

Computer-aided Lighting Design

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- Computer-aided design
- Practical examples
- Lighting software
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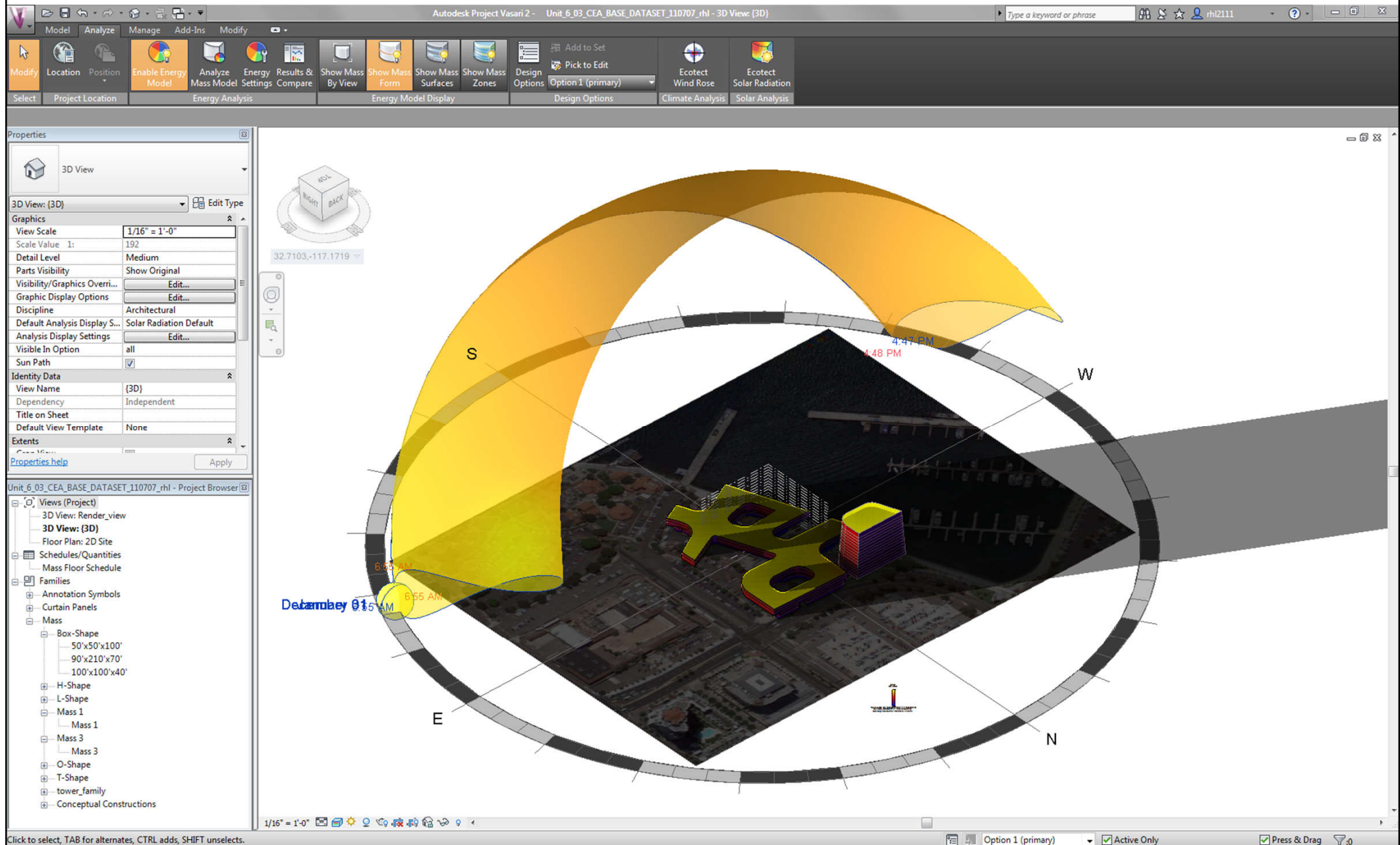


Computer-aided design



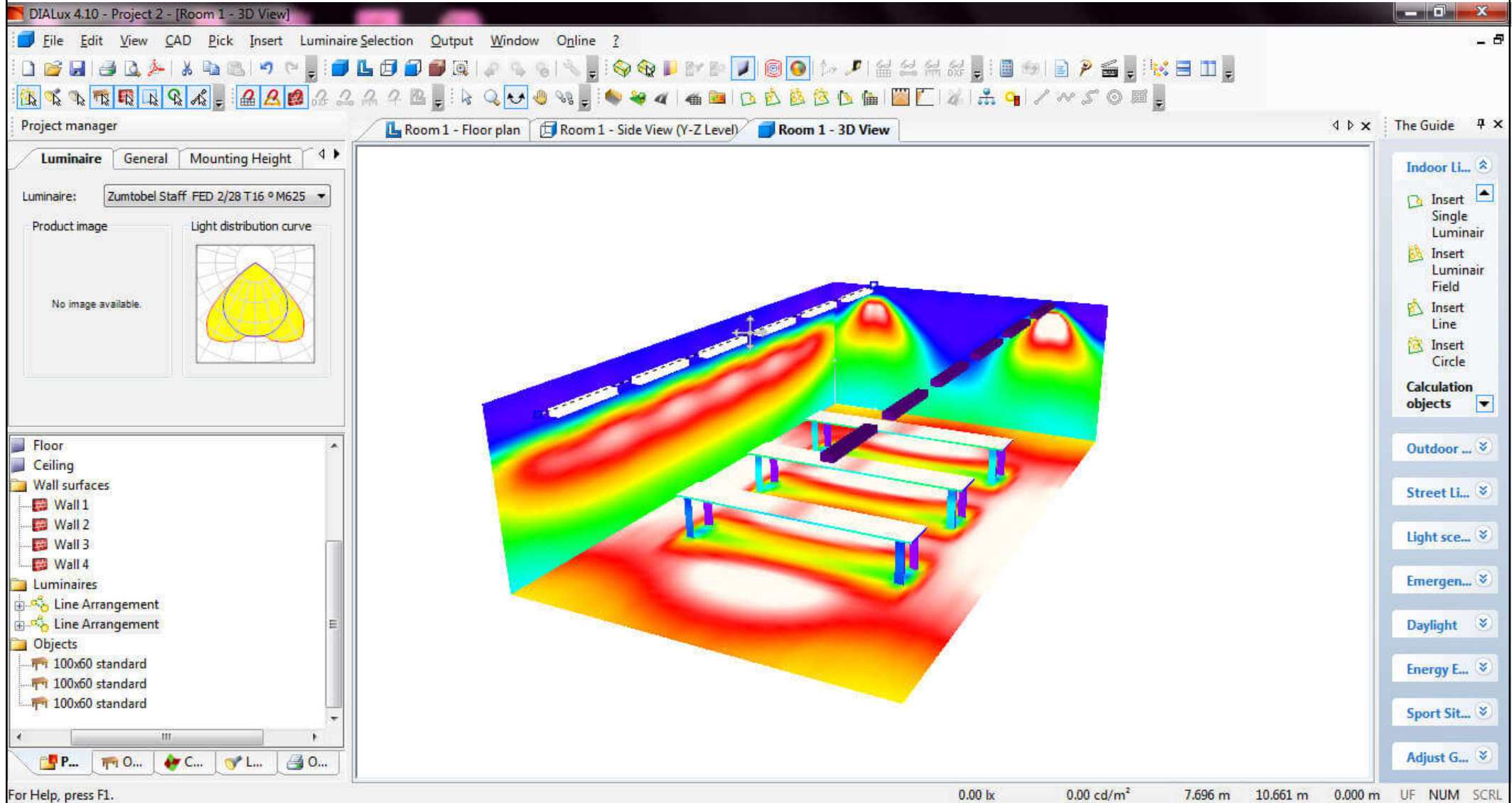
- Lighting designers often use computer software as a design tool to complement & contribute to the design process
 - Perform simple calculations, develop lighting concept & strategy (for design/control)
 - Assist in space analysis, lighting layouts, or specification of lighting products
 - Provide photo-realistic rendering & visualization
 - Check compliance with building energy codes & green building rating systems (e.g. LEED)

Conceptual energy analysis: study how the sun affects the design



(Source: Autodesk Project Vasari (retired))

Lighting calculations & simulation with DIALux 4.10 (now replaced by DIALux evo)



Lighting calculations & analysis using ADELINe & Radiance

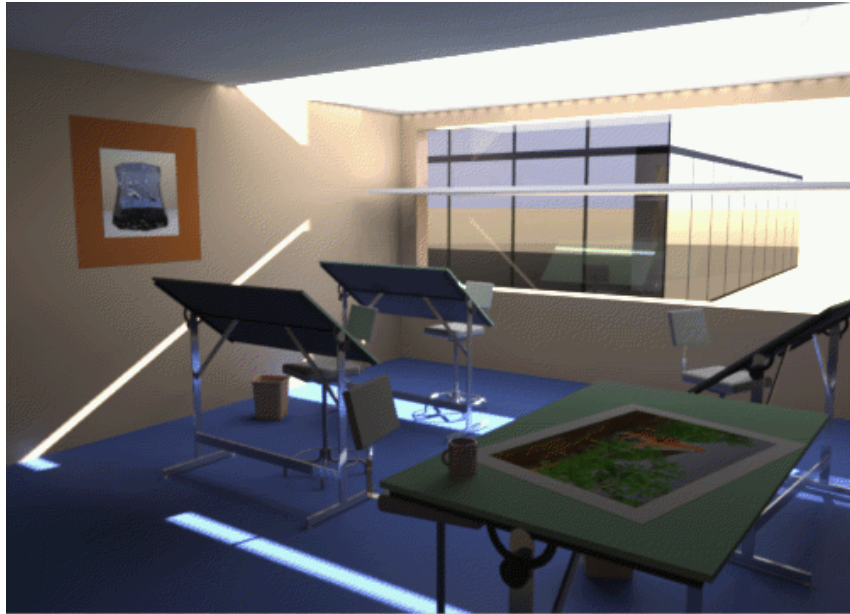


Figure 9a. A drafting office with a mirror light shelf slicing the window and redirecting light upwards.

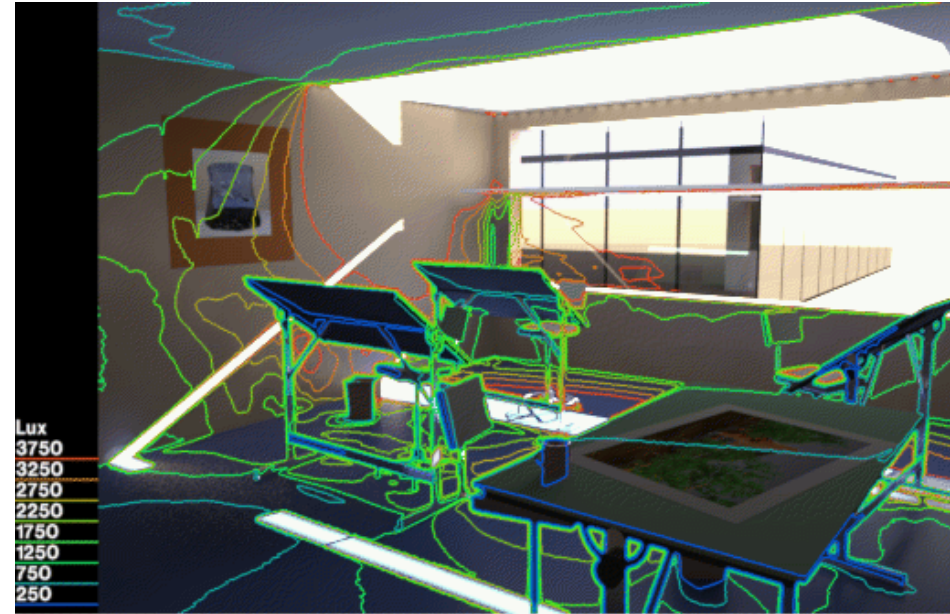


Figure 9c. A visualization of the illuminance levels on the room surfaces in the drafting office.



Lighting simulation using Radiance (real vs. simulated)



Figure I-1. Real vs. Radiance simulations of conference room and bathroom.

(Source: <http://radsite.lbl.gov/radiance/refer/>)

Computer-aided design



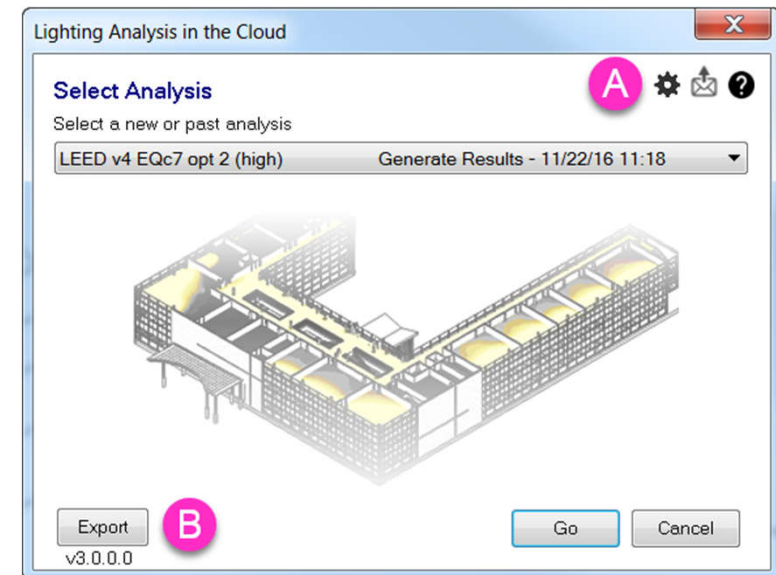
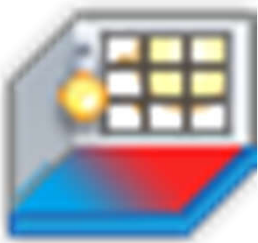
- Lighting design tools: practical application
 - Building information modelling (BIM)
 - BIM & AutoCAD library files for lighting products
 - Digital model & platform for design coordination
 - Information about building geometry, lighting products & mounting positions (BIM workflow integration)
 - Lighting analysis & simulation
 - Calculations, simulation/modelling & visualization
 - Lighting product plug-ins (from manufacturers)
 - Technical data & information for design & installation
 - Databases & standard format



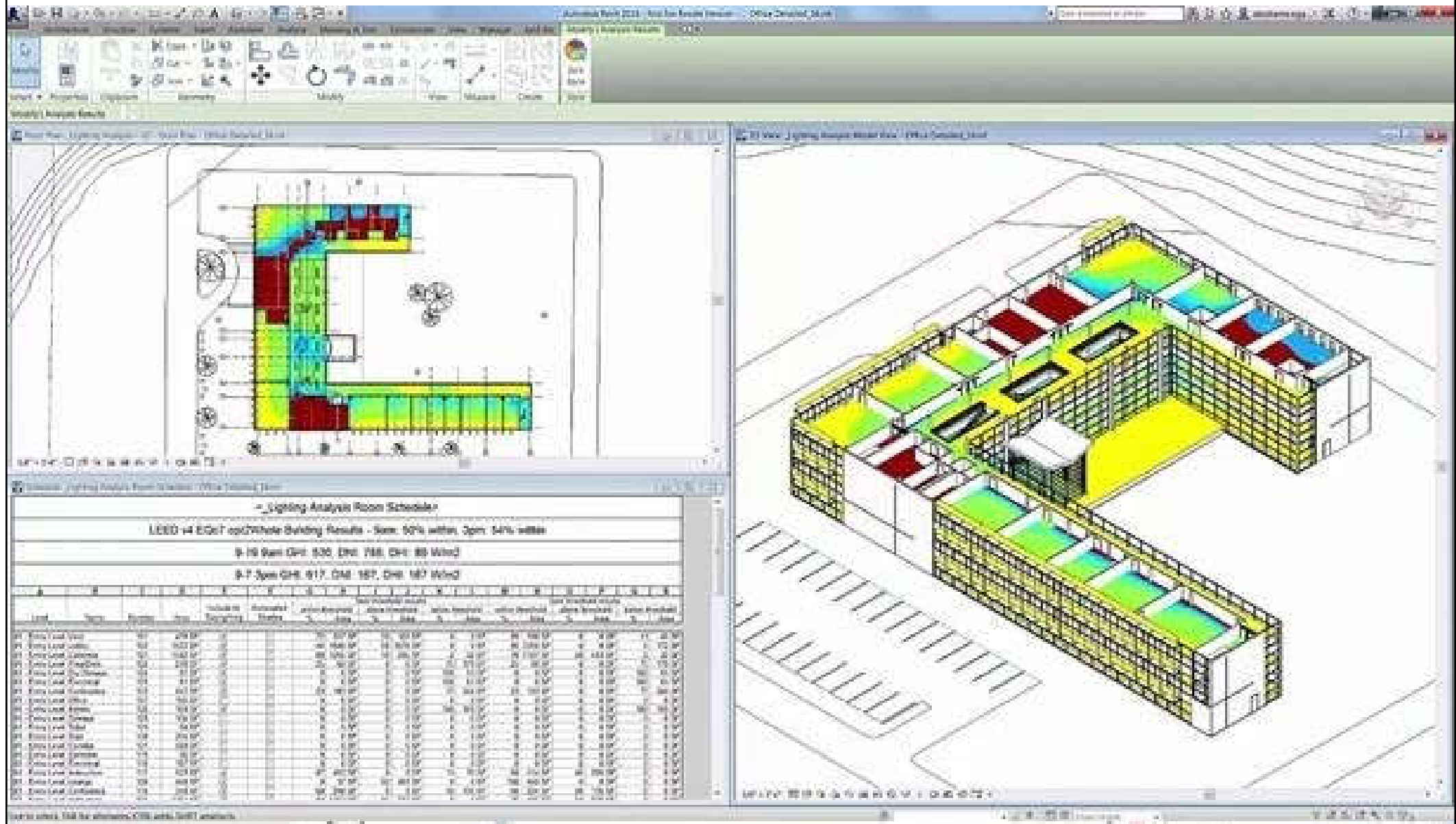
Computer-aided design



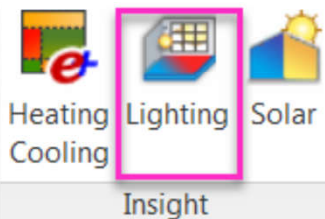
- Lighting & daylighting analysis with Revit
 - Applied to 3D & plan views of the BIM model
 - Use Autodesk A360/Drive & Insight (in the cloud)
 - Types of analysis:
 - Illuminance analysis
 - Daylight factor
 - Spatial daylight autonomy (sDA)
 - Annual sunlight exposure (ASE)
 - LEED v4 EQc7 (sDA+ASE)
 - Solar access
 - 3D perspective illuminance rendering (in the cloud)



Daylighting analysis using Insight for Revit (cloud-based)



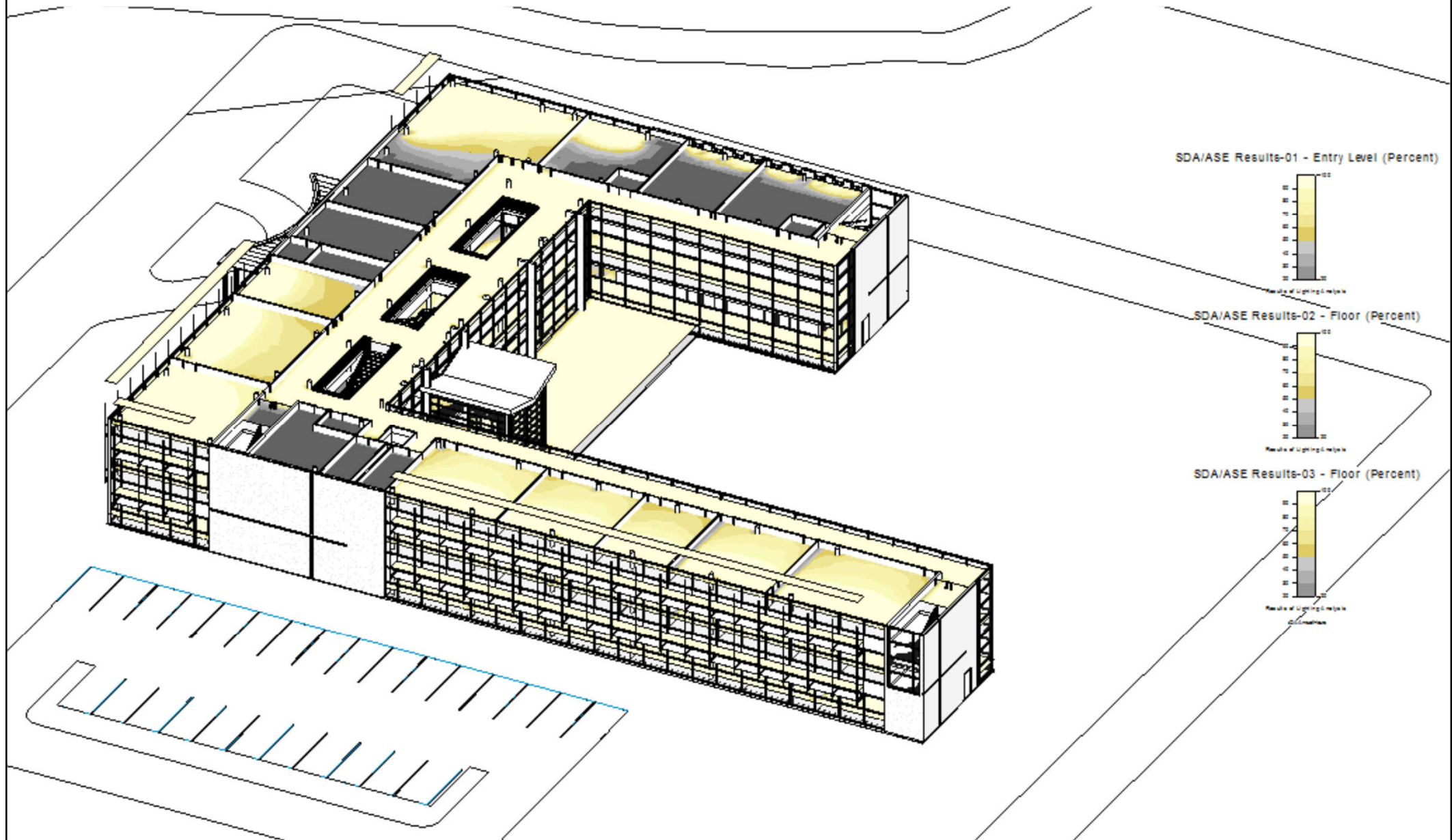
Insight Lighting Analysis to produce spatial daylight autonomy (sDA) & annual sunlight exposure (ASE) results according to LEED v4 EQc7



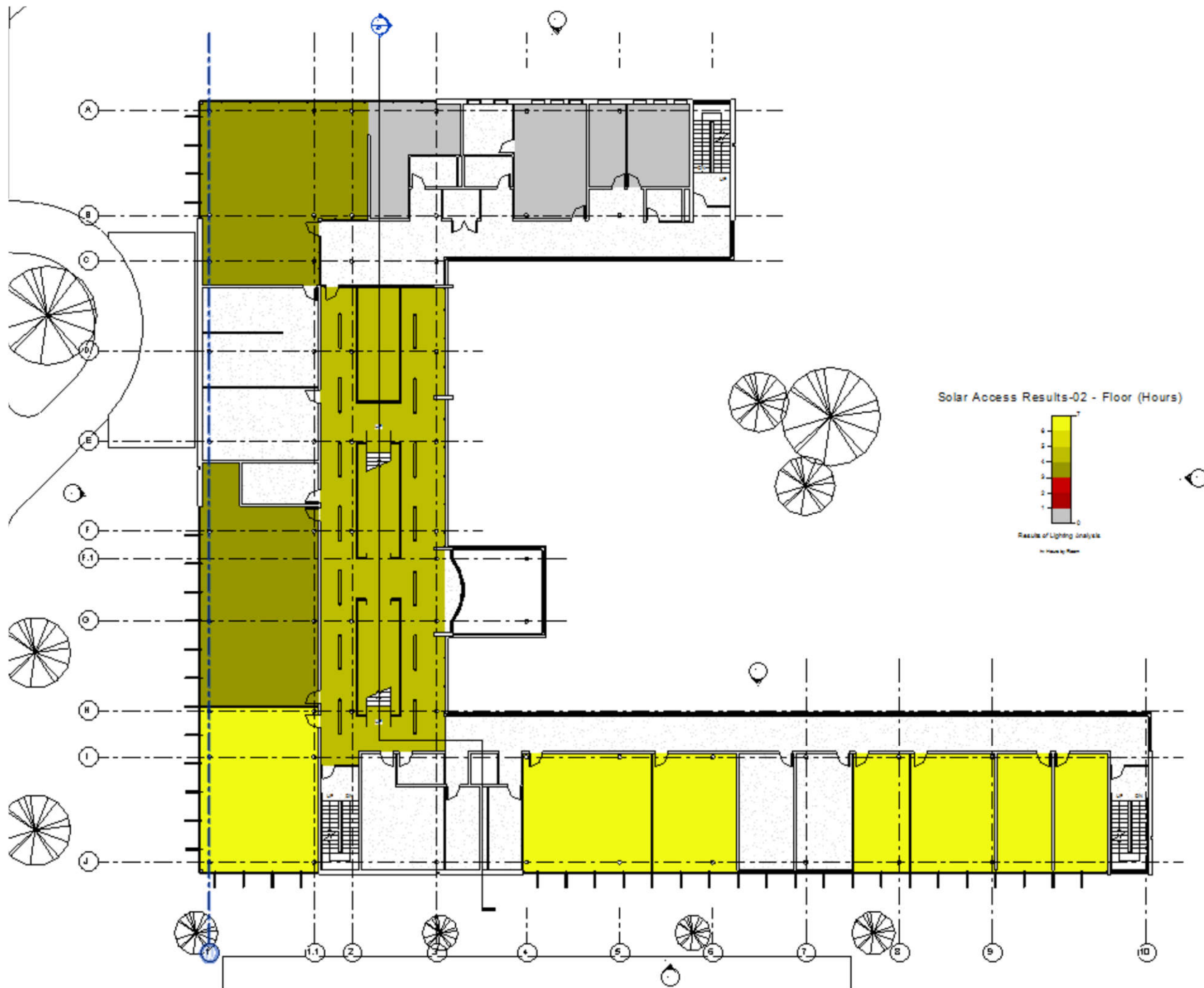
<_Lighting Analysis Room Schedule>										
LEED Daylight Autonomy Results Summary: Manchester, NH										
3% of Building Area meets sDA & ASE for 8:00am - 6:00pm, January 1 - December 31										
LEED points for % Building Area >sDA300/50 in Rooms with ASE1000/250 < 10% of Room area - 55% (2 pts) or 75% (3 pts)										
A	B	C	D	E	F	G	H	I	J	K
Level	Name	Number	Area	Include In Daylighting	sDA 300/50		ASE 1000/250		sDA/ASE	
					%	Points	%	Pass	%	Points
02 - Floor	Stair	201	19 m ²	<input type="checkbox"/>						
02 - Floor	Instruction	202	31 m ²	<input checked="" type="checkbox"/>	68	2 pt	33	No	0	none
02 - Floor	Computer Lab	203	32 m ²	<input checked="" type="checkbox"/>	88	3 pt	32	No	0	none
02 - Floor	Instruction	204	48 m ²	<input checked="" type="checkbox"/>	97	3 pt	34	No	0	none
02 - Floor	Instruction	205	32 m ²	<input checked="" type="checkbox"/>	82	3 pt	32	No	0	none
02 - Floor	Corridor	215	138 m ²	<input type="checkbox"/>						

