

Designers Light Forum

**When you come to a fork in the
road, take it:**

Exploring the paths to energy code compliance

Marty Salzberg, IALD, IES

March 13, 2018



Credit(s) earned on completion of this course will be reported to **AIA CES** for AIA members. Certificates of Completion for both AIA members and non-AIA members are available upon request.

This course is registered with **AIA CES** for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

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

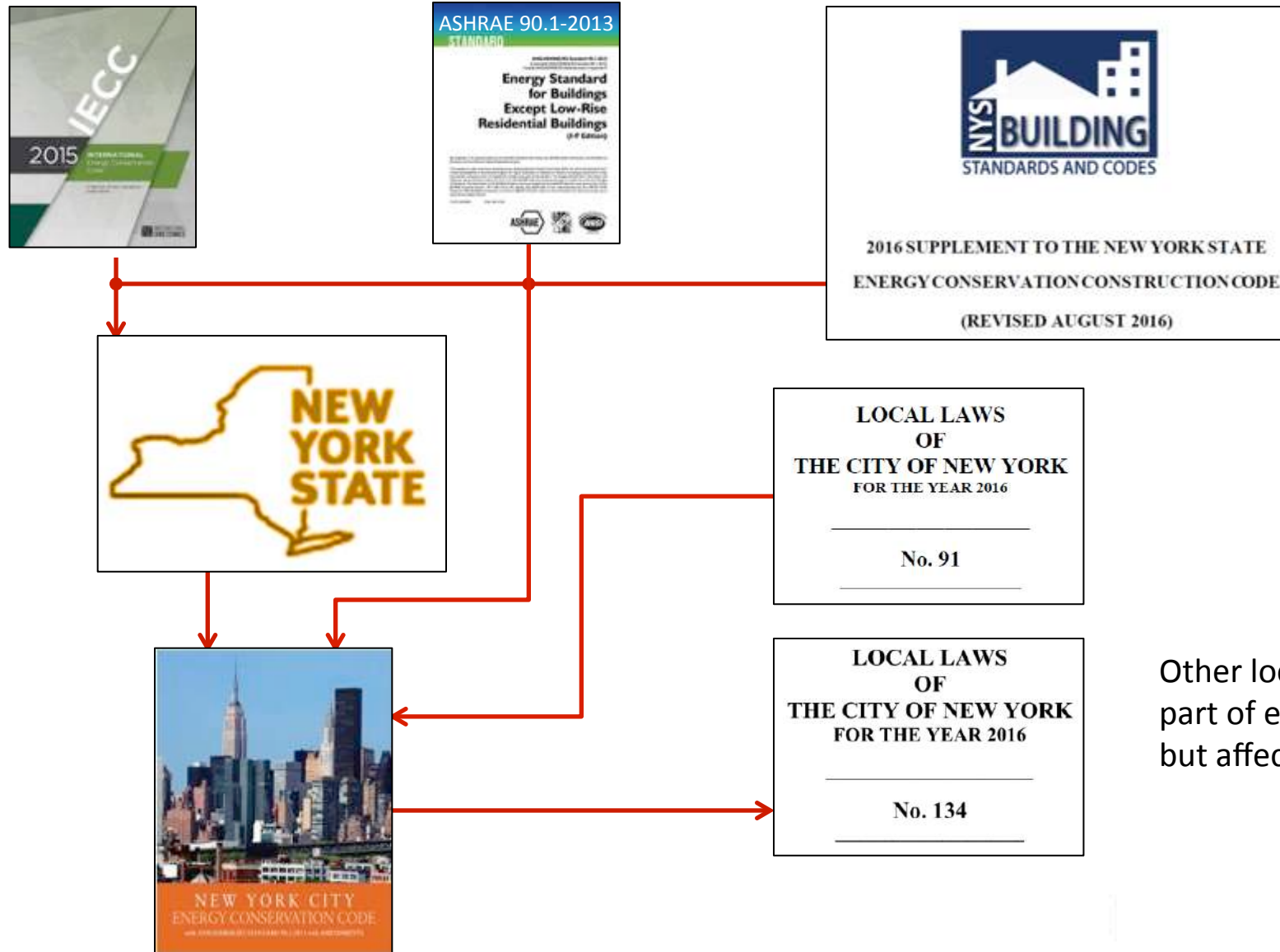
Learning Objectives

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

1. Confidently evaluate the differences between the two compliance paths to choose the one that is best for your projects
2. Determine where the exceptions to Lighting Power Allowances and Controls diverge and how to use them
3. Understand how the codes vary on the daylight design and daylight responsive control requirements
4. Summarize the knowledge gained by seeing it applied to specific project types.

How was the NYCECC 2016 Developed?

Components that form the code



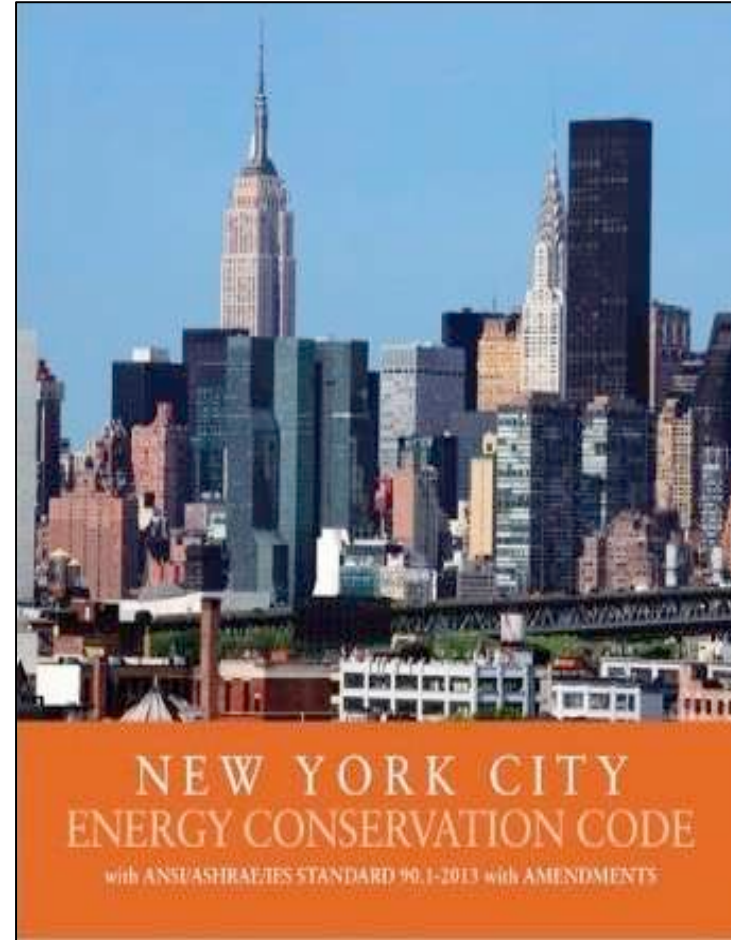
Energy Conservation Code of New York State (ECCNYS) 2016

2016 NYC Energy Conservation Code (NYCECC)

Other local laws: Not part of energy code, but affect compliance

Which code book should be used?

NOT the IECC or ASHRAE books



<https://codes.iccsafe.org/public/document/details/toc/780>



https://www1.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2016_APPENDIX_CA.pdf§ion=energy_code_2016

NYCECC 2106

COMMERCIAL ENERGY EFFICIENCY

C405.2 Lighting controls (Mandatory). Lighting systems shall be provided with controls as specified in Sections C405.2.1, C405.2.2, C405.2.3, C405.2.4 and C405.2.5. Lighting controls shall be commissioned and completed in accordance with the requirements of Section C408.3.

Exceptions: Lighting controls are not required for the following:

1. Areas designated as security or emergency areas that are required to be continuously lighted.
2. Interior exit stairways, interior exit ramps and exit passageways.
3. Emergency egress lighting that is normally off.

C405.2.1 Occupant sensor controls. Occupant sensor controls shall be installed to control lights in the following space types:

NYC
NYC
NYC

Which code book should be used?

