

## Designers Lighting Forum

Façade Lighting: Reducing It's Contribution to  
Skyglow

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Parsons School of Design

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

## Learning Objectives

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At the end of this course, participants will be able to:

1. Identify different facade typologies
2. Characterize different lighting methodologies relative to facade typology
3. Recognize how lighting analysis software can be a tool for assessing the sky glow generated by facade lighting
4. Compare facade lighting techniques to ascertain their respective contributions to sky glow

# Building Facade



Past

Was a threshold between interior and exterior space



Present

Influences human experience, building performance and urban context



**Facade Lighting**



**Purpose/Effect**

**Limitation**



**Improved Night-Time Environment**



**Light Pollution**

what we have



what we **don't** have



(left) <https://www.dreamstime.com/nyc-new-york-september-skyline-night-skyscrapers-background-long-exposure-photo-shoot-image165364089>  
(right) <https://www.darksky.org/our-work/conservation/idsp/become-a-dark-sky-place/>

How does the city look?



How does the city look?



# 1

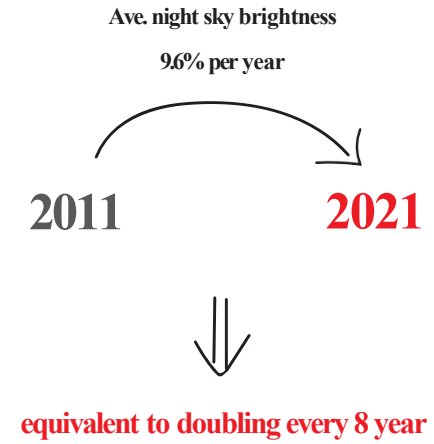
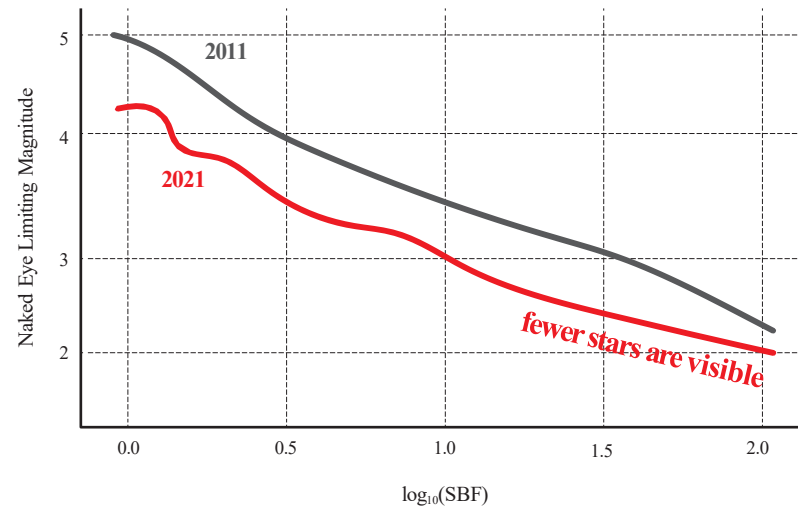
Why do we need to reduce light pollution?



<https://ehp.niehs.nih.gov/doi/10.1289/ehp.117-a20>



## Skyrocketing Light Pollution



NELM estimated by Globe at Night participants as a function of the night sky brightness

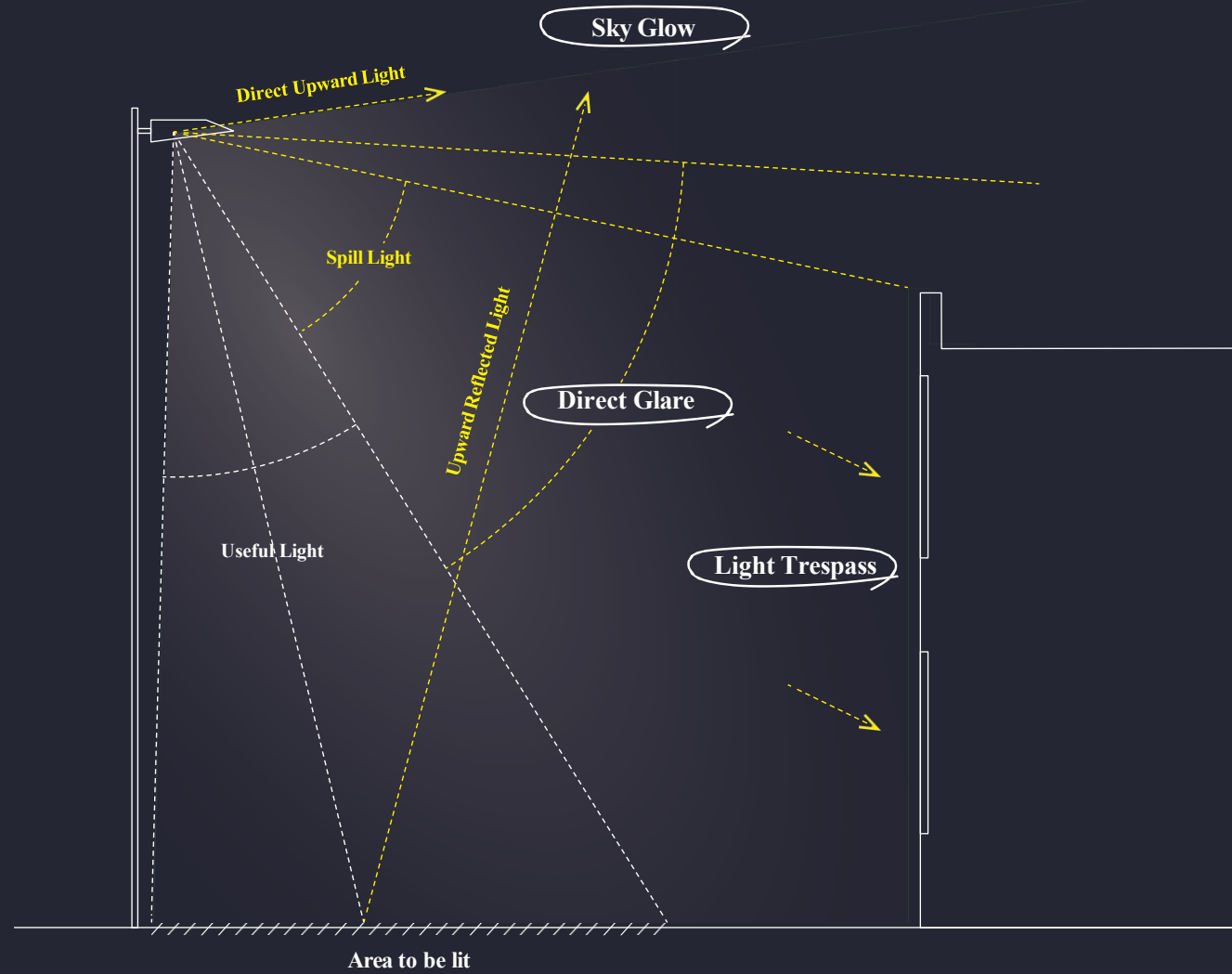
\*SBF: Sky Brightness Factor, the ratio of total radiance to natural sky radiance

\*NELM: Naked Eye Limiting Magnitude, smaller NELM values means that fewer stars are visible

**How does the light pollution impact to our globe?**



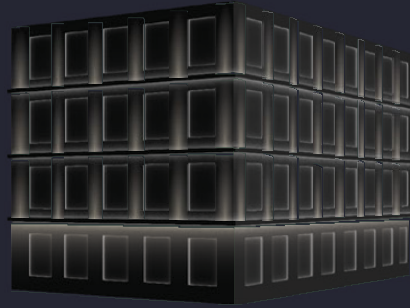
# Light Pollution Terminology



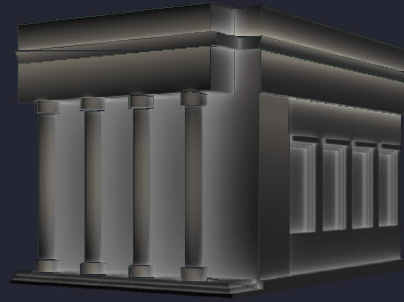
## 2

How can we classify facade types?

