Come to the Light! Revit Lighting and Daylighting Analysis for Everyone

David Scheer, AIA BEMP

Sr Product Manager, BPA Design Integration

Class summary

Until recently, daylighting performance analysis has been one of the truly apprentice skills in the field of building design. Though collaborative work with experienced lighting professionals will always be part of designing successful daylit buildings, recent releases for Revit do away with much of the tedious, redundant, and highly technical modeling setup required in standard specialty software, and speed the process tremendously by leveraging a fast, cloud-based simulation engine.

This class will show how the Lighting Analysis tool set for Revit can be used by architects and designers to actively engage in lighting and daylighting analysis, including LEED, informing decisions throughout the design process; and by engineers and specialist consultants to extend your influence and spend less time modeling and more time consulting on more projects.

Class summary

This class will review 3 tools that leverage the Lighting Analysis tool set in Revit for cloud-based simulation for lighting analysis:

1. Deep dive into **Lighting Analysis for Revit** plugin - automate simulation and results management for typical daylighting analyses like LEED, and custom analyses with advanced settings.
2. Intro to **Rendering Illuminance** output in Revit - enables flexible and general visualization of illuminance levels for any time, location, or sky condition for any Revit 3D view
3. Intro to **Dynamo Daylighting** nodes - provide the ultimate in flexibility and automation of analysis and optimization using the same cloud simulation engine used for LAR and Rendering Illuminance.

What we will cover

- Section 1.0 - **Why should architects do daylighting analysis?**
- Section 2.0 – **Lighting Analysis for Revit demo and deep dive.**
  - 2.1 – LAR Run Analysis dialog
  - 2.2 – Controlling Cloud Credit costs
  - 2.3 – Revit Materials for Illuminance Analysis
  - 2.4 – Custom Analysis with LAR
  - 2.5 – Raw data export
- Section 3.0 – (Intro) **Rendering Illuminance Workflows**
- Section 4.0 – (Intro) **Dynamo Daylighting**
- Section 5.0 – **Validation – Engine and Workflow**

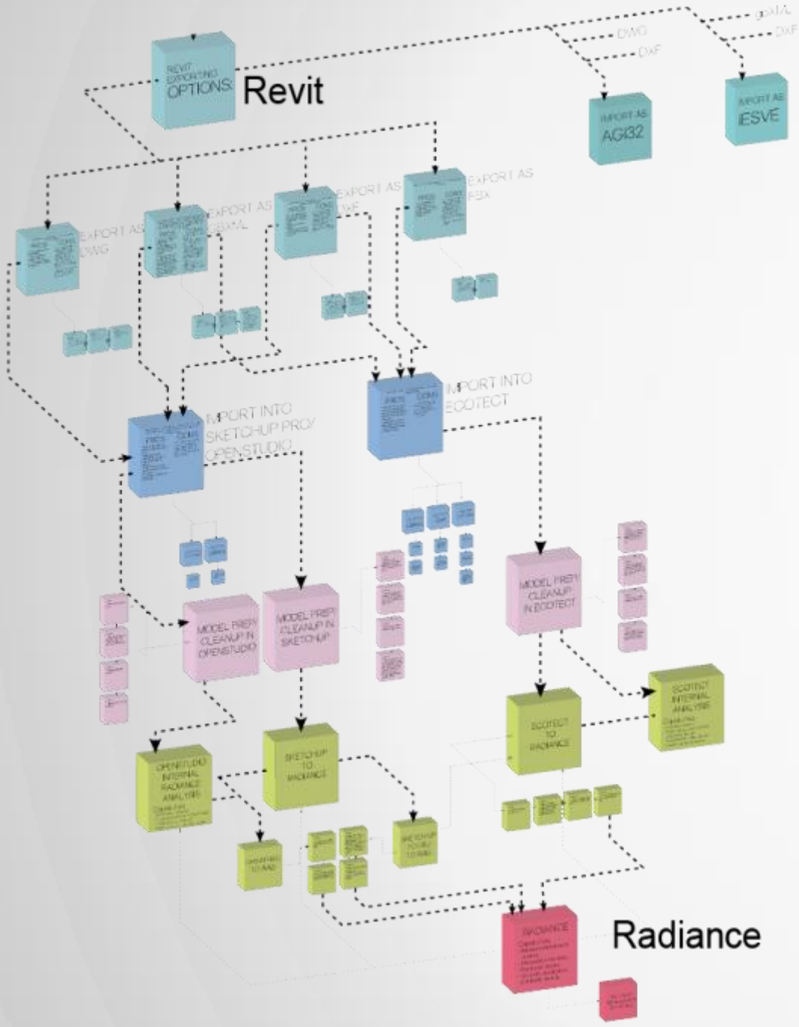
Section 1

Why should architects do daylighting analysis?

- More analysis needs to be done to facilitate better buildings that can take advantage of significant known benefits of daylighting.
- There are not enough specialists available to do the analysis and consult on solutions for all the buildings that need it.
- Architects are in the best position to start early, act on analysis information, and carry benefits through to completion
- Making the job easier for specialists also frees them up to focus on consulting and design rather than simulation management.

How can we enable architects to do daylighting analysis?

How can we incorporate valid and useful daylighting analysis into the architects' working environment?



Revit-to-Radiance translation workflows

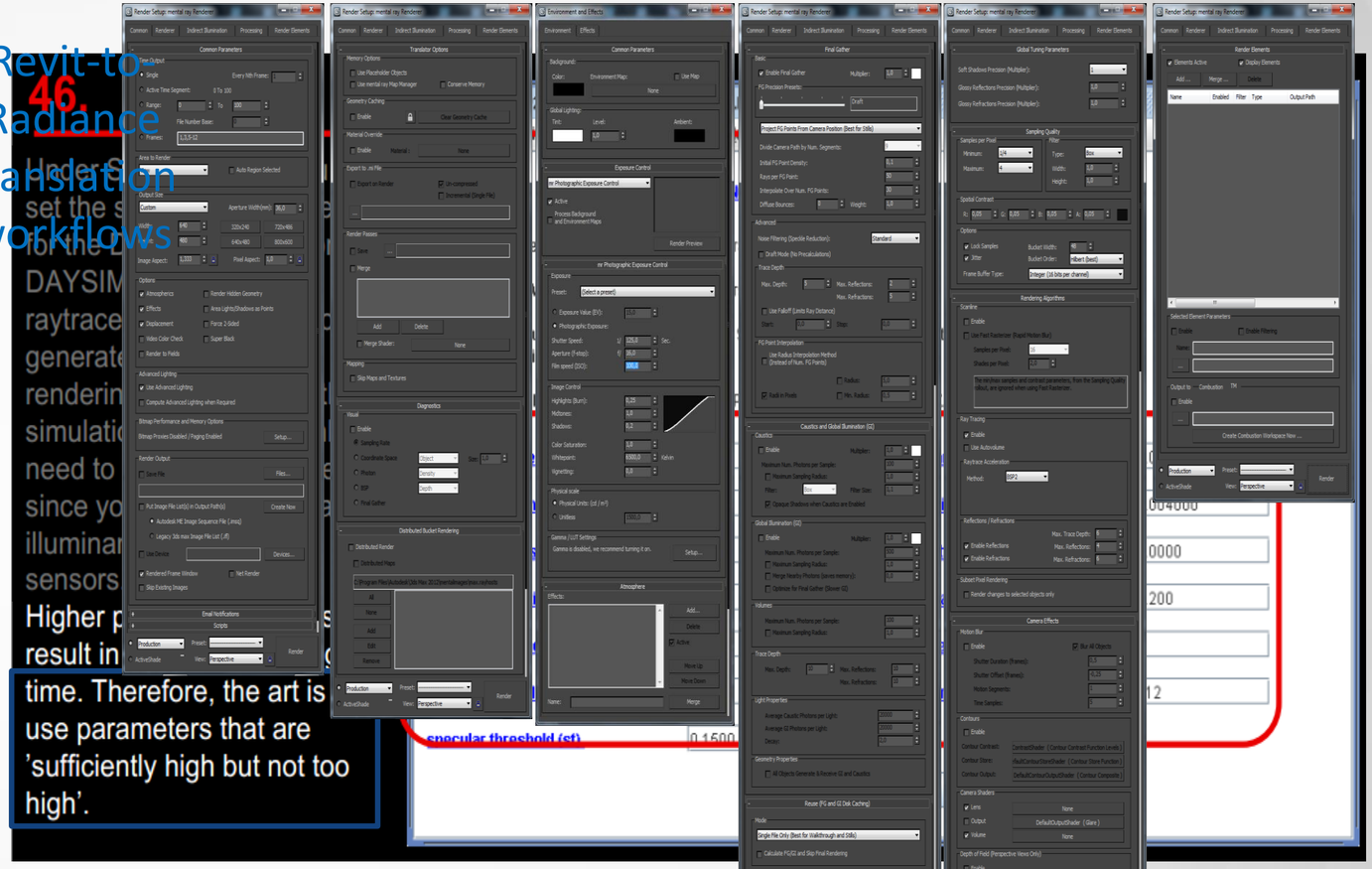
46

infographic

export

revit

Univ. of Idaho



Integrated Design Lab

prezi.com/soq5njqnktk9/2014-02-23/

Jacob Dunn

The Art of Analysis

Render Options in Autodesk® 3D Studio Max®

Advanced Daylight Simulations us

http://web.mit.edu/SustainableDesignLab/pro

STOPH REINHART

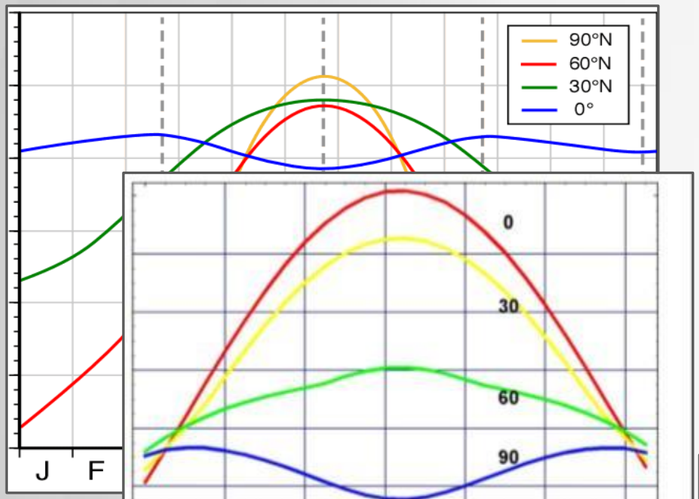
dianceDaysim.pdf

http://www.physicalgeography.net/fundamentals/6i.html
http://www.polyphasicsociety.com/polyphasic-sleep/adaptation/night-lighting/

LEONARDO DA VINCI (1955). Das Lebensbild eines Genies, Emil Vollmer Verlag, Wiesbaden Berlin. Dokumentation der DA VINCI Ausstellung in Mailand 1938
http://www.jimonlight.com/2009/11/1

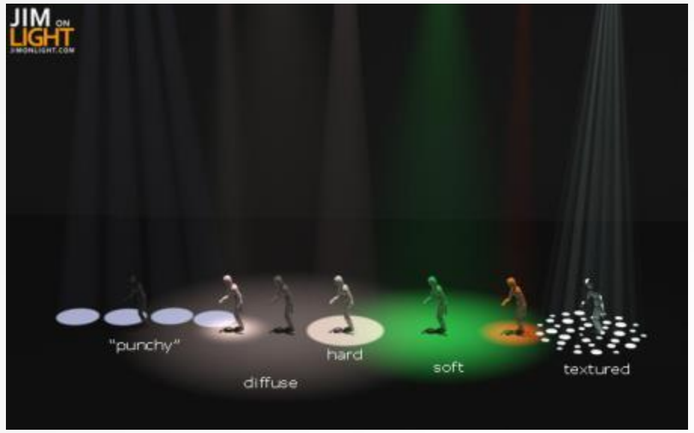
Location and Time

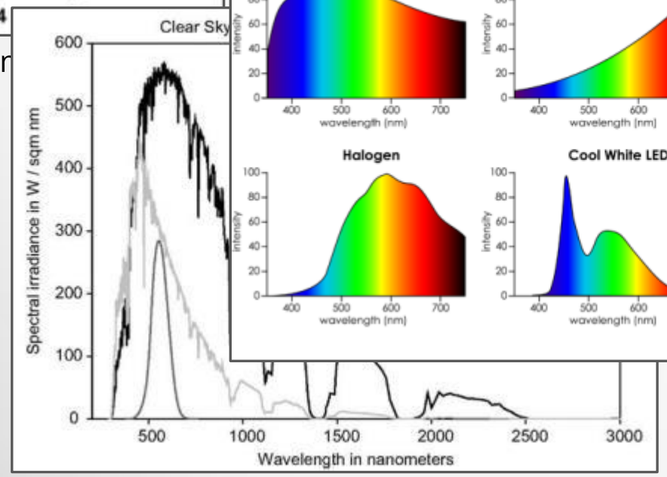
Insolation by Month and Latitude



Insolation by Hour ar

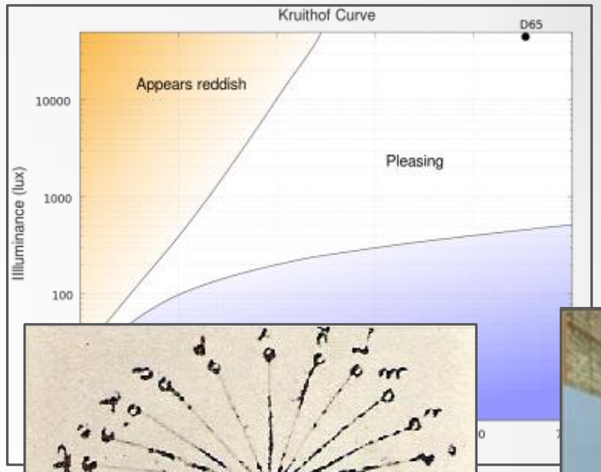
Distribution

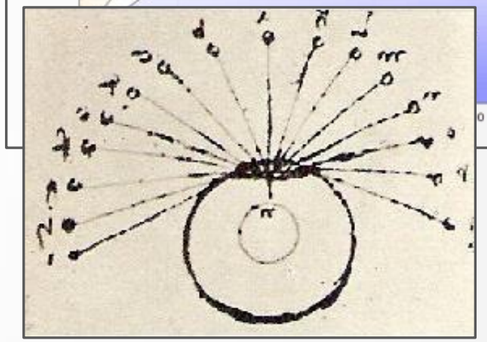




Wavelength and Source

Perception and Use





Contrast

Science Channel's "How It's Made"
http://www.wimp.com/baseballsmade/

Tool Makers

Daylighting Specialists

Architects

- Remove the tedious activities that break design flow
- Automate settings not related to design thinking
- Keep the analysis model coupled with the design model
- Show the results in canvas
- Do it all fast to maintain flow with the design process
  (get the answer before you forget the question!)

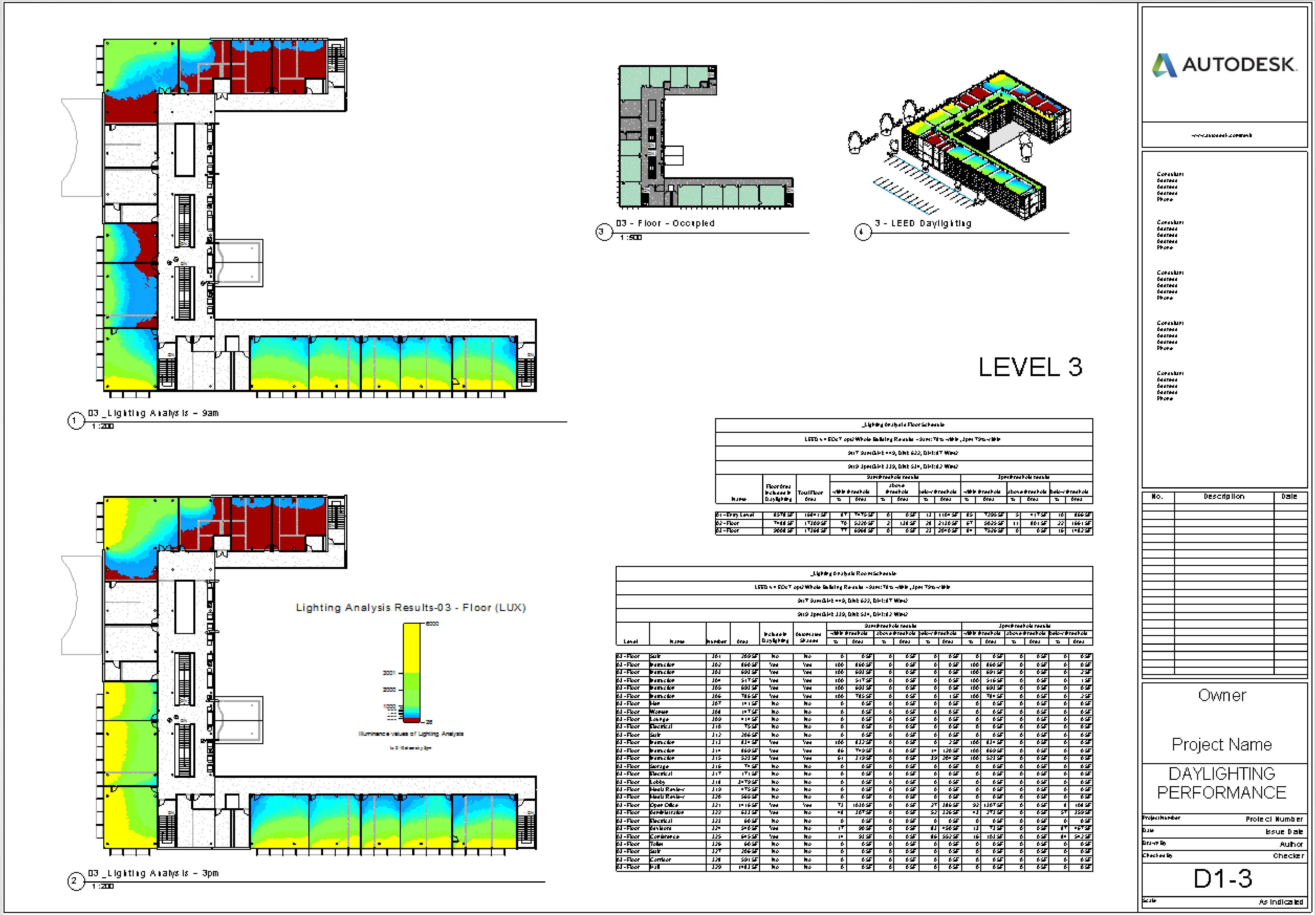
Offering | Questions

Questions?

Section 2

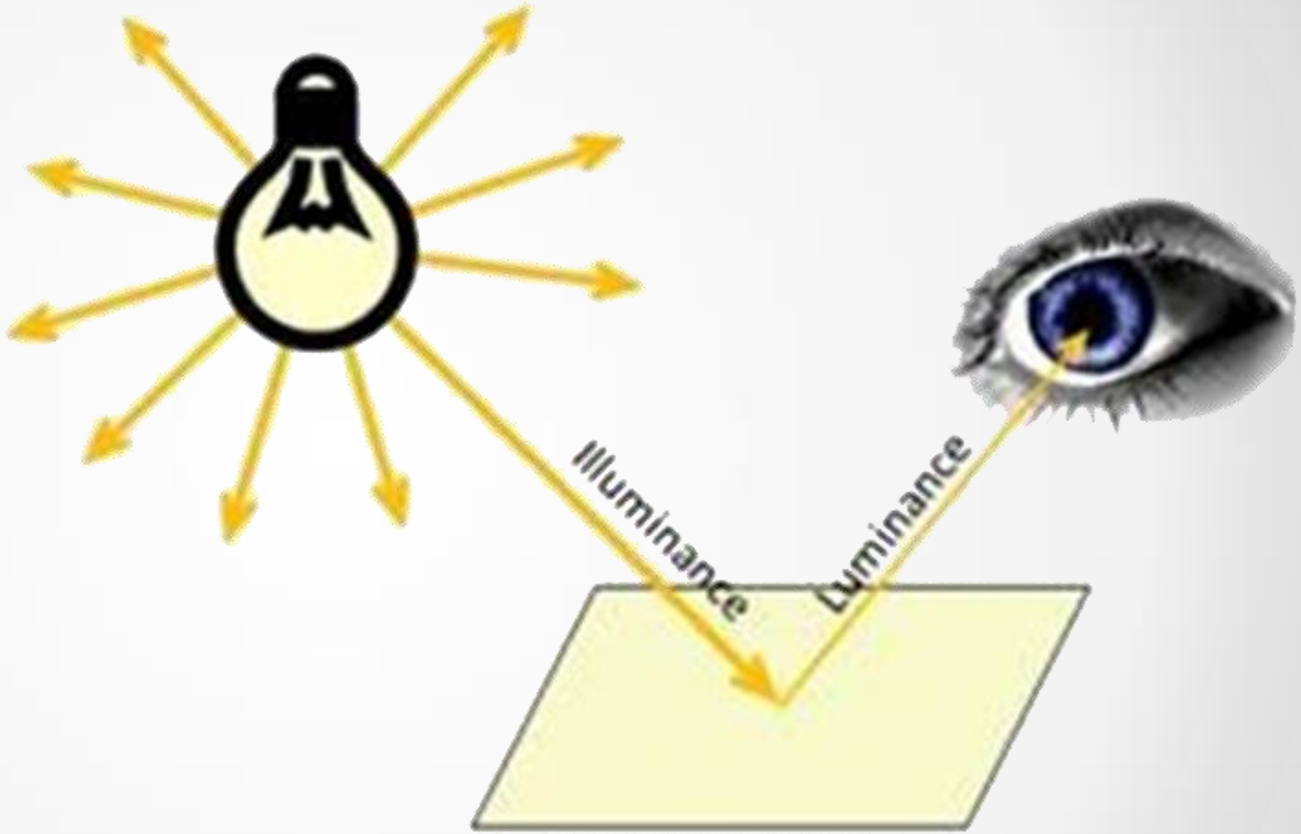
Lighting Analysis for Revit

Handout Exercise 1.0


AUTODESK
LEVEL 3
03 - Floor - Occupied
1 : 500
3 - LEED Daylighting
03 _Lighting Analysis - 9am
1 : 200
03 _Lighting Analysis - 3pm
1 : 200
Lighting Analysis Results-03 - Floor (LUX)
Lighting Analysis Floor Schedule
Lighting Analysis Room Schedule
Owner
Project Name
DAYLIGHTING PERFORMANCE
Project Number
Issue Date
Author
Checker
D1-3
As indicated

Metrics

Benchmarks



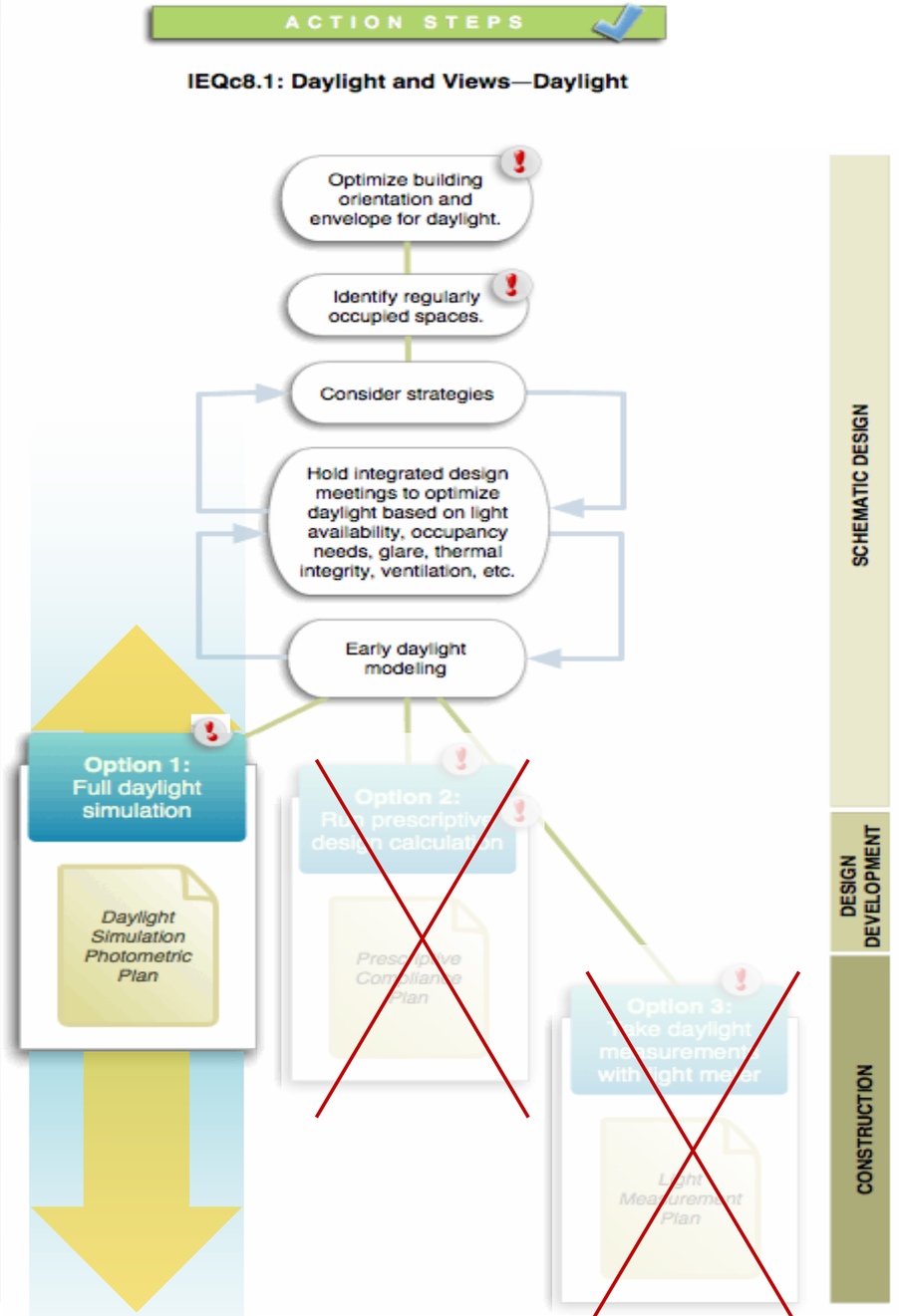
Metrics
(Illuminance - footcandles)

Benchmarks
(IES minimums)

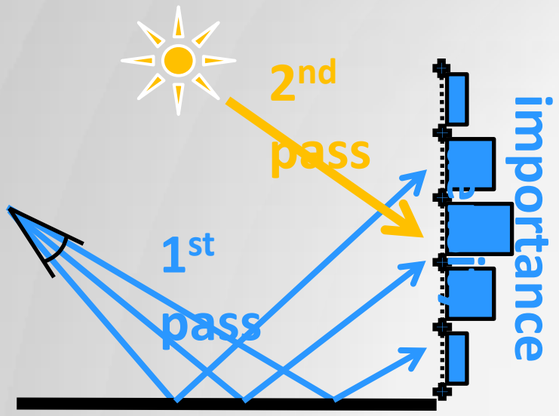
	Illuminance (min fc)	
Public spaces	2-5 fc	
Lobby and Reception	0-20 fc	
Dining Areas	5-20 fc	
Hotel corridors	10-20 fc	
Conference areas	20-50 fc	
School reading areas	20-100 fc	
Drafting Office	50-200 fc	(Illuminating Enginee
Fine Assembly tasks	200-2000 fc	Source: IES

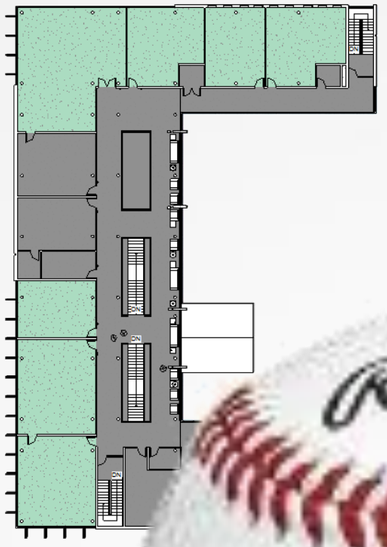
Metrics
(Illuminance - footcandles)

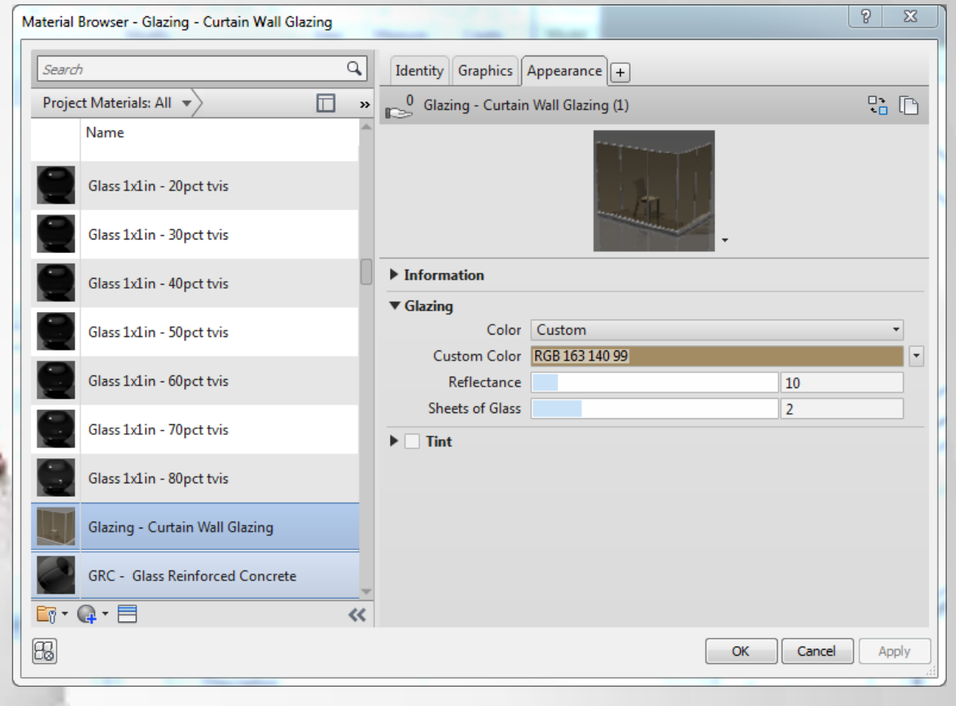
Benchmarks
(LEED Daylighting Credits)

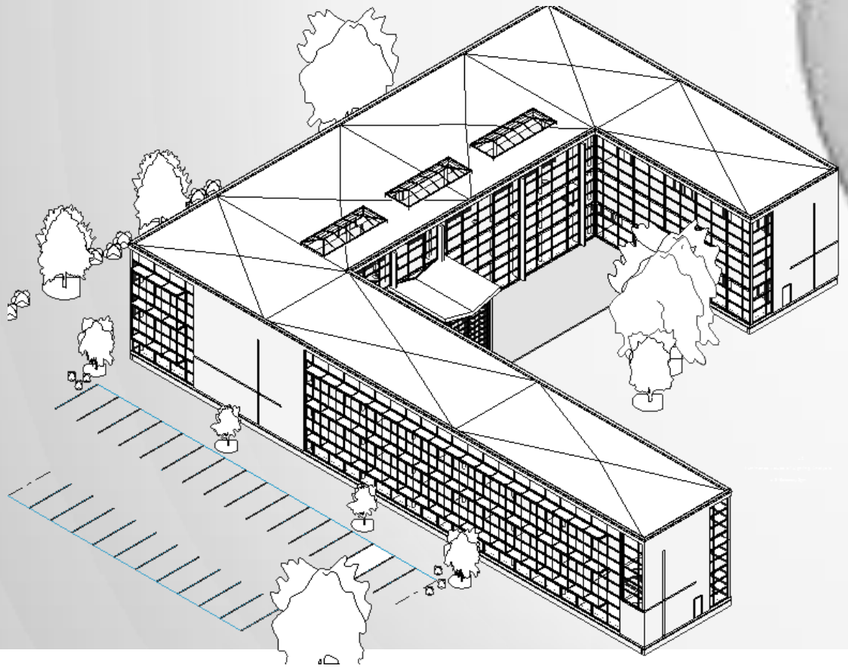


LEED Reference Guide – p549 for IEQ 8.1, Option 1
http://www.leeduser.com/credit/NC-2009/IEQc8.1



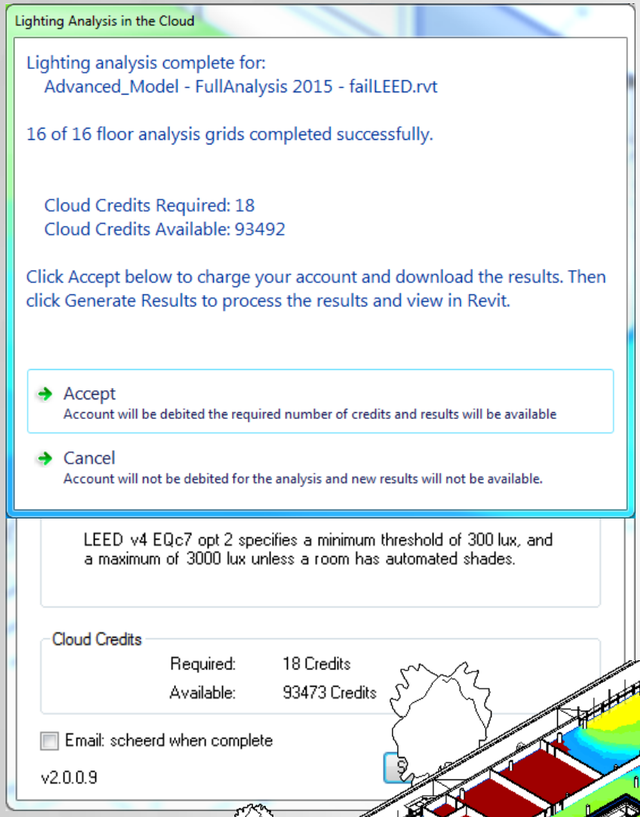


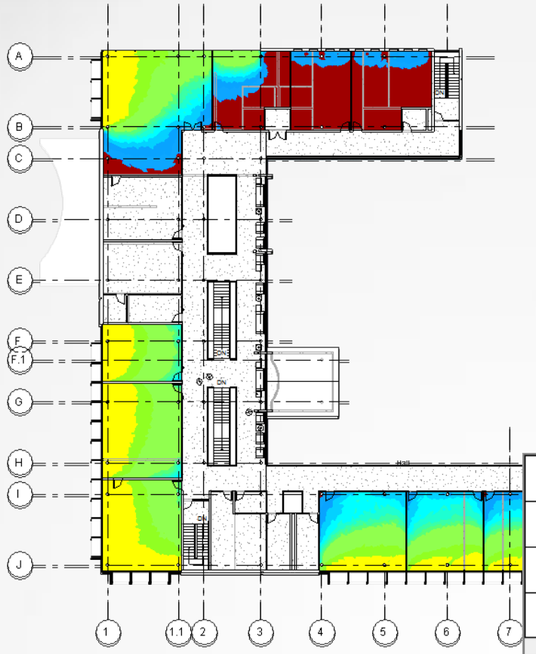


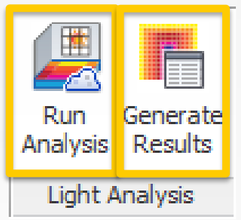


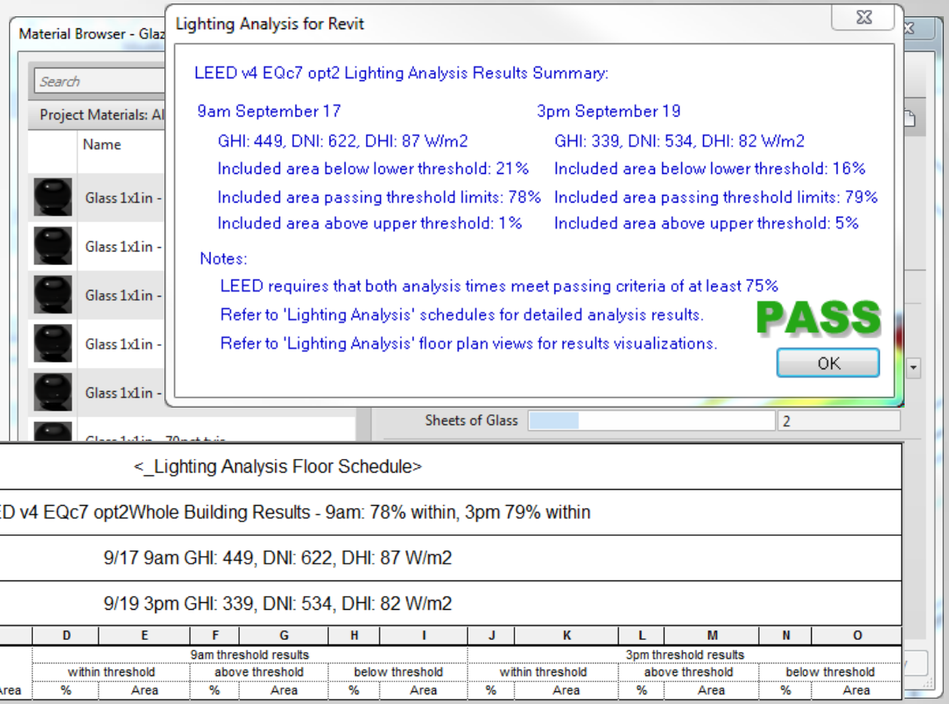
<Room Schedule>

A	B	C	D	E	F
Level	Name	Number	Area	Include In Daylighting	Automated Shades
03 - Floor	Administration	322	633 SF	☑	☐
03 - Floor	Advisors	324	540 SF	☑	☐
03 - Floor	Conference	325	645 SF	☑	☐
03 - Floor	Corridor	328	591 SF	☐	☐
03 - Floor	Electrical	310	75 SF	☐	☐
03 - Floor	Electrical	317	171 SF	☐	☐
03 - Floor	Electrical	323	60 SF	☐	☐
03 - Floor	Hall	213	1483 SF	☐	☐
03 - Floor	Instruction	302	860 SF	☑	☑
03 - Floor	Instruction	303	693 SF	☑	☑
03 - Floor	Instruction	304	517 SF	☑	☑
03 - Floor	Instruction	305	693 SF	☑	☑
03 - Floor	Instruction	306	786 SF	☑	☑
03 - Floor	Instruction	313	834 SF	☑	☑
03 - Floor	Instruction	314	869 SF	☑	☑
03 - Floor	Instruction	315	523 SF	☑	☑
03 - Floor	Lobby	318	3479 SF	☐	☐
03 - Floor	Lounge	309	414 SF	☐	☐
03 - Floor	Media Review	319	475 SF	☐	☐
03 - Floor	Media Review	320	565 SF	☐	☐
03 - Floor	Men	307	141 SF	☐	☐









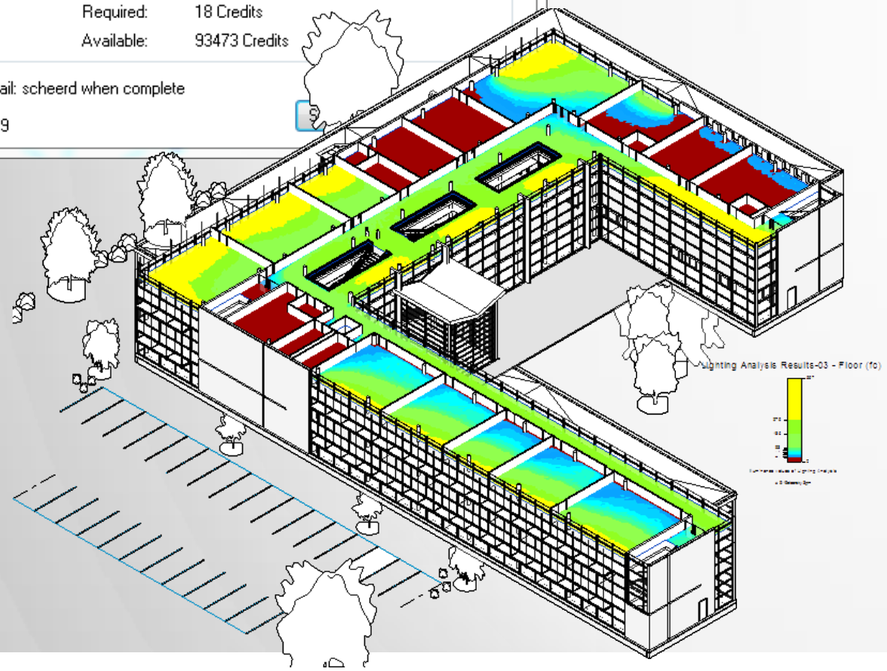
<_Lighting Analysis Floor Schedule>

LEED v4 EQc7 opt2Whole Building Results - 9am: 78% within, 3pm 79% within

9/17 9am GHI: 449, DNI: 622, DHI: 87 W/m2

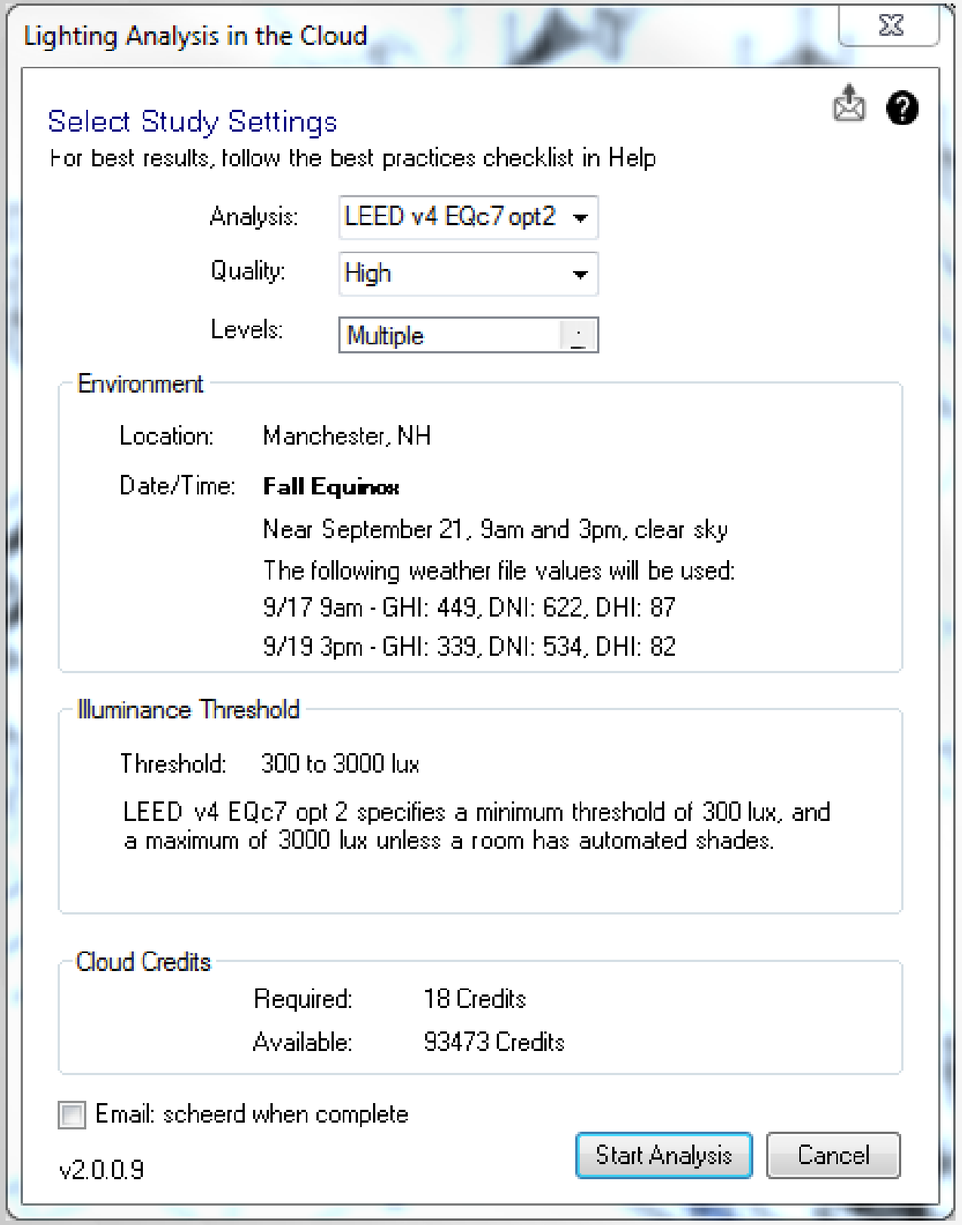
9/19 3pm GHI: 339, DNI: 534, DHI: 82 W/m2

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
			9am threshold results						3pm threshold results					
			within threshold		above threshold		below threshold		within threshold		above threshold		below threshold	
Name	Floor Area Included in Daylighting	Total Floor Area	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area
01 - Entry Level	8578 SF	16841 SF	87	7475 SF	0	0 SF	13	1104 SF	85	7295 SF	5	417 SF	10	866 SF
02 - Floor	7488 SF	17309 SF	70	5220 SF	2	138 SF	28	2130 SF	67	5025 SF	11	801 SF	22	1661 SF
03 - Floor	9008 SF	17368 SF	77	6968 SF	0	0 SF	23	2040 SF	84	7526 SF	0	0 SF	16	1482 SF



