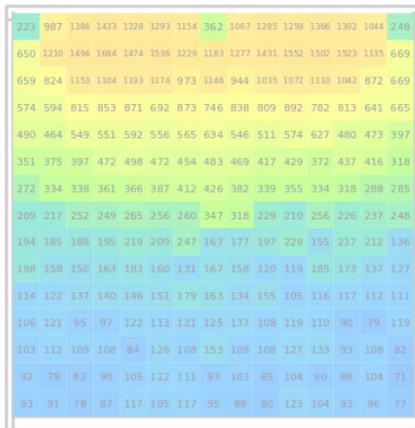
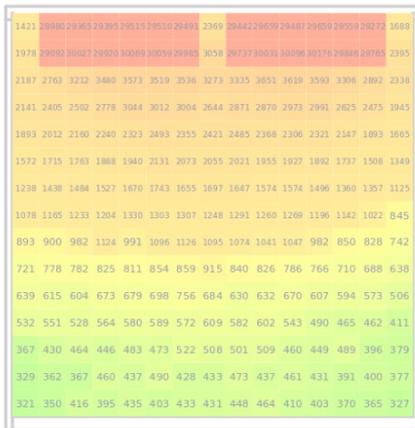
September 21, 12:00 PM

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Pacific Energy Center, 6/9/2016
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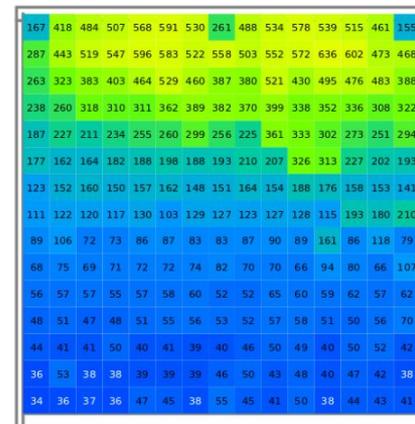
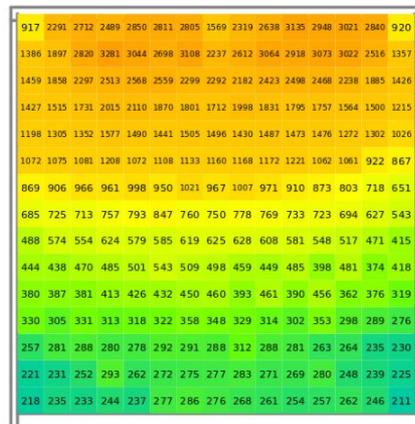
Classroom Model with Blinds NOT Operating:



Classroom Model with Blinds NOT Operating:



Classroom Model with Blinds Operating:



Daylight Metrics In-Class Exercise

Design A

- Clear Glass (90% VLT) Windows
- Windows facing S



September 21, 12:00 PM

Design B

- Clear Glass (90% VLT) Windows
- Windows facing NW



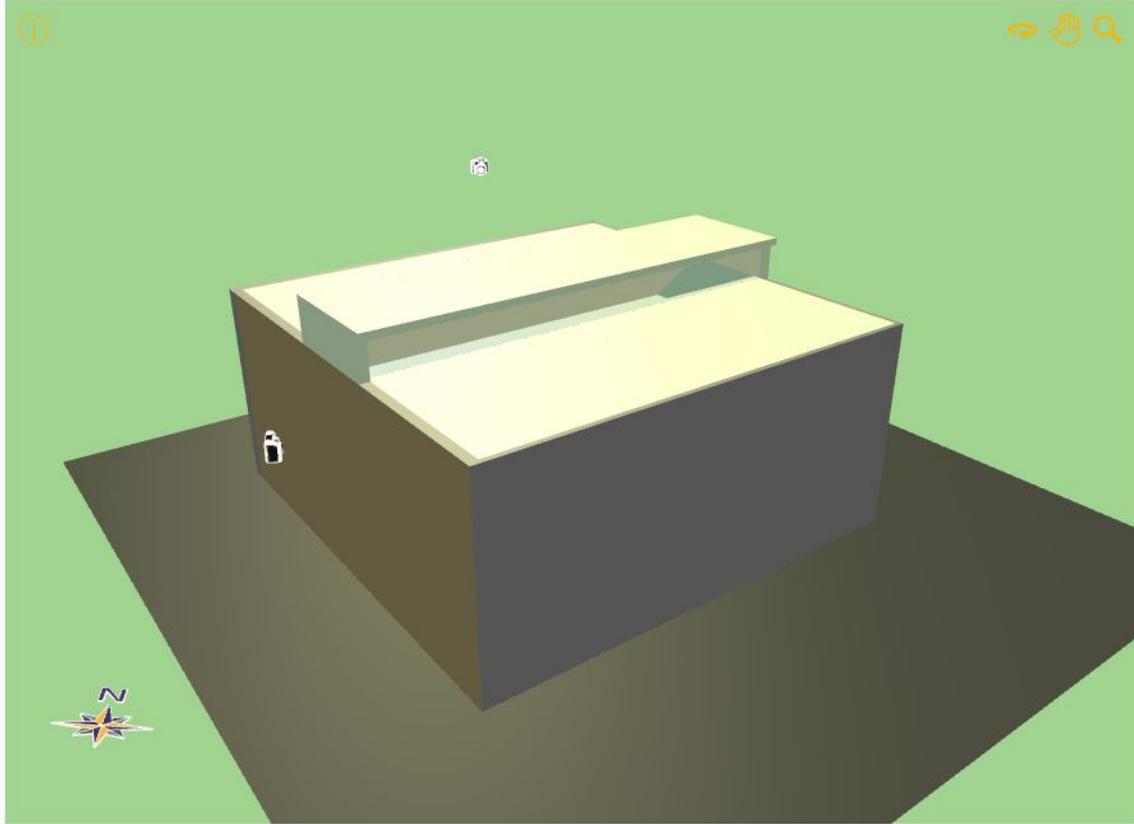
September 21, 12:00 PM

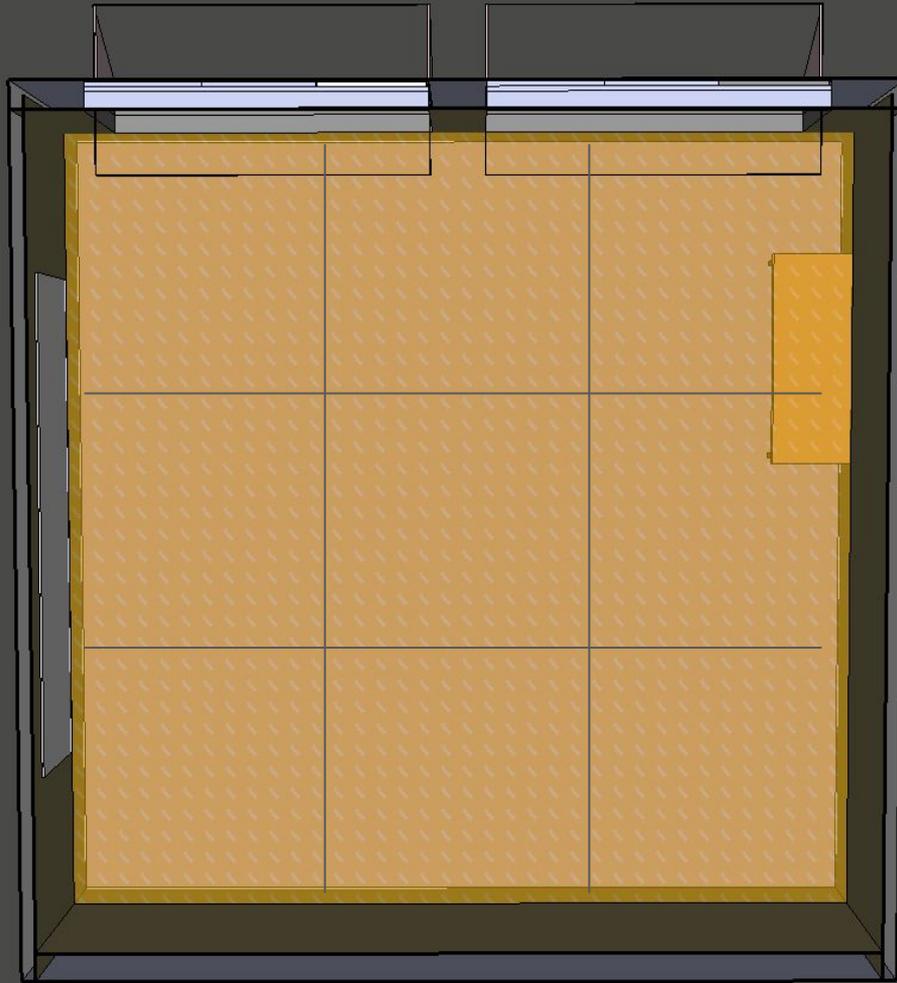
Classroom facing NW

Materials Window Groups Site Layers Illuminance Grids Viewpoints

<input type="checkbox"/> Custom Material		91.8%
<input type="checkbox"/> Glass 50%		45.9%
<input type="checkbox"/> Translucent		
Material	Properties	
	DT ST DR SR A RA	
<input type="checkbox"/> Opaque		
Material	Properties	
	Color	Ref.