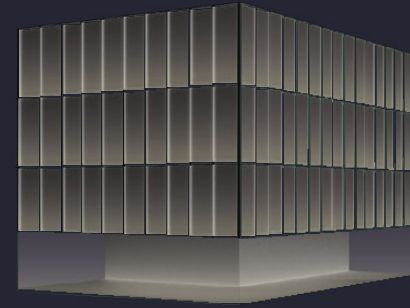
1. Solid Facades



2. Historic Facades

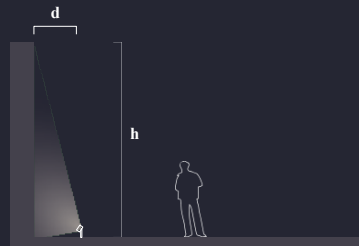
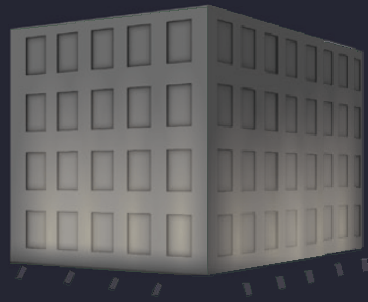


3. Transparent Facades

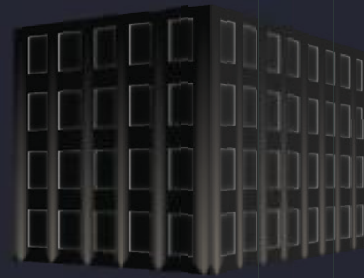


## How can we classify facade lighting types?

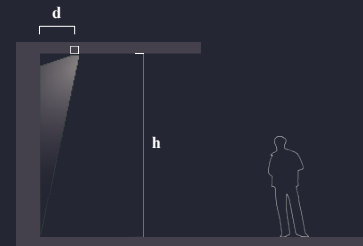
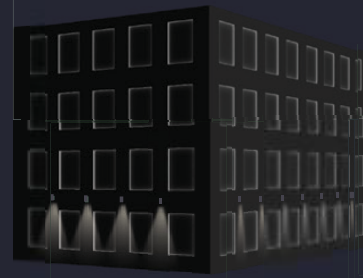
1. Floodlights



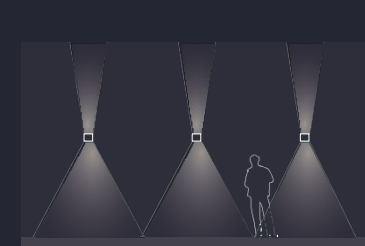
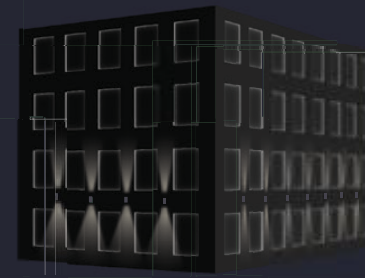
2. Ground-recessed