<_Lighting Analysis Room Schedule>

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
						9am threshold results						3pm threshold results					
						within threshold		above threshold		below threshold		within threshold		above threshold		below threshold	
Level	Name	Number	Area	Include In Daylighting	Automated Shades	%	Area	%	Area	%	Area	%	Area	%	Area	%	Area
03 - Floor	Administration	322	633 SF	☑	☐	48	307 SF	0	0 SF	52	326 SF	43	273 SF	0	0 SF	57	359 SF
03 - Floor	Advisors	324	540 SF	☑	☐	17	90 SF	0	0 SF	83	450 SF	13	73 SF	0	0 SF	87	467 SF
03 - Floor	Conference	325	645 SF	☑	☐	14	93 SF	0	0 SF	86	552 SF	16	103 SF	0	0 SF	84	542 SF
03 - Floor	Corridor	328	591 SF	☐	☐	0	0 SF	0	0 SF	0	0 SF	0	0 SF	0	0 SF	0	0 SF
03 - Floor	Electrical	310	75 SF	☐	☐	0	0 SF	0	0 SF	0	0 SF	0	0 SF	0	0 SF	0	0 SF
03 - Floor	Electrical	317	171 SF	☐	☐	0	0 SF	0	0 SF	0	0 SF	0	0 SF	0	0 SF	0	0 SF
03 - Floor	Electrical	323	60 SF	☐	☐	0	0 SF	0	0 SF	0	0 SF	0	0 SF	0	0 SF	0	0 SF
03 - Floor	Hall	213	1483 SF	☐	☐	0	0 SF	0	0 SF	0	0 SF	0	0 SF	0	0 SF	0	0 SF
03 - Floor	Instruction	302	860 SF	☑	☑	100	860 SF	0	0 SF	0	0 SF	100	860 SF	0	0 SF	0	0 SF
03 - Floor	Instruction	303	693 SF	☑	☑	100	693 SF	0	0 SF	0	0 SF	100	691 SF	0	0 SF	0	2 SF
03 - Floor	Instruction	304	517 SF	☑	☑	100	517 SF	0	0 SF	0	0 SF	100	516 SF	0	0 SF	0	1 SF
03 - Floor	Instruction	305	693 SF	☑	☑	100	693 SF	0	0 SF	0	0 SF	100	693 SF	0	0 SF	0	0 SF
03 - Floor	Instruction	306	786 SF	☑	☑	100	785 SF	0	0 SF	0	1 SF	100	784 SF	0	0 SF	0	2 SF
03 - Floor	Instruction	313	834 SF	☑	☑	100	832 SF	0	0 SF	0	2 SF	100	834 SF	0	0 SF	0	0 SF
03 - Floor	Instruction	314	869 SF	☑	☑	86	749 SF	0	0 SF	14	120 SF	100	869 SF	0	0 SF	0	0 SF
03 - Floor	Instruction	315	523 SF	☑	☑	61	319 SF	0	0 SF	39	204 SF	100	523 SF	0	0 SF	0	0 SF
03 - Floor	Lobby	318	3479 SF	☐	☐	0	0 SF	0	0 SF	0	0 SF	0	0 SF	0	0 SF	0	0 SF
03 - Floor	Lounge	309	414 SF	☐	☐	0	0 SF	0	0 SF	0	0 SF	0	0 SF	0	0 SF	0	0 SF
03 - Floor	Media Review	319	475 SF	☐	☐	0	0 SF	0	0 SF	0	0 SF	0	0 SF	0	0 SF	0	0 SF
03 - Floor	Media Review	320	565 SF	☐	☐	0	0 SF	0	0 SF	0	0 SF	0	0 SF	0	0 SF	0	0 SF
03 - Floor	Men	307	141 SF	☐	☐	0	0 SF	0	0 SF	0	0 SF	0	0 SF	0	0 SF	0	0 SF

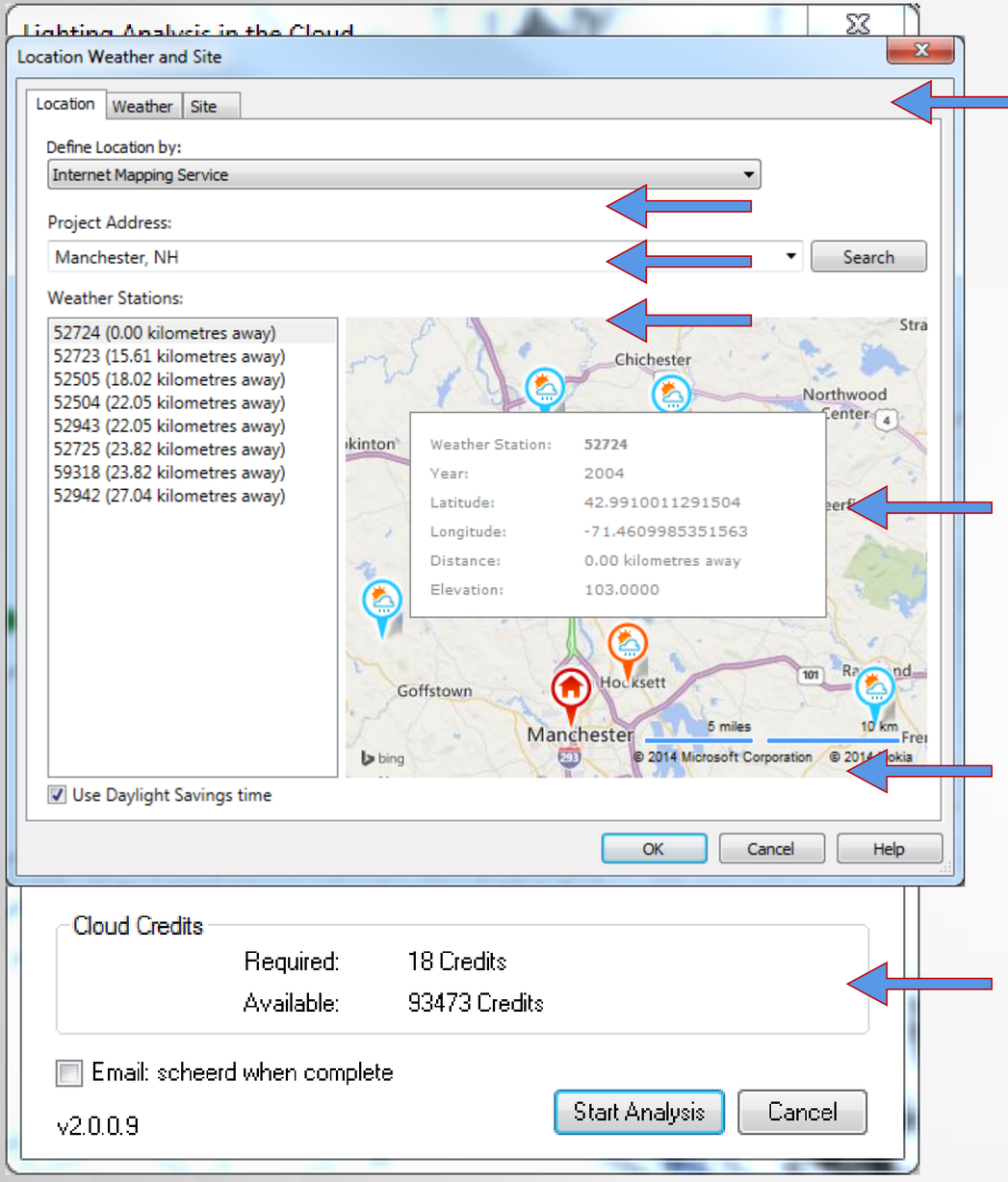


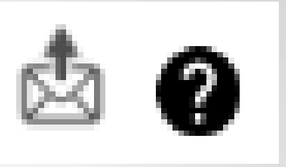
RUN ANALYSIS

Section 2.1

Lighting Analysis in Revit

Run Analysis Dialog





Analysis: LEED v4 EQc7 opt2

Quality: High

Levels: All; 01 - Entry Level

Environment

Location: Manchester, NH

Date/Time: Near September 21, 9am and 3pm, clear sky

The following weather file values will be used:

9/17 9am - GHI: 449, DNI: 622, DHI: 87

Illuminance Threshold

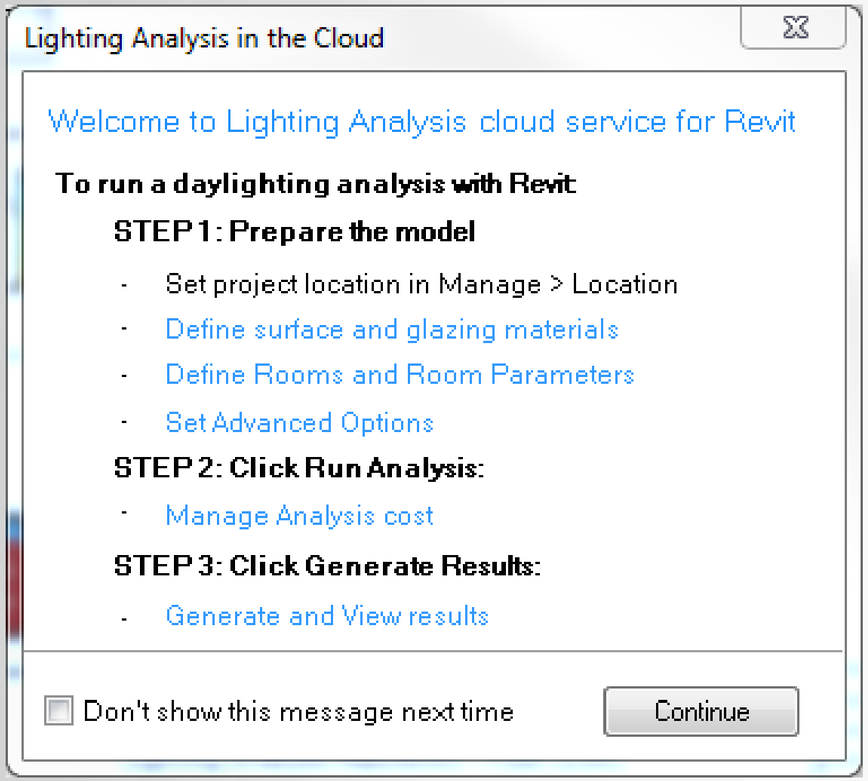
Threshold: 300 to 3000 lux

LEED v4 EQc7 opt 2 specifies a minimum threshold of 300 lux, and a maximum of 3000 lux unless a room has automated shades.

Cloud Credits

Required: 18 Credits

Available: 93473 Credits

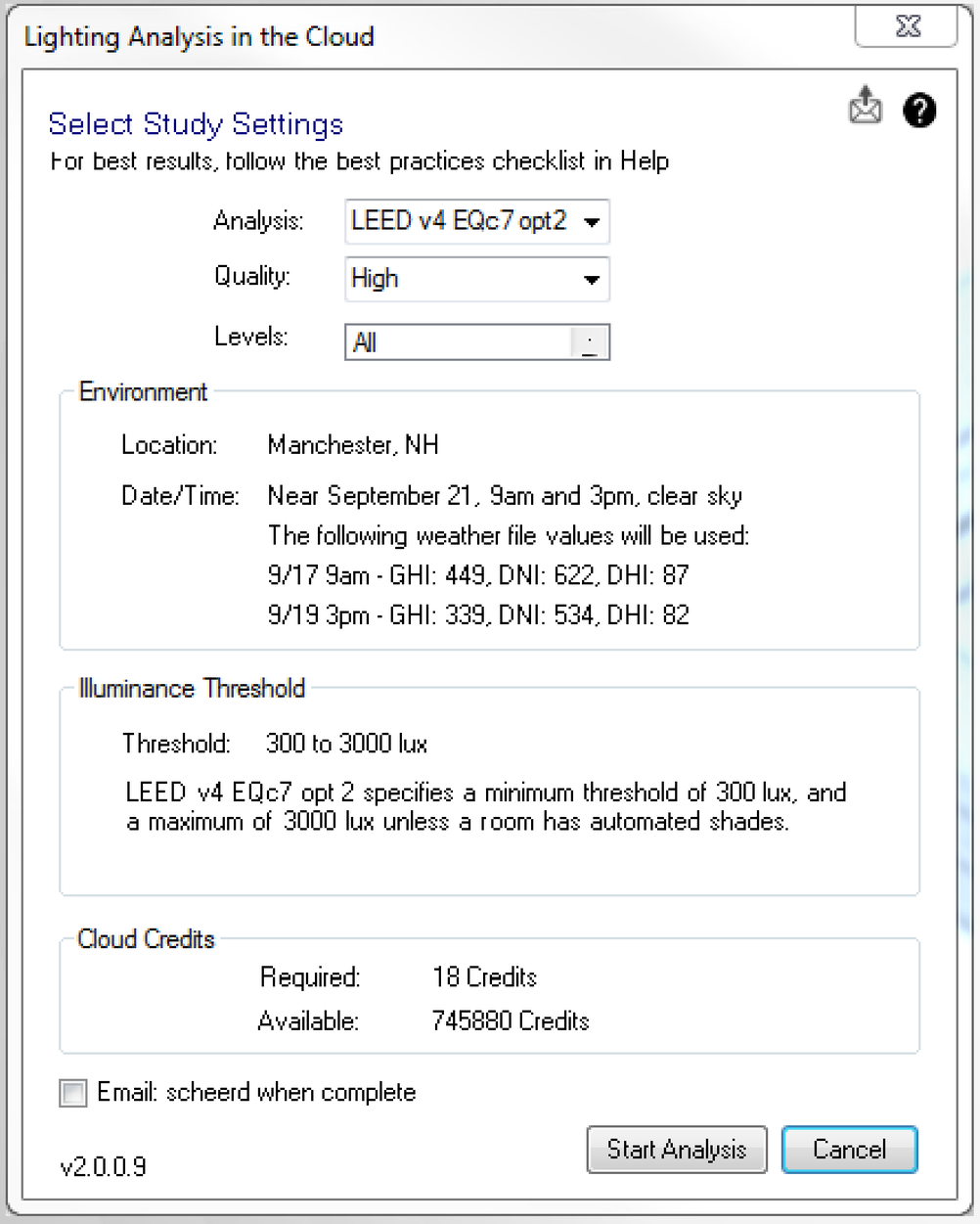

Lighting Analysis in the Cloud
Welcome to Lighting Analysis cloud service for Revit
To run a daylighting analysis with Revit:
STEP 1: Prepare the model
- Set project location in Manage > Location
- Define surface and glazing materials
- Define Rooms and Room Parameters
- Set Advanced Options
STEP 2: Click Run Analysis:
- Manage Analysis cost
STEP 3: Click Generate Results:
- Generate and View results
Don't show this message next time
Continue

DEMO

Section 2.2

Lighting Analysis in Revit

Controlling Cloud Credit Costs

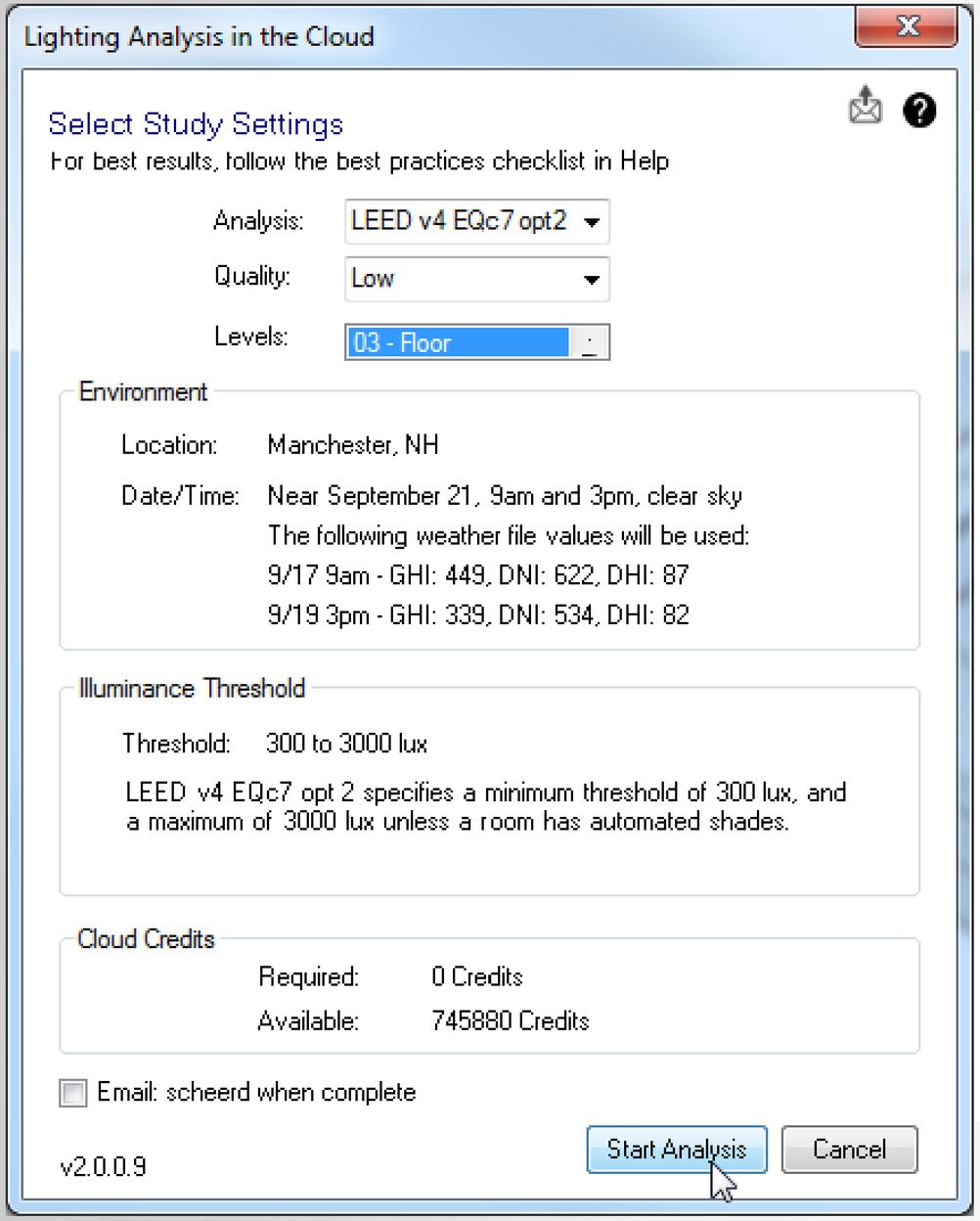


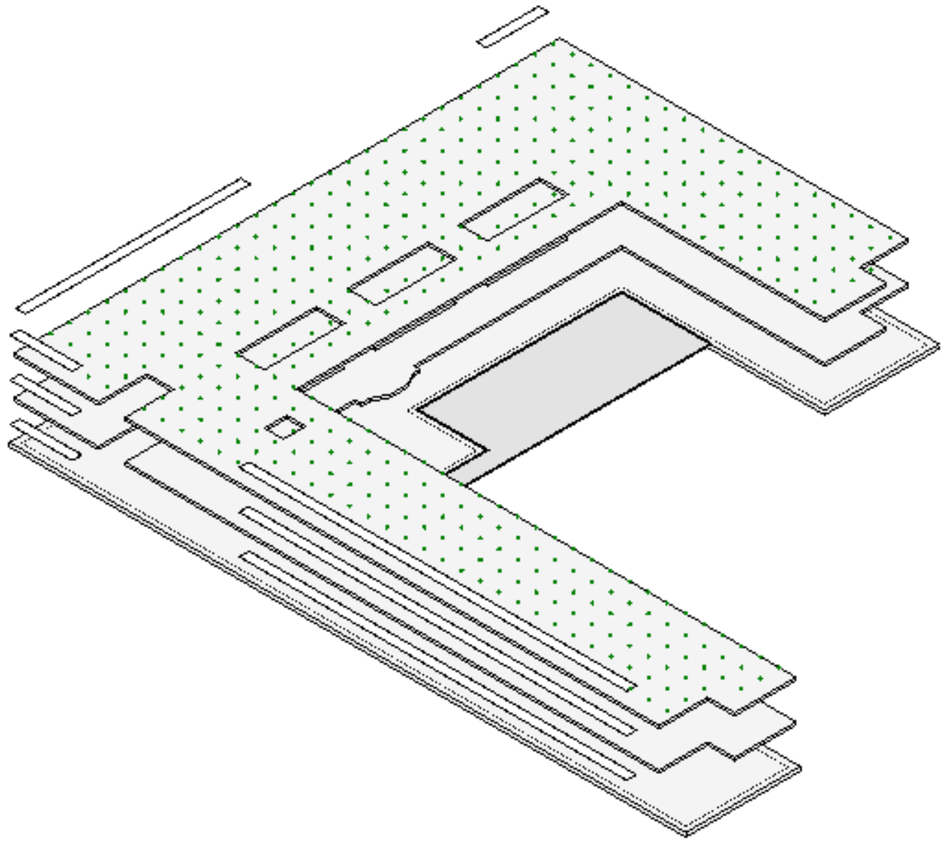
FREE | *1CC/3ksf*
< 6ksf | *>6ksf*

	2,500 sf	6,000 sf	10,000 sf	25,000 sf	50,000 sf
High Res *1 foot grid resolution* *LEED documentation* *Small buildings all phases* *Detailed design decisions*	0 CC	0 CC	4 CC	9 CC	17 CC
Low Res *6 foot grid resolution* *Large building design review* *Preview settings and materials* *Schematic design decisions*	0 CC	0 CC	0 CC	0 CC	4 CC

