Glare Study of Highly Reflective Cool Roofing Membrane

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National Institute of Building Sciences Provider #G168

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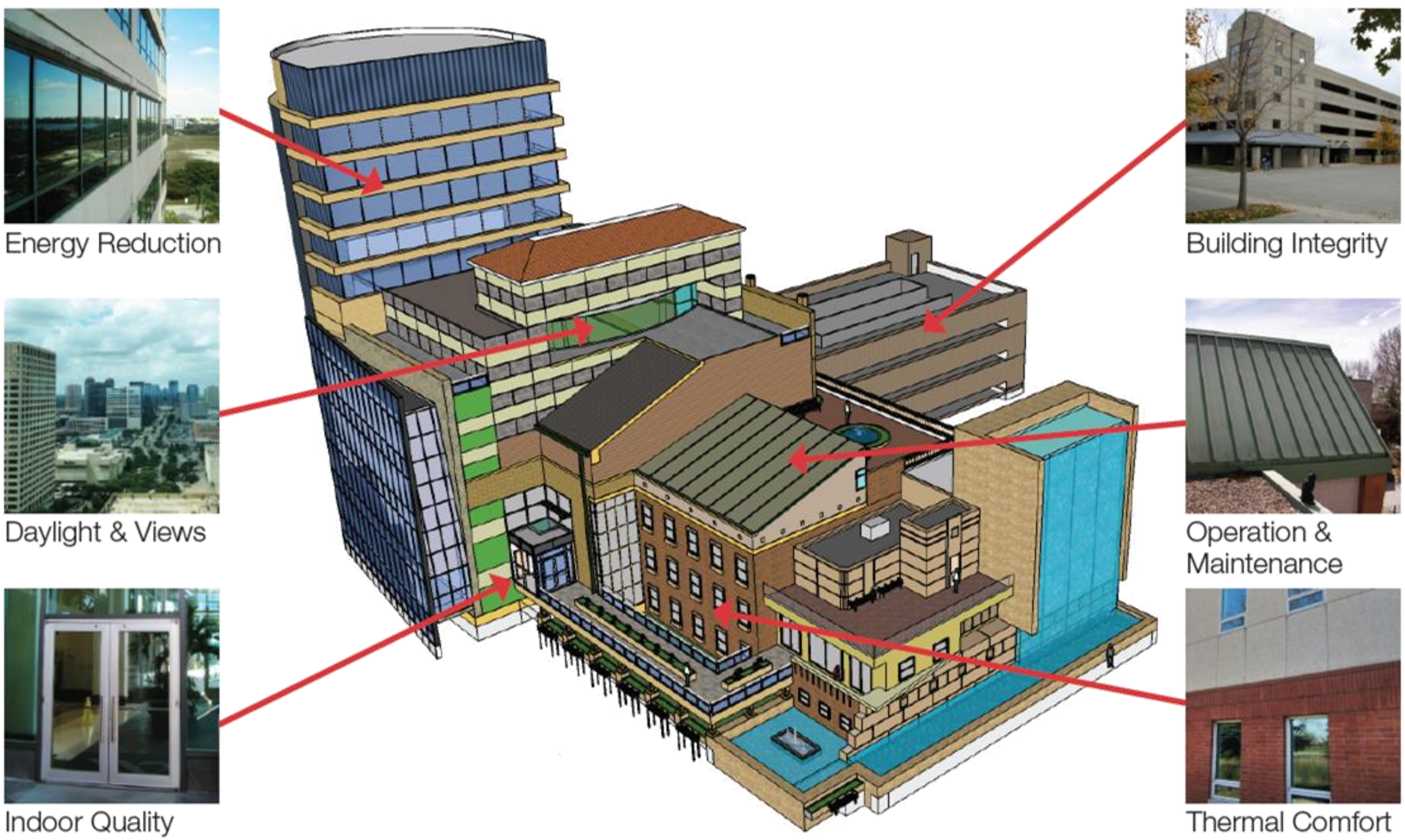
Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Learning Objectives

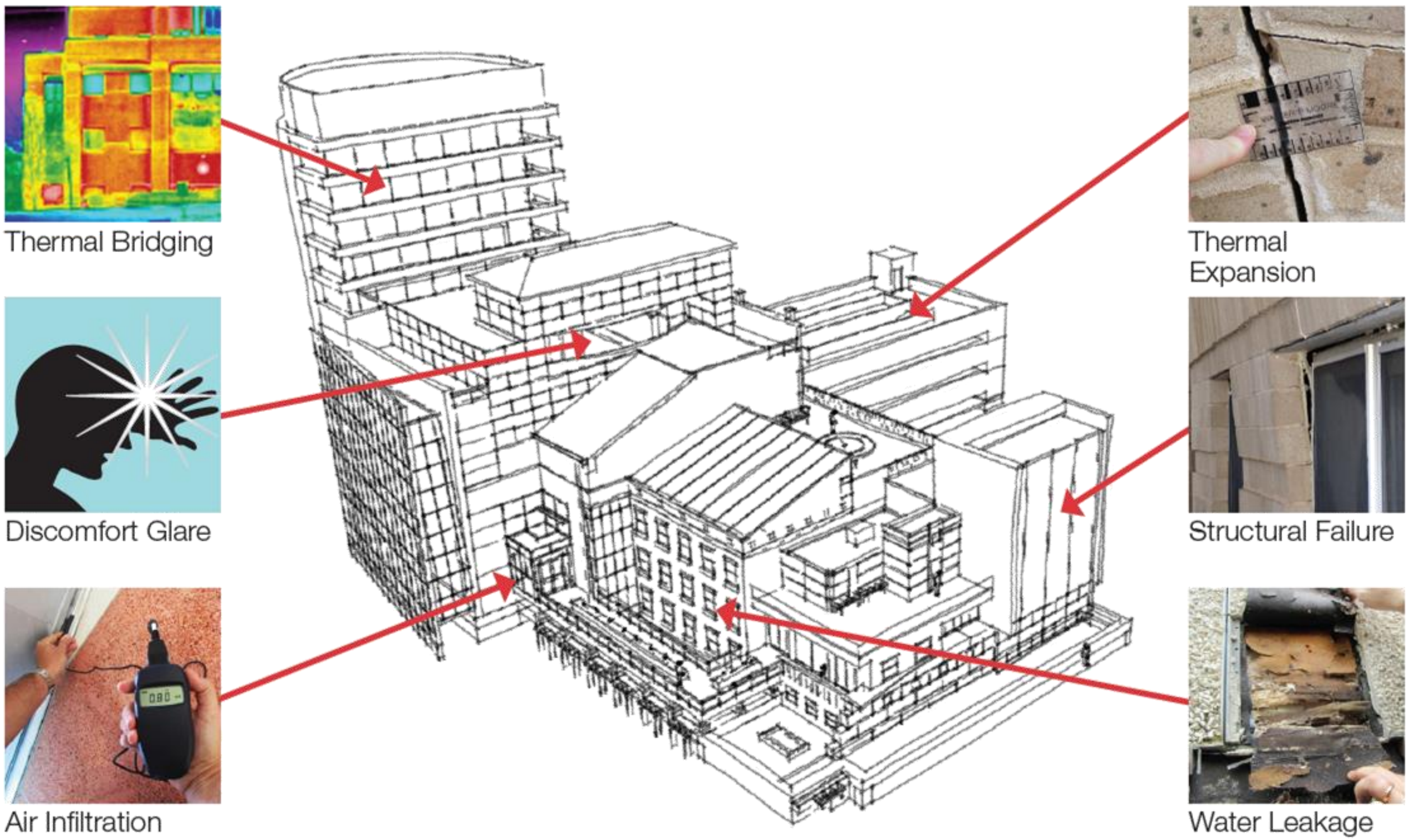
Participants will :