Browse free online

ASHRAE 90.1 as modified by NYC

9. LIGHTING

9.1 General

9.1.1 Scope. This section shall apply to the following:

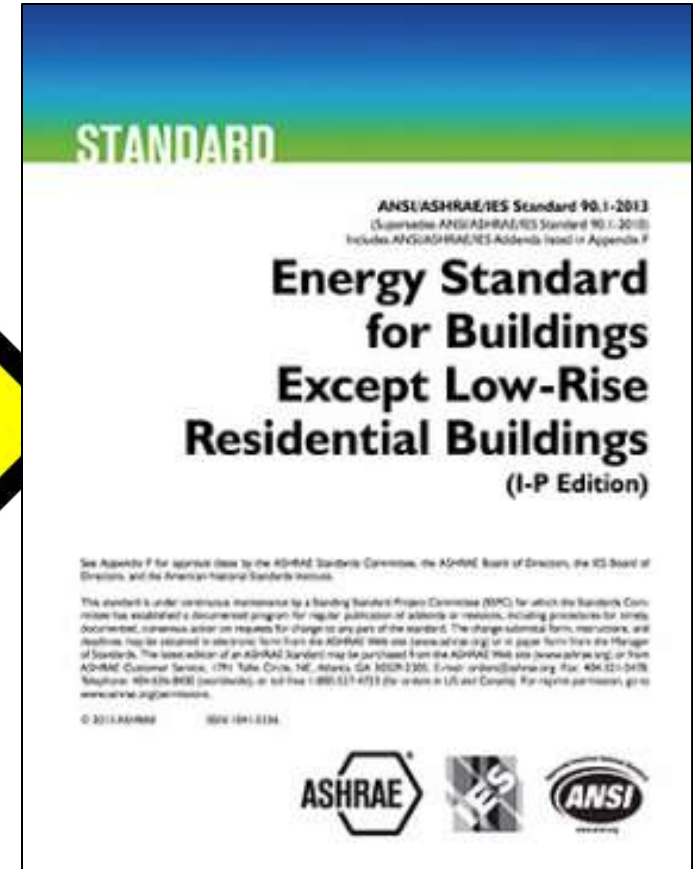
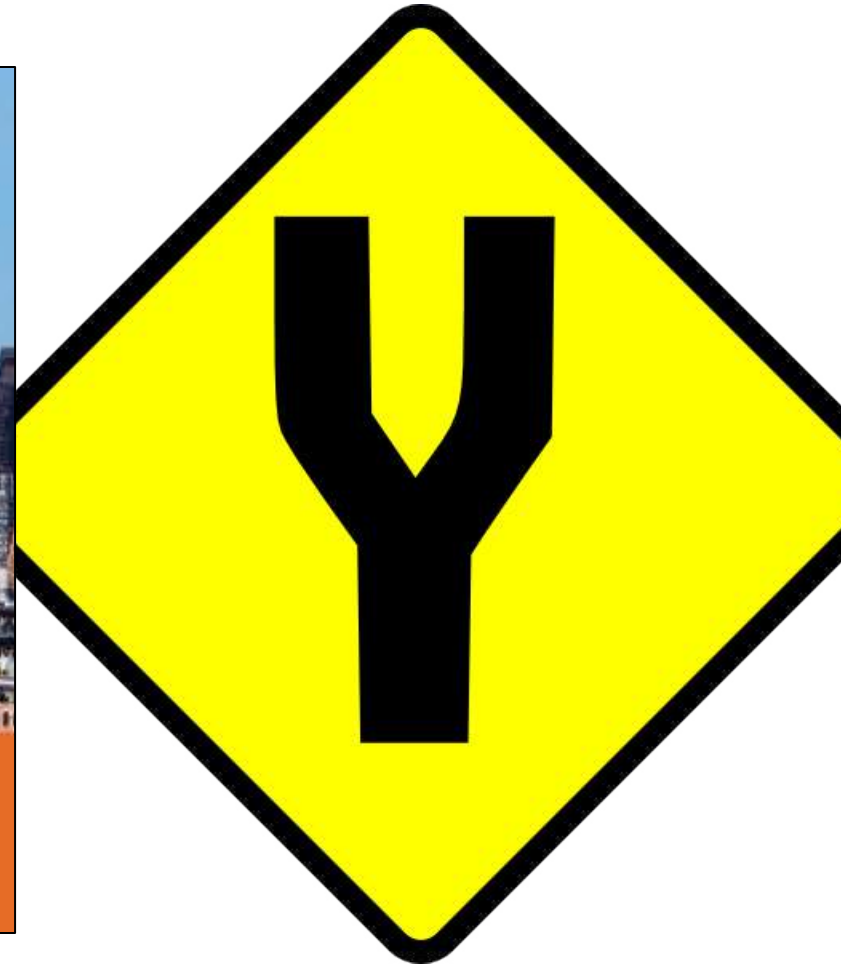
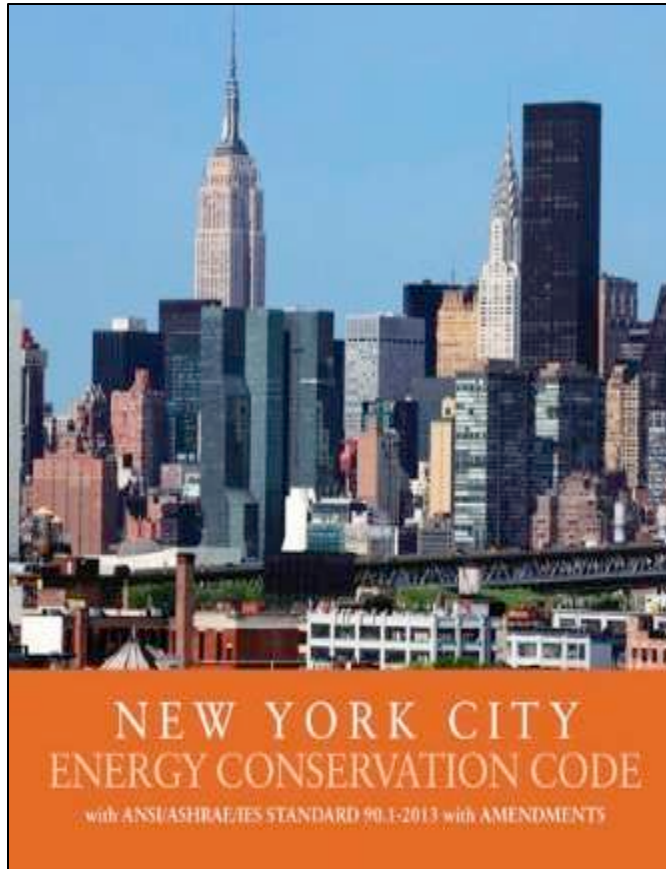
- a. Interior spaces of buildings
- b. Exterior building features, including façades, illuminated roofs, architectural features, entrances, exits, loading docks, and illuminated canopies
- c. Exterior building grounds lighting provided through the building's electrical service

Exceptions:

1. Emergency lighting that is automatically off during normal building operation
2. Dwelling units within commercial buildings shall not be required to comply with this section provided that not less than 75 percent of the permanently installed fixtures, other than low-voltage lighting, shall be fitted for, and contain only, high efficacy lamps.
3. Lighting that is specifically designated as required by a health or life safety statute, ordinance, or regulation
4. Decorative gas lighting systems

NYC
NYC
NYC
NYC
NYC
NYC
NYC
NYC

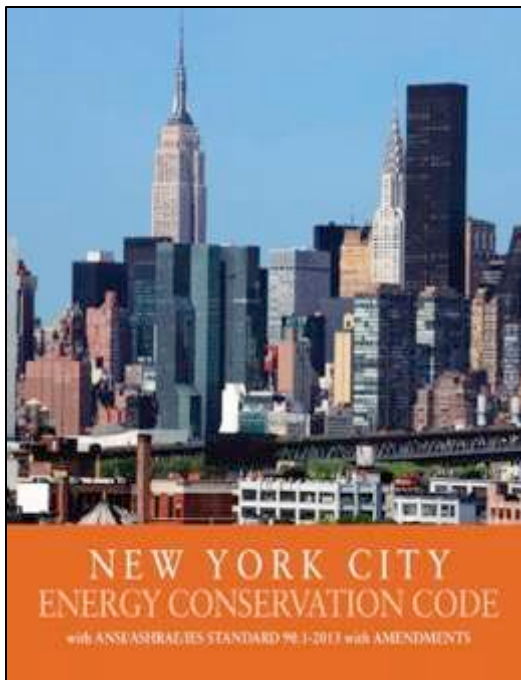
Which code path is preferred for Lighting?



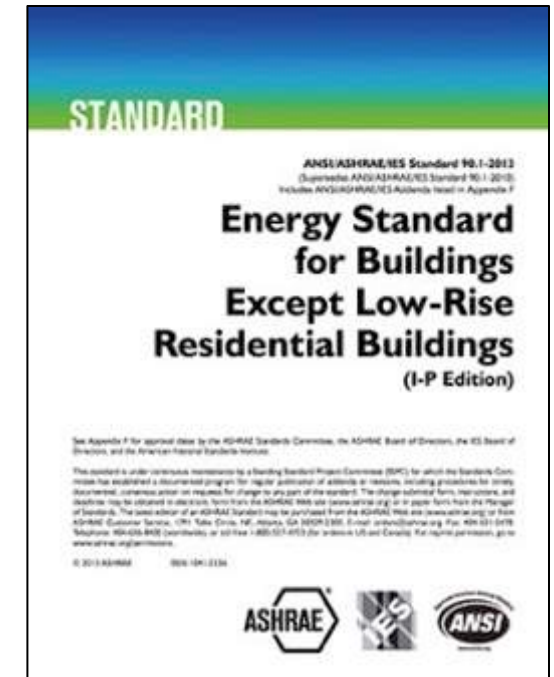
As amended by NYC



Where requirements are equivalent in NYC ECC and ASHRAE :



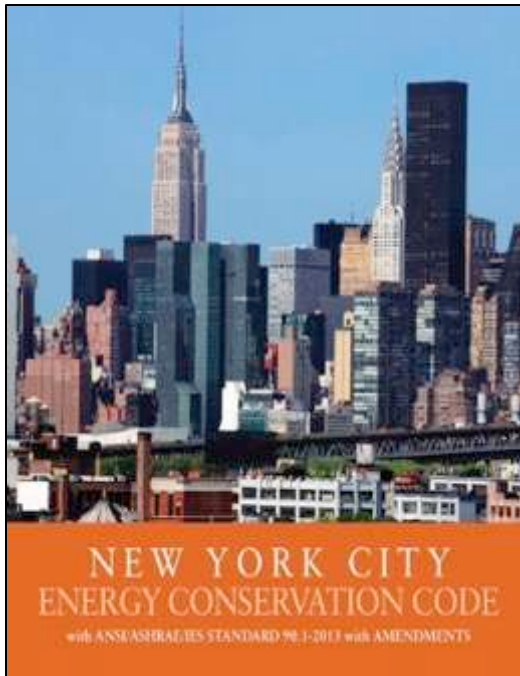
1. Voltage Drop – Now references National Electric Code for both paths
2. Dwelling Units in high rise residential: Both have a 75% source or fixture efficacy requirement.
3. Exemption for Historic Buildings – Federal and State listed – per NYS Law



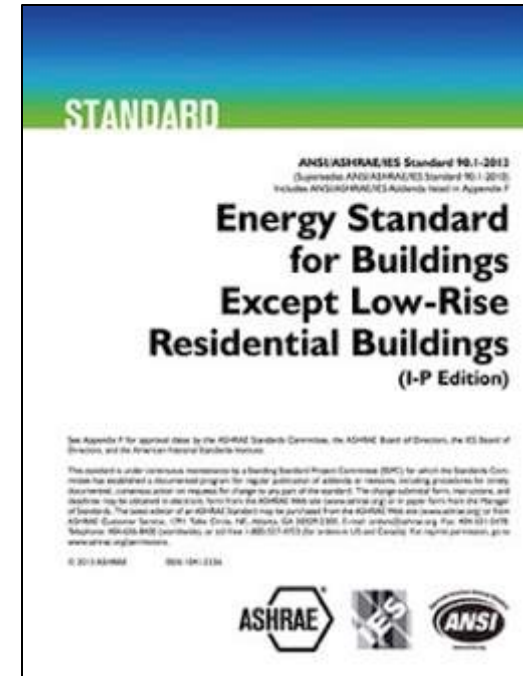
As amended by NYC



NYC made changes but results are not equivalent: **Exceptions to Alterations**



Alterations that replace less than 20% of the luminaires in a space.



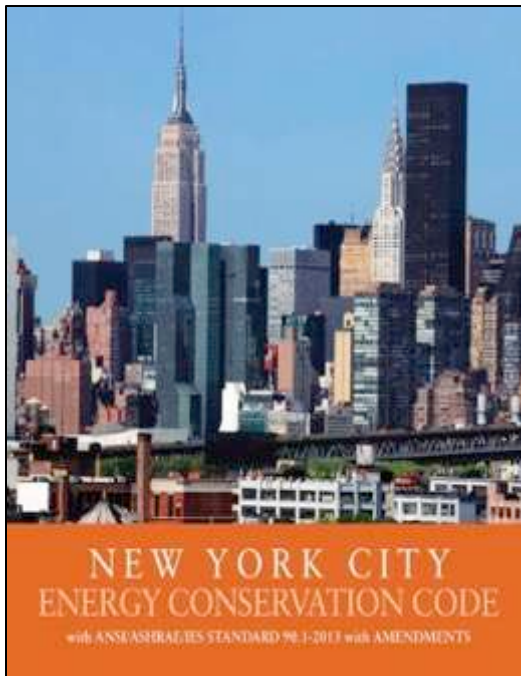
As amended by NYC

Alterations that involve 20% or less of the connected lighting load in a space



Which code path is preferred for Lighting?

