

Daylighting Metrics Static vs. Dynamic Assessment

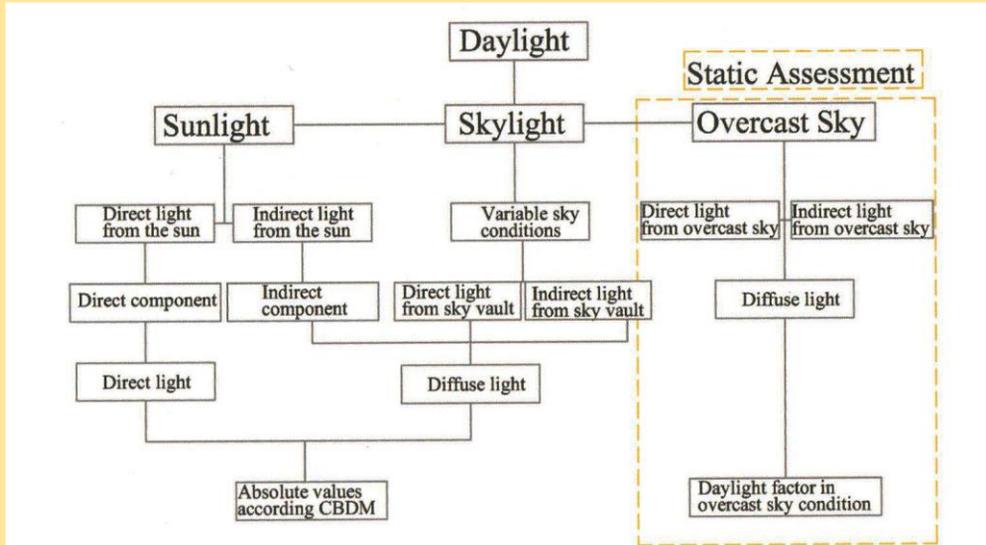


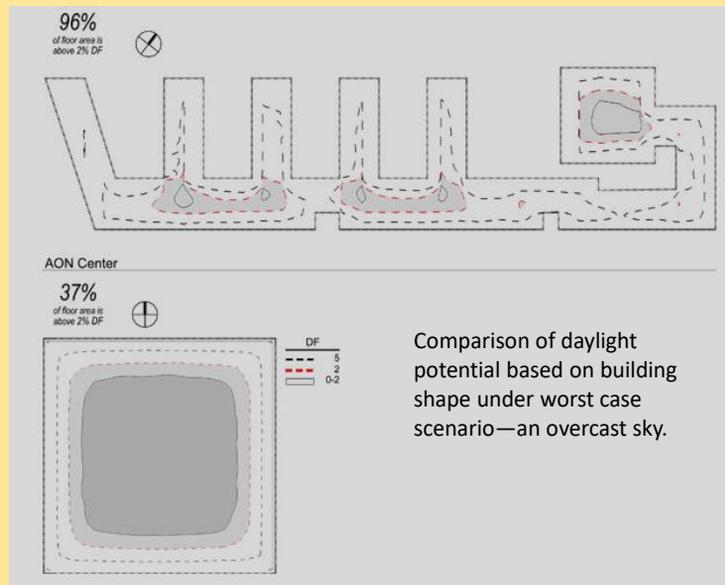
Figure 65: Diagram of the components that the static evaluation method considers.

Daylight Factors (static)

The concept of Daylight Factor (DF) was developed in the United Kingdom in the early 20th century. Daylight Factor is a ratio that represents the amount of illumination available indoors relative to the illumination present outdoors at the same time under overcast skies.

Daylight Factor is typically calculated by dividing the horizontal work plane illumination indoors by the horizontal illumination on the roof of the building being tested and then multiplying by 100.

For example, if there were 20,000 lux available outdoors and 400 lux available at a given point indoors, then the DF for that point would be calculated as follows $DF = 400/20,000 * 100$ or $DF=2$



Comparison of daylight potential based on building shape under worst case scenario—an overcast sky.

European Daylight Assessment (dynamic)

Useful daylight illuminance (UDI) [110–2,500 lux] Based on climate data analysis

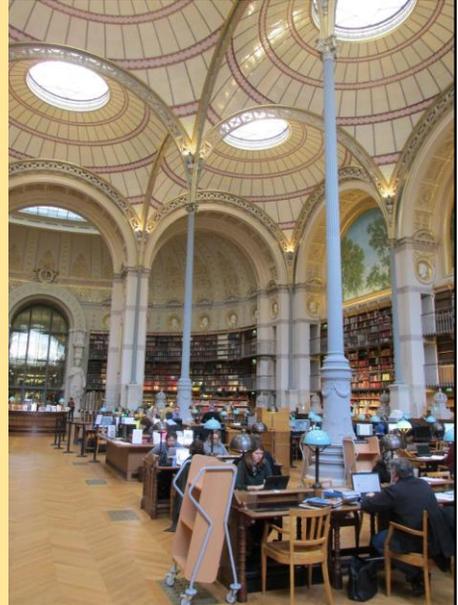
- UDI fell short [0–100 lux] insufficient illumination
- UDI supplementary [100–300 (500) lux] integrate with electric light
- UDI autonomous [300 (500)–2,500 lux] no electric light required
- UDI exceeded [$>2,500$ lux] bad situation: glare, overheating, etc.