1. Understand the impact of solar exposures in different seasons per the building orientation
2. Identify the reflective index of roofing materials
3. Recognize the appropriate simulation tools in analyzing daylight luminance at interior and glare issues
4. Recognize the appropriate simulation tools in different design stages

Enclosure Design Performance Factors



Enclosure Design Performance Defects



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Integrated System Analysis

- Performance Mandates

● Critical implications for the delivery of this performance mandate
○ Some implication for the delivery of this performance mandate

EXAMPLES OF ENVELOPE SYSTEM DESIGN DECISIONS AFFECTING PERFORMANCE						
ENVELOPE	SPATIAL QUALITY	THERMAL QUALITY	AIR QUALITY	ACOUSTIC QUALITY	VISUAL QUALITY	BUILDING INTEGRITY
Wall / roof / exterior floor						
Exterior surface, material properties		○				●
Composite materials, thickness	●	○	○	○		●
Interior surface	○	○	○	●	●	○
Form: planar, curved	●	○		●	○	○
Slope, orientation	●	○		●	●	○
Module size, shape	●	○				●
Connection to other env. components	○	●	○	○		●
Windows / openings						
Material Properties	●	●		●	●	●
Size, shape, spacing	●	●	●	○	●	
Orientation		●	●	○	●	○
Control systems, sunshading	○	●		○	●	●
Control systems, heat loss		●				○
Control systems, ventilation	○	●	●		○	●
Frame connections, plan/section	○	●	○	○	●	●
Access, visual and physical	●	○	○		●	●
Expansion potential (vert/horiz)	○				○	
Change potential for access/image	○				○	○
Color, texture, ornament	○		○		●	●

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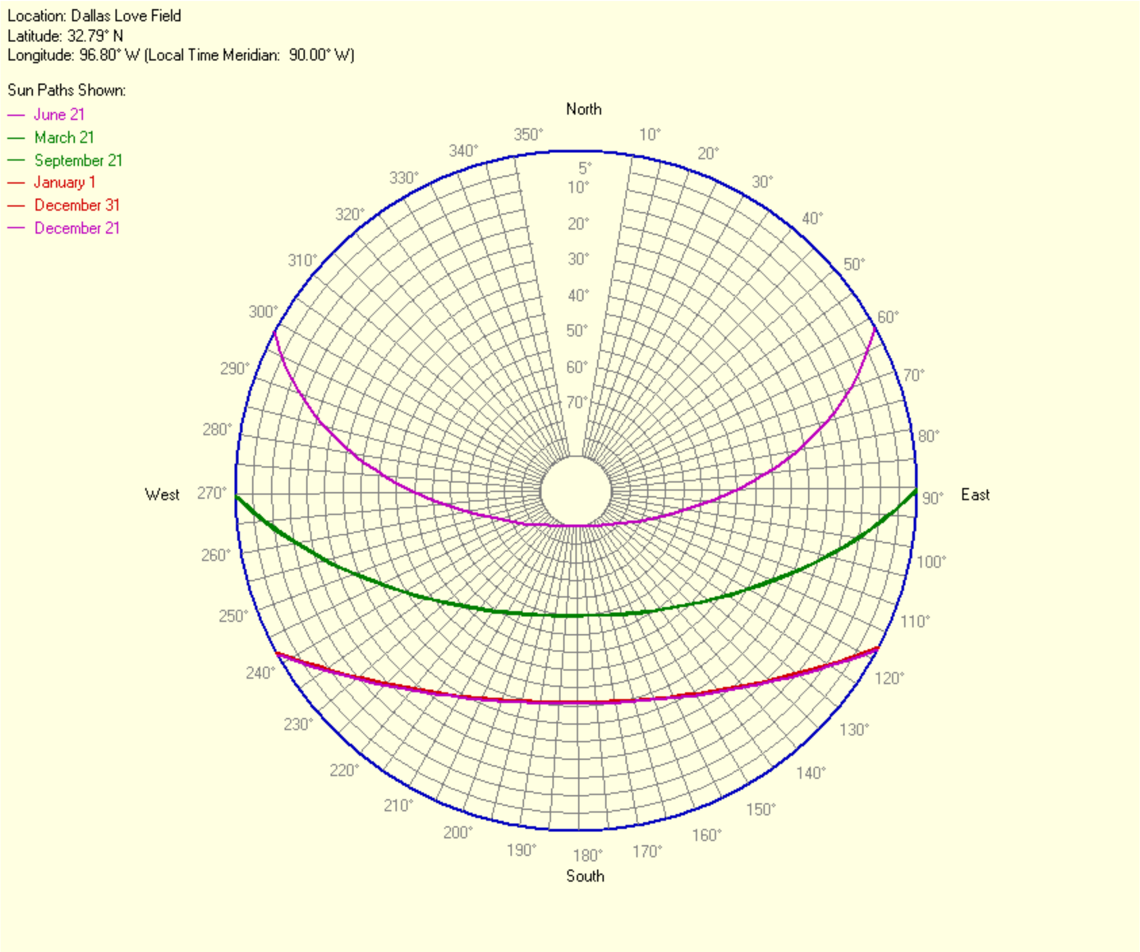
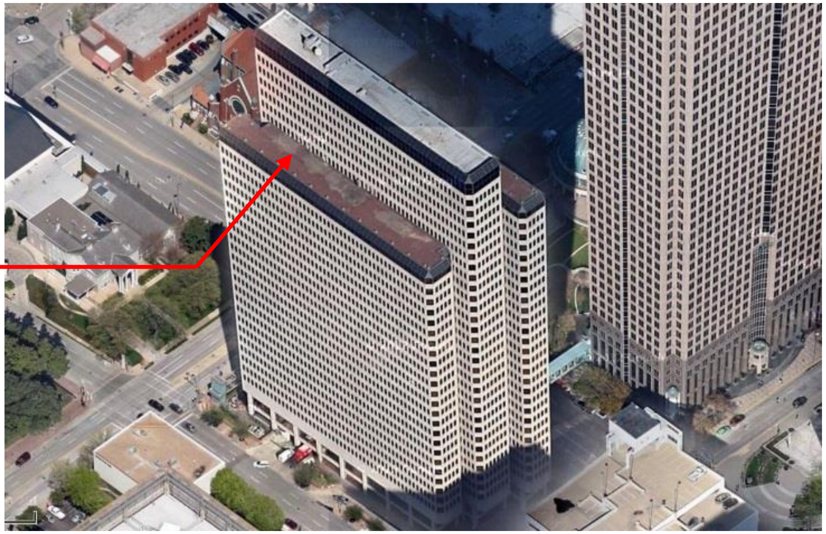
SunPath Diagram



