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?

- 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 regularly occupied areas of the building.

LEED v4 EQc7 - 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 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

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

LEED v4 EQc7 - Daylight
**Option 1 (2-3 Points): Simulation: Spatial Daylight Autonomy (sDA) & Annual Sunlight Exposure (ASE)**

1. Demonstrate through annual computer simulations that Spatial Daylight Autonomy of at least 55%, 75%, or 90% is achieved. Use regularly occupied floor area.

2. Demonstrate through annual computer simulations that Annual Sunlight Exposure of no more than 10% is achieved. Use regularly occupied floor area that is daylit per the sDA simulations.
LEED v4 Daylighting EQc7: Compliance Paths

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.
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
# Measure Point’s Illuminance Hourly

<table>
<thead>
<tr>
<th>Time</th>
<th>January 1</th>
<th>July 1</th>
<th>December 31</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 am</td>
<td>72</td>
<td>102</td>
<td>72</td>
</tr>
<tr>
<td>10 am</td>
<td>101</td>
<td>261</td>
<td>99</td>
</tr>
<tr>
<td>11 am</td>
<td>118</td>
<td>366</td>
<td>118</td>
</tr>
<tr>
<td>12 pm</td>
<td>137</td>
<td>462</td>
<td>137</td>
</tr>
<tr>
<td>1 pm</td>
<td>154</td>
<td>489</td>
<td>110</td>
</tr>
<tr>
<td>2 pm</td>
<td>317</td>
<td>454</td>
<td>302</td>
</tr>
<tr>
<td>3 pm</td>
<td>371</td>
<td>412</td>
<td>366</td>
</tr>
<tr>
<td>4 pm</td>
<td>314</td>
<td>349</td>
<td>305</td>
</tr>
<tr>
<td>5 pm</td>
<td>0</td>
<td>335</td>
<td>0</td>
</tr>
<tr>
<td>6 pm</td>
<td>0</td>
<td>312</td>
<td>0</td>
</tr>
</tbody>
</table>

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Determine if Point Meets Target Threshold (300 lux)

<table>
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<td>349</td>
<td>368</td>
</tr>
<tr>
<td>5 pm</td>
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<td>335</td>
<td>305</td>
</tr>
<tr>
<td>6 pm</td>
<td>0</td>
<td>312</td>
<td>0</td>
</tr>
</tbody>
</table>

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Continuous Daylight Autonomy (cDA) - Partial Credit

**January 1**
- 9 am: 0.24
- 10 am: 0.34
- 11 am: 0.39
- 12 pm: 0.46
- 1 pm: 0.51
- 2 pm: 1
- 3 pm: 1
- 4 pm: 1
- 5 pm: 0
- 6 pm: 0

**July 1**
- 9 am: 0.8
- 10 am: 0.9
- 11 am: 1
- 12 pm: 1
- 1 pm: 1
- 2 pm: 1
- 3 pm: 1
- 4 pm: 1
- 5 pm: 1
- 6 pm: 1

**December 31**
- 9 am: 0.24
- 10 am: 0.33
- 11 am: 0.39
- 12 pm: 0.46
- 1 pm: 0.36
- 2 pm: 1
- 3 pm: 1
- 4 pm: 1
- 5 pm: 0
- 6 pm: 0
Score Each Point

Percent of time at or above illuminance threshold of 300 lux

0%  50%  100%

71 (%)
Final Result

Daylight Autonomy 300 lux = 27%
- Light On

Daylight Autonomy 300 lux = 82%
- Light Off
Useful Daylight Illuminance (UDI)

72.39 %

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

0%  50%  100%
The New LEED v4 Metrics: ASE & sDA
ASE 1000, 250h
Annual Sunlight Exposure
Annual Sunlight Exposure: First Measure Workplane

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Evaluate Lighting Levels

3,438h 〇 212h
The point is not in direct sun for 3,438 hours.
The point is in direct sun for 212 hours.

9 am 10 am 11 am 12 pm 1 pm 2 pm 3 pm 4 pm 5 pm 6 pm

January 1 〇 〇 〇 〇 〇 〇 4396 3121 〇 〇 〇 〇

July 1 〇 〇 〇 〇 9625 〇 〇 〇 〇 〇 〇 〇

December 31 〇 〇 〇 〇 〇 〇 4340 1658 〇 〇 〇 〇

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Score Each Point

The final number on the grid represents the number of hours the point is in direct sun.
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

Hours of direct sun/year

<250h  >250h

18.57 %
Classroom Example: With Overhangs and Shelves
Office Example

Removal of Circulation Area:

ASE = 21.5% ✗

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
sDA_{300/50}\% \text{ Sample Space}

| Points on the grid meet the threshold for at least 50\% of the time. | 68 |
| Points on the grid do not meet the threshold for at least 50\% of the time. | 32 |

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 ≥ 50% (SDA)
Workplane

1x Quick Zoom

× 49.28%

WITHOUT BLINDS
Spatial Daylight Autonomy ≥ 50% (SDA)
Workplane

1x Quick Zoom

✓ 64.49%
Workplane Limitations

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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 659.9 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
Redirecting Film 1
Redirecting Film 2