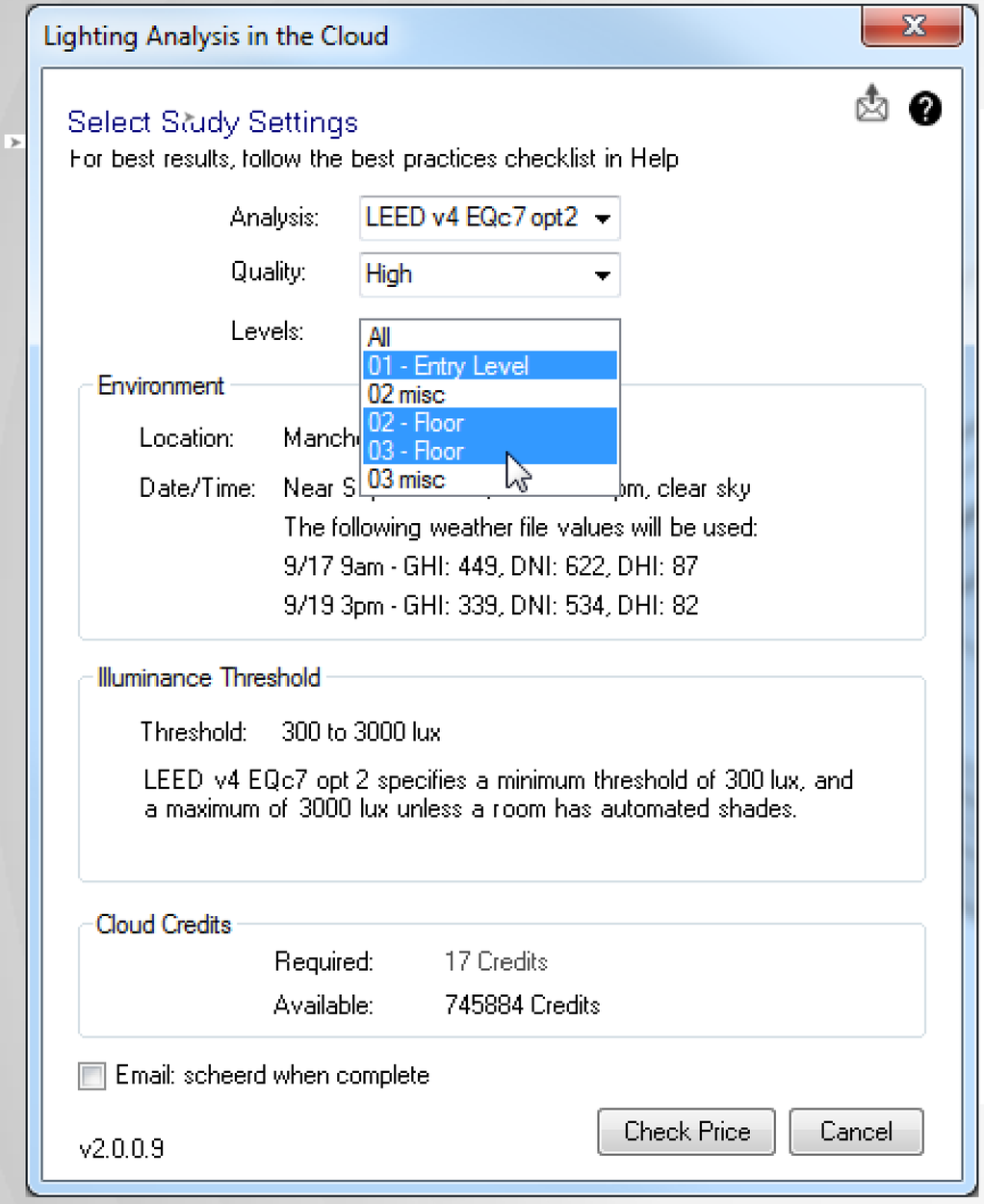
< 25ksf | *>25ksf*
FREE | *1CC/12.5ksf*

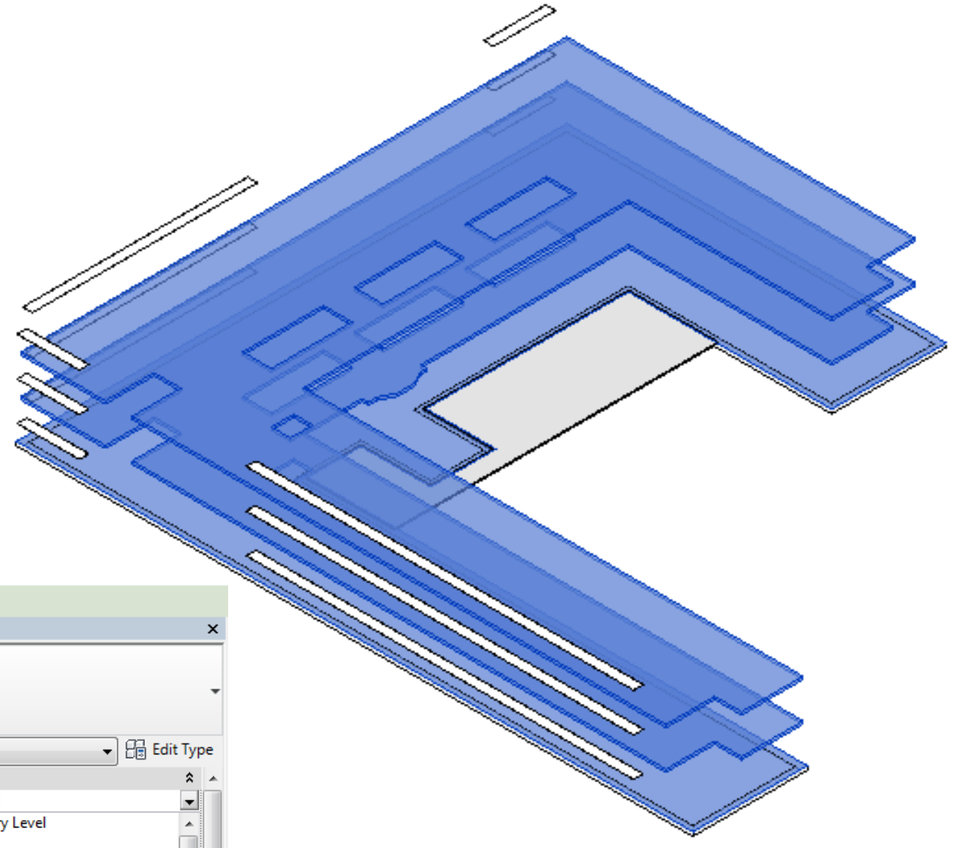
Choose the Quality

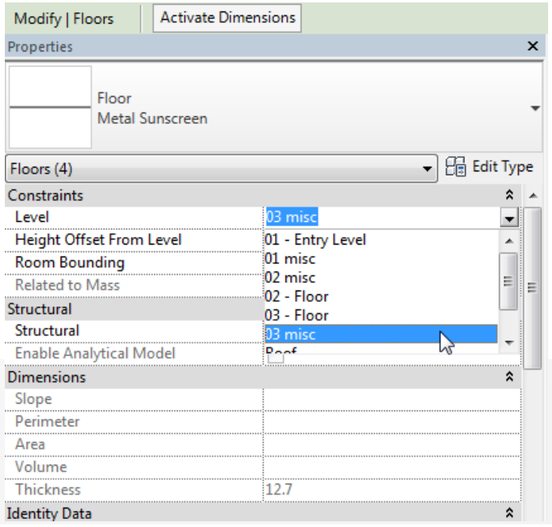




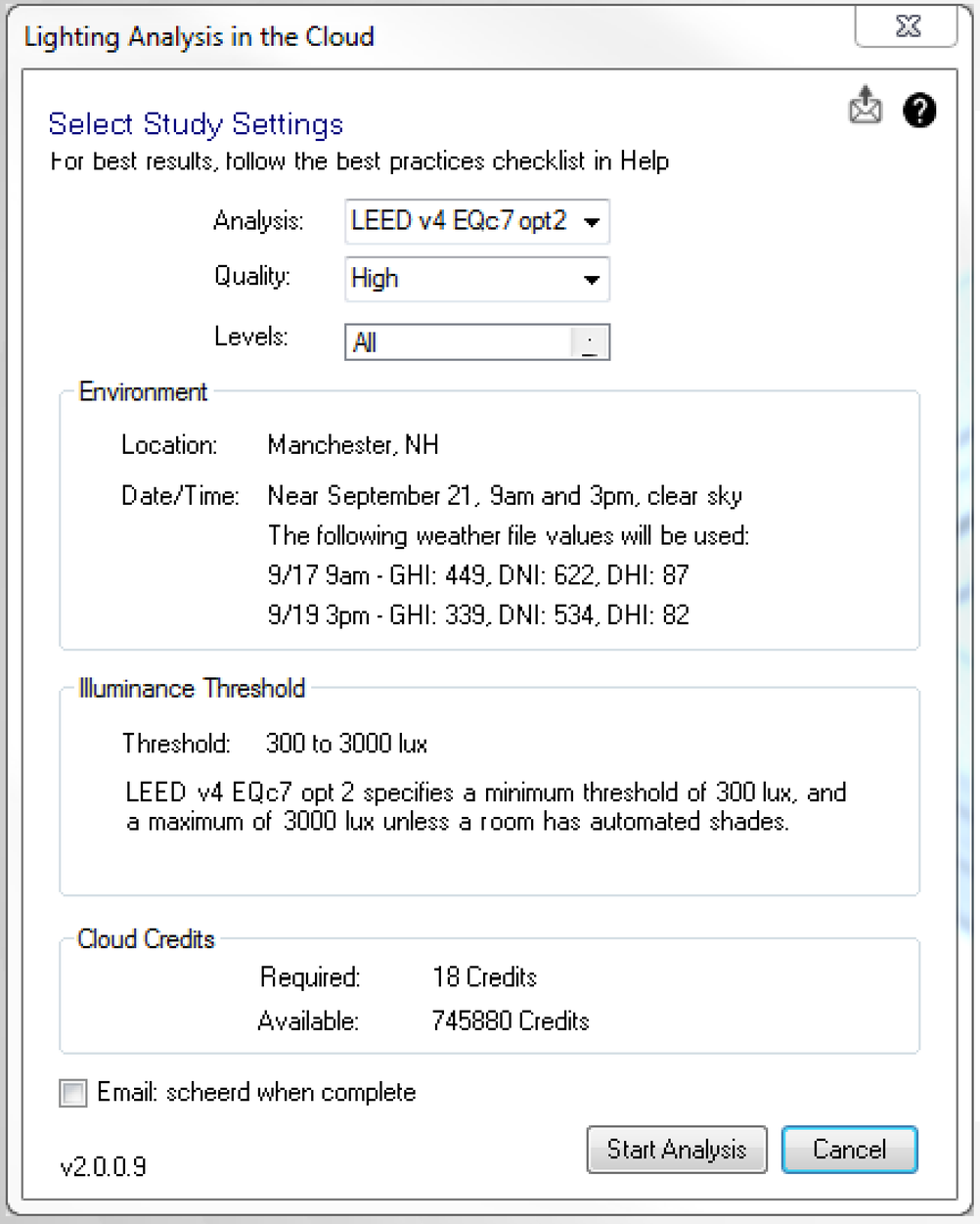
Separate Floors that aren't Floors

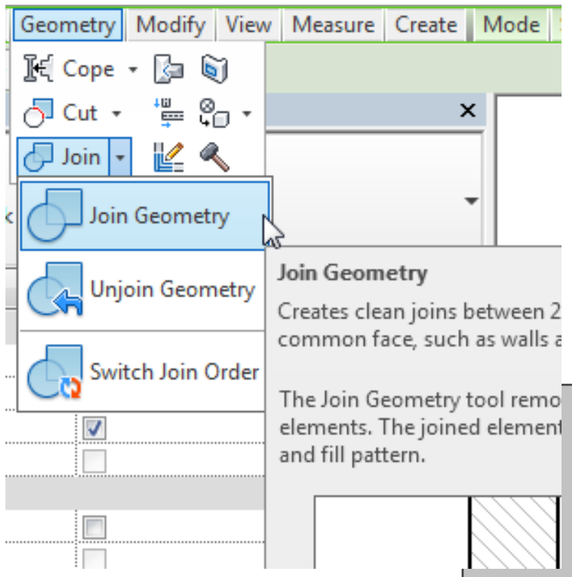


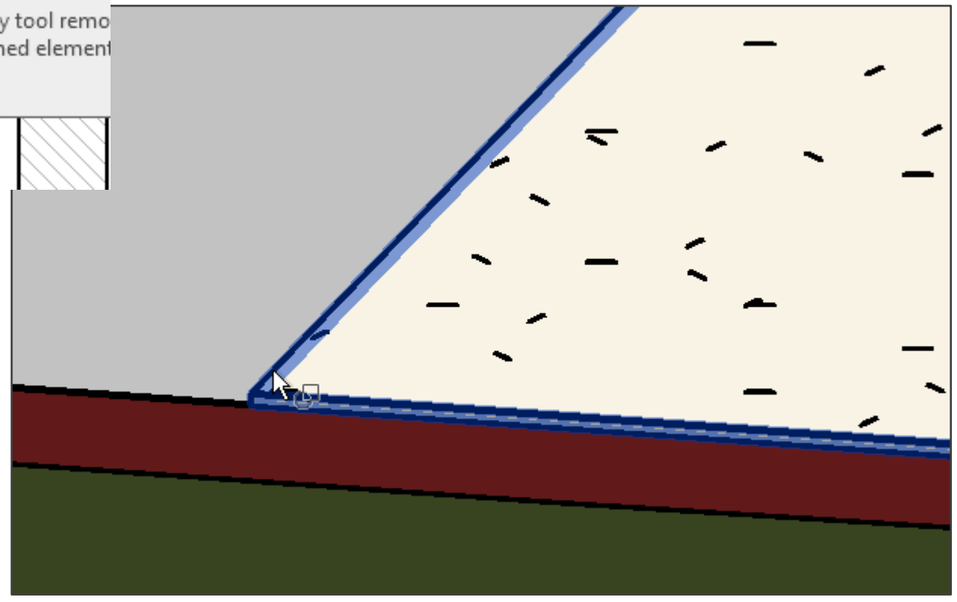




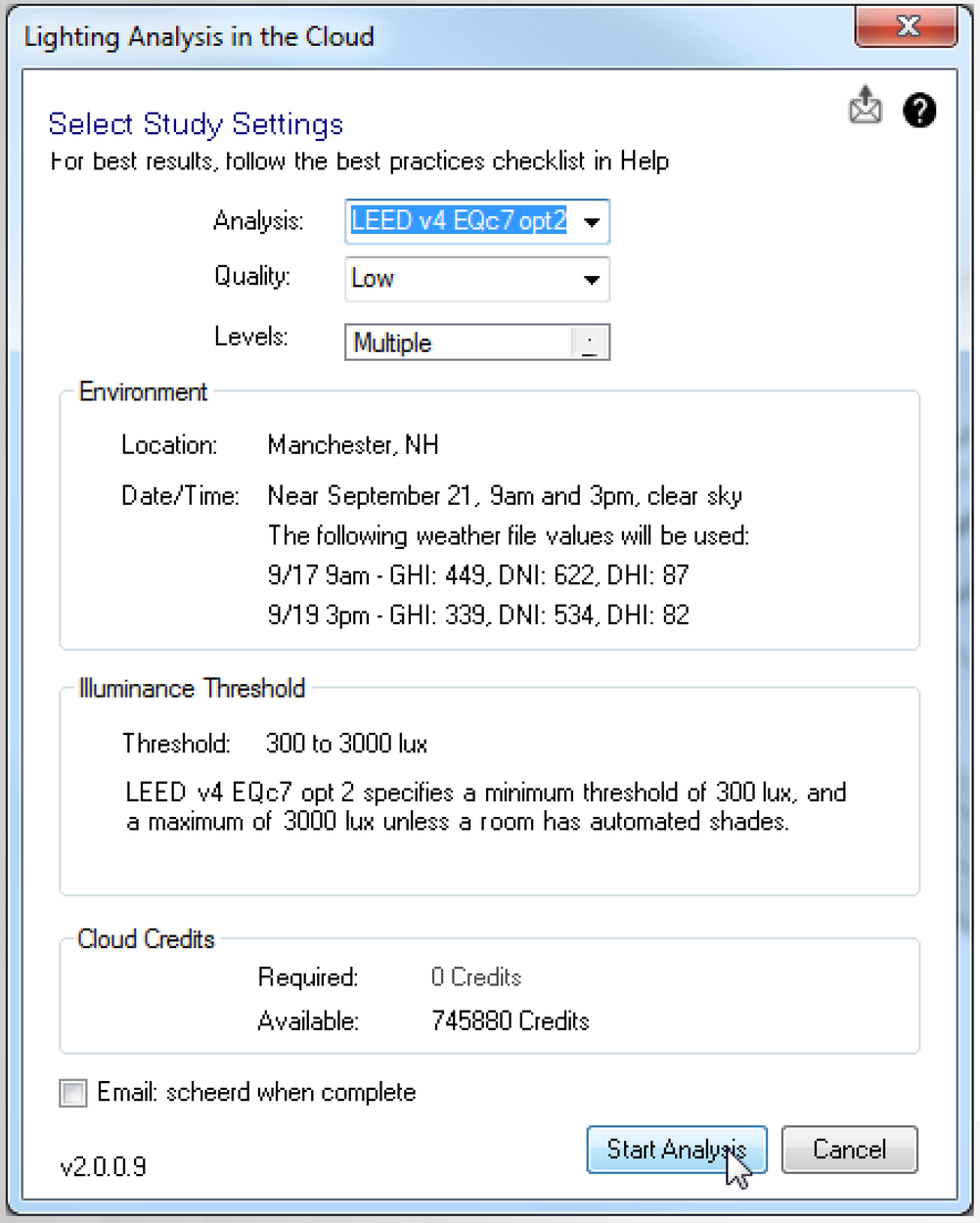
Join Finish floor to Main floor

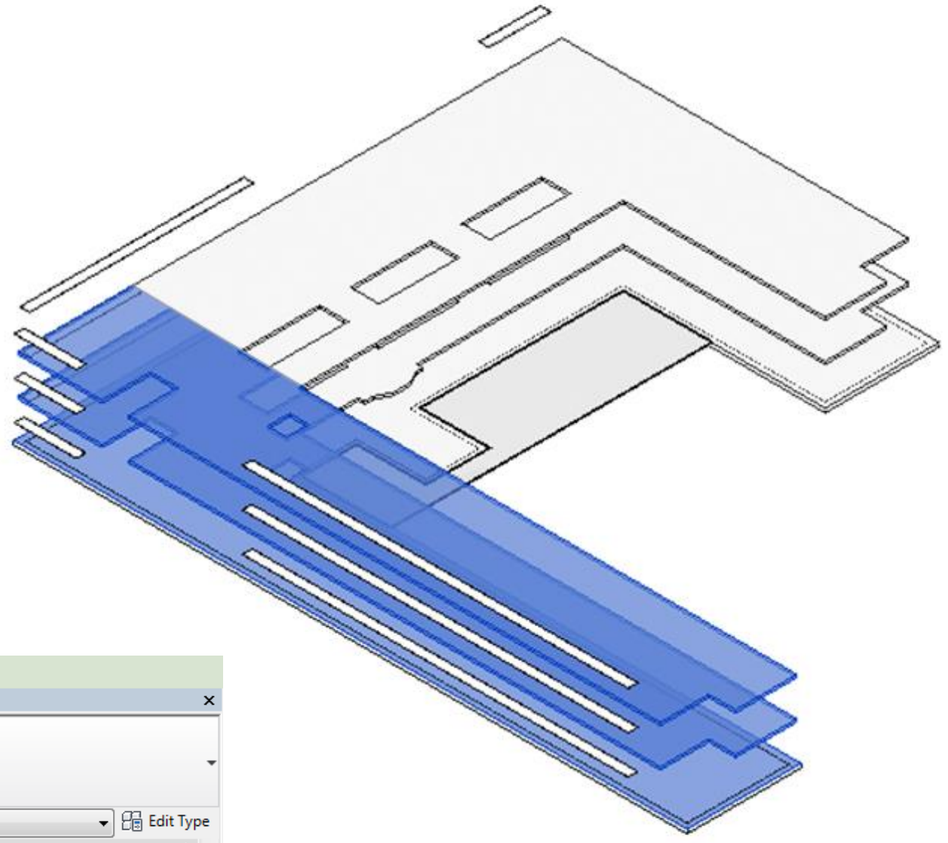


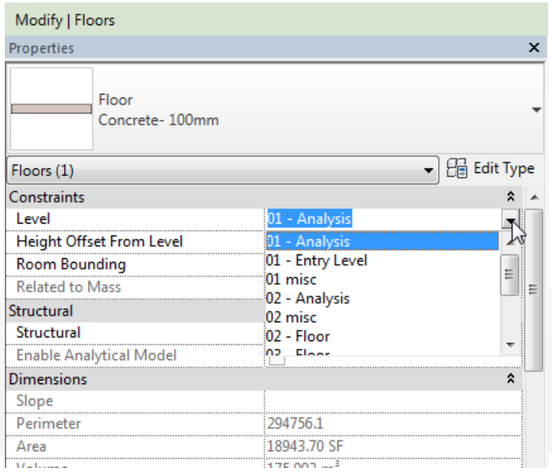




Subdivide Floors to Analysis Levels



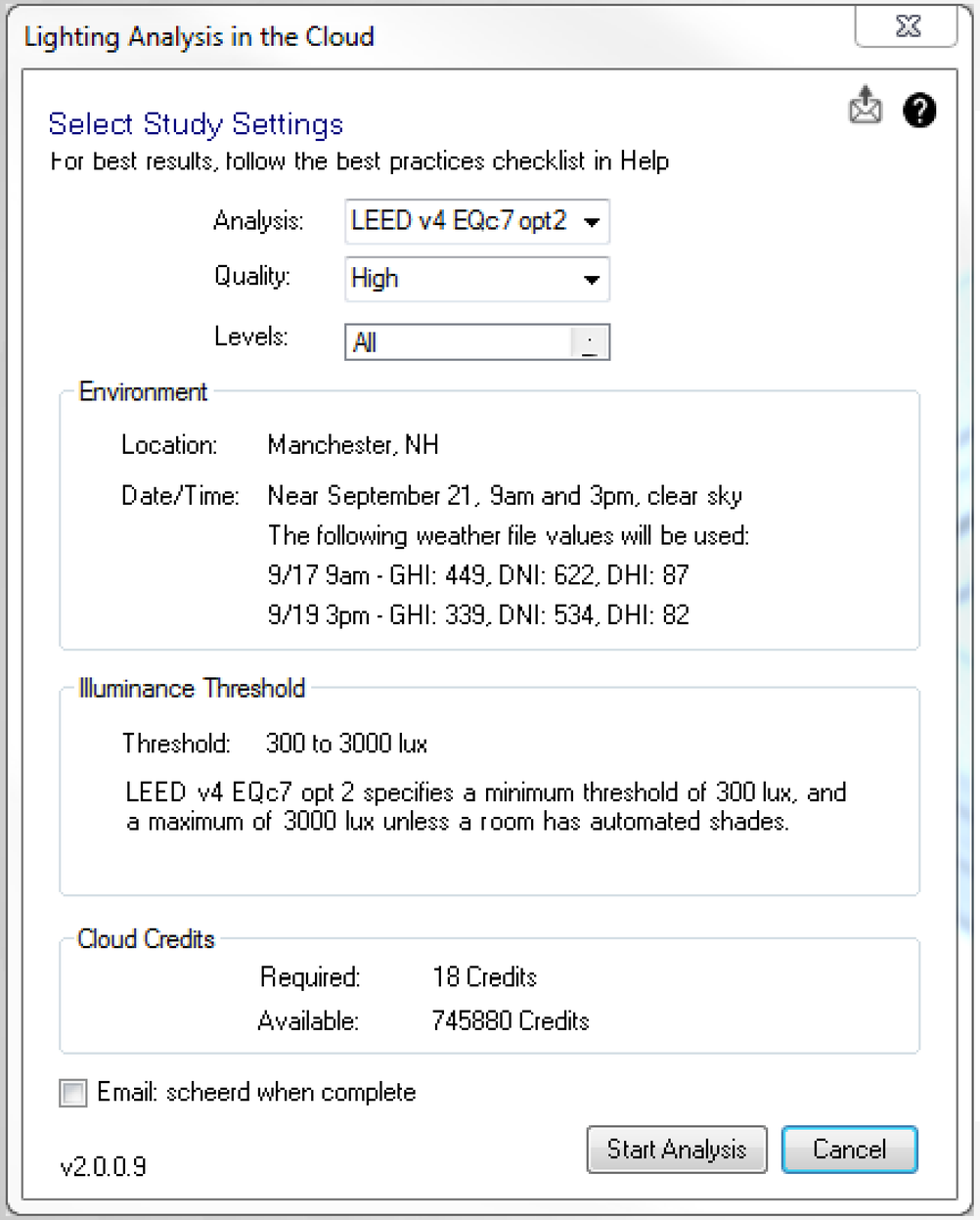


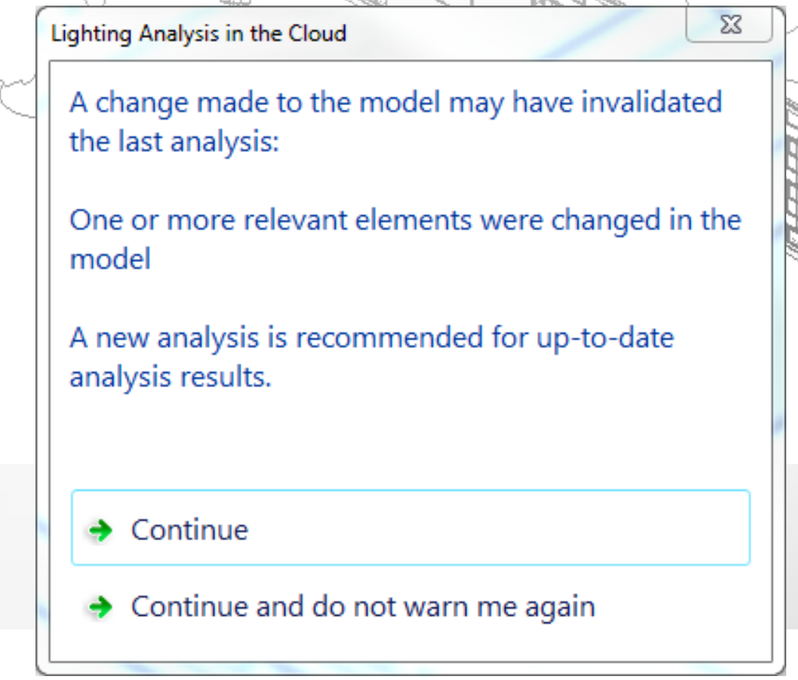


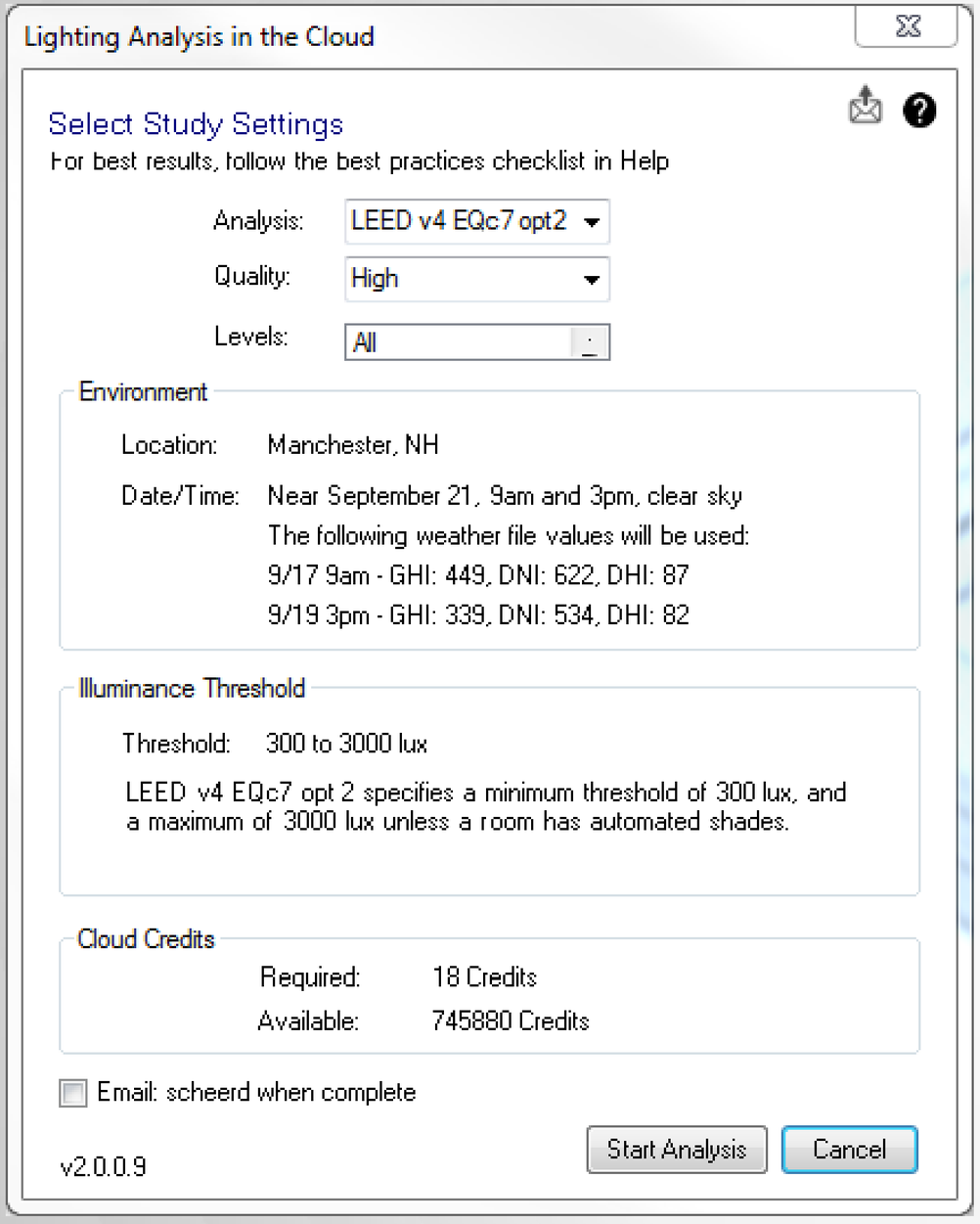
Run Analysis only when invalidated

Simply Generate Results after:

- **Create and modify Rooms**
- **Change Include in Analysis**
- **Change Automated Shades**
- **Change AVF visualization**
- **Turn on/off AVF layers**
- **Create new “_Lighting” views and Sheets**
- **Modify Schedules including LAR results**





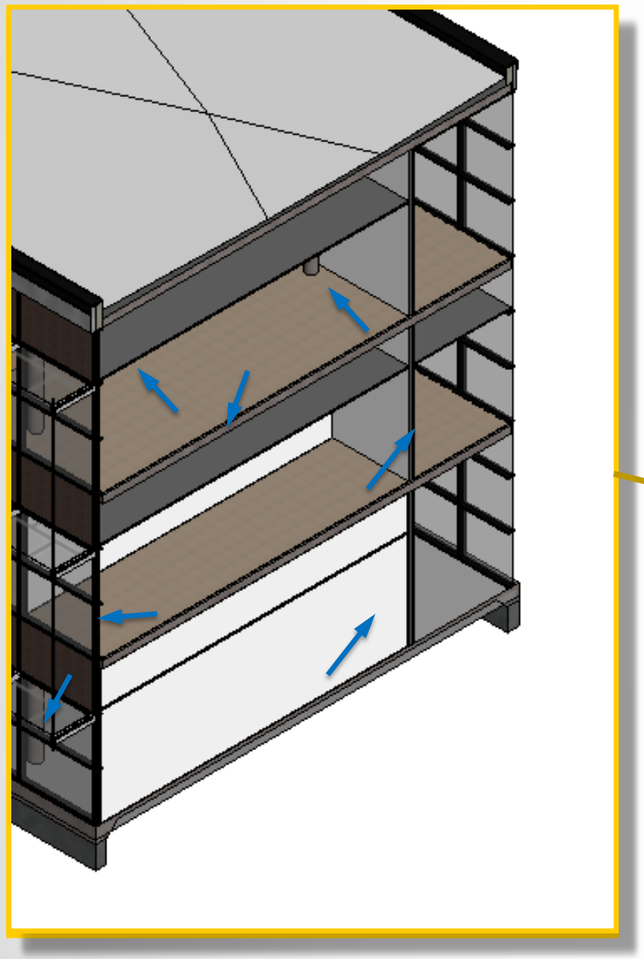

Lighting Analysis in the Cloud
Select Study Settings
For best results, follow the best practices checklist in Help
Analysis:
LEED v4 EQc7 opt2
Quality:
High
Levels:
All
Environment
Location:
Manchester, NH
Date/Time:
Near September 21, 9am and 3pm, clear sky
The following weather file values will be used:
9/17 9am - GHI: 449, DNI: 622, DHI: 87
9/19 3pm - GHI: 339, DNI: 534, DHI: 82
Illuminance Threshold
Threshold:
300 to 3000 lux
LEED v4 EQc7 opt 2 specifies a minimum threshold of 300 lux, and a maximum of 3000 lux unless a room has automated shades.
Cloud Credits
Required:
18 Credits
Available:
745880 Credits
Email: scheerd when complete
v2.0.0.9
Start Analysis
Cancel

Section 4.1

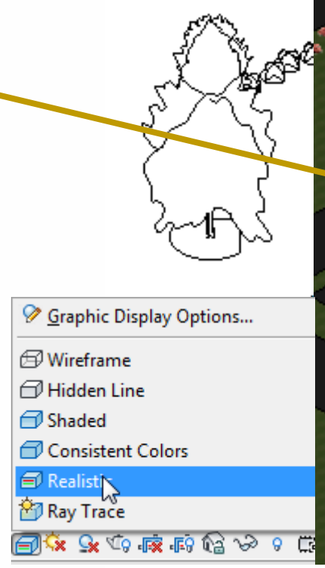
Lighting Analysis in Revit

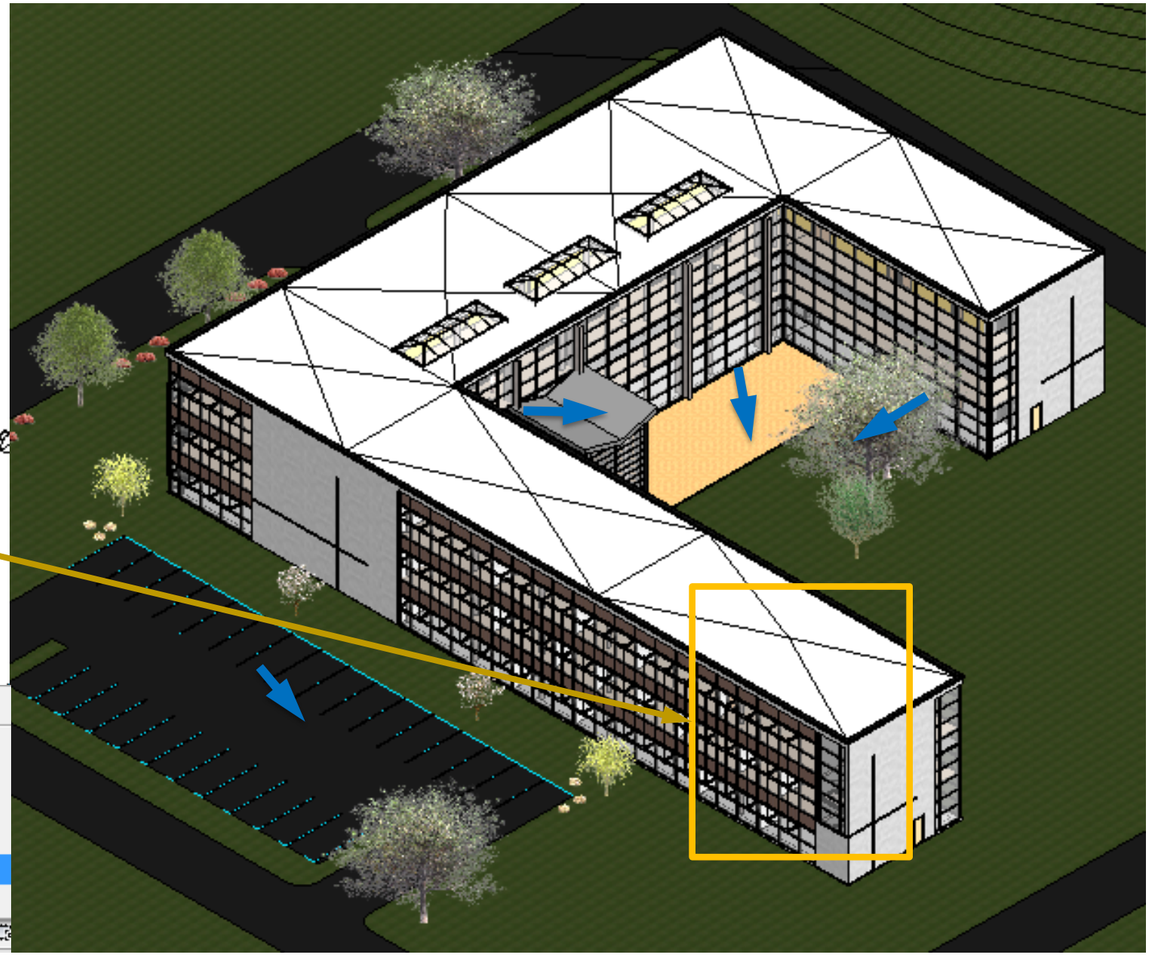
Revit Materials for Illuminance Analysis

Opaque materials - Reflectance

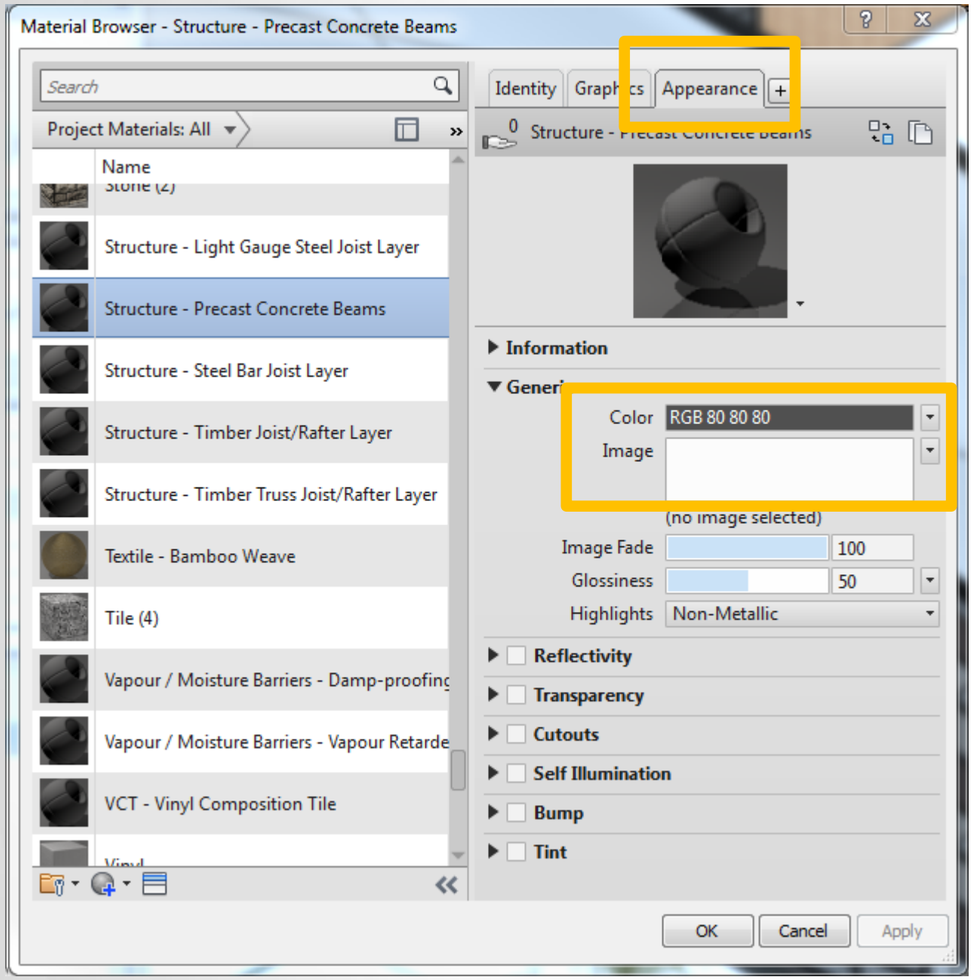


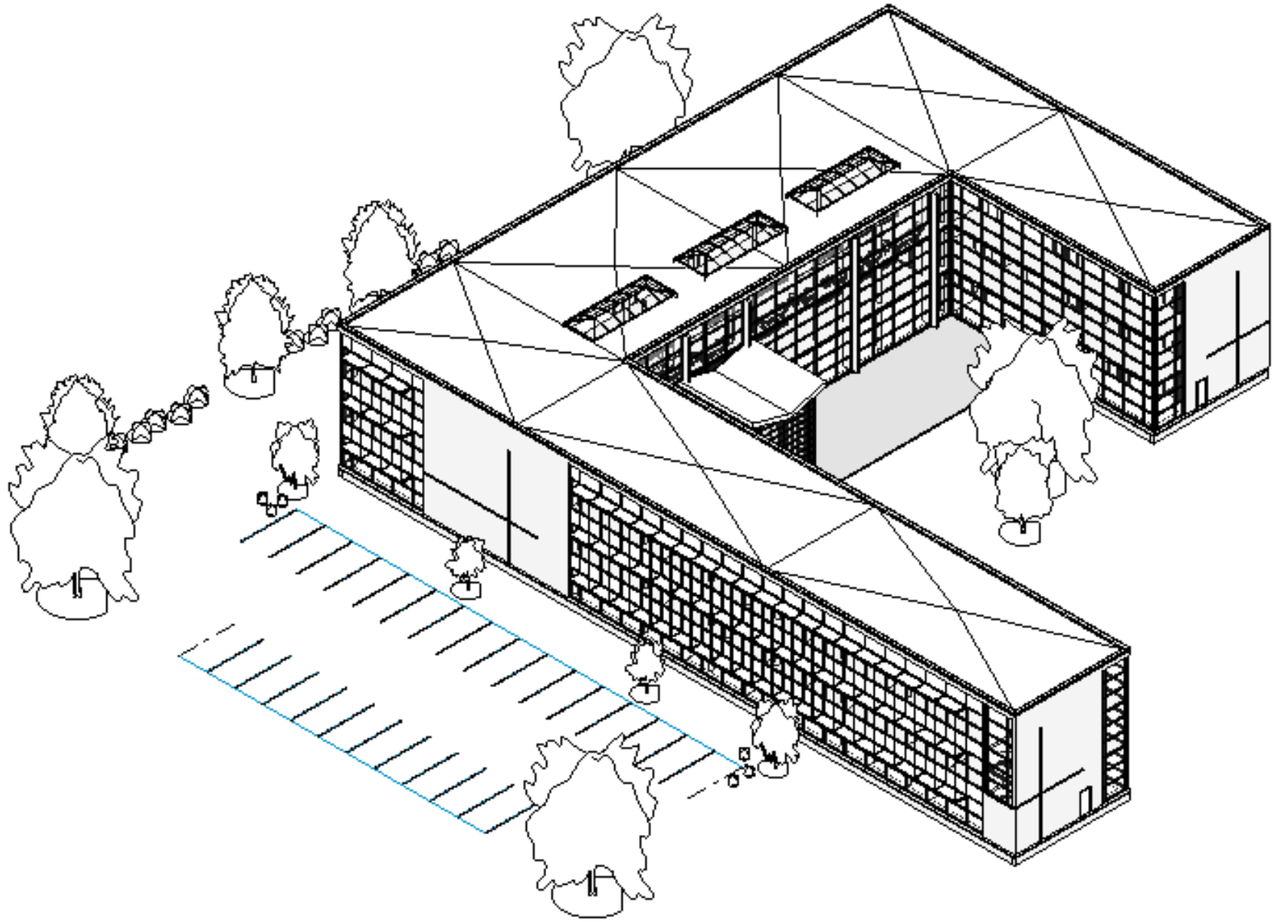
Walls
Ceilings
Floors
Frames
Structure
etc…





Opaque materials - Reflectance

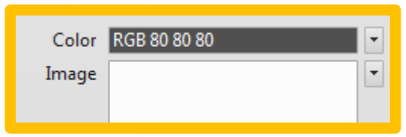


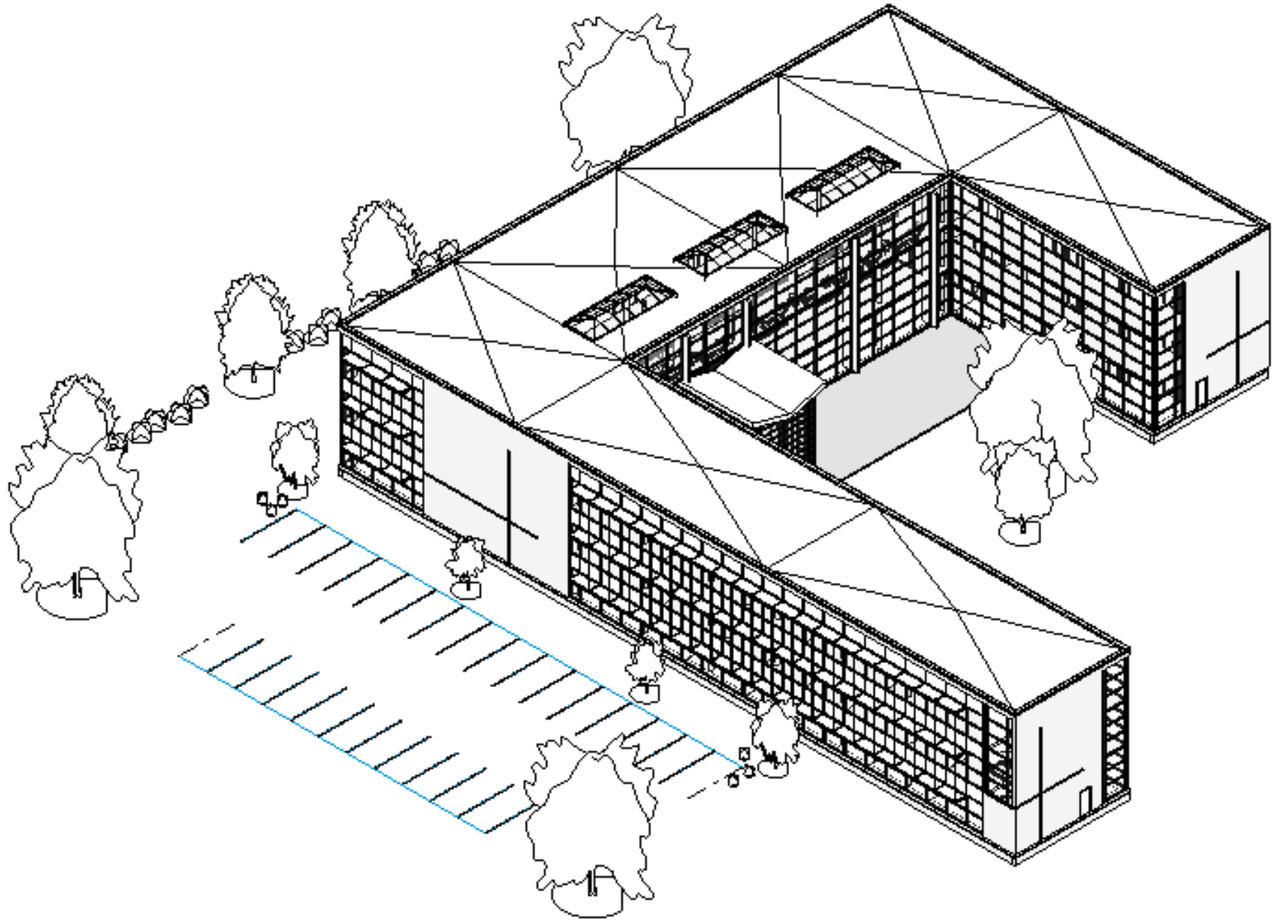


Opaque materials - Reflectance

Reflectance % =

% of visible light energy reflected by the surface





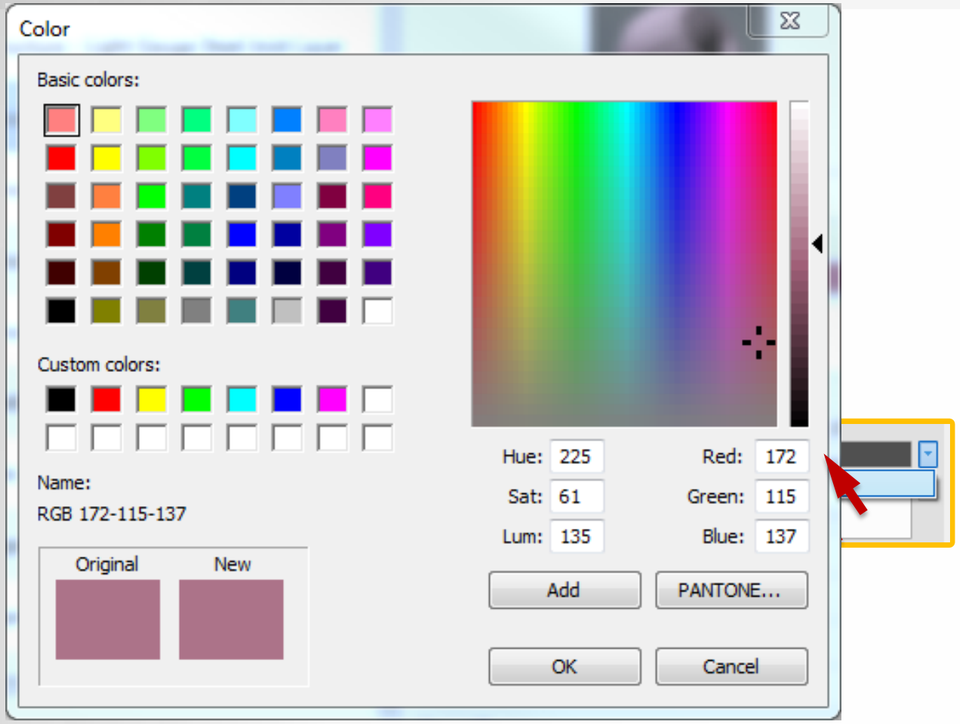
Reflectance (RGB$_{0\text{-}255}$)=

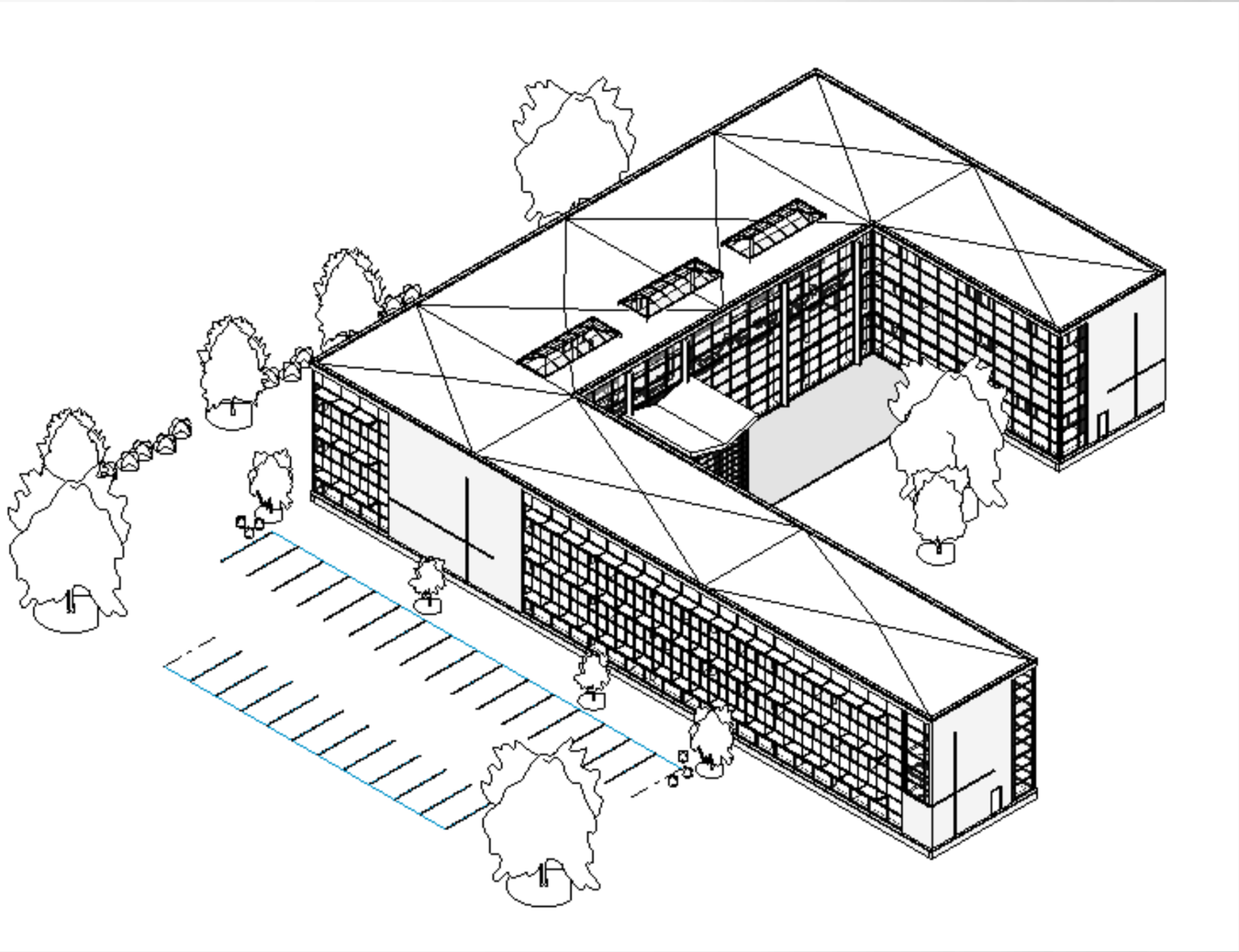
(0.2126 Red +

0.7152 Green +

0.0722 Blue) / 255

Opaque materials - Reflectance



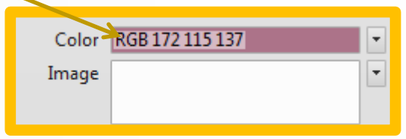


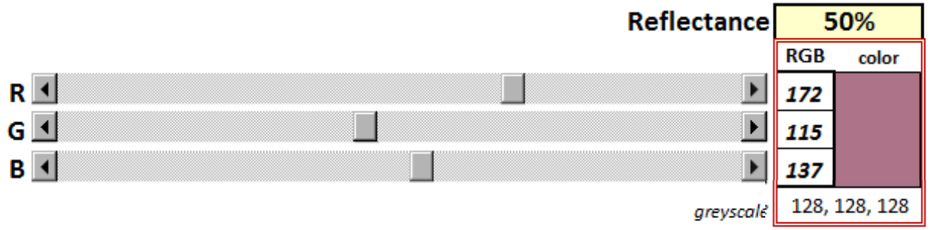
Reflectance (RGB$_{0\text{-}255}$)=

(0.2126 R + 0.7152 G + 0.0722 B) / 255

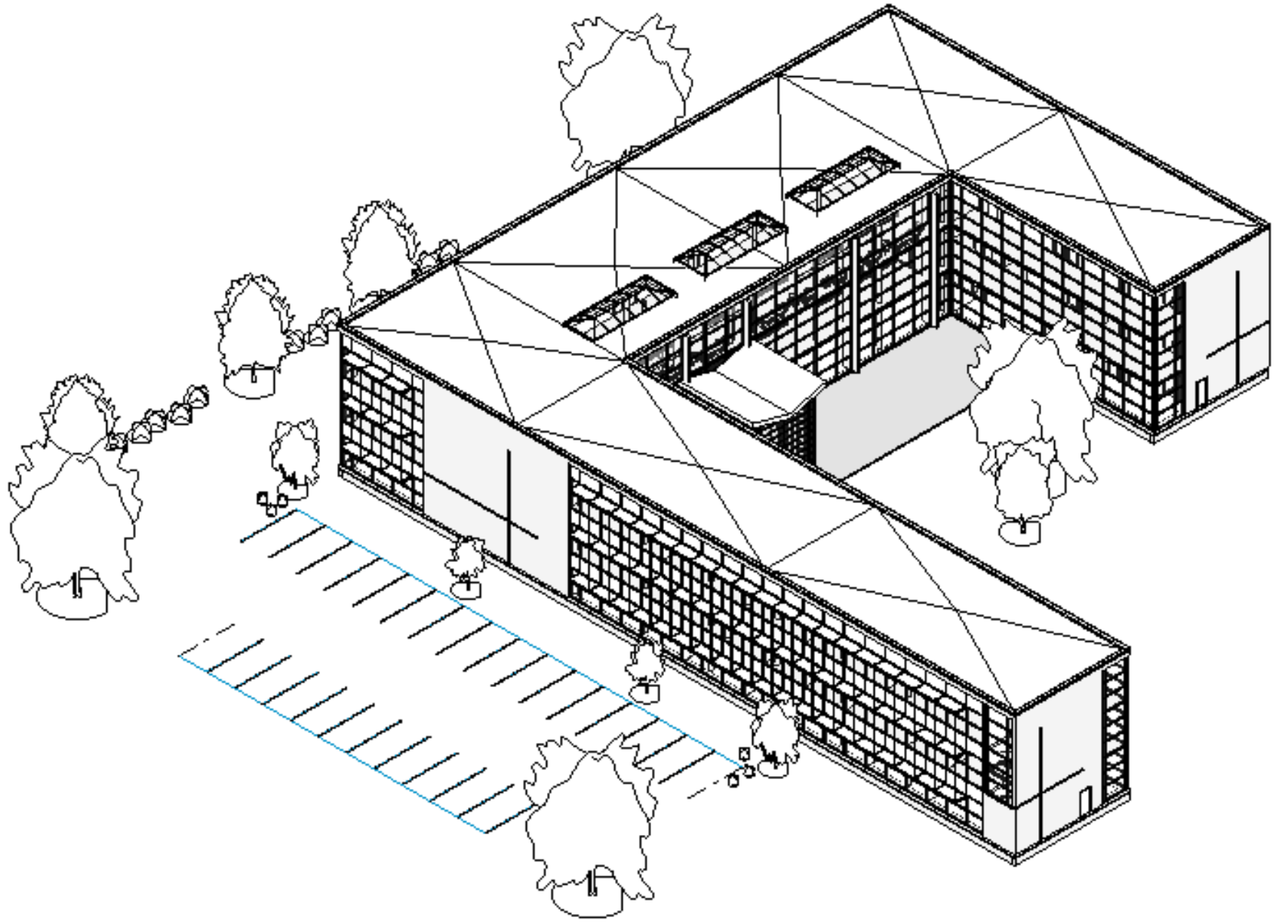
Opaque materials - Reflectance

Reflectance	**RGB**
100%	255, 255, 255
90%	230, 230, 230
80%	204, 204, 204
70%	179, 179, 179
60%	153, 153, 153
50%	128, 128, 128
40%	102, 102, 102
30%	77, 77, 77
20%	51, 51, 51
10%	26, 26, 26
0%	0, 0, 0

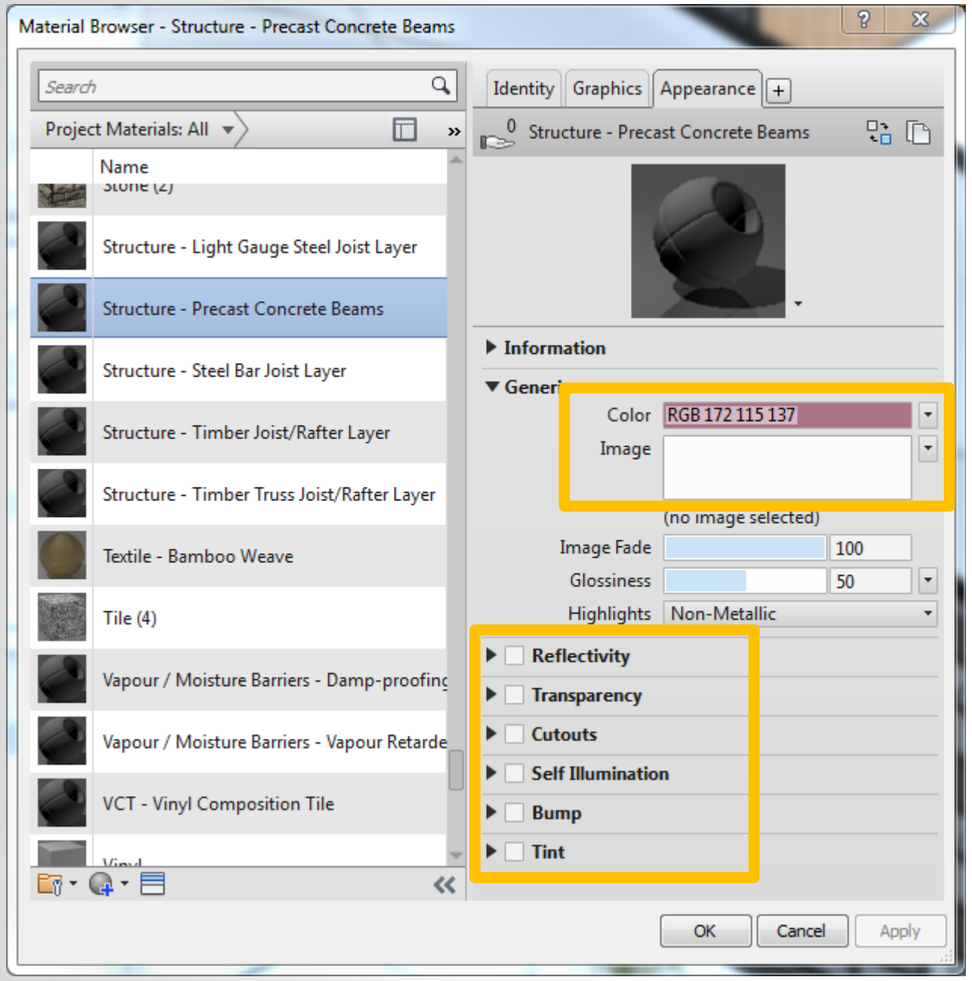


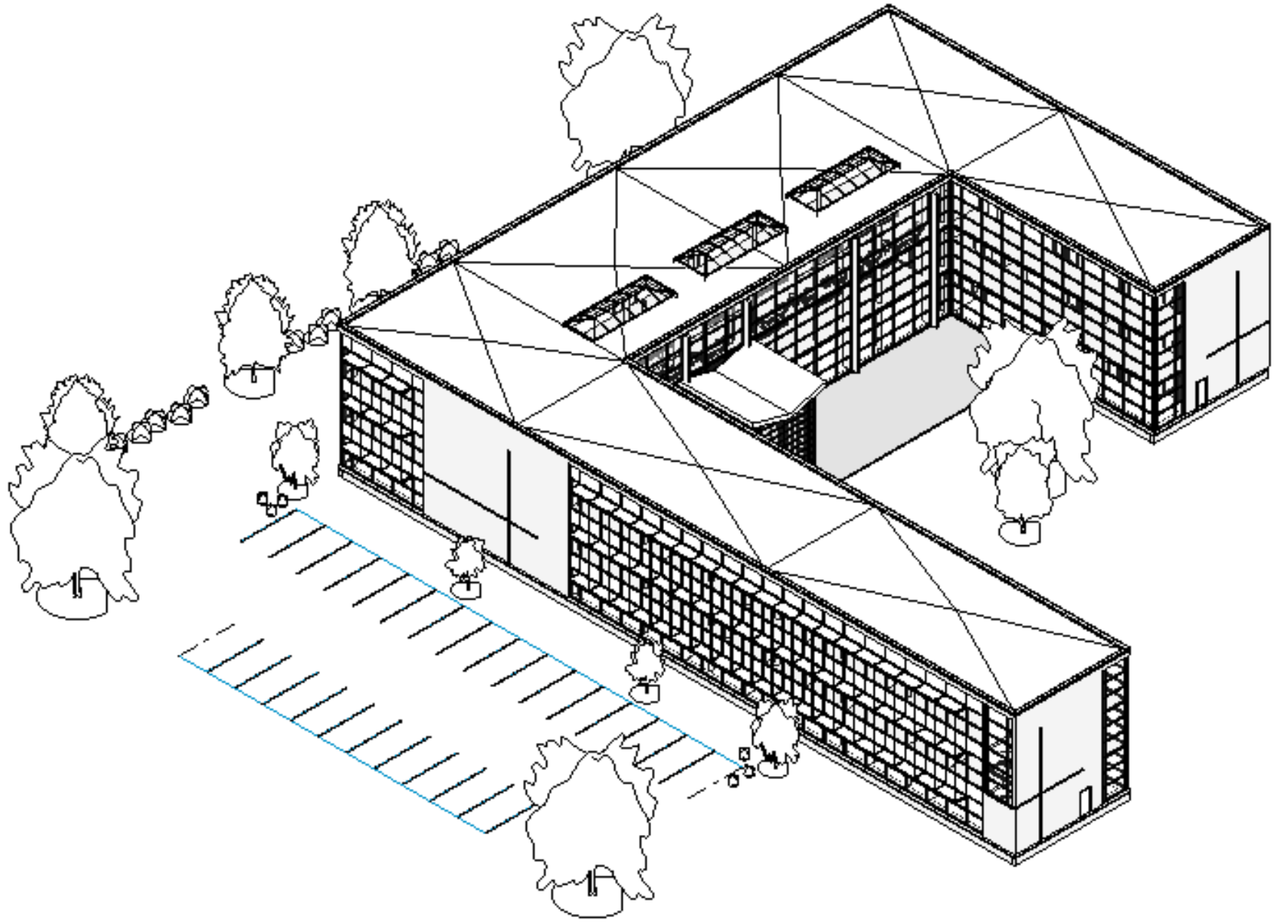


Use these values for the RGC custom color of the surface Material Appearance Asset