Glare & Daylighting Study

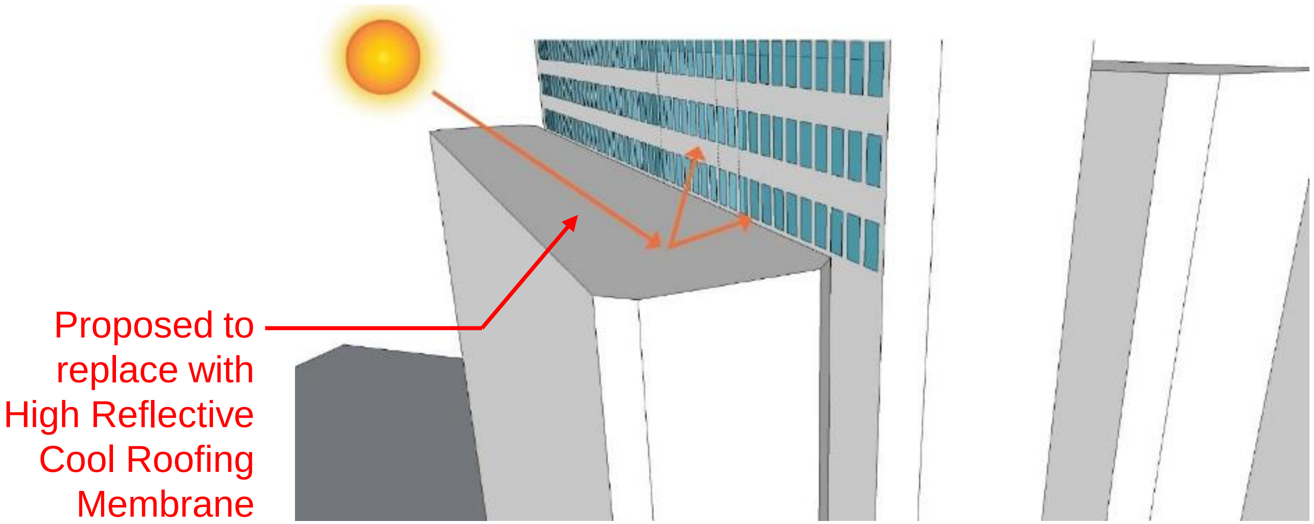
- Location: Dallas, TX
- Building Type: Office (High-rise)
- Orientation: Facing South

Existing Red Modified Bitumen Roofing Membrane



Daylighting & Glare Study

- Sun Path & Solar Reflectance
- Roofing Membrane Reflective Index
- SRI = 84 / Reflectivity = 69%