(Source: <https://adskinsight.gitbooks.io/insight-lighting-analysis-help/content/leed-sda-ase-studies.html>)

Insight Lighting Analysis to produce spatial daylight autonomy (sDA) & annual sunlight exposure (ASE) results according to LEED v4 EQc7



Insight Lighting Analysis to produce solar access results



(Source: <https://adskinsight.gitbooks.io/insight-lighting-analysis-help/content/solar-access.html>)

Insight Lighting Analysis to produce solar access results

<_Lighting Analysis Room Schedule>

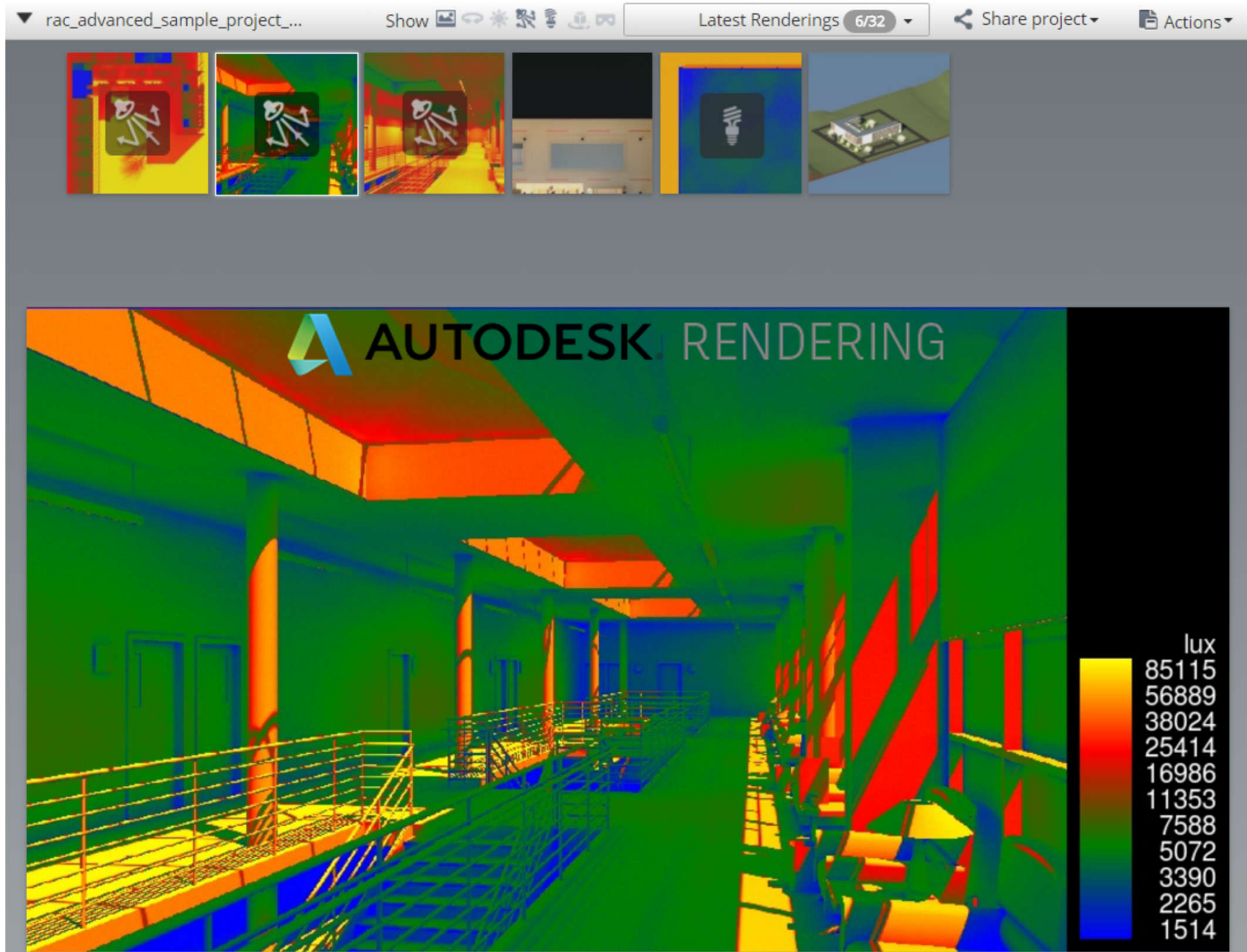
Direct Solar Access Results Summary: Manchester, NH

76% of Rooms Analyzed meet minimum number of hours of Direct Solar

Direct Solar - 9-21 9am to 3pm - minimum 3 hours

A	B	C	D	E	F	G
Level	Name	Number	Area	Include In Daylighting	Hours Direct Solar	
					Hours	Pass
01 - Entry Level	Vest.	101	41 m ²	<input checked="" type="checkbox"/>	0	No
01 - Entry Level	Lobby	102	327 m ²	<input checked="" type="checkbox"/>	4	Yes
01 - Entry Level	Cafeteria	121	147 m ²	<input checked="" type="checkbox"/>	3	Yes
01 - Entry Level	Prep/Dish	122	22 m ²	<input checked="" type="checkbox"/>	0	No
01 - Entry Level	Dry Storage	124	8 m ²	<input type="checkbox"/>		
01 - Entry Level	Electrical	125	6 m ²	<input type="checkbox"/>		
01 - Entry Level	Conference	123	42 m ²	<input checked="" type="checkbox"/>	0	No
01 - Entry Level	Office	127	15 m ²	<input type="checkbox"/>		
01 - Entry Level	Admin	126	16 m ²	<input type="checkbox"/>		
01 - Entry Level	Storage	128	10 m ²	<input type="checkbox"/>		
01 - Entry Level	Toilet	129	6 m ²	<input type="checkbox"/>		
01 - Entry Level	Stair	130	19 m ²	<input type="checkbox"/>		

3D perspective illuminance rendering with Autodesk A360



(Source: <https://adskinsight.gitbooks.io/insight-lighting-analysis-help/content/perspective-illuminance-renderings.html>)

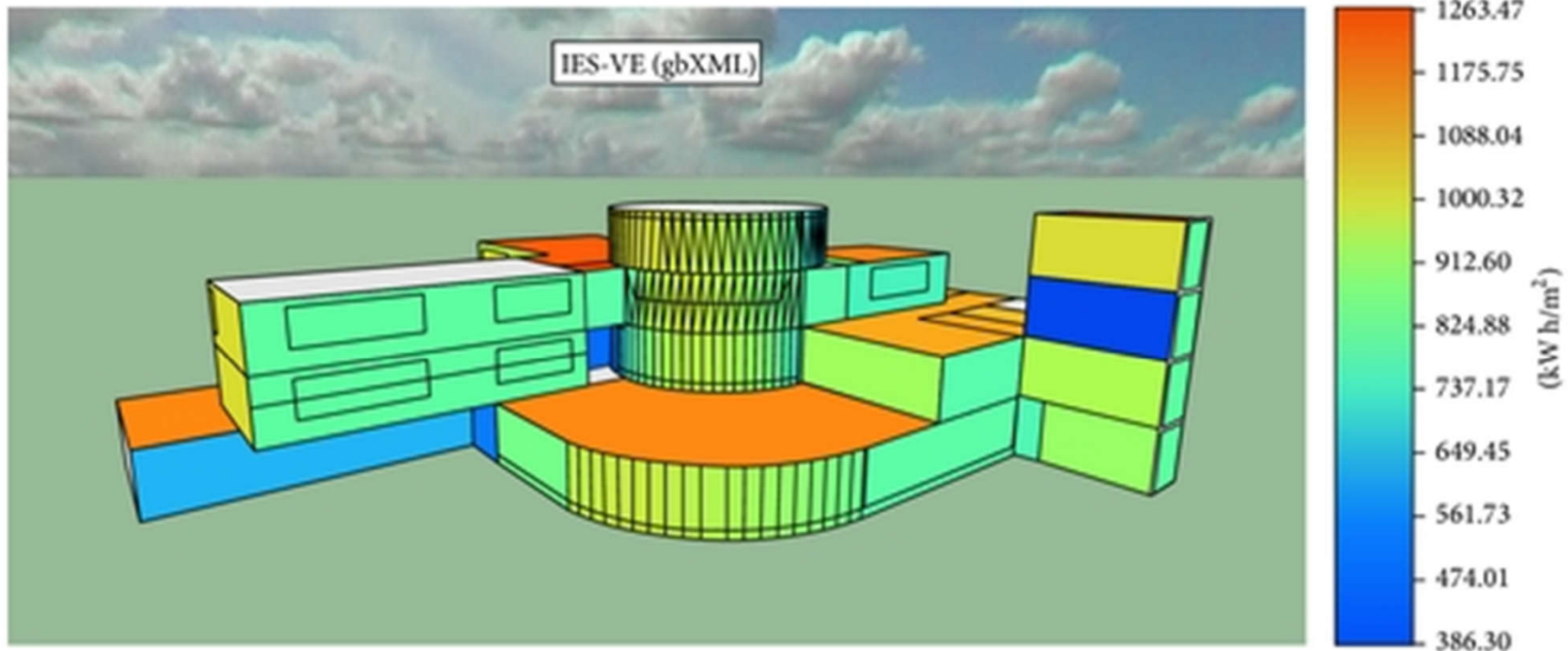
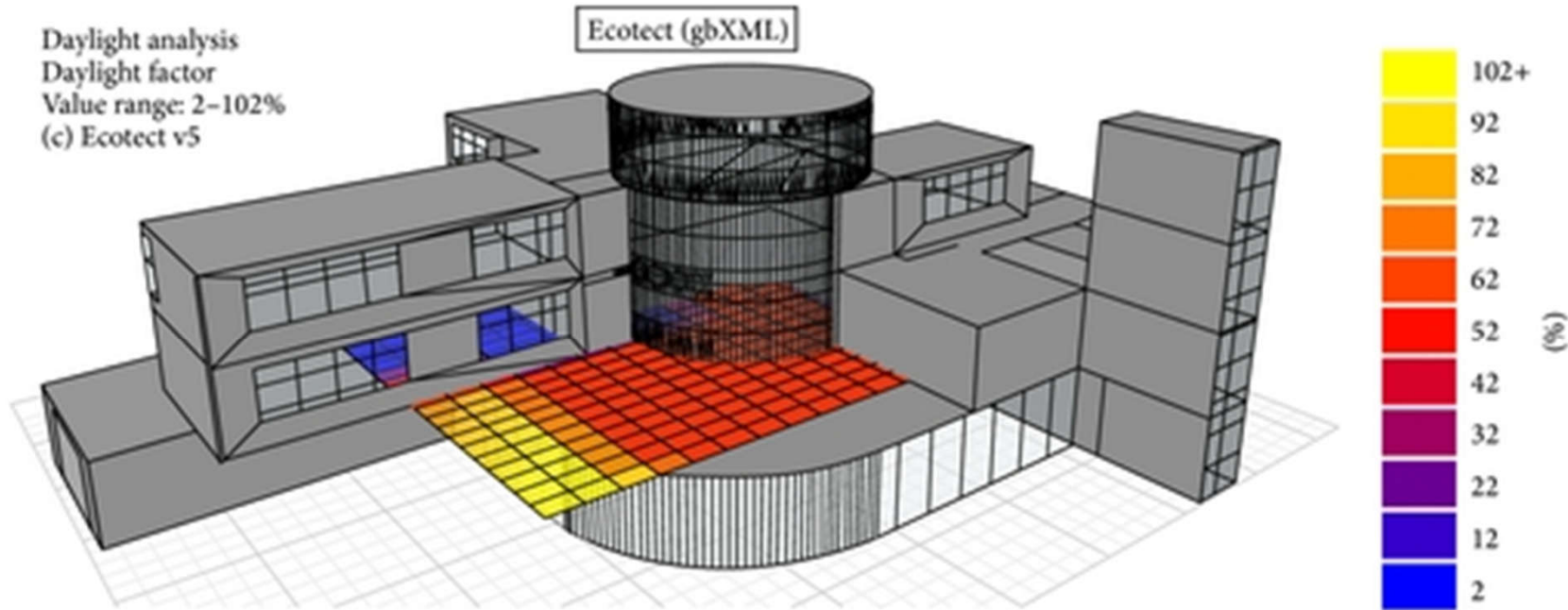
Computer-aided design



- Daylight simulation & lighting design with IESVE
 - Daylight modelling & daylight autonomy
 - Daylight factor & useful daylight illuminance (UDI)
 - Daylight, sunlight & overshadowing analysis
 - Spatial daylight autonomy & annual sunlight exposure
 - Daylight harvesting & dimming control assessments
 - Daylight credits for LEED, BREEAM & WELL
 - Uniformity, luminance & glare prediction

Snapshot of the daylighting simulation in Ecotect & IES-VE

Daylight analysis
Daylight factor
Value range: 2-102%
(c) Ecotect v5

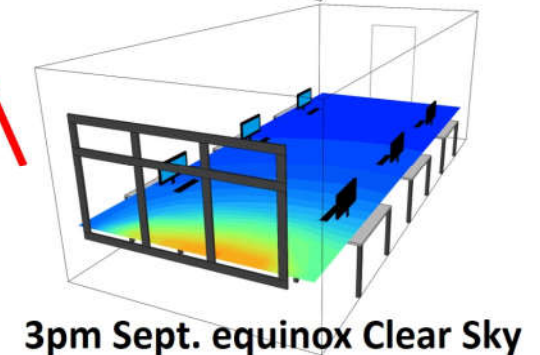
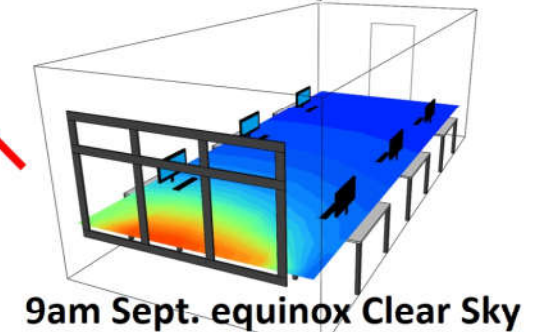
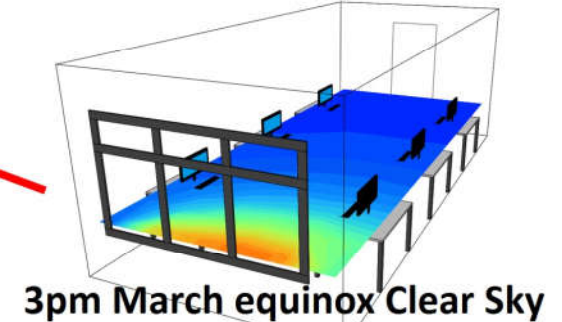
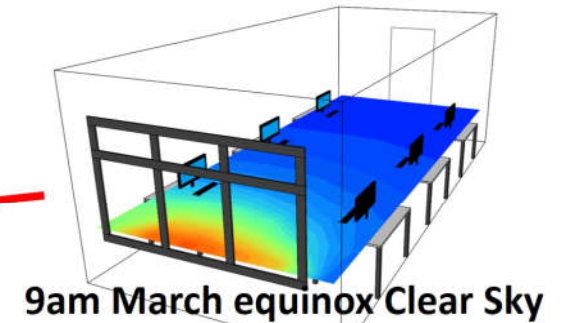
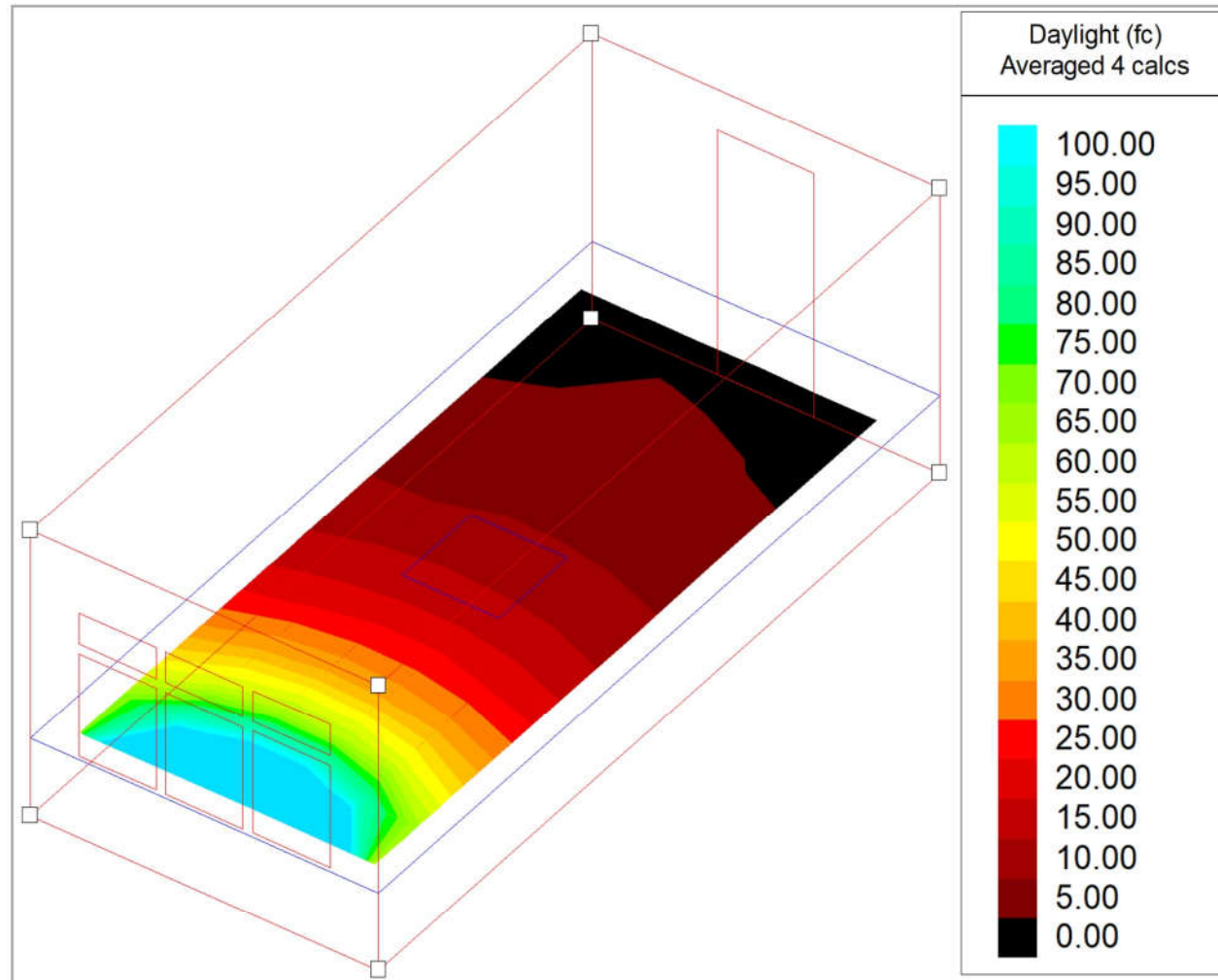


0.1/Jan-00:00 to 31/Dec-23:00

(Source: https://www.researchgate.net/figure/Snapshot-of-the-sample-daylighting-simulation-in-Ecotect-and-IES-VE_fig7_286297458)

LEED v4.1 IEQ Daylight (Option 2) simulation: illuminance calculations

LEED v4.1 IEQ Daylight Option 2- Simulation: Illuminance Calculations

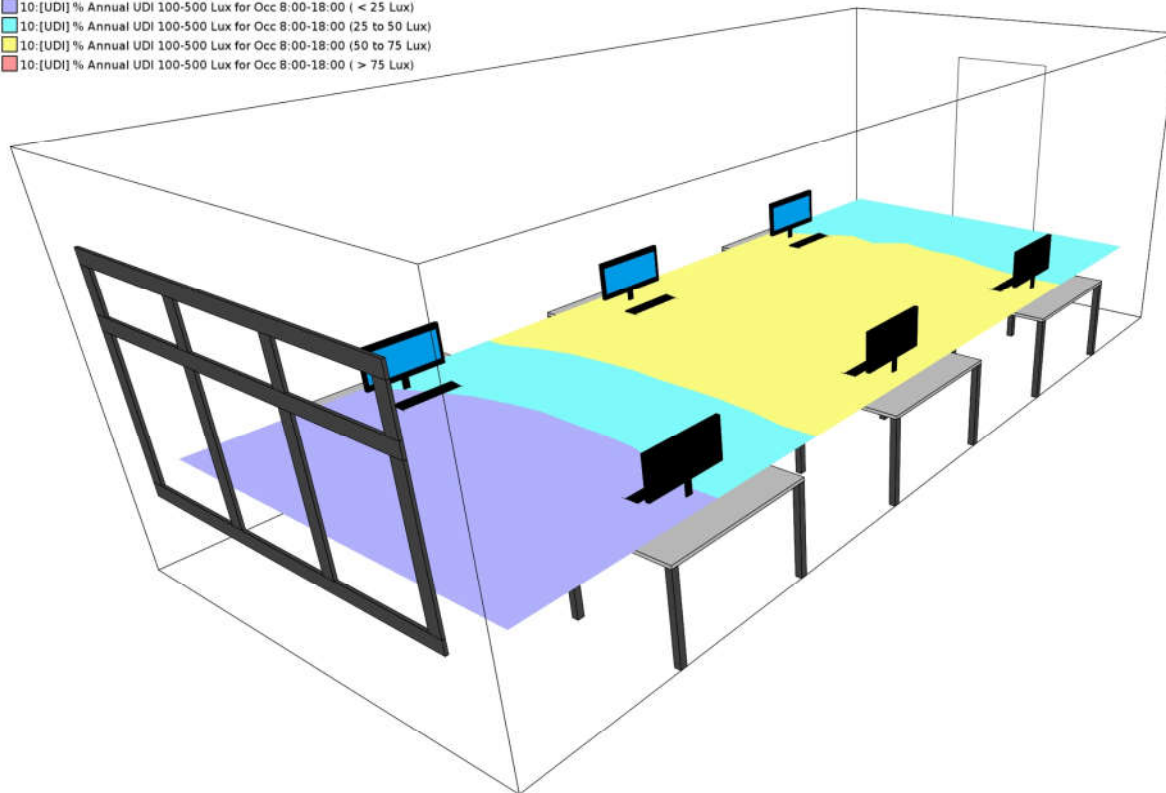


New Construction, Core and Shell, Schools, Retail, Data Centers, Warehouses and Distribution Centers, Hospitality		Healthcare	
Percentage of regularly occupied floor area	Points	Percentage of regularly occupied floor area within perimeter area	Points
55%	1	55%	1
75%	2	75%	2
90%	3	90%	Exemplary performance

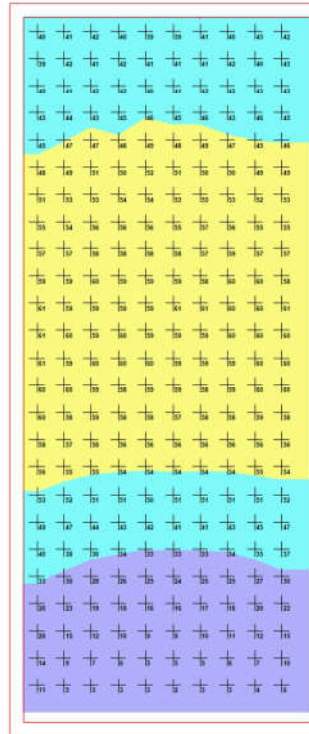
(Source: <https://www.iesve.com/discoveries/article/3813/ten-key-daylight-and-electric-metrics>)

Useful daylight illuminance (UDI) simulations with IESVE

10:[UDI] % Annual UDI 100-500 Lux for Occ 8:00-18:00 (< 25 Lux)
 10:[UDI] % Annual UDI 100-500 Lux for Occ 8:00-18:00 (25 to 50 Lux)
 10:[UDI] % Annual UDI 100-500 Lux for Occ 8:00-18:00 (50 to 75 Lux)
 10:[UDI] % Annual UDI 100-500 Lux for Occ 8:00-18:00 (> 75 Lux)