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Case Study: Focus on Details

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

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.
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.
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

3ft ceiling thickness
3x3 foot skylight
Window Groups

A

B

C

Group 1  Group 1  Group 1
Group 1  Group 1  Group 1

Group 1

Group 2

Group 3

Group 1  Group 1  Group 1
Group 2  Group 2*  Group 2
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 21st at noon
Blinds open 28%
2% Rule: Blinds Close

Dec 21st at noon
Blinds open  28%

Dec 21st at noon
Blinds closed  0%
Blinds Operate for 1 Year

Dec 21st at noon
Blinds open 28%

Dec 21st at noon
Blinds closed 0%

x 10 x 365
Daylight Metrics In-Class Exercise

Classroom Model with Blinds NOT Operating:

sDA: 100.00%

Classroom Model with Blinds Operating:

sDA: 64.89%
Classroom Model with Blinds NOT Operating:

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Daylight Metrics In-Class Exercise

**Design A**
- Clear Glass (90% VLT) Windows
- Windows facing S

**Design B**
- Clear Glass (90% VLT) Windows
- Windows facing NW
# Classroom facing NW

### Materials

<table>
<thead>
<tr>
<th>Material</th>
<th>DT</th>
<th>ST</th>
<th>DR</th>
<th>SR</th>
<th>A</th>
<th>RA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Custom Material</td>
<td></td>
<td>91.8%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glass 50%</td>
<td></td>
<td></td>
<td>45.9%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Translucent

#### Properties

<table>
<thead>
<tr>
<th>Material</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DT</td>
</tr>
</tbody>
</table>

### Opaque

#### Properties

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<tr>
<th>Material</th>
<th>Color</th>
<th>Ref.</th>
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</thead>
<tbody>
<tr>
<td>Ceiling</td>
<td></td>
<td>86.6%</td>
</tr>
<tr>
<td>Exterior Shelf</td>
<td></td>
<td>80.1%</td>
</tr>
<tr>
<td>Roof</td>
<td></td>
<td>47.0%</td>
</tr>
<tr>
<td>Ground Plane</td>
<td></td>
<td>23.9%</td>
</tr>
<tr>
<td>Light Shelf</td>
<td></td>
<td>78.7%</td>
</tr>
<tr>
<td>Mullions and Sill</td>
<td></td>
<td>49.0%</td>
</tr>
<tr>
<td>Side Shade</td>
<td></td>
<td>74.4%</td>
</tr>
<tr>
<td>SketchUp Default</td>
<td></td>
<td>50.2%</td>
</tr>
<tr>
<td>Skylight_Sides</td>
<td></td>
<td>93.6%</td>
</tr>
<tr>
<td>Walls</td>
<td></td>
<td>53.3%</td>
</tr>
<tr>
<td>White Board</td>
<td></td>
<td>94.1%</td>
</tr>
<tr>
<td>Wood - Door and Desk</td>
<td></td>
<td>46.4%</td>
</tr>
</tbody>
</table>

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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): \( \frac{13}{30} = 0.43 \)
2. Divide total in (1) by 10: \( \frac{13}{30} \times 10 = 4.3 \%
3. Multiply answer in (2) by 100: \( 43 \% \) PASS, \( <50\% \) NO PASS
Artifacts

S-Facing 12:00pm September 21st

NW-Facing 6:00pm June 21st
<table>
<thead>
<tr>
<th></th>
<th>83%*</th>
<th>87%*</th>
<th>80%*</th>
</tr>
</thead>
<tbody>
<tr>
<td>77%*</td>
<td>67%*</td>
<td>67%*</td>
<td></td>
</tr>
<tr>
<td>63%*</td>
<td>63%*</td>
<td>57%*</td>
<td></td>
</tr>
</tbody>
</table>

**Total Passed:**

<table>
<thead>
<tr>
<th></th>
<th>83%*</th>
<th>87%*</th>
<th>80%*</th>
</tr>
</thead>
<tbody>
<tr>
<td>77%*</td>
<td>67%*</td>
<td>67%*</td>
<td></td>
</tr>
<tr>
<td>63%*</td>
<td>63%*</td>
<td>57%*</td>
<td></td>
</tr>
</tbody>
</table>

**Total Squares:**

\[(\text{total passed}) / (\text{total squares})\]:

\[\geq 55\% - 2 \text{ LEED v4 points}\]

\[\geq 75\% - 3 \text{ LEED v4 points}\]

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

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<table>
<thead>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>83%*</td>
<td>83%*</td>
<td>83%*</td>
</tr>
<tr>
<td>70%*</td>
<td>77%*</td>
<td>73%*</td>
</tr>
<tr>
<td>33%</td>
<td>43%</td>
<td>30%</td>
</tr>
</tbody>
</table>

Total Passed:

Total Squares:

\[
\frac{\text{total passed}}{\text{total squares}}:
\]

- \( \geq 55\% \) - 2 LEED v4 points
- \( \geq 75\% \) - 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
Questions/Comments?
Contact Us!

Daniel Glaser

📞 (720) 722.0771
✉️ daniel@lightstanza.com

LightStanza Support

📞 (720) 722.0771
✉️ support@lightstanza.com

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