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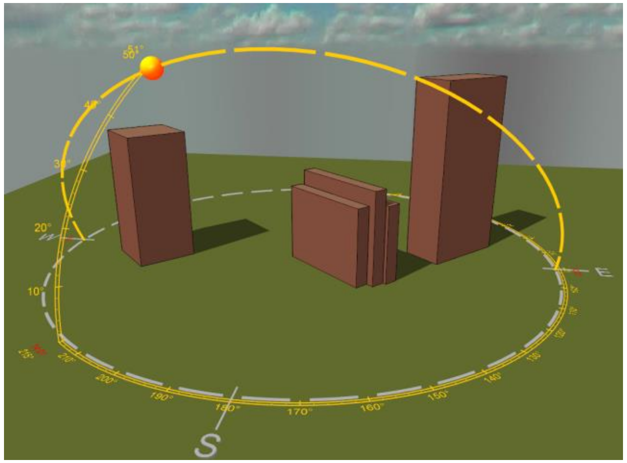
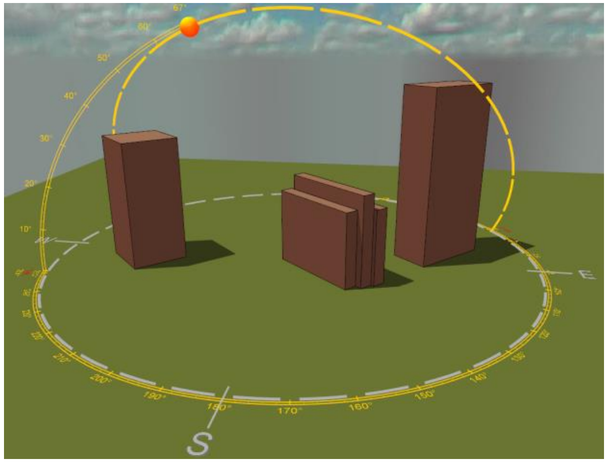
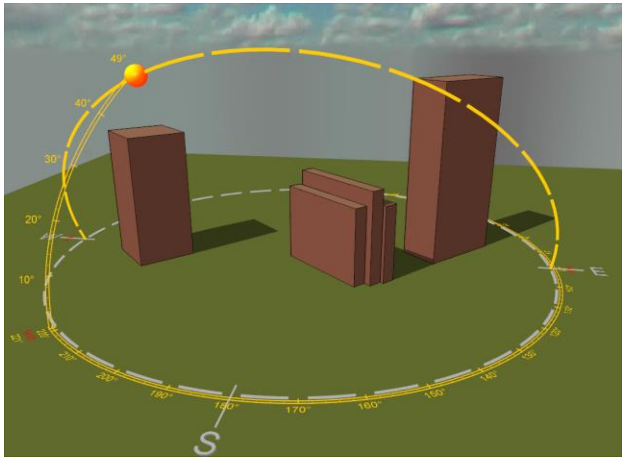
SunPath Studies



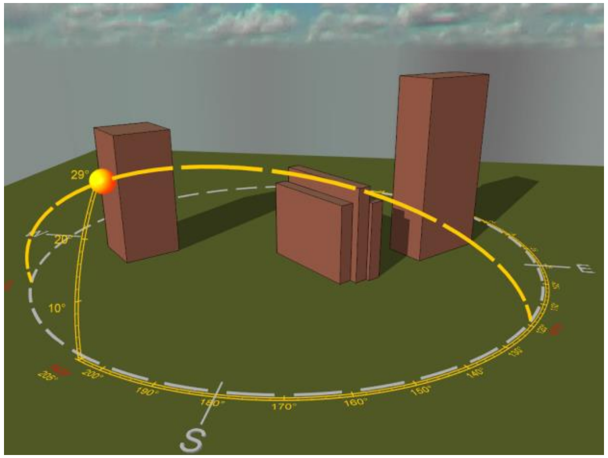
Spring Equinox



Summer Solstice



Fall Equinox



Winter Solstice

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Illuminance Values

I. ILLUMINANCE CATEGORIES AND ILLUMINANCE VALUES FOR GENERIC TYPES OF ACTIVITIES IN INTERIORS				
		RANGE OF ILLUMINANCES		
TYPE OF ACTIVITY	CATEGORY	LUX	FOOTCANDLES	REFERENCE WORK-PLANE
Public spaces with dark surroundings	A	20-30-50	2-3-5	General lighting throughout spaces
Simple orientation for short temporary visits	B	50-75-100	5-7,5-10	
Working spaces where throughout spaces visual tasks are only occasionally performed	C	100-150-200	10-15-20	
Performance of visual tasks of high contrast or large size	D	200-300-500	20-30-50	
Performance of visual tasks of medium contrast or small size	E	500-750-1000	50-75-100	Illuminance on task
Performance of visual tasks of low contrast or very small size	F	1000-1500-2000	100-150-200	
Performance of visual tasks of low contrast and very small size over a prolonged period	G	2000-3000-5000	200-300-500	Illuminance on task, obtained by a combination of general and local (supplementary lighting)
Performance of very prolonged and exacting visual tasks	H	5000-7500-10000	500-750-1000	
Performance of very special visual tasks of extremely low contrast and small size	I	10000-15000-20000	1000-1500-2000	

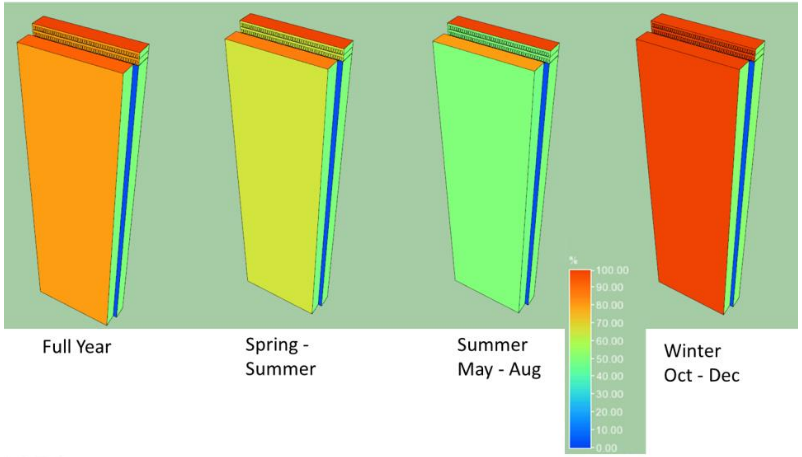
What is Glare?

- Glare is a measure of the physical discomfort of an occupant caused by excessive light or contrast in a specific field of view.
- Brighter luminance, larger source size, and a more-centered location in the viewing field increase probability of experiencing glare.
- First metric which considered large glare sources: the sky viewed through the window.

http://www.gsd.harvard.edu/research/gsdsquare/Publications/2010RadianceWorkshop_GlareIndices.pdf

Definitions

- Luminous Intensity
  - The luminous flux emitted from a source per unit *solid angle*
  - Units = Candela
- Illuminance
  - Surface density of incident Luminous Flux
  - Units = lux
- Luminance
  - Objective brightness
  - Units = candelas/ ft2