Plan View (Working Plane)

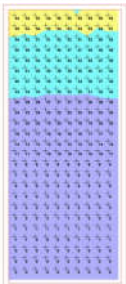


[UDI] % Annual UDI 100-500 Lux for Occ 8:00-18:00

< 25 % = 40 (250)
 25 - 50 % = 84
 50 - 75 % = 126
 > 75 % = 0

Percentage	250
> 75.00	0.0 %
50.00 - 75.00	50.4 %
25.00 - 50.00	33.6 %
< 25.00	16.0 %

Insufficient UDI (< 100 lux)

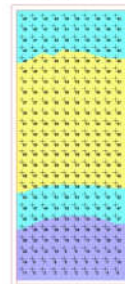


9:[UDI] % Annual UDI <100 Lux for Occ 8:00-18:00

< 25 % = 160 (250)
25 - 50 % = 99
50 - 75 % = 31
> 75 % = 0

Percentage	250
> 75.00	0.0 %
50.00 - 75.00	12.4 %
25.00 - 50.00	23.6 %
< 25.00	64.0 %

Supplementary UDI (100–500 lux)

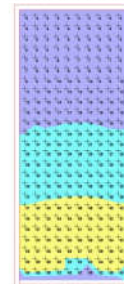


10:[UDI] % Annual UDI 100-500 Lux for Occ 8:00-18:00

< 25 % = 40 (250)
25 - 50 % = 84
50 - 75 % = 126
> 75 % = 0

Percentage	250
> 75.00	0.0 %
50.00 - 75.00	50.4 %
25.00 - 50.00	33.6 %
< 25.00	16.0 %

Autonomous UDI (500–2,500 lux)

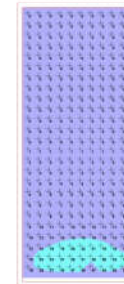


11:[UDI] % Annual UDI 500-2500 Lux for Occ 8:00-18:00

< 25 % = 121 (250)
25 - 50 % = 73
50 - 75 % = 56
> 75 % = 0

Percentage	250
> 75.00	0.0 %
50.00 - 75.00	22.4 %
25.00 - 50.00	29.2 %
< 25.00	48.4 %

Exceedance UDI (> 2,500 lux)



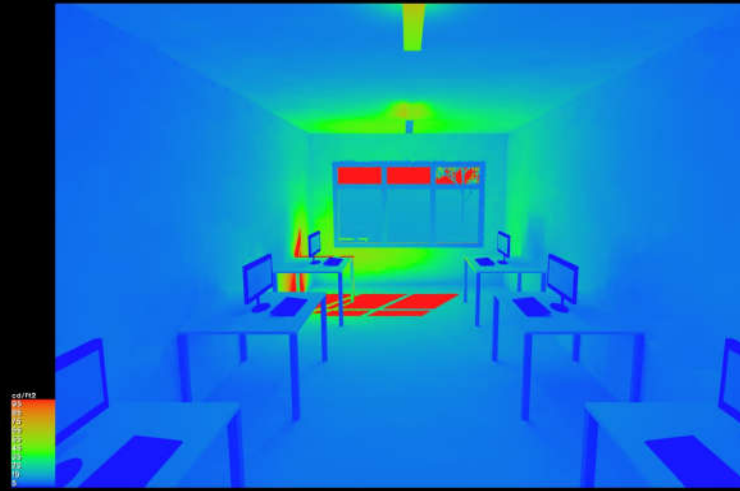
12:[UDI] % Annual UDI >2500 Lux for Occ 8:00-18:00

< 25 % = 236 (250)
25 - 50 % = 14
50 - 75 % = 0
> 75 % = 0

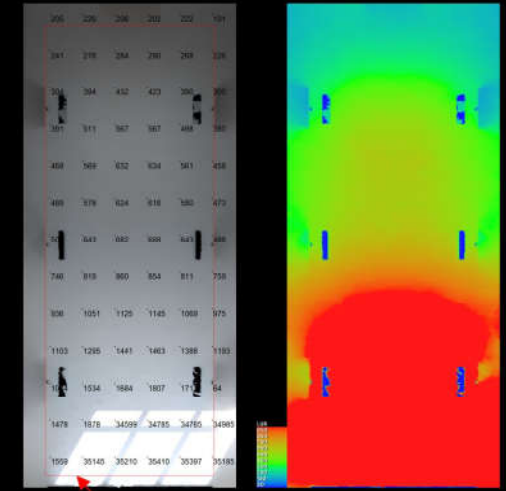
Percentage	250
> 75.00	0.0 %
50.00 - 75.00	0.0 %
25.00 - 50.00	5.6 %
< 25.00	94.4 %

Uniformity calculations & daylight factor simulations with IESVE

No shades / blinds – [Uniformity = 0.06]

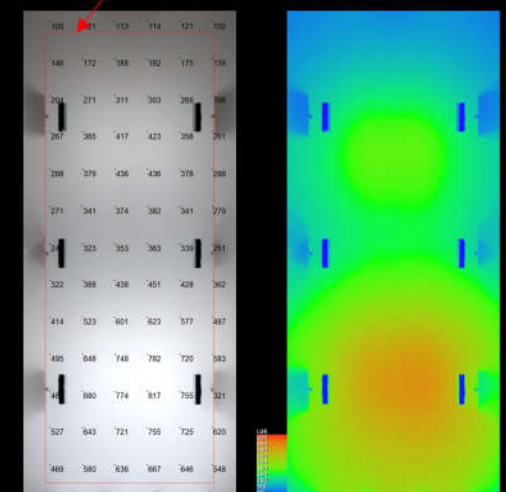


Plan View on working plane



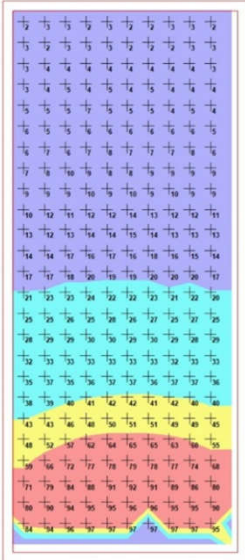
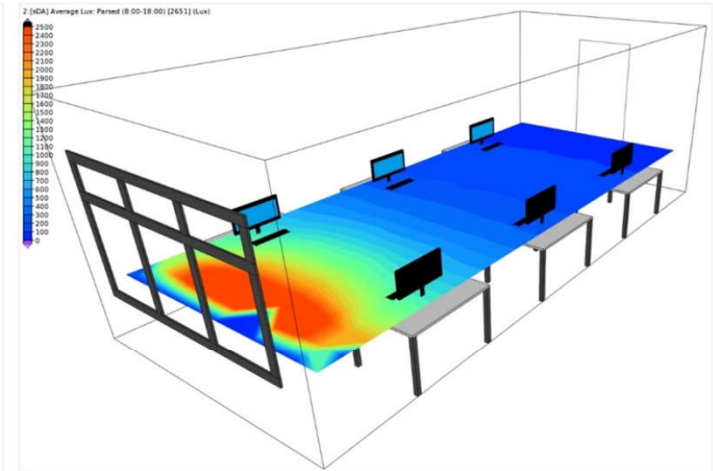
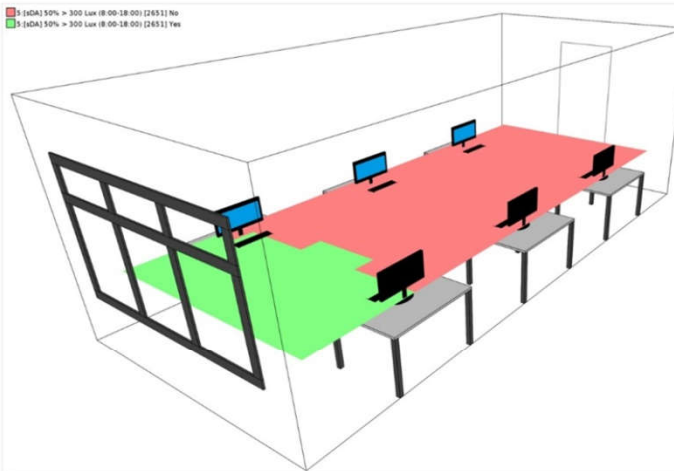
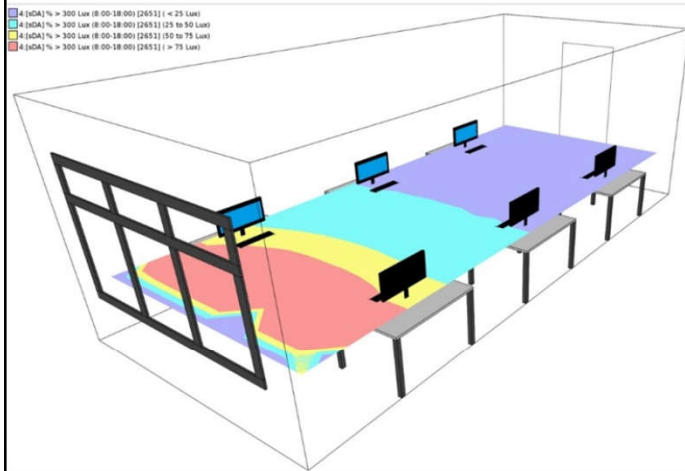
Area of Interest defined

With daylight-redirecting blinds – [Uniformity = 0.31]



Plan View on working plane

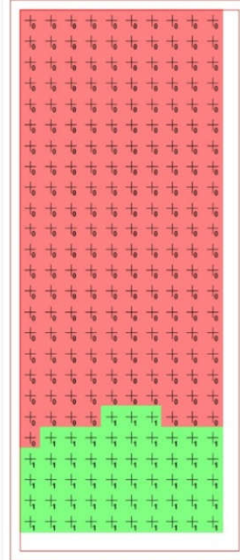
Spatial daylight autonomy (sDA) analysis with IESVE



4:[sDA] % > 300 Lux (8:00-18:00)

< 25 % = 140 (250)
25 - 50 % = 58
50 - 75 % = 18
> 75 % = 34

Percentage	250
> 75.00	13.6 %
50.00 - 75.00	7.2 %
25.00 - 50.00	23.2 %
< 25.00	56.0 %



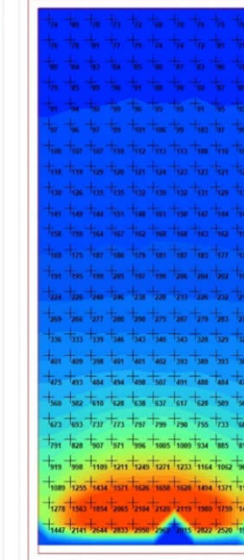
5:[sDA] 50% > 300 Lux (8:00-18:00)

Yes = 52 of 250 = 20.80 %

sDA_{300lux/50%} = 20.8%

Yes/No 250

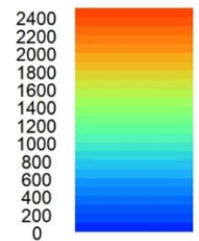
Yes	52
No	198



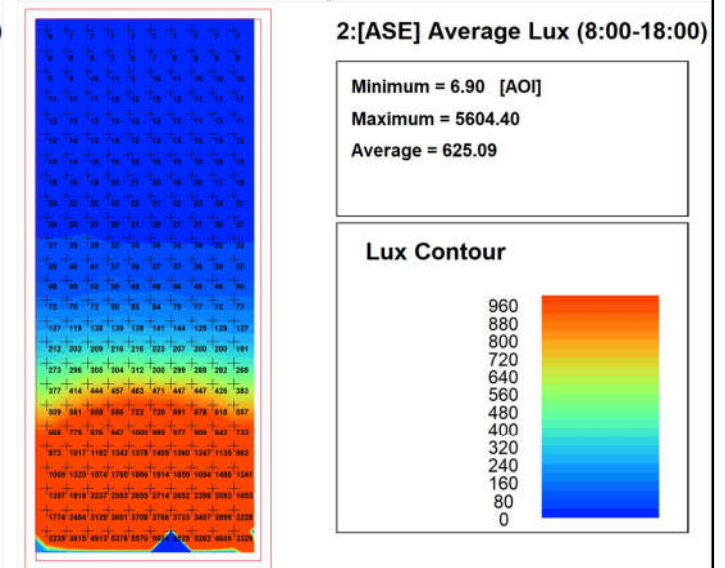
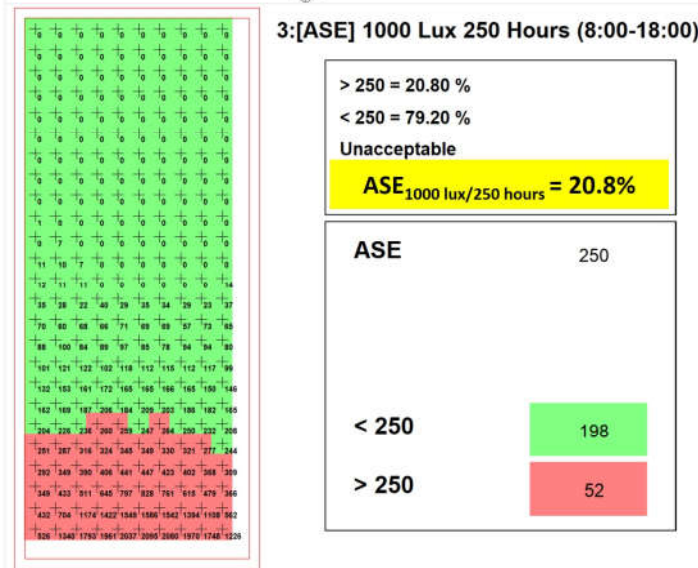
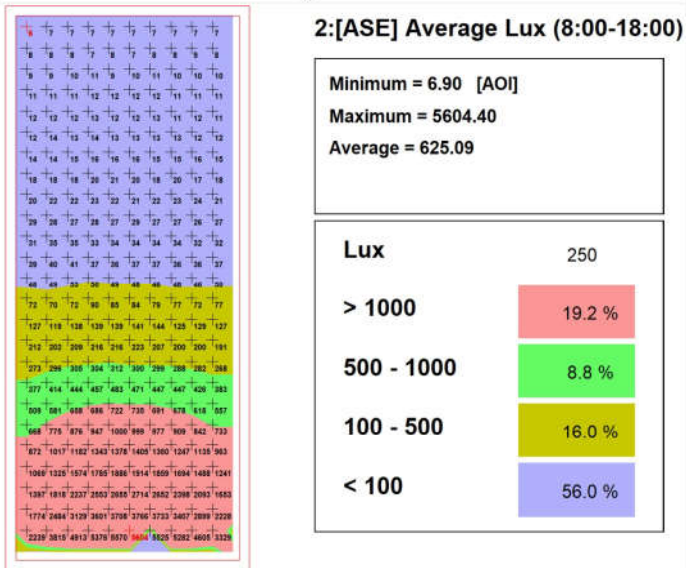
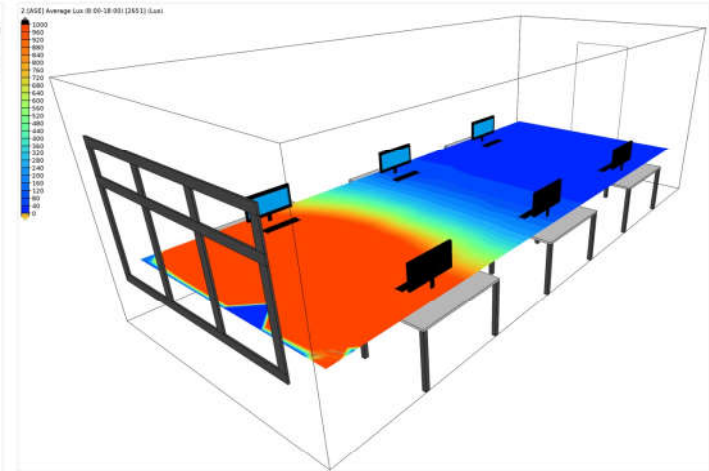
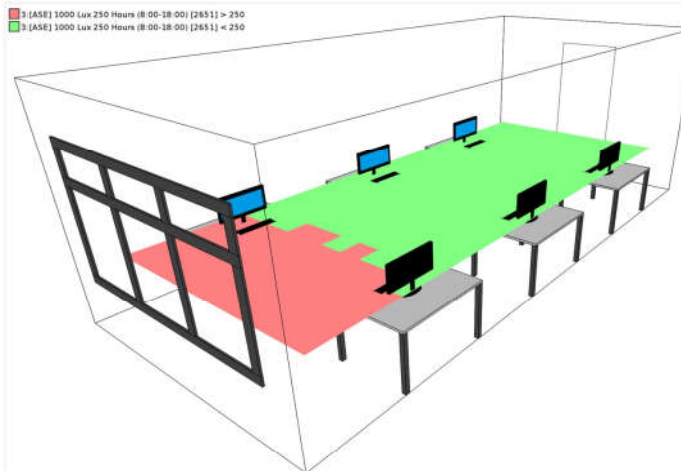
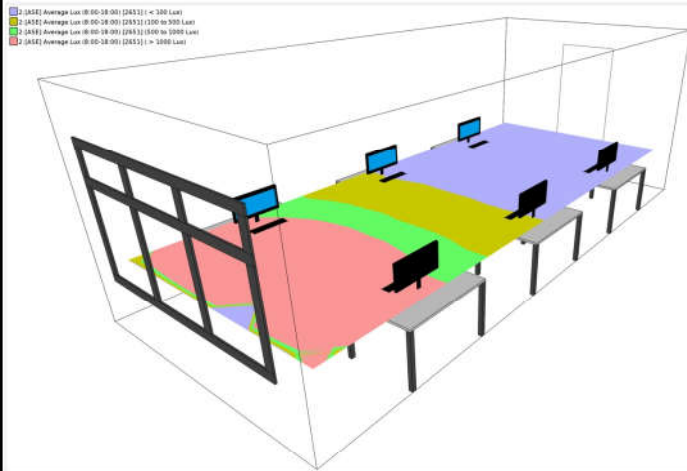
2:[sDA] Average Lux: Parsed (8:00-18:00)

Minimum = 68.80 [AOI]
Maximum = 2969.80
Average = 498.77

Lux Contour



Annual sunlight exposure (ASE) analysis with IESVE

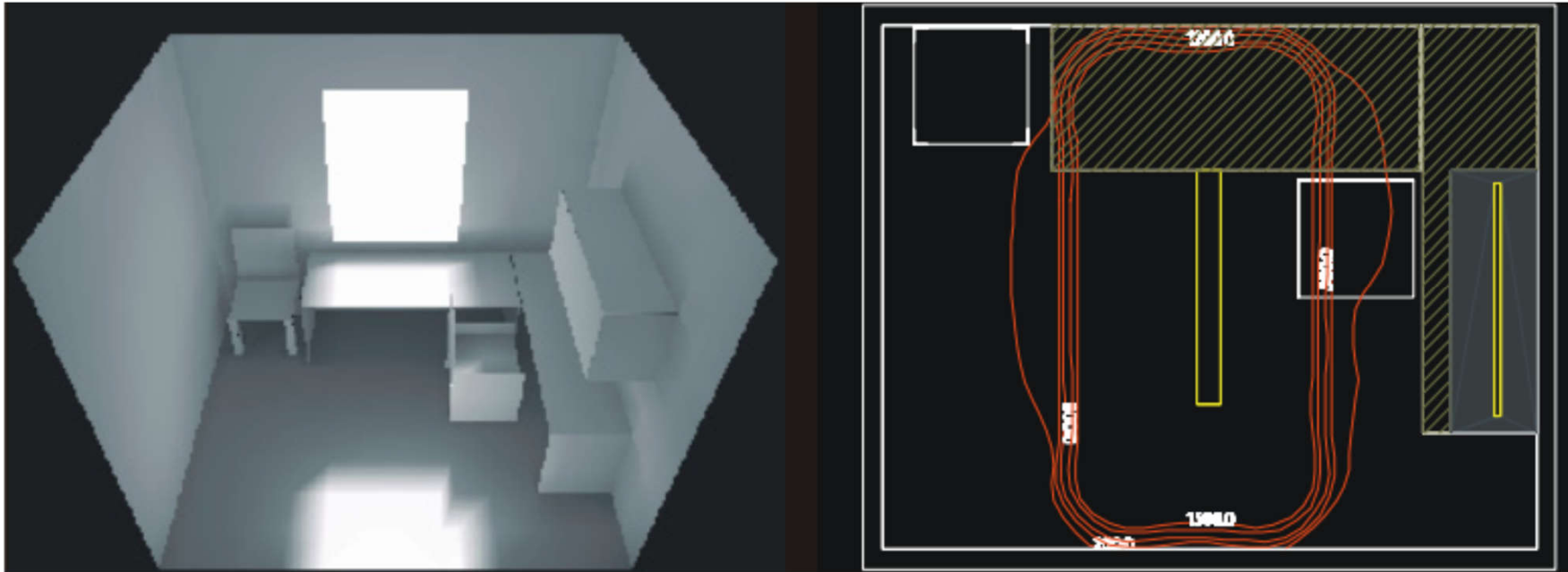


Practical examples

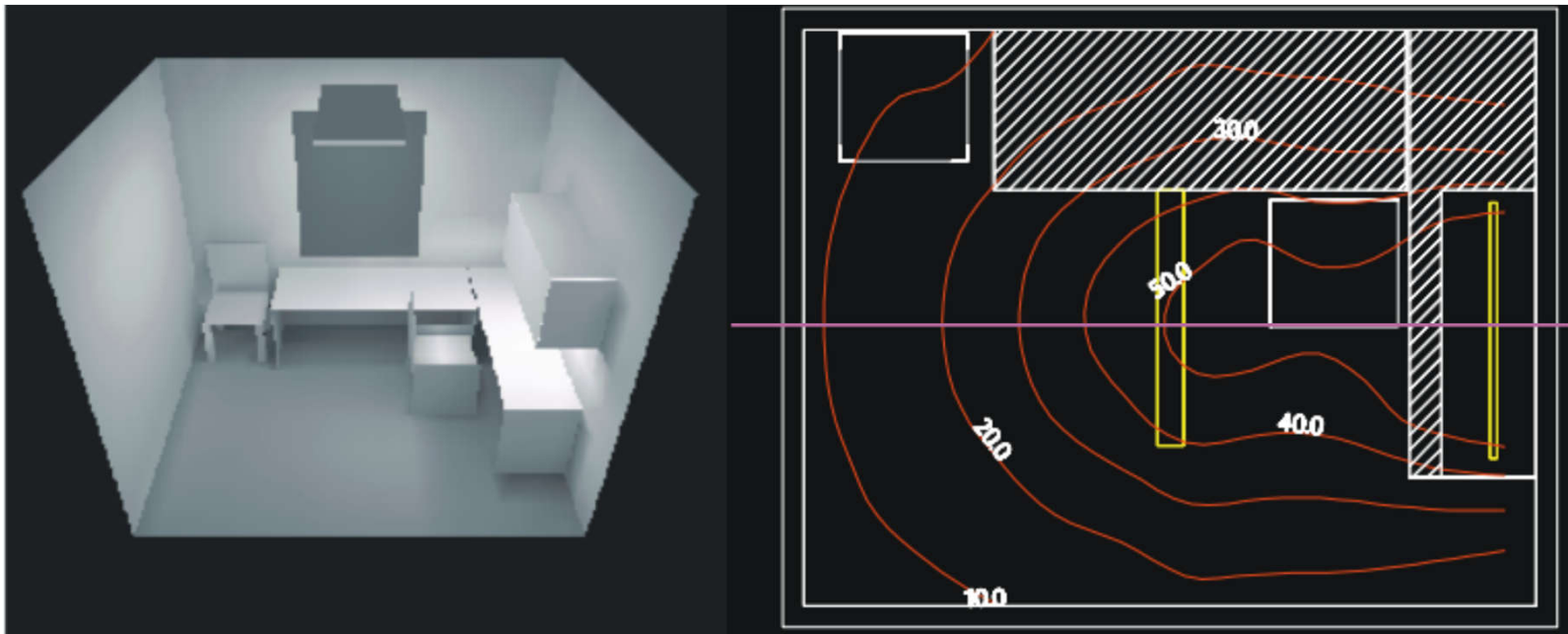


- 1. Private office & small work rooms
 - With a window for admitting daylight
 - General lighting (on ceiling): recessed indirect luminaire, two F32 T8 lamps
 - Task light: under cabinet, one F25 T8 lamp
 - Analyse light distribution at daytime & nighttime
- 2. Open office plan areas
 - Gray-scale rendering: daytime, daylight + electric light; evaluate the design & control strategies

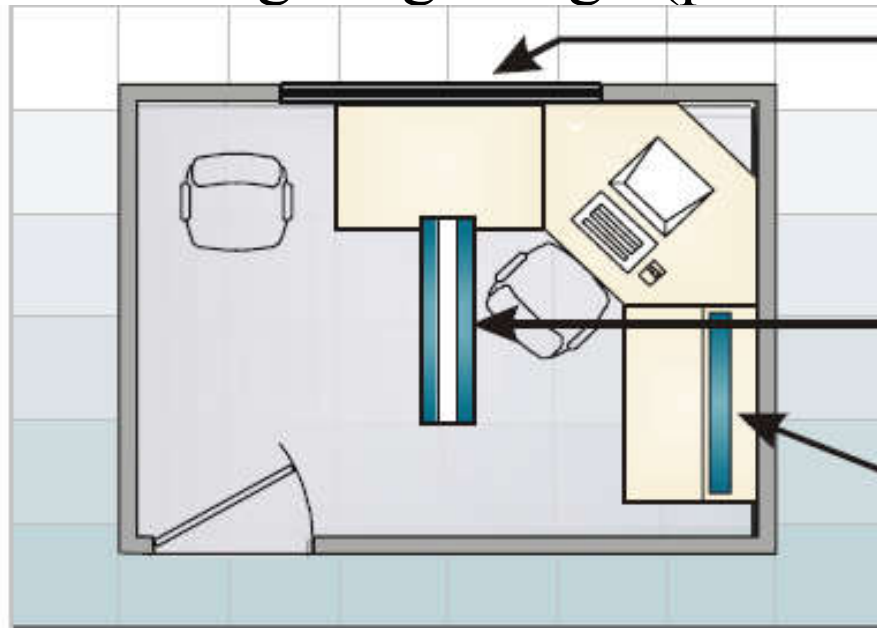
Daylighting distribution, private office at daytime



Electric lighting distribution, private office at night



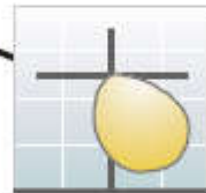
Lighting design (private office) with one luminaire in ceiling



Daylight, from window with horizontal blinds, provides sufficient ambient light in space for part of the day and controls direct glare by directing direct beam sunlight upwards towards ceiling.