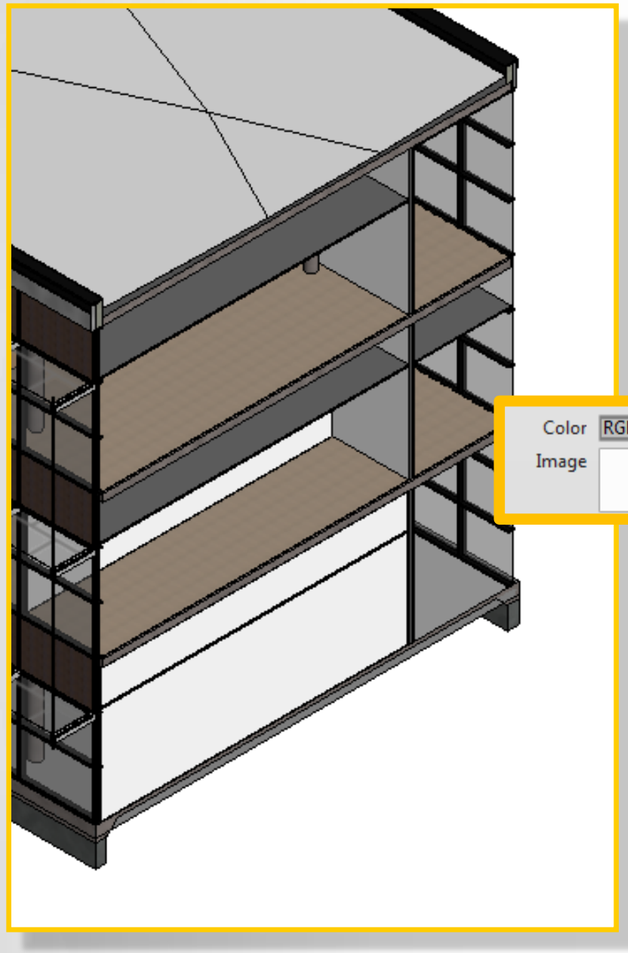


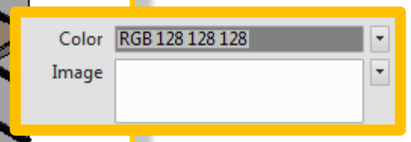
Opaque materials - Reflectance

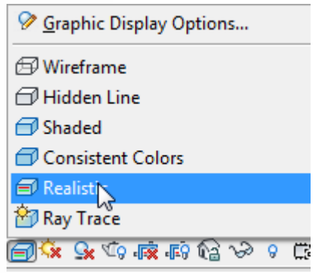


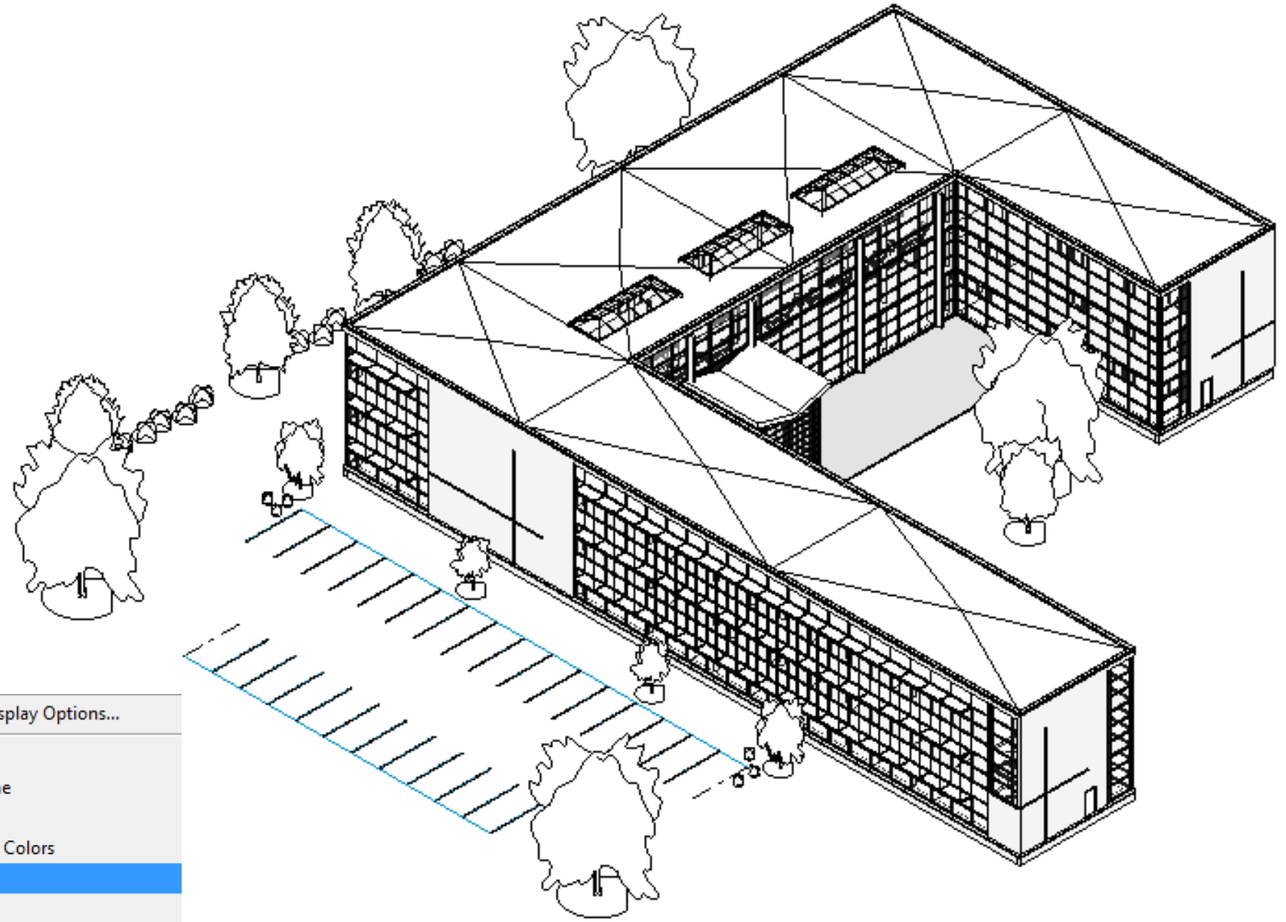


Opaque materials - Reflectance



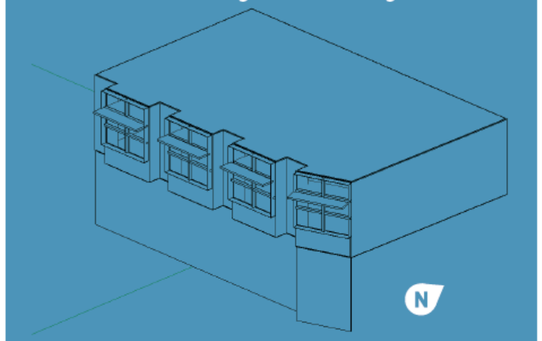






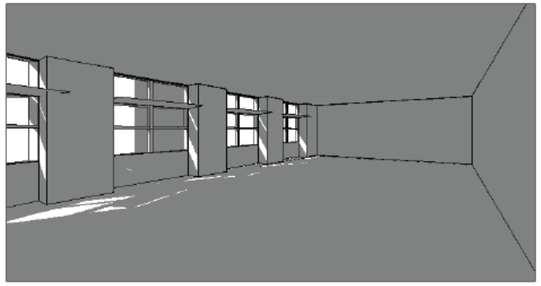
SMF04

Surface Reflectance Sensitivity Study



AXON PERSPECTIVE

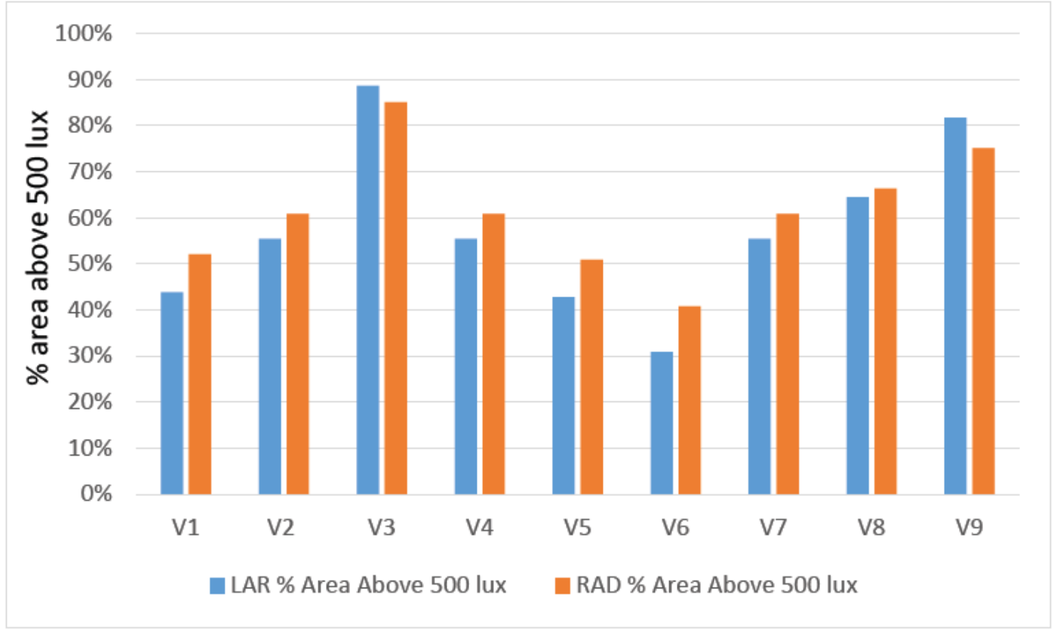
INTERIOR PERSPECTIVE



9 /21 /9.00 AM

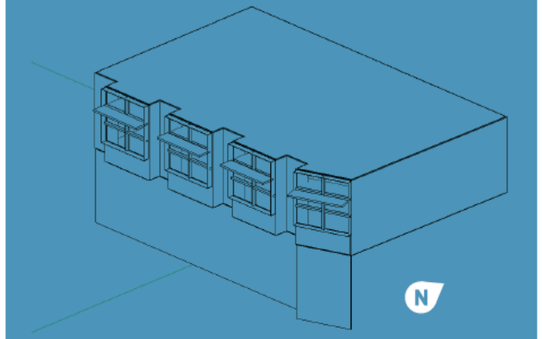
	V1_CR80_FR30_WR40	V2_CR80_FR30_WR60	V3_CR80_FR30_WR80	V4_CR80_FR30_WR60	V5_CR60_FR30_WR60	V6_CR40_FR30_WR60	V7_CR80_FR30_WR60	V8_CR80_FR40_WR60	V9_CR80_FR50_WR60
Wall Ref	40%	60%	80%	60%	60%	60%	60%	60%	60%
Ceiling Ref	80%	80%	80%	80%	60%	40%	80%	80%	80%
Floor Ref	30%	30%	30%	30%	30%	30%	30%	40%	50%

% AREA ABOVE 300 LUX - 9AM AND 3PM



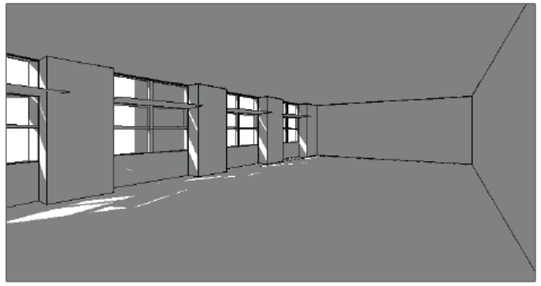
SMF04

Surface Reflectance Sensitivity Study



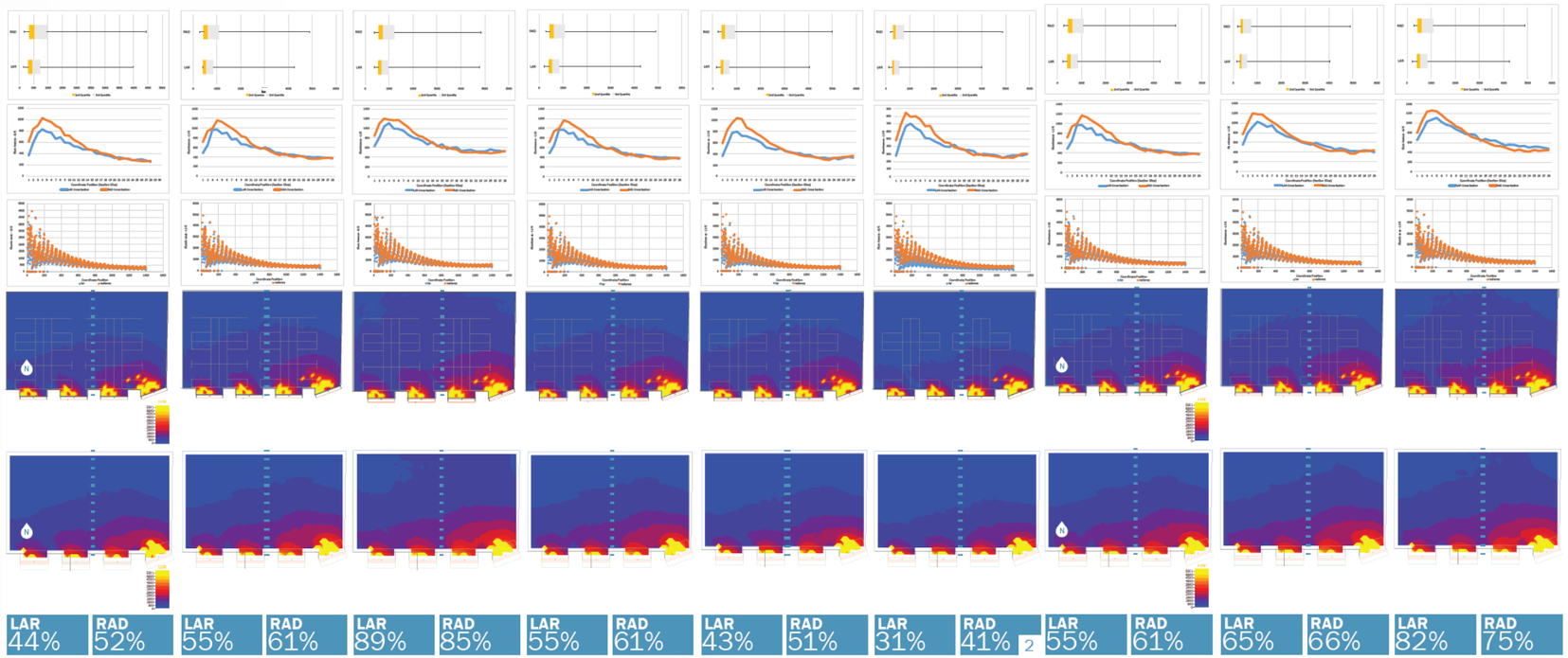
AXON PERSPECTIVE

INTERIOR PERSPECTIVE



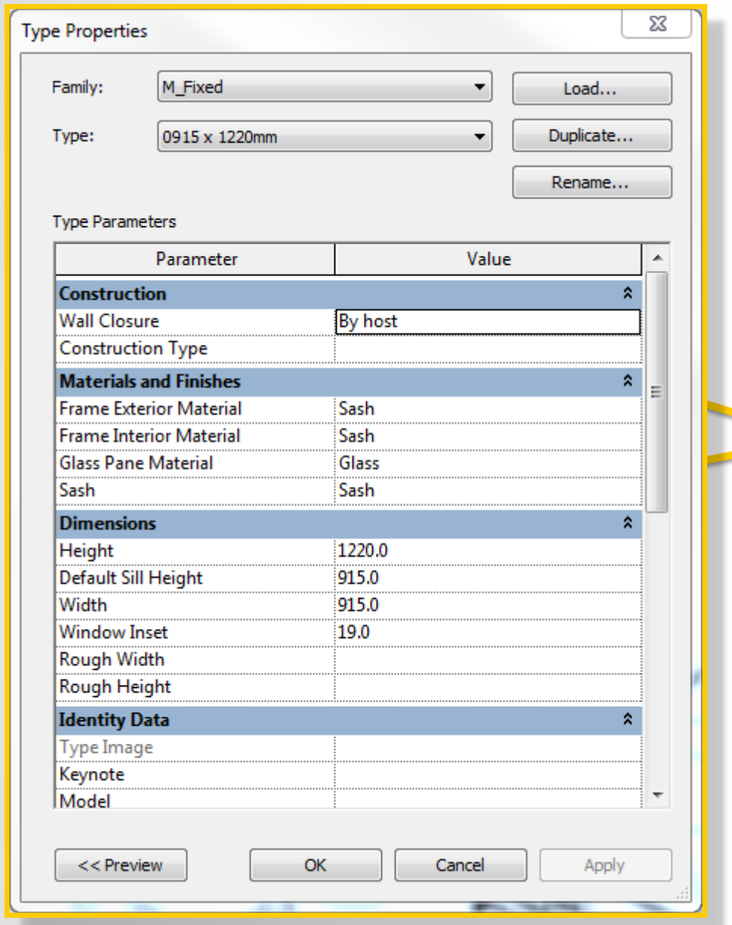
9 /21 /9.00 AM

	V1_CR80_FR30_WR40	V2_CR80_FR30_WR60	V3_CR80_FR30_WR80	V4_CR80_FR30_WR60	V5_CR60_FR30_WR60	V6_CR40_FR30_WR60	V7_CR80_FR30_WR60	V8_CR80_FR40_WR60	V9_CR80_FR50_WR60
Wall Ref	40%	60%	80%	60%	60%	60%	60%	60%	60%
Ceiling Ref	80%	80%	80%	80%	60%	40%	80%	80%	80%
Floor Ref	30%	30%	30%	30%	30%	30%	30%	40%	50%

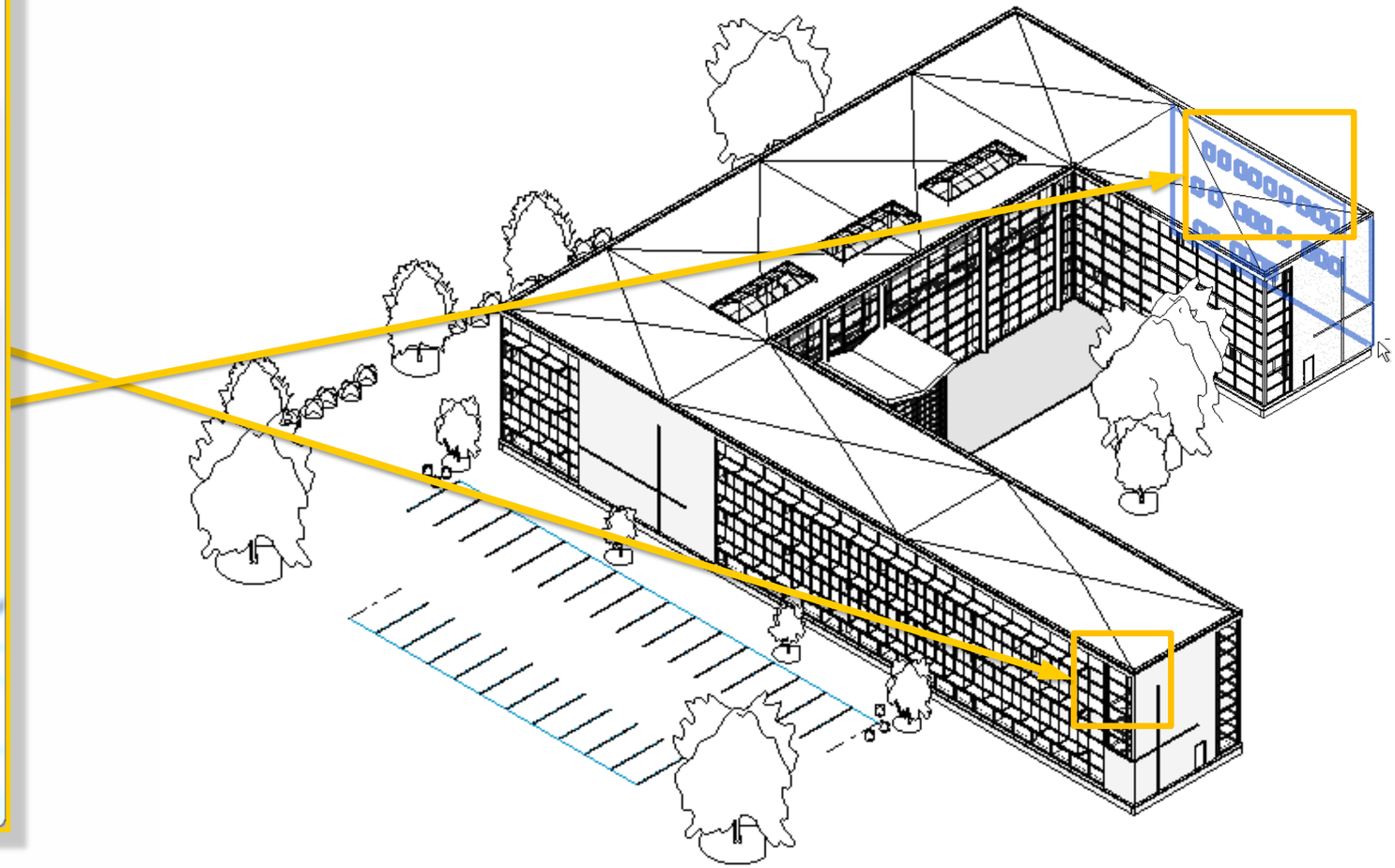


LAR	RAD	LAR	RAD	LAR	RAD	LAR	RAD	LAR	RAD	LAR	RAD	LAR	RAD	LAR	RAD	LAR	RAD
44%	52%	55%	61%	89%	85%	55%	61%	43%	51%	31%	41%	55%	61%	65%	66%	82%	75%

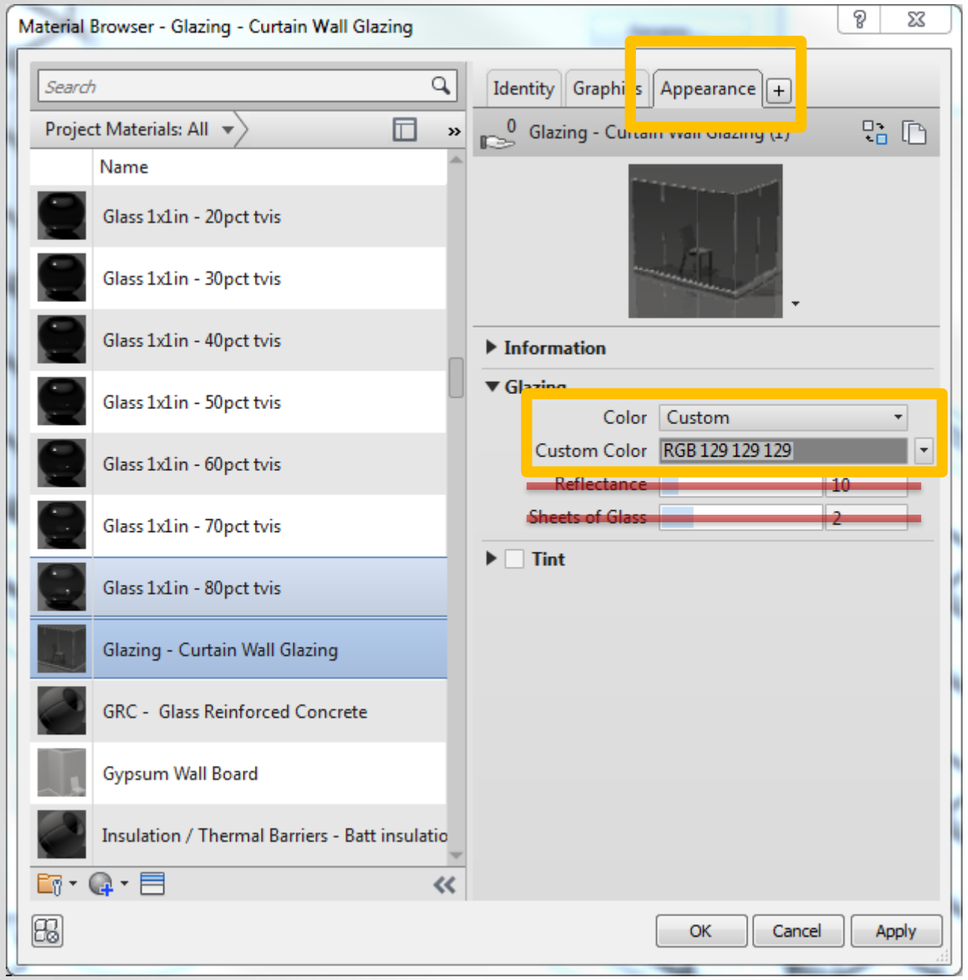
Transparent materials – Visible Transmittance

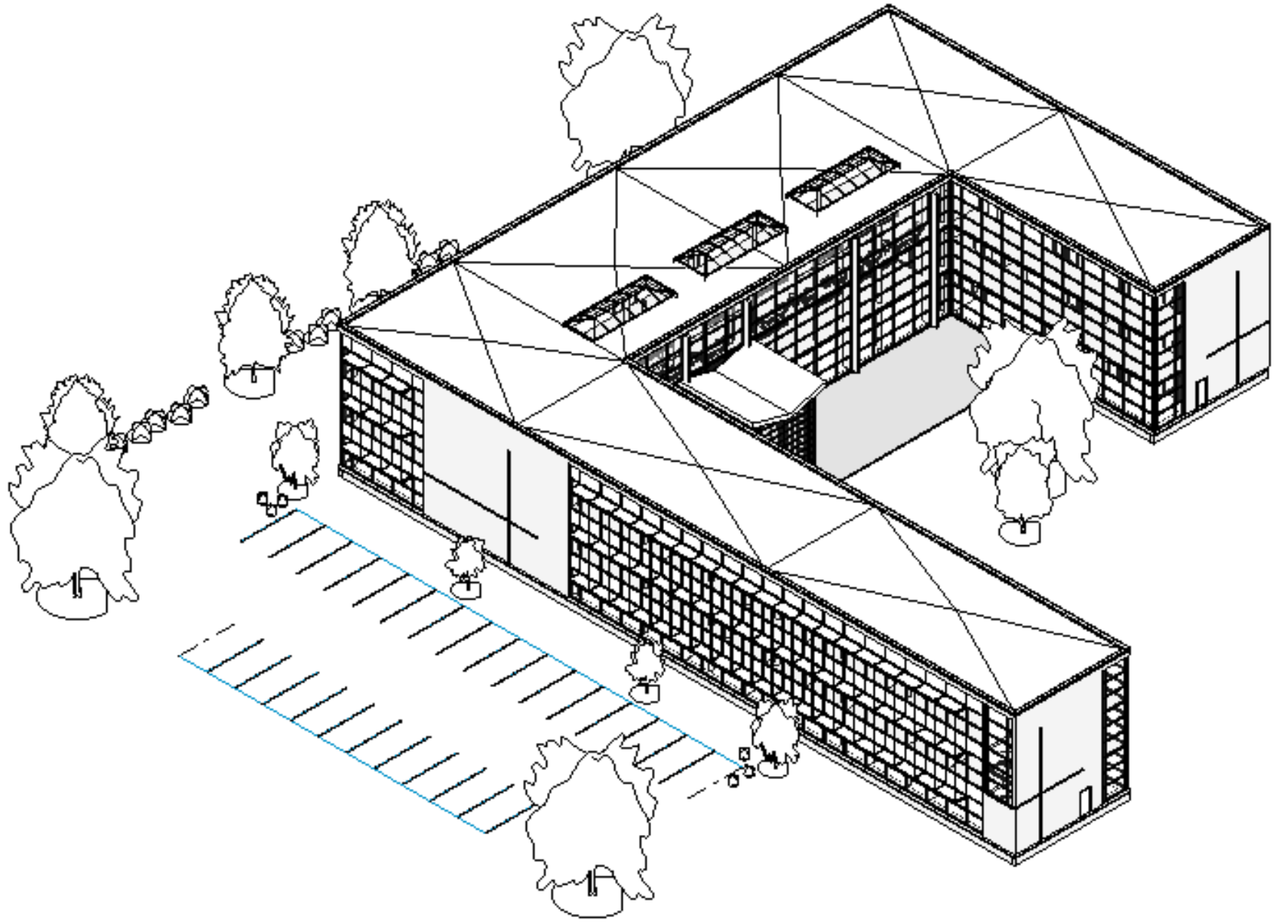


Window Families



Transparent materials – Visible Transmittance





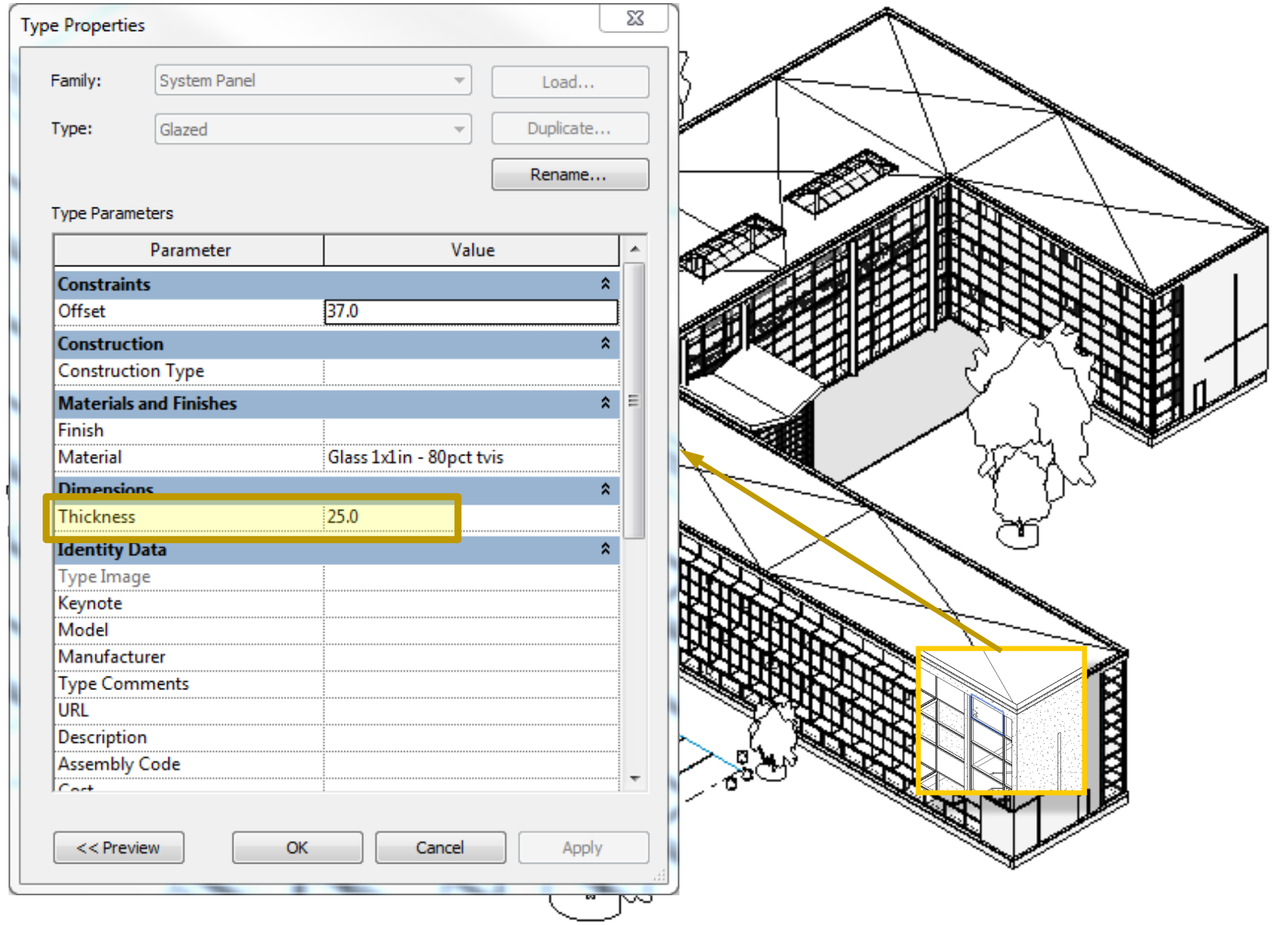
Transparent materials – Visible Transmittance

RGB (0-255) =

$$\sqrt{10^{\frac{\log_{10}\left(\frac{T}{F^p}\right)}{p \times \frac{d}{100}}}}$$

T = desired Tvis (decimal)
d = pane thickness (mm)
p = number of panes
F = Fresnel transmission of standard glass = 0.9216

Color	Custom
Custom Color	RGB 129 129 129



Transparent materials – Visible Transmittance

F 0.9216

p	1	panes modeled
d	25.4	mm modeled thickness

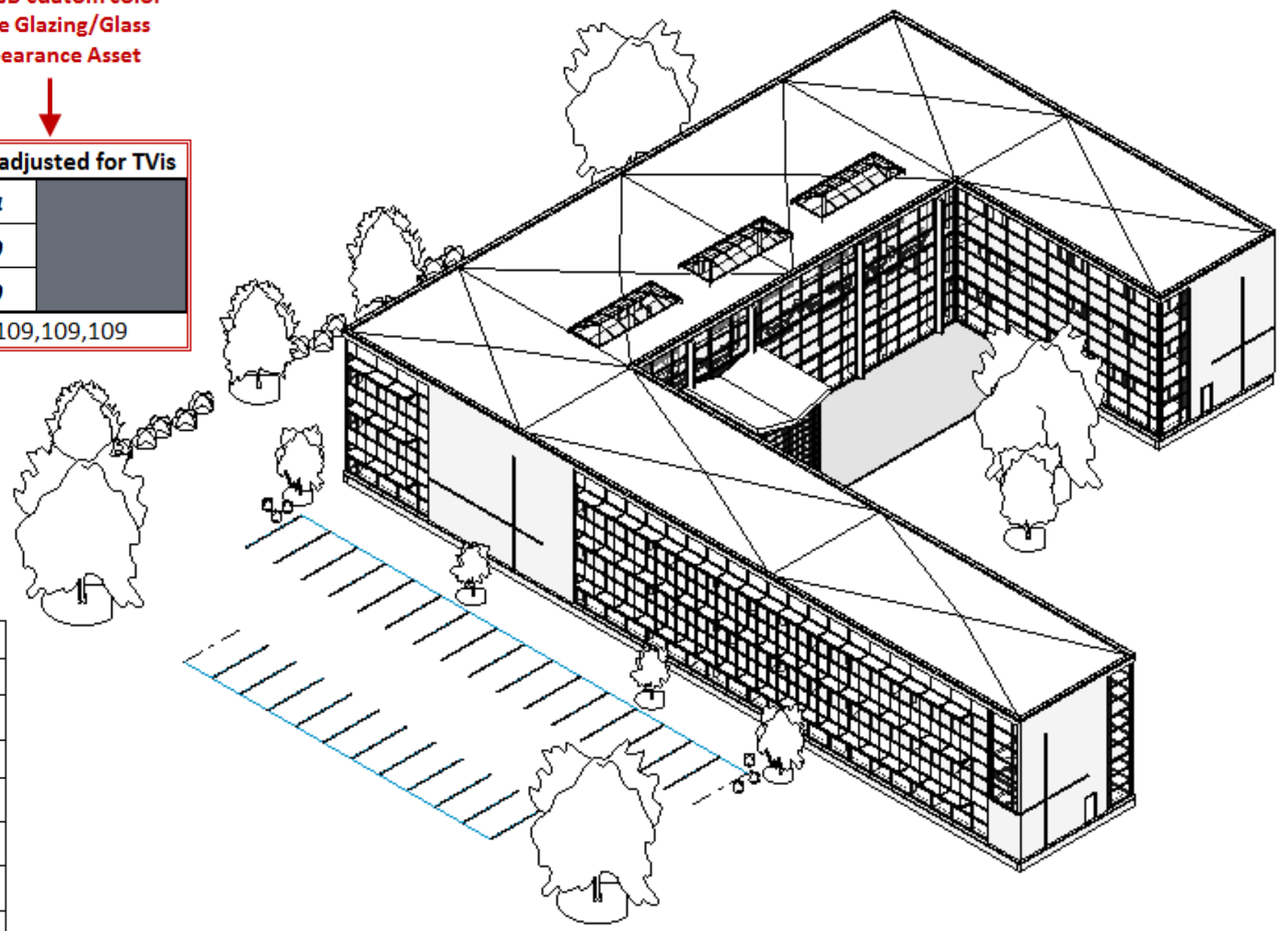
Tvis 60%

Use these values for the RGB cuatom color of the Glazing/Glass Appearance Asset

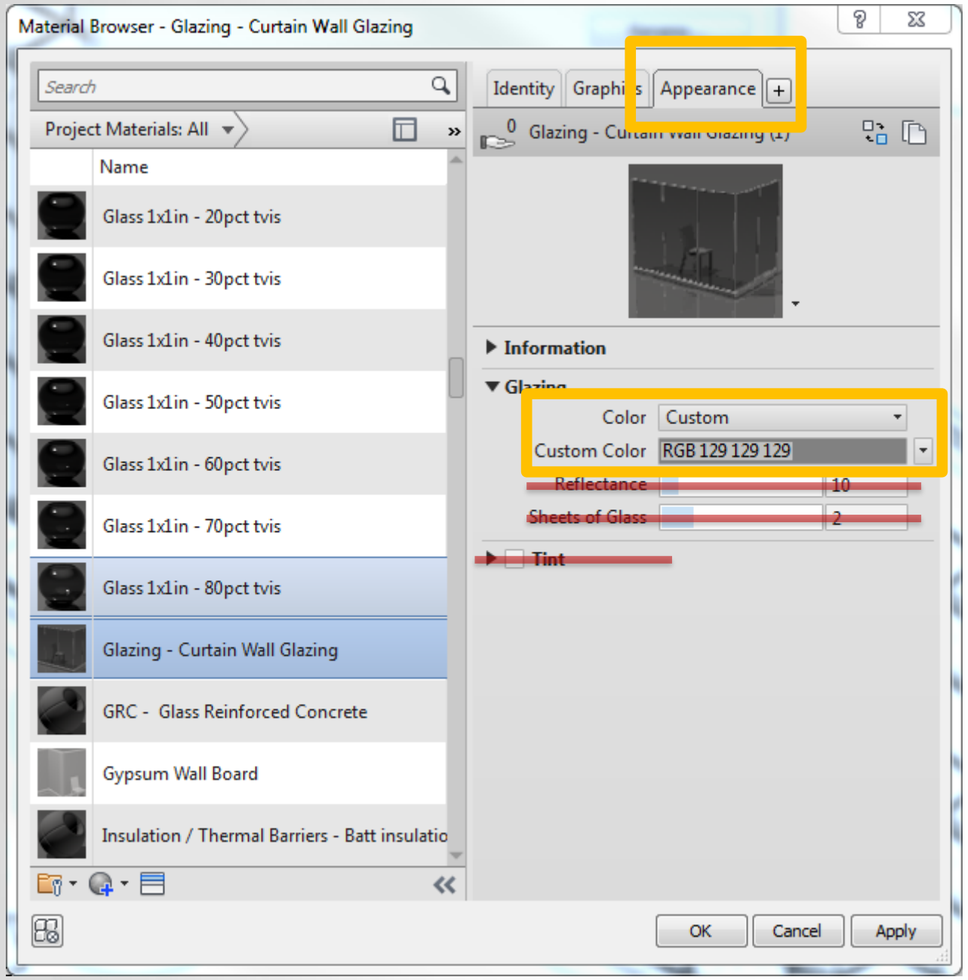
	Target color	RGB adjusted for TVis
R	177	104
G	187	110
B	204	120
		109,109,109

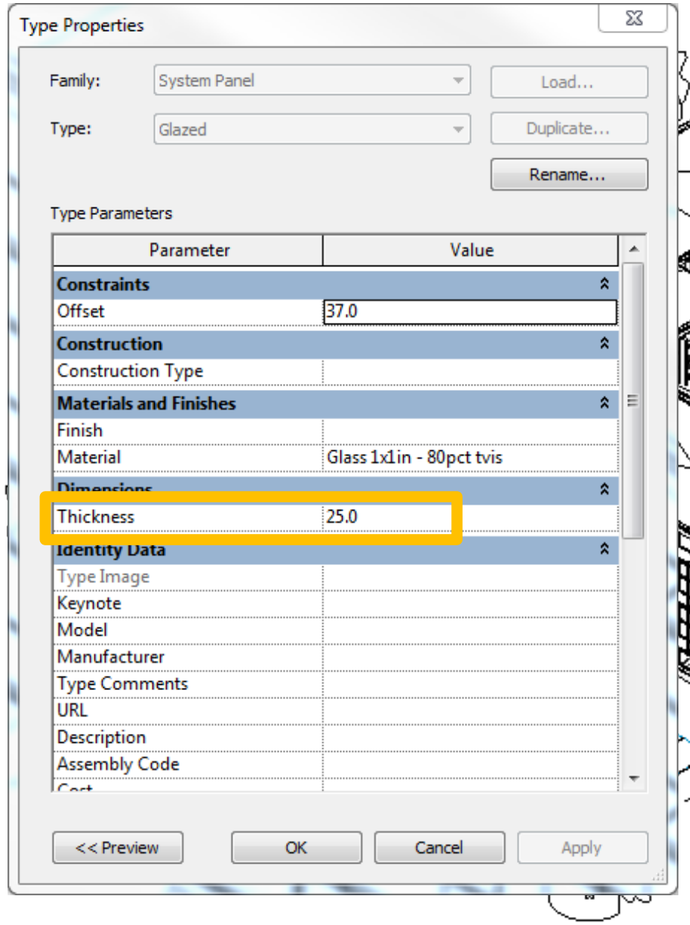
Color: Custom
Custom Color: RGB 109 109 109

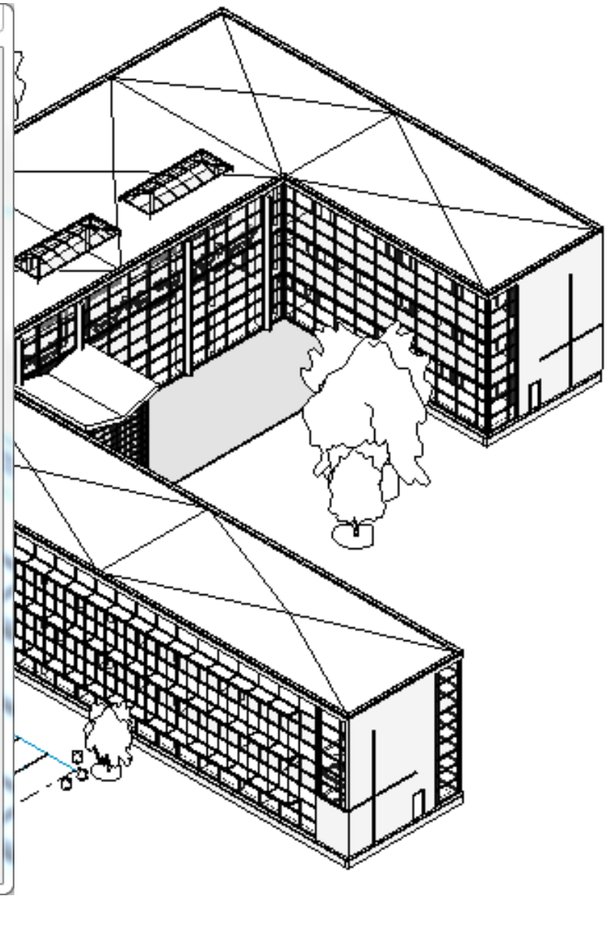
Modeled # panes	Modeled Thickness	Tvis 90%	80%	70%	60%	50%	40%	30%	20%	10%
1	3.0 mm	171	24	2	0	0	0	0	0	0
	4.0 mm	189	43	8	1	0	0	0	0	0
	5.0 mm	201	61	16	3	0	0	0	0	0
	6.0 mm	209	78	25	7	1	0	0	0	0
	8.0 mm	219	105	45	17	5	1	0	0	0
	10.0 mm	226	125	64	29	11	3	0	0	0
	12.7 mm	232	146	86	47	22	9	3	0	0
	25.4 mm	243	193	148	109	76	49	27	12	3



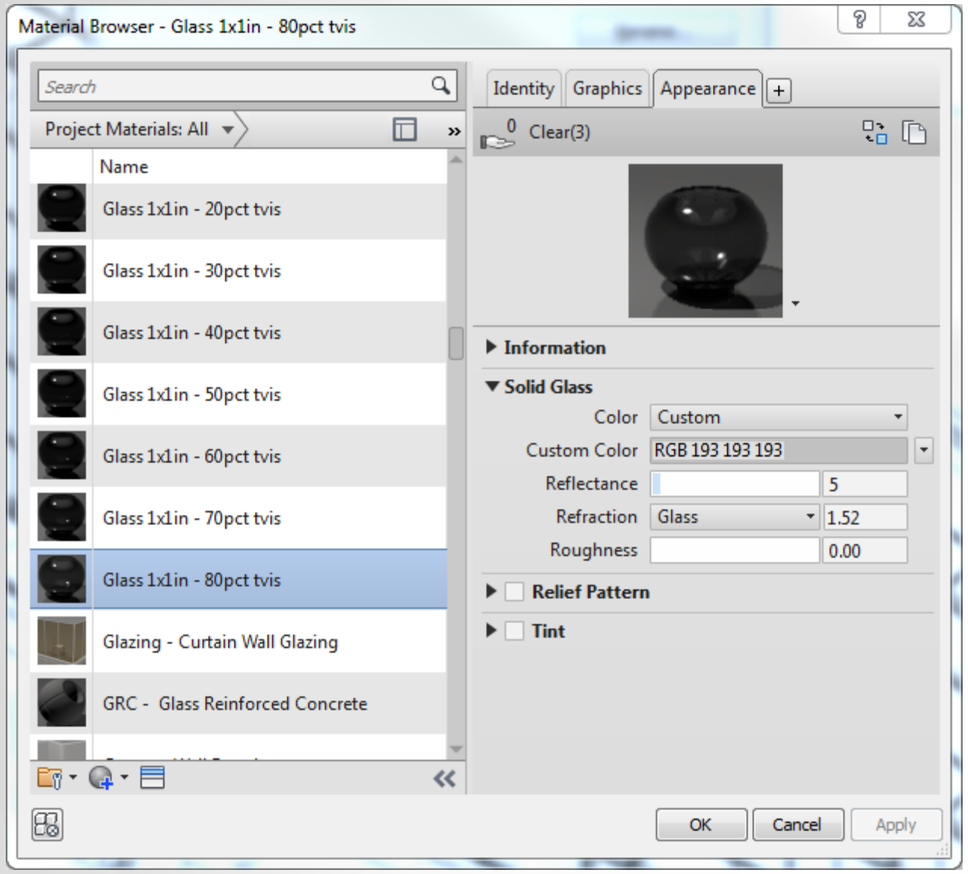
Transparent materials – Visible Transmittance