Daylight autonomy (DA) and Continuous daylight autonomy (cDA)

- DA = percentage of annual daylight hours 500–2,500 lux
- cDA = DA + the sum of (x/500) when illumination x is below 500 lux

Daylight Saturation Percentage (DSP)

- Full credit for hours between 430 and 4,300 lux
- Penalty $>4,300$ lux



Bibliothecque Nationale, Paris, LaBrouste

Lisa Heschong

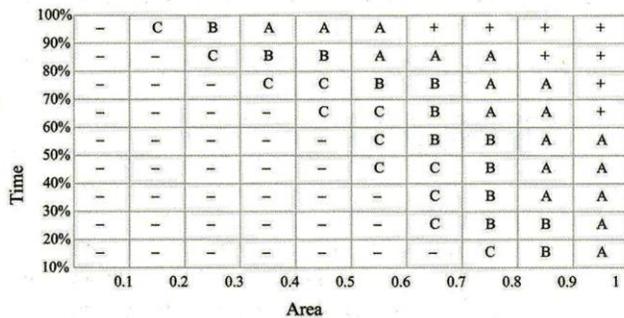
Spatial Daylight Autonomy (sDA)

Compares % time above threshold illumination to % floor area above threshold

e.g., sDA300/50% = analysis point exceeds 300 lux for 50% of the time (or more)

Daylight credits

sDA - Spatial Daylight Autonomy



A Appreciable Daylight levels
 > 75% of the area
 B Required Daylight levels
 > 55% of the space
 C Inadequate Daylight levels
 + Inadequate zones
 - Not available

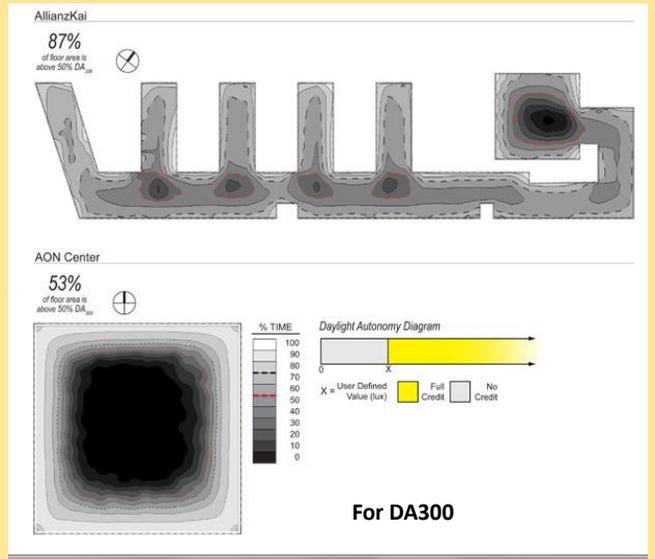
Figure 62: DA scheme.

Daylight Autonomy

Daylight Autonomy (DA) was the first of a string of annual daylight metrics, now commonly referred to as 'dynamic daylight metrics'. It is represented as a percentage of annual daytime hours that a given point in a space is above a specified illumination level.

It was originally proposed by the Association Suisse des Electriciens in 1989 and was improved by Christoph Reinhart between 2001-2004. It is a major innovation since it considers a geographic location's specific weather information on an annual basis. It also has power to relate to electric lighting energy savings if the user-defined threshold is set based upon electric lighting criteria. The user is free to set the threshold above which Daylight Autonomy is calculated.

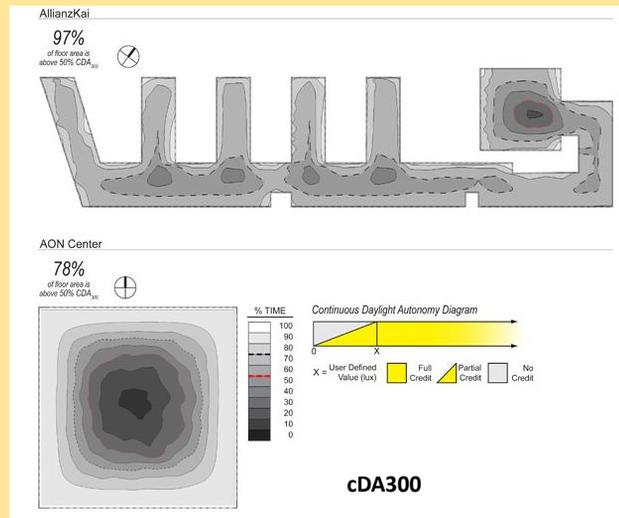
For the graphs to the right, we selected a Daylight Autonomy threshold of 300 lux (DA300). The graphical percent values represent the percentage of the floor area that exceeds 300 lux for at least 50% of the time