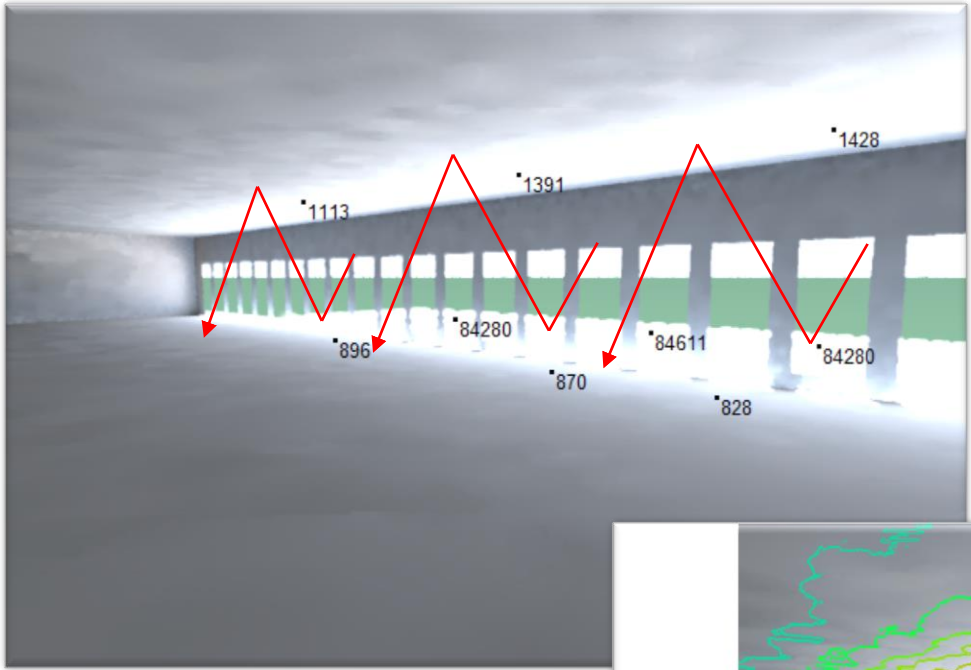


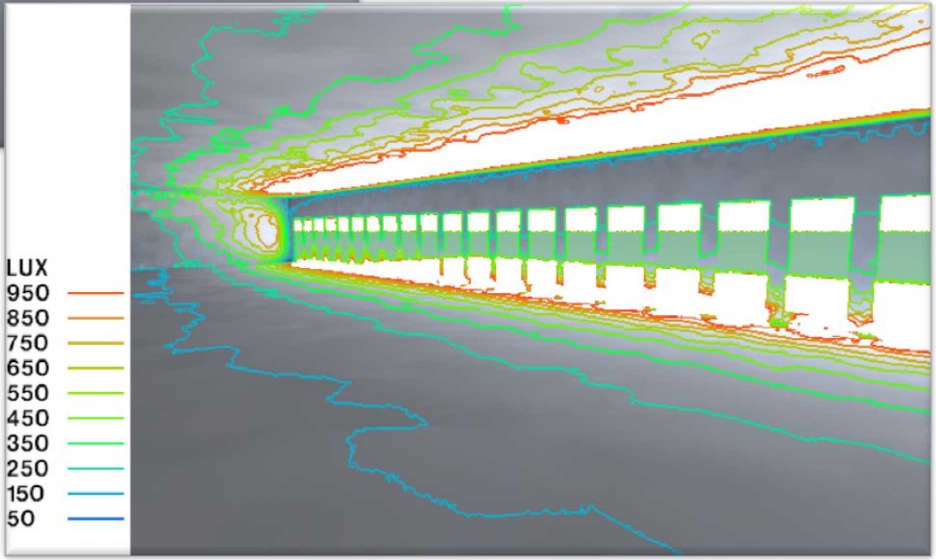
Illuminance

Examples	
Illuminance	**Surfaces illuminated by:**
10^{-4} lux	Moonless, overcast night sky (starlight)[2]
0.002 lux	Moonless clear night sky with airglow[2]
0.27–1.0 lux	Full moon on a clear night[2][3]
3.4 lux	Dark limit of civil twilight under a clear sky[4]
50 lux	Family living room lights (Australia, 1998)[5]
80 lux	Office building hallway/toilet lighting[6][7]
100 lux	Very dark overcast day[2]
320–500 lux	Office lighting[8][9][10]
400 lux	Sunrise or sunset on a clear day.
1,000 lux	Overcast day;[2] typical TV studio lighting
10,000–25,000 lux	Full daylight (not direct sun)[2]
32,000–130,000 lux	Direct sunlight