NYC Amendments

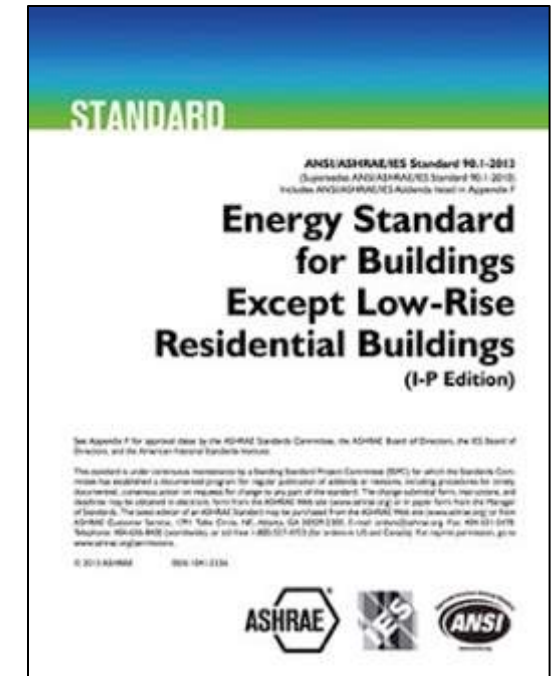


1. Lighting Power Allowances
- Exceptions

2. Lighting Controls
- Exceptions

3. Daylight Design and Response
- Exceptions

4. Additional Efficiency Options
- vs. Automatic Receptacle Control



As amended by NYC



Lighting Power Allowances - Interior



Storage Room < 50 sf.
ASHRAE 1.24 w/sf.
NYCECC/IECC 0.63 w/sf.
– all storage



Confinement Cells
ASHRAE 0.81 w/sf.
NYCECC/IECC N/A



Hospital Corridors
ASHRAE 0.99 w/sf.
NYCECC/IECC 0.79 w/sf.



Lighting Power Allowances - Interior



Electrical/Mechanical Rooms
ASHRAE 0.42 w/sf. +

ASHRAE allows an additional
0.52 w/sf. with separate
controls non-tradable

NYCECC/IECC 0.95 w/sf.

Guest Room
ASHRAE 0.91 w/sf.
NYCECC/IECC 0.47 w/sf.



Dining in Facility for Visually Impaired
ASHRAE 2.65 w/sf.
NYCECC/IECC 1.9 w/sf.

NYCECC/IECC

NEW YORK CITY
ENERGY CONSERVATION CODE
with ANSI/ASHRAE/IES STANDARD 90.1-2013 with AMENDMENTS

Exceptions:

1. The connected power associated with the following lighting equipment is not included in calculating total connected lighting power.
 - 1.1. Professional sports arena playing field lighting.
 - 1.2. Lighting in sleeping units, provided that the lighting complies with Section R404.1.
 - 1.3. Emergency lighting automatically off during normal building operation.
 - 1.4. Lighting in spaces specifically designed for use by occupants with special lighting needs, including those with visual impairment and other medical and age-related issues.
 - 1.5. Lighting in interior spaces that have been specifically designated as a registered interior historic landmark.
 - 1.6. Casino gaming areas.
 - 1.7. Mirror lighting in dressing rooms.
2. Lighting equipment used for the following shall be exempt provided that it is in addition to general lighting and is controlled by an independent control device:
 - 2.1. Task lighting for medical and dental purposes.
 - 2.2. Display lighting for exhibits in galleries, museums and monuments.
3. Lighting for theatrical purposes, including performance, stage, film production and video production.
4. Lighting for photographic processes.
5. Lighting integral to equipment or instrumentation and installed by the manufacturer.
6. Task lighting for plant growth or maintenance.
7. Advertising signage or directional signage.
8. In restaurant buildings and areas, lighting for food warming or integral to food preparation equipment.
9. Lighting equipment that is for sale.
10. Lighting demonstration equipment in lighting education facilities.
11. Lighting approved because of safety or emergency considerations, inclusive of exit lights.
12. Lighting integral to both open and glass-enclosed refrigerator and freezer cases.
13. Lighting in retail display windows, provided the display area is enclosed by ceiling-height partitions.
14. Furniture-mounted supplemental task lighting that is controlled by automatic shutoff.
15. Exit signs.

ASHRAE



Exceptions: The following lighting equipment and applications shall not be considered when determining the interior lighting power allowance developed in accordance with Section 9.5 or 9.6, nor shall the wattage for such lighting be included in the installed interior lighting power identified in accordance with Section 9.1.3. However, any such lighting shall not be exempt unless it is an addition to general lighting and is controlled by an independent control device.

1. Display or accent lighting that is an essential element for the function performed in galleries, museums, and monuments
2. Lighting that is integral to equipment or instrumentation and is installed by its manufacturer
3. Lighting specifically designed for use only during medical or dental procedures and lighting integral to medical equipment
4. Lighting integral to both open and glass-enclosed refrigerator and freezer cases
5. Lighting integral to food warming and food preparation equipment
6. Lighting specifically designed for the life support of nonhuman life forms
7. Lighting in retail display windows, provided the display area is enclosed by ceiling-height partitions
8. Lighting in interior spaces that have been specifically designated as a registered interior historic landmark
9. Lighting that is an integral part of advertising or directional signage

10. Exit signs
11. Lighting that is for sale or lighting educational demonstration systems
12. Lighting for theatrical purposes, including performance, stage, and film and video production
13. Lighting for television broadcasting in sporting activity areas
14. Casino gaming areas
15. Furniture-mounted supplemental task lighting that is controlled by automatic shutoff and complies with Section 9.4.1.3(c)
16. Mirror lighting in dressing rooms and accent lighting in religious pulpit and choir areas
17. Parking garage transition lighting—lighting for covered vehicle entrances and exits from buildings and parking structures—that complies with Section 9.4.1.2(a) and 9.4.1.2(c); each transition zone shall not exceed a depth of 66 ft inside the structure and a width of 50 ft



NYCECC/IECC

Exceptions:

1. The connected power associated with the following lighting equipment is not included in calculating total connected lighting power.

...

2. Lighting equipment used for the following shall be exempt provided that it is in addition to general lighting and is controlled by an independent control device:

...

3 -15 No mention of control requirements or general lighting, except #14 – Furniture mounted task lights

Lighting Power Allowances - Exceptions

Independent Control and Separate from General Lighting

ASHRAE

Exceptions: The following lighting equipment and applications shall not be considered when determining the interior lighting power allowance developed in accordance with Section 9.5 or 9.6, nor shall the wattage for such lighting be included in the installed interior lighting power identified in accordance with Section 9.1.3. However, any such lighting shall not be exempt unless it is an addition to general lighting and is controlled by an independent control device.



Lighting Power Allowances - Exceptions

Where Exceptions Vary

NYCECC/IECC

Exceptions:

1. The connected power associated with the following lighting equipment is not included in calculating total connected lighting power.
 - 1.1. Professional sports arena playing field lighting.
 - 1.2. Lighting in sleeping units, provided that the lighting complies with Section R404.1.
 - 1.4. Lighting in spaces specifically designed for use by occupants with special lighting needs, including those with visual impairment and other medical and age-related issues.
4. Lighting for photographic processes.
6. Task lighting for plant growth or maintenance.
11. Lighting approved because of safety or emergency considerations, inclusive of exit lights.
- 1.7. Mirror lighting in dressing rooms.

ASHRAE



Exceptions: The following lighting equipment and applications shall not be considered when determining the interior lighting power allowance developed in accordance with Section 9.5 or 9.6, nor shall the wattage for such lighting be included in the installed interior lighting power identified in accordance with Section 9.1.3. However, any such lighting shall not be exempt unless it is an addition to general lighting and is controlled by an independent control device.

6. Lighting specifically designed for the life support of nonhuman life forms

13. Lighting for television broadcasting in sporting activity areas
16. Mirror lighting in dressing rooms and accent lighting in religious pulpit and choir areas
17. Parking garage transition lighting—lighting for covered vehicle entrances and exits from buildings and parking structures—that complies with Section 9.4.1.2(a) and 9.4.1.2(c); each transition zone shall not exceed a depth of 66 ft inside the structure and a width of 50 ft

NYCECC/IECC

Exceptions:

1. The connected power associated with the following lighting equipment is not included in calculating total connected lighting power.
 - 1.1. Professional sports arena playing field lighting.

ASHRAE

13. Lighting for television broadcasting in sporting activity areas



Professional sports area – exempt in both

Non-professional sports broadcast lighting – **ASHRAE only**

NYCECC/IECC

Exceptions:

1. The connected power associated with the following lighting equipment is not included in calculating total connected lighting power.
 - 1.2. Lighting in sleeping units, provided that the lighting complies with Section R404.1.

R404.1 Lighting equipment (Mandatory). Not less than 75 percent of the lamps in permanently installed lighting fixtures shall be high-efficacy lamps or not less than 75 percent of the permanently installed lighting fixtures shall contain only high-efficacy lamps.

Exception: Low-voltage lighting.



ASHRAE – Allowances only

Guest Room

ASHRAE 0.91 w/sf.

NYCECC/IECC **0.47 w/sf.**

Dormitory-living quarters

ASHRAE 0.38 w/sf.

NYCECC/IECC 0.38 w/sf.



Exempt only in IECC

NYCECC/IECC

Exceptions:

1. The connected power associated with the following lighting equipment is not included in calculating total connected lighting power.
- 1.4. Lighting in spaces specifically designed for use by occupants with special lighting needs, including those with visual impairment and other medical and age-related issues.

ASHRAE – Allowances only

Allowances for Facility for the Visually Impaired:

Corridor – ASHRAE and IECC/NYC 0.92 w/sf.

Dining – ASHRAE 2.65 w/sf. ♦ IECC/NYC 1.9 w/sf.

Chapel – ASHRAE and IECC/NYC 2.12 w/sf.

Recreation room – ASHRAE and IECC/NYC 2.41 w/sf.



NYCECC/IECC

Exceptions:

1. The connected power associated with the following lighting equipment is not included in calculating total connected lighting power.
- 1.3. Emergency lighting automatically off during normal building operation.



ASHRAE

9.1 General

9.1.1 Scope.

Exceptions:

1. Emergency lighting that is automatically off during normal building operation



NYCECC/IECC

Exceptions:

1. The connected power associated with the following lighting equipment is not included in calculating total connected lighting power.
 - 1.7. Mirror lighting in dressing rooms.