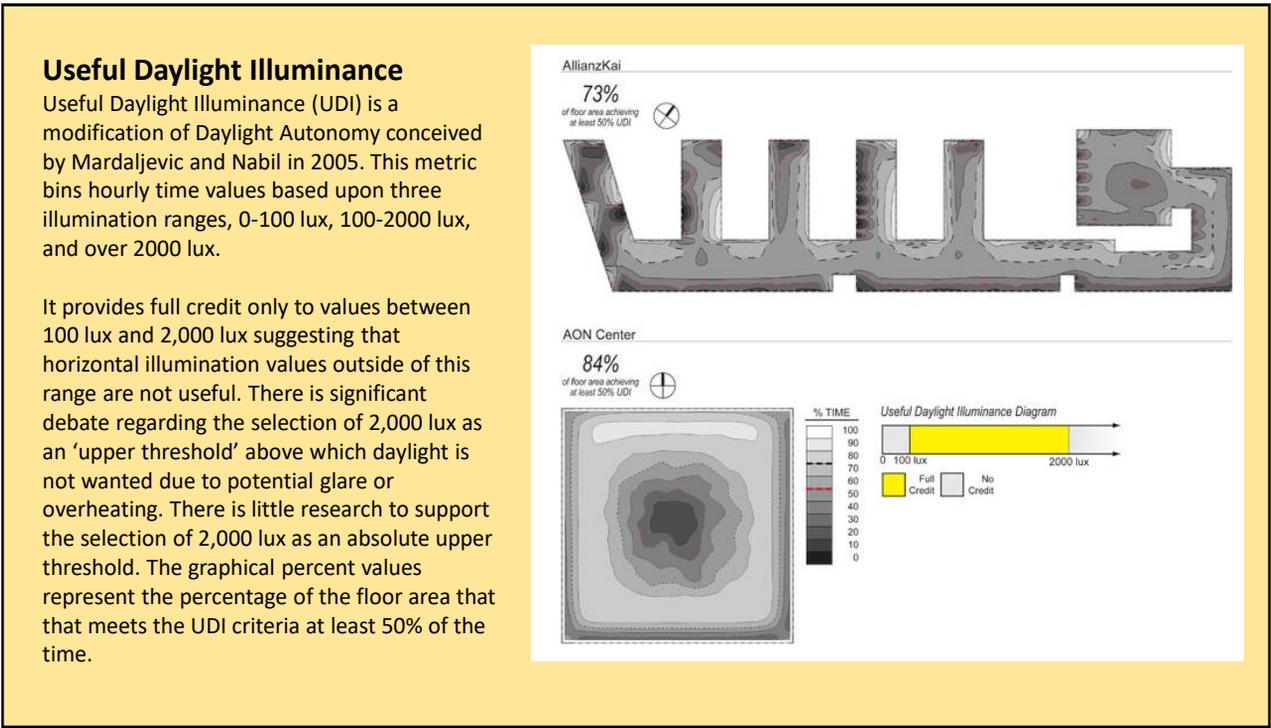
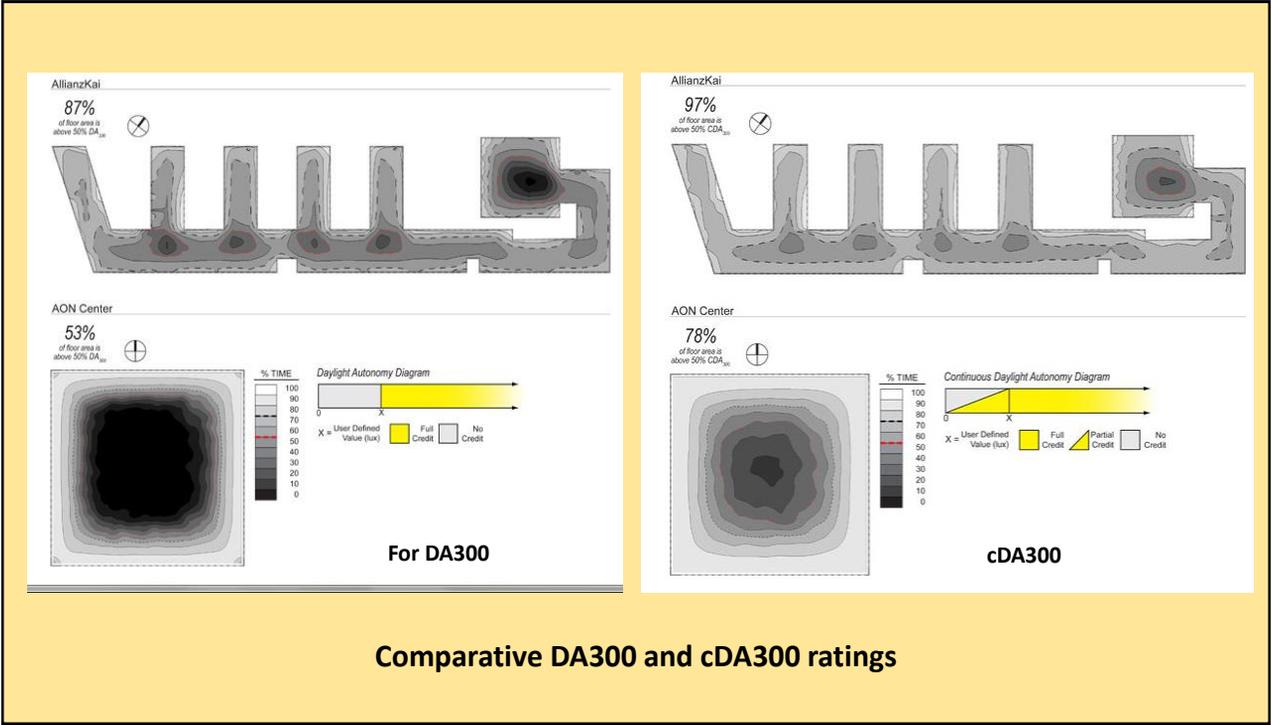