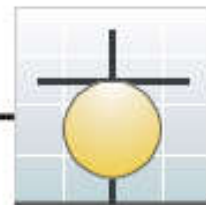
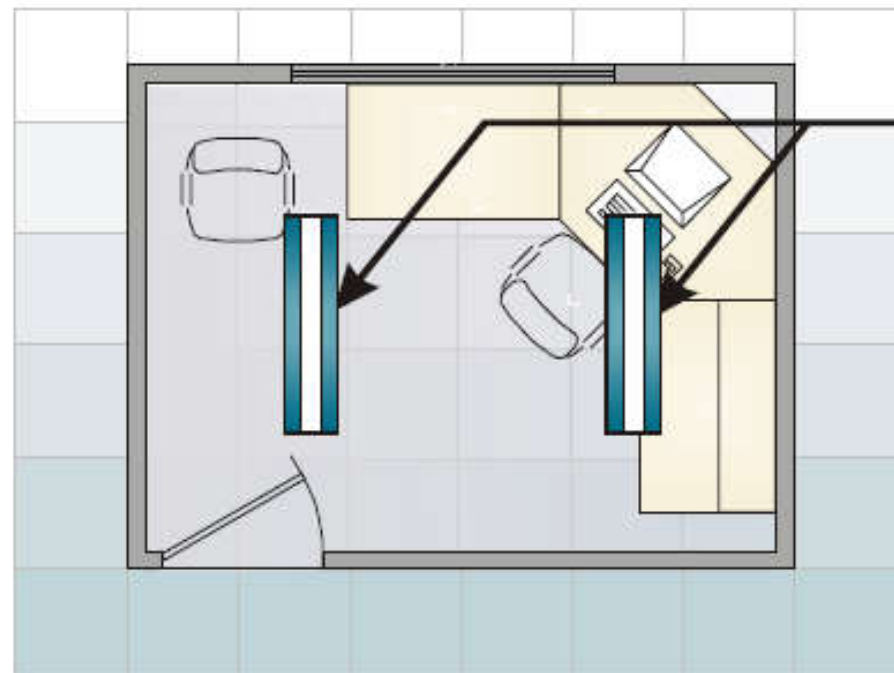


Recessed "indirect" basket luminaire produces direct light using two F32 T8 lamps and NLO/EE ballast. Dimming electronic ballasts allow for user and automatic photosensor control of light levels.



Under-cabinet task light, with one F25T8 lamp and RLO/EE ballast allows high illumination levels at task surface. User control or occupancy sensor.

Lighting design (private office) – alternate design with two luminaires



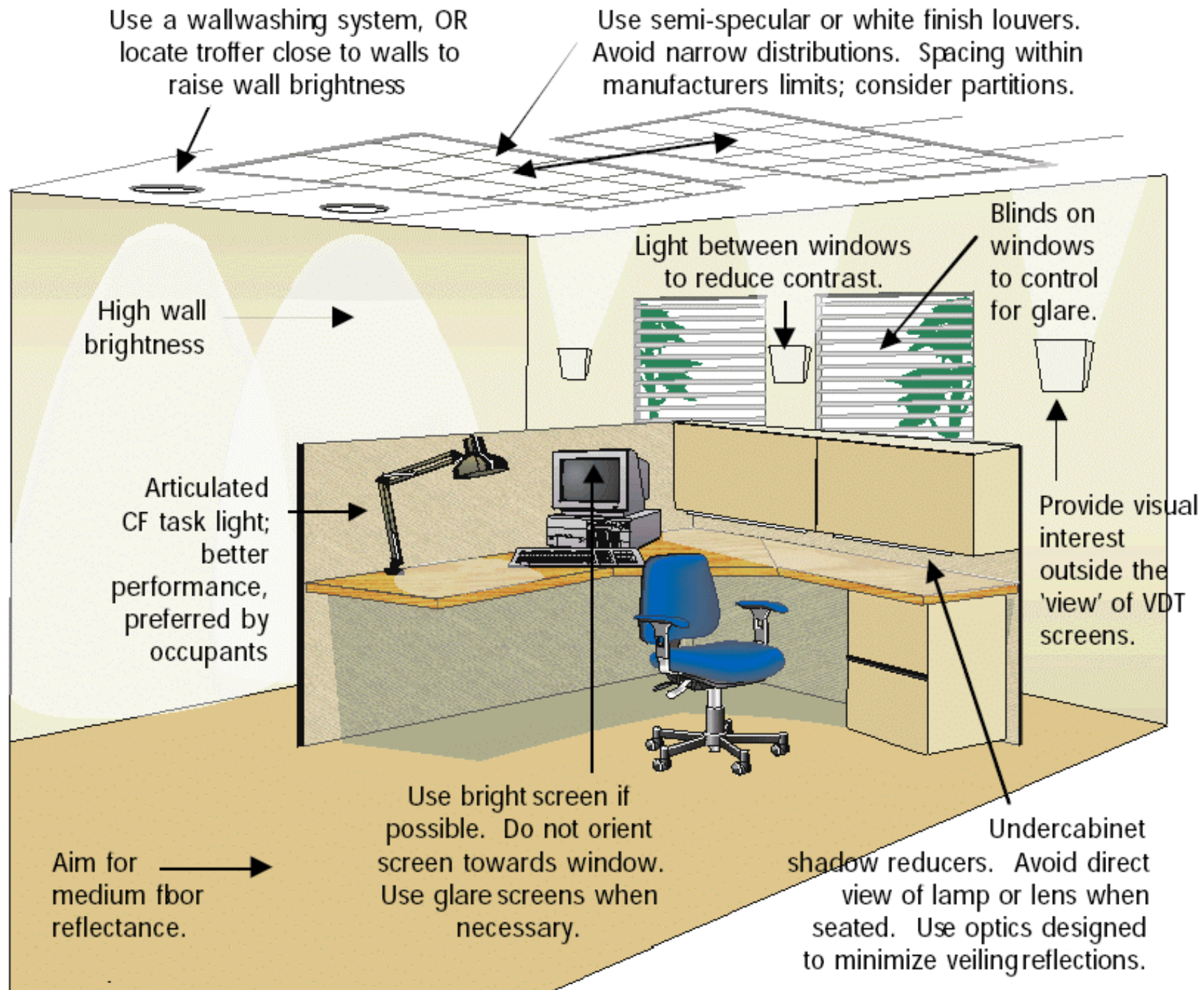
Alternate design using two recessed "indirect" basket luminaires, spaced about 6' apart, each with a single F32 T8 lamp and wired in tandem to a single NLO/EE ballast, distributes light more evenly over entire area but costs more.

Example of lighting design (open plan office)



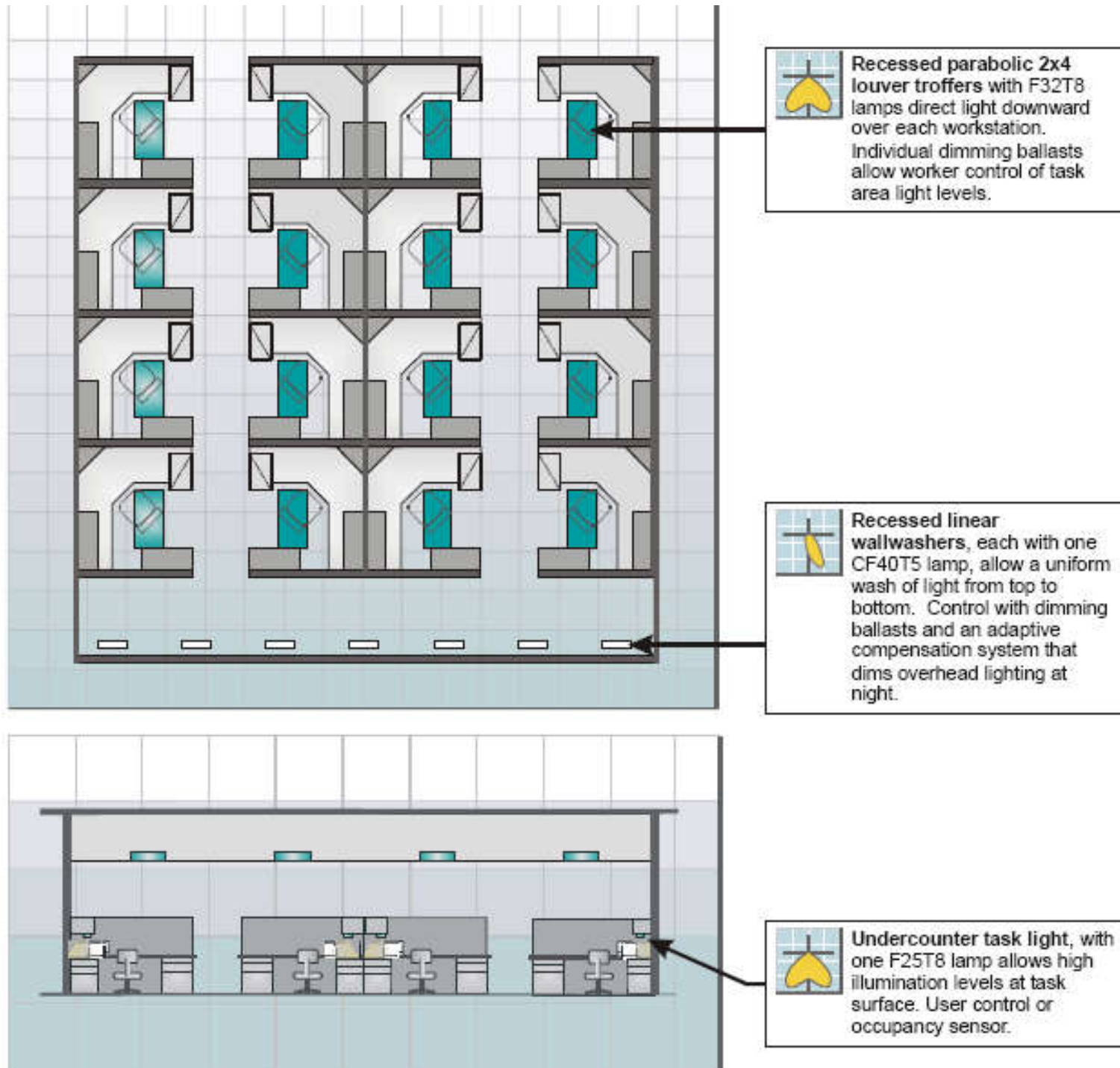
(Source: Advanced Lighting Guidelines 2003)

Lighting quality recommendations for open plan spaces

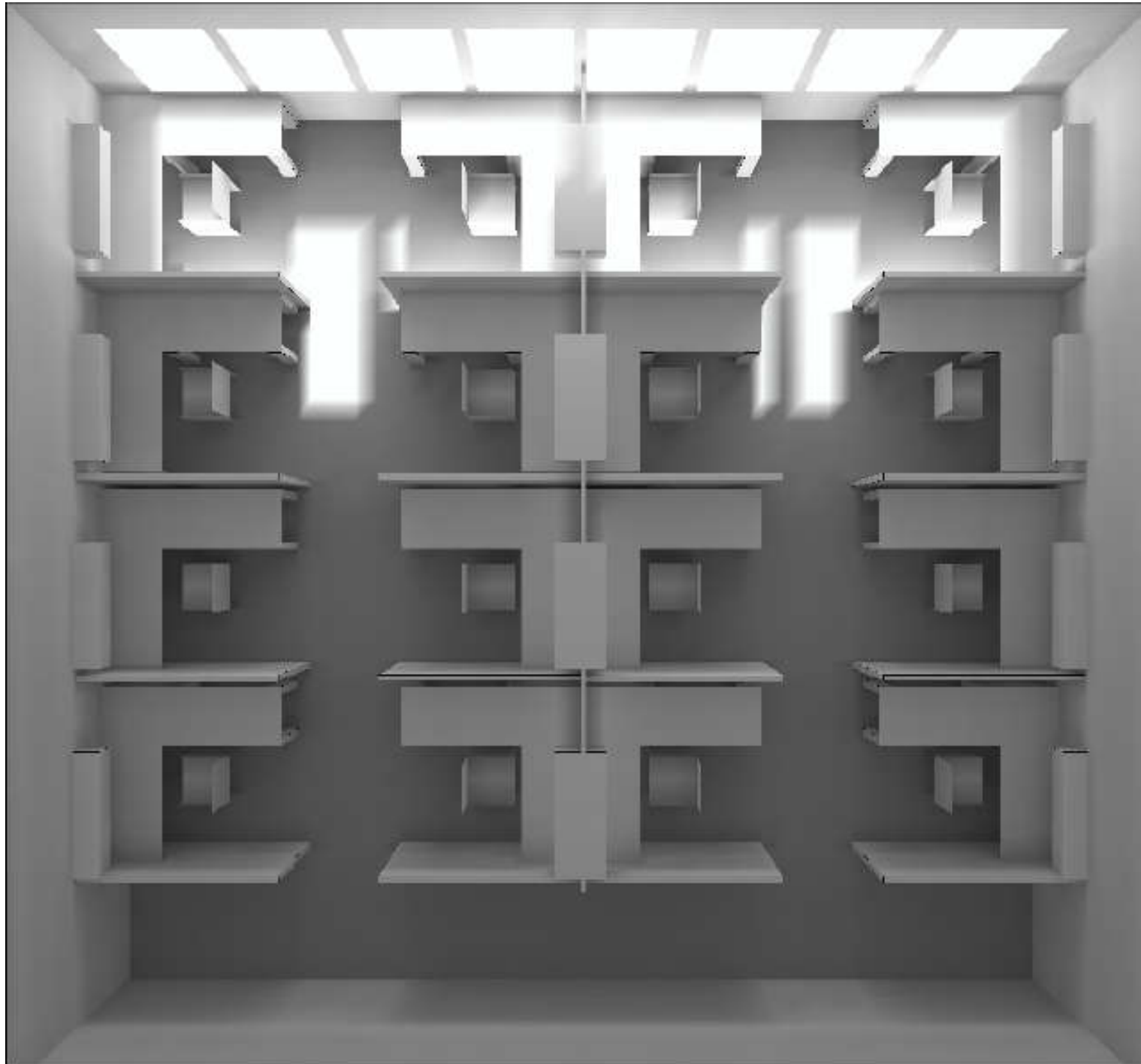


(Source: *Federal Lighting Guide*, USDOE, June 1998)

Lighting design for open plan office

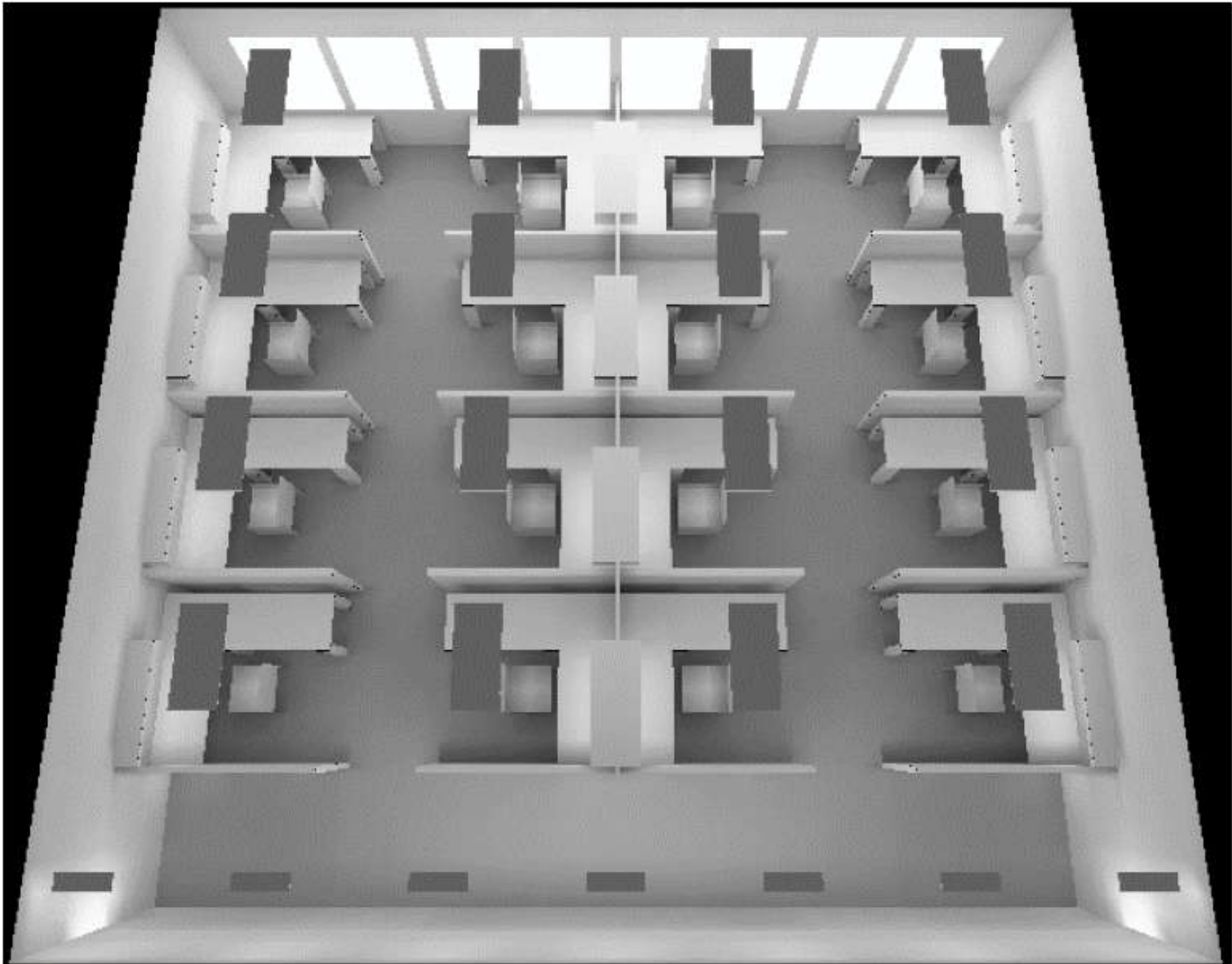


Gray scale rendering, open plan office (daytime)



(Source: Advanced Lighting Guidelines 2003)

Gray scale rendering, open plan office (daylight + electric light)



(Source: Advanced Lighting Guidelines 2003)

Lighting Strategies: Open Office 1

Strategy	Performance	Issues
Electric Lighting: (16) Parabolic 2x4 troffers with two F32T8 lamps, 48 W each. Task lighting using (16) undercabinet 25-W lights. Circulation areas illuminated by (7) wallwashers with CF40T5 lamps, 38 W each.	Using non-dimming, efficient electronic reduced light output (RLO) ballasts BF = 0.74–0.78, the LPD = 0.93 W/ft ² . The connected load is 1,418 W.	Assumes 2,700 hrs/yr use = 2.6 kWh/f ² per year, annual energy cost is about \$0.25/ft ² for lighting plus an amount for HVAC up to about \$0.08/ft ² . Task lighting may be T-8, T-5, or T-2.
Minimal control: Separate manual switching near window areas. Local zone override switches or overhead occupancy sensors. "Sweep" system automatic shutoff at night.	Daylit zone switching can reduce lighting power by 50% in the space if used.	The suggested 2,700 hour annual use assumes motion sensing. Manual daylight control has been shown to be predictable, but savings will be modest.
Good control: Manual controls with automatic shutoff. Automatic daylight dimming for luminaires near windows.	The connected load will rise slightly because dimming ballasts tend to be 1.00 BF. The new connected load with all dimming ballasts will be 1,716 W, LPD = 1.12 W/ft ²	Automatic balancing of light levels near windows when daylighting is abundant. With daylight zone dimming only, energy reduction will be about 25% annually compared to not dimming. Annual energy is estimated at about 0.65 (2,700 hours x 1.12 W) = 1.96 kWh per year per ft ²
Optimal control: Manual controls with zone adaptive dimming and automatic shutoff on all troffers. Individual remote dimming control of overhead luminaires. Occupancy sensor for task lights, plug strip control in each workstation	As above.	Progressive, multi-zone daylight dimming allows dimming of interior zone some portion of the time. Approximate energy reduction will be about 42% annually. Annual energy is estimated at about 0.50 (2,700 hours x 1.12 W) = 1.96 kWh per year per ft ² Including plug strip controls, the impact is estimated at 40% for 22% of the lighting load, making the total energy savings about 50% annually compared to the base design.

(Source: Advanced Lighting Guidelines 2003)



Lighting software

- Many of the lighting calculations can be carried out using a computer software, spreadsheet or online tools
- Common software for lighting designers:
 - 1. Manufacturers' programmes, normally linked to detailed databases of their own equipment
 - 2. General design programmes without links to any particular lighting manufacturer
 - 3. Advanced programmes with simulation & visualisation (rendering) techniques

Lighting software



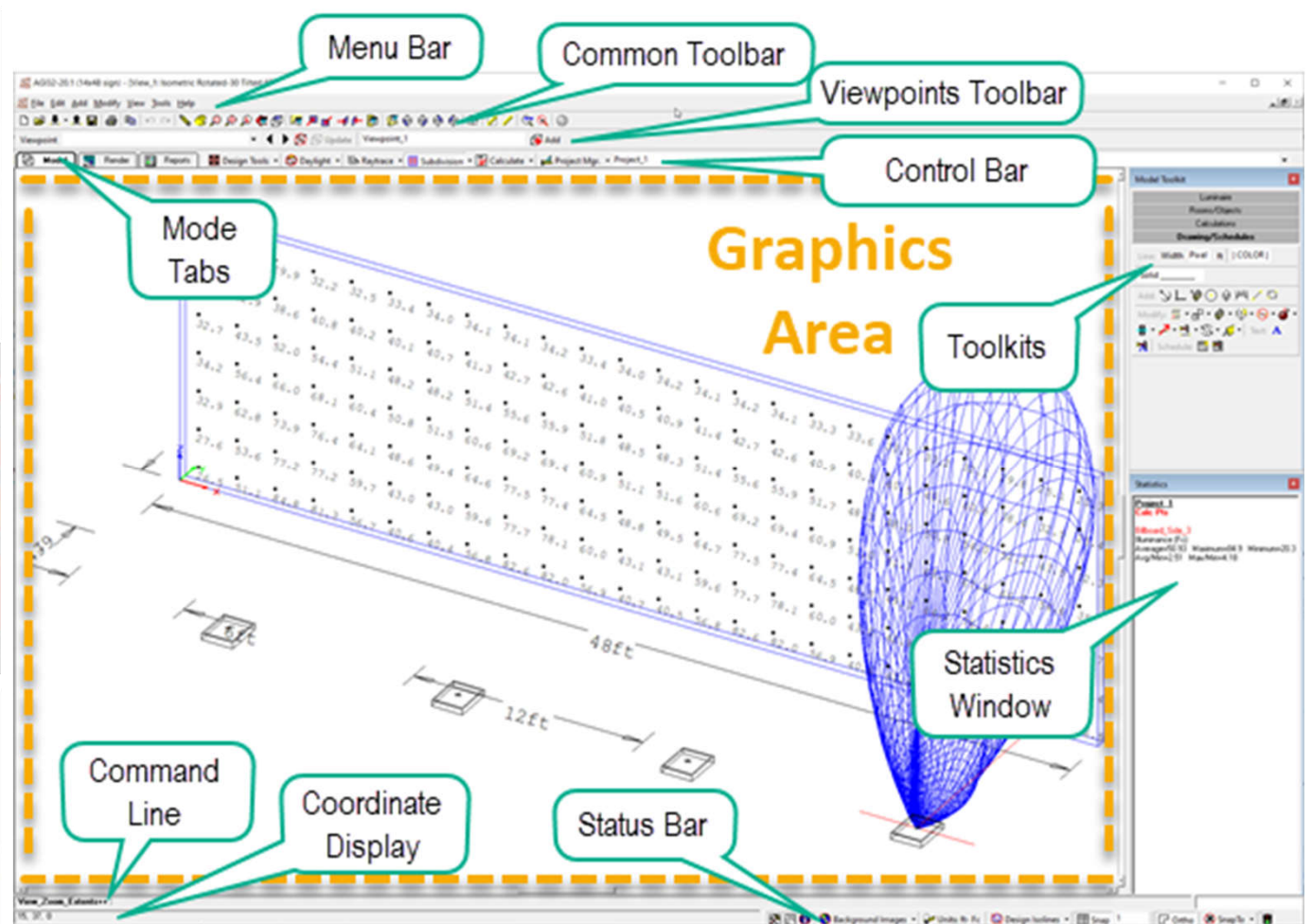
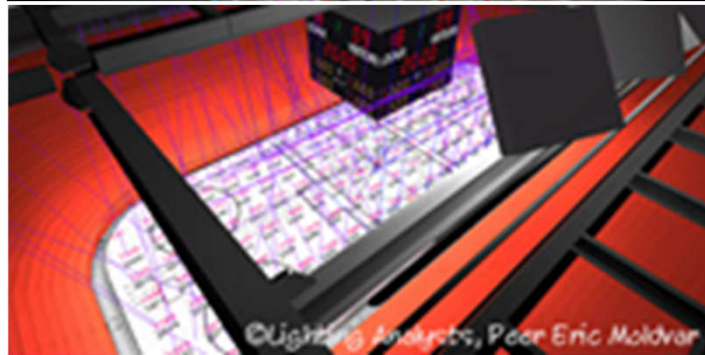
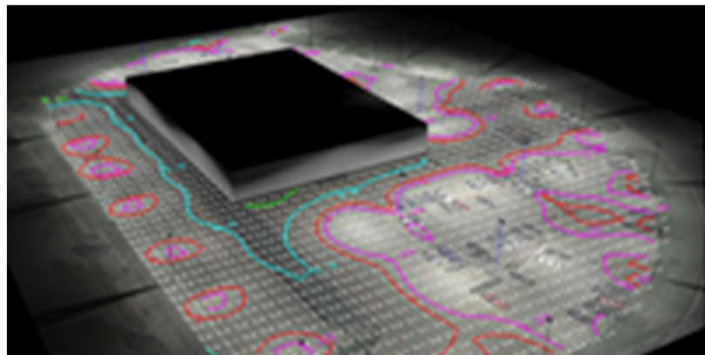
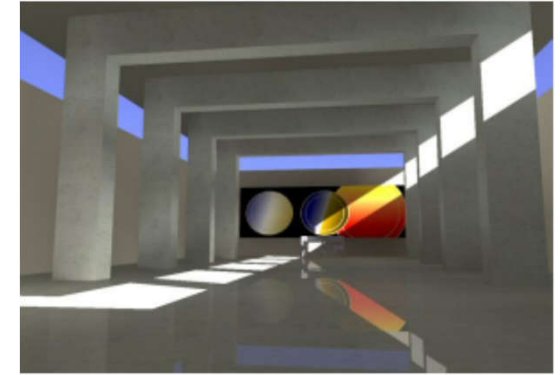
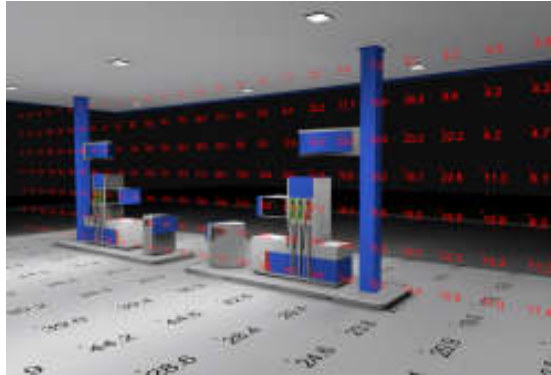
- Types of lighting related software:
 - 1. Lighting design software (e.g. AGi32, Calculux, DIALux, Radiance, Relux, Visual3D)
 - 2. Modelling & rendering software (e.g. Autodesk Maya, Blender, Houdini, Modo, Zbrush)
 - 3. Software for graphic resources (e.g. Adobe Photoshop, Adobe Illustrator, Autodesk 3ds Max, Paintshop Pro, SketchUp)
 - 4. Other tools (e.g. economic analysis, code compliance, photometric viewer)