Exempt in both

ASHRAE

16. Mirror lighting in dressing rooms and accent lighting in religious pulpit and choir areas



Exempt only in ASHRAE

NYCECC/IECC

Exceptions:

6. Task lighting for plant growth or maintenance.



Exempt in both

ASHRAE

6. Lighting specifically designed for the life support of nonhuman life forms



"Trust me, I saw a book on human anatomy and this is not the worst thing that could be growing on my back."



Exempt only in ASHRAE

NYCECC/IECC

Exceptions:

4. Lighting for photographic processes.
11. Lighting approved because of safety or emergency considerations, inclusive of exit lights.



ASHRAE

2. SCOPE

2.1 This standard provides

- a. minimum energy-efficient requirements for the design and construction, and a plan for operation and maintenance of
 4. new equipment or building systems specifically identified in the standard that are part of industrial or manufacturing processes

9.1 General

9.1.1 Scope

Exceptions

3. Lighting that is specifically designated as required by a health or life safety statute, ordinance, or regulation

NYCECC/IECC

Decorative

Retail

Additional interior lighting power allowance =
500 watts + (Retail Area 1 · 0.6 W/ft²) +
(Retail Area 2 · 0.6 W/ft²) + (Retail Area 3 ·
1.4 W/ft²) + (Retail Area 4 · 2.5 W/ft²)

ASHRAE

Decorative

Retail

Additional Interior Lighting Power Allowance =
1000 W + (Retail Area 1 × 0.6 W/ft²)
+ (Retail Area 2 × 0.6 W/ft²)
+ (Retail Area 3 × 1.4 W/ft²)
+ (Retail Area 4 × 2.5 W/ft²)



ASHRAE – only

Non-Mandatory Controls

TABLE 9.6.3 Control Factors Used in Calculating Additional Interior Lighting Power Allowance

Additional Control Method (in Addition to Mandatory Requirements)	Space Type				
	Open Office	Private Office	Conference Room, Meeting Room, Classroom (Lecture/Training)	Retail Sales Area	Lobby, Atrium, Dining Area, Corridors/ Stairways, Gym/Pool, Mall Concourse, Parking Garage
Manual, continuous dimming control or programmable multilevel dimming control	0.05	0.05	0.10	0.10	0
Programmable multilevel dimming control using programmable time scheduling	0.05	0.05	0.10	0.10	0.10
Occupancy sensors controlling the downlight component of workstation specific luminaires with continuous dimming to off capabilities	0.25 ^a	0	0	0	0
Occupancy sensors controlling the downlight component of workstation specific luminaires with continuous dimming to off operation, in combination with personal continuous dimming control of downlight illumination by workstation occupant	0.30 ^{a,b}	0	0	0	0
Automatic continuous daylight dimming in secondary sidelighted areas	0.10 ^c	0.10 ^c	0.10 ^c	0.10 ^c	0.10 ^c

- a. Control factor is limited to workstation-specific luminaires in partitioned single occupant work spaces contained within an open office environment (i.e. direct-indirect luminaires with separately controlled downlight and uplight components, with the downward component providing illumination to a single occupant in an open plan workstation). Within 30 minutes of the occupant leaving the space, the downward component shall continuously dim to off over a minimum of two minutes. Upon the occupant entering the space, the downward component shall turn on at the minimum level and continuously raise the illumination to a preset level over a minimum of 30 seconds. The uplight component of workstation specific luminaire shall comply with Section 9.4.1.1(h) (automatic full off).
- b. In addition to the requirements described in footnote (b), the control shall allow the occupant to select their preferred light level via a personal computer, handheld device, or similarly accessible device located within the workstation.
- c. Control factors may not be used if controls are used to satisfy exceptions to Section 5.5.4.2.3

ASHRAE – only Room Cavity Ratio

Common Space Types ¹	LPD W/ft ²	RCR Threshold
Audience Seating Area		
... in an auditorium	0.63	6
in a performing arts theater	2.43	8
Corridor²		
... in a facility for the visually impaired (and not used primarily by the staff) ³	0.92	width < 8 ft
... in a hospital	0.99	width < 8 ft



9.6.4 Room Geometry Adjustment. When using the Space-by-Space Method, an adjustment of the space LPD is allowed for individual spaces where room cavity ratio (RCR) calculated for the empty room is documented to be greater than the RCR threshold for that space type shown in Table 9.6.1.

For corridor/transition spaces, this adjustment is allowed when the corridor is less than 8 ft wide, regardless of the RCR.

The LPD allowance for these spaces may be increased by the following amount:

$$\text{LPD Increase} = \text{Base Space LPD} \times 0.20$$





NYCECC/IECC

ASHRAE – only

N/A

TABLE 9.4.2-2 Individual Lighting Power Allowances for Building Exteriors

	Zone 0	Zone 1	Zone 2	Zone 3	Zone 4
Landscaping	No allowance	0.04 W/ft ²	0.05 W/ft ²	0.05 W/ft ²	0.05 W/ft ²
Loading docks	No allowance	0.5 W/ft ²	0.5 W/ft ²	0.5 W/ft ²	0.5 W/ft ²



NYCECC/IECC

**TABLE C405.5.2(2)
INDIVIDUAL LIGHTING POWER ALLOWANCES FOR BUILDING EXTERIORS**

	LIGHTING ZONES			
	Zone 1	Zone 2	Zone 3	Zone 4
Building facades	No allowance	0.075 W/ft ² of gross above-grade wall area	0.113 W/ft ² of gross above-grade wall area	0.15 W/ft ² of gross above-grade wall area



ASHRAE

<https://www.ashrae.org/standards-research--technology/standards-interpretations/interpretations-for-standard-90-1-2013>

Interpretation 90.1-2013-8 – March 11, 2016

NYCECC/IECC

Exception: Lighting used for the following exterior applications is exempt where equipped with a control device independent of the control of the nonexempt lighting:

1. Specialized signal, directional and marker lighting associated with transportation.
2. Advertising signage or directional signage.
3. Integral to equipment or instrumentation and is installed by its manufacturer.
4. Theatrical purposes, including performance, stage, film production and video production.
5. Athletic playing areas.
6. Temporary lighting.
7. Industrial production, material handling, transportation sites and associated storage areas.
8. Theme elements in theme/amusement parks.
9. Used to highlight features of public monuments and registered historic landmark structures or buildings.

ASHRAE

Exceptions:

1. Lighting used for the following exterior applications is exempt when equipped with a control device that complies with the requirements of Section 9.4.1.4 and is independent of the control of the nonexempt lighting:
 - a. Lighting that is integral to signage and installed in the signage by the manufacturer
 - b. Lighting for athletic playing areas
 - c. Lighting for industrial production, material handling, transportation sites, and associated storage areas
 - d. Theme elements in theme/amusement parks
 - e. Lighting used to highlight features of public monuments and registered historic landmark structures or buildings.
 - f. Lighting for water features

2. Lighting used for the following exterior applications is exempt when controlled separately:
 - a. Specialized signal, directional, and marker lighting associated with transportation
 - b. Lighting integral to equipment or instrumentation and installed by its manufacturer
 - c. Lighting for theatrical purposes, including performance, stage, film production, and video production
 - d. Temporary lighting
 - e. Lighting for hazardous locations
 - f. Lighting for swimming pools
 - g. Searchlights

NYCECC/IECC

Exception: Lighting used for the following exterior applications is exempt where equipped with a control device independent of the control of the nonexempt lighting:

ASHRAE**Exceptions:**

1. Lighting used for the following exterior applications is exempt when equipped with a control device that complies with the requirements of Section 9.4.1.4 and is independent of the control of the nonexempt lighting:
2. Lighting used for the following exterior applications is exempt when controlled separately:

NYCECC/IECC

Exception: Lighting used for the following exterior applications is exempt where equipped with a control device independent of the control of the nonexempt lighting:

2. Advertising signage or directional signage.



Exempt only in IECC

ASHRAE

Exceptions:

1. Lighting used for the following exterior applications is exempt when equipped with a control device that complies with the requirements of Section 9.4.1.4 and is independent of the control of the nonexempt lighting:
 - a. Lighting that is integral to signage and installed in the signage by the manufacturer



Exempt in both

Lighting Power Allowances – Exterior Exceptions

Water Features and Swimming Pools

NYCECC/IECC – N/A



ASHRAE - only

Exceptions:

1. Lighting used for the following exterior applications is exempt when equipped with a control device that complies with the requirements of Section 9.4.1.4 and is independent of the control of the nonexempt lighting:
 - f. Lighting for water features
2. Lighting used for the following exterior applications is exempt when controlled separately:
 - f. Lighting for swimming pools

Exempt only in ASHRAE

Lighting Power Allowances – Exterior Exceptions

Searchlights and Hazardous Locations

NYCECC/IECC – N/A

ASHRAE - only

2. Lighting used for the following exterior applications is exempt when controlled separately:

e. Lighting for hazardous locations

g. Searchlights



Exempt only in ASHRAE



NYCECC/IECC

C405.2.5 Exterior lighting controls. Lighting for exterior applications other than emergency lighting that is intended to be automatically off during building operation, lighting specifically required to meet health and life safety requirements or decorative gas lighting systems shall:

2. Where lighting the building façade or landscape, the lighting shall have controls that automatically shut off the lighting as a function of dawn/dusk and a set opening and closing time.



ASHRAE








9.4.1.4 Exterior Lighting Control. Lighting for exterior applications not exempted in Section 9.1 shall meet the following requirements:

- b. All building façade and landscape lighting shall be automatically shut off between midnight or business closing, whichever is later, and 6 a.m. or business opening, whichever comes first, or between times established by the authority having jurisdiction.

Exceptions:

2. Lighting that is integral to signage and installed in the signage by the manufacturer



NYC – ECC IECC path	ASHRAE 90.1-2013 path in NYC ECC
Section C405.2 Lighting Controls Mandatory	Section 9.4.1 Lighting Control
C405.2.1 Occupant Sensor Controls 	9.4.1.1 a. Local Control
C405.2.2 Time-switch Controls 	9.4.1.1 b. Restricted to Manual ON 
*C405.2.2.2 Light-Reduction Controls	9.4.1.1 c. Restricted to Partial Automatic ON 
* C405.2.2.3 Manual Controls	9.4.1.1 d. Bi-level
C405.2.3 Daylight Responsive Controls	9.4.1.1 e. Daylight responsive – sidelighting
C405.2.3.1 Daylight responsive control function	9.4.1.1 f. Daylight responsive – toplighting
C405.2.3.2 Sidelight daylight zone	9.4.1.1 g. Automatic Partial OFF 
C405.2.3.2 Toplight daylight zone	9.4.1.1 h. Automatic Full OFF 
C405.2.4 Specific Application Controls	9.4.1.1 i. Scheduled OFF 
C405.2.5 Exterior Lighting Controls	9.4.1.2 Parking Garage
	9.4.1.3 Special Application
	9.4.1.4 Exterior Lighting Control



NYCECC/IECC

C405.2 Lighting controls (Mandatory). Lighting systems shall be provided with controls as specified in Sections C405.2.1, C405.2.2, C405.2.3, C405.2.4 and C405.2.5. Lighting controls shall be commissioned and completed in accordance with the requirements of Section C408.3.