Continuous Daylight Autonomy

Zach Rogers proposed Continuous Daylight Autonomy (cDA) in 2006 as a basic modification of Daylight Autonomy. Continuous Daylight Autonomy awards partial credit in a linear fashion to values below the user defined threshold. If 300 lux were specified as the DA threshold (DA300) and a specific point exceeded 300 lux 50% of the time on an annual basis, then the cDA300 might result in a value of approximately 55-60% or more.

For example, say a certain interior grid point has 150 lux due to daylight at a given time step, DA300 would give it 0 credit for that time step whereas cDA300 would give it $150/300=0.5$ credit for that time step. For the graphs to the right, we selected a Continuous Daylight Autonomy threshold of 300 lux (cDA300). The graphical percent values represent the percentage of the floor area that exceeds 300 lux for at least 50% of the time giving partial credit for time steps below 300 lux.



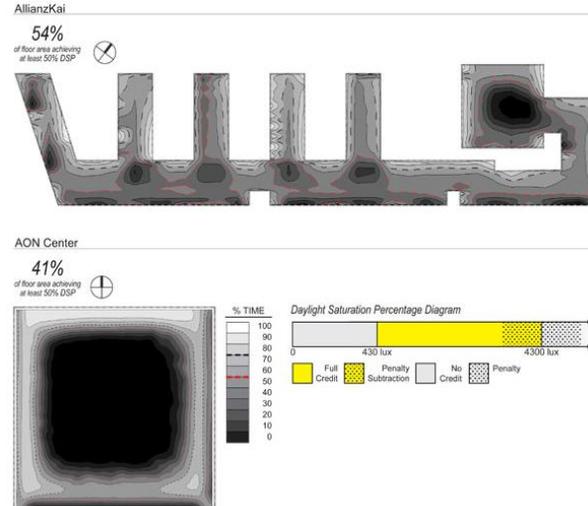
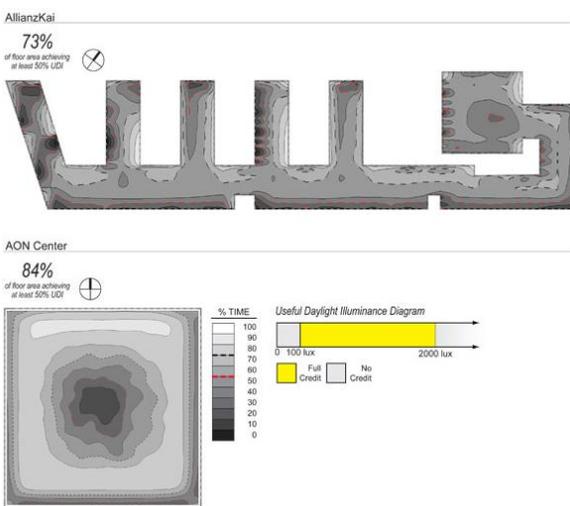
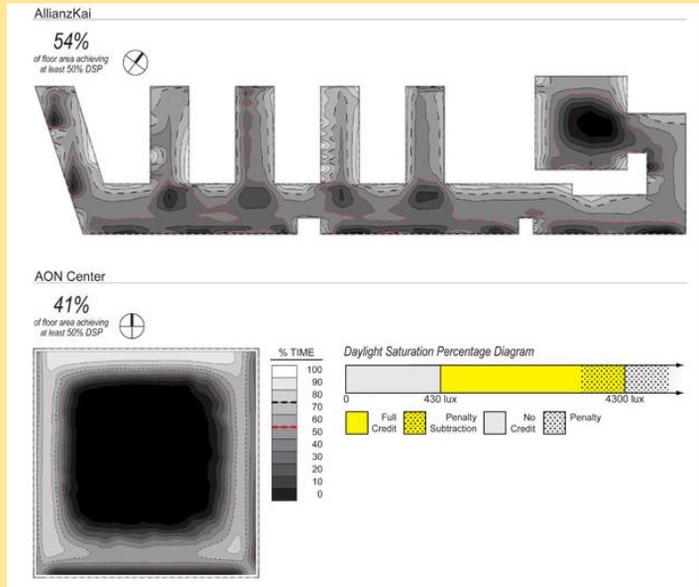


Daylight Saturation Percentage

Daylight Saturation Percentage (DSP) is a modification of Useful Daylight Illuminance that increases the lower limit to 40 footcandles (precisely 430 lux) and increases the upper limit to 400 footcandles (precisely 4,300 lux).