<input type="checkbox"/> Ceiling		86.6%
<input type="checkbox"/> Exterior Shelf		80.1%
<input type="checkbox"/> floor		47.0%
<input type="checkbox"/> Ground Plane		23.9%
<input type="checkbox"/> Light Shelf		78.7%
<input type="checkbox"/> Mullions and Sill		49.8%
<input type="checkbox"/> Side Shade		74.4%
<input type="checkbox"/> SketchUp Default		50.2%
<input type="checkbox"/> Skylight_Sides		93.6%
<input type="checkbox"/> Walls		53.3%
<input type="checkbox"/> White Board		94.1%
<input type="checkbox"/> Wood - Door and Desk		46.4%







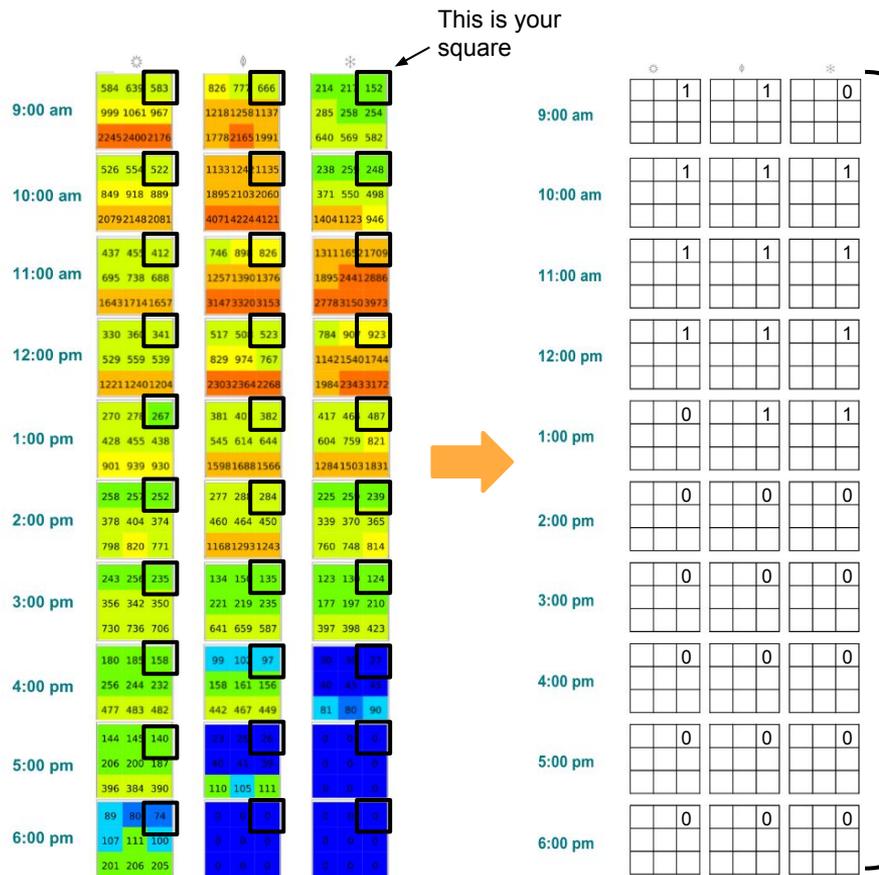


Daylight Metrics In-Class Exercise

Directions:

- Get into groups of 2-3
- Get assigned an individual square (grid point) in the 3x3 grid
- At each square (for all 30 of the timepoints in the handout) determine whether or not the value is above/equal to or below the threshold of 300
 - If above/equal to 300, mark as 1
 - If below 300, mark as 0
- Total your 1's and write down a final score (between 0 and 30) in the last row of empty grids
- After your final score is computed, divide by 30 and write this percent
 - If this % is ≥ 50 , give your square a **PASS**
 - If this % is < 50 give your square a **NO PASS**

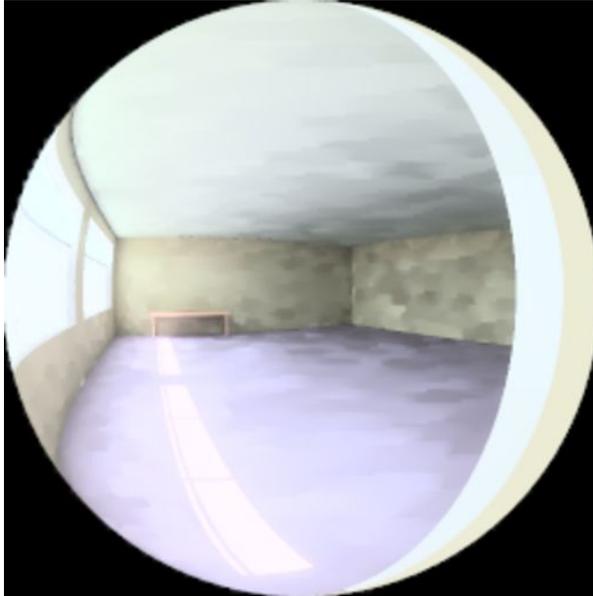
For Example:



1. Total your individual squares (All 3 seasons): 13
2. Divide total in (1) by 30: $13 / 30 = 0.43$
3. Multiply answer in (2) by 10: 43 % $\geq 50\%$ PASS: <50% NO PASS

Artifacts

S-Facing 12:00pm September 21st



September 21, 12:00 PM

NW-Facing 6:00pm June 21st



June 21, 06:00 PM

Final LEED v4 Score: Design A=100%=3 credits

83%*	87%*	80%*
77%*	67%*	67%*
63%*	63%*	57%*

Total Passed:

Total Squares:

(total passed) / (total squares):

≥55% - 2 LEED v4 points

≥75% - 3 LEED v4 points

Final LEED v4 Score: Design B=67%=2 credits

83%*	83%*	83%*
70%*	77%*	73%*
33%	43%	30%

Total Passed:

Total Squares:

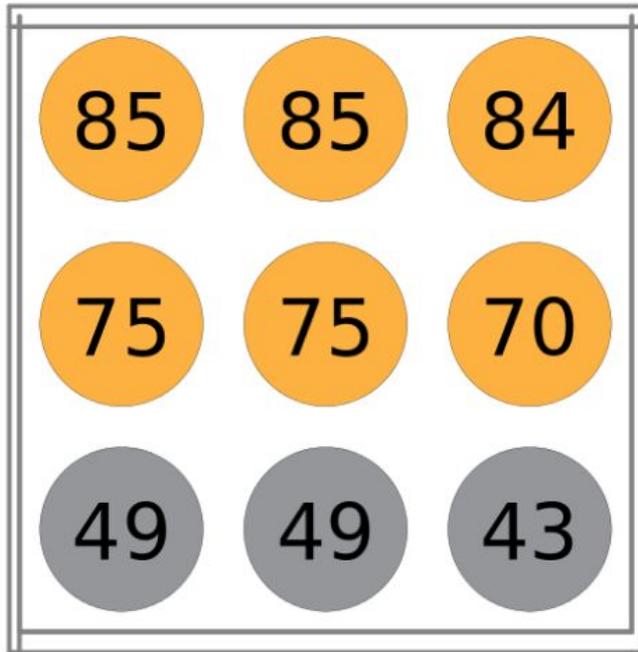
(total passed) / (total squares):