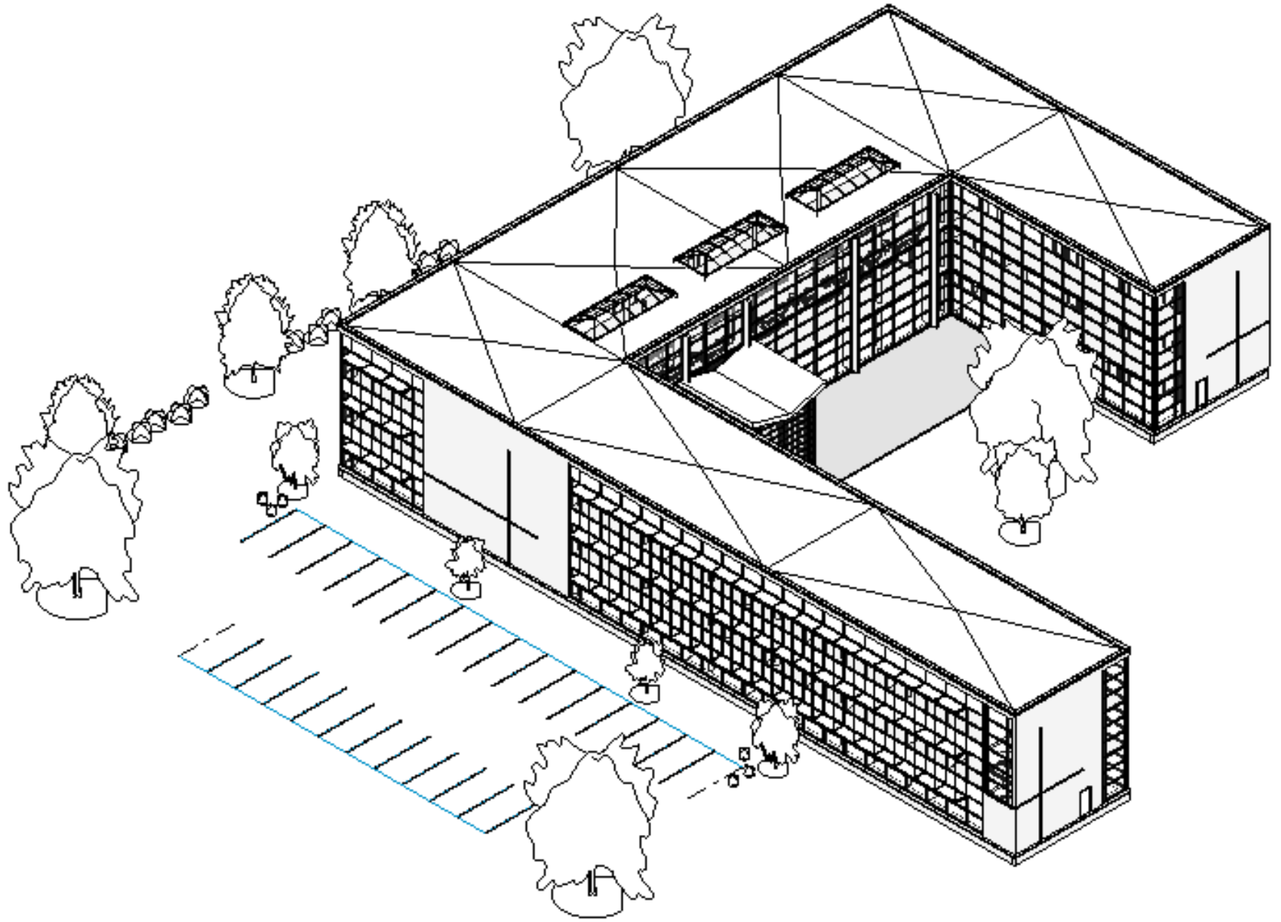


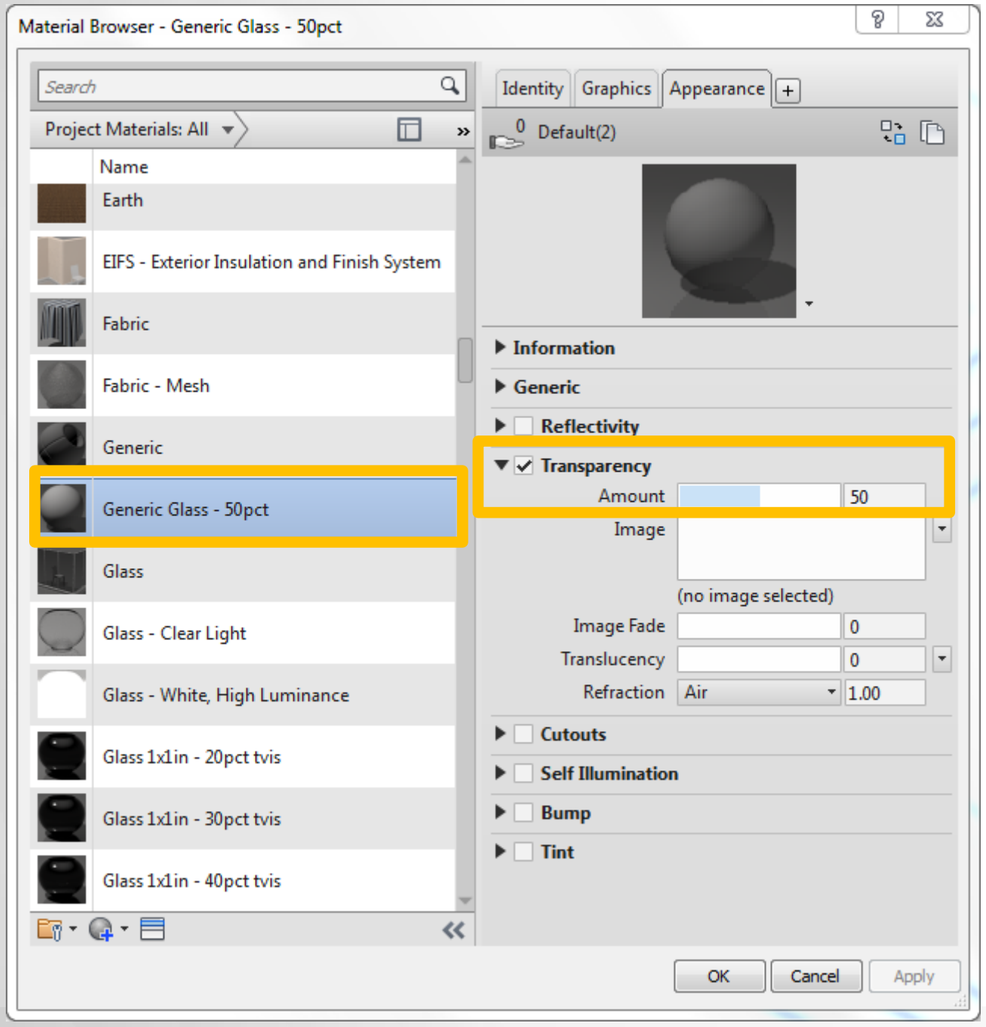


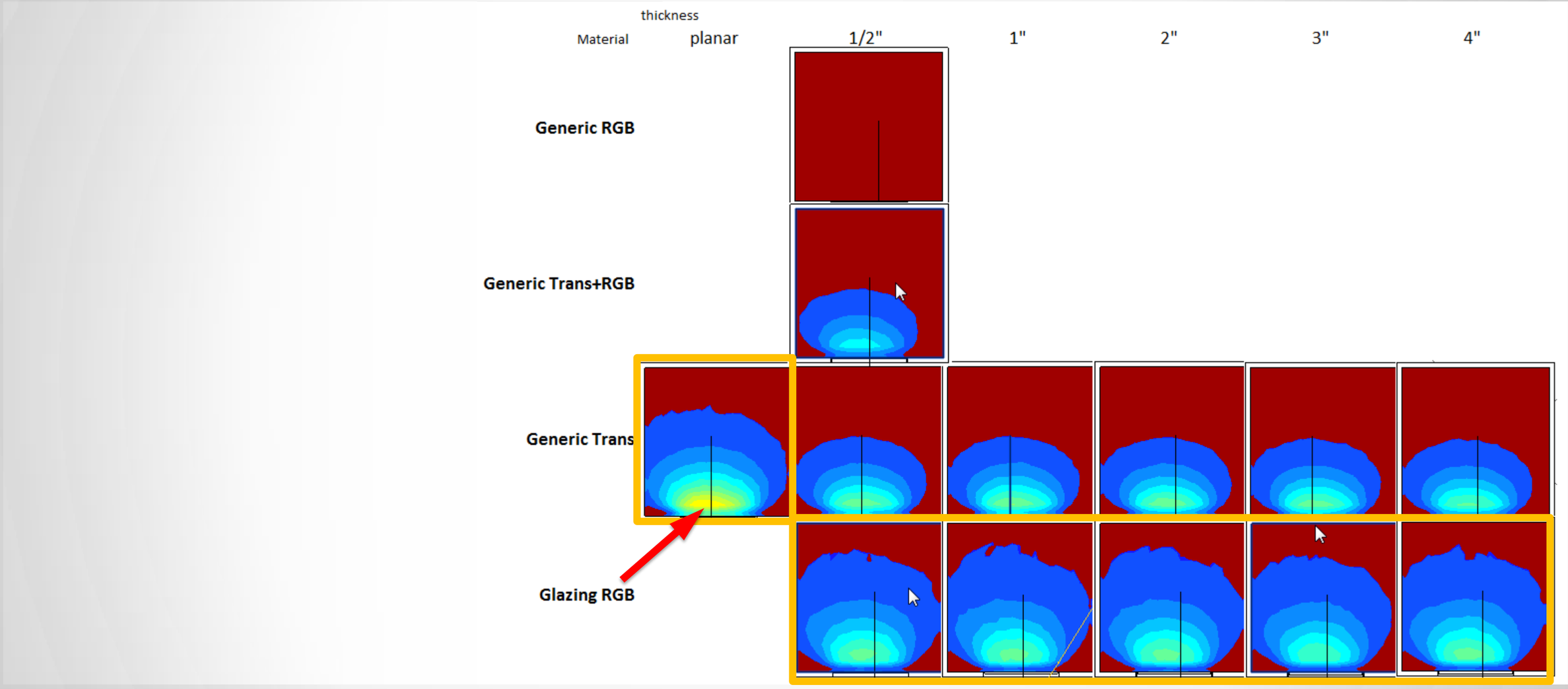
Transparent materials – Visible Transmittance

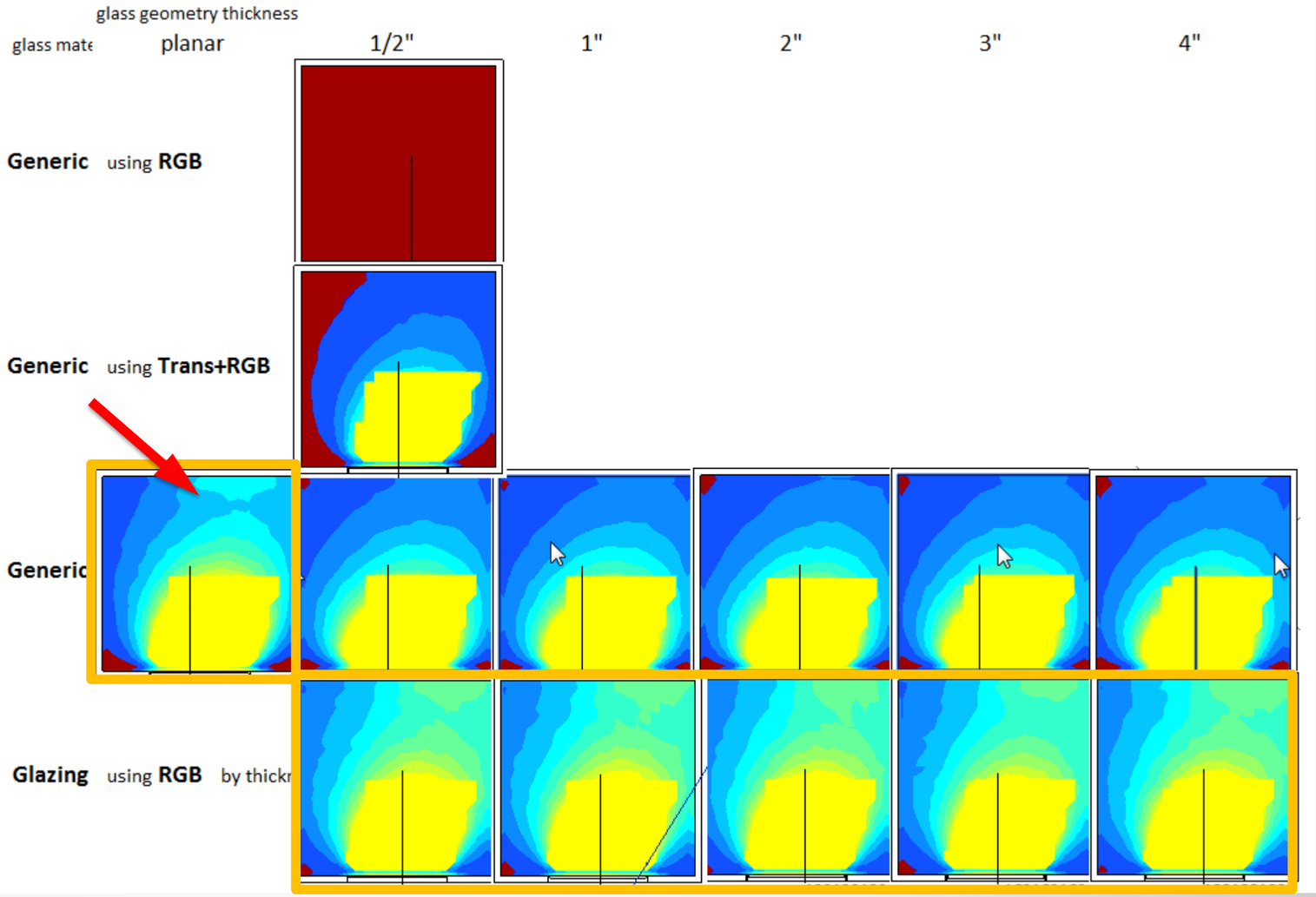


Library



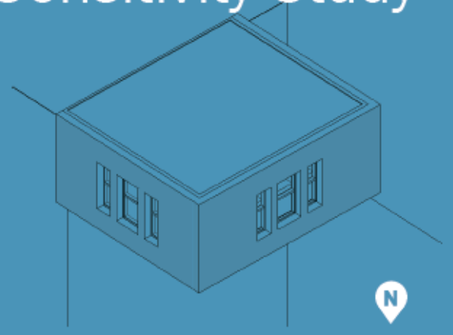

Material Browser - Generic Glass - 50pct
Search
Project Materials: All
Name
Earth
EIFS - Exterior Insulation and Finish System
Fabric
Fabric - Mesh
Generic
Generic Glass - 50pct
Glass
Glass - Clear Light
Glass - White, High Luminance
Glass 1x1in - 20pct tvis
Glass 1x1in - 30pct tvis
Glass 1x1in - 40pct tvis
Identity
Graphics
Appearance
Default(2)
Information
Generic
Reflectivity
Transparency
Amount
50
Image
(no image selected)
Image Fade
0
Translucency
0
Refraction
Air
1.00
Cutouts
Self Illumination
Bump
Tint
OK
Cancel
Apply


thickness
Material
planar
1/2"
1"
2"
3"
4"
Generic RGB
Generic Trans+RGB
Generic Trans
Glazing RGB


glass geometry thickness
glass mate
planar
1/2"
1"
2"
3"
4"
Generic using RGB
Generic using Trans+RGB
Generic
Glazing using RGB by thickr

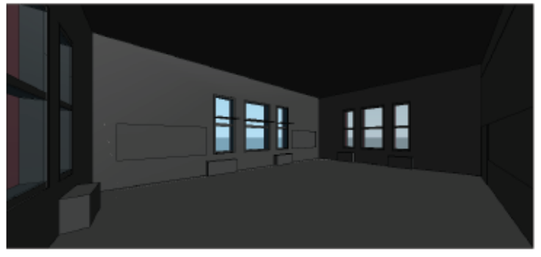
NYC05

Glazing Detail Sensitivity Study



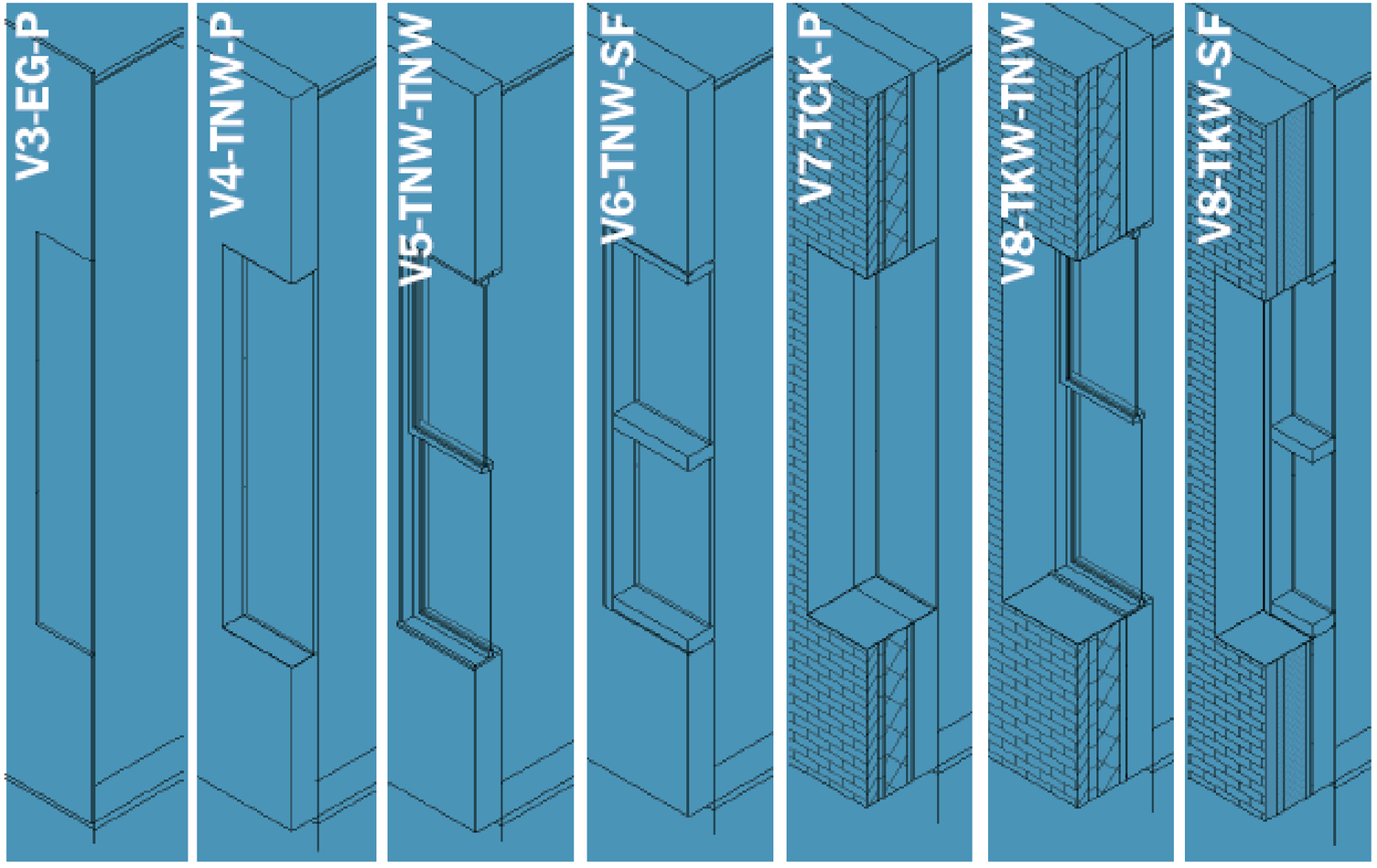
AXON PERSPECTIVE

INTERIOR PERSPECTIVE



9 /21 /9AM /3PM

VERSION KEY (VERSION - WALL TYPE - WINDOW TYPE)

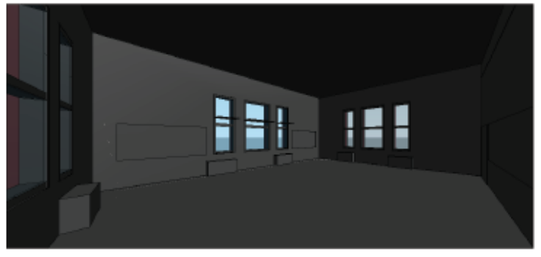


NYC05

Glazing Detail Sensitivity Study

AXON PERSPECTIVE

INTERIOR PERSPECTIVE

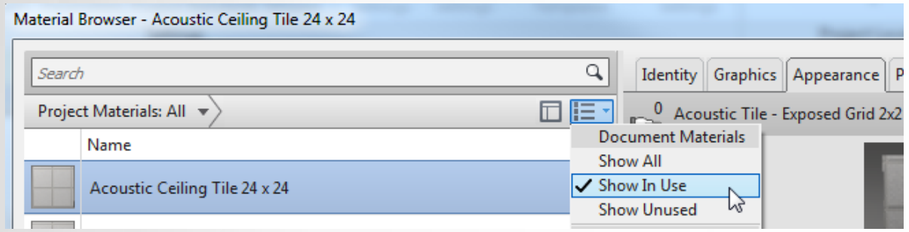


9 /21 /9AM /3PM

V3-EG-P		V4-TNW-P		V5-TNW-TNW		V6-TNW-SF		V7-TCK-P		V8-TKN-TNW		V9-TKW-SF	
LAR 100%	RAD 100%	LAR 96%	RAD 100%	LAR 92%	RAD 100%	LAR 89%	RAD 99%	LAR 86%	RAD 99%	LAR 82%	RAD 97%	LAR 72%	RAD 92%

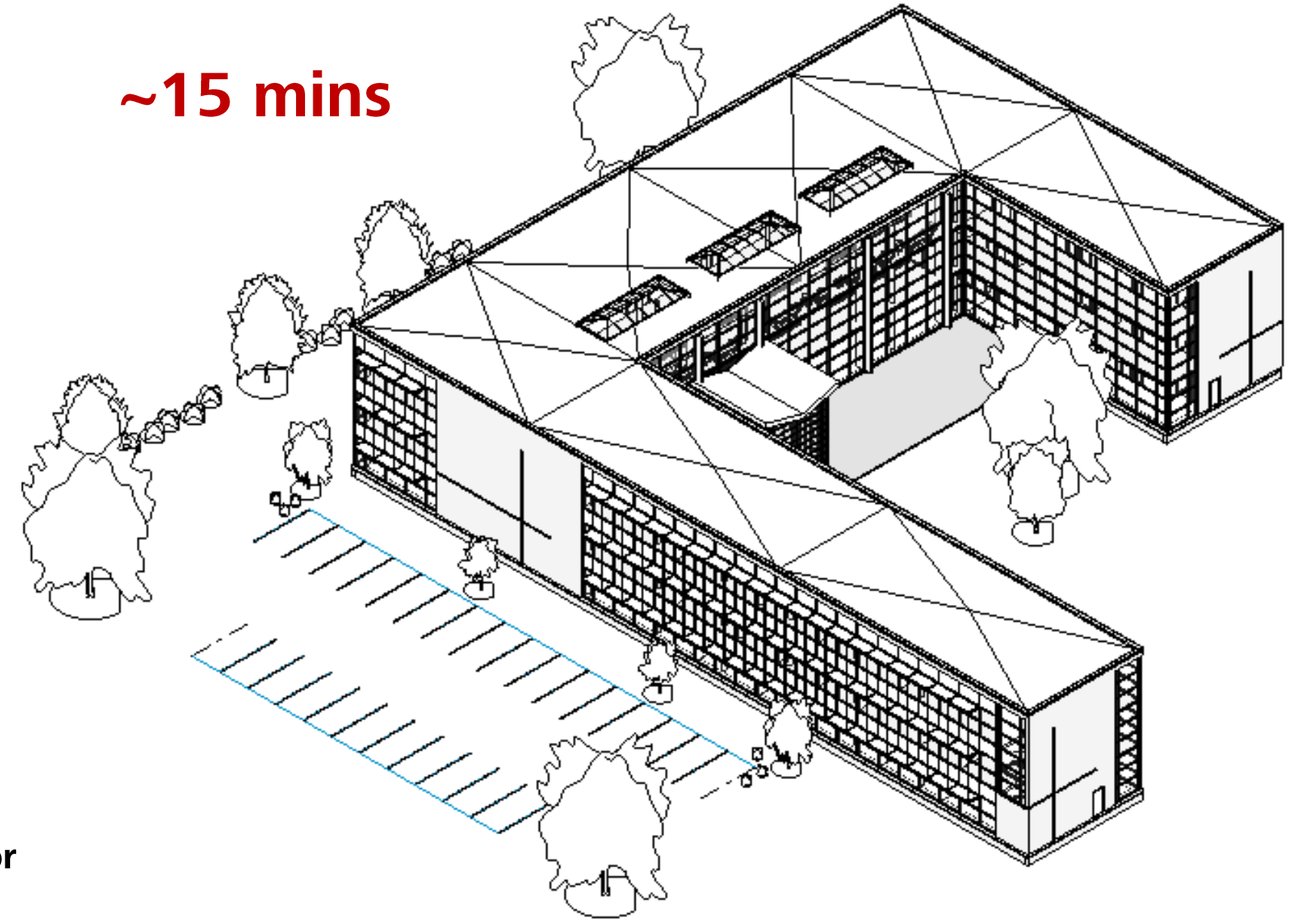
Best Practices for reviewing materials

1. Start by reviewing the materials library in the Materials Browser - Manage > Settings > Materials
2. If preparing an existing Revit model for analysis, focus on the Materials in Use.



3. Simplify all materials as much as possible, and remove unnecessary Appearance Asset properties other than Generic RGB custom color.
4. Use simple Generic (opaque) or Glazing (transparent) Appearance Assets, and do not use the difficult opaque material modifiers of Reflectivity and Self-Illumination.
5. Review project opaque objects visually with 'Realistic' style, and review transparent objects by type, looking for coordination of thickness and Appearance Asset RGB.

~15 mins



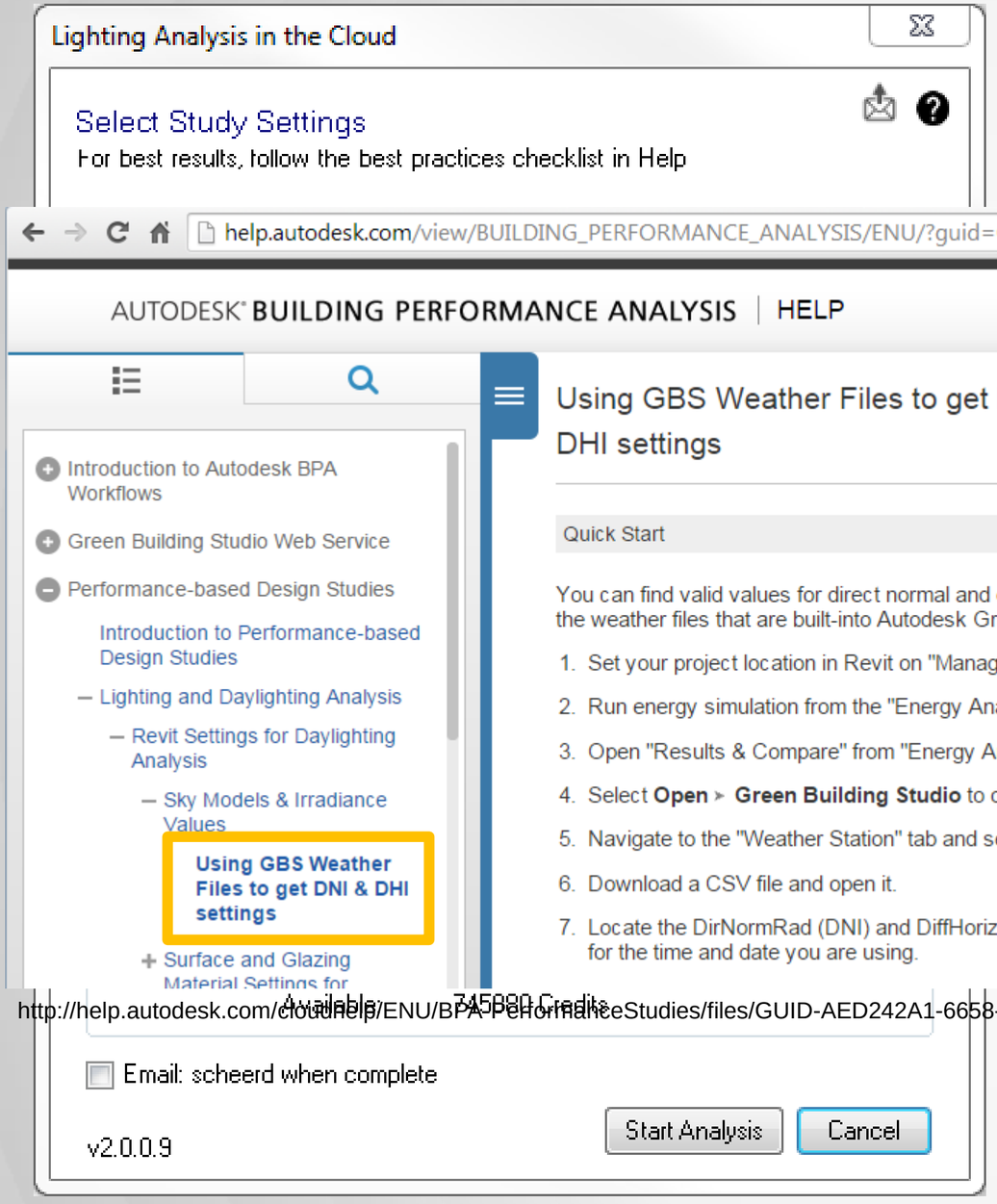
Offering | Questions

Questions?

Section 2.4

Lighting Analysis in Revit

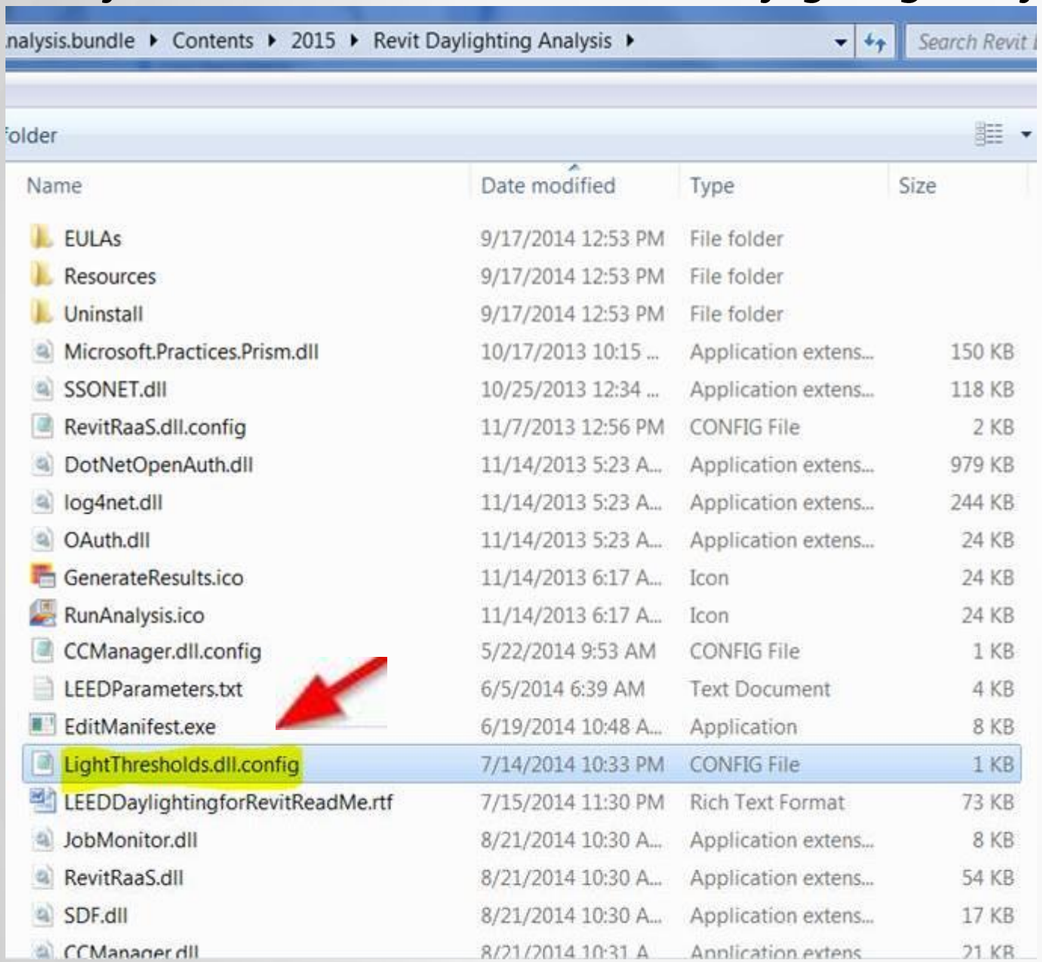
Custom Analysis for LAR



14739 BOSTON MA -5 N 42 22 W 71 2 5

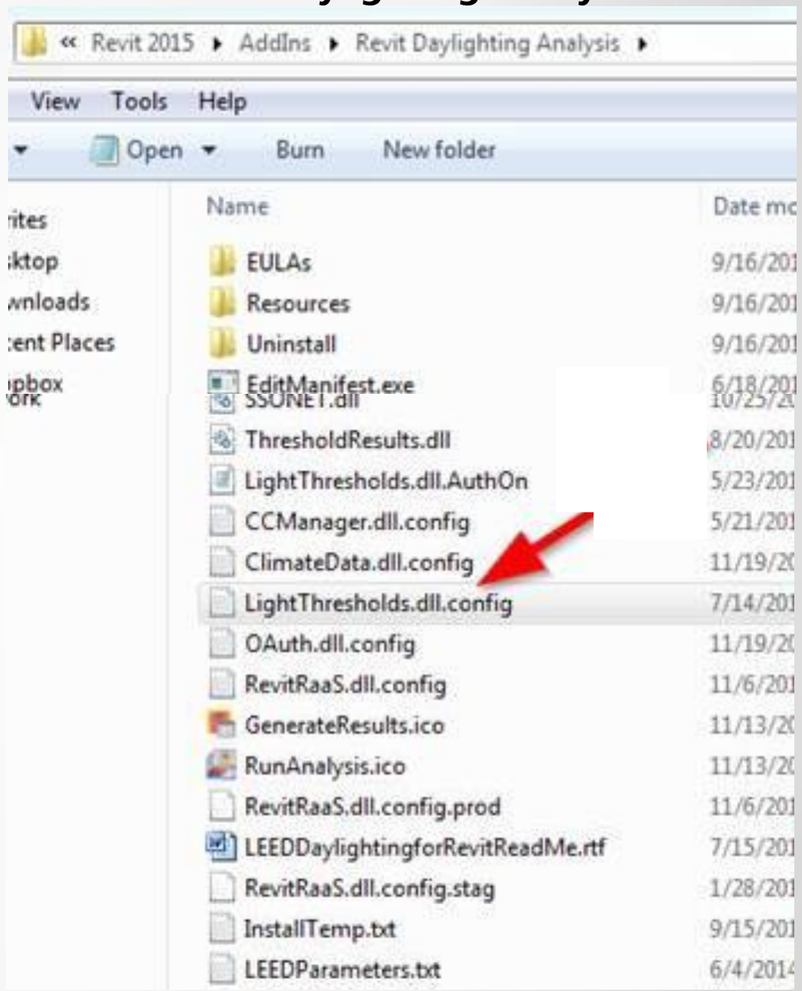
			ghr	dnr	dhr
5	12	1	0	0	0
5	12	2	0	0	0
5	12	3	0	0	0
5	12	4	0	0	0
5	12	5	13	3	13
5	12	6	93	177	62
5	12	7	238	286	135
5	12	8	324	265	183
5	12	9	427	260	249
5	12	10	725	515	313
5	12	11	867	567	369
5	12	12	672	378	329
5	12	13	653	240	439
5	12	14	668	473	275
5	12	15	619	445	297
5	12	16	426	388	199
5	12	17	321	426	142
5	12	18	136	95	113
5	12	19	25	7	25
5	12	20	0	0	0
5	12	21	0	0	0
5	12	22	0	0	0
5	12	23	0	0	0
5	12	24	0	0	0

%programdata%\Autodesk\ApplicationPlugins\Analysis.bundle\Contents\2015\Revit Daylighting Analysis



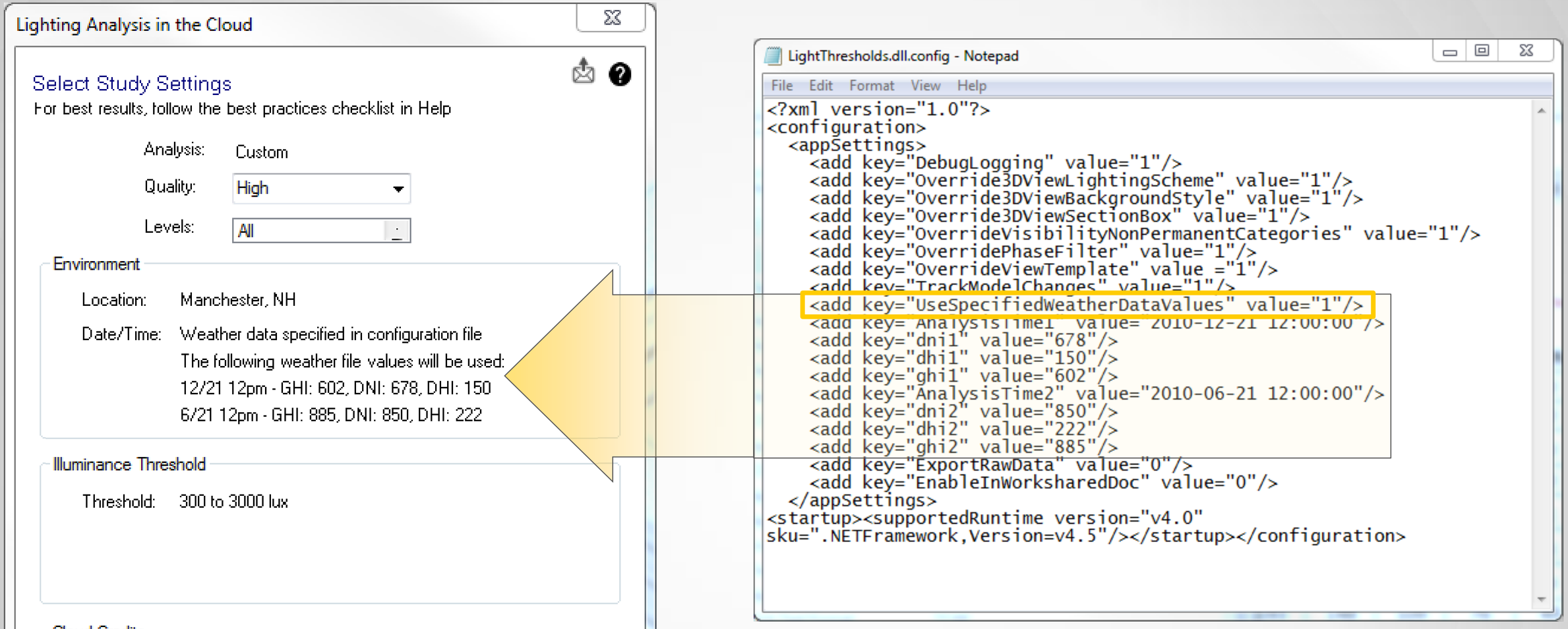
Exchange Store Installation

C:\Program Files\Autodesk\Revit 2015\AddIns\Revit Daylighting Analysis



LAR Product Installation

14739 BOSTON		MA -5 N 42 22 W 71 2 5			
			ghr	dnr	dhr
5	12	1	0	0	0
5	12	2	0	0	0
5	12	3	0	0	0
5	12	4	0	0	0
5	12	5	13	3	13
5	12	6	93	177	62
5	12	7	238	286	135
5	12	8	324	265	183
5	12	9	427	260	249
5	12	10	725	515	313
5	12	11	867	567	369
5	12	12	672	378	329
5	12	13	653	240	439
5	12	14	668	473	275
5	12	15	619	445	297
5	12	16	426	388	199
5	12	17	321	426	142
5	12	18	136	95	113
5	12	19	25	7	25
5	12	20	0	0	0
5	12	21	0	0	0
5	12	22	0	0	0
5	12	23	0	0	0
5	12	24	0	0	0


Lighting Analysis in the Cloud
Select Study Settings
For best results, follow the best practices checklist in Help
Analysis: Custom
Quality: High
Levels: All
Environment
Location: Manchester, NH
Date/Time: Weather data specified in configuration file
The following weather file values will be used:
12/21 12pm - GHI: 602, DNI: 678, DHI: 150
6/21 12pm - GHI: 885, DNI: 850, DHI: 222
Illuminance Threshold
Threshold: 300 to 3000 lux
Cloud Credits
Required: 18 Credits
Available: 745880 Credits
Email: scheerd when complete
v2.0.0.9
Start Analysis
Cancel
LightThresholds.dll.config - Notepad
File Edit Format View Help
<?xml version="1.0"?>
<configuration>
<appSettings>
<add key="DebugLogging" value="1"/>
<add key="Override3DViewLightingScheme" value="1"/>
<add key="Override3DViewBackgroundStyle" value="1"/>
<add key="Override3DViewSectionBox" value="1"/>
<add key="OverrideVisibilityNonPermanentCategories" value="1"/>
<add key="OverridePhaseFilter" value="1"/>
<add key="OverrideViewTemplate" value ="1"/>
<add key="UseSpecifiedWeatherDataValues" value="1"/>
<add key="dni1" value="678"/>
<add key="dhi1" value="150"/>
<add key="ghi1" value="602"/>
<add key="AnalysisTime2" value="2010-06-21 12:00:00"/>
<add key="dni2" value="850"/>
<add key="dhi2" value="222"/>
<add key="ghi2" value="885"/>
<add key="ExportRawData" value="0"/>
<add key="EnableInWorksharedDoc" value="0"/>
</appSettings>
<startup><supportedRuntime version="v4.0"
sku=".NETFramework,Version=v4.5"/></startup></configuration>

Lighting Analysis in the Cloud

Select Study Settings

For best results, follow the best practices checklist in Help

Analysis: Custom

Quality: High

Levels: 03 - Floor

Environment

Location: Manchester, NH

Date/Time: Weather data specified in configuration file

The following weather file values will be used:

5/12 5pm - GHI: 136, DNI: 95, DHI: 113

5/12 6pm - GHI: 25, DNI: 7, DHI: 25

Illuminance Threshold

Threshold: 300 to 3000 lux

LEED v4 EQc7 opt 2 specifies a minimum threshold of 300 lux, and a maximum of 3000 lux unless a room has automated shades.