It goes further to penalize grid point annual hour values above 400 footcandles by forcing them to be subtracted from the grid point annual hour values within the range of 40-400 footcandles. The Lighting and Daylighting Committee for the Collaborative for High Performance Schools program developed it in 2006.

The graphical percent values represent the percentage of the floor area that meets the DSP criteria at least 50% of the time while also accounting for the penalty for hours above the 400 footcandle upper threshold.



Useful Daylight Illuminance vs. Daylight Saturation Percentage

LEED awards up to 3pts for Daylighting

Awarded
Projected
Not Available
Max Points

38 30 42 16 Project Totals (pre-certification estimates)
 Certified 40-49 points Silver 50-59 points Gold 60-79 points Platinum 80 or more points

16	2	8	36	Sustainable Sites
Y				Prereq 1 Construction Activity Pollution Prevention
1				Credit 1 Site Selection
5	1			Credit 2 Development Density & Community Connectivity
				Credit 3 Brownfield Redevelopment
6				Credit 4.1 Alternative Transportation, Public Transportation Access
		1		Credit 4.2 Alternative Transportation, Bicycle Storage & Changing Rooms
		3		Credit 4.3 Alternative Transportation, Low-Emitting/Fuel-Efficient Vehicles
2				Credit 4.4 Alternative Transportation, Parking Capacity
	1			Credit 5.1 Site Development, Protect or Restore Habitat
1				Credit 5.2 Site Development, Maximize Open Space
	1			Credit 6.1 Stormwater Design, Quantity Control
	1			Credit 6.2 Stormwater Design, Quality Control
	1			Credit 7.1 Heat Island Effect, Non-Roof
1				Credit 7.2 Heat Island Effect, Roof
	1			Credit 8 Light Pollution Reduction

7	3	16	Water Efficiency
Y			Prereq 1 Water Use Reduction
2			Credit 1.1 Water Efficient Landscaping, Reduce by 50%
2			Credit 1.2 Water Efficient Landscaping, No Potable Use or No Irrigation
	2		Credit 2 Innovative Wastewater Technologies
3	1		Credit 3 Water Use Reduction, 20-40% Reduction

8	9	16	36	Energy & Atmosphere
Y				Prereq 1 Fundamental Commissioning of the Building Energy Systems
Y				Prereq 2 Minimum Energy Performance
Y				Prereq 3 Fundamental Refrigerant Management
6	13			Credit 1 Optimize Energy Performance
4	3			Credit 2 On-Site Renewable Energy
2				Credit 3 Enhanced Commissioning
				Credit 4 Enhanced Refrigerant Management
3				Credit 5 Measurement & Verification
	2			Credit 6 Green Power

2	2	4	Regional Priority
2	2		Credit 1-4 Regional Priority Credits

8	6	14	Materials & Resources
Y			Prereq 1 Storage & Collection of Recyclables
2	1		Credit 1.1 Building Reuse, Maintain 55-95% of Existing Walls, Floors & Roof
			Credit 1.2 Building Reuse, Maintain 50% of Interior Non-Structural Elements
2			Credit 2 Construction Waste Management, Divert 50-75% from Disposal
	2		Credit 3 Materials Reuse, 5-10%
	2		Credit 4 Recycled Content, 10-20% (post-consumer + 1/3 pre-consumer)
	1	1	Credit 5 Regional Materials, 10-20% Extracted, Processed, Manuf'd Regionally
	1		Credit 6 Rapidly Renewable Materials
1			Credit 7 Certified Wood

2	6	7	19	Indoor Environmental Quality
Y				Prereq 1 Minimum IAQ Performance
Y				Prereq 2 Environmental Tobacco Smoke (ETS) Control
	1			Credit 1 Outdoor Air Delivery Monitoring
	1			Credit 2 Increased Ventilation
1				Credit 3.1 Construction IAQ Management Plan, During Construction
1				Credit 3.2 Construction IAQ Management Plan, Before Occupancy
	1			Credit 4.1 Low-Emitting Materials, Adhesives & Sealants
	1			Credit 4.2 Low-Emitting Materials, Paints & Coatings
	1			Credit 4.3 Low-Emitting Materials, Carpet Systems
	1			Credit 4.4 Low-Emitting Materials, Composite Wood & Aqrfiber Products
1				Credit 5 Indoor Chemical & Pollutant Source Control
	1			Credit 6.1 Controllability of Systems, Lighting
	1			Credit 6.2 Controllability of Systems, Thermal Comfort
	1			Credit 7.1 Thermal Comfort, Design
	1			Credit 7.2 Thermal Comfort, Verification
	1			Credit 8.1 Daylight & Views, Daylight 75% of Spaces
	1			Credit 8.2 Daylight & Views, Views for 90% of Spaces