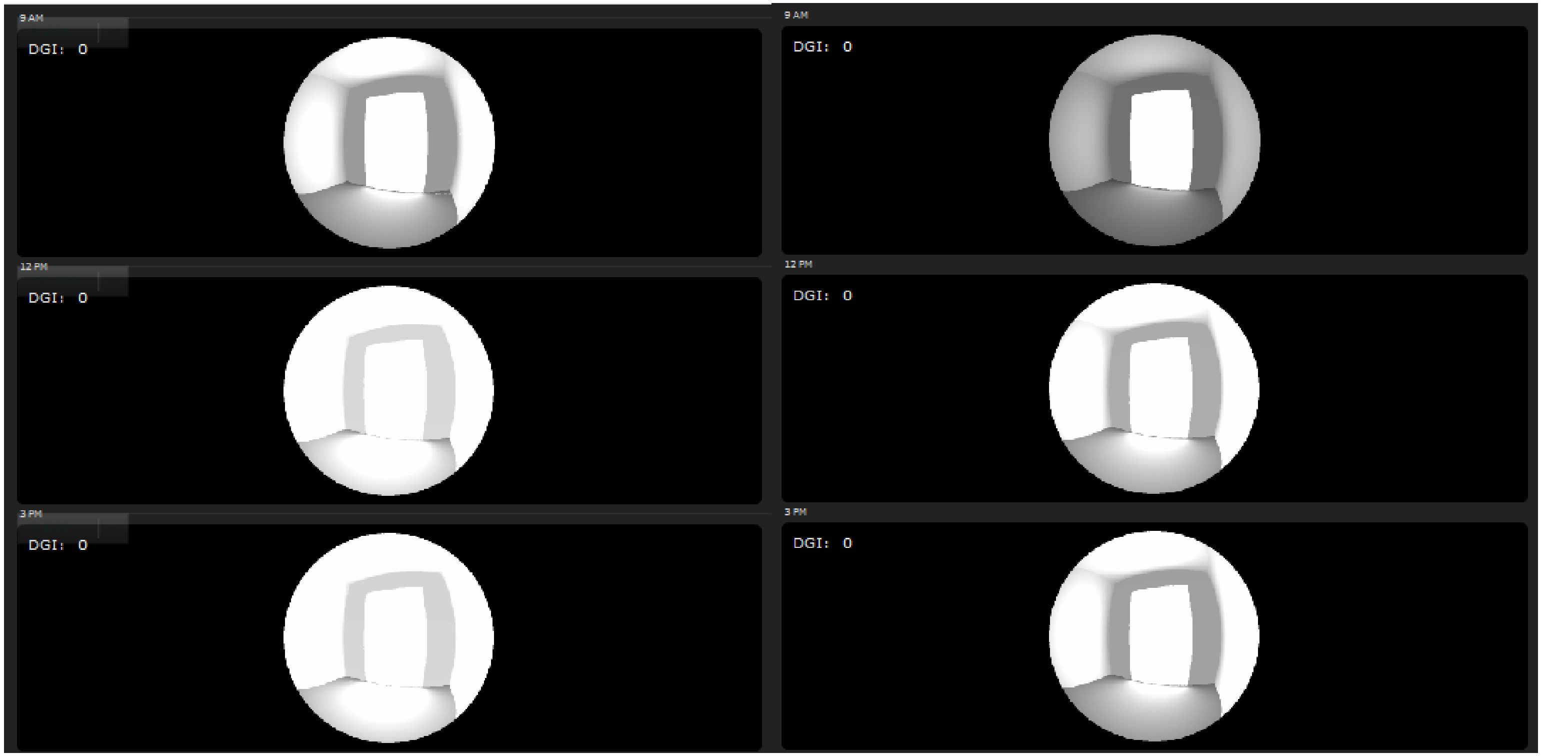
https://en.wikipedia.org/wiki/Lux

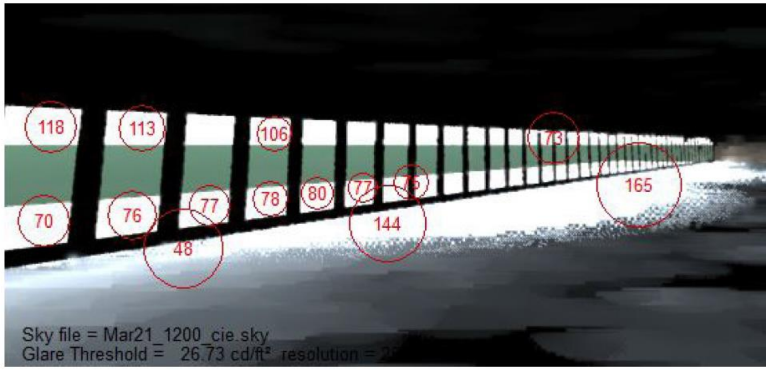
Illuminance





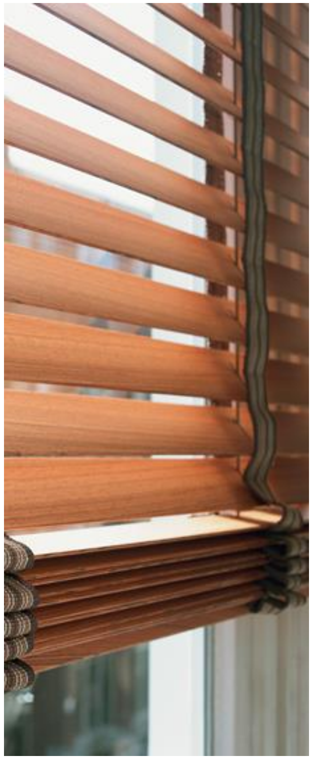
Glare Studies (March 21 Vs. June 21)