3. Downlight

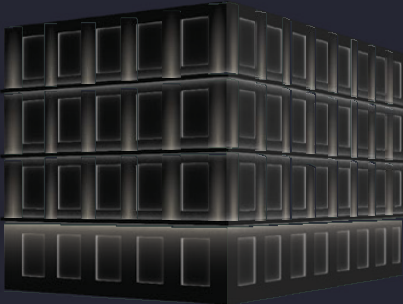


4. Uplight and downlight



# Field Research

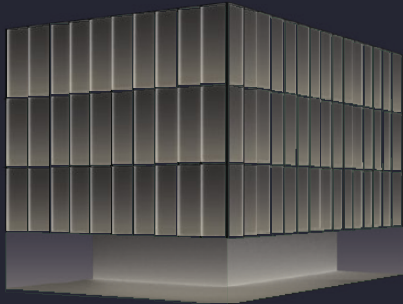
1.Solid Facades



2.Historic Facades



3.Transparent Facades



## Field Research

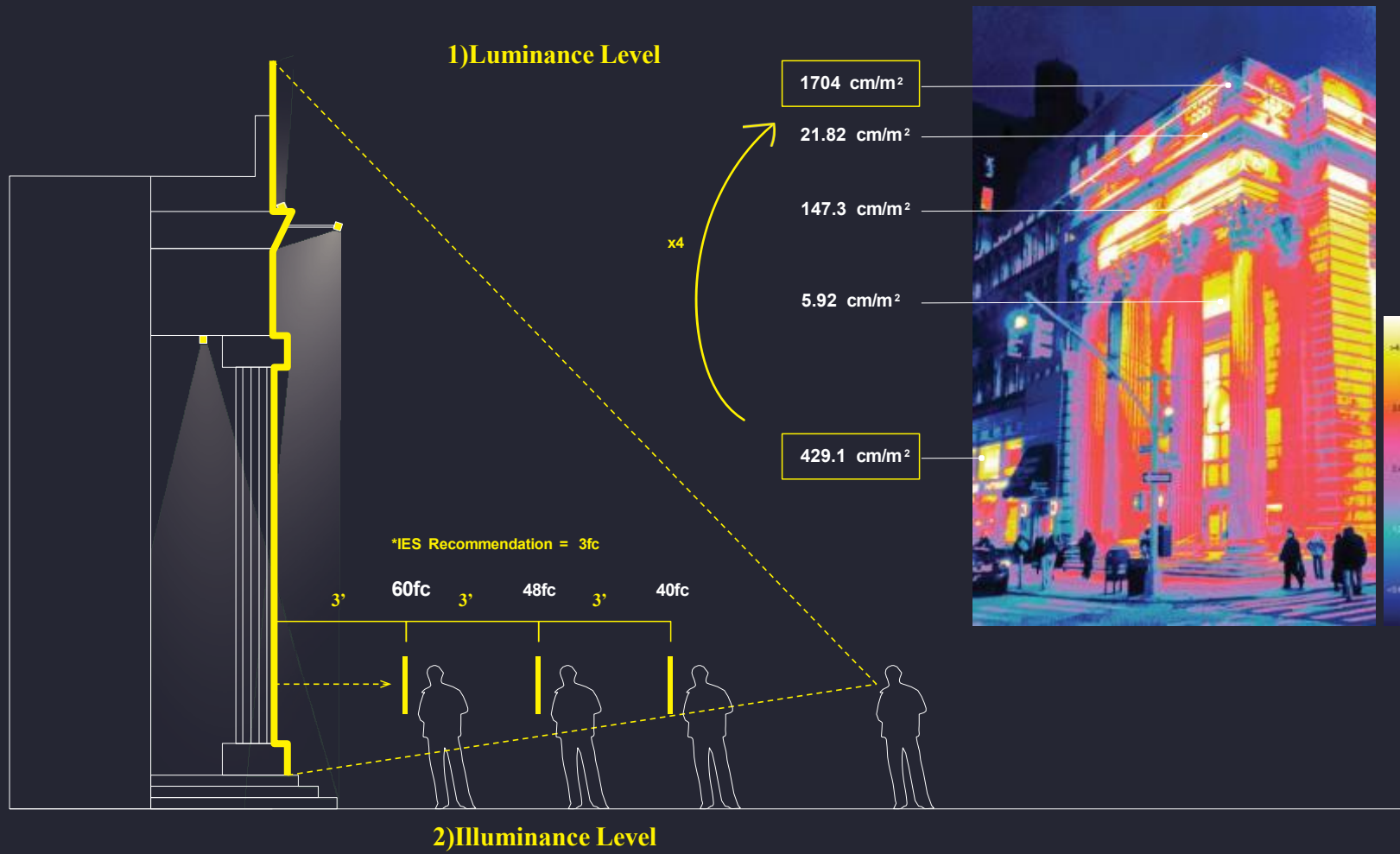


Daryl Roth Theatre

101 E 15th St, New York, NY 10003

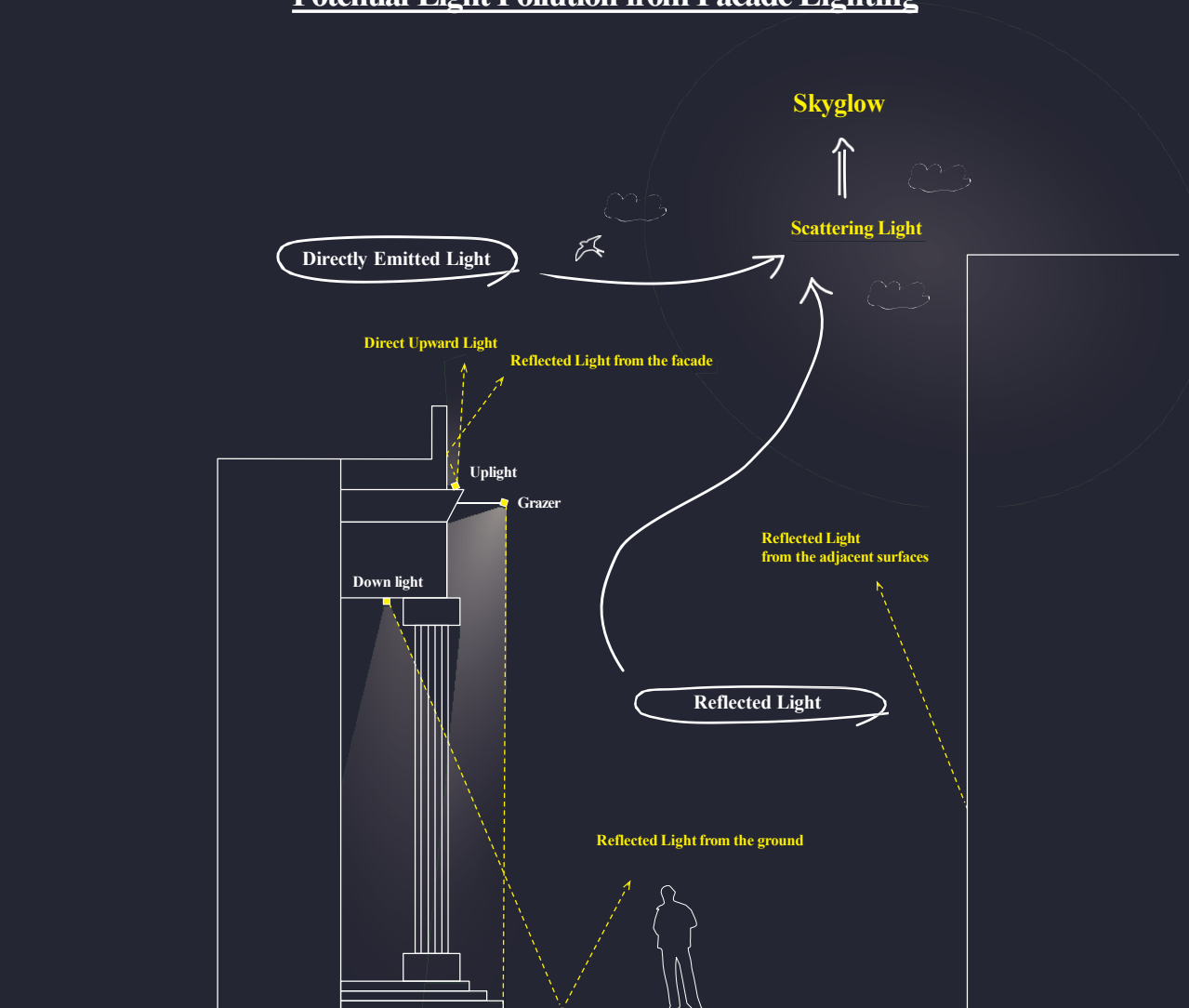
- Historic Facade
- Grazing + Flooding

# Field Research





# Potential Light Pollution from Facade Lighting



### 3

**What should our globe look like?  
And, how do we get there?**



(left) Illuminating Engineering Society, 2022. ANSI/IES RP-43-22 RECOMMENDED PRACTICE: LIGHTING EXTERIOR APPLICATIONS  
(right) <https://www.darksky.org/our-work/conservation/idsp/become-a-dark-sky-place/>

## [Five Principles for Responsible Outdoor Lighting]

Illuminating Engineering Society (IES) and the International Dark-Sky Association (IDA), 2020

1. **Useful** — All lighting should have a clear purpose
2. **Targeted** — Light should be directed only where it is needed
3. **Low Light Levels** — Light should be no brighter than necessary
4. **Controlled** — Lighting should only be used when it is useful
5. **Color** — Warmer color lighting should be used when possible.

## Existing Recommendations for Outdoor Lighting

Table A-3: Recommended Illuminance Criteria for People in Outdoor Environments

Varying Reflection Risk Light Level for Task or Area?  Task High or Med Area Low  APPLICATION TASK/AREA*	Lighting for Human Vision, Visibility, and Reassurance								Lighting for Responsible Design						
	Recommended Average Maintained Illuminance Targets*														
	Illuminances are at height of Task Surface (TS) above finished grade (AFG)														
	Horizontal Illuminance				Vertical Illuminance				Optic Control		Controls	Spectrum			
	Target $E_{h,0}$ @ Height AFG	Uniformity	Ratio	Ratio Basis	Target $E_{v,0}$ @ Height AFG	Uniformity	Ratio	Ratio Basis							
Lux @ m	fC @ F0	(Avg/Min)	Ratio Basis	Lux @ m	fC @ F0	(Avg/Min)	Ratio Basis	Glare, Uplight Ratings							
								Max Glare Rating (G)	Max Uplight Rating (U)	Light Output/ Shielding Controls Reduction	Acceptable Short Wavelength Content <sup>†</sup> (PL, SL, ML, HL, (HL)12)				
<b>Trees, Gardens, Landscape (can be horizontal or vertical) †</b>															
LZ4															
Lower limit (avg.)				1 @ 2.00	(0.1 @ 0.2)	0.0		2 @ TS	(0.2 @ TS)			G2	U3	0%	VL, L, M
Upper limit (avg.)				10 @ 2.00	(1 @ 0.2)	0.0		30 @ TS	(3 @ TS)						
LZ3															
Lower limit (avg.)				1 @ 2.00	(0.1 @ 0.2)	0.1		2 @ TS	(0.2 @ TS)			G2	U3	0% to 50%	VL, L, M
Upper limit (avg.)				3 @ 2.00	(0.3 @ 0.2)	0.1		20 @ TS	(2 @ TS)						
LZ2															
Lower limit (avg.)				0.1 @ 2.00	(0.01 @ 0.2)	10:1		1 @ TS	(0.1 @ TS)			G2	U2	0% to 20%	VL, L, M
Upper limit (avg.)				4 @ 2.00	(0.4 @ 0.2)	10:1		10 @ TS	(1 @ TS)						
LZ1															
Lower limit (avg.)				0.5 @ 2.00	(0.05 @ 0.2)	10:1		0.5 @ TS	(0.05 @ TS)			G3	U1	0%	VL, L
Upper limit (avg.)				2 @ 2.00	(0.2 @ 0.2)	10:1		2 @ TS	(0.4 @ TS)						
LZ0															
Lower limit (avg.)															
Upper limit (avg.)															