≥55% - 2 LEED v4 points

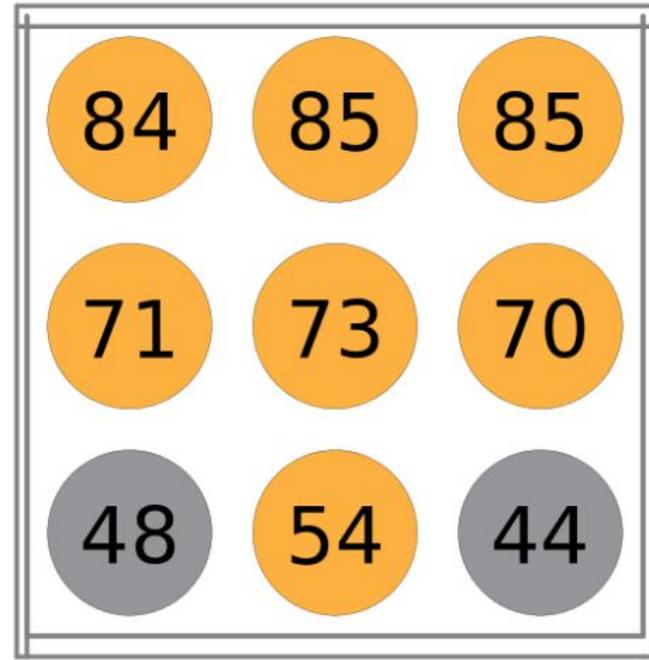
≥75% - 3 LEED v4 points

Actual sDA scores for Designs A and B

Design A (Windows Facing S) **66.7%**

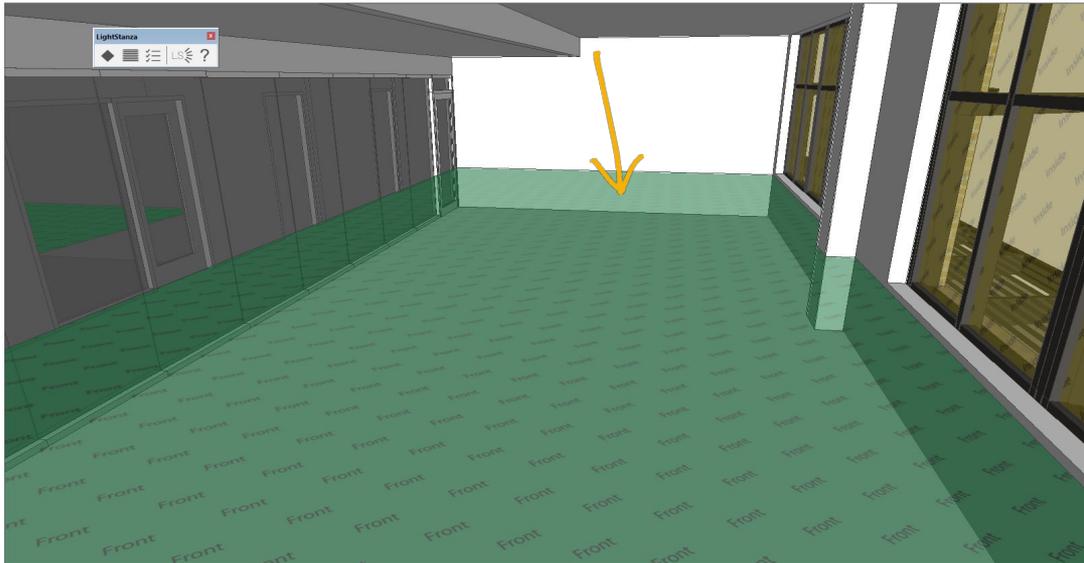


Design B (Windows Facing NW) **77.8%**

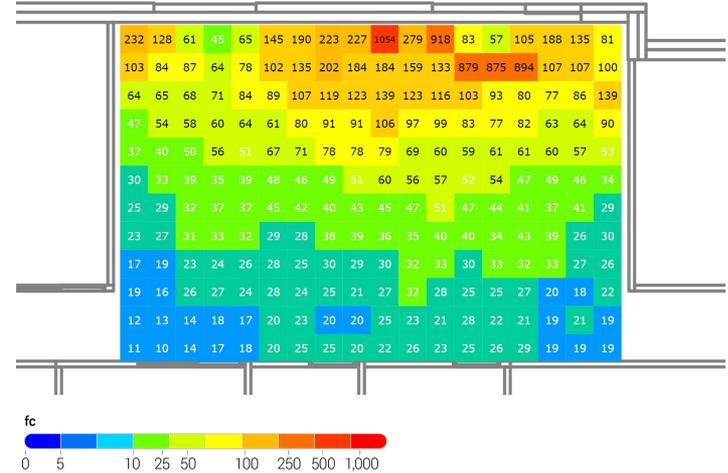


Demo

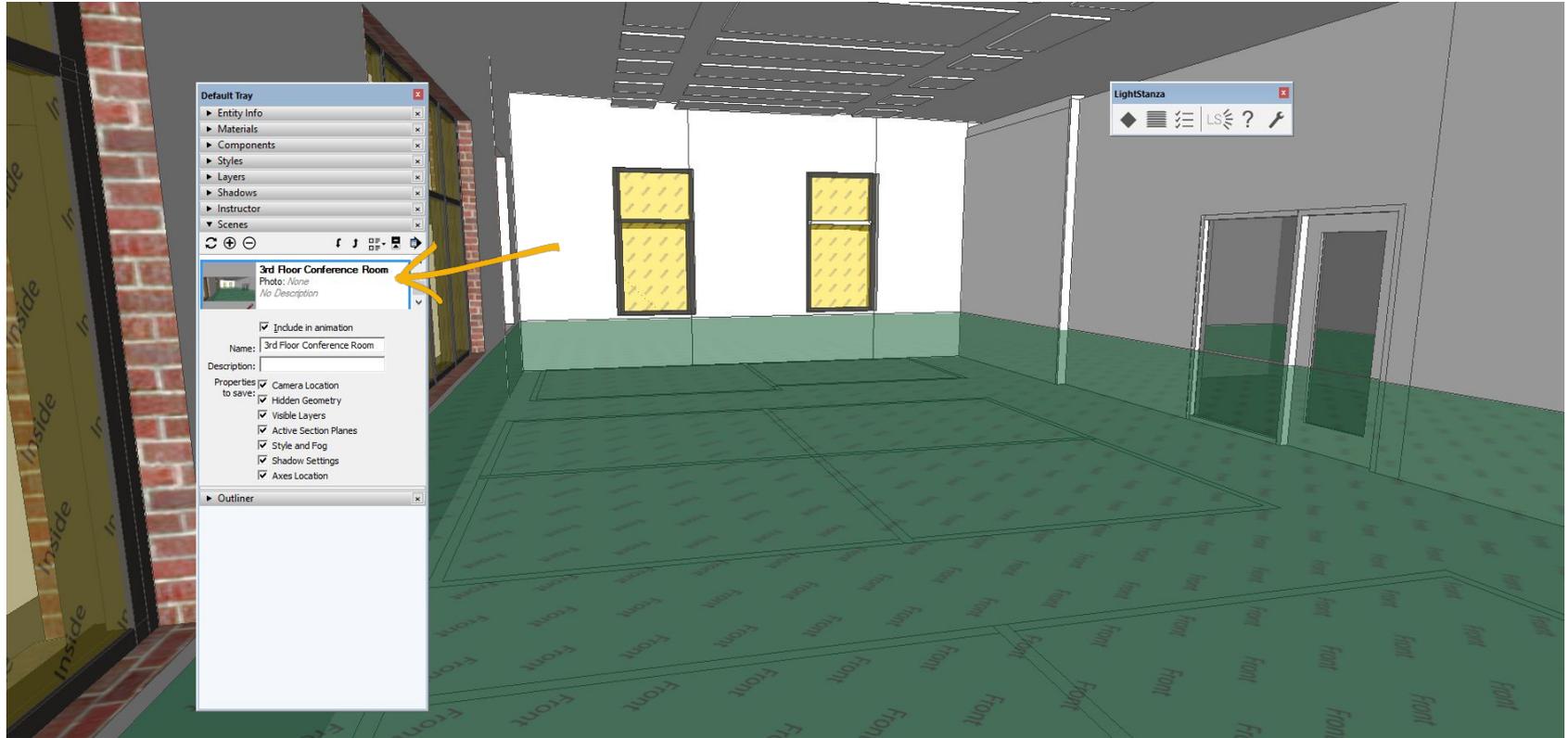
Create Illuminance Grids in SketchUp



Model Design by RNL Design



Create Viewpoints in SketchUp



A Complete Picture of Daylight, D. Glaser
Pacific Energy Center, 6/9/2016
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Questions/Comments?

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