Exceptions: Lighting controls are not required for the following:

- ~~1. Areas designated as security or emergency areas that are required to be continuously lighted.~~
2. Interior exit stairways, interior exit ramps and exit passageways.
- ~~3. Emergency egress lighting that is normally off.~~

ASHRAE

9.1 General



9.1.1 Scope. This section shall apply to the following:

- a. Interior spaces of buildings
- b. Exterior building features, including façades, illuminated roofs, architectural features, entrances, exits, loading docks, and illuminated canopies
- c. Exterior building grounds lighting provided through the building's electrical service

Exceptions:

- ~~1. Emergency lighting that is automatically off during normal building operation~~
- ~~3. Lighting that is specifically designated as required by a health or life safety statute, ordinance, or regulation~~

NYC
NYC
NYC



NYCECC/IECC

C405.2.1 Occupant sensor controls. Occupant sensor controls shall be installed to control lights in the following space types:

1. Classrooms/lecture/training rooms.
2. Conference/meeting/multipurpose rooms.
3. Copy/print rooms.
4. Lounges.
5. Employee lunch and break rooms.
6. Private offices.
7. Restrooms.
8. Storage rooms.
9. Janitorial closets.
10. Locker rooms.
11. Other spaces 300 square feet (28 m²) or less that are enclosed by floor-to-ceiling height partitions.
12. Warehouses.
13. Open Plan Offices.

ASHRAE

Excerpt from Table 9.6.1

The control functions below shall be implemented in accordance with the descriptions found in the referenced paragraphs within Section 9.4.1.1. For each space type: (1) All REQs shall be implemented. (2) At least one ADD1 (when present) shall be implemented. (3) At least one ADD2 (when present) shall be implemented.

Informative Note: This table is divided into two sections; this first section covers space types that can be commonly found in multiple building types. The second part of this table covers space types that are typically found in a single building type.

Common Space Types ¹	LPD W/ ft ²	RCR Threshold	a	b	c	d	e	f	g	h	i
Office											
...enclosed and ≤ 250 ft ² (8,9)	1.00	8	REQ	REQ	ADD1	REQ	REQ	REQ	---	REQ	---
...enclosed and > 250 ft ²	1.00	8	REQ	ADD1	ADD1	REQ	REQ	REQ	---	ADD2	ADD2
<u>...open plan</u>	<u>0.90</u>	4	REQ	---	<u>REQ</u>	REQ	REQ	REQ	---	<u>REQ</u>	---

SPACE TYPE	NYC ECC 2016 – incorporating LL48-2010			ASHRAE 90.1-2013 mod. NYC2016 Incorporating LL48-2010		
	Manual ON required - VACANCY Sensor	Manual On or 50% automatic ON	Full ON Allowed	Manual ON required - VACANCY Sensor	Manual On or 50% automatic ON	Full ON Allowed
	20 Minute Time Out - NYC			20 Minute Time Out		
Classrooms*						
Lecture, Training						
Conference/meeting rooms						
Copy/print rooms						
Lounges						
Employee lunch /break rooms						
Private office	< 200 sf	≥ 200		< 200 sf	≥ 200	
Restrooms						
Storage rooms					≥ 50 sf and ≤ 1000 sf	
Janitorial closets						
Locker rooms						
Other enclosed spaces <300 sf				N/A		
Warehouses		50% Auto OFF ON not defined		Option: Sensor or Scheduled		
Open Offices					≤ 2500 sf.	
PAC & Retail dressing room	N/A					
* Exceptions - Shop, laboratory and preschool classrooms		See Time- Switch		No automatic shut-off required		

SPACE TYPE	NYC ECC 2016		ASHRAE 90.1-2013 mod. NYC2016 <u>CHOICE</u>	
	Manual or 50% automatic ON	Full ON Allowed	Auto Full OFF (sensor)	Scheduled OFF
Public Corridors		Full ON Allowed	Full ON Allowed	Full ON Allowed
Stairways		Full ON Allowed	Full ON Allowed	Full ON Allowed
Primary Building Entrance/Lobby		Full ON Allowed	Full ON Allowed	Full ON Allowed
Where Manual ON endangers safety or security		Full ON Allowed	Full ON Allowed	Full ON Allowed

NYCECC/IECC

M	Classrooms, Lecture, Training	P
M	Conference/meeting rooms	
P	Copy/print rooms	
P	Lounges,	
M	Employee lunch and breakrooms	
M	Private office ≤ 200 sf.	
F	Restrooms	
P	Storage rooms	
P	Janitorial closets	
P	Locker rooms	
P	Other enclosed spaces <300 sf	
	Warehouses	
F	Open Offices	
P ?	* Exceptions - Shop, laboratory	
P ?	and preschool classrooms	

F	Public Corridors
F	Stairways
F	Primary Building Entrance/Lobby
F	Where Manual ON endangers safety or security

C405.2.1.1 Occupant sensor control function. Occupant sensor controls in spaces other than warehouses specified in Section C405.2.1 shall comply with the following:

1. Automatically turn off lights within 20 minutes of all occupants leaving the space.
2. Be manual on or controlled to automatically turn the lighting on to not more than 50 percent power.

Exceptions:

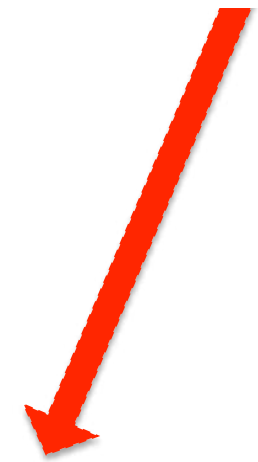
1. Full automatic-on controls shall be permitted to control lighting in open plan offices, public corridors, stairways, restrooms, primary building entrance areas and lobbies, and areas where manual-on operation would endanger the safety or security of the room or building occupants.
2. Manual on controls shall be required for classrooms (not including shop classrooms, laboratory classrooms, and preschool classrooms), conference/meeting rooms, employee lunch and break rooms, and offices smaller than 200 square feet (18.5 m²) in

area. Such sensors and controls shall not have an override switch that converts from manual-on to automatic-on functionality, and may have a grace period of up to 30 seconds to turn on the lighting automatically after the sensor has turned off the lighting if occupancy is detected.

NYC
NYC
NYC
NYC
NYC
NYC
NYC
NYC

3. Shall incorporate a manual control to allow occupants to turn lights off.

C405.2.1.2 Occupant sensor control function in warehouses



3. Shall incorporate a manual control to allow occupants to turn lights off.



ASHRAE

	Restricted to Manual ON [See Section 9.4.1.1(b)]	Restricted to Partial Automatic ON [See Section 9.4.1.1(c)]	Automatic Full OFF [See Section 9.4.1.1(h)]	Scheduled Shutoff [See Section 9.4.1.1(i)]	NYC
	b	c	h	i	NYC
Lounge/Breakroom ^{8,9}					NYC
... in a healthcare facility	REQ	ADD1	REQ	—	NYC
... all other lounges/breakrooms	REQ	ADD1	REQ	—	NYC
Office					NYC
... enclosed and ≤ 250 ft ² (8,9)	REQ	ADD1	REQ	—	NYC
... enclosed and > 250 ft ²	ADD1	ADD1	ADD2	ADD2	NYC
... open plan	—	REQ	REQ	—	NYC
Pharmacy Area	ADD1	ADD1	ADD2	ADD2	NYC
Restroom					NYC
... in facility for the visually impaired	—	—	REQ	—	NYC
... all other restrooms	—	—	REQ	—	NYC

Lounge/Breakroom^{8,9}

Office

Pharmacy Area

Restroom

REQ

REQ

REQ

REQ

REQ

REQ



ASHRAE



Common Space Types¹

	Restricted to Manual ON [See Section 9.4.1.1(b)]	Restricted to Partial Automatic ON [See Section 9.4.1.1(c)]	Automatic Full OFF [See Section 9.4.1.1(h)]	Scheduled Shutoff [See Section 9.4.1.1(i)]	NYC
	b	c	h	i	NYC
Lounge/Breakroom^{8,9}					NYC
... in a healthcare facility	REQ	ADD1	REQ	—	NYC
... all other lounges/breakrooms	REQ	ADD1	REQ	—	NYC
Office					NYC
... enclosed and ≤ 250 ft ² (k,9)	REQ	ADD1	REQ	—	NYC
... enclosed and > 250 ft ²	ADD1	ADD1	ADD2	ADD2	NYC
... open plan	—	REQ	REQ	—	NYC
Pharmacy Area	ADD1	ADD1	ADD2	ADD2	NYC
Restroom					NYC
... in facility for the visually impaired	—	—	REQ	—	NYC
... all other restrooms	—	—	REQ	—	NYC

Lounge/Breakroom^{8,9}

Office

Pharmacy Area

Restroom

NYCECC/IECC – N/A

ASHRAE

Exceptions: The following lighting is not required to be automatically shut off:

1. General lighting and task lighting in shop, laboratory, and preschool classrooms
2. General lighting and task lighting in spaces where automatic shutoff would endanger the safety or security of room or building occupants
3. Lighting required for 24/7 operation
4. Lighting in offices smaller than 200 square feet in area equipped with lighting controls activated by photosensor

NYC
NYC

NYC
NYC



Shop classrooms



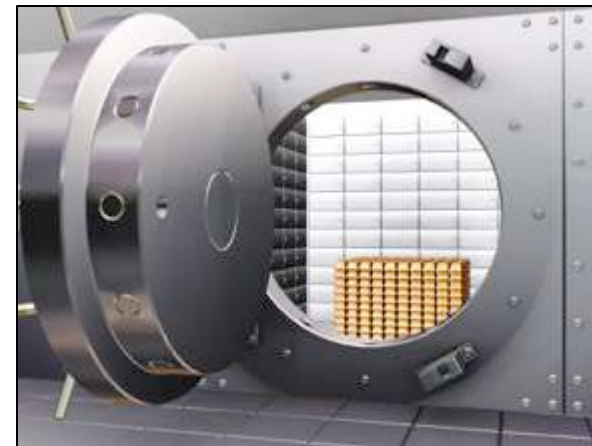
Laboratory classrooms



Preschool classrooms



Offices < 200 sf with photosensor controls



Endanger the safety/security of room/building

NYCECC/IECC

ASHRAE

Find info through iterative process vs. Find info on Space-by-space table

Occupancy Sensors
required in all Spaces
< 300 square feet

NYC modifications to control
requirements in Open Office
more stringent with Partial
ON and Square Footage
limitation