Lighting software



- Typical lighting design software:
 - AGi32 (from Lighting Analysts)
 - <https://lightinganalysts.com/software-products/agi32/>
 - Calculux (from Philips Lighting)
 - <https://calculux-indoor.software.informer.com/>
 - <https://calculux.software.informer.com/7.7/>
 - DIALux <http://www.dial.de/>
 - Radiance <http://www.radiance-online.org/>
 - Relux <http://relux.com>
 - Visual Lighting <http://www.visual-3d.com/>

AGi32 (Advanced Graphical Illumination/Interface)



(Source: <https://lightinganalysts.com/software-products/agi32/>; <https://docs.agi32.com/AGi32/>)

Lighting software



- Selected examples for study:
 - [Calculux](#) (from Philips Lighting)
 - “Calculux Indoor”: indoor lighting
 - “Calculux Area”: outdoor lighting
 - [DIALux](#)
 - Professional lighting software
 - For calculating lighting layout
 - Perform simple rendering
 - [Visual Lighting](#) (from Lightolier)
 - Basic & Professional versions
 - Simple lighting design & modelling



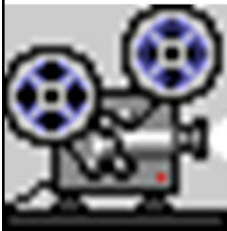
DIALux



Lighting software



- Calculux (from Philips Lighting)
 - Download at:
 - <https://calculux.software.informer.com/>
 - Calculux Indoor, version 5.0: indoor lighting
 - Video: video tuto calculux (9:53)
 - <https://youtu.be/muh8A68-Q2A>
 - Calculux Area, version 5.0/6.6 : outdoor lighting
 - Video: Calculux demonstration (2:06)
 - <https://youtu.be/Am14Rs7ZXIM>



Lighting design analysis report using Calculux Indoor

My Second Design

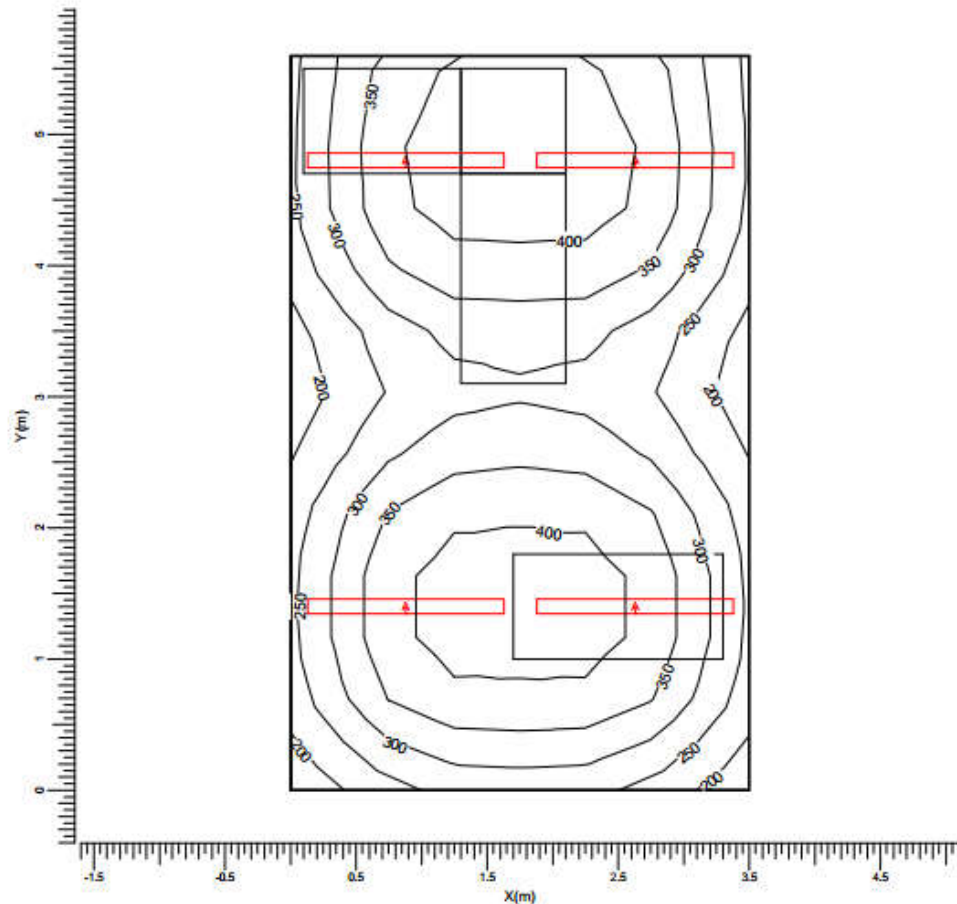
Example 1b

Philips Lighting B.V.
Date: 27-04-1999

3.2 Working Plane: Iso Contour

General Lighting

Grid : Working Plane at Z = 0.80 m
Calculation : Surface Illuminance (lux)
Result Type : Total



A : TBS 600/135 C7-60

Average	Min/Ave	Min/Max	Project maintenance factor	Scale
331	0.60	0.47	0.80	1:40

My Second Design

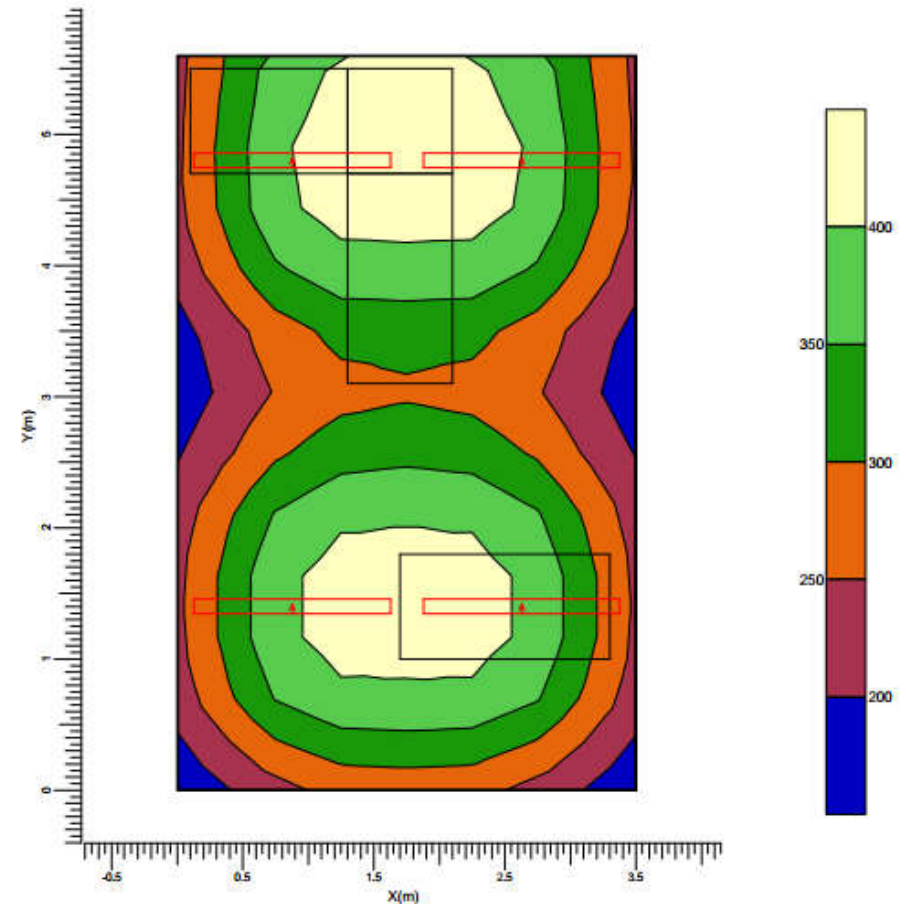
Example 1b

Philips Lighting B.V.
Date: 27-04-1999

3.3 Working Plane: Filled Iso Contour

General Lighting

Grid : Working Plane at Z = 0.80 m
Calculation : Surface Illuminance (lux)
Result Type : Total



A : TBS 600/135 C7-60

Average	Min/Ave	Min/Max	Project maintenance factor	Scale
331	0.60	0.47	0.80	1:40



Lighting software

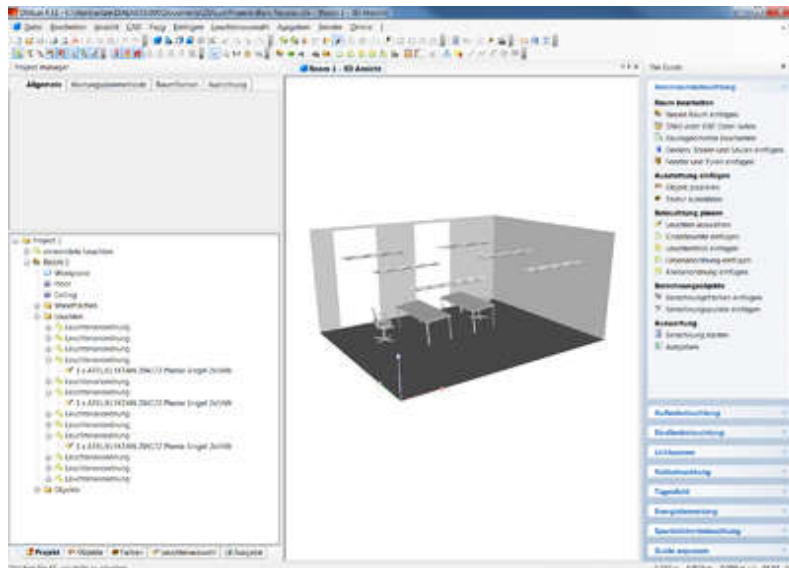
- DIALux (<http://www.dial.de/>)

DX

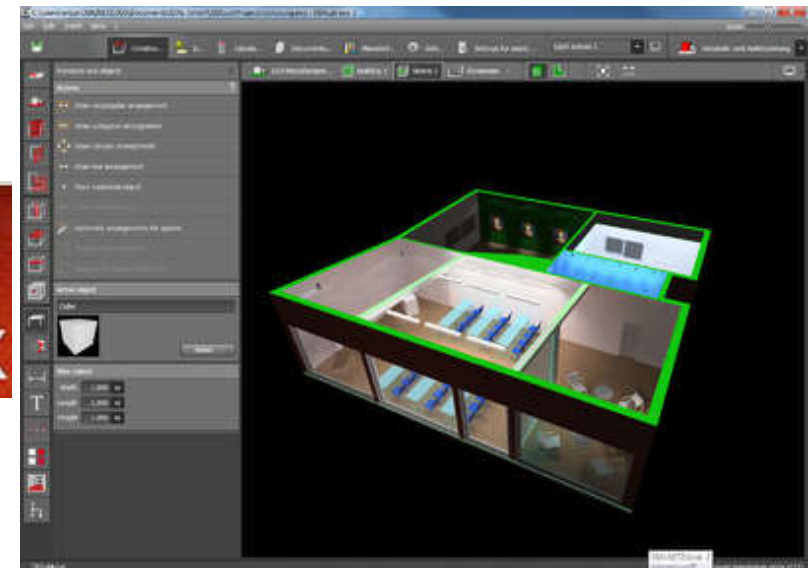
- Plan, calculate & visualize lighting for indoor & outdoor areas (latest version: DIALux evo 13.2)

- Learning resources:

- DIALux video tutorials <http://www.youtube.com/user/TheDIALux>

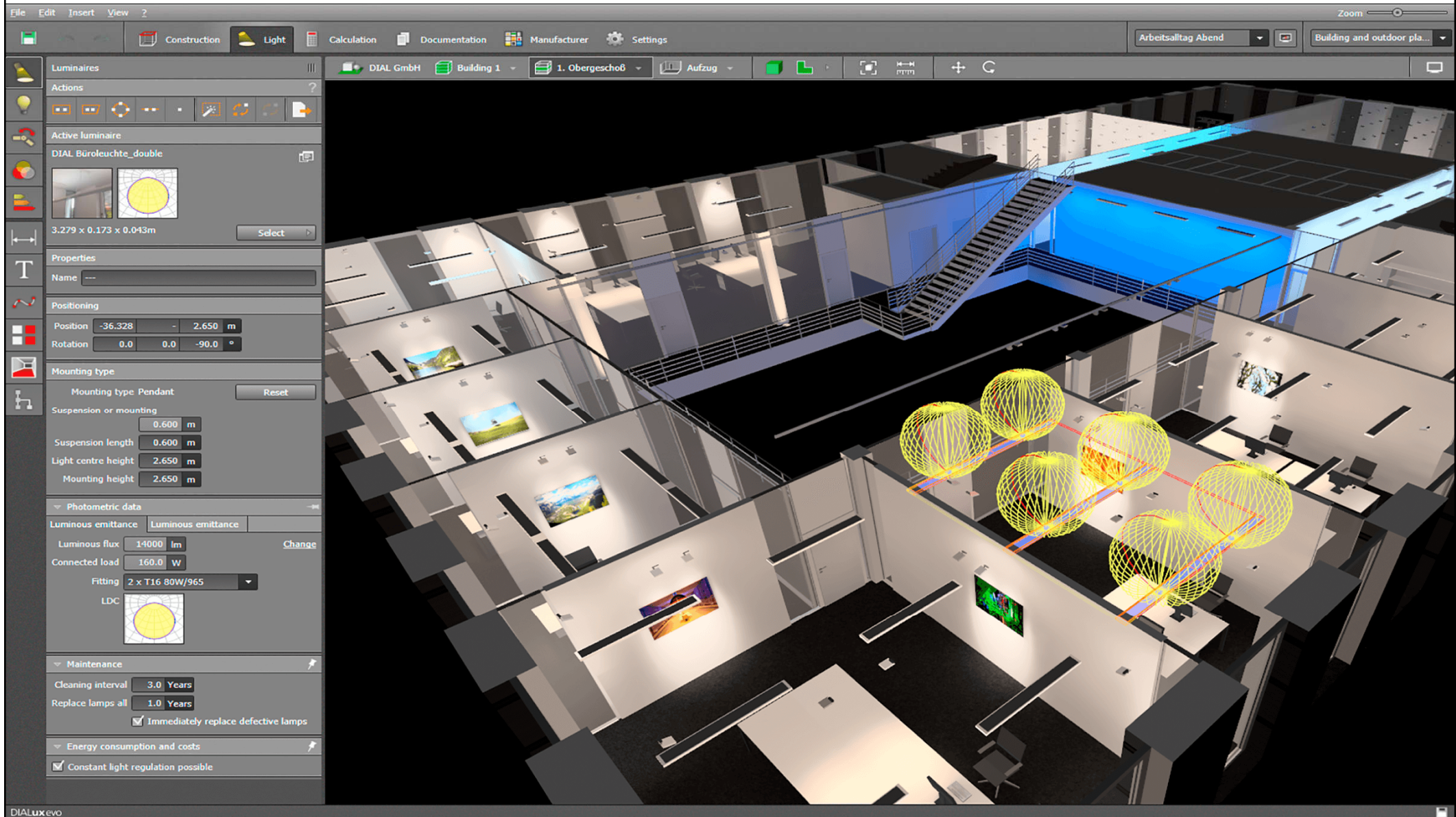


DIALux 4.13 (no more update)

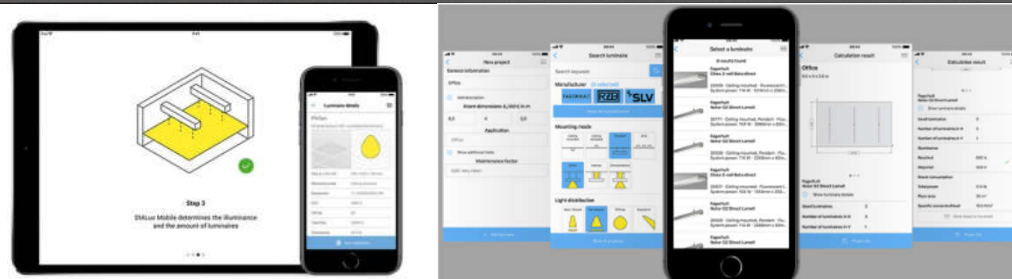


DIALux evo (new successor)

Interface of DIALux evo & DIALux Mobile app



(Source: DIALux <http://www.dial.de/>)



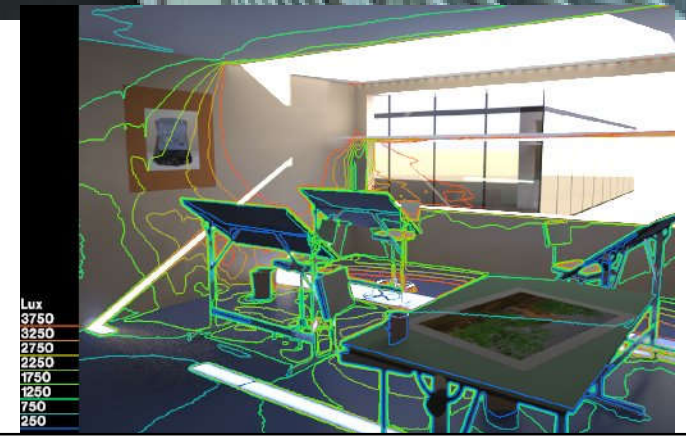
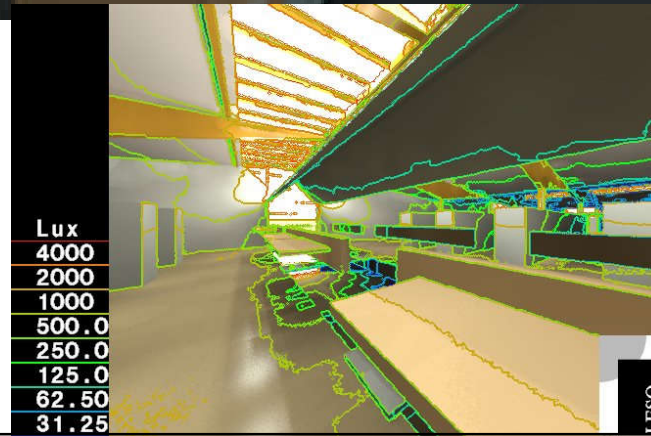
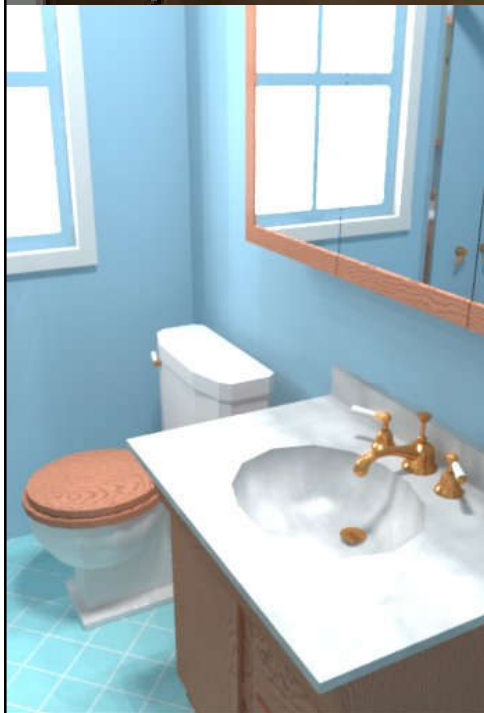
Lighting software



- [Radiance](http://www.radiance-online.org/) (<http://www.radiance-online.org/>)
 - <https://floyd.lbl.gov/radiance/>
 - Analysis & visualization of lighting in design
 - Daylight calculations & rendering
 - Synthetic imaging system (ray-tracing)
 - Calculated values include spectral radiance (luminance + colour), irradiance (illuminance + colour) & glare indices
 - Simulation results may be displayed as colour images, numerical values & contour plots



Radiance lighting simulation & visualization tool



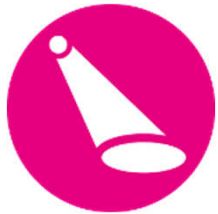
(Source: <https://floyd.lbl.gov/radiance/>)

Lighting software



RELUX[®]

- Relux (<http://relux.com>)

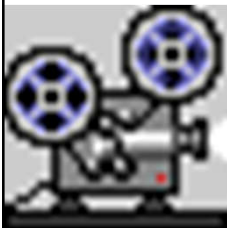


- ReluxDesktop <https://relux.com/en/relux-desktop.html>

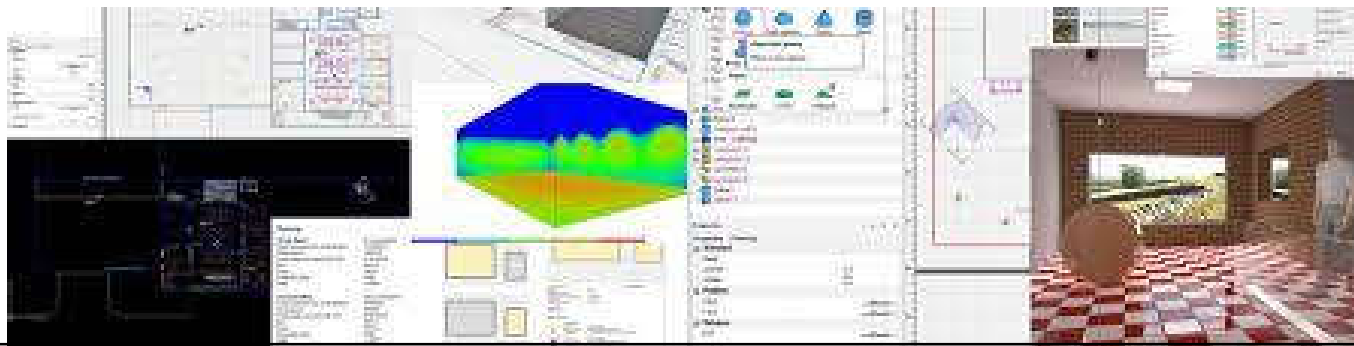
- Training Tutorials <http://relux.com/en/tutorials.html>



- ReluxCAD for Revit
<https://relux.com/en/reluxcad-revit.html>



- Video: What is new in ReluxDesktop - 2021.1.0.0 (36:00) <https://youtu.be/FJ95rllp-ag>



Dynamic planning with ReluxDesktop

Dynamic_Planning Alpha_Kreisel.rdf - Relux (** BETA 2017 **)