Cloud Credits

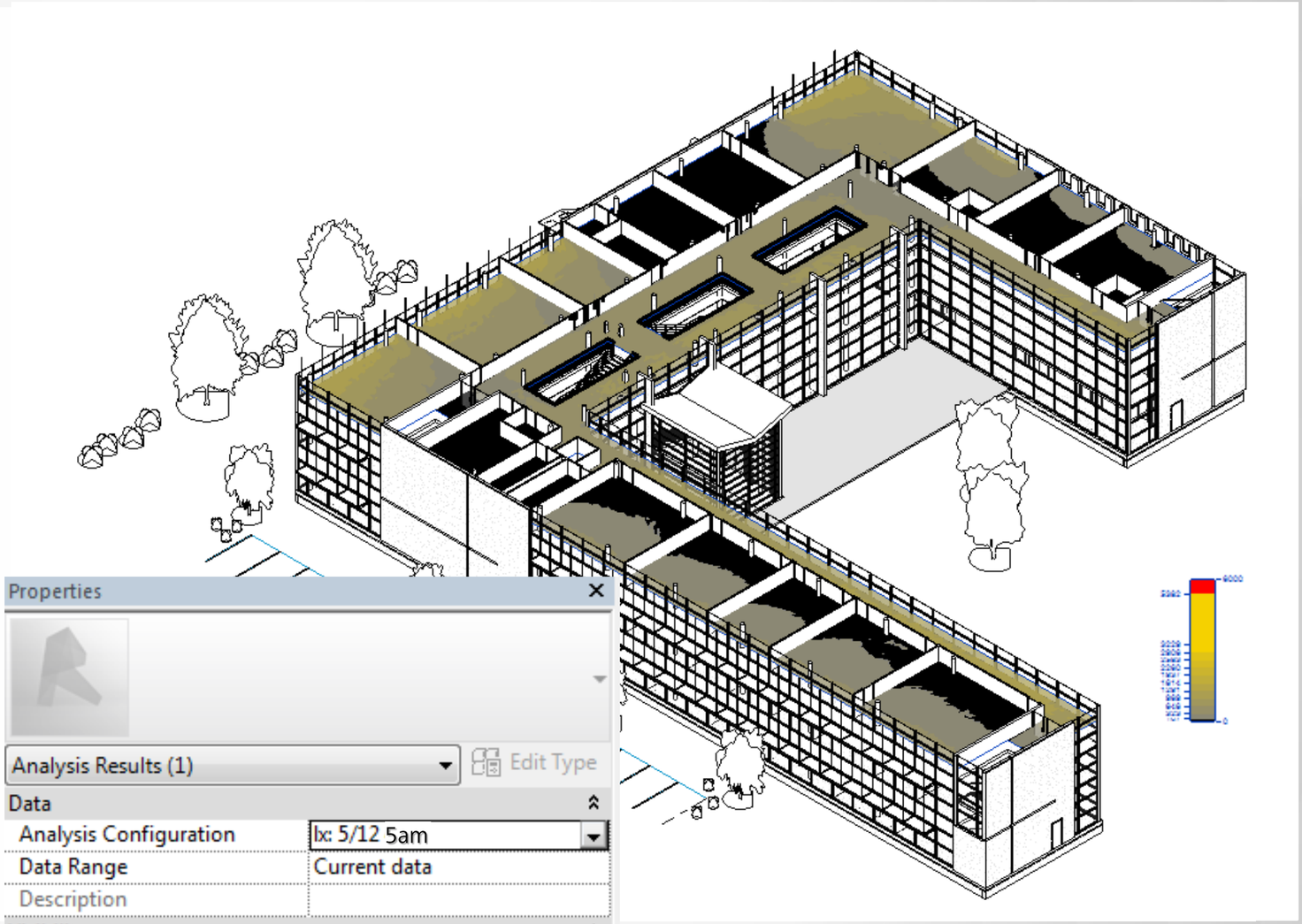
Required: 18 Credits

Available: 745880 Credits

Email: scheerd when complete

v2.0.0.9

Start Analysis | Cancel



Properties

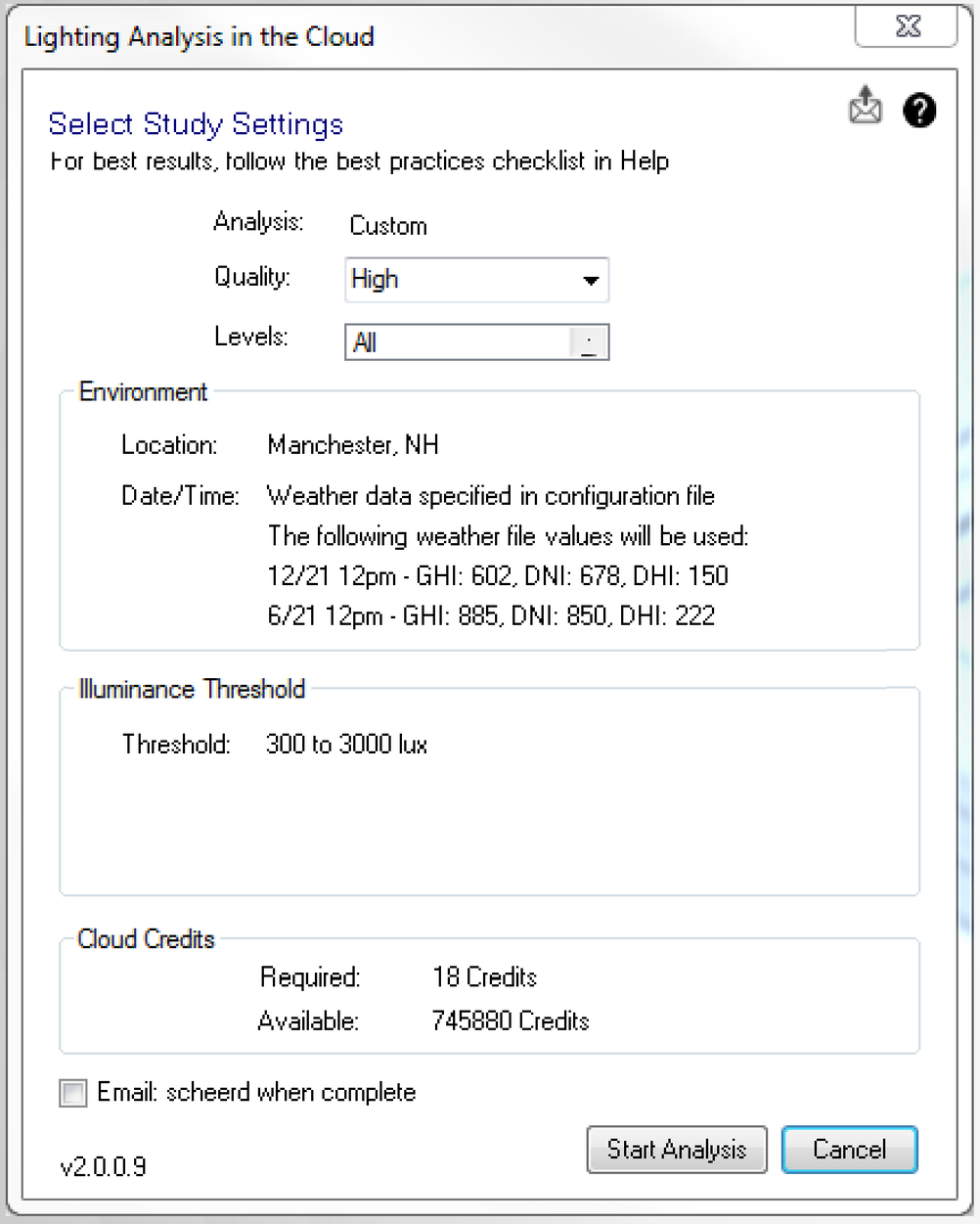
Analysis Results (1) | Edit Type

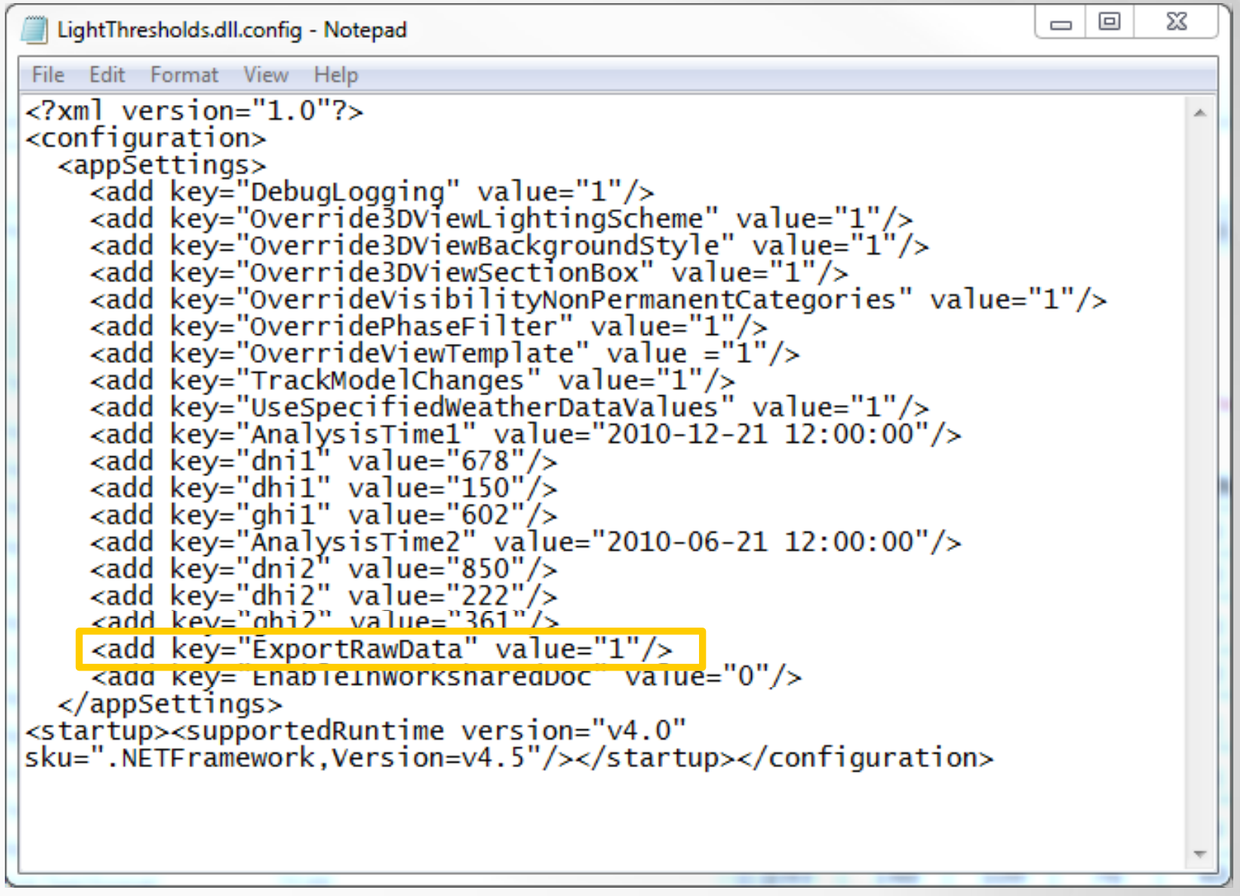
Data	
Analysis Configuration	lx: 5/12 5am
Data Range	Current data
Description	
Visibility	
Results Visibility	Edit...
Overall Legend	
Show Configuration Name	☑
Show Description	☑
Overall Legend Text	7mm Arial

Section 2.5

Lighting Analysis in Revit

Raw Output from LAR


Lighting Analysis in the Cloud
Select Study Settings
For best results, follow the best practices checklist in Help
Analysis: Custom
Quality: High
Levels: All
Environment
Location: Manchester, NH
Date/Time: Weather data specified in configuration file
The following weather file values will be used:
12/21 12pm - GHI: 602, DNI: 678, DHI: 150
6/21 12pm - GHI: 885, DNI: 850, DHI: 222
Illuminance Threshold
Threshold: 300 to 3000 lux
Cloud Credits
Required: 18 Credits
Available: 745880 Credits
Email: scheerd when complete
v2.0.0.9
Start Analysis
Cancel


LightThresholds.dll.config - Notepad
File Edit Format View Help
<?xml version="1.0"?>
<configuration>
<appSettings>
<add key="DebugLogging" value="1"/>
<add key="Override3DViewLightingScheme" value="1"/>
<add key="Override3DViewBackgroundStyle" value="1"/>
<add key="Override3DViewSectionBox" value="1"/>
<add key="OverrideVisibilityNonPermanentCategories" value="1"/>
<add key="OverridePhaseFilter" value="1"/>
<add key="OverrideViewTemplate" value ="1"/>
<add key="TrackModelChanges" value="1"/>
<add key="UseSpecifiedWeatherDataValues" value="1"/>
<add key="AnalysisTime1" value="2010-12-21 12:00:00"/>
<add key="dni1" value="678"/>
<add key="dhi1" value="150"/>
<add key="ghi1" value="602"/>
<add key="AnalysisTime2" value="2010-06-21 12:00:00"/>
<add key="dni2" value="850"/>
<add key="dhi2" value="222"/>
<add key="ghi2" value="361"/>
<add key="ExportRawData" value="1"/>
<add key="EnableInWorksharedDoc" value="0"/>
</appSettings>
<startup><supportedRuntime version="v4.0"
sku=".NETFramework,Version=v4.5"/></startup></configuration>

	A	B	C
1	**Location**	**lx: 12/15 11am**	**lx: 12/15 12pm**
2	(-31.065273285, -75.306518555, 27.434383392)	22542.27927	23160.97129
3	(-30.065250397, -75.306518555, 27.434383392)	22807.32233	22869.16105
4	(-29.065227509, -75.306518555, 27.434383392)	6924.929257	21899.58351
5	(-28.065204620, -75.306518555, 27.434383392)		
6	(-27.065181732, -75.306518555, 27.434383392)		
7	(-26.065158844, -75.306518555, 27.434383392)		
8	(-25.065135956, -75.306518555, 27.434383392)		
9	(-24.065116882, -75.306518555, 27.434383392)		
10	(-23.065093994, -75.306518555, 27.434383392)		
11	(-22.065071106, -75.306518555, 27.434383392)		
12	(-21.065048218, -75.306518555, 27.434383392)		
13	(-20.065025330, -75.306518555, 27.434383392)		
14	(-19.065006256, -75.306518555, 27.434383392)		
15	(-18.064983368, -75.306518555, 27.434383392)		
16	(-17.064960480, -75.306518555, 27.434383392)		
17	(-16.064937592, -75.306518555, 27.434383392)		
18	(-15.064914703, -75.306518555, 27.434383392)		
19	(-14.064891815, -75.306518555, 27.434383392)		
20	(-13.064868927, -75.306518555, 27.434383392)		
21	(-12.064846039, -75.306518555, 27.434383392)		
22	(-11.064823151, -75.306518555, 27.434383392)		
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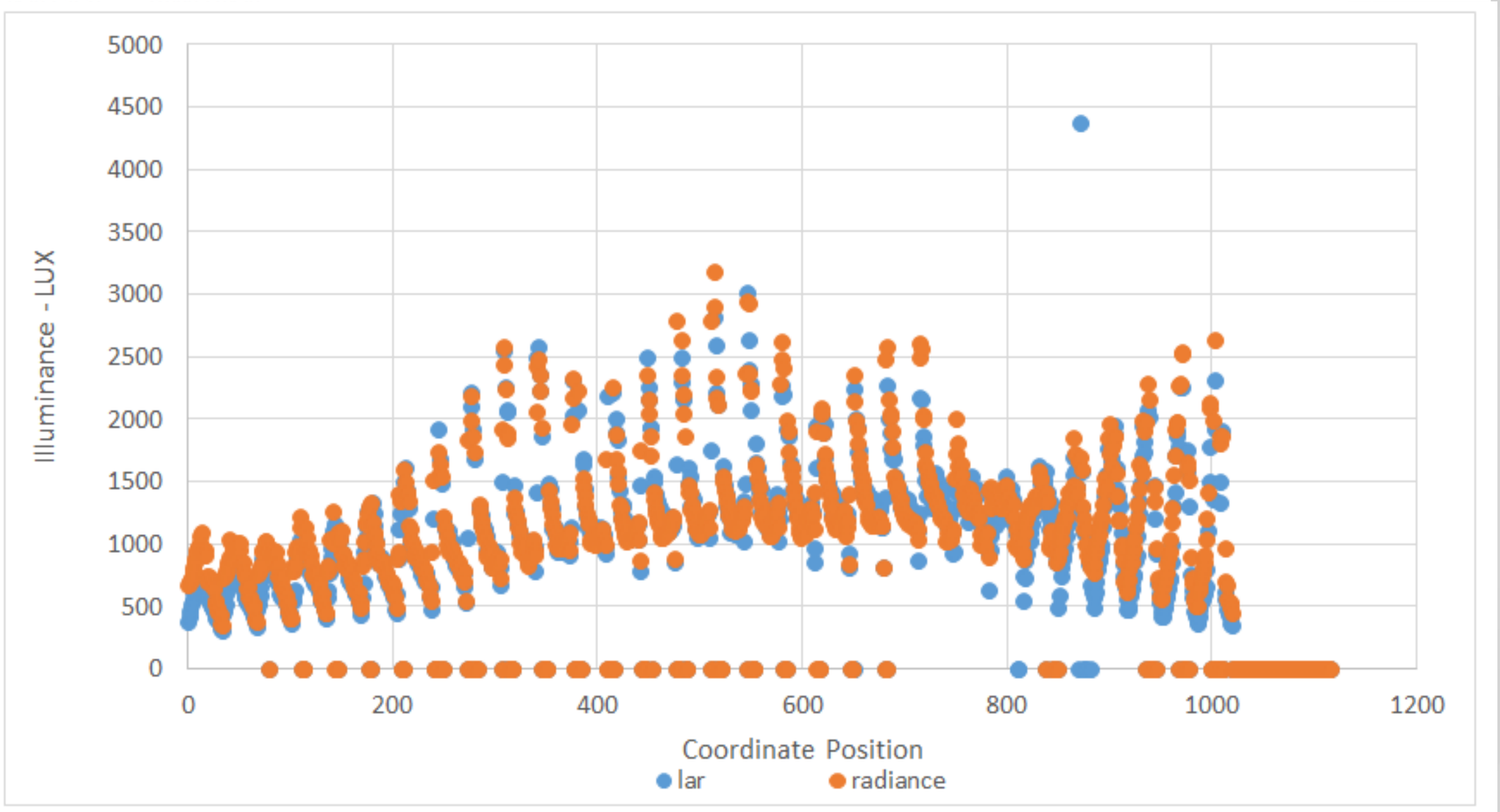
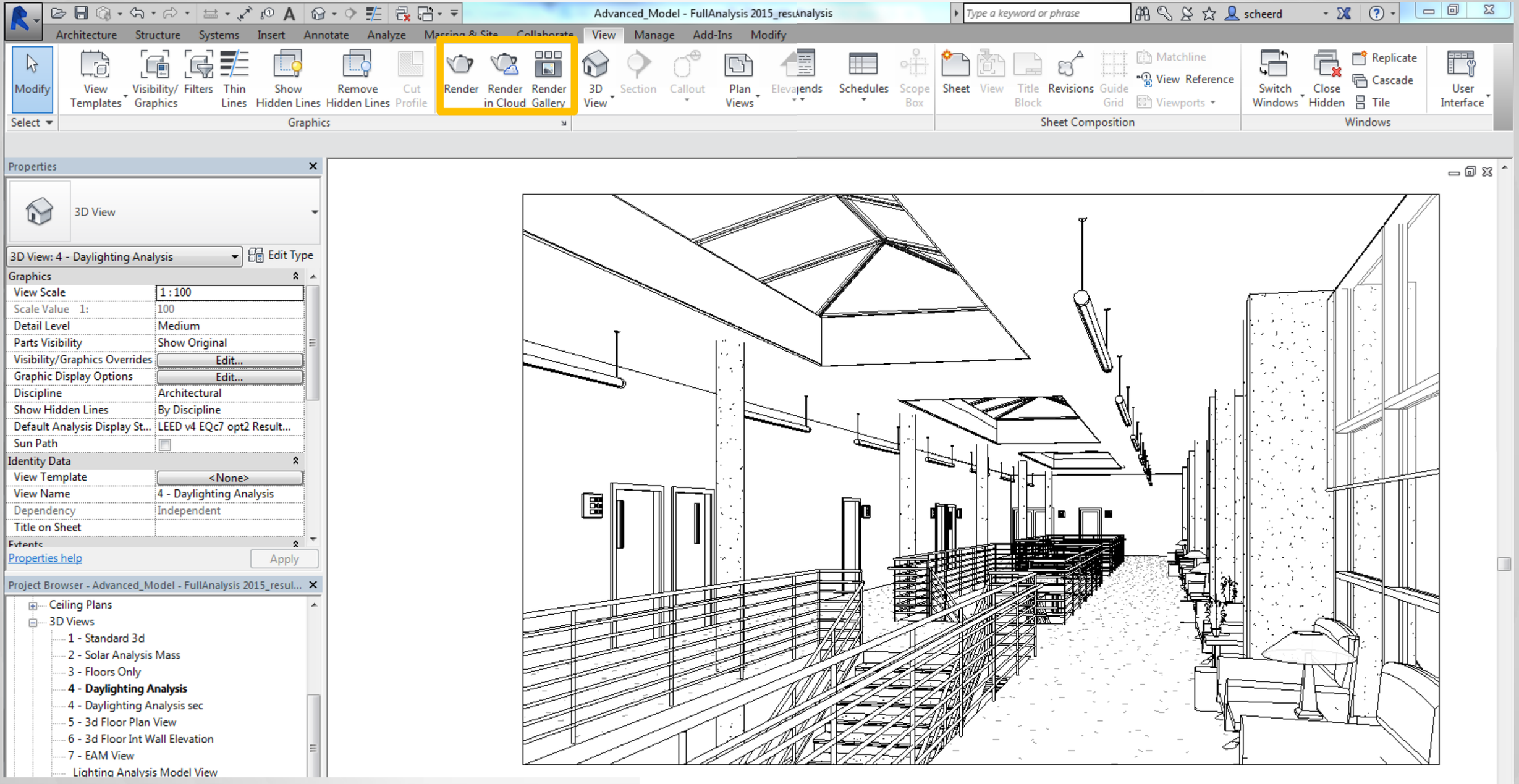
24	(-9.064781189, -75.306518555, 27.434383392)		
25	(-8.064758301, -75.306518555, 27.434383392)		
26	(-7.064739227, -75.306518555, 27.434383392)		
27	(-6.064716339, -75.306518555, 27.434383392)		
28	(-5.064693451, -75.306518555, 27.434383392)		
29	(4.935531616, -75.306518555, 27.434383392)		
30	(5.935554504, -75.306518555, 27.434383392)		
31	(6.935573578, -75.306518555, 27.434383392)		
32	(7.935596466, -75.306518555, 27.434383392)		
33	(8.935619354, -75.306518555, 27.434383392)	0	0
34	(9.935642242, -75.306518555, 27.434383392)	0	0
35	(10.935665131, -75.306518555, 27.434383392)	0	0
36	(11.935688019, -75.306518555, 27.434383392)	0	0
37	(12.935710907, -75.306518555, 27.434383392)	0	0

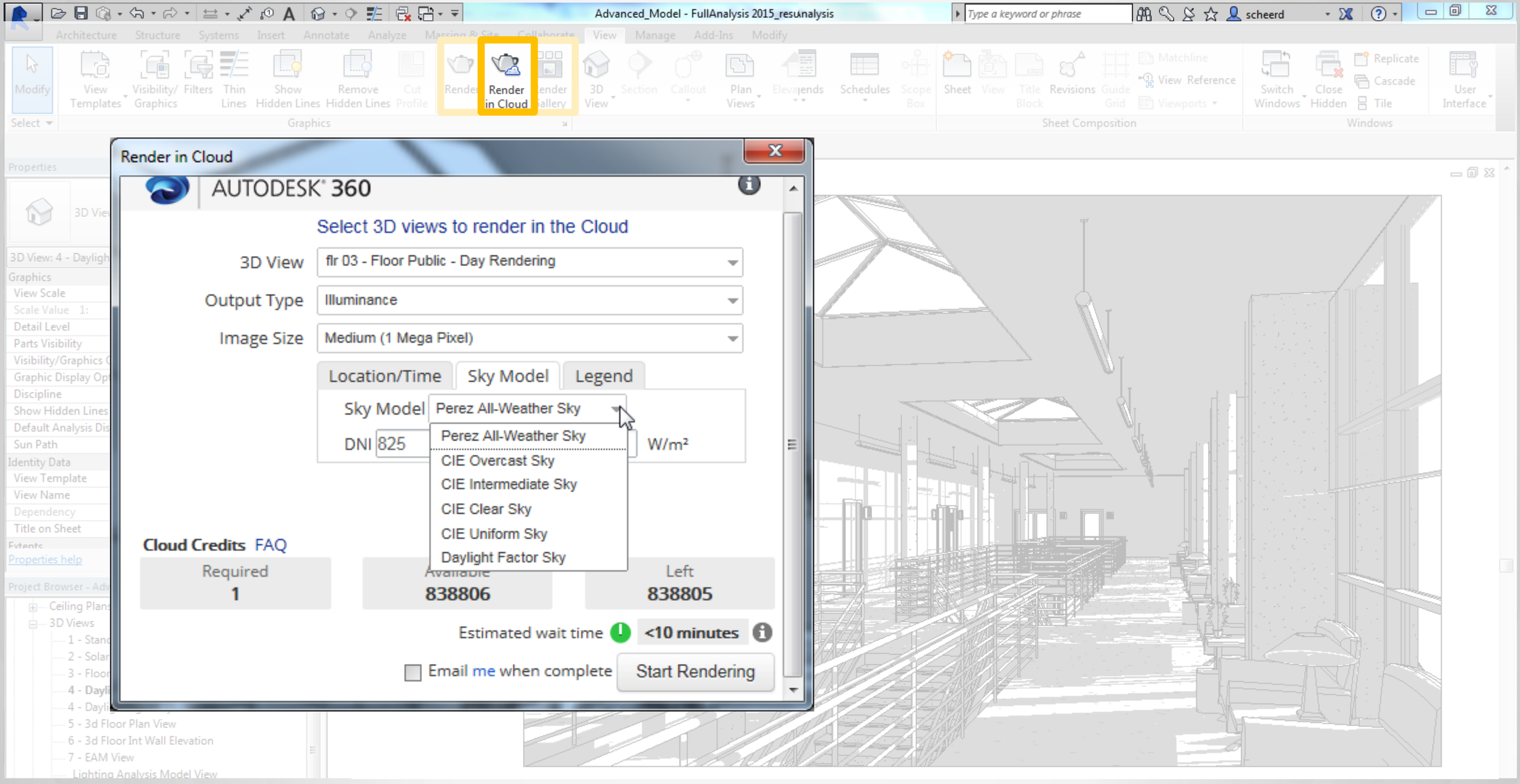


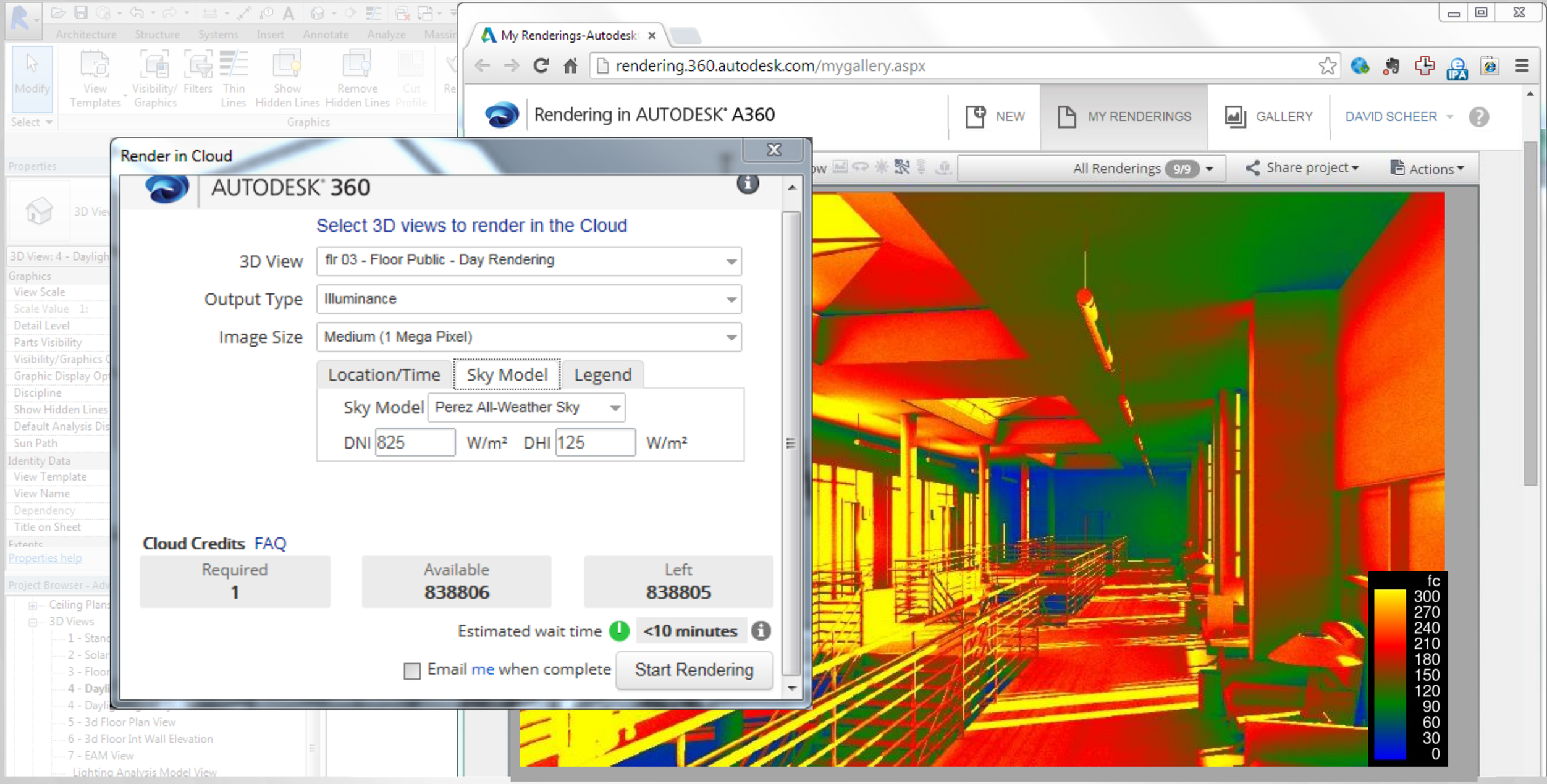
Section 3.0

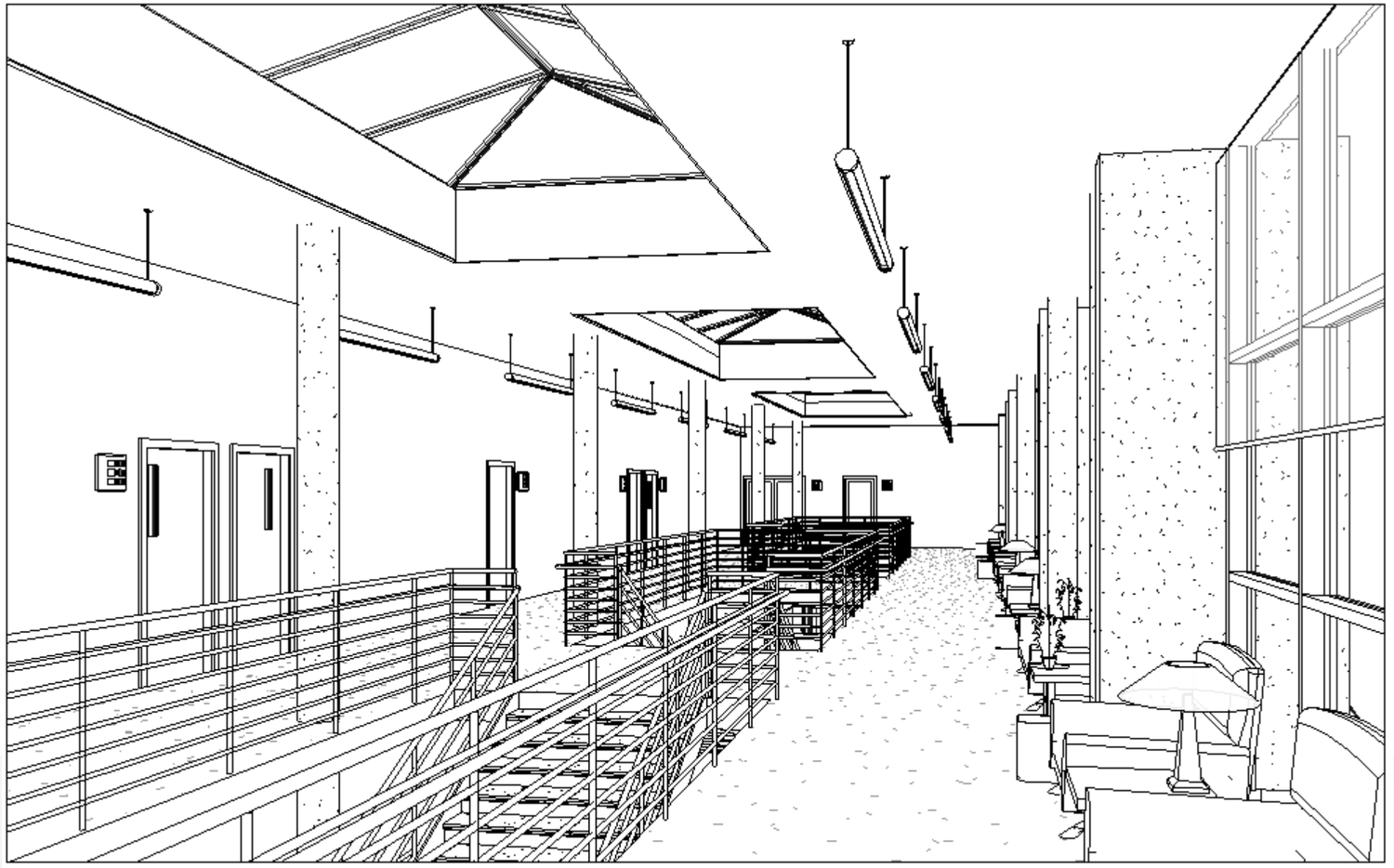
Lighting Analysis in Revit

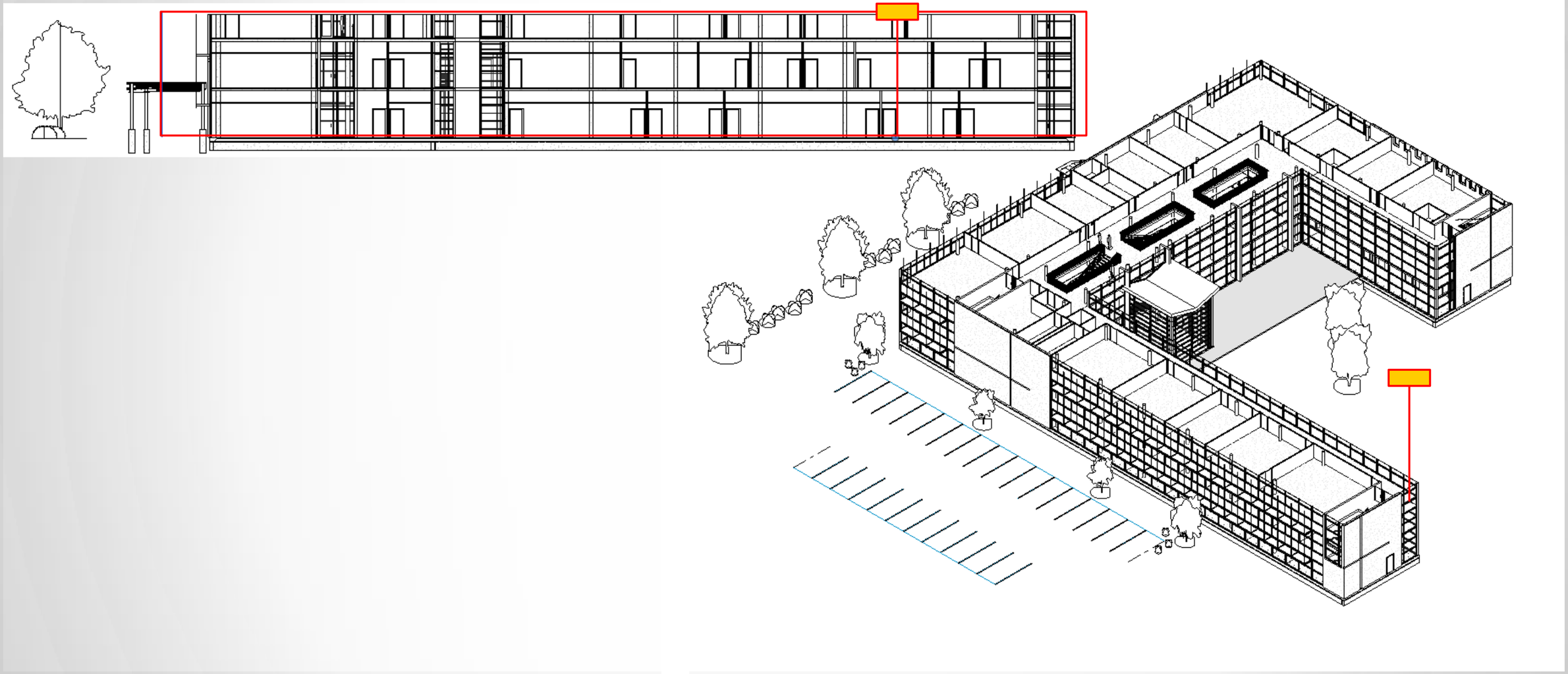
Rendering Illuminance Workflows


Advanced_Model - FullAnalysis 2015_resu\nalysis
Type a keyword or phrase
scheerd
Architecture
Structure
Systems
Insert
Annotate
Analyze
Massing & Site
Collaborate
View
Manage
Add-Ins
Modify
Modify
View Templates
Visibility/ Graphics
Filters
Thin Lines
Show Hidden Lines
Remove Hidden Lines
Cut Profile
Render
Render in Cloud
Render Gallery
3D View
Section
Callout
Plan Views
Elevations
Schedules
Scope Box
Sheet
View
Title Block
Revisions
Guide Grid
Matchline
View Reference
Viewports
Switch Windows
Close Hidden
Replicate
Cascade
Tile
User Interface
Select
Graphics
Sheet Composition
Windows
Properties
3D View
3D View: 4 - Daylighting Analysis
Edit Type
Graphics
View Scale
1 : 100
Scale Value 1:
100
Detail Level
Medium
Parts Visibility
Show Original
Visibility/Graphics Overrides
Edit...
Graphic Display Options
Edit...
Discipline
Architectural
Show Hidden Lines
By Discipline
Default Analysis Display St...
LEED v4 EQc7 opt2 Result...
Sun Path
Identity Data
View Template
<None>
View Name
4 - Daylighting Analysis
Dependency
Independent
Title on Sheet
Extents
Properties help
Apply
Project Browser - Advanced_Model - FullAnalysis 2015_resul...
Ceiling Plans
3D Views
1 - Standard 3d
2 - Solar Analysis Mass
3 - Floors Only
4 - Daylighting Analysis
4 - Daylighting Analysis sec
5 - 3d Floor Plan View
6 - 3d Floor Int Wall Elevation
7 - EAM View
Lighting Analysis Model View


Advanced_Model - FullAnalysis 2015_resanalysis
Render in Cloud
AUTODESK 360
Select 3D views to render in the Cloud
3D View
flr 03 - Floor Public - Day Rendering
Output Type
Illuminance
Image Size
Medium (1 Mega Pixel)
Location/Time
Sky Model
Legend
Sky Model
Perez All-Weather Sky
DNI 825
W/m²
Perez All-Weather Sky
CIE Overcast Sky
CIE Intermediate Sky
CIE Clear Sky
CIE Uniform Sky
Daylight Factor Sky
Cloud Credits FAQ
Required
1
Available
838806
Left
838805
Estimated wait time
<10 minutes
Email me when complete
Start Rendering


My Renderings-Autodesk
rendering.360.autodesk.com/mygallery.aspx
Rendering in AUTODESK® A360
NEW
MY RENDERINGS
GALLERY
DAVID SCHEER
All Renderings 9/9
Share project
Actions
Render in Cloud
AUTODESK® 360
Select 3D views to render in the Cloud
3D View
flr 03 - Floor Public - Day Rendering
Output Type
Illuminance
Image Size
Medium (1 Mega Pixel)
Location/Time
Sky Model
Legend
Sky Model
Perez All-Weather Sky
DNI 825 W/m²
DHI 125 W/m²
Cloud Credits FAQ
Required
1
Available
838806
Left
838805
Estimated wait time
<10 minutes
Email me when complete
Start Rendering
fc
300
270
240
210
180
150
120
90
60
30
0





Properties

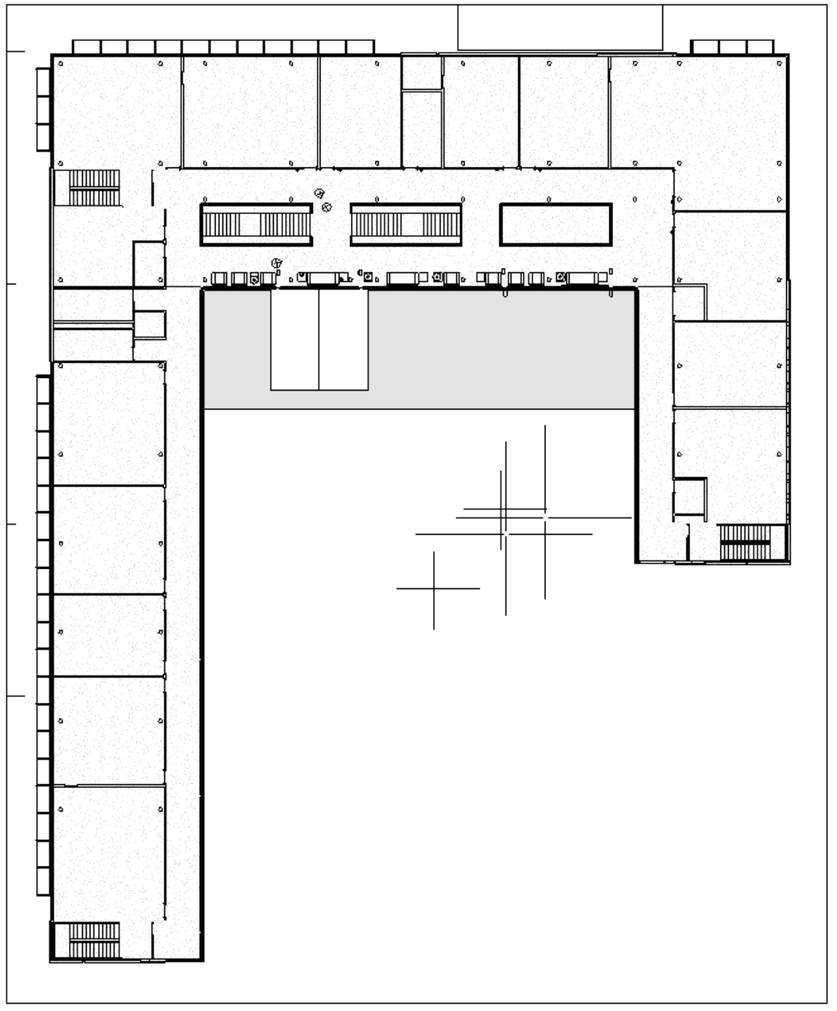
3D View

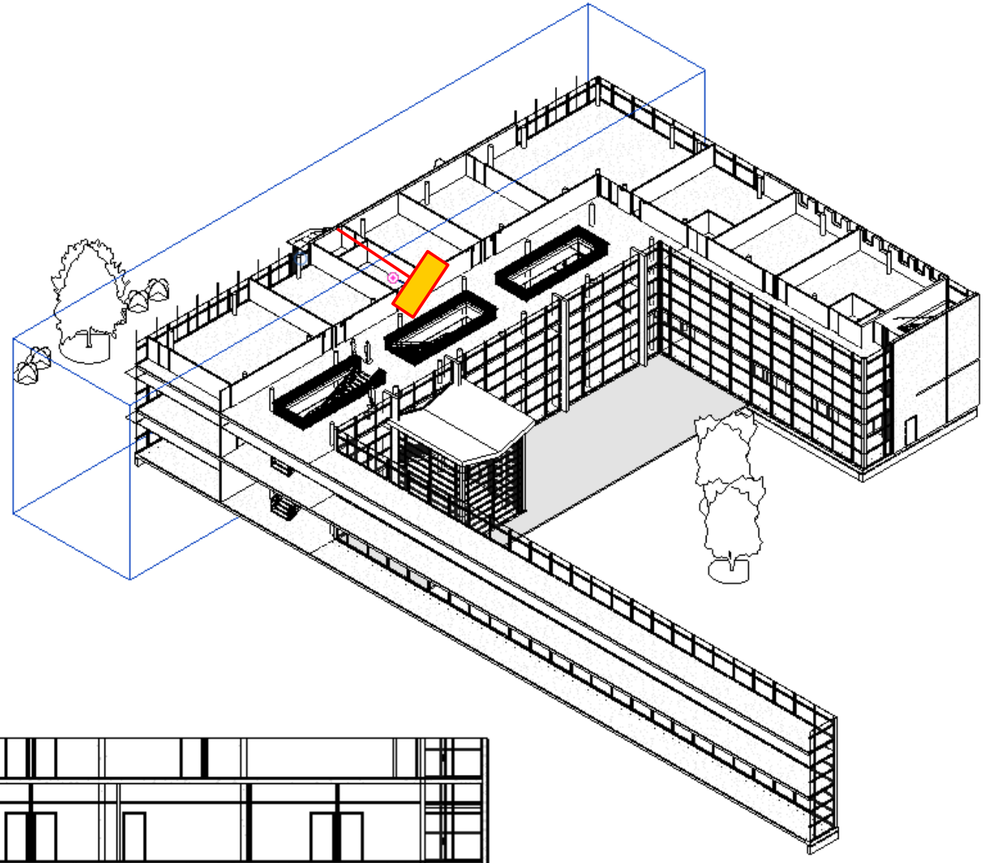
3D View: 5 - 3d Floor Plan View 05/12 090(| Edit Type

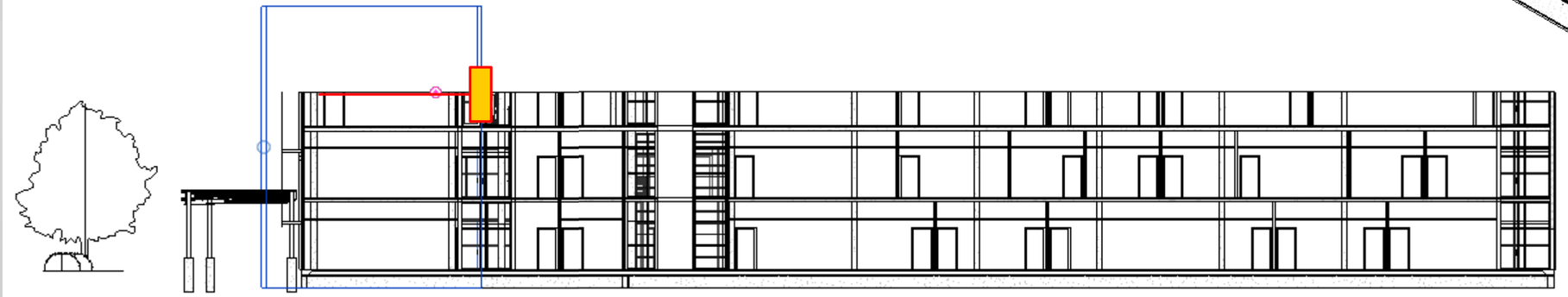
Title on Sheet	
Extents	
Crop Region Visible	☐
Annotation Crop	☐
Far Clip Active	☐
Far Clip Offset	6300.2
Section Box	☐
Crop View	☑
Camera	
Rendering Settings	Edit...
Locked Orientation	☐
Perspective	☐
Eye Elevation	9100.0
Target Elevation	0.0
Camera Position	Explicit

Project Browser - Advanced_Model - FullAnalysis 2015_work...