NYCECC/IECC

C405.2.2.1 Time-switch control function

- **No Choice of Control Signal Source**
- **No Coverage Limits**
- **Programming Requirements**
 - 7-day clock minimum
 - Seven different day types per week
 - Auto Holiday Shutoff
 - Program backup capabilities
- **Manual override switch required**
- **Manual Light Reduction switch for spaces with Time-switch**

ASHRAE

i. Scheduled shutoff

- **Choice of Control Signal Source**
 - Time-of-day device
 - Signal from another device or system
- **Coverage Limits**
 - No more than 25,000 square feet,
 - No more than one floor
- **Programming for Weekends and Holidays**
- **Manual override optional**



Lighting Controls – Scheduled

Find Scheduled OFF in ASHRAE Table

ASHRAE

Common Space Types¹

Lounge/Breakroom^{8,9}

- ... in a healthcare facility
- ... all other lounges/breakrooms

Office

- ... enclosed and $\leq 250 \text{ ft}^2$ (k,9)
- ... enclosed and $> 250 \text{ ft}^2$
- ... open plan

Pharmacy Area

Restroom

- ... in facility for the visually impaired
- ... all other restrooms

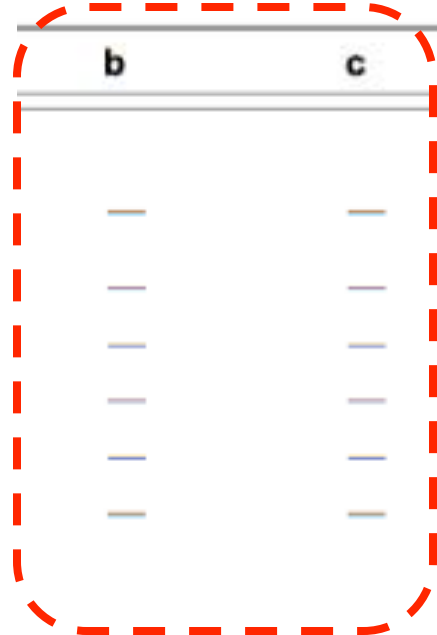
Restricted to Manual ON [See Section 9.4.1.1(b)]	Restricted to Partial Automatic ON [See Section 9.4.1.1(c)]	Automatic Full OFF [See Section 9.4.1.1(h)]	Scheduled Shutoff [See Section 9.4.1.1(i)]	NYC
b	c	h	i	NYC
REQ	ADD1	REQ	—	NYC
REQ	ADD1	REQ	—	NYC
REQ	ADD1	REQ	—	NYC
ADD1	ADD1	ADD2	ADD2	NYC
—	REQ	REQ	—	NYC
ADD1	ADD1	ADD2	ADD2	NYC
—	—	REQ	—	NYC
—	—	REQ	—	NYC





ASHRAE

Common Space Types ¹	Restricted to Manual ON [See Section 9.4.1.1(b)]	Restricted to Partial Automatic ON [See Section 9.4.1.1(c)]	Automatic Full OFF [See Section 9.4.1.1(h)]	Scheduled Shutoff [See Section 9.4.1.1(i)]	NYC
	b	c	h	i	NYC
Lobby					NYC
... in a facility for the visually impaired (and not used primarily by the staff) ³	—	—	ADD2	ADD2	NYC
... for an elevator	—	—	ADD2	ADD2	NYC
... in a hotel	—	—	ADD2	ADD2	NYC
... in a motion picture theater	—	—	ADD2	ADD2	NYC
... in a performing arts theater	—	—	ADD2	ADD2	NYC
... all other lobbies	—	—	ADD2	ADD2	NYC



NYCECC/IECC

C405.2.2 Time-switch controls. Each area of the building that is not provided with occupant sensor controls complying with Section C405.2.1.1 shall be provided with time switch controls complying with Section C405.2.2.1.

Exception: Where a manual control provides light reduction in accordance with Section C405.2.2.2, automatic controls shall not be required for the following:

- ? 1. Sleeping units.
- ✓ 2. Spaces where patient care is directly provided.
- ✓ 3. Spaces where an automatic shutoff would endanger occupant safety or security.
- ✓ 4. Lighting intended for continuous operation.
- ? 5. Shop and laboratory classrooms.

ASHRAE**9.4.1.1 Interior Lighting Controls**

i. Scheduled Shut-off

Exceptions: The following lighting is not required to be on scheduled shutoff:

- ✓ 1. Lighting in spaces where lighting is required for 24/7 continuous operation
- ✓ 2. Lighting in spaces where patient care is rendered
- ✓ 3. Lighting in spaces where automatic shutoff would endanger the safety or security of the room or building occupants



NYCECC/IECC

C405.2.2 Time-switch controls. Each area of the building that is not provided with occupant sensor controls complying with Section C405.2.1.1 shall be provided with time switch controls complying with Section C405.2.2.1.

Exception: Where a manual control provides light reduction in accordance with Section C405.2.2.2, automatic controls shall not be required for the following:

- ✓ 1. Sleeping units.
- ✓ 2. Spaces where patient care is directly provided.
- ✓ 3. Spaces where an automatic shutoff would endanger occupant safety or security.
- ✓ 4. Lighting intended for continuous operation.
- ✓ 5. Shop and laboratory classrooms.

ASHRAE

9.4.1.1 Interior Lighting Controls
i. Scheduled Shut-off

Building Type/Specific/Space Types ¹	Automatic Full OFF [See Section 9.4.1.1(h)]	Scheduled Shutoff [See Section 9.4.1.1(i)]	NYC NYC NYC NYC NYC NYC NYC NYC NYC NYC
	h	i	
Domitory-Living Quarters	—	—	
Fire Station-Sleeping Quarters	—	—	





NYCECC/IECC

Exceptions:

1. Within malls, arcades, auditoriums, single-tenant retail spaces, industrial facilities and arenas:
 - 1.1. The time limit shall be permitted to be greater than 2 hours, provided that the override switch is a captive key device.
 - 1.2. The area controlled by the override switch is permitted to be greater than 5,000 square feet (465 m²), but shall not be greater than 20,000 square feet (1860 m²).

ASHRAE – N/A



NYCECC/IECC

Understand Code nuance to learn that OS NOT Required does not mean Time-Switch Required – still a choice

Requires Manual Override

- **Has exceptions for override function**

Requires Light Reduction to claim exceptions

ASHRAE

Table format is clear that there is a choice where OS not required

Choice of device for control signal

Limits area of coverage



Lighting Controls – Manual Light Reduction or Bi-Level Exceptions

NYCECC/IECC

C405.2.2.2 Light-reduction controls. Spaces required to have light-reduction controls shall have a manual control that allows the occupant to reduce the connected lighting load in a reasonably uniform illumination pattern by at least 50 percent. Lighting reduction shall be achieved by one of the following or another approved method:

1. Controlling all lamps or luminaires.
2. Dual switching of alternate rows of luminaires, alternate luminaires or alternate lamps.
3. Switching the middle lamp luminaires independently of the outer lamps.
4. Switching each luminaire or each lamp.

Exception: Light reduction controls are not required in daylight zones with daylight responsive controls complying with Section C405.2.3.

C405.2.2.3 Manual controls. Manual controls for lights shall comply with the following:

1. Shall be readily accessible to occupants.
2. Shall be located where the controlled lights are visible, or shall identify the area served by the lights and indicate their status.

ASHRAE

- d. Bilevel lighting control: The general lighting in the space shall be controlled so as to provide at least one intermediate step in lighting power or continuous dimming in addition to full ON and full OFF. At least one intermediate step shall be between 30% and 70% (inclusive) of full lighting power.





Lighting Controls – Manual Light Reduction or Bi-Level

Exceptions

NYCECC/IECC

C405.2.2.1 Time-switch control function

Exceptions:

2. Where provided with manual control, the following areas are not required to have light reduction control:



- 2.1. Spaces that have only one luminaire with a rated power of less than 100 watts.
- 2.2. Spaces that use less than 0.6 watts per square foot (6.5 W/m²).
- 2.3. Corridors, equipment rooms, public lobbies, electrical or mechanical rooms.



One luminaire
< 100 watts
IECC Only



Spaces that use < 0.6 watts ~ allowance 0.54

ASHRAE

Bilevel Lighting Control(See Section9.4.1.1(d))

d

Audience Seating Area

...in an auditorium	0.63	REQ
...in a convention center	0.82	REQ
...in a gymnasium	0.65	REQ
...in a motion picture theater	1.14	REQ
...in a penitentiary	0.28	-
...in a performing arts theater	2.43	REQ
...in a religious building	1.53	REQ
...in a sports arena	0.43	-
...all other audience seating areas	0.43	-



Lighting Controls – Exceptions to Light Reduction

Exceptions

NYCECC/IECC

C405.2.2.1 Time-switch control function

Exceptions:

2. Where provided with manual control, the following areas are not required to have light reduction control:
 - 2.1. Spaces that have only one luminaire with a rated power of less than 100 watts.
 - 2.2. Spaces that use less than 0.6 watts per square foot (6.5 W/m²).
 - 2.3. Corridors, equipment rooms, public lobbies, electrical or mechanical rooms.



ASHRAE

Lobby

- ... in a facility for the visually impaired (and not used primarily by the staff)³
- ... for an elevator
- ... in a hotel
- ... in a motion picture theater
- ... in a performing arts theater
- ... all other lobbies

Bilevel
Lighting
Control
[See
Section
9.4.1.1(d)]

d

—

—

—

—

—

—





Lighting Controls – Automatic Partial OFF

ASHRAE Only

NYCECC/IECC – N/A

ASHRAE



Corridors

- ...facility for the visually impaired
- ...Hospital – option with other controls
- ... all other corridors

Laboratory classroom

Lobby

- ...facility for the visually impaired
- ... performing arts theater
- ... all other lobbies

Stairwell

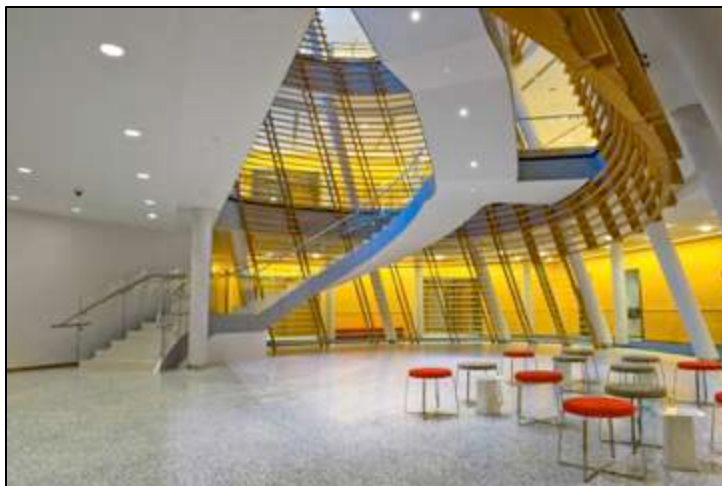
Storage rooms > 1000 ft²

Library Stacks

Post Office Sorting Area

Warehouse – Storage Area

- ...medium to bulky, palletized
- ...smaller, hand carried items





NYCECC/IECC

C405.2.4 Specific application controls. Specific application controls shall be provided for the following:

- ✓ 1. Display and accent light shall be controlled by a dedicated control that is independent of the controls for other lighting within the room or space.
- ✓ 2. Lighting in cases used for display case purposes shall be controlled by a dedicated control that is independent of the controls for other lighting within the room or space.
- ✓ 3. Hotel and motel sleeping units and guest suites shall have a master control device that is capable of automatically switching off all installed luminaires and switched receptacles within 20 minutes after all occupants leave the room.