Start Project Products Insert Calculation View Window Luminaire Dyn. Planning

Clipboard Edit Tools Measure Alignment Snap

Office: Dynamic Planning: preview

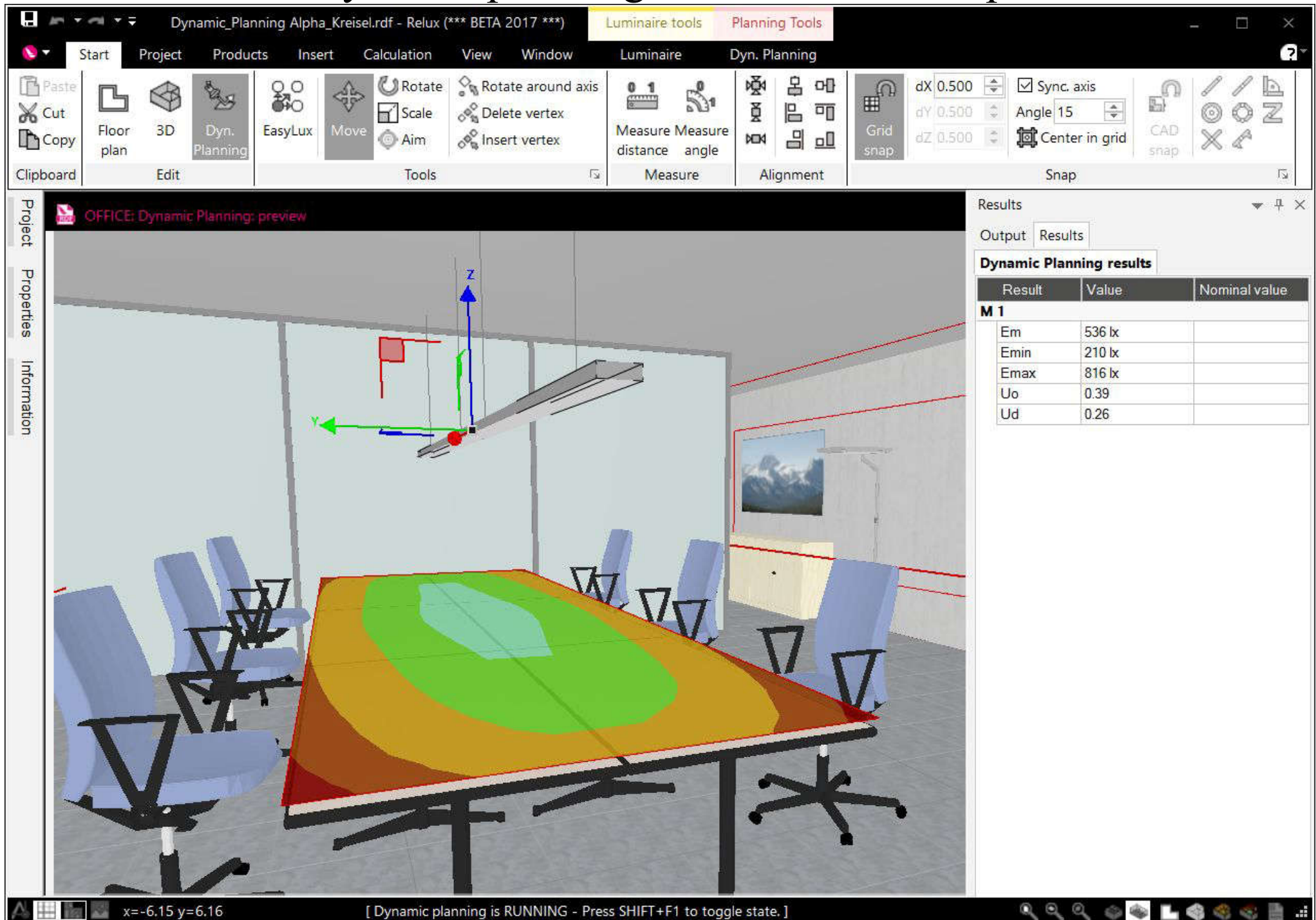
Results

Output Results

Dynamic Planning results

Result	Value	Nominal value
M 1		
Em	536 lx	
Emin	210 lx	
Emax	816 lx	
Uo	0.39	
Ud	0.26	

x=-6.15 y=6.16 [Dynamic planning is RUNNING - Press SHIFT+F1 to toggle state.]



(Source: <https://live-erp.relux.com/forum/dynamic-planning-46/question/dynamic-planning-1444>)

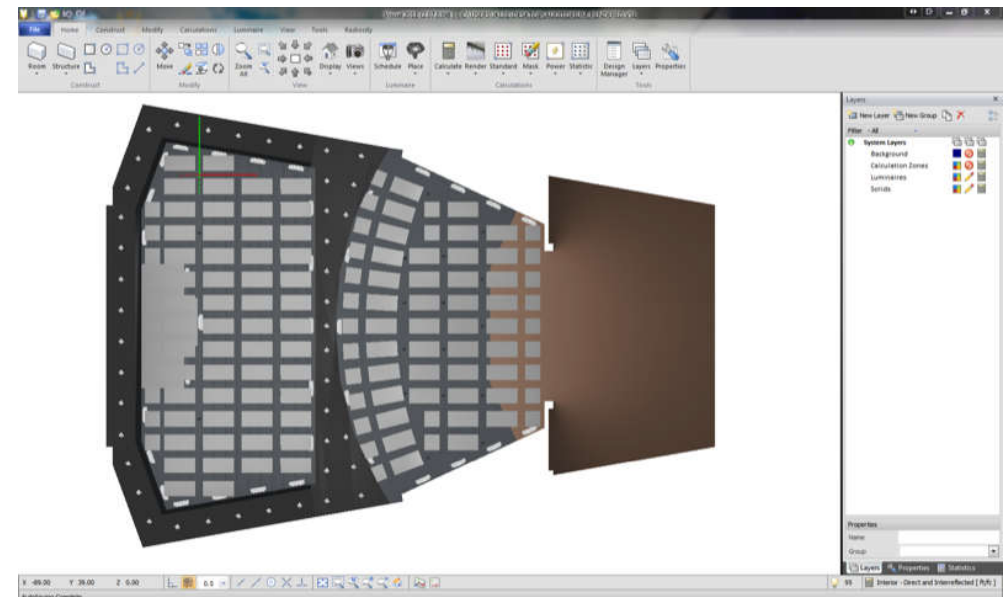
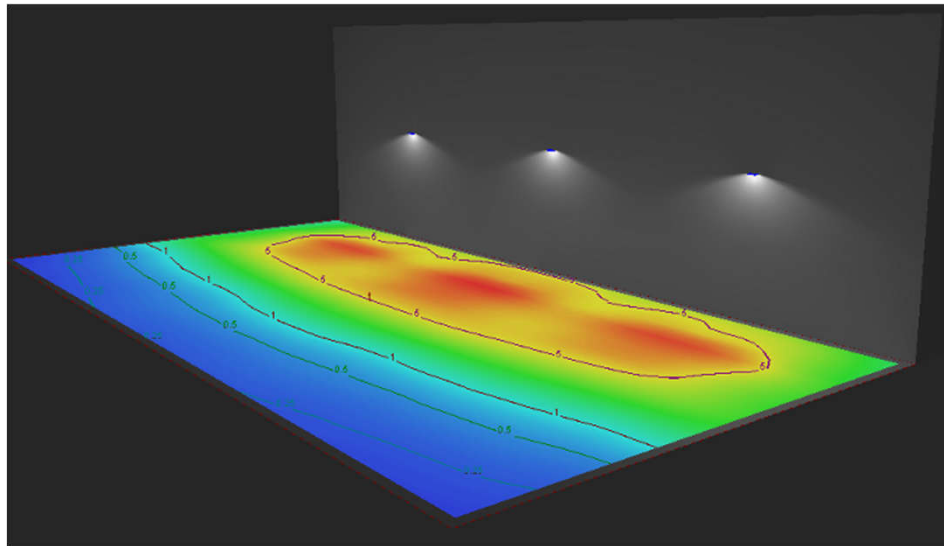
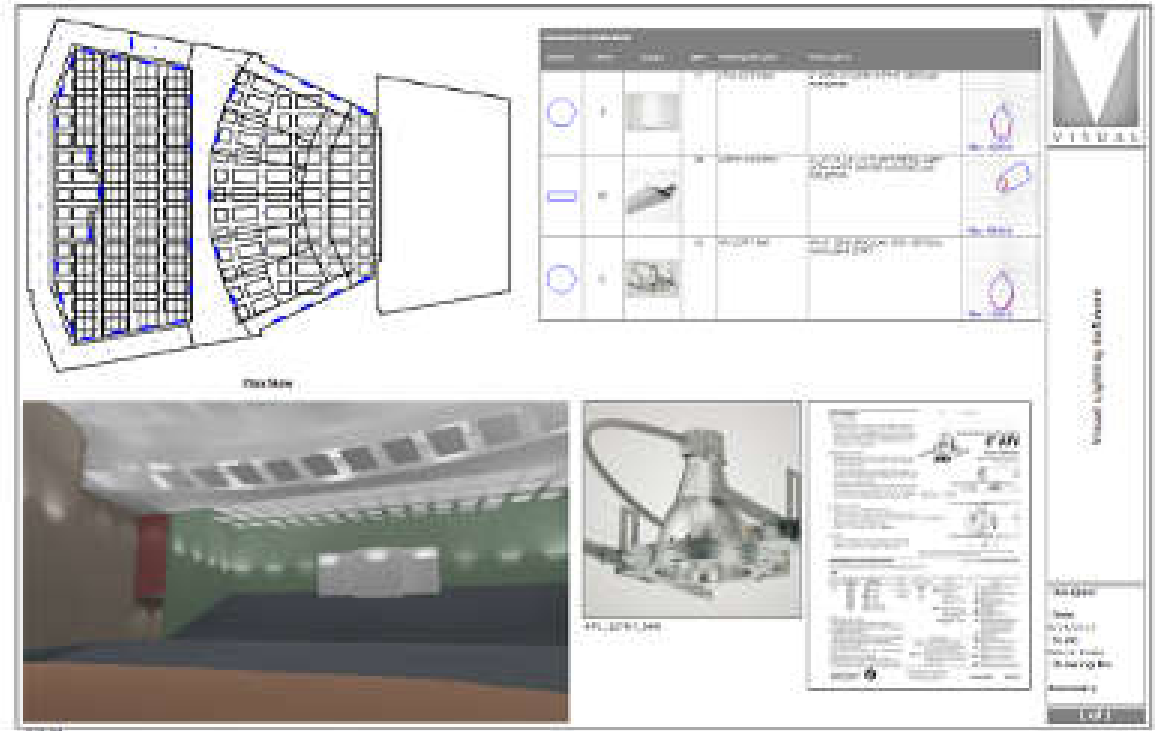
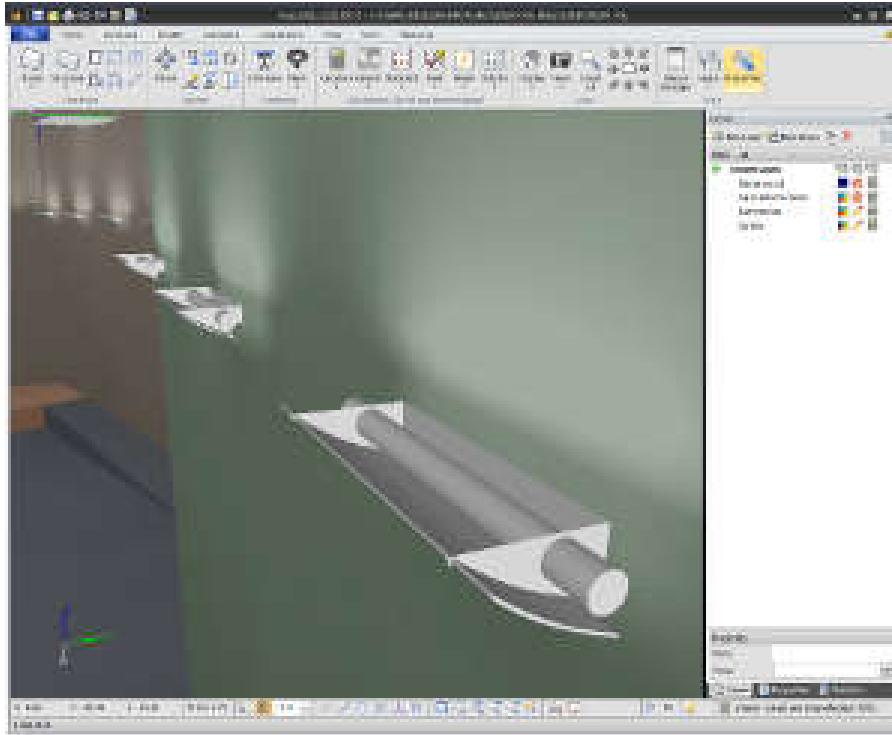
Lighting software



- Visual Lighting (<http://www.visual-3d.com/>)
 - Training Videos
 - <http://www.visual-3d.com/support/trainingvideos/2012.aspx>
 - Tutorial Projects
 - <http://www.visual-3d.com/support/tutorials.aspx>
 - Visual 2012 Documentation
 - <http://www.visual-3d.com/support/documentation.aspx>
 - Online Design Tools
 - <http://www.visual-3d.com/software/designtools.aspx>



Visual Lighting software (from Acuity Brands)

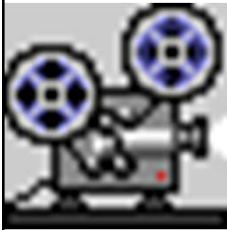


(Source: <http://www.acuitybrands.com/resources/tools-and-documents/visual-lighting-software>)

Lighting software

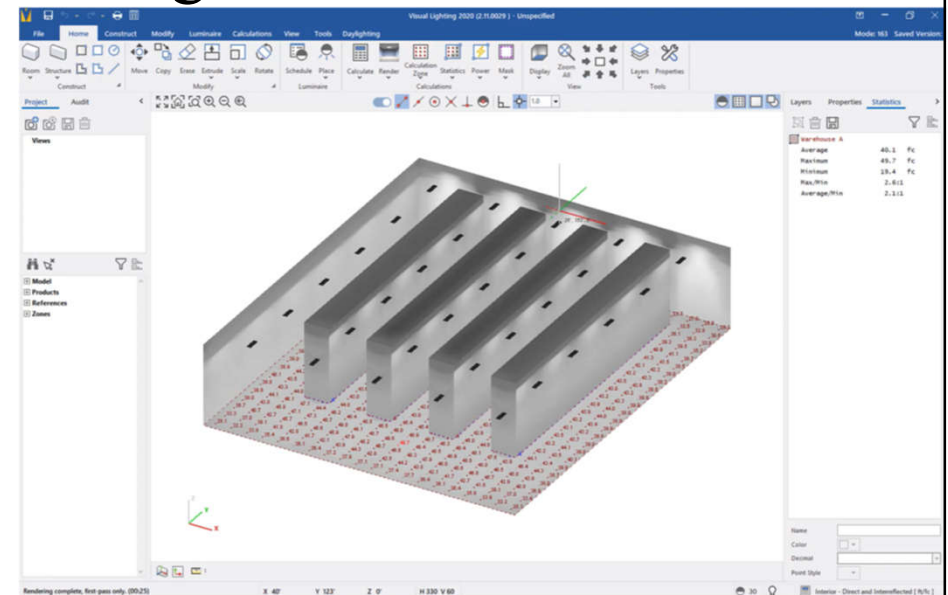


- The process of designing a warehouse using a lighting design software (Visual Lighting)



- Visual Lighting - Warehouse Design (13:11)
<https://youtu.be/pKm-RoXNVII>

- Building the warehouse & creating the racks
- Inserting a calculation zone
- Schedule
- Inserting luminaires
- Masking
- Comparing designs



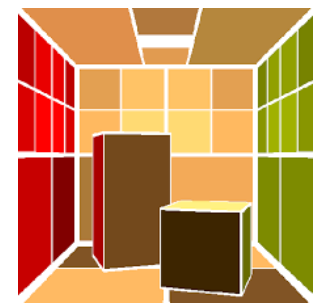
Lighting software



- Lighting Calculator, Excel spreadsheet (for checking compliance with National Construction Code in Australia)
 - <http://www.abcb.gov.au/Resources/Tools-Calculators/Lighting-Calculator>



Lighting simulation

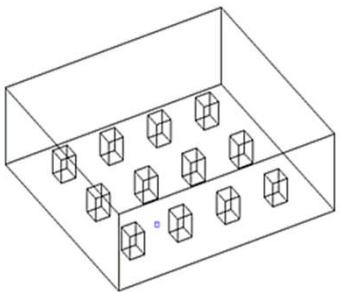


- Lighting simulation (or rendering) 照明模擬 (渲染)

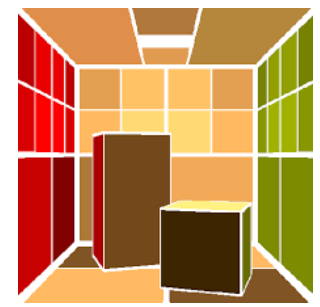
- Process of creating realistic images by simulating how light interacts with objects in a 3D digital environment
 - For architectural design and product visualization
- Involves calculating how light bounces, refracts, and diffuses to accurately represent shadows, reflections, and highlights, allowing designers to visualize a scene's appearance before it is built

- Key techniques:

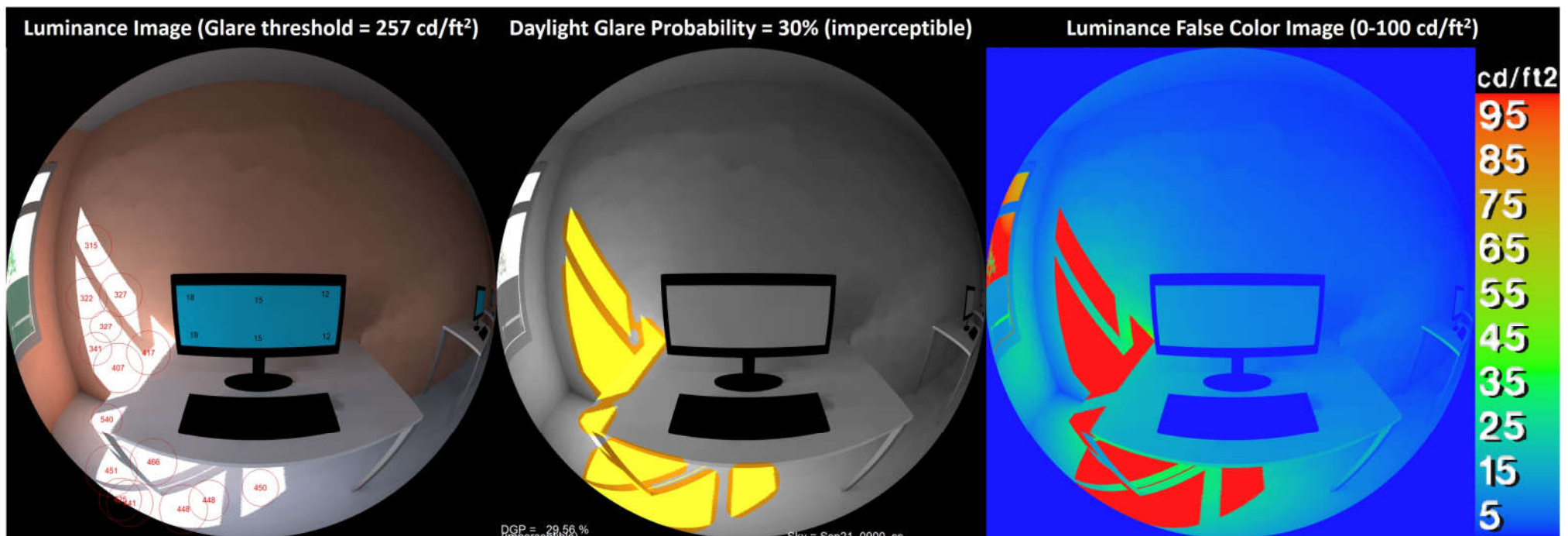
- Physically-based rendering
- Global illumination
- Ray tracing
- Hybrid approach



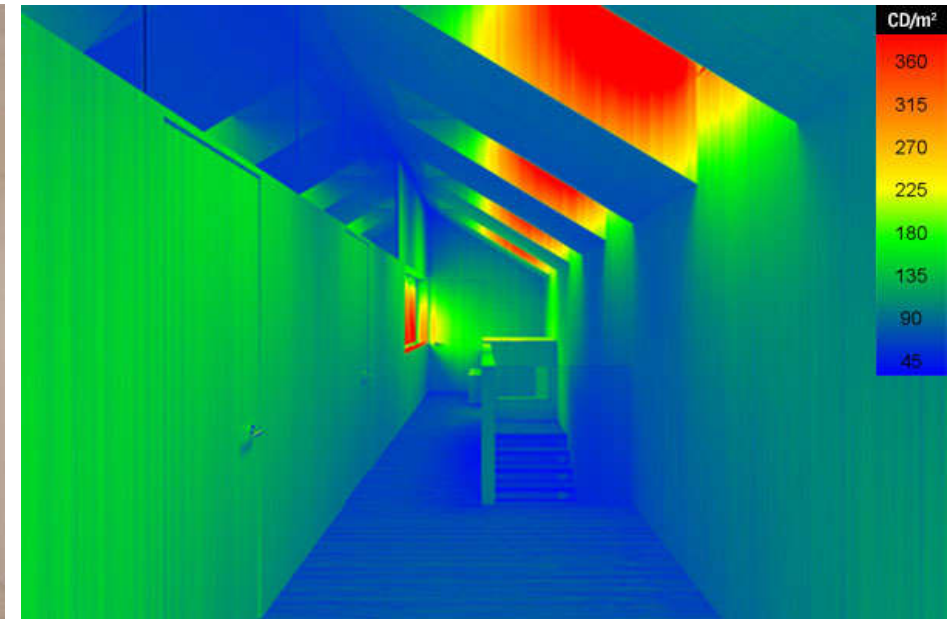
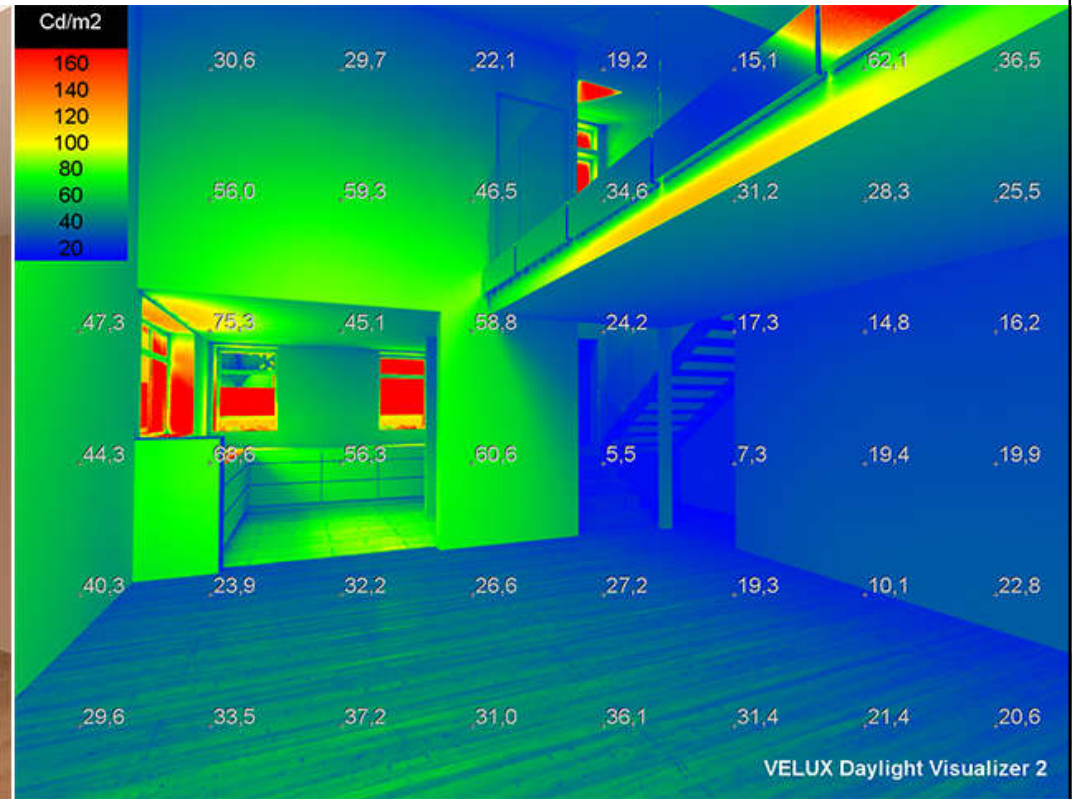
Lighting simulation



- Photo-realistic & false colour visualisation
 - Visualise the appearance of daylight with photo-realistic images, and quantify the amount & distribution of daylight with false colour images