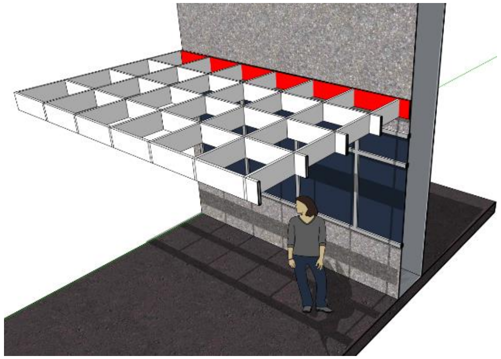




Recommendations

- Blinds
- Tinted Film
- Canopy
- Dynamic Glass





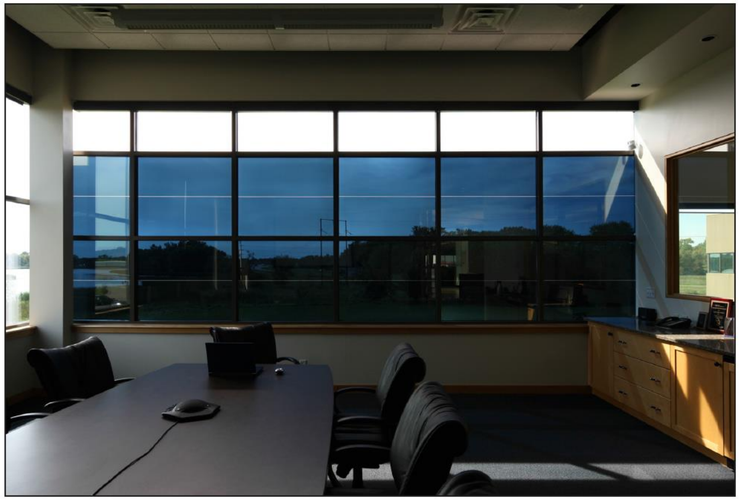
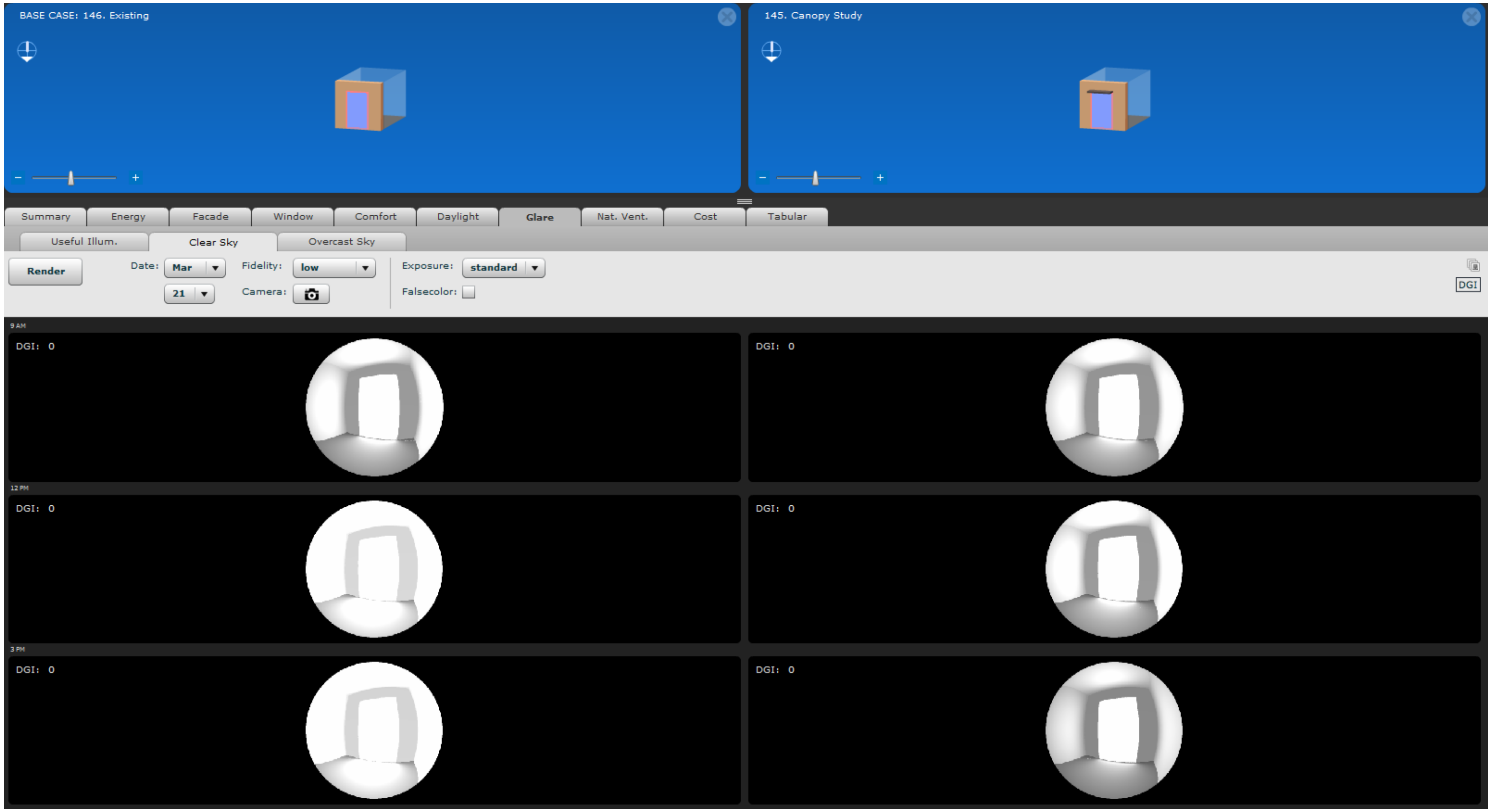


Image source: SAGE Electrochromics, Inc.