Exception: Lighting and switched receptacles controlled by captive key systems.

- ✓ 4. Supplemental task lighting, including permanently installed under-shelf or under-cabinet lighting, shall have a control device integral to the luminaires or be controlled by a wall-mounted control device provided that the control device is readily accessible.
- ✓ 5. Lighting for nonvisual applications, such as plant growth and food warming, shall be controlled by a dedicated control that is independent of the controls for other lighting within the room or space.
- ✓ 6. Lighting equipment that is for sale or for demonstrations in lighting education shall be controlled by a dedicated control that is independent of the controls for other lighting within the room or space.

ASHRAE

9.4.1.3 Special Applications

a. The following lighting shall be separately controlled from the general lighting in all spaces:

- ✓ 1. Display or accent lighting
- ✓ 2. Lighting in display cases
- ✓ 3. Nonvisual lighting, such as for plant growth or food warming
- ✓ 4. Lighting equipment that is for sale or used for demonstrations in lighting education



b. Guestrooms

- 1. All lighting and all switched receptacles in guestrooms and suites in hotels, motels, boarding houses, or similar buildings shall be automatically controlled such that the power to the lighting and switched receptacles in each enclosed space will be turned off within 20 minutes after all occupants leave that space.

Exception: Enclosed spaces where the lighting and switched receptacles are controlled by captive key systems and bathrooms are exempt.

- 2. Bathrooms shall have a separate control device installed to automatically turn off the bathroom lighting within 30 minutes after all occupants have left the bathroom.

Exception: Night lighting of up to 5 W per bathroom is exempt.

- ✓ c. All supplemental task lighting, including permanently installed undershelf or undercabinet lighting, shall be controlled from either (1) a control device integral to the luminaires or (2) by a wall-mounted control device that is readily accessible and located so that the occupant can see the controlled lighting.



NYCECC/IECC- N/A



Lighting Controls – Special Application Controls

Guestrooms

ASHRAE

9.4.1.3 Special Applications

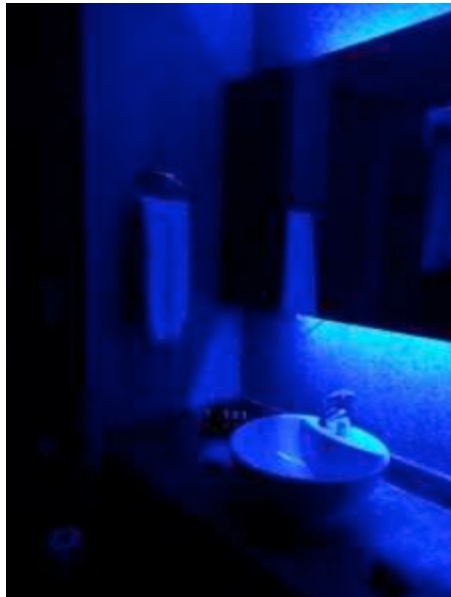
b. Guestrooms

1. All lighting and all switched receptacles in guestrooms and suites in hotels, motels, boarding houses, or similar buildings shall be automatically controlled such that the power to the lighting and switched receptacles in each enclosed space will be turned off within 20 minutes after all occupants leave that space.
2. Bathrooms shall have a separate control device installed to automatically turn off the bathroom lighting within 30 minutes after all occupants have left the bathroom.

Exception: Night lighting of up to 5 W per bathroom is exempt.



NYCECC/IECC- N/A



Lighting Controls – Special Application Controls

Guestrooms

ASHRAE

9.4.1.3 Special Applications

b. Guestrooms

1. All lighting and all switched receptacles in guestrooms and suites in hotels, motels, boarding houses, or similar buildings shall be automatically controlled such that the power to the lighting and switched receptacles in each enclosed space will be turned off within 20 minutes after all occupants leave that space.
- ➔ 2. Bathrooms shall have a separate control device installed to automatically turn off the bathroom lighting within 30 minutes after all occupants have left the bathroom.
- ➔ **Exception:** Night lighting of up to 5 W per bathroom is exempt.



Lighting Controls – Parking Garage Controls

NYCECC/IECC



ASHRAE - only

1. Automatic shut-off per 9.4.1.1 (i) – scheduled shut-off
2. Partial Automatic Off (30%) reduction – 20 minute vacancy
 - IECC – no Light reduction < 0.6 w/sf
3. Separate control of daylight transition zones, with automatic 50% reduction from sunset to sunrise
4. Daylight responsive lighting for fixtures within 20 feet of perimeter – depending on percent open
 - Exceptions for daylight transition zones – ASHRAE



Lighting Controls – Parking Garage Controls

NYCECC/IECC

- ✓ 1. Time-switch required since not on OS required list
- 2. IECC does not have Partial Automatic Off category and
 - IECC – no Light reduction < 0.6 w/sf
- 3. No mention of sunset to sunrise reduction. Exception in exterior controls for turning lights off during daylight hours at covered vehicle entrances/exits
- 4. Daylight responsive lighting – IF space meets Daylight Zone criteria

ASHRAE - only

- ✓ 1. Automatic shut-off per 9.4.1.1 (i) – scheduled shut-off
- 2. Partial Automatic Off (30%) reduction – 20 minute vacancy
 - IECC – no Light reduction < 0.6 w/sf
- 3. Separate control of daylight transition zones, with automatic 50% reduction from sunset to sunrise
- 4. Daylight responsive lighting for fixtures within 20 feet of perimeter – depending on percent open
 - Exceptions for daylight transition zones – ASHRAE



Daylight – Sidelight Daylight Zones

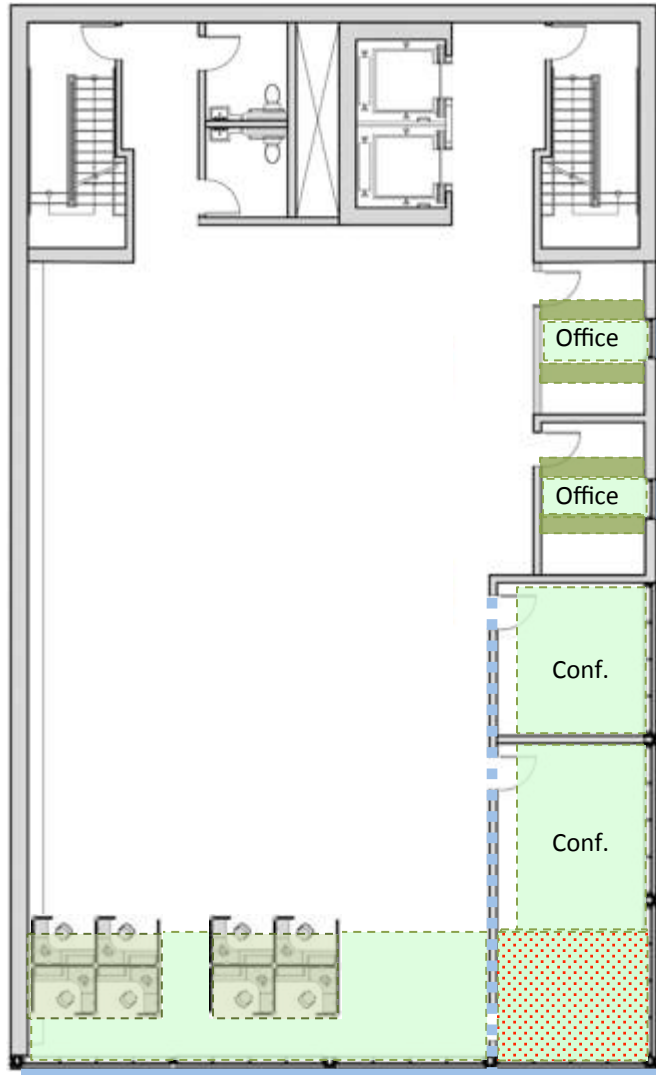
NYCECC/IECC

Depth = Window Head Height or **FULL height obstruction**

Width = Window Width + 2' to each side or **FULL height obstruction**

Separate control of lights in daylight zones with **different cardinal direction > 150w**

Minimum total glazing area ≥ 24 sf.



12' Window Head Height

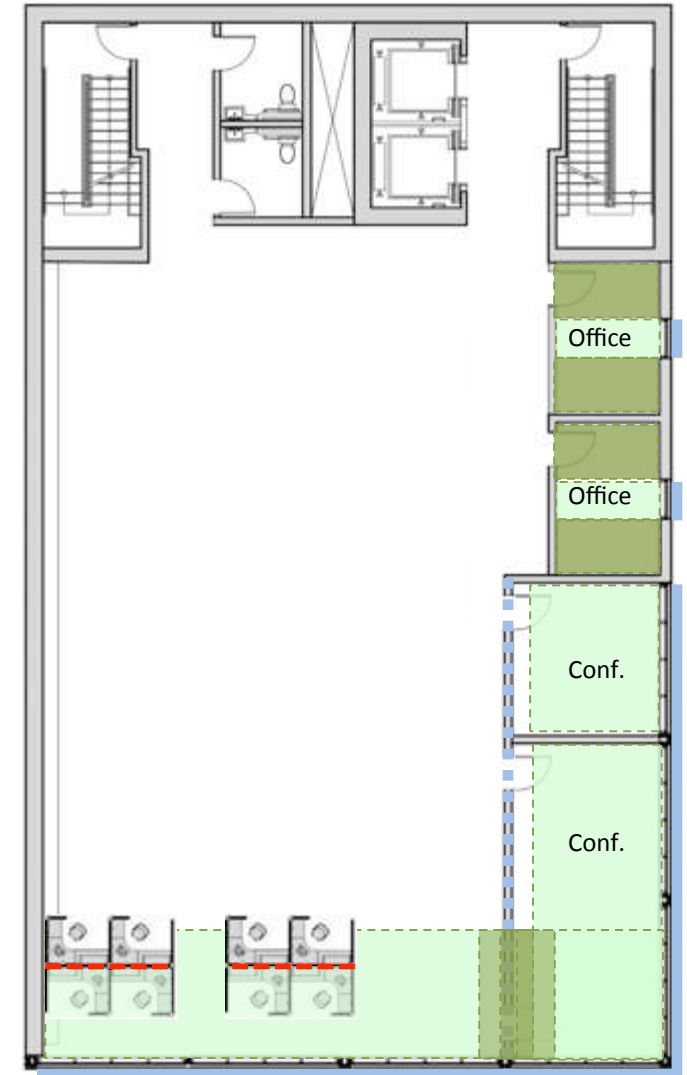
ASHRAE

Primary sidelighted Area

Depth = Window Head Height or **5' or higher OPAQUE obstruction**

Width = Window Width + $\frac{1}{2}$ Window Head Height to each side or **5' or higher OPAQUE obstruction**

Minimum total glazing area ≥ 20 sf.