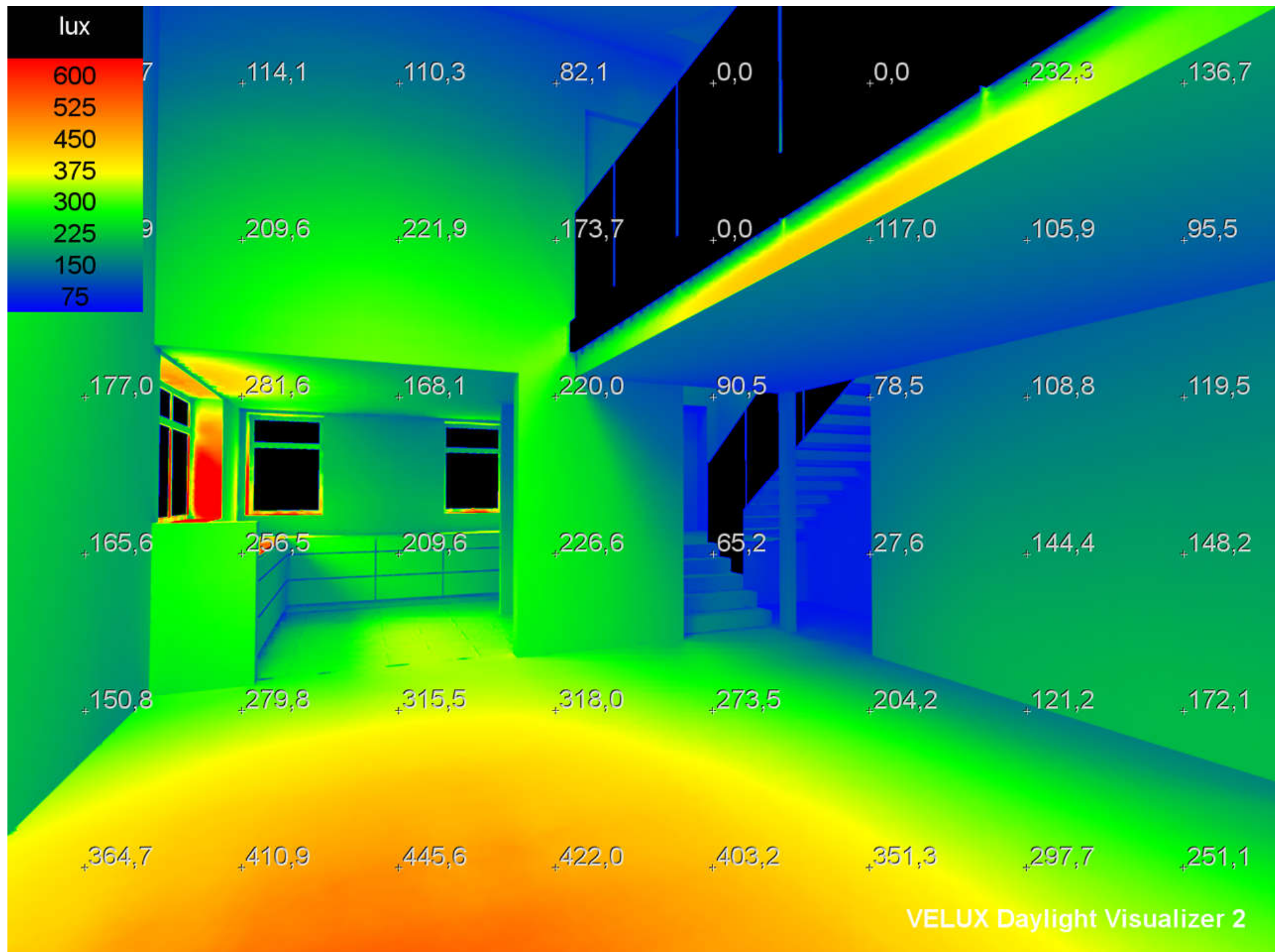


Luminance rendering using VELUX Daylight Visualizer 2



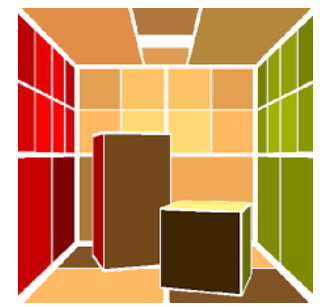
(Source: <https://www.velux.com/what-we-do/research-and-knowledge/deic-basic-book/daylight/daylight-calculations-and-measurements>)

Illuminance rendering using VELUX Daylight Visualizer 2

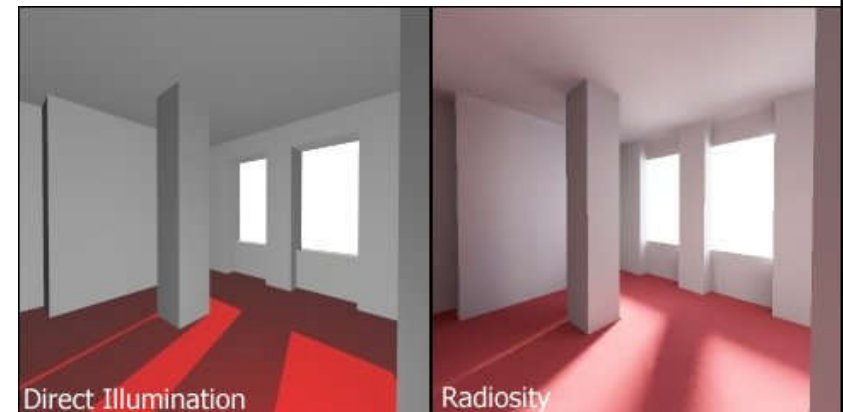


(Source: <https://www.velux.com/what-we-do/research-and-knowledge/deic-basic-book/daylight/daylight-calculations-and-measurements>)

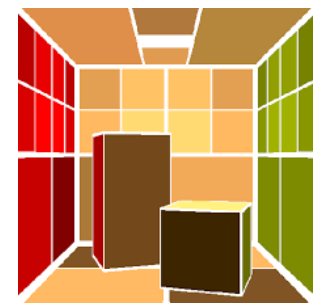
Lighting simulation



- Lighting simulation software depends on two important components to produce accurate calculations:
 - The selected light sources
 - The surfaces within the model
- Three methods of calculation for lighting simulation or rendering:
 - 1. Radiosity 輻射度演算法
 - 2. Raytracing 光線追蹤
 - 3. Photon mapping 光子映射

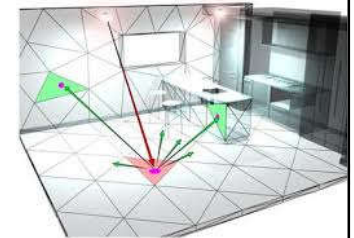


Lighting simulation

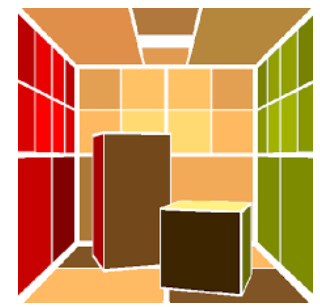


- Radiosity 輻射度演算法

- Divides each surface into small pieces (patches)
- Each patch is calculated individually for the amount of light that enters or leaves that surface
- Solves the system of equations in the model by determining the quantity of light on each patch as a result of the total sum of all the patches
- This method works well for all matte model surfaces (perfectly diffusing), and it cannot include translucent, transparent & specular (shiny) surfaces

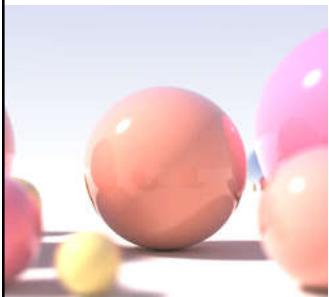
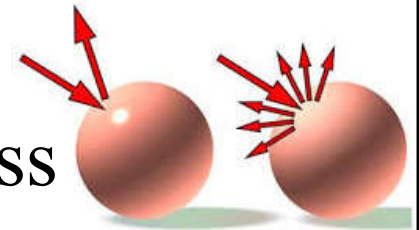


Lighting simulation



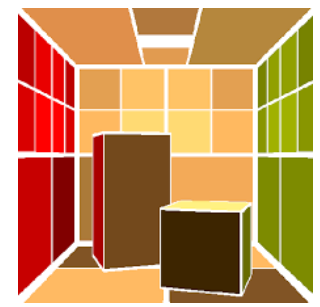
- Raytracing 光線追蹤

- A point-specific lighting calculation process
- Calculation rays are sent outward from a particular viewpoint and the program follows each ray as it hits & reflects off different surfaces and divides into more rays
- This method works for all object types including transparent, translucent & specular surfaces



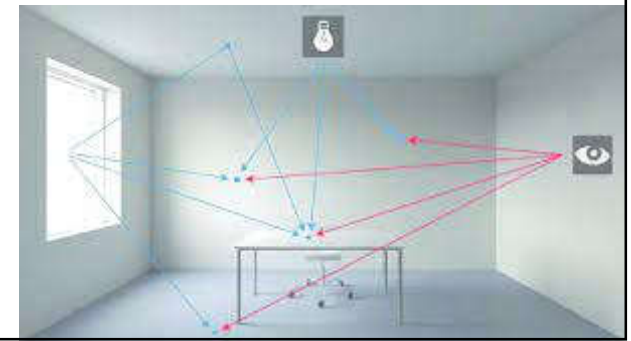
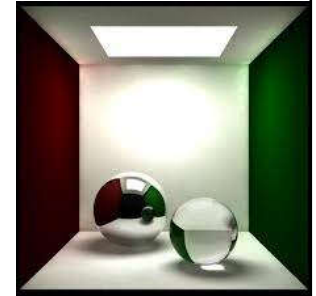
- Creates beautiful renderings & presentation-quality images (e.g. sparkle on specular materials)
- View dependent & greater computational cost

Lighting simulation



- **Photon mapping 光子映射**

- Similar to the ray tracing process
- While ray tracing is based on rays from the observers/camera position, photon mapping is based on rays emitted from the light source
- Virtual “photons” radiating light into the room. When they hit a surface, they are reflected back & the luminance values are summated. The photon outputs are stored in a photon map
- Render the image using the map
- Can be combined with ray tracing



Online tools



- GE Lighting Tools (for simple estimating)
 - <https://www.led.com/lighting-tools>
 - Cost of Waiting Estimator
 - LED Retrofit Tool (Excel file)
 - Lighting Layout Estimator
 - Simple Life Cycle Cost Estimator
 - Simple Lighting Energy Estimator
 - UVC LPU Calculator
 - Watts Per Square Foot Estimator



Online tools

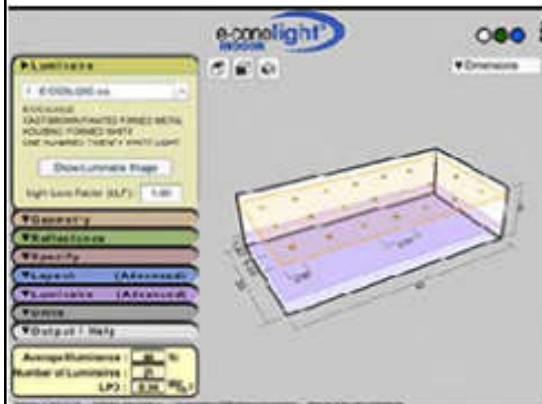


TRY IT
YOUR
SELF!

- Indoor & Outdoor Lighting layout Tools
 - <https://www.tdpi.com/tcp-distributor-hub/lighting-layout-tool/>

INDOOR LIGHTING LAYOUT TOOL

- Model a fixture's light output in a custom-sized room
- Calculate the number & layout of fixtures needed to reach a target level of illumination
- Generate a clean, detailed & printable summary



STEP-BY-STEP GUIDES

PRINTABLE >

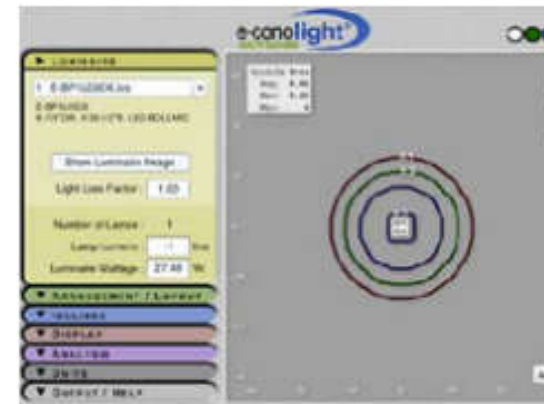
VIDEO >

(<https://v1-zonal-tools.luxiflux.com/>)

INDOOR CALCULATOR

OUTDOOR LIGHTING LAYOUT TOOL

- Model a fixture's light output based on mounting height, orientation, placement & tilt
- Create a photometric layout for the selected fixture
- Generate a clean, detailed & printable summary



STEP-BY-STEP GUIDES

PRINTABLE >

VIDEO >

(<https://v1-area-tools.luxiflux.com/>)

OUTDOOR CALCULATOR

Online tools



- The Visual Lighting Design Tools
 - <http://www.visual-3d.com/software/designtools.aspx>
 - A set of web based tools that allow users to analyze many common lighting scenarios & view photometric files
 - Can be used to quickly calculate scenarios with simple geometries
 - Complex lighting designs & geometries should be studied by professional software tools

Online tools



- The Visual Lighting Design Tools

- 1. [Interior design tools](#)

- Interior Tool
 - Wallwash Tool

- 2. [Exterior design tools](#)

- Area Tool
 - Floodlight Tool
 - Template Tool
 - Roadway Tool

- 3. [Report tool](#)

- Photometric Tool
 - Economic Tool & Simple Economic Tool



Interior Tool



Roadway Tool



Photometric Tool



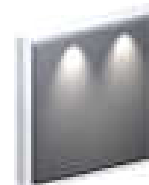
Floodlight Tool



Area Tool



Economic Tool



Wallwash Tool



Template Tool



Simple Economic Tool

TRY IT
YOUR
SELF!

Online tools



- The Visual Lighting Design Tools

- <http://www.visual-3d.com/software/designtools.aspx>

- Learning the Interior Tool



- Lighting Design Calculations by Using On-line Tools

- http://www.electrical-knowhow.com/2013/01/lighting-design-calculations-by-using_16.html



- Tutorial Video (4:01):

- <http://www.visual-3d.com/tools/interior/helpvideos/video.html>

- Learning the Area Tool



- Tutorial Video (3:52):

- <http://www.visual-3d.com/tools/area/HelpVideos/Video.html>

Settings

Units Meters - Lux

Room Dimensions

Length [X] 10 m

Width [Y] 8 m

Height [Z] 3.5 m

Workplane 1 m

Ceiling Type 2x2

Room Reflectances

Ceiling 80 %

Walls 50 %

Floor 20 %

Criteria

Illuminance 500 lux

Power Density W/m²

Quantity

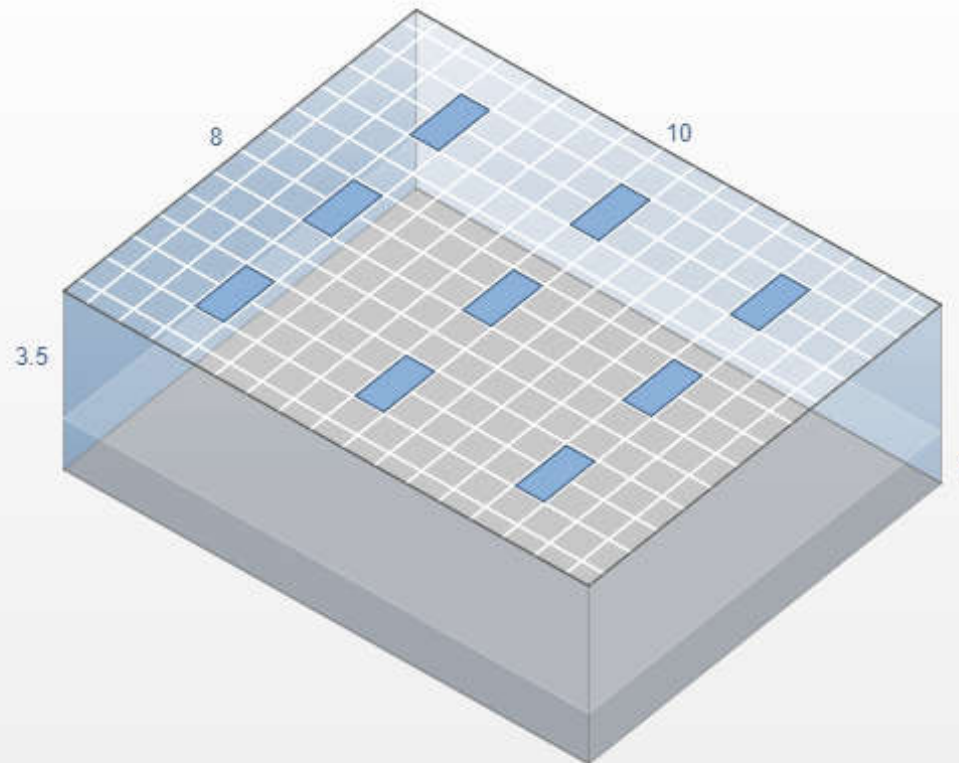
Constraints

Spacing X [SC=3.6] m

Spacing Y [SC=3.1] m

Rows

Columns



Calculation Results [A]

Illuminance 462 lux

Power Density 6.52 W/m²

Quantity 9

Spacing Results [A]

Spacing 3.05 x 2.44 m

Arrangement 3 x 3

Outside Spacing X 1.68 m

Outside Spacing Y 0.99 m

Display



Dimensions Room ☒ Layout ☐

Show Zonal Cavity Info [+]

Project Information

A ✖ +



Holophane

[A] - HT24 2 32 A12 GEB10IS

Light Loss Factor 1

Suspension Length 0

Orientation 0

Symbol Shape Rectangular

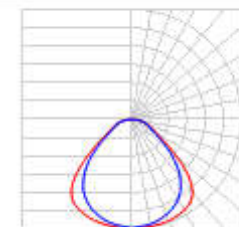
Symbol Length .54

Symbol Width 1.15

Lamp Quantity 2

Lumens Per Lamp 2850

Wattage 58



■ - 0° H ■ - 90° H

Settings

Units Meters - Lux
Precision 0.00

Criteria

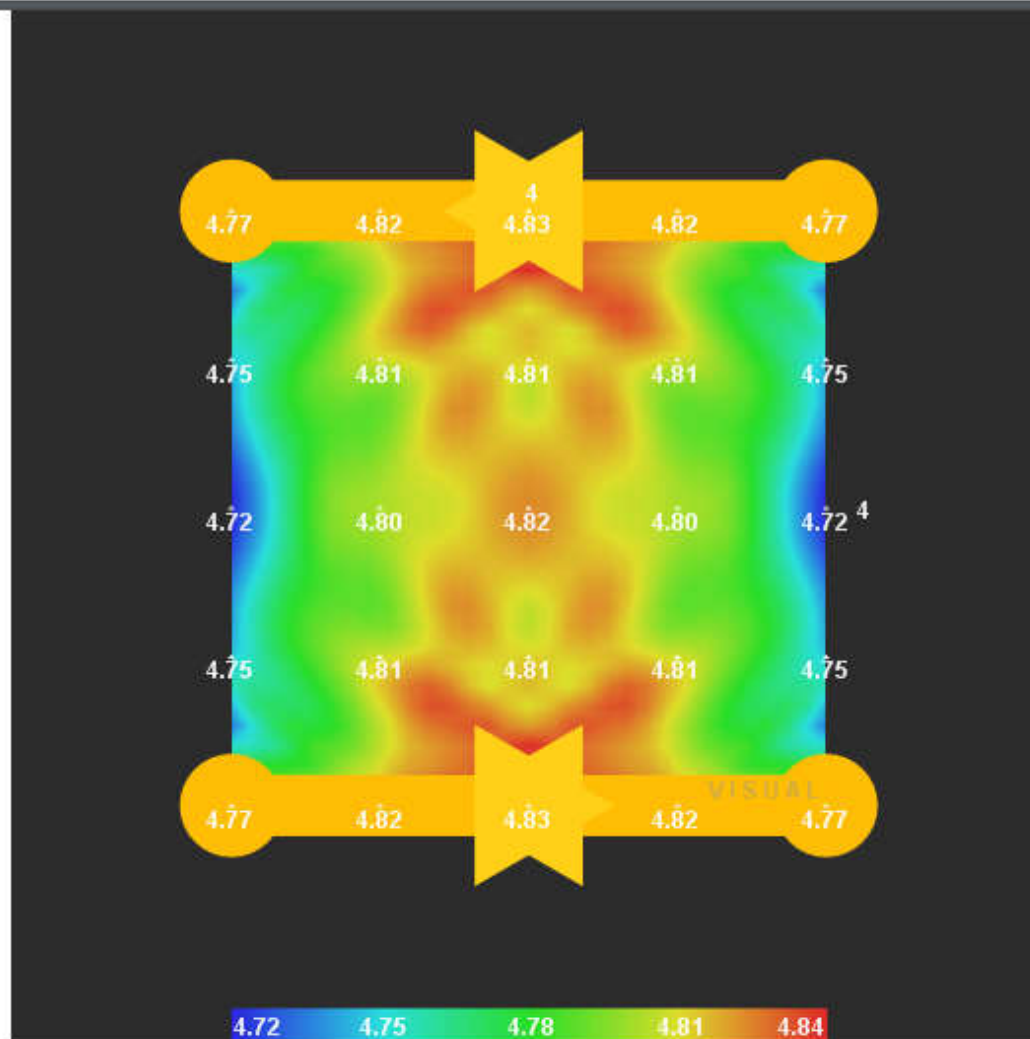
Minimum 10 lux
Average lux
Max / Min lux
Parking Lanes 60 m
Pole Arrangement

Constraints

Spacing X 4 m
Spacing Y 4 m

Calculation Points

Point Spacing X 1 m
Point Spacing Y 1 m



Spacing Results [A]

Spacing 4 x 4 m
Area Between Poles 16 m²
Wattage / Area 15.75 W/m²
Optional Spacing

Calculation Results [A]

Minimum 4.72 lux
Average 4.79 lux
Maximum 4.83 lux
Max / Min 1.02
Ave / Min 1.01
Point Spacing 1.00 x 1.00 m
iterations 1
Points Calculated 986

Display

Points ☒

[A]
☒ 0.1 lux
☒ 0.2 lux
☒ 0.5 lux
☒ 1 lux
[View Grid Detail](#)

Project Information

A



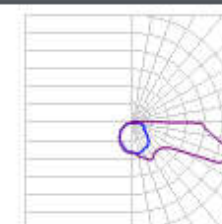
Holophane

[A] - PK050HP00CXA

Configuration Single
Mounting Height 20
Support Length .3

Light Loss Factor 1
Orientation 0
Tilt 0

Lamp Quantity 1
Lumens Per Lamp 4000
Wattage 63

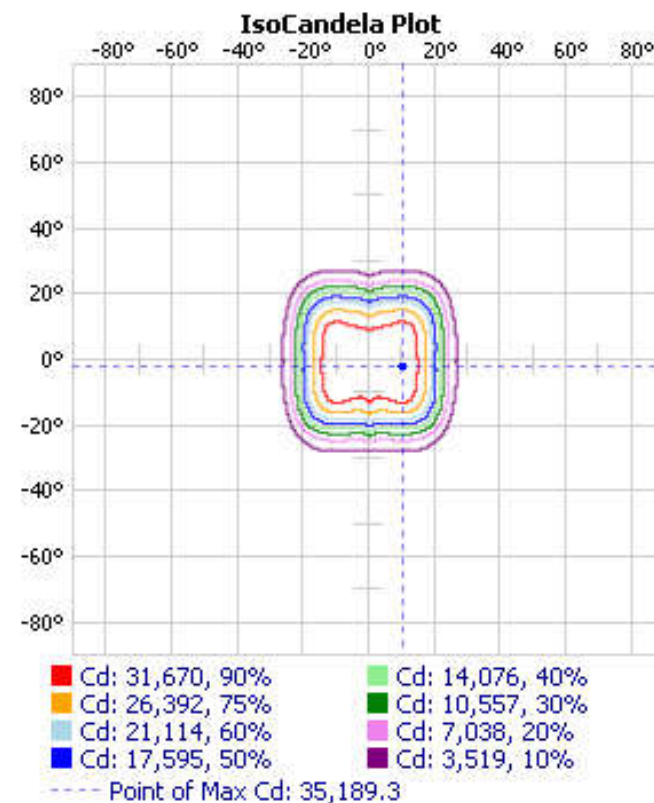
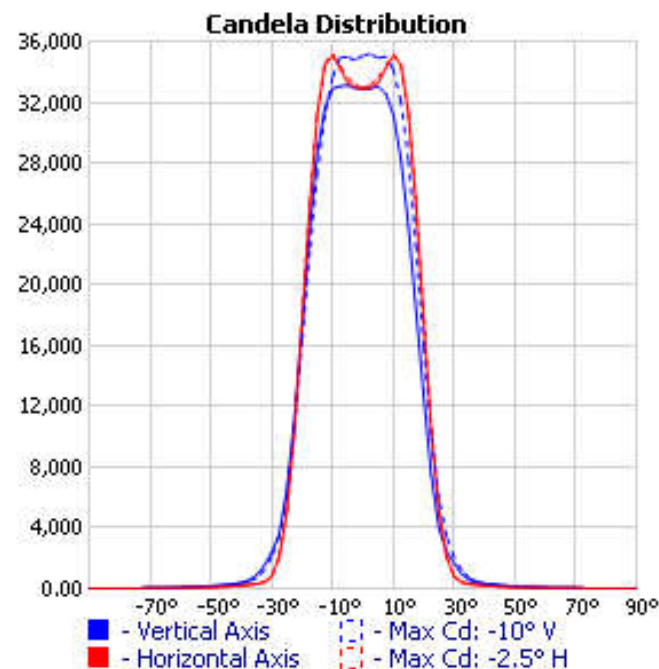