Illuminating Engineering Society of North America. 2022. ANSI/IES RP-43-22 RECOMMENDED PRACTICE: LIGHTING EXTERIOR APPLICATIONS

## Existing Recommendations for Outdoor Lighting

Table A-3. Recommended Illuminance Criteria for People in Outdoor Environments

Vexing Reflection Risk Light Level for Task or Area?  Task High or Med Low Area Low	Lighting for Human Vision, Visibility, and Reassurance								Lighting for Responsible Design					
	Recommended Average Maintained Illuminance Targets*								Optic Control	Controls	Spectrum			
	Illuminances are at height of Task Surface (TS) above finished grade (AFG)								Glare, Uplight Ratings  Max Glare Rating (G)  Max Uplight Rating (U)	Vacancy, Seasonal, & Time of Day  Light Output During Controls Reduction	Acceptable Short Wavelength Emission? (W <sub>L</sub> , S <sub>L</sub> , W <sub>L</sub> , H), (W <sub>L</sub> , S <sub>L</sub> , W <sub>L</sub> , H), (W <sub>L</sub> , S <sub>L</sub> , W <sub>L</sub> , H)			
	Horizontal Illuminance				Vertical Illuminance									
	Target E <sub>h</sub> @ Height AFG		Uniformity		Target E <sub>v</sub> @ Height AFG		Uniformity							
Lux @ m	f/c @ ft	(Avg./Min)	Ratio Basis	Lux @ m	f/c @ ft	(Avg./Min)	Ratio Basis							
APPLICATION TASK/AREA*	Task High or Med Low	Area Low	Lux @ m	f/c @ ft	(Avg./Min)	Ratio Basis	Lux @ m	f/c @ ft	(Avg./Min)	Ratio Basis	Max Glare Rating (G)	Max Uplight Rating (U)	Light Output During Controls Reduction	(W <sub>L</sub> , S <sub>L</sub> , W <sub>L</sub> , H), (W <sub>L</sub> , S <sub>L</sub> , W <sub>L</sub> , H), (W <sub>L</sub> , S <sub>L</sub> , W <sub>L</sub> , H)
<b>Façades (medium reflectance materials, ≥0.3 and ≤0.6)<sup>10</sup></b>														
LZ4														
Lower limit (avg.)							4 @ TS	0.4 @ TS					0% to 15%	W, L, M, H
Upper limit (avg.)							30 @ TS	3 @ TS						
LZ3														
Lower limit (avg.)							2 @ TS	0.2 @ TS					0% to 15%	W, L, M
Upper limit (avg.)							15 @ TS	1.5 @ TS						
LZ2														
Lower limit (avg.)							1 @ TS	0.1 @ TS					0% to 15%	W, L, M
Upper limit (avg.)							8 @ TS	0.8 @ TS						
LZ1														
Lower limit (avg.)							0.1 @ TS	0.05 @ TS					0% to 20%	W, L
Upper limit (avg.)							4 @ TS	0.4 @ TS						
LZ0														
Lower limit (avg.)														
Upper limit (avg.)														

Illuminating Engineering Society of North America. 2022. ANSI/IES RP-43-22 RECOMMENDED PRACTICE: LIGHTING EXTERIOR APPLICATIONS

## Existing Study on Skyglow

### MACRO



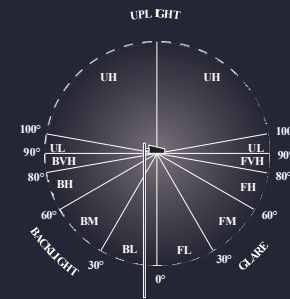
#### Light Pollution Map

<https://www.lightpollutionmap.info/>

.....  
Astronomers  
Educators

.....  
Monitoring the night sky quality  
for regulating lights for needed area

### MICRO



#### BUG Rating System

(ANSI/IES TM-15-20, Technical Memorandum: Luminaire Classification System)

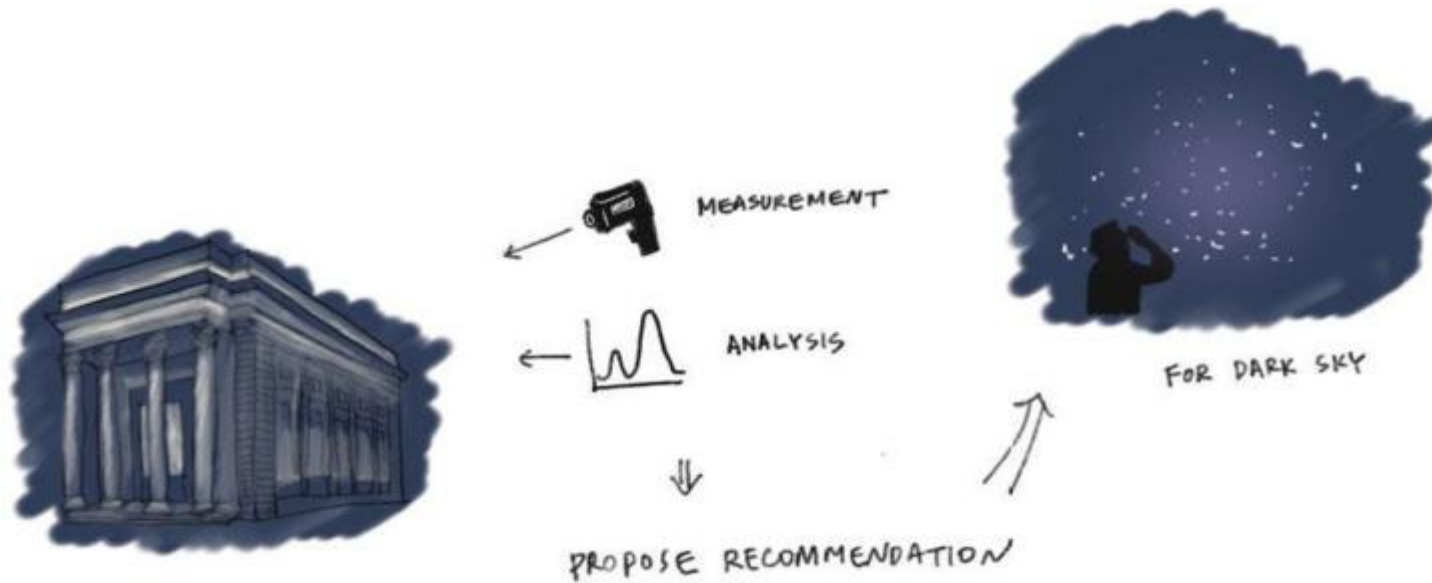
.....  
Manufacturers  
Lighting Designers

.....  
Careful selection of luminaires  
for appropriate brightness and distribution

# 4

## Thesis Statement

: As there is no method to quantify the adverse effects of facade lighting, lighting designers should assess direct upward light and reflected light during the design process to reduce facade lighting's contribution to skyglow. This study proposes a new methodology that utilizes the existing widespread photometric calculation tool in the lighting design industry.