3	3	6	Innovation & Design Process
1			Credit 1.1 Innovation in Design: Green Housekeeping
	1		Credit 1.2 Innovation in Design: Hardscape Management
1			Credit 1.3 Innovation in Design: Interior Pest Management
	1		Credit 1.4 Exemplary Performance: MRc2 (95%)
1			Credit 1.5 Innovation in Design: Low Mercury Bulbs
	1		Credit 2 LEED® Accredited Professional

Daylighting Metrics for LEED

LEED credit is based on the availability of daylight to the regularly occupied spaces, which are distinguishable from other spaces such as utility rooms, rest rooms, or storage locations. Glare-control devices (manually operated or automatic with a manual override) are required for all regularly occupied spaces.

LEED Compliance Methods

- 1) Spatial Daylight Autonomy sDA [sDA300/50%] **and** Annual Sunlight Exposure ASE [ASE1,000/250]
- 2) Illuminance Calculations [75% @ 300-3,000 lux on the equinoxes]
- 3) Light Measurements [75% @ 300-3,000 lux on the equinoxes]

Source: <http://continuingeducation.bnpmmedia.com/article.php?L=167&C=1443&P=1>
http://support.sefaira.com/hc/en-us?flash_digest=eb62ae2e865eff5698c2faf56d54bac8055eff17

1.) Spatial Daylight Autonomy sDA [*sDA300/50%*]

Computer simulation of sDA

- daylight levels across a 2-foot (max) grid @ 30" work plane in occupied spaces
- different times of the day and of the year
- minimum threshold of 300 lux of daylight necessary in order to be considered effective
- for at least 50 percent of the time

If 55-74% of the locations in regularly occupied spaces meet or exceed the sDA300/50% threshold, then **two points** can be achieved

If 75% or more is demonstrated, then **three points** can be earned

+

Annual Sunlight Exposure ASE [*ASE1,000/250*]

Computer simulation of ASE

a maximum of 1,000 lux of daylight is permitted without the use of any operable shades, blinds

- Same grid as sDA
- Max of 1,000 lux no more than 250 hours annually

In order to earn the daylighting credit points, the ASE threshold must not be breached for more than 10% of the area illuminated by daylighting.

2.) Illuminance Calculations [*75% @ 300-3,000 lux on the equinoxes*]

Computer simulation

- clearest sky conditions within 15 days of September 21 and within 15 days of March 21
- considered daylighted if illuminance levels are 300 to 3,000 lux
- The average hourly values of the two dates shall be used for two simulations—one run for 9 a.m. and the other for 3 p.m.
- The results must present the percentage of regularly occupied floor area, which meets the daylight criteria

if 75% of the floor area meets this calculated level, then **one credit point** is earned

If 90% of the floor area is demonstrated as daylighted, then **two credit points** are earned

or

3.) Light Measurements [*75% @ 300-3,000 lux on the equinoxes*]

For an actual building

- illuminance levels of 300 to 3,000 lux taken on a given day between 9 a.m. and 3 p.m.
- any two days of regular operation during the year, as long as the days are five to six months apart
- measurements must be taken on days of regular operation, not during breaks or normal shutdown times
- measurements should be taken at the standard 30-inch height above the floor
- The two sets of data are then averaged to demonstrate compliance.

if 75% of the floor area meets this calculated level, then **two credit points** are earned

If 90% of the floor area is demonstrated as daylighted, then **three credit points** are earned

DA300
Red, orange, and yellow meet the criteria.

Percentage of occupied hours where illuminance is at least 300 lux, measured at 0.85 meters above the floor plate.

■ 0% ■ 25% ■ 50% ■ 75% ■ 100%

Combining energy & daylighting
Sefaira's Real-Time Analysis plugins provide constant feedback on both energy & daylighting metrics as you work. This frees you to test unlimited design options without worrying about the time or cost of analysis.