- Views (all)
  - Floor Plans
  - Ceiling Plans
  - 3D Views
    - 1 - Standard 3d
    - 2 - Solar Analysis Mass
    - 3 - LEED Daylighting
    - 4 - Daylighting Analysis
    - 4 - Floors Only
    - **5 - 3d Floor Plan View 05/12 0900**
    - 5 - 3d Interior Elevation 05/12 0900
    - 6 - EAM View - surfaces
    - 7 - EAM View - glazing
    - 8 - EAM View - spaces
    - 9 - EAM View - spaces1







Properties

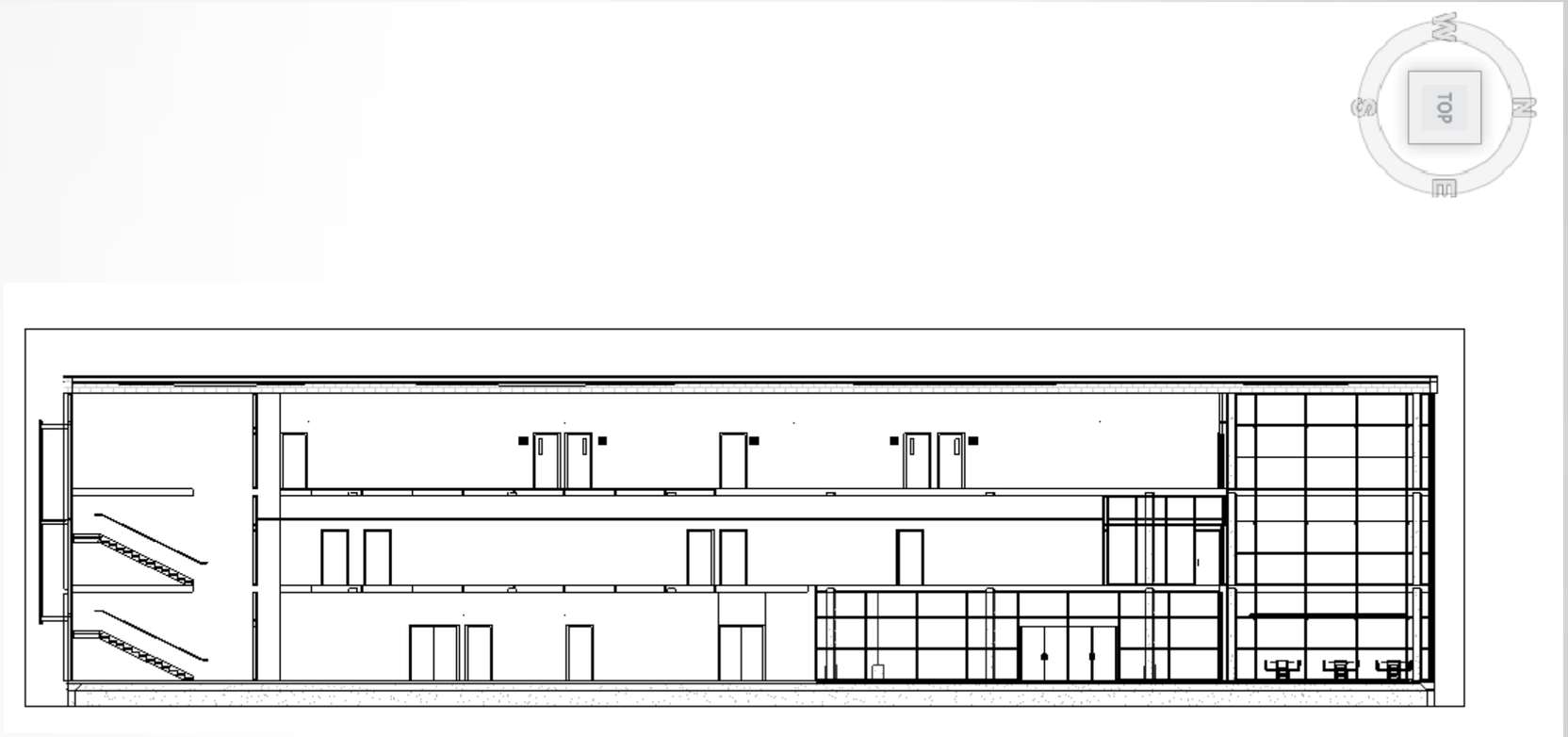
3D View

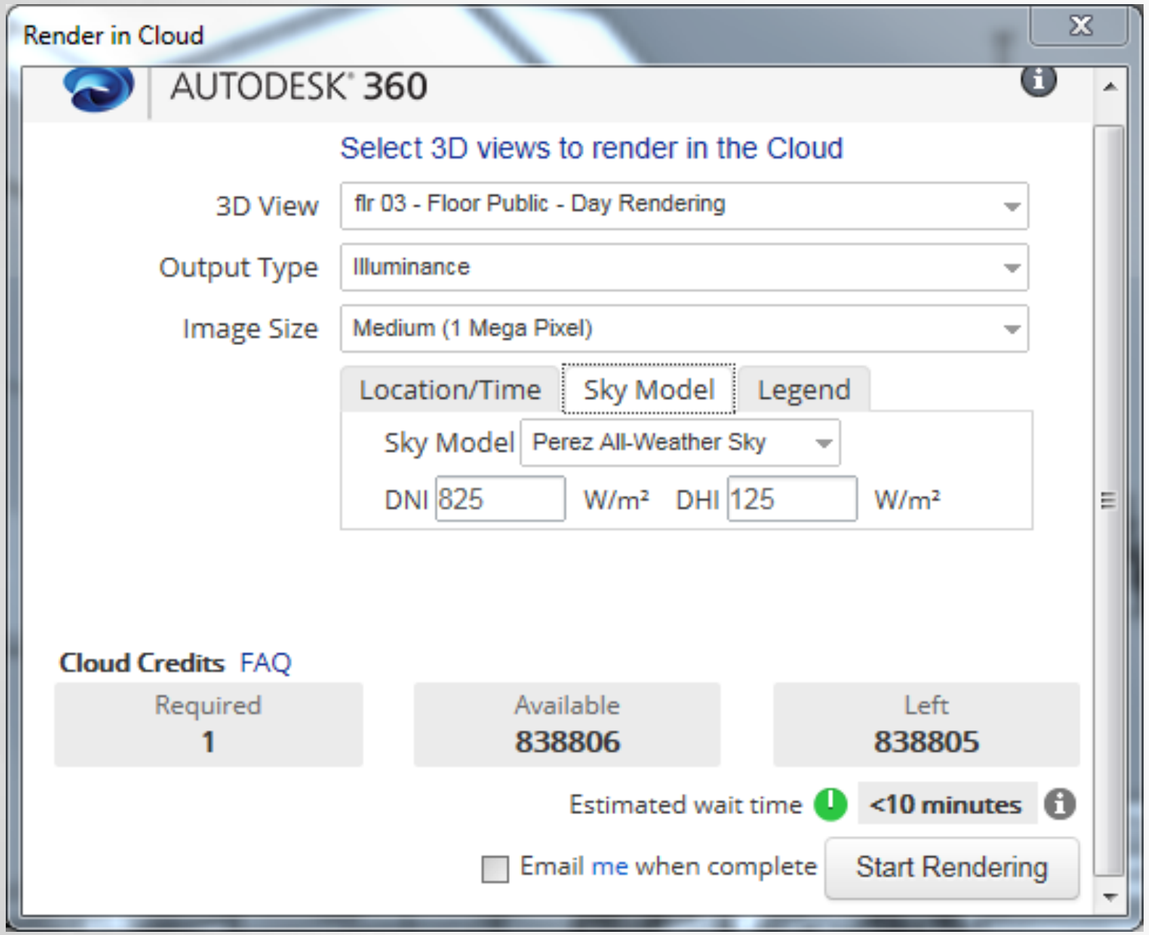
3D View: 6 - 3d Floor Int Wall Elevation | Edit Type

Title on Sheet	
Extents	
Crop Region Visible	☑
Annotation Crop	☐
Far Clip Active	☑
Far Clip Offset	11464.9
Section Box	☐
Crop View	☑
Camera	
Rendering Settings	Edit...
Locked Orientation	☐
Perspective	☐
Eye Elevation	9350.0
Target Elevation	9350.0
Camera Position	Explicit

Project Browser - Advanced_Model - FullAnalysis 2015_resul...

- Ceiling Plans
- 3D Views
  - 1 - Standard 3d
  - 2 - Solar Analysis Mass
  - 3 - Floors Only
  - 4 - Daylighting Analysis
  - 4 - Daylighting Analysis sec
  - 5 - 3d Floor Plan View
  - **6 - 3d Floor Int Wall Elevation**
  - 7 - EAM View
  - _Lighting Analysis Model View
  - flr 03 - Floor Public - Day Rendering
  - flr 03 - Floor Public - Night Rendering
  - From Parking Area
- Elevations (Building Elevation)



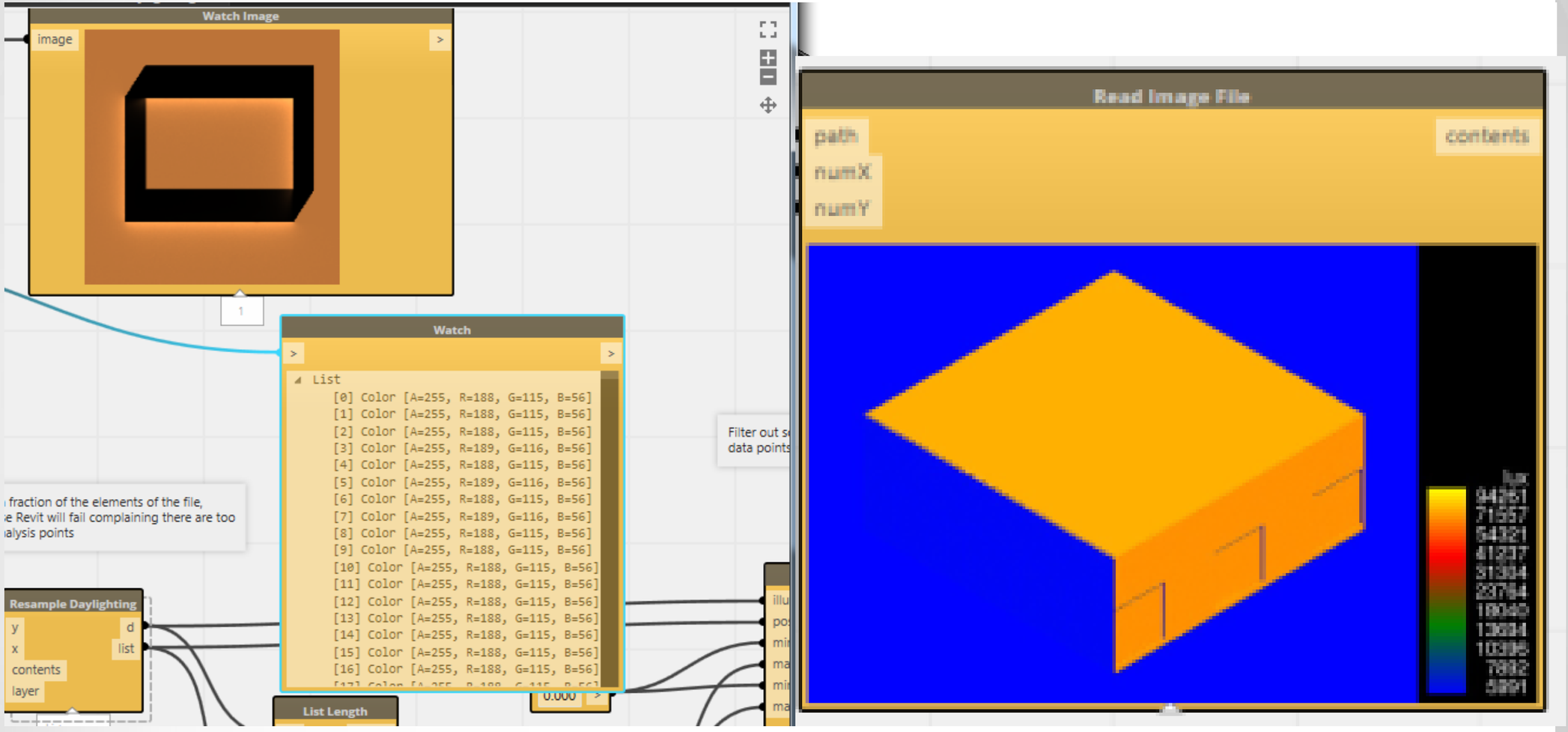


RENDER GALLERY

Section 4.0

Lighting Analysis in Revit

Dynamo Nodes for Daylighting


Watch Image
image
1
Watch
List
[0] Color [A=255, R=188, G=115, B=56]
[1] Color [A=255, R=188, G=115, B=56]
[2] Color [A=255, R=188, G=115, B=56]
[3] Color [A=255, R=189, G=116, B=56]
[4] Color [A=255, R=188, G=115, B=56]
[5] Color [A=255, R=189, G=116, B=56]
[6] Color [A=255, R=188, G=115, B=56]
[7] Color [A=255, R=189, G=116, B=56]
[8] Color [A=255, R=188, G=115, B=56]
[9] Color [A=255, R=188, G=115, B=56]
[10] Color [A=255, R=188, G=115, B=56]
[11] Color [A=255, R=188, G=115, B=56]
[12] Color [A=255, R=188, G=115, B=56]
[13] Color [A=255, R=188, G=115, B=56]
[14] Color [A=255, R=188, G=115, B=56]
[15] Color [A=255, R=188, G=115, B=56]
[16] Color [A=255, R=188, G=115, B=56]
fraction of the elements of the file,
e Revit will fail complaining there are too
alysis points
Resample Daylighting
y
x
contents
layer
d
list
List Length
0.000
Filter out s
data points
Read Image File
path
numX
numY
contents
lux
94361
71557
54321
41237
31304
23764
18040
13694
10396
7892
5991

Section 5.0

Lighting Analysis in Revit

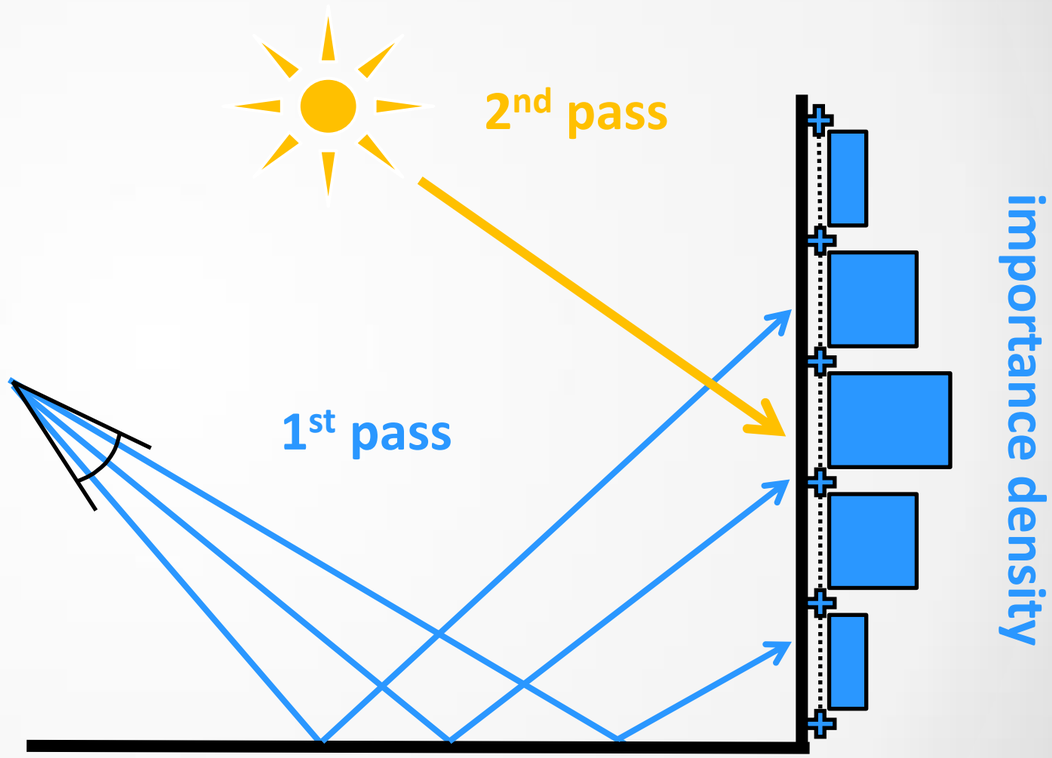
Validation

Proprietary engine based on Multi-dimensional Lightcuts

Many Lights Algorithm
Virtual Point Lights

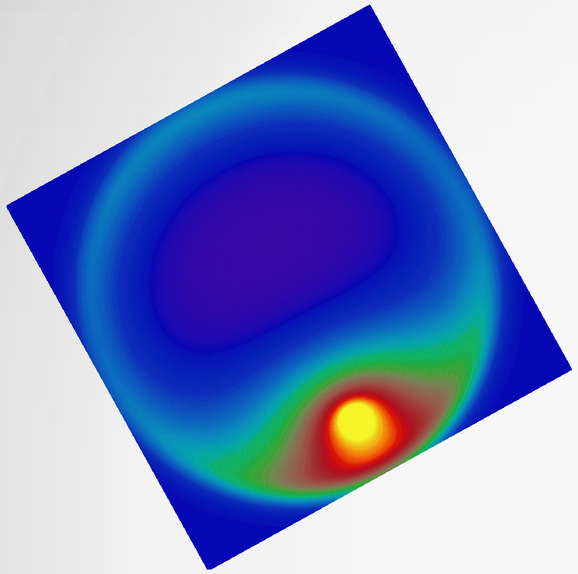
Two-pass Algorithm

1. Trace eye ray samples
2. Build importance function using eye sample density
3. Use importance function to reject VPLs with Russian roulette

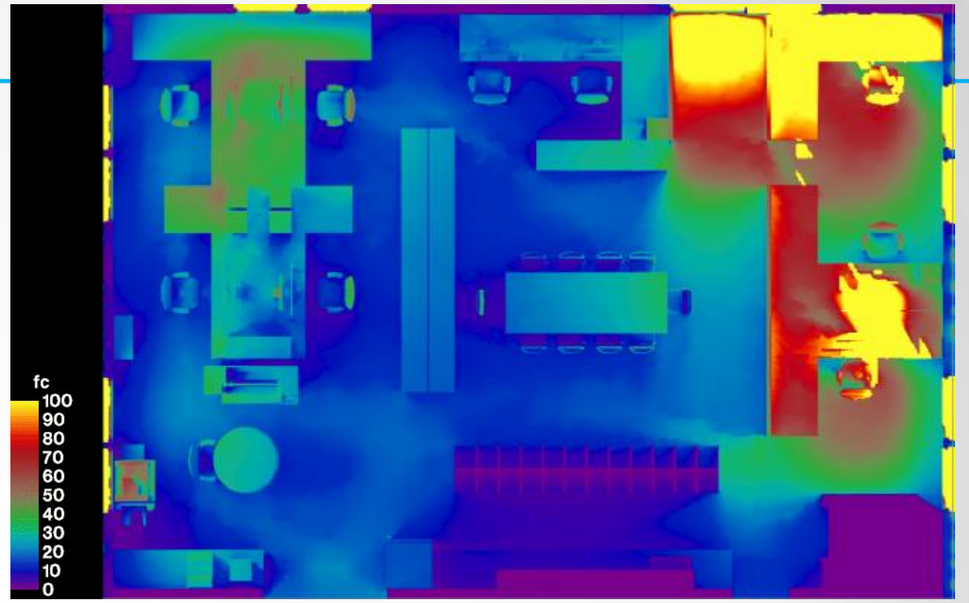


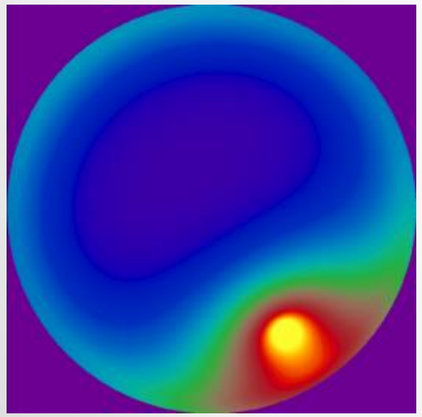
Per Christensen. *Adjoints and Importance in Rendering: An Overview*. TVCG 2003.
Georgiev et al. *Simple and Robust Iterative Importance Sampling of Virtual Point Lights*. EG 2010.
MultiDimensional Lightcuts - http://www.graphics.cornell.edu/~bjw/mdlc.pdf

Under the Skin | Validation

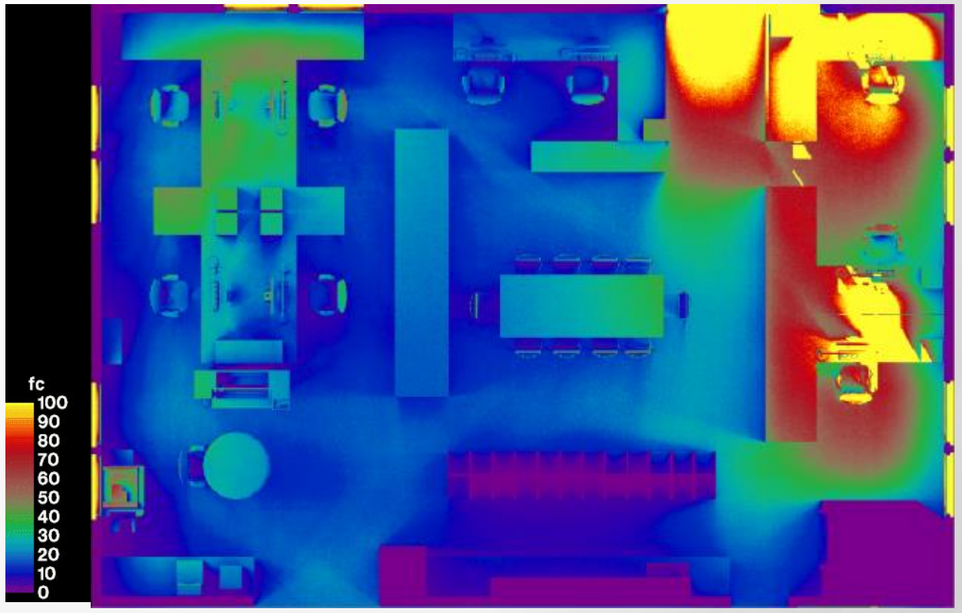


Radiance





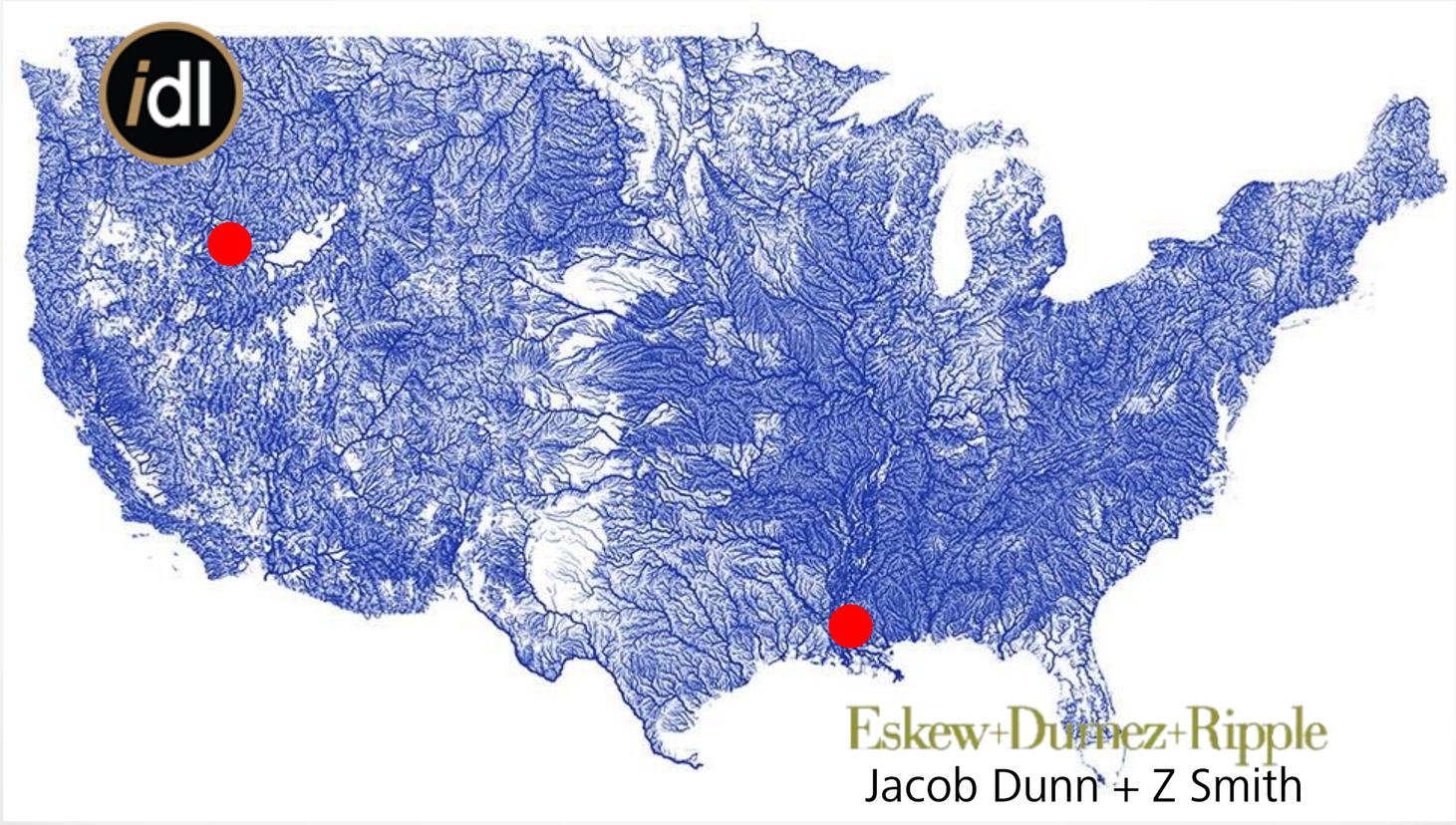
Rendering



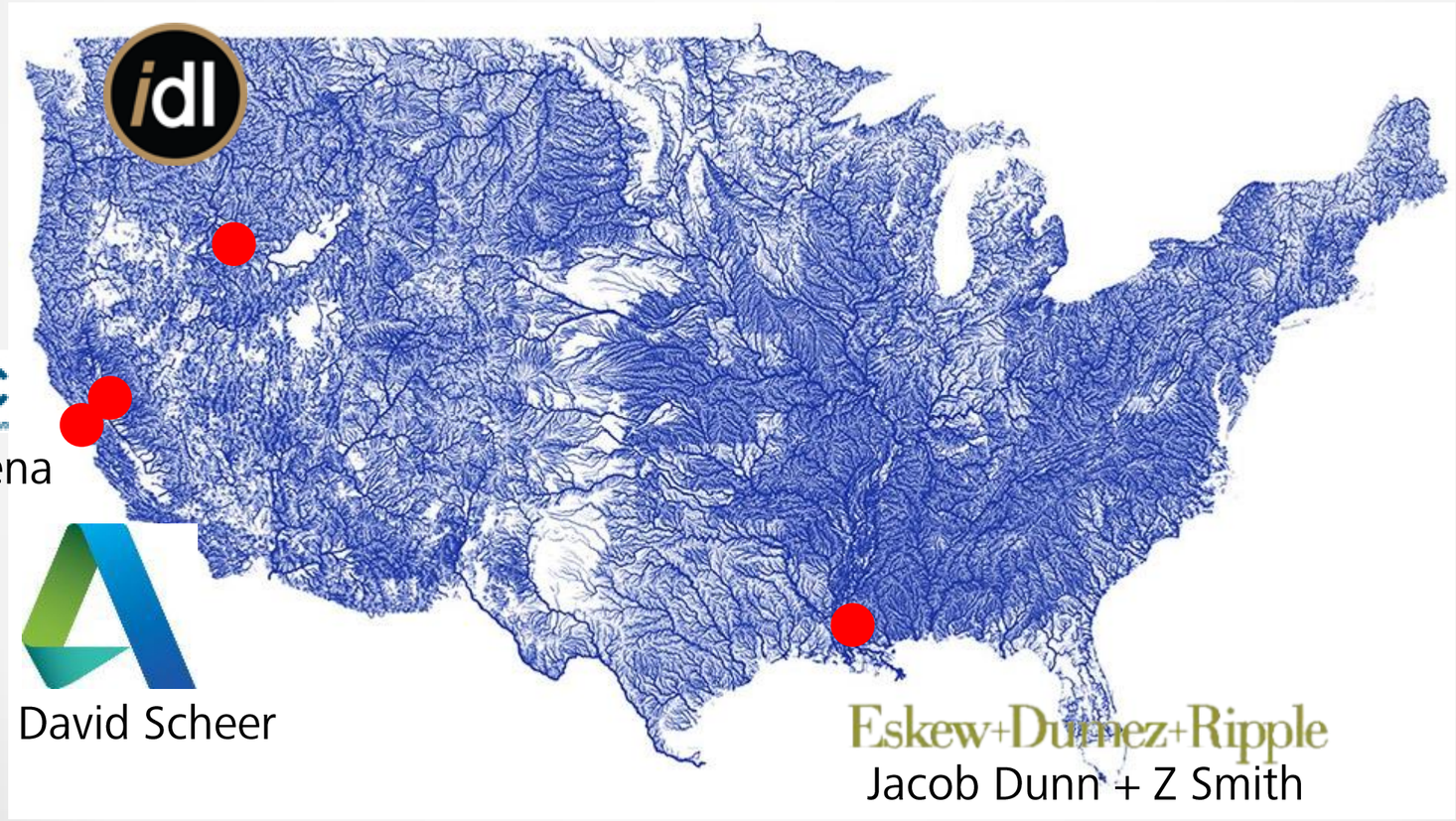
Office, Alamed

Loi Desautbert 2

Under the Skin | Validation

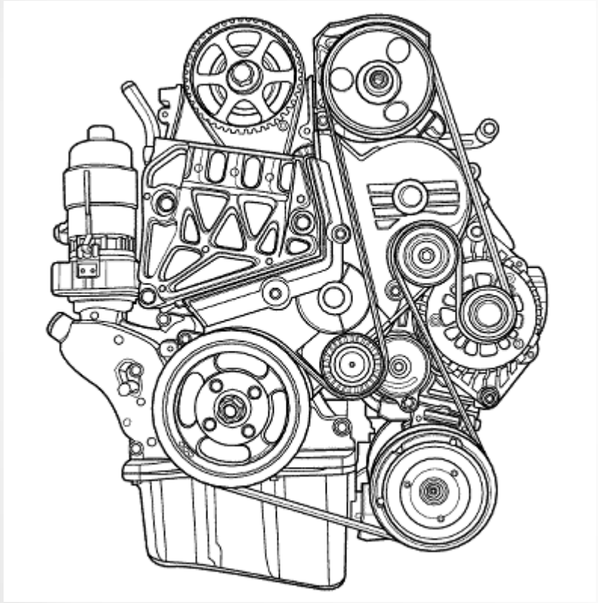


Under the Skin | Validation



Under the Skin | Validation

GOALS

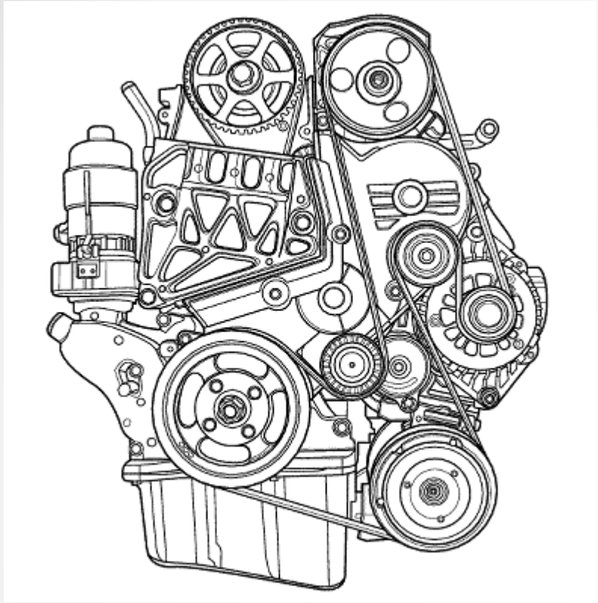


+

Engine Validation

Workflow Validation

Under the Skin | Validation



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Engine Validation

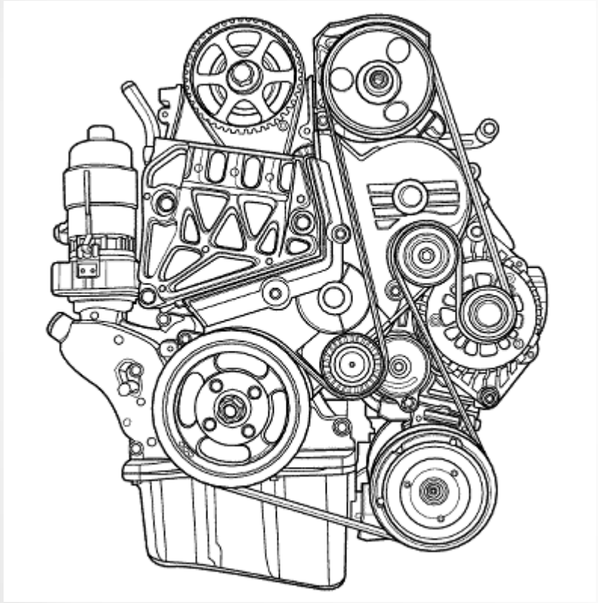
- Christoph-Breton
  3ds max validation paper
- NRC methodology

Workflow Validation

- Comparisons on real world models (61 TRC/HMG PIER study)
- Sensitivity studies (windows, thresholds, site, linked models, etc.)

Under the Skin | Validation

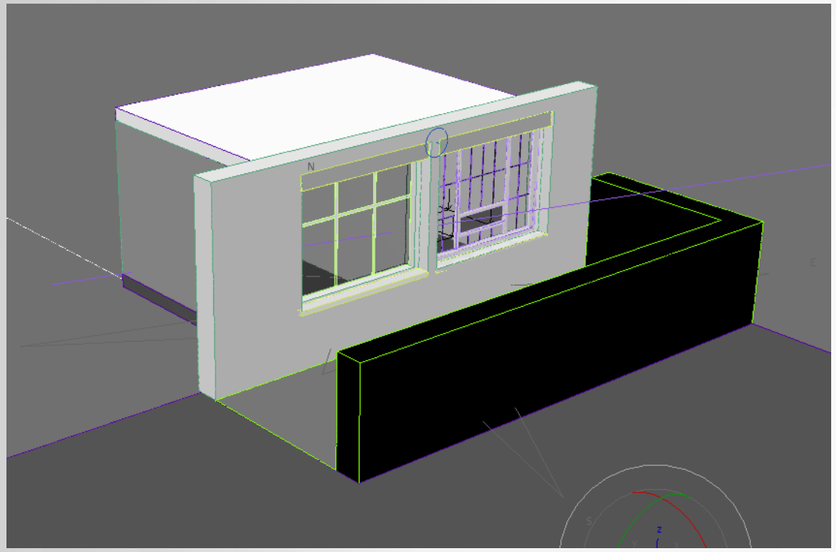
GOALS



Engine Validation

1. Supplement to Christoph-Breton 3ds max validation
2. The Test Bed - NRC Daylighting Lab – Measured and simulation results
3. Statistical comparisons

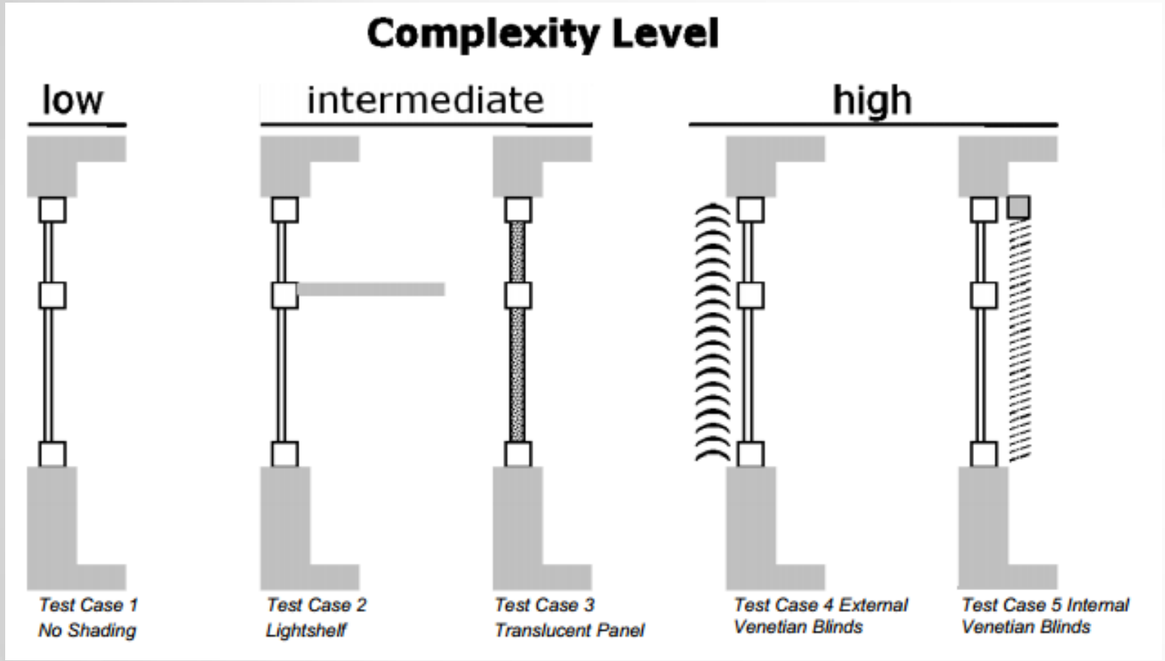
Under the Skin | Validation - Engine



The Test Bed - NRC Daylighting Lab

- well documented
- measured irradiance values
- simple

Under the Skin | Validation - Engine



5 test cases

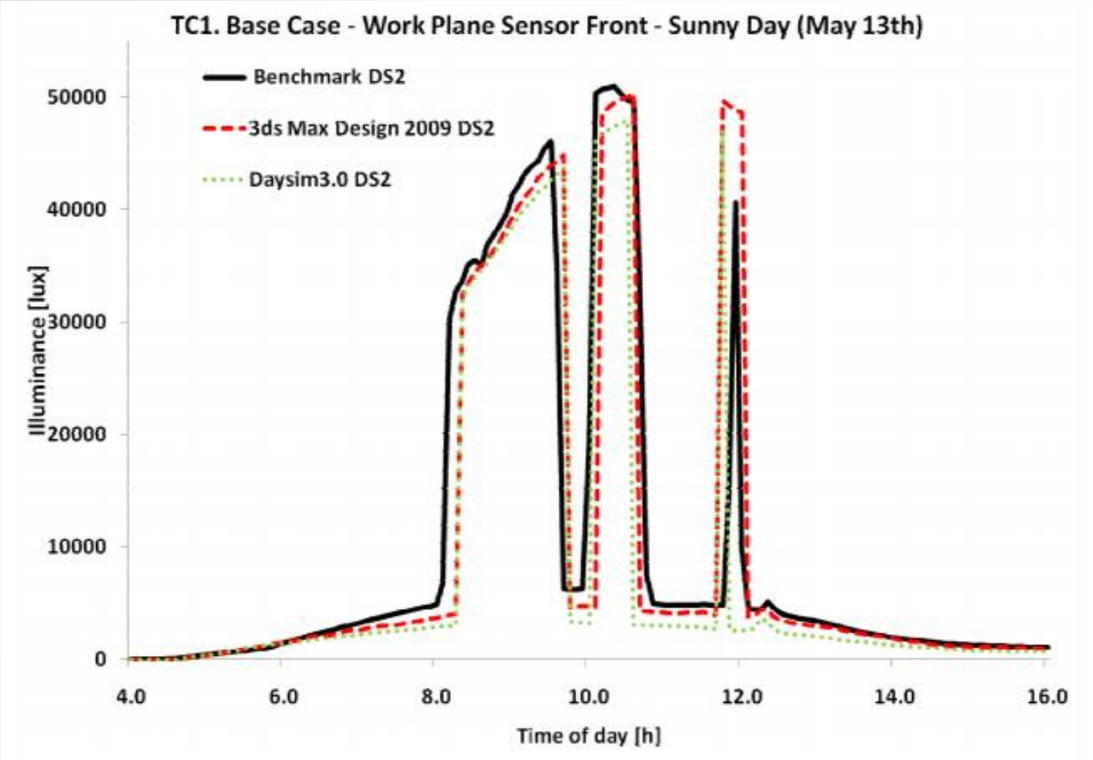
X 70 days

4am-4pm

15-minute time steps
multiple sensor pts

Under the Skin | Validation - Engine

2 types of analysis



Test Case		MBE [outside illuminance > 1000 lux]				RMSE [outside illuminance > 1000 lux]			
TC.0 Outside Sensor	3dsMax	9				17			
	Daysim	7				14			
		Work Plane		Ceiling		Work Plane		Ceiling	
		Front	Back	Front	Back	Front	Back	Front	Back
TC.1 No Shading Device	3dsMax	11	6	-5	18	110 (28)	29	28	28
	Daysim	-11	-4	-16	-7	73 (31)	24	34	22
TC.2 Lightshelf	3dsMax	2	8	13	20	24	28	21	28
	Daysim	-10	-2	1	0	26	21	21	20
TC.3 Translucent Panel	3dsMax	-22	-28	-18	-39	25	30	22	40
	Daysim	4	10	8	1	15	21	20	17
TC.4 External Blinds	3dsMax	20	18	6	15	41	30	24	27
	Daysim	-6	-12	7	11	21	24	22	25
TC.5 Internal Blinds	3dsMax	-12	2	-12	-16	49	25	32	28
	Daysim	-31	-12	-27	-3	34	26	32	25

$$MBE = \frac{1}{N}\sum_{i=1}^{N}\frac{\left(x_{test,i} - x_{ref,i}\right)}{x_{ref,i}}$$

$$RMSE = \frac{1}{N}\sqrt{\sum_{i=1}^{N}\left(\frac{\left(x_{test,i} - x_{ref,i}\right)^2}{x_{ref,i}^2}\right)}$$

Under the Skin | Validation - Workflow

GOALS

1. Real world models
2. Sensitivity Studies
3. LEED % values, threshold distributions, building section illuminance profiles

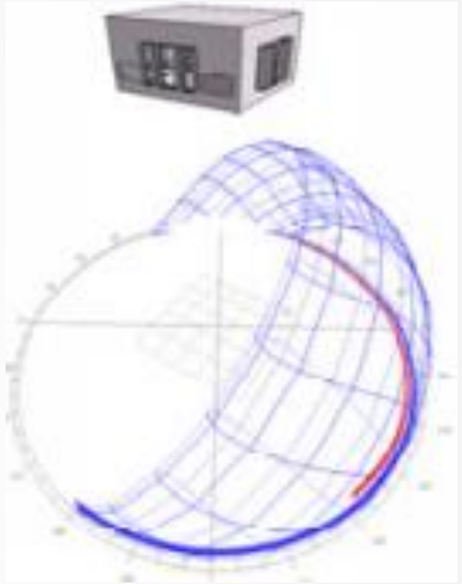
+

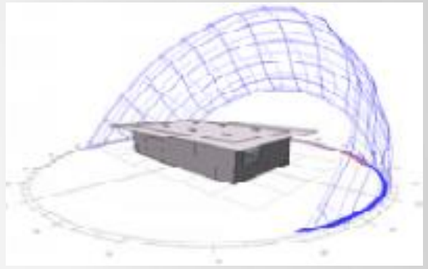
Workflow Validation

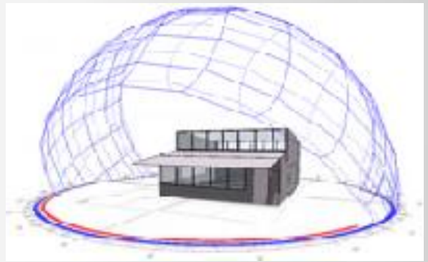
Under the Skin | Validation - Workflow

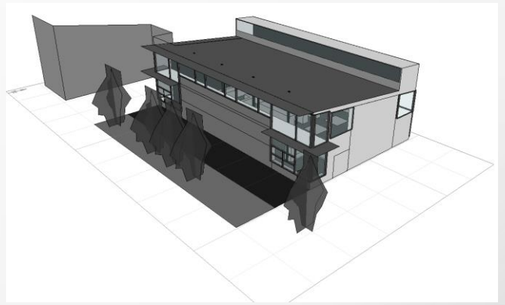
1. Real World Models

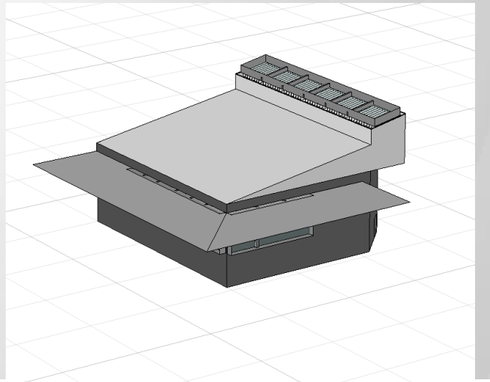
- 61 Public Interest Energy Research (PIER) models from TRC/HMG
  (buildings used for the study that led to IES-LM83 daylighting standard metrics of sDA and ASE)
- Includes field studies from 6 cities
- Annual simulation data available