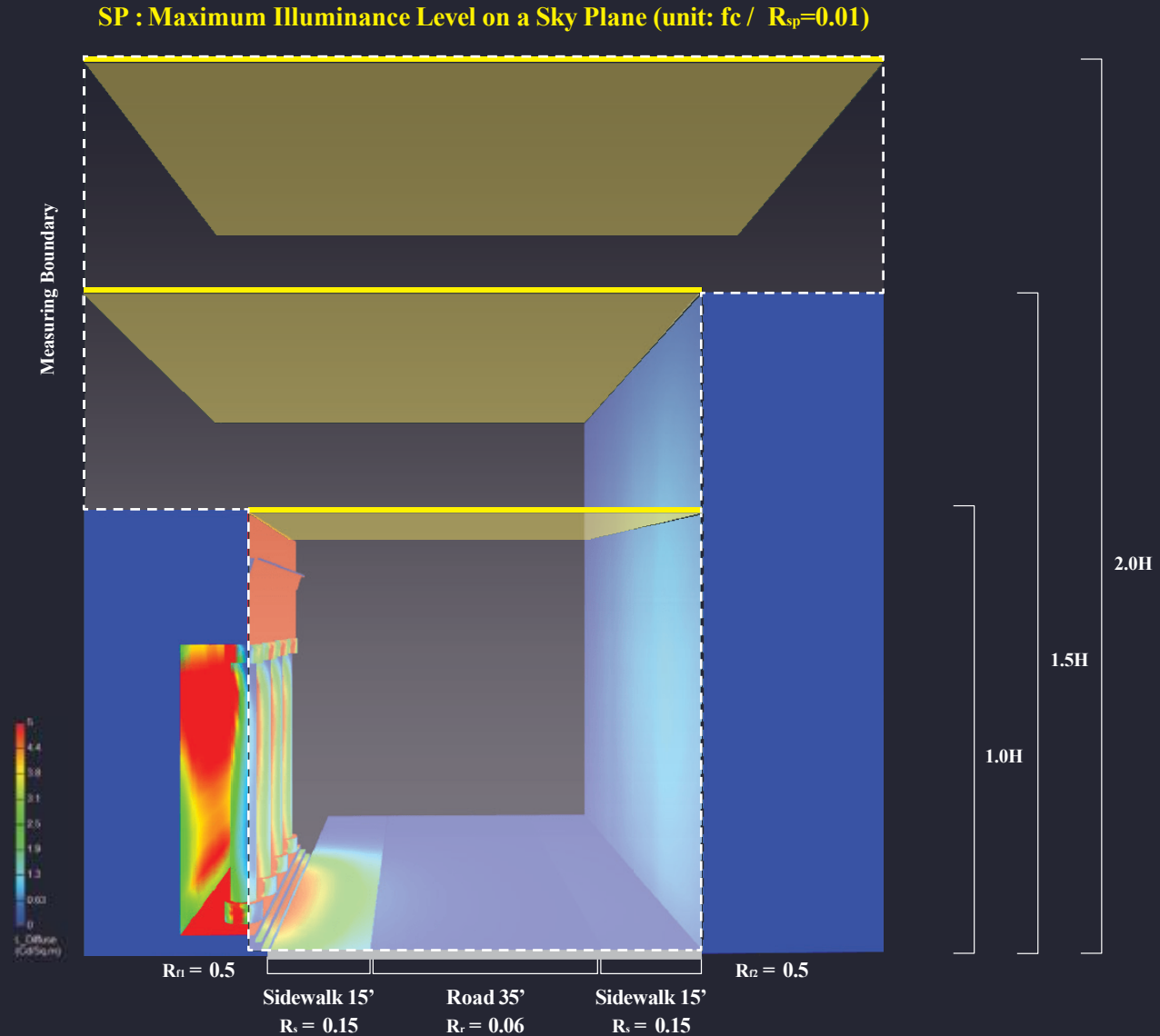
# Proposed Methodology

## Assumed Scenario

1. Clear Sky
2. Fixed Reflectance Values
  - model surface
  - ground
  - adjacent building surface
3. Fixed LED Light Source
4. Fixed Light Loss Factor (LLF)
5. Fixed Color Temperature (CCT)

## Variable Parameters

1. Lumen Output
2. Upward Light Ratio (ULR)
  - beam angle
  - tilted angle





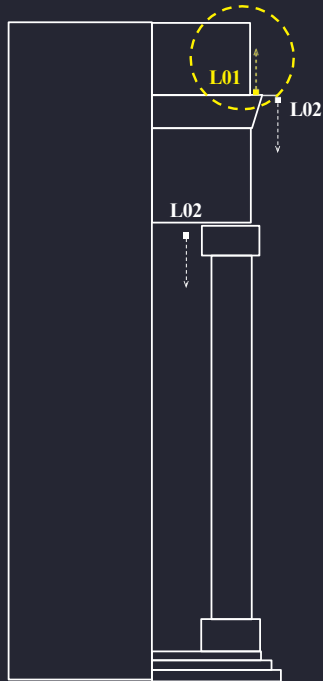
# ANALYSIS

Ecosense Trov L50

L01: L50-I-12-POWER-27-OUTPUT-MULT-BEAM ANGLE

L02: L50-I-12-POWER-27-80-MULT-15x35

LLF: 0.9  
CCT: 2700K



## SCENARIO #1

LUMEN OUTPUT

L01: L50-I-12-POWER-27-OUTPUT-MULT-9x9

8W (813lm) / 6W (584lm) / 4W (366lm)

## SCENARIO #2

ULR  
(Upward Light Ratio)

L01: L50-I-12-8W-27-OUTPUT-MULT-9x9

90% / 40% / 0%

## SCENARIO #3

ULR  
(Upward Light Ratio)

L01: L50-I-12-8W-27-OUTPUT-MULT-25x45

60% / 45% / 0%

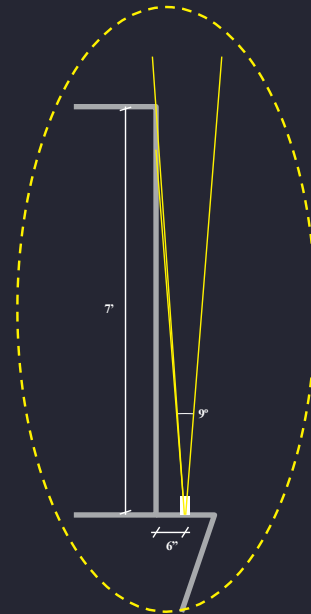
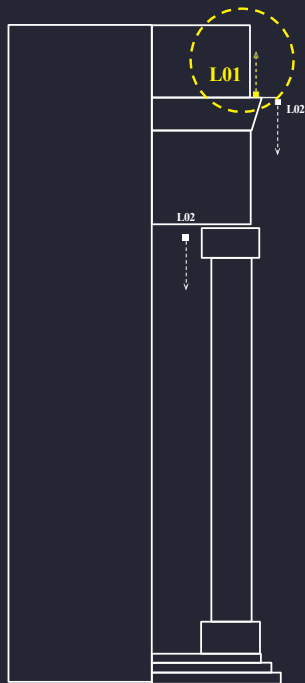
**SCENARIO #1**

LUMEN OUTPUT

L01: L50-I-12-POWER-27-OUTPUT-MULT-9x9

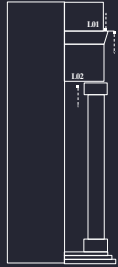


**8W (813lm) / 6W (584lm) / 4W (366lm)**



TILT 0°

ULR 90%



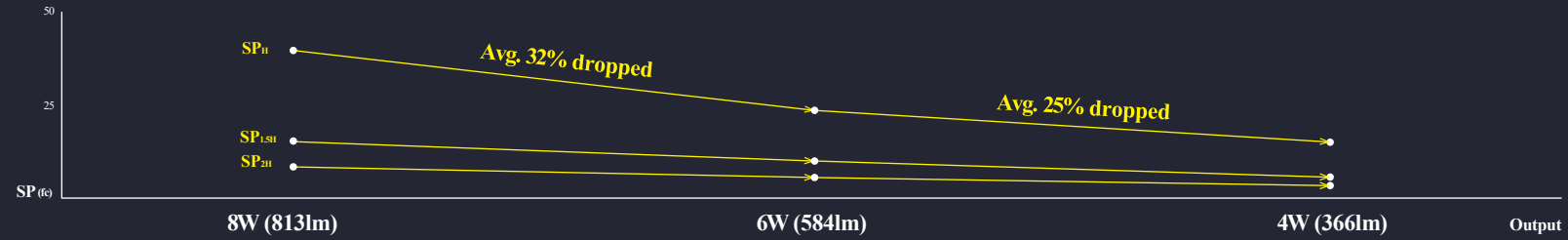
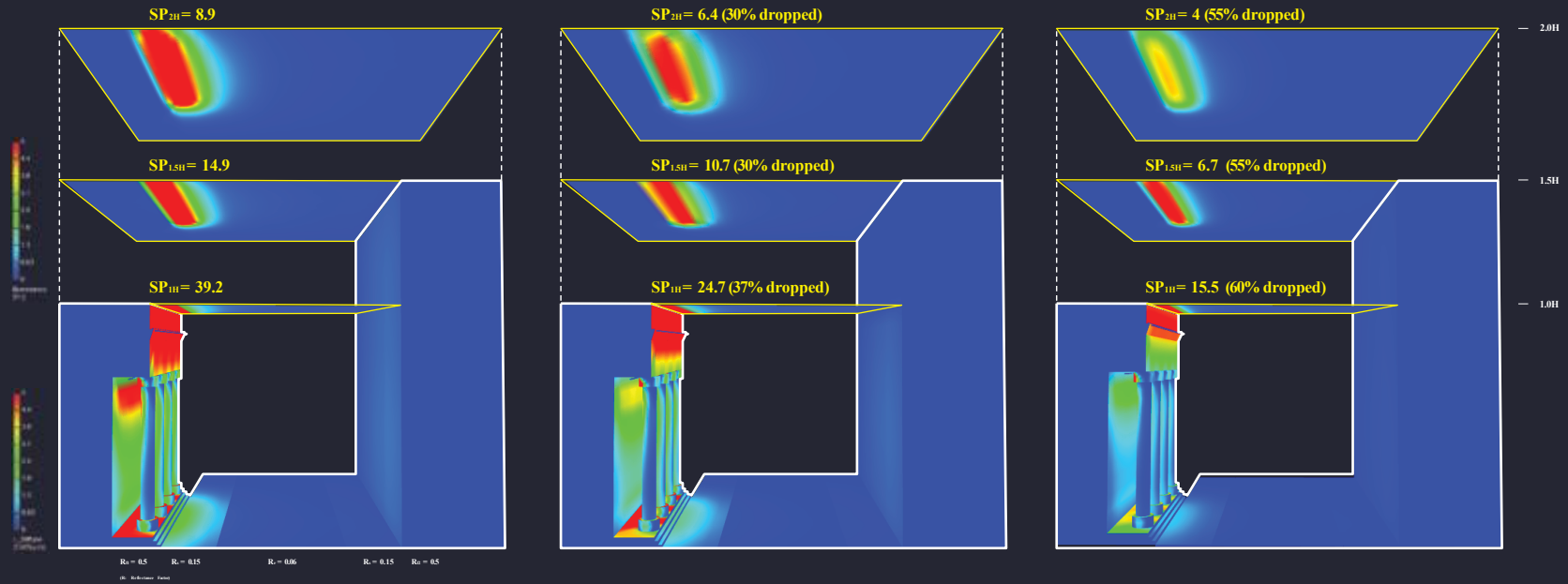
# SCENARIO #1