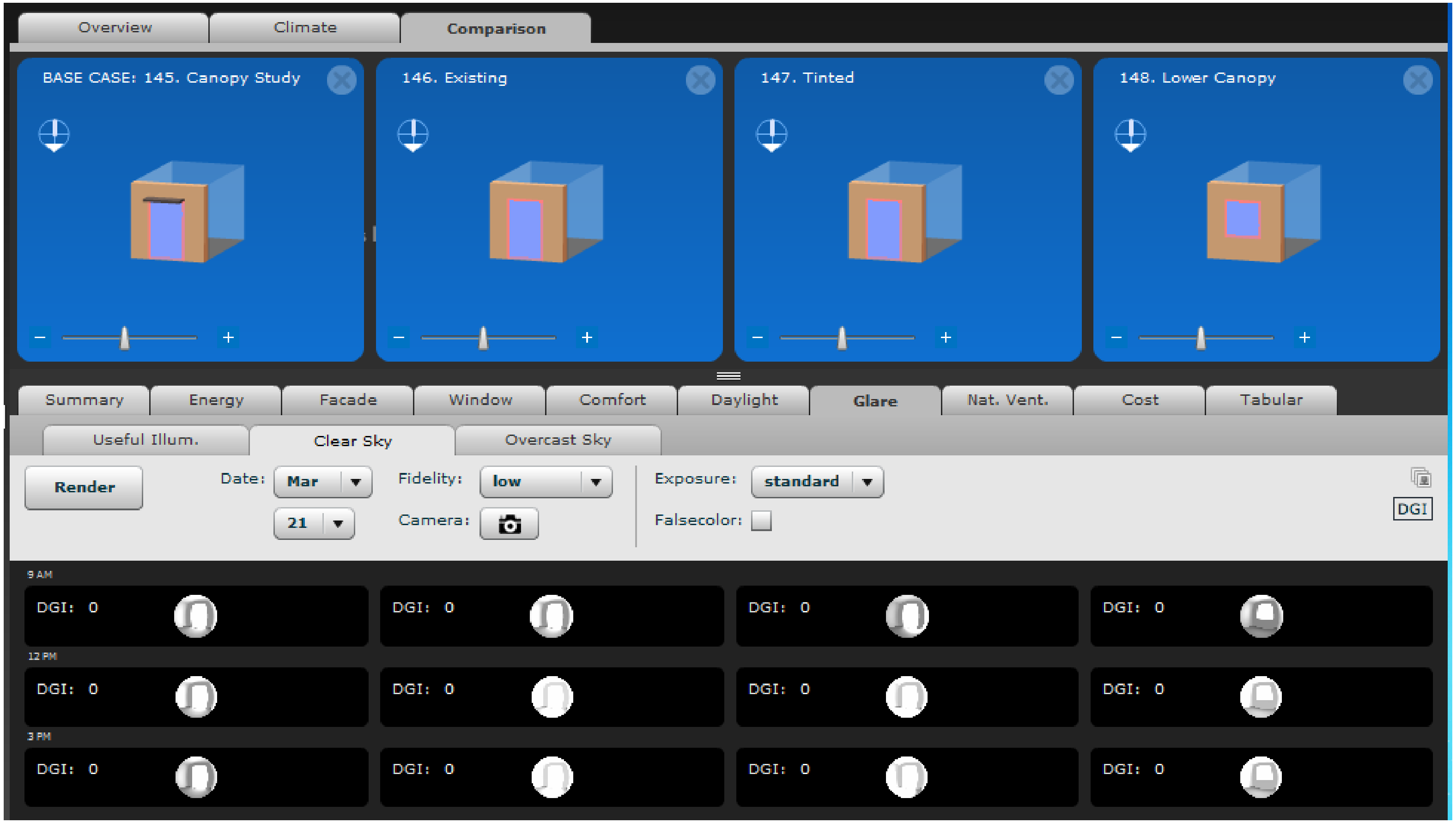
Recommendations

- With or Without Canopy



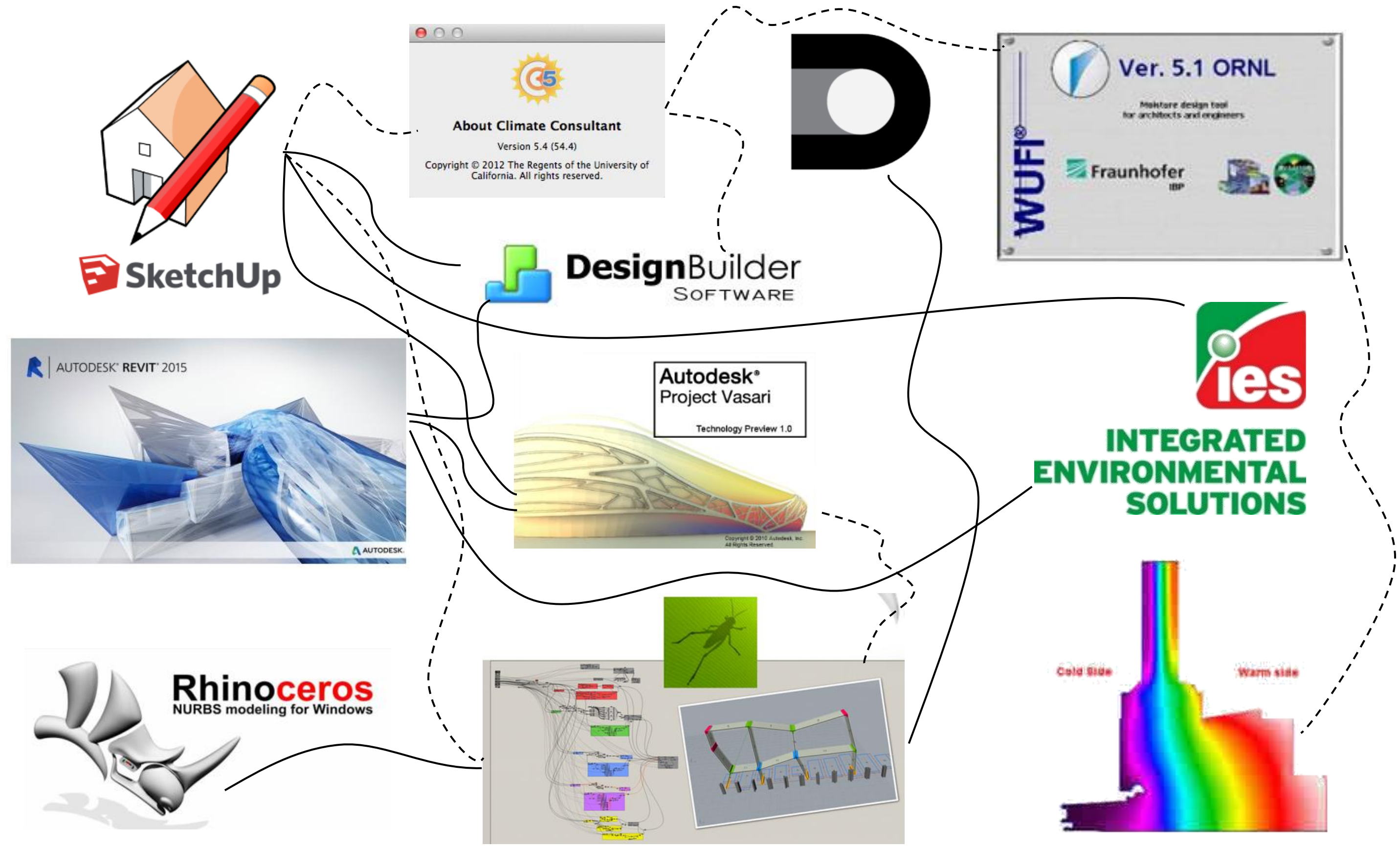
Recommendations

- Canopy Vs. Existing Vs. Tinted Glass Vs. Dynamic Glass



One Tool Fits All?

- Interoperability



Simulation Tools for Performance Analysis

SOFTWARE	ANALYSIS						
	Daylighting	Heat Gain / Loss	Thermal Bridging	Condensation	Thermal Comfort	Energy Usage	CFD
Revit / Vasari	X	X				X	
Climate Consultant	X	X					
Ecotect	X	X			X	X	
Rhino / DIVA	X						
ComFen	X					X	
IES VE	X	X		X	X	X	X
DesignBuilder	X	X			X	X	X
Therm		X	X				
WUFI		X		X			

- Conceptual / Schematic Design Stage
- Schematic / Design Development Stage
- Design Development / Construction Document Stage

Conclusions

- To understand the solar path and the sun angles can impact daylighting and glare
- To narrow down the areas based on the orientation, floor height, solar impact hours and seasons to optimize the computational time
- Materials properties and total numbers of light reflection bounds is crucial for the input
- No one tool can analyze all the performance factors during different design stages

Questions

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THANK YOU!