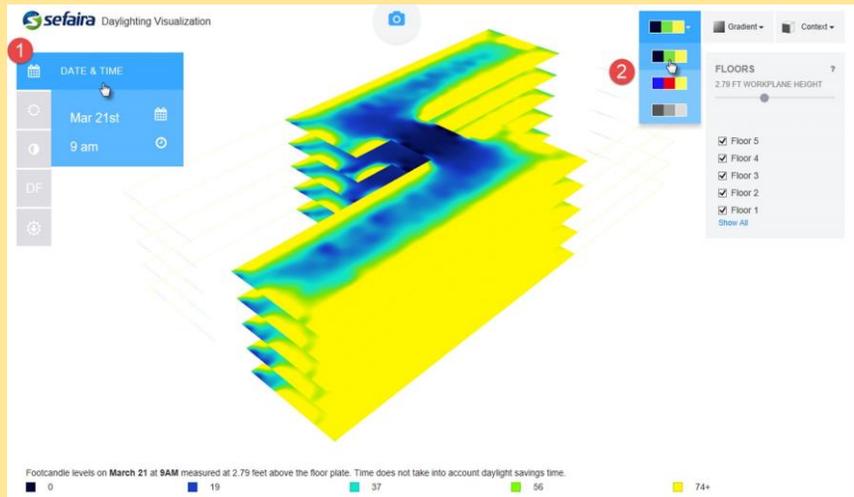
Gain insights for good daylighting decisions
With DAYSIM and Radiance-based rapid daylighting analysis, gain rapid insight into the daylight performance of your buildings while you design. Guidance, such as a clear visualization of under- and over-lit spaces, allows you to make better decisions around glazing, shading and façade design, without requiring knowledge of building physics.

Visualize & present daylighting graphics
Use daylight visualization to improve daylight distribution and communicate with clients. Exportable graphics for both annual and point-in-time analysis allow you to add powerful visuals to client presentations. You can customize reports to grid, contour and gradient views.

Available metrics include **Daylight Autonomy**, **Daylight Factor**, and **time-of-day visualizations**, as well as **Direct Sunlight Analysis** (used for certifications like SEPP 65 and BRE).

Daylighting Visualizations in Sefaira Architecture

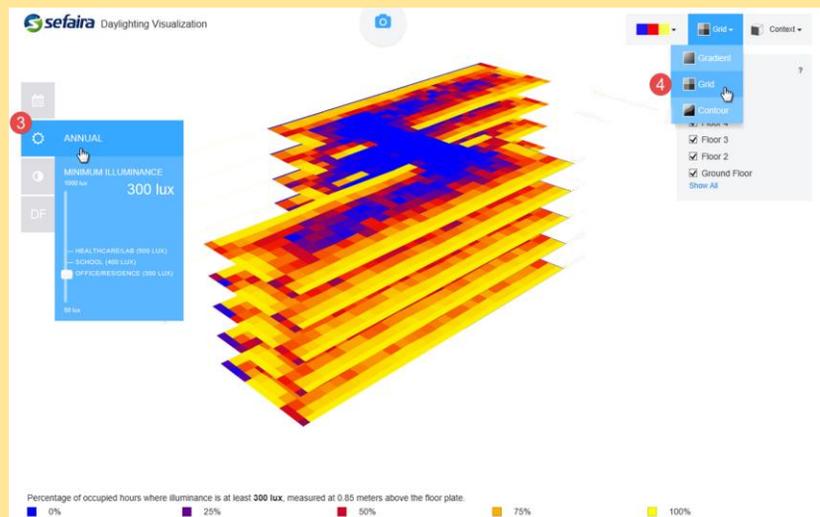
Time-of-day visualizations are useful for understanding the experience in a space at a given point in time (1). Different color palettes allow you to customize graphics for any type of output to match your presentation style, including a grey-scale option that can easily be converted to any color palette using a photo editor



You can specify a precise time and date to examine daylight distribution, here March 21 at 9am.

Daylighting Visualizations in Sefaira Architecture

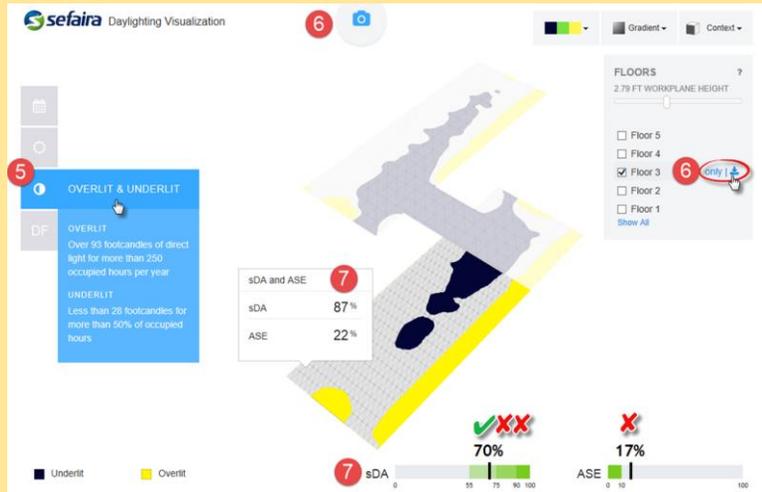
Annual daylighting metrics summarize the daylighting performance of your building throughout an entire year, taking into account design, location, and weather (3). For better graphics, you can also choose between three different rendering styles when you communicate your design intent: gradient, grid, or contour (4).



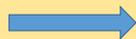
Red, orange, and yellow areas meet the DA300 criteria.

Daylighting Visualizations in Sefaira Architecture

Overlit/underlit. Sefaira provides visualizations of overlit & underlit spaces to help you understand which sections of your design need more light or experience glare (5). And while Sefaira daylighting visualization runs in real-time and directly within SketchUp and Revit, remember that you can export high-quality graphics for your presentations by either taking a snapshot with the camera button, or by exporting individual floor plans (6).