## LUMEN OUTPUT

Ecosense Trov L50  
 L01: L50-I-12-POWER-27-OUTPUT-MULT-9x9  
 L02: L50-I-12-POWER-27-80-MULT-15x35

ULR: 90%  
 CCT: 2700K  
 LLF: 0.9

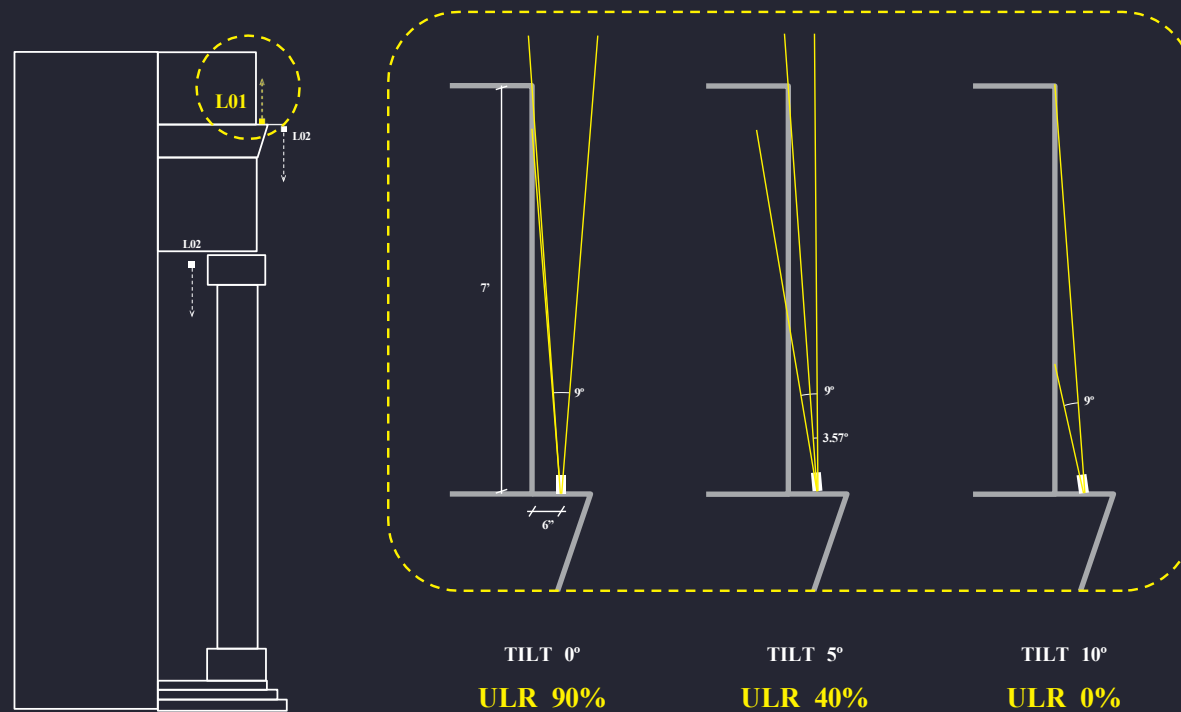
SP : Maximum Illuminance Level on a Sky Plane (unit: fc /  $R_{\sigma}=0.01$ )

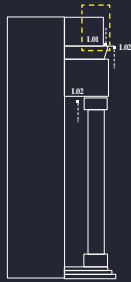


## SCENARIO #2

UPWARD LIGHT RATIO

L01: L50-I-12-8W-27-OUTPUT-MULT-9x9





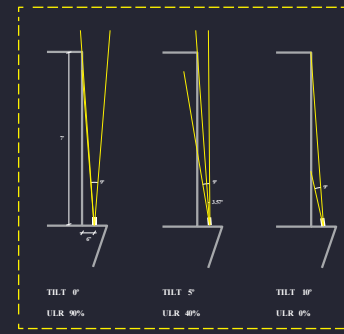
## SCENARIO #2

### UPWARD LIGHT RATIO

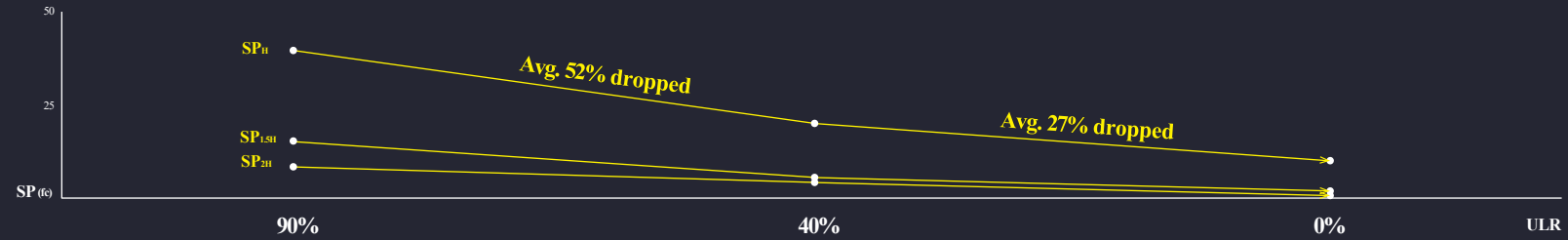
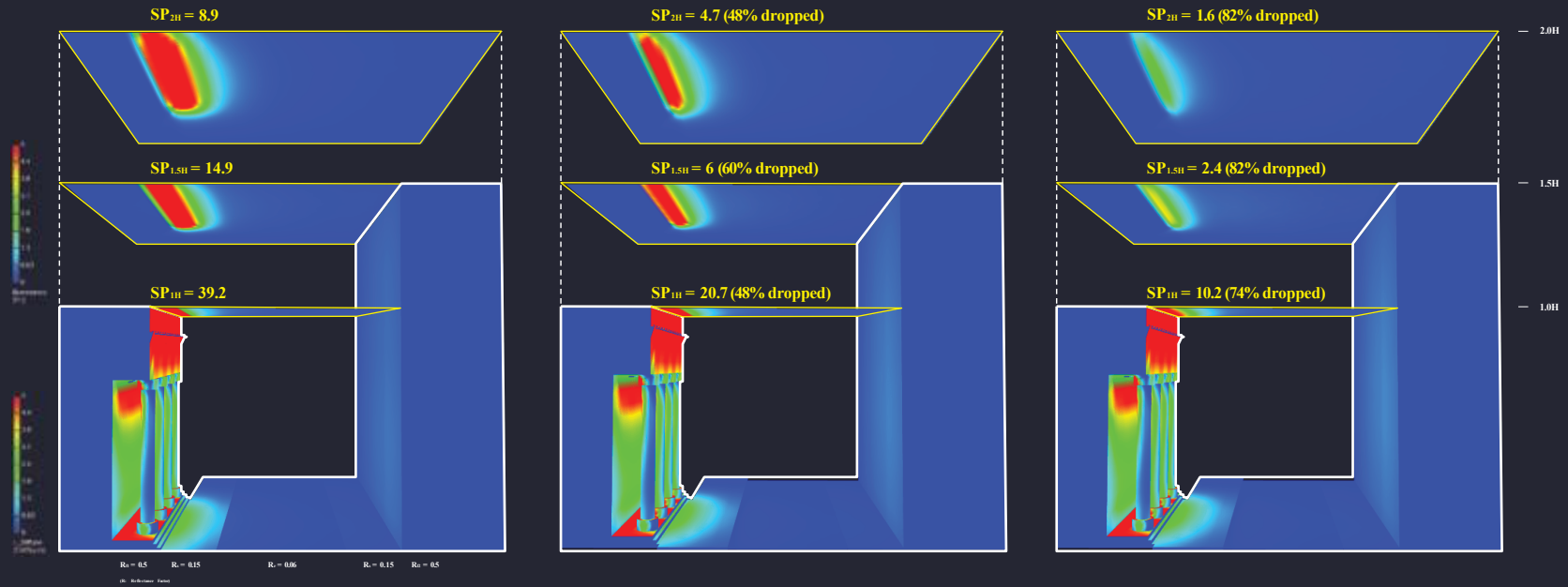
Ecosense Trov L50  
 L01: L50-I-12-POWER-27-80-MULT-9x9  
 L02: L50-I-12-POWER-27-80-MULT-15x35