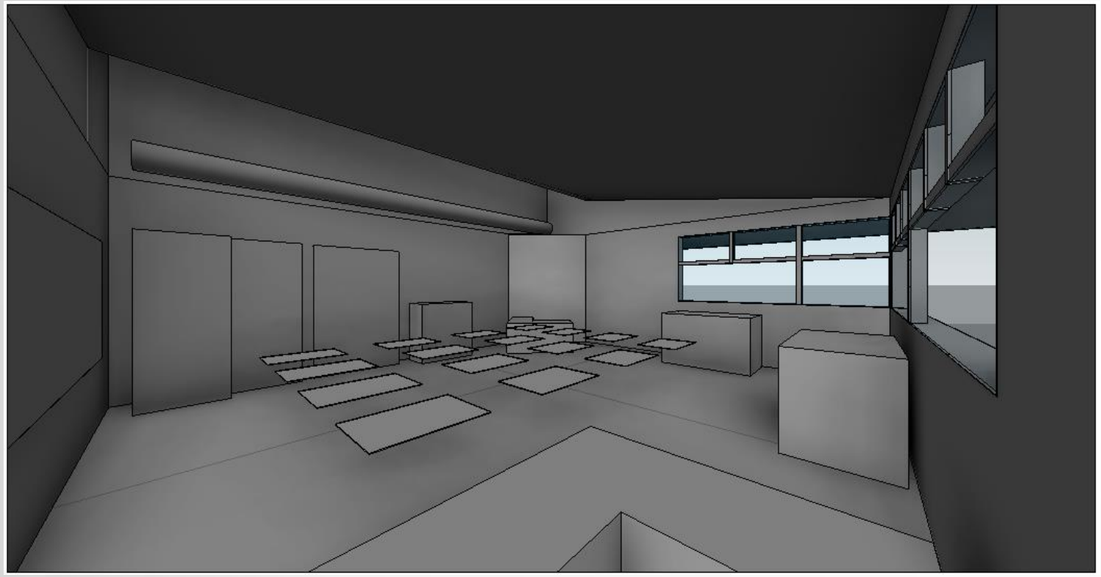


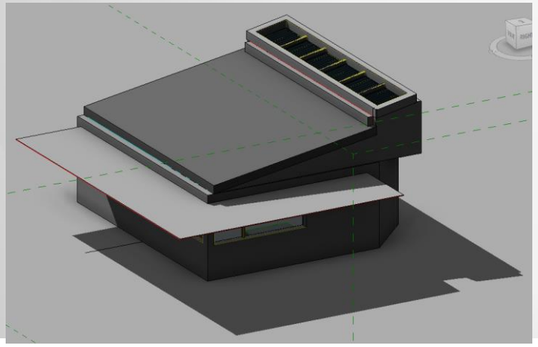


Under the Skin | Validation - Workflow

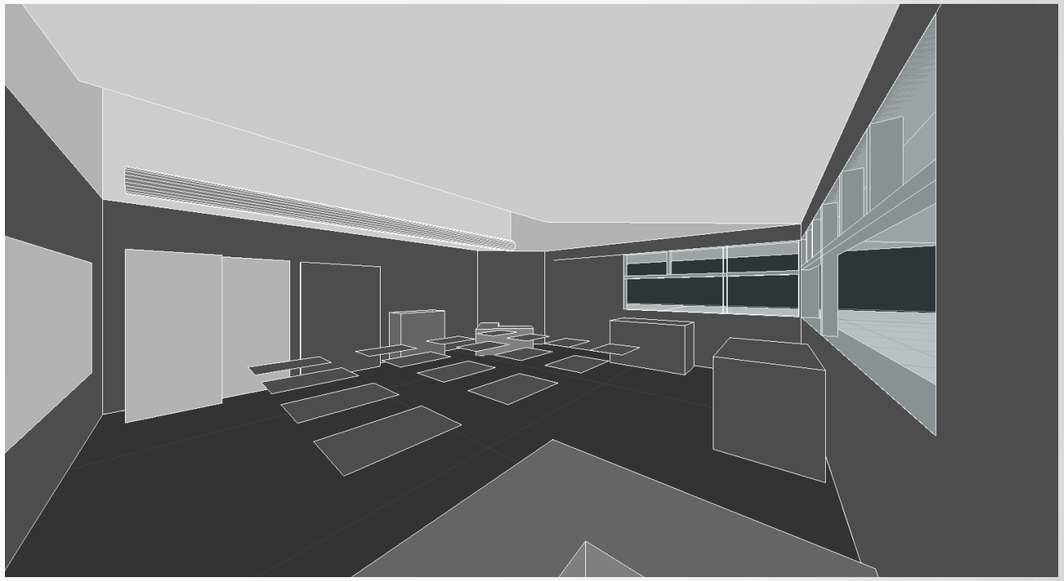
MODEL 1 (2-SIDED GLAZING, SKYLIGHT, BAFFLES, NO DIRECT SUN)

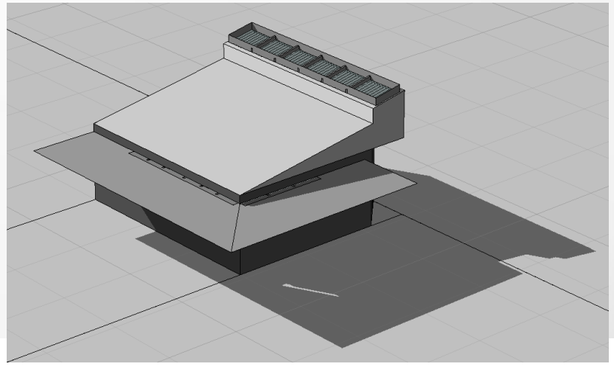
LAR





ECOTECT/RADIANCE

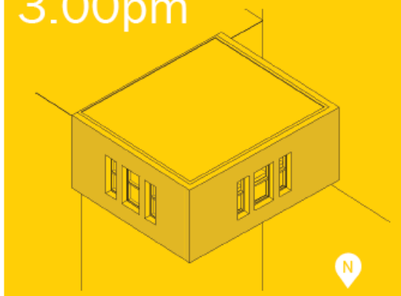




LAR to Radiance

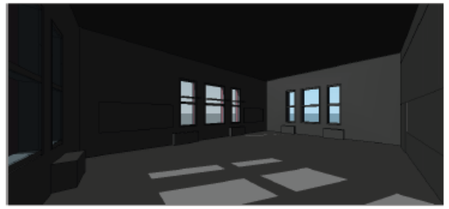
NYC05

Initial Comparison 3.00pm



AXON PERSPECTIVE

INTERIOR PERSPECTIVE

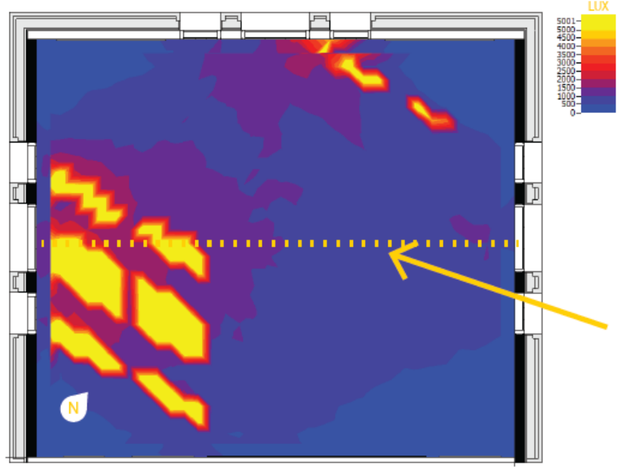


9 /21 / 3.00PM

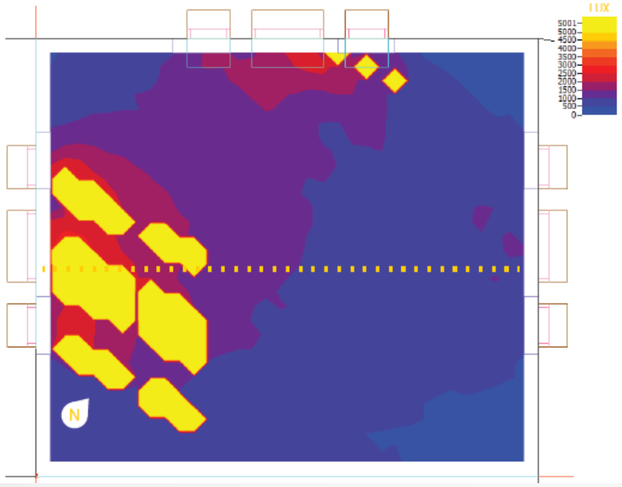
LAR	RAD	% DIF
87%	93%	7%

X > 300 LUX

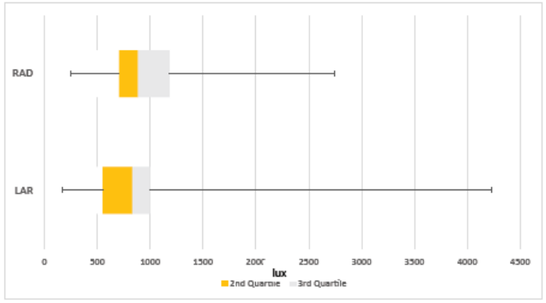
LAR ILLUMINANCE GRID



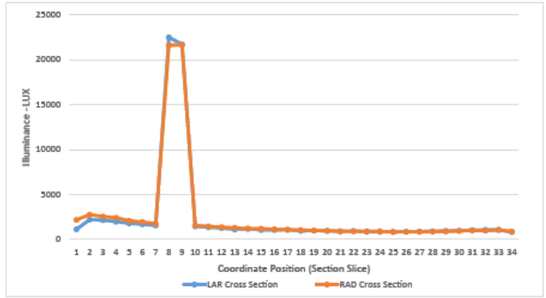
RADIANCE ILLUMINANCE GRID



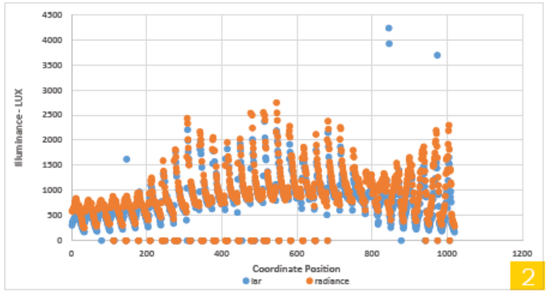
ILLUMINACE DISTRIBUTION



CROSS SECTION ANALYSIS



SCATTERPLOT OF ALL SENSORS



2

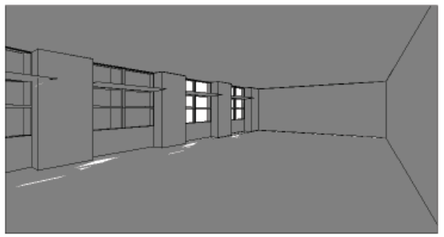
LAR to Radiance

SMF04

Initial Comparison 3.00pm

AXON PERSPECTIVE

INTERIOR PERSPECTIVE

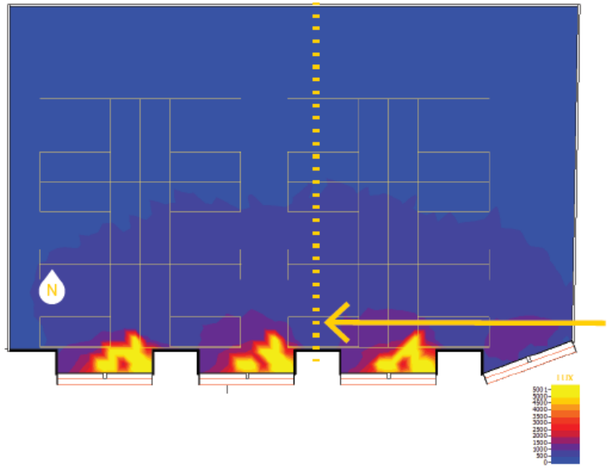


9 /21 / 3.00PM

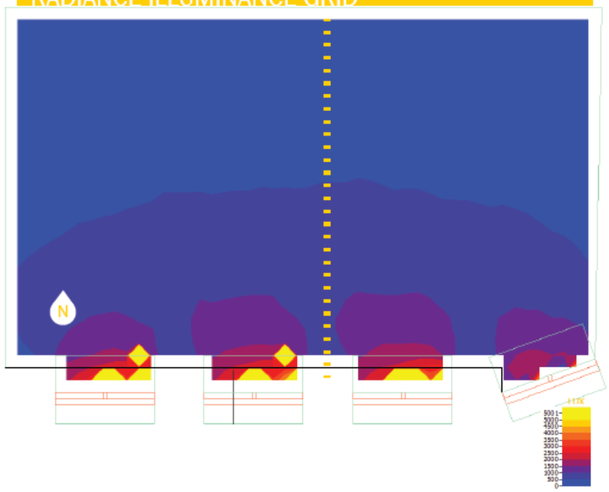
LAR	RAD	% DIF
38%	46%	17%

X > 500 LUX

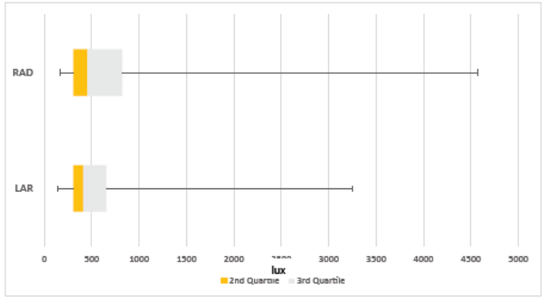
LAR ILLUMINANCE GRID



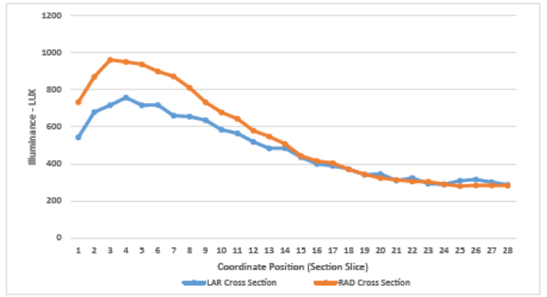
RADIANCE ILLUMINANCE GRID



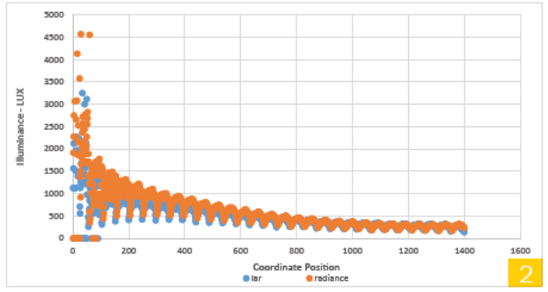
ILLUMINACE DISTRIBUTION



CROSS SECTION ANALYSIS



SCATTERPLOT OF ALL SENSORS

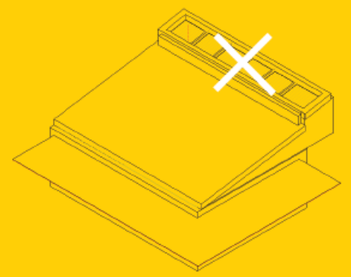


2

LAR to Radiance

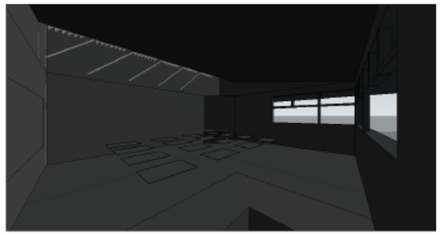
SMF06b

No Skylight



AXON PERSPECTIVE

INTERIOR PERSPECTIVE

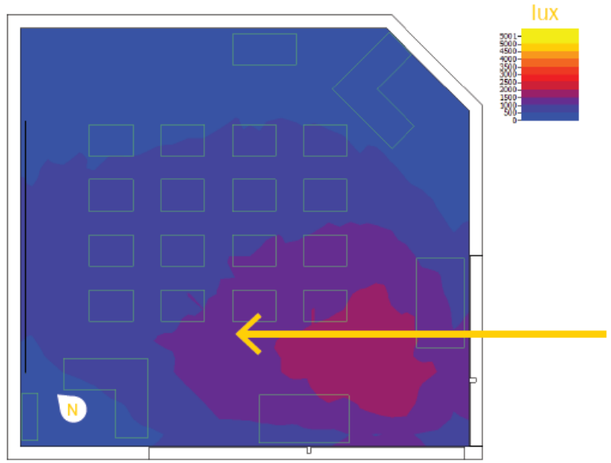


9 /21 / 9.00AM

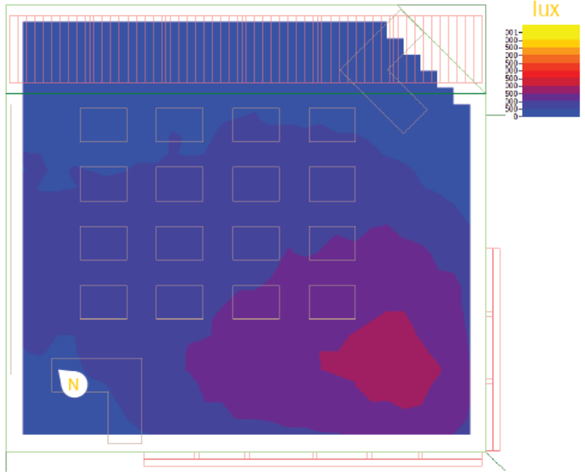
LAR	RAD	% DIF
93%	89%	5%

X > 1000 LUX

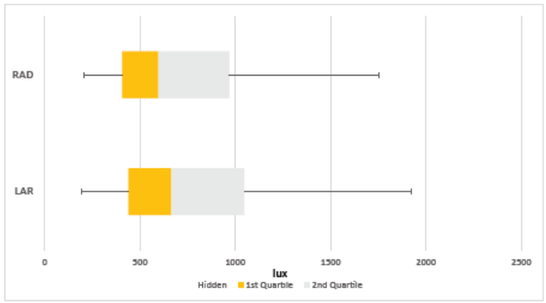
LAR ILLUMINANCE GRID



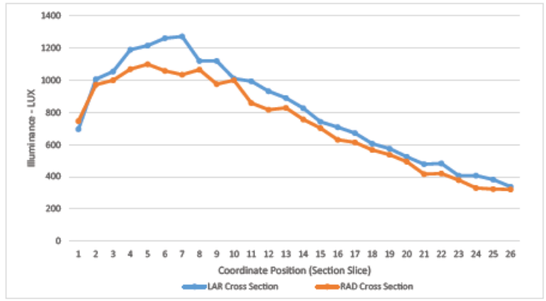
RADIANCE ILLUMINANCE GRID



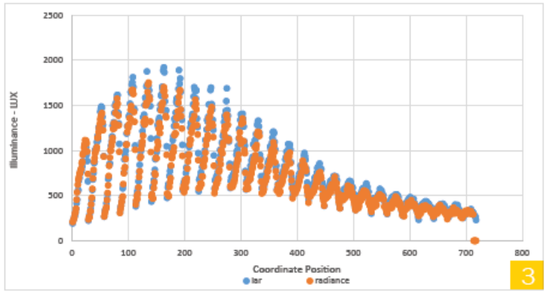
ILLUMINACE DISTRIBUTION



CROSS SECTION ANALYSIS



SCATTERPLOT OF ALL SENSORS

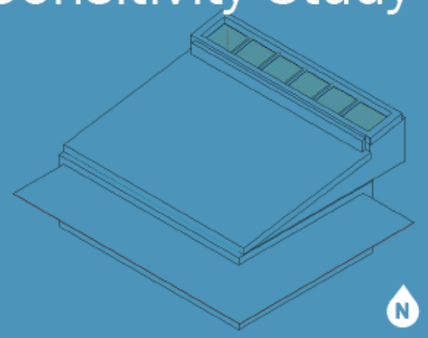


3

LAR to Radiance

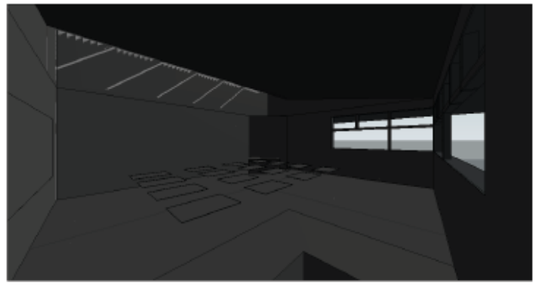
SMF06

Blind Spacing Sensitivity Study

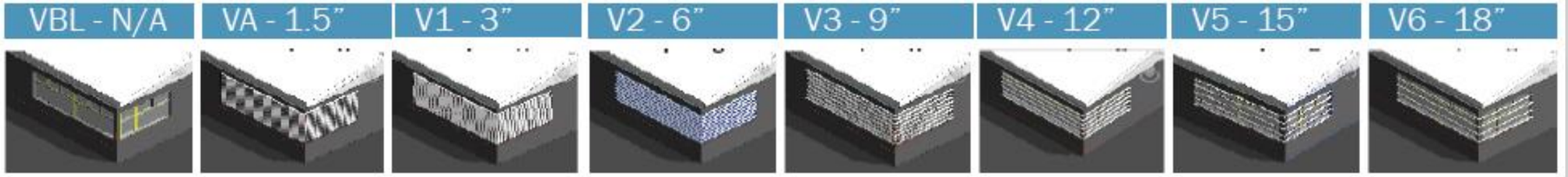


AXON PERSPECTIVE

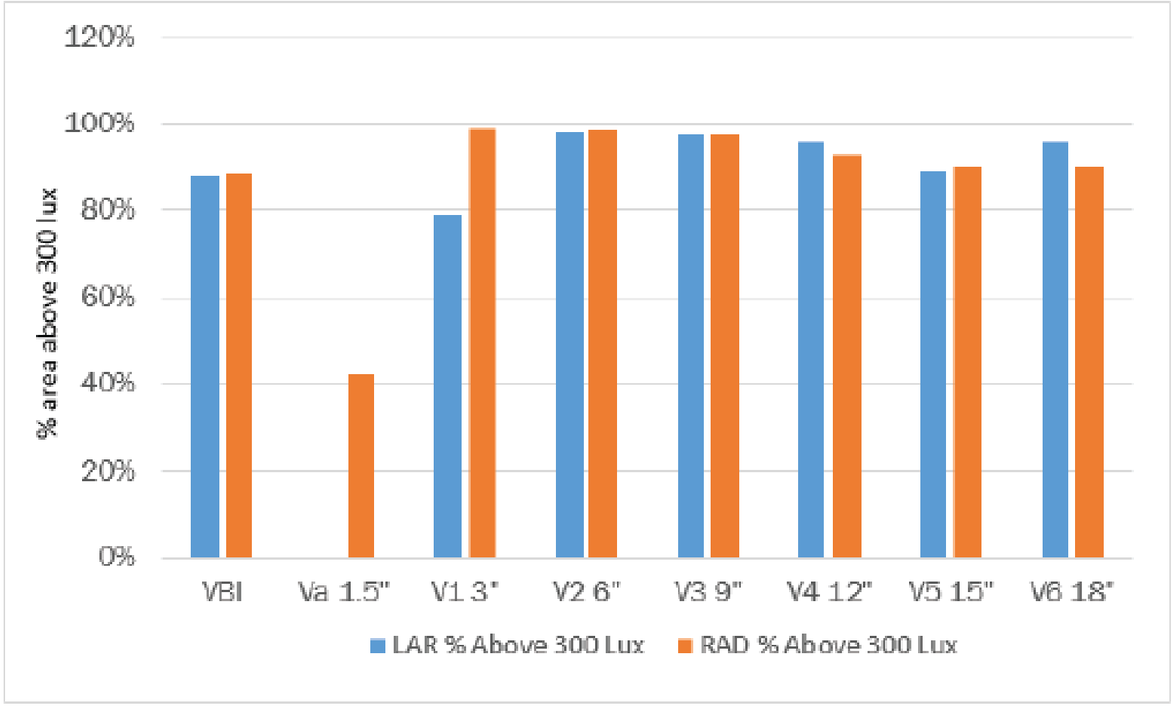
INTERIOR PERSPECTIVE



9 /21 / 9.00AM



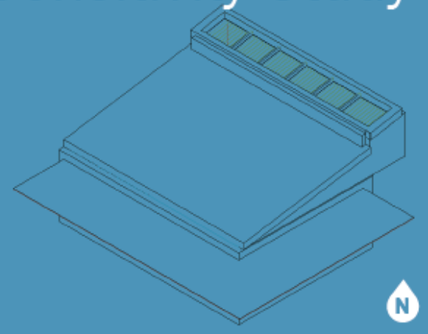
% AREA ABOVE 300 LUX



Sensitivity

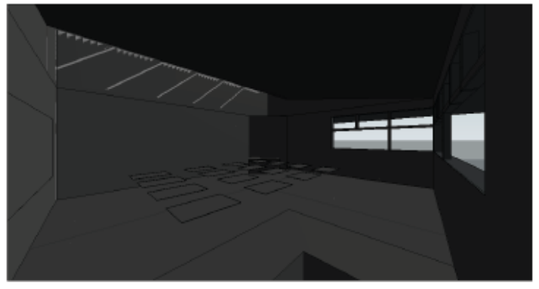
SMF06

Blind Spacing Sensitivity Study



AXON PERSPECTIVE

INTERIOR PERSPECTIVE

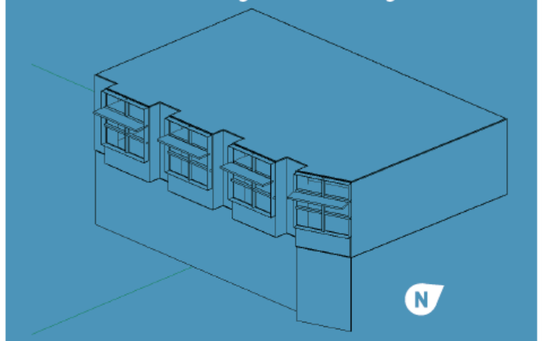


9 /21 / 9.00AM

VBL - N/A	VA - 1.5”	V1 - 3”	V2 - 6”	V3 - 9”	V4 - 12”	V5 - 15”	V6 - 18”
LAR 88%	LAR 0%	LAR 79%	LAR 98%	LAR 97%	LAR 96%	LAR 89%	LAR 96%
RAD 89%	RAD 43%	RAD 99%	RAD 99%	RAD 93%	RAD 93%	RAD 90%	RAD 90%

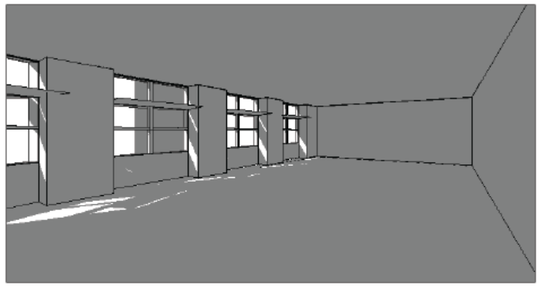
SMF04

Surface Reflectance Sensitivity Study



AXON PERSPECTIVE

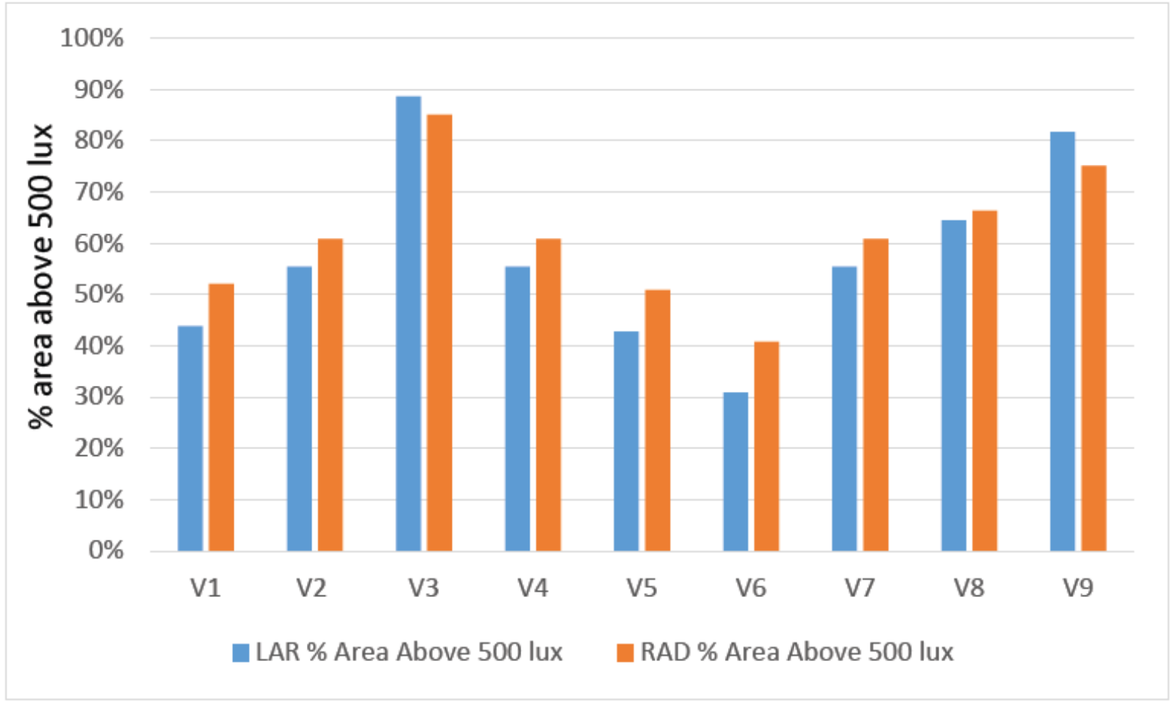
INTERIOR PERSPECTIVE



9 /21 /9.00 AM

	V1_CR80_FR30_WR40	V2_CR80_FR30_WR60	V3_CR80_FR30_WR80	V4_CR80_FR30_WR60	V5_CR60_FR30_WR60	V6_CR40_FR30_WR60	V7_CR80_FR30_WR60	V8_CR80_FR40_WR60	V9_CR80_FR50_WR60
Wall Ref	40%	60%	80%	60%	60%	60%	60%	60%	60%
Ceiling Ref	80%	80%	80%	80%	60%	40%	80%	80%	80%
Floor Ref	30%	30%	30%	30%	30%	30%	30%	40%	50%

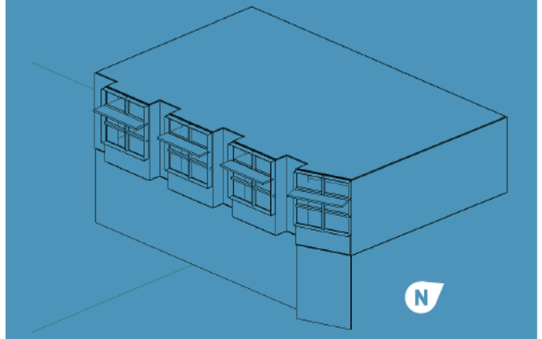
% AREA ABOVE 300 LUX - 9AM AND 3PM



Sensitivity

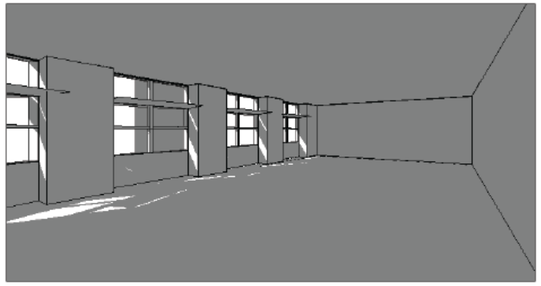
SMF04

Surface Reflectance Sensitivity Study



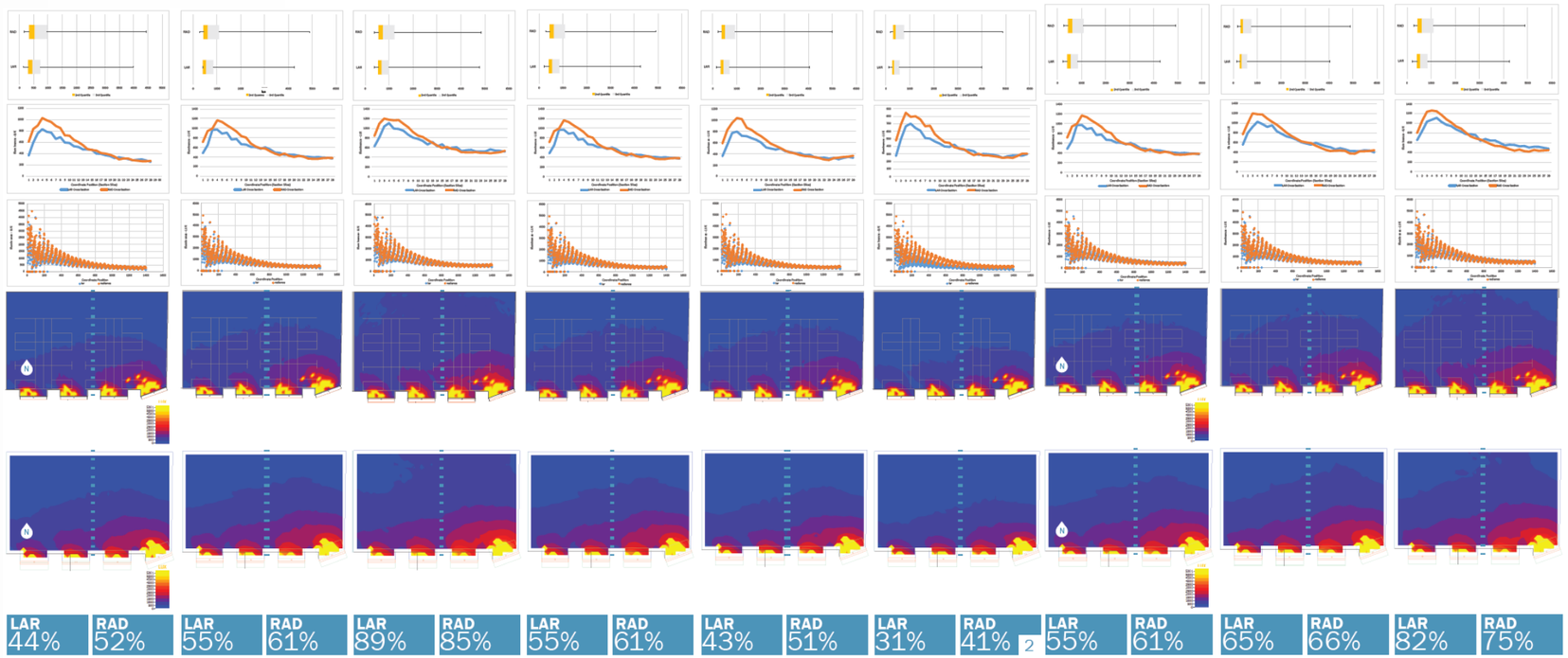
AXON PERSPECTIVE

INTERIOR PERSPECTIVE



9 /21 /9.00 AM

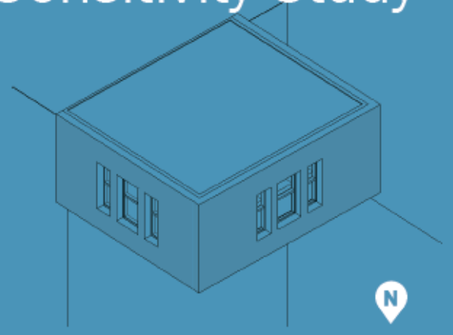
	V1_CR80_FR30_WR40	V2_CR80_FR30_WR60	V3_CR80_FR30_WR80	V4_CR80_FR30_WR60	V5_CR60_FR30_WR60	V6_CR40_FR30_WR60	V7_CR80_FR30_WR60	V8_CR80_FR40_WR60	V9_CR80_FR50_WR60
Wall Ref	40%	60%	80%	60%	60%	60%	60%	60%	60%
Ceiling Ref	80%	80%	80%	80%	60%	40%	80%	80%	80%
Floor Ref	30%	30%	30%	30%	30%	30%	30%	40%	50%



LAR	RAD	LAR	RAD	LAR	RAD	LAR	RAD	LAR	RAD	LAR	RAD	LAR	RAD	LAR	RAD	LAR	RAD
44%	52%	55%	61%	89%	85%	55%	61%	43%	51%	31%	41%	55%	61%	65%	66%	82%	75%

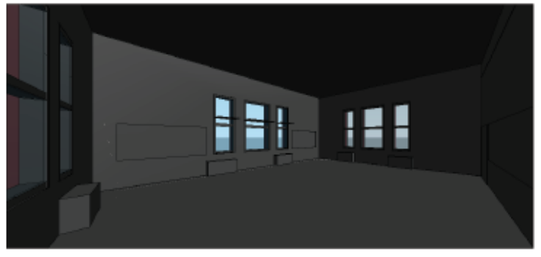
NYC05

Glazing Detail Sensitivity Study



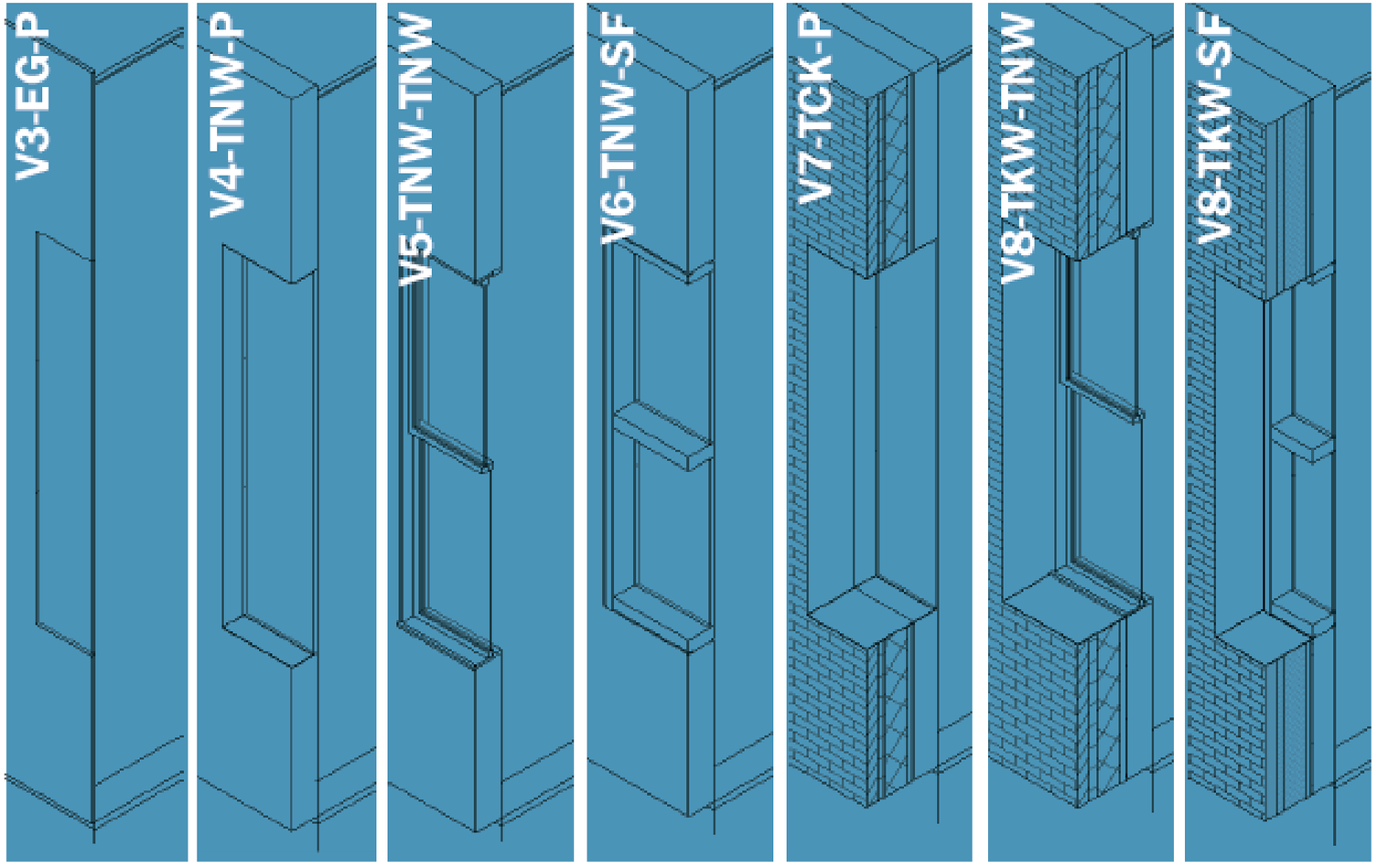
AXON PERSPECTIVE

INTERIOR PERSPECTIVE



9 /21 /9AM /3PM

VERSION KEY (VERSION - WALL TYPE - WINDOW TYPE)

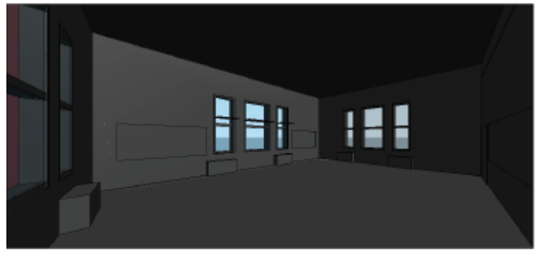


NYC05

Glazing Detail Sensitivity Study

AXON PERSPECTIVE

INTERIOR PERSPECTIVE



9 /21 /9AM /3PM

V3-EG-P		V4-TNW-P		V5-TNW-TNW		V6-TNW-SF		V7-TCK-P		V8-TKN-TNW		V9-TKW-SF	
LAR 100%	RAD 100%	LAR 96%	RAD 100%	LAR 92%	RAD 100%	LAR 89%	RAD 99%	LAR 86%	RAD 99%	LAR 82%	RAD 97%	LAR 72%	RAD 92%

Section 6

Thank You!

Thank you !

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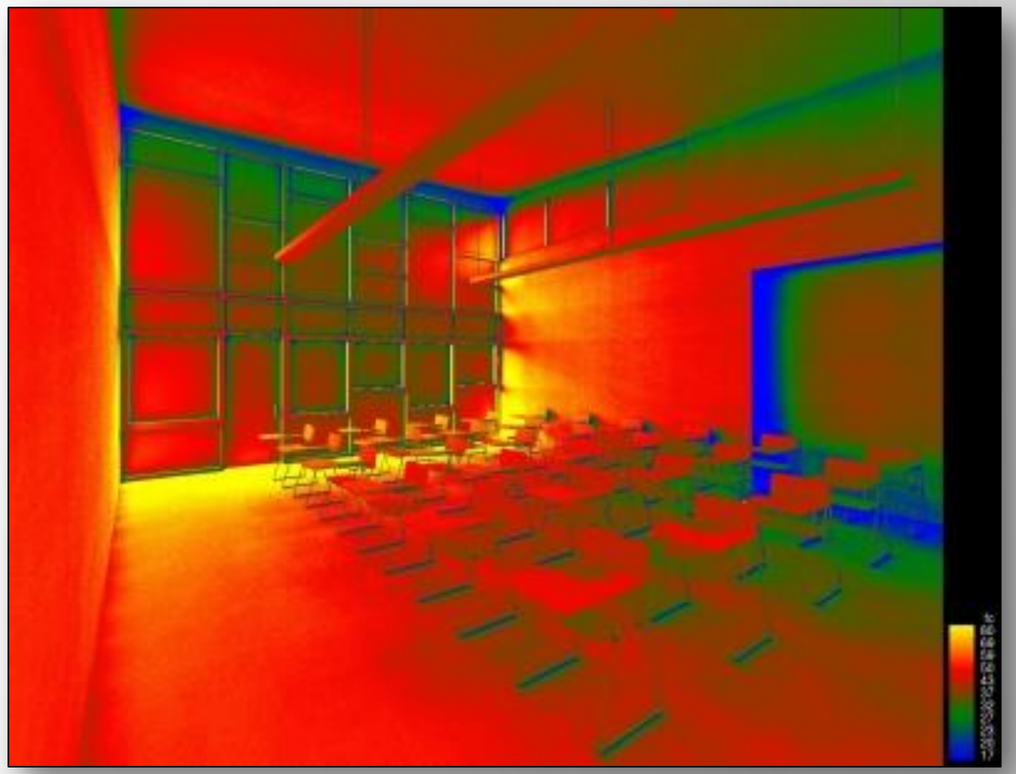

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