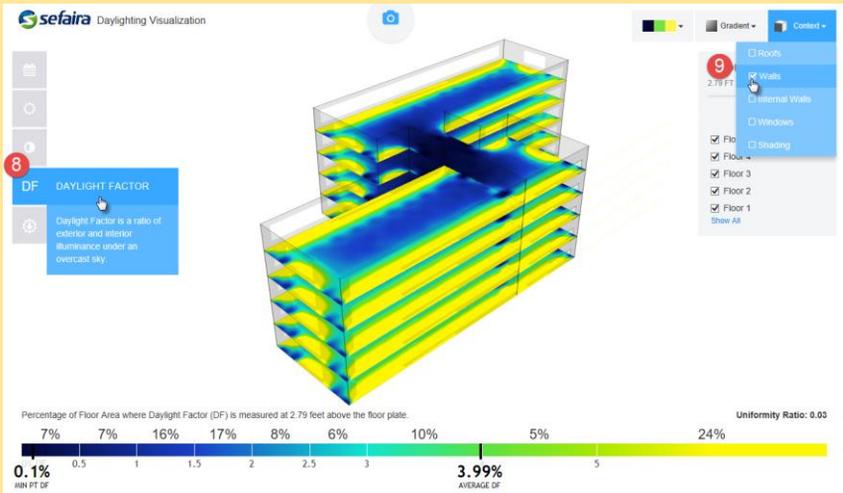
Key to LEED compliance



Sefaira helps to keep **Spatial Daylight Autonomy (sDA)** and **Annual Sunlight Exposure (ASE)** on track by aligning with LEEDv4 daylighting credits (7). You can see these metrics on a per room basis or for the entire selected floor. LEED points can be earned with minimum sDA levels of 55%, 75%, and 90% and maximum ASE is 10%.

Daylighting Visualizations in Sefaira Architecture

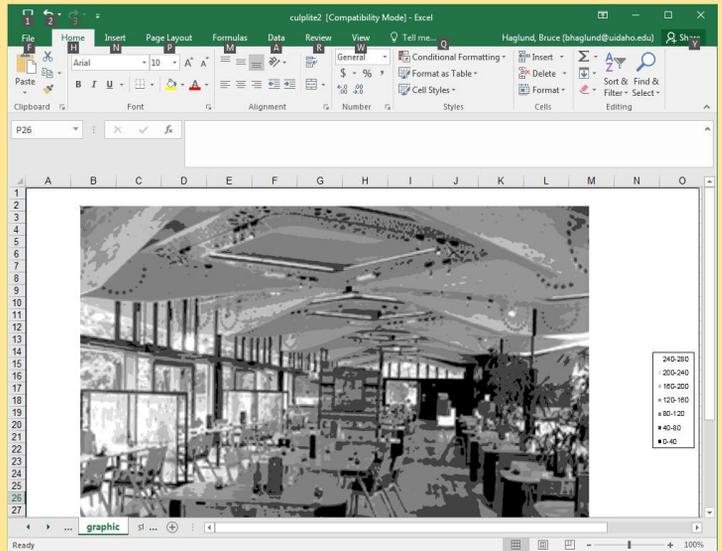
Daylight factor is an annual simulation of the daylight ratio under overcast sky conditions, providing the “worst case scenario” of a design (8). Sefaira provides three overall daylight factor metrics for the analysis area: Average Daylight Factor, Minimum Daylight Factor, and Uniformity Ratio. The last style option allows you to add context elements like walls, roofs, glazing, and shading to provide visual context as you design (9).



The graphic shows the percent of floor area in each DF bin (0 – 0.5, 0.5 – 1, etc.) plus the minimum DF, average DF and uniformity ratio.

Glare

Luminance based analysis methods have been historically difficult to conduct in scenes with daylight due to expensive equipment and the variable nature of scenes with daylight. Hand held luminance meters are not only expensive but it is difficult to record data in a space with daylight in a comprehensive manner before the daylight conditions change. High Dynamic Range (HDR) photography techniques have made access to luminance data from real daylighted spaces far more feasible to generate and computational methods are facilitating rapid development of new luminance-based analysis metrics. These techniques have been available in digital daylight simulations for many years but the development of these techniques for real spaces is more recent.



Culplite recognizes that your camera is a multipoint luminance meter. Each pixel gives relative luminance.

Glare

The images to the right reveal the potential of luminance-based analysis methods with calibrated fisheye lens cameras and HDR photography. In these images simple luminance ratios are shown for a space that a user rated as 'preferable' (above) and for a space that a user rated as 'just disturbing glare' (below).

Advanced computational methods allow designers to examine real spaces and digitally simulated spaces with emerging luminance based metrics to assess visual comfort and aspects of quality. However, there is currently very little guidance for designers seeking to refine design solutions based upon these metrics because it is still an emerging research area