OUTPUT: 8W (813lm)  
 CCT: 2700K  
 LLF: 0.9

SP : Maximum Illuminance Level on a Sky Plane (unit: fc /  $R_v=0.01$ )



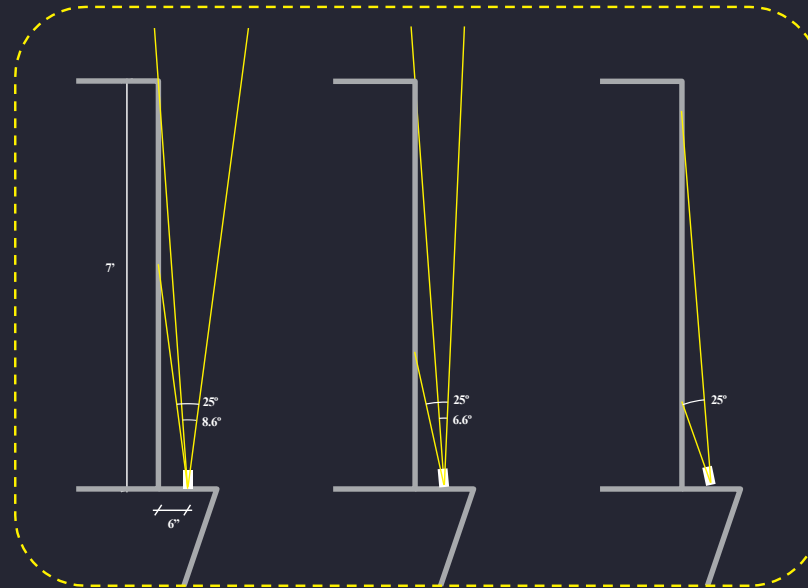
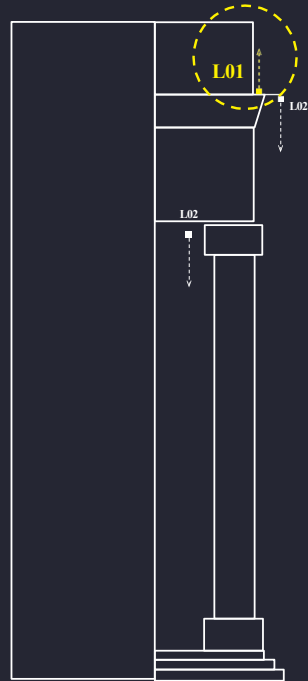
L01 9x9 Beam Angle



### SCENARIO #3

UPWARD LIGHT RATIO  
+BEAM ANGLE

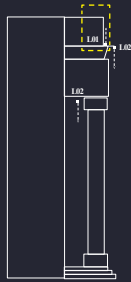
L01: L50-I-12-8W-27-OUTPUT-MULT-25x45



TILT 0°  
ULR 60%

TILT 5°  
ULR 45%

TILT 12°  
ULR 0%



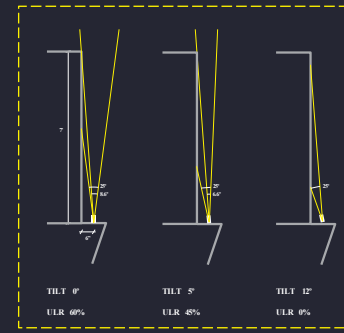
### SCENARIO #3

### UPWARD LIGHT RATIO + BEAM ANGLE

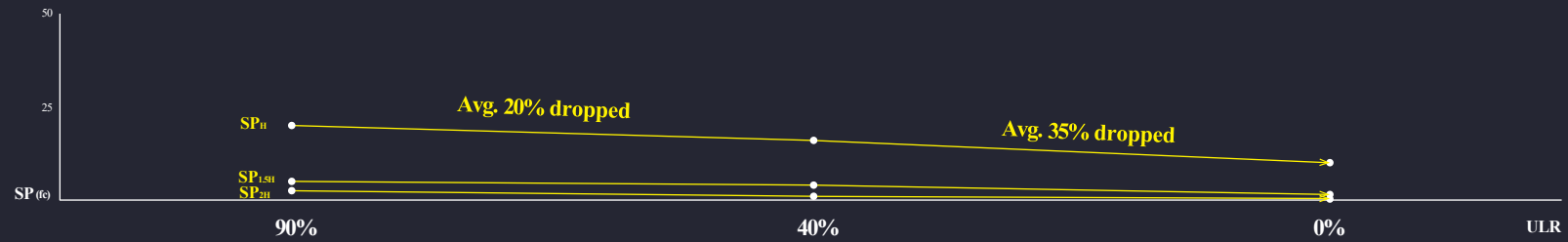
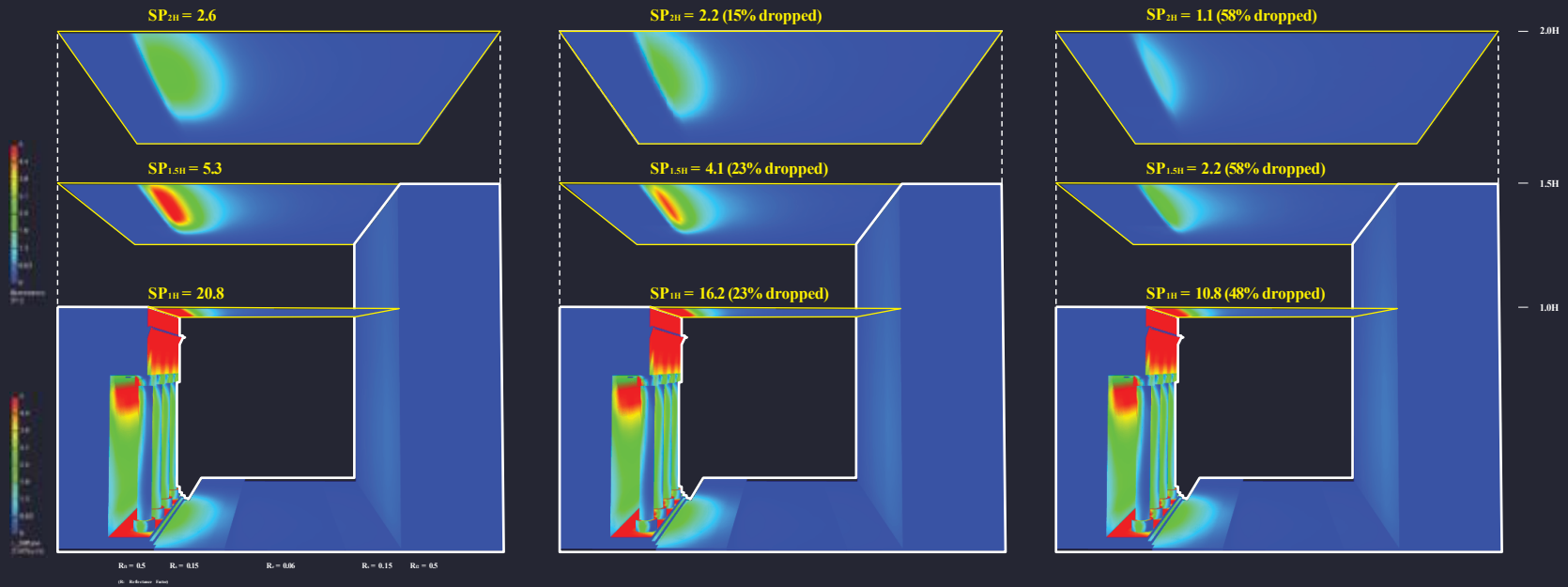
Ecosense Trov L50  
 LO1: L50-I-12-POWER-27-80-MULT-25x45  
 LO2: L50-I-12-POWER-27-80-MULT-15x35