■ - 0° H
■ - Max Cd: 65° H

TEST #: 107267P22
 TEST LAB: SCALED PHOTOMETRY
 TEST NOTES: SCALED FROM ABSOLUTE TEST: 107267
 TEST DATE: 4/11/2016
 CATALOG: HPFL 7 4K 07A 44
 DESCRIPTION: HAZARDOUS PREDATOR LARGE LED WITH 7 COBS, 4000K COLOR TEMPERATURE, 700MA DRIVE CURRENT, 4X4 DISTRIBUTION
 SERIES: PREDATOR HPFL LARGE LED
 LAMP CATALOG: C08
 LAMP: LED
 LAMP OUTPUT: TOTAL LUMINAIRE LUMENS: 16852, ABSOLUTE PHOTOMETRY *
 BALLAST / DRIVER: LED DRIVER
 INPUT WATTAGE: 185
 LUMINOUS OPENING: POINT
 NEMA TYPE: 4 X 4
 MAX CD: 35,189.3 AT HORIZONTAL: -10°, VERTICAL: -2.5°



PRODUCT LINKS



Assumptions

Life Cycle (years): 12

Discount Rate (%): 5

Electricity Rate (¢/kWh): 8

Electricity Escalation (%): 0

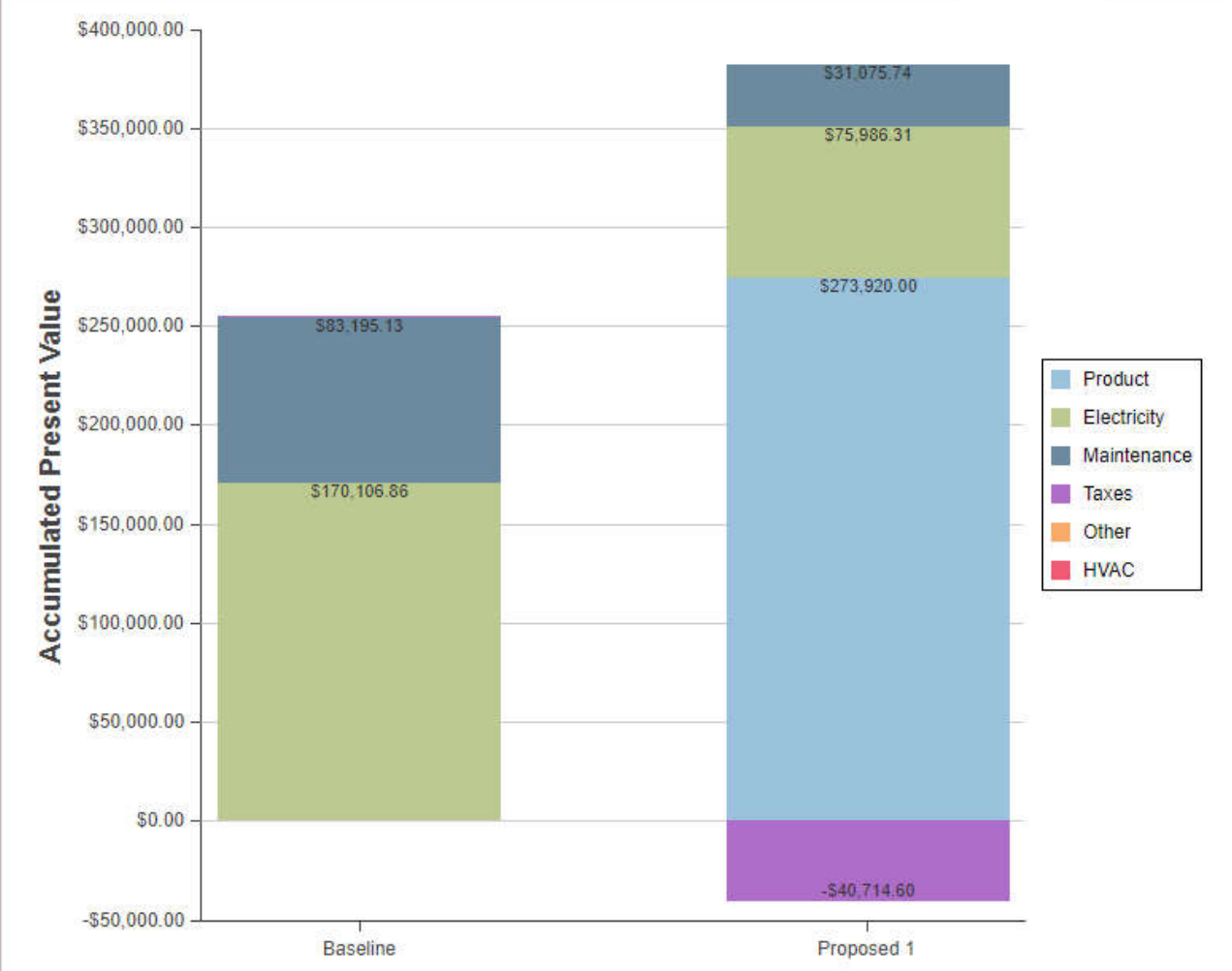
Reinvestment Rate (%): 0

Taxes

Local Sales Tax (%): 6

Income Tax Rate (%): 30

Depreciation Years: 10



Design Summary		
Category	Baseline	Proposed 1
Initial Cost	\$0.00	\$288,288.20
Ave. Operation Cost (FV)	\$28,713.47/Year	\$6,710.69/Year
Total Operation Cost (PV)	\$254,494.74	\$51,979.25
Life Cycle Cost	\$254,494.74	\$340,267.45
Net Present Value	--	(\$85,772.71)
Simple Payback	--	No Payback
Discounted Payback	--	No Payback
Internal Rate of Return	--	--



Summary
results of the
Economic Tool

Online tools



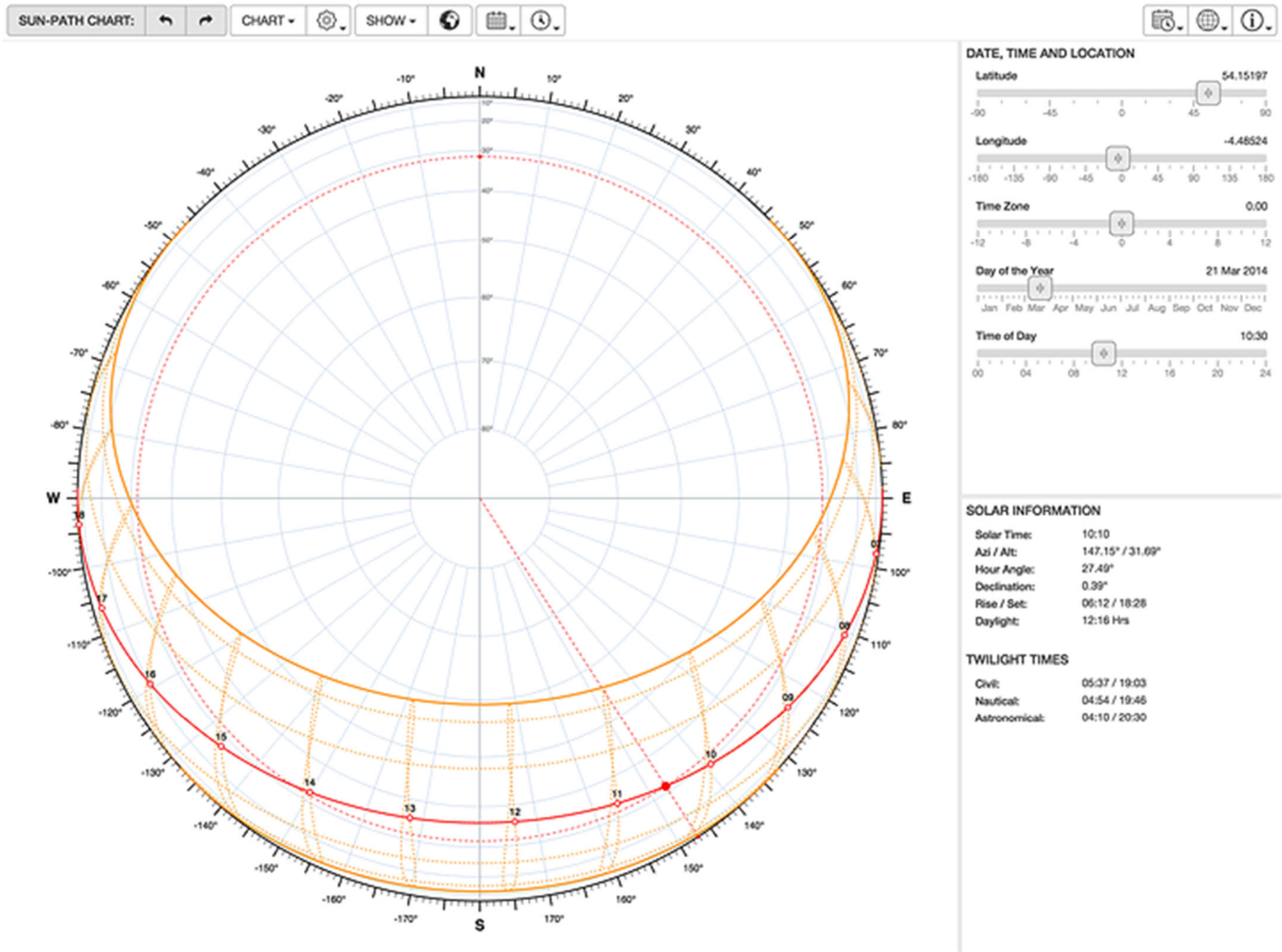
- Daylighting analysis tools (by Dr. Andrew Marsh)



- 2D Sun-Path <http://andrewmarsh.com/software/sunpath2d-web/>
- 3D Sun-Path <http://andrewmarsh.com/software/sunpath3d-web/>
- Dynamic Daylighting
<http://andrewmarsh.com/software/daylight-box-web/>
- Dynamic Overshadowing
<http://andrewmarsh.com/software/shading-box-web/>
- Dynamic Shadows
<http://andrewmarsh.com/software/shadows3d-web/>

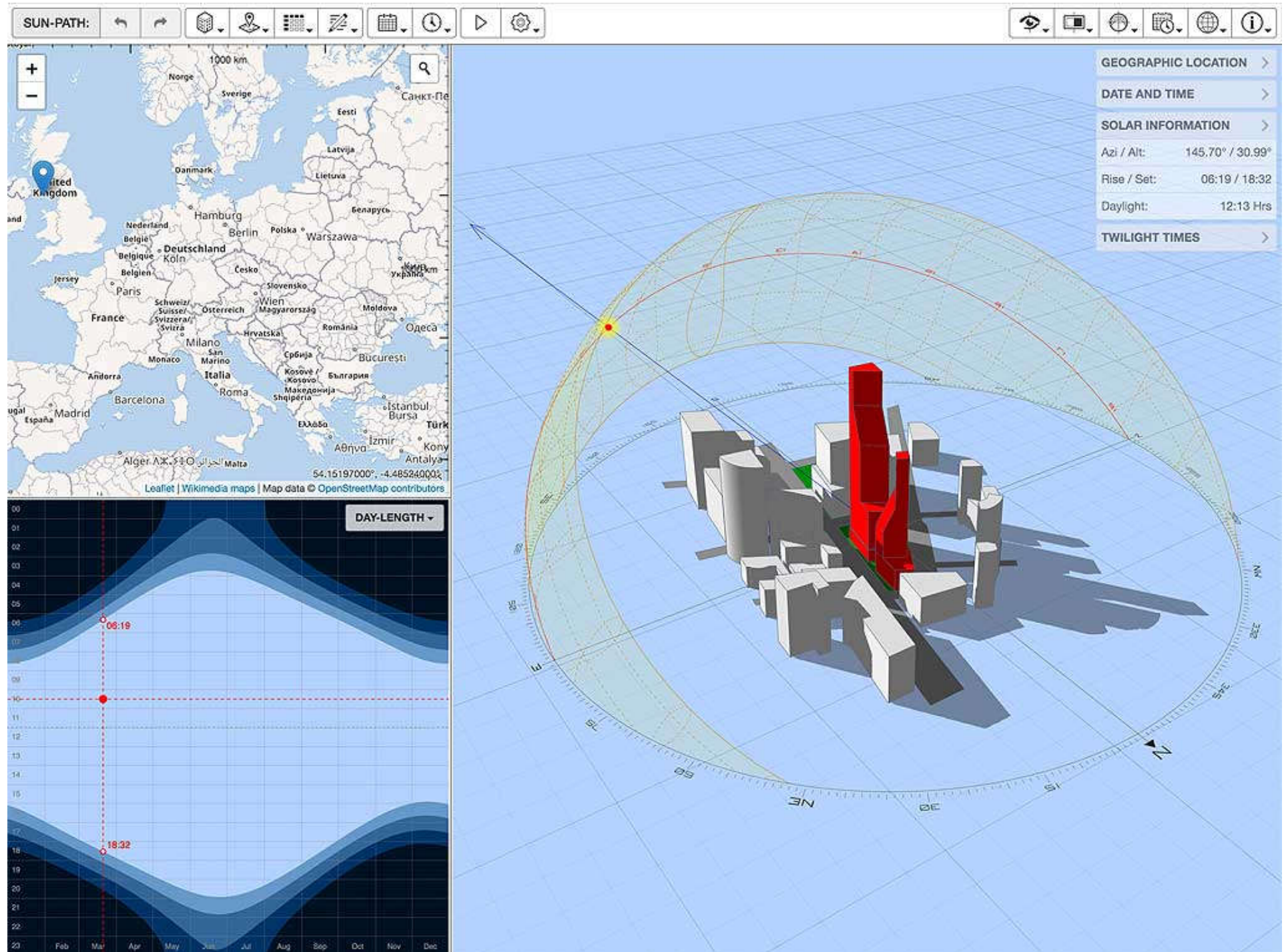
TRY IT
YOUR
SELF!

2D Sun-Path



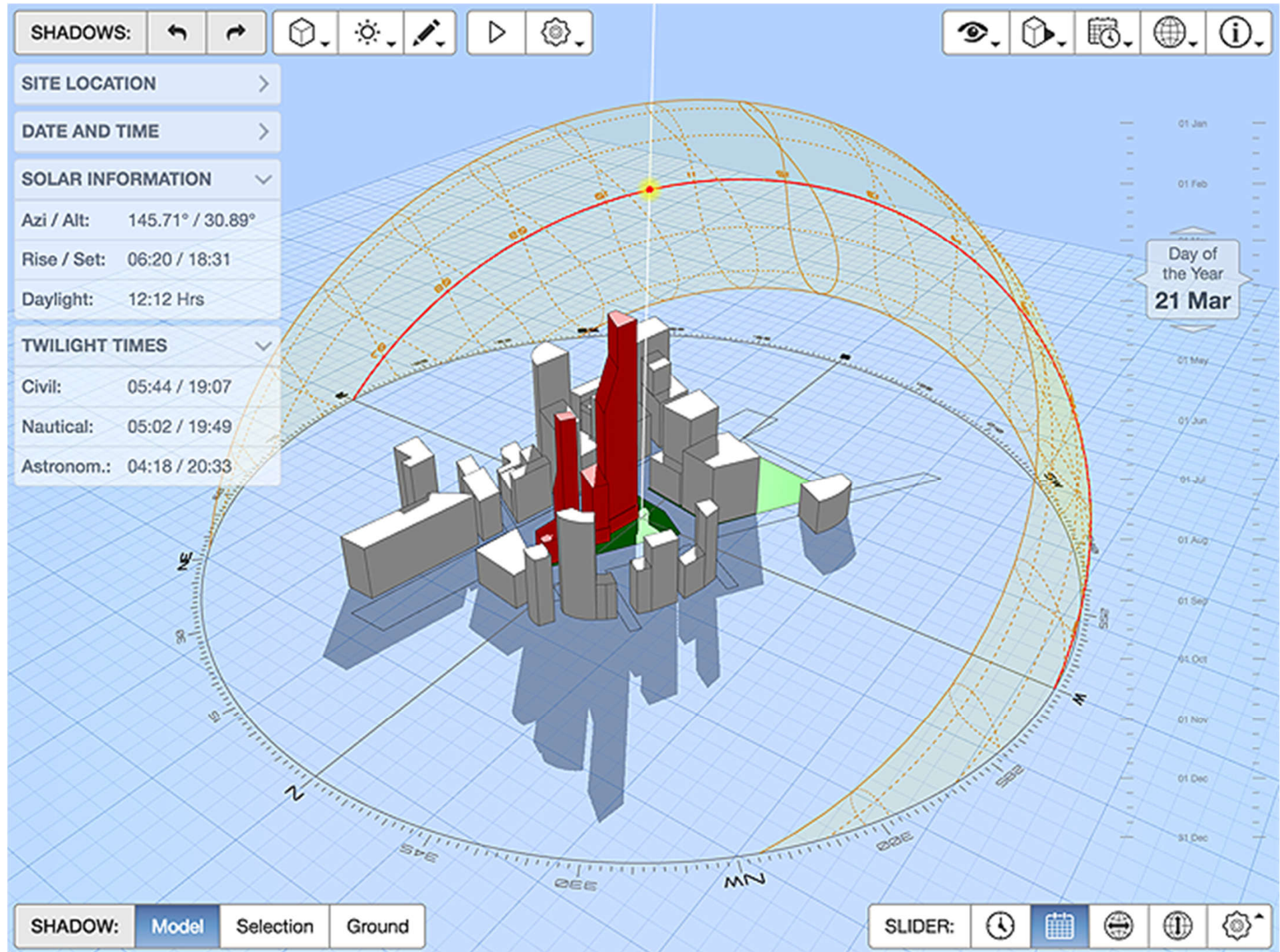
(Source: 2D Sun-Path <http://andrewmarsh.com/software/sunpath2d-web/>)

3D Sun-Path



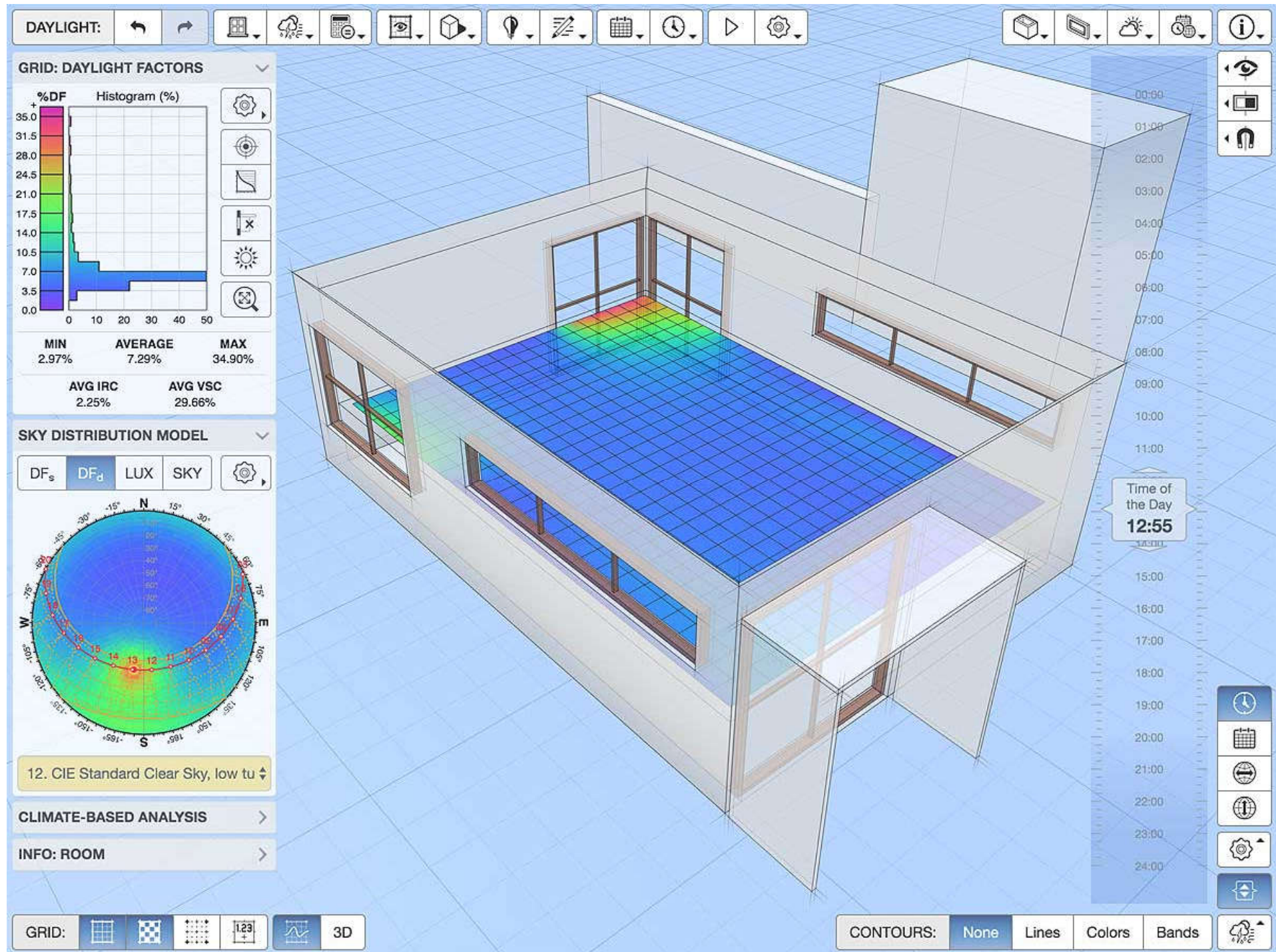
(Source: 3D Sun-Path <http://andrewmarsh.com/software/sunpath3d-web/>)

Dynamic Shadows



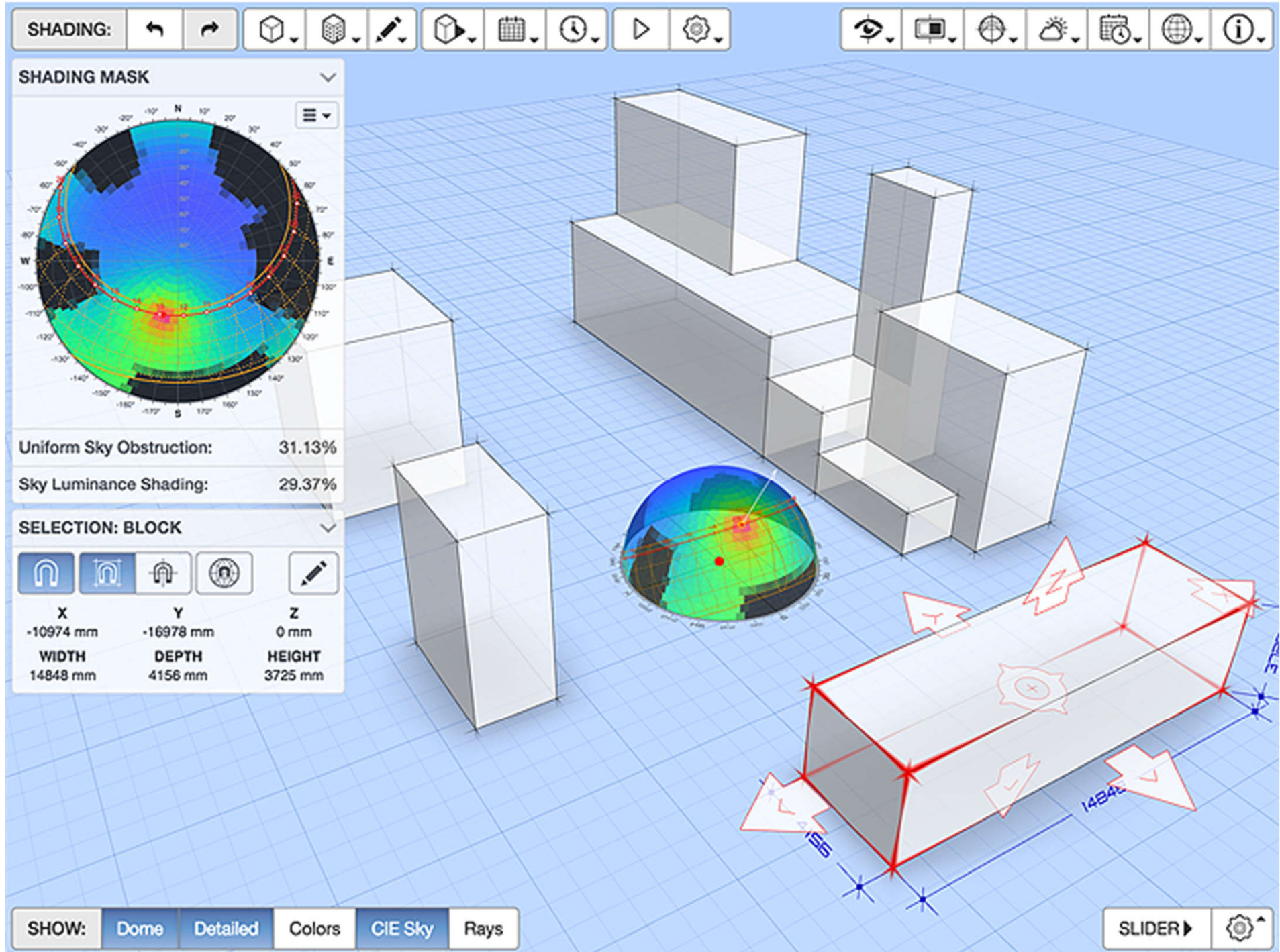
(Source: Dynamic Shadows <http://andrewmarsh.com/software/shadows3d-web/>)

Dynamic Daylighting



(Source: Dynamic Daylighting <http://andrewmarsh.com/software/daylight-box-web/>)

Dynamic Overshadowing



(Source: Dynamic Overshadowing <http://andrewmarsh.com/software/shading-box-web/>)



Further Reading

- LEARN (different stages of the lighting design process) by E-light
<https://iarc.uncg.edu/elight/learn/learn.html>
- Lighting Layout Calculator Tool - Indoor & Outdoor <https://www.tcpi.com/tcp-distributor-hub/lighting-layout-tool/>
- Visual Design Tools (online)
<http://www.visual-3d.com/software/designtools.aspx>