OUTPUT: 8W (813lm)  
 CCT: 2700K  
 LLF: 0.9

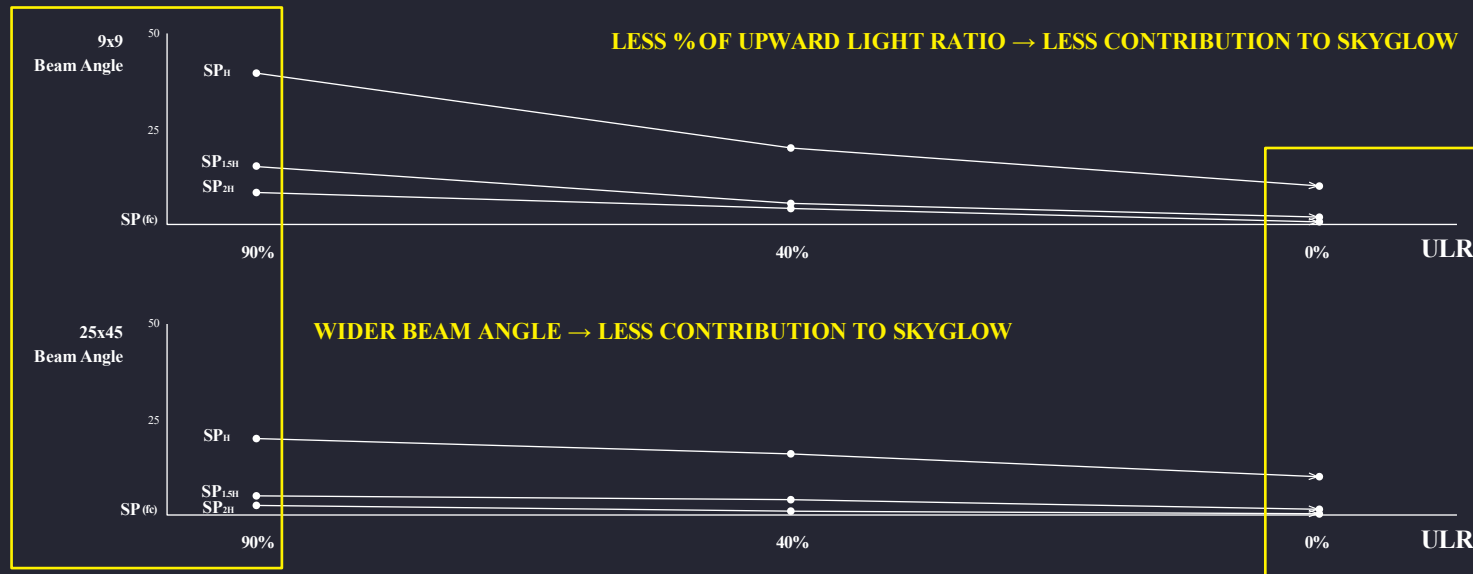
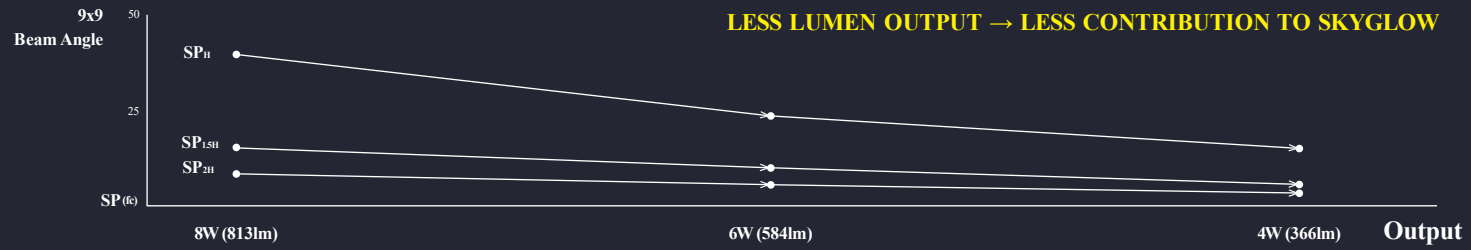
SP : Maximum Illuminance Level on a Sky Plane (unit: fc /  $R_v=0.01$ )



L01 25x45 Beam Angle



# CONCLUSION

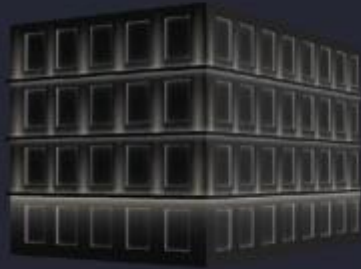


**0% UPWARD LIGHT RATIO DOES NOT INDICATE AN ABSENCE OF LIGHT POLLUTION**



## FURTHER STUDY

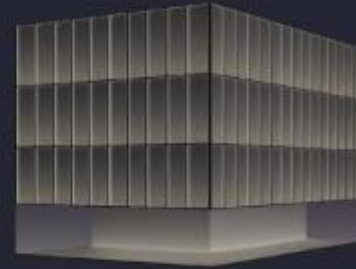
1.Solid Facades



2.Historic Facades



3.Transparent Facades



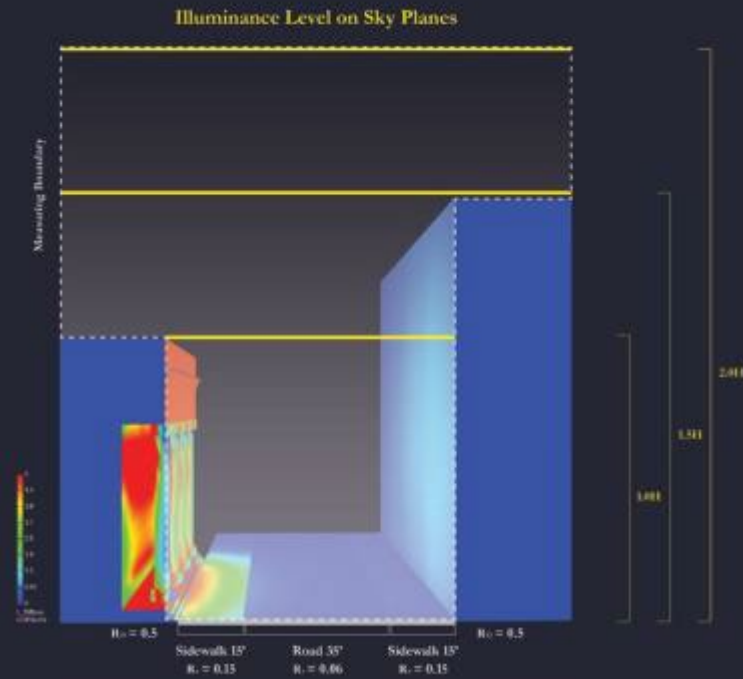
## FURTHER STUDY

### Assumed Scenario

1. Clear Sky
2. Fixed Reflectance Values  
-model surface, ground, adjacent building surface
3. Fixed LED Light Source
4. Fixed Light Loss Factor (LLF)
5. Fixed Color Temperature (CCT)

### Variable Parameters

1. Lumen Output
2. Upward Light Ratio (ULR)  
-beam angle  
-tilted angle



This concludes The American Institute of Architects Continuing  
Education Systems Course