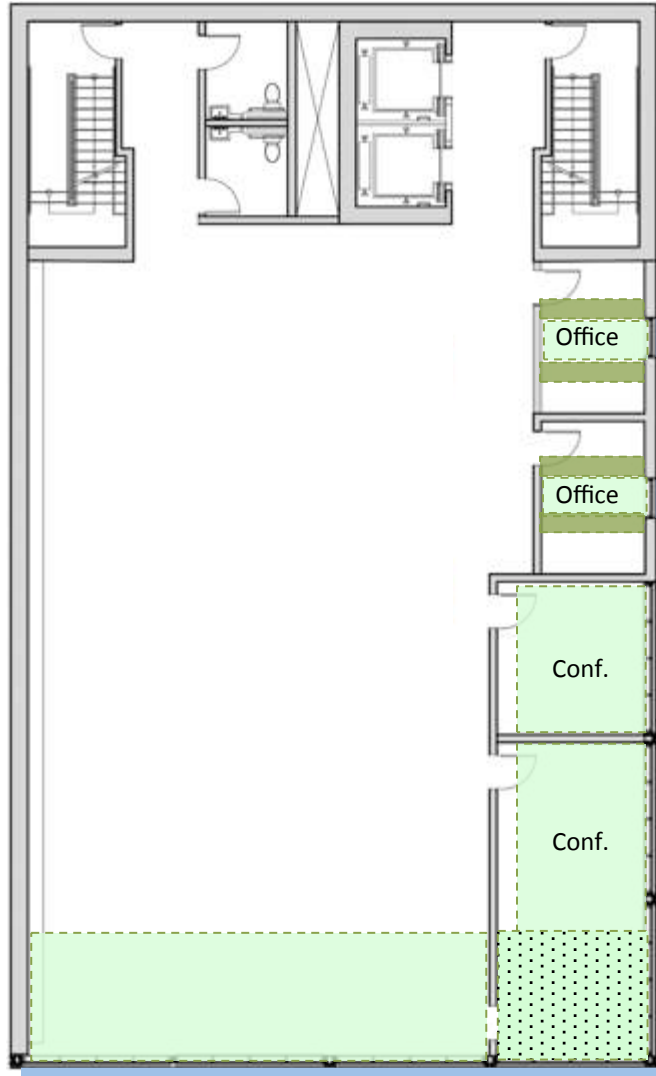


12' Window Head Height



Daylight – Sidelight Daylight Zones

NYCECC/IECC –
N/A



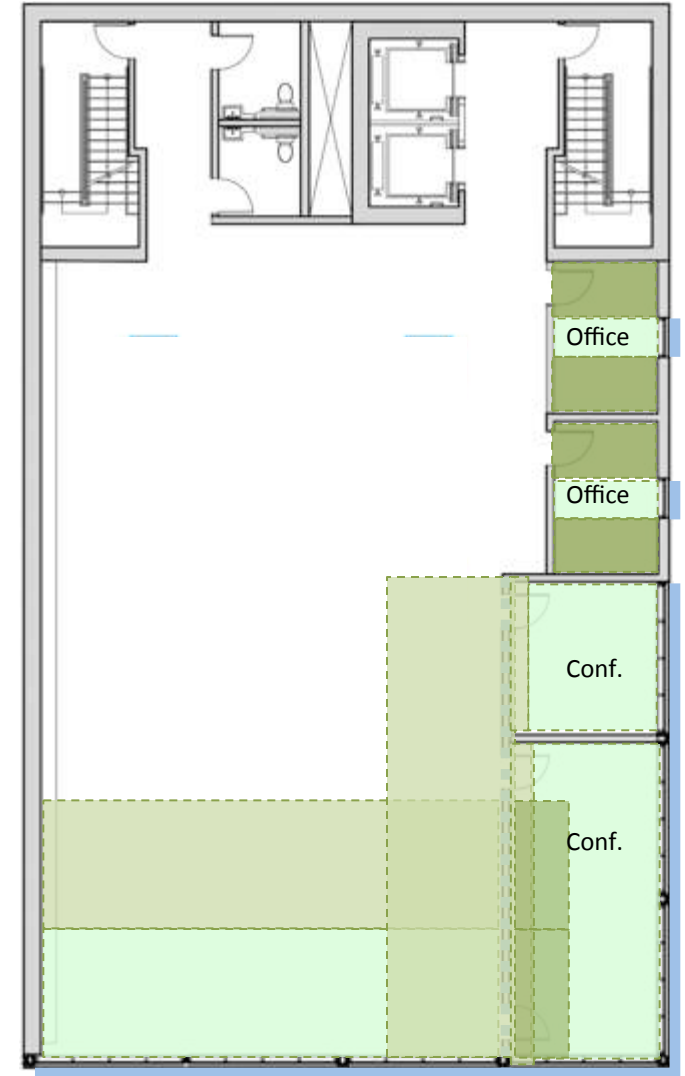
12' Window Head Height

ASHRAE

*Secondary
Sidelighted Area*

Depth = Window Head
Height or
5' or higher
OPAQUE obstruction

Width = Window
Width + $\frac{1}{2}$
Window Head
Height to each
side or *5' or higher*
OPAQUE
obstruction



12' Window Head Height



NYCECC/IECC

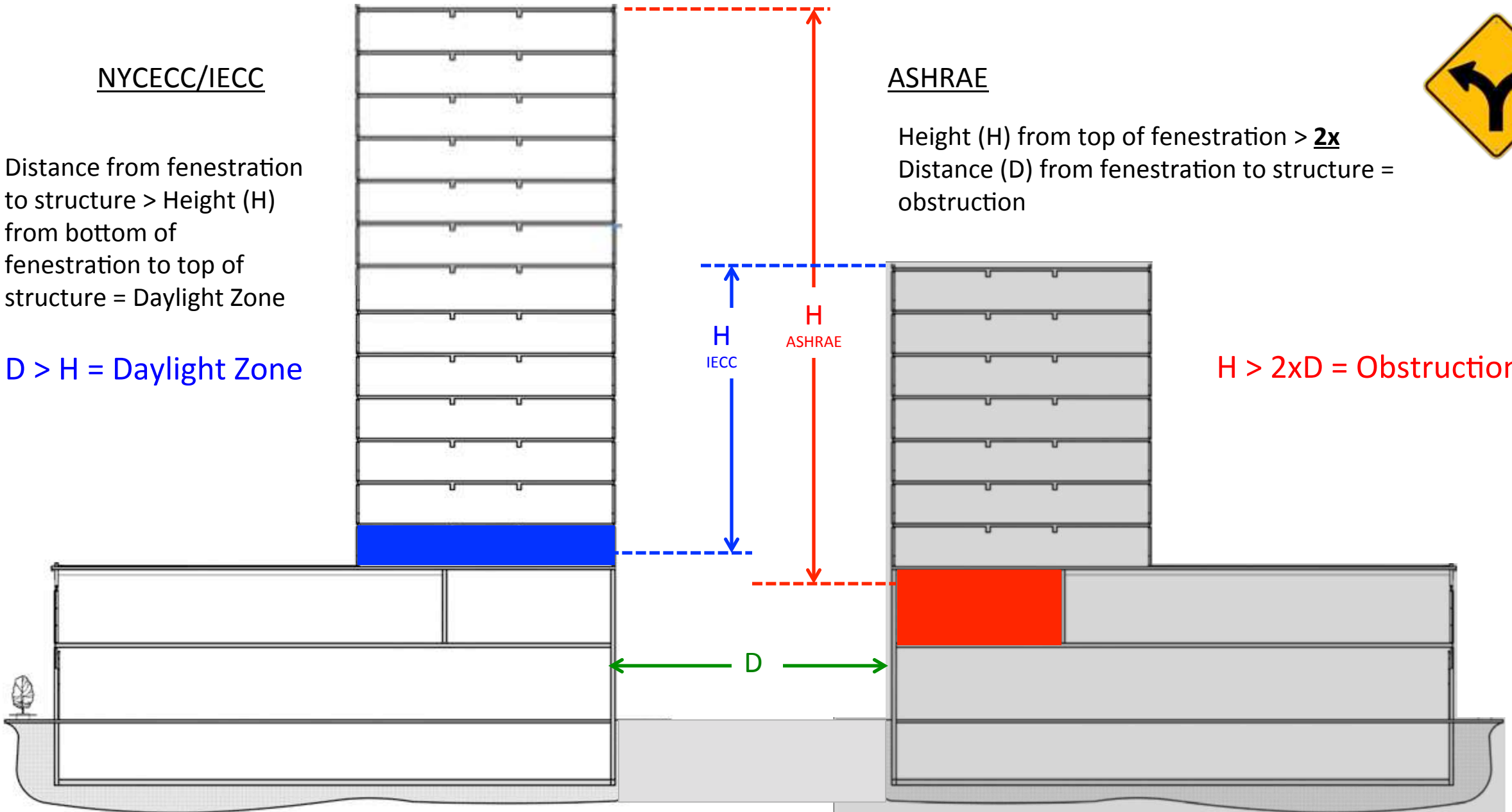
Distance from fenestration to structure > Height (H) from bottom of fenestration to top of structure = Daylight Zone

$D > H = \text{Daylight Zone}$

ASHRAE

Height (H) from top of fenestration > $2x$ Distance (D) from fenestration to structure = obstruction

$H > 2xD = \text{Obstruction}$



Spaces where skylights are required in New Construction

Code Path	Space Type																								
	Office	Lobby	Atrium	Concourse	Corridor	Storage	Non-refrigerated warehouse	Gymnasium	Fitness/ Exercise Area	Playing Area	Gymnasium Seating Area	Convention Center	Convention Exhibit/ event space	Courtroom	Automotive Service	Fire Station Engine Room	Space where Manufacturing Occurs	Manufacturing Corridor/ transition	Manufacturing Bay Areas	Retail	Library Reading and Stacks	Distribution/ Sorting Area	Transportation Depot	Transportation Baggage and Seating Areas	Workshop
ASHRAE 90.1-2013 (Section 5.5.4.2.3)	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X		X	X	X	X	X		X	X
IECC 2015 (C402.4.2)	X	X	X	X	X	X	X	X	X			X			X		X			X		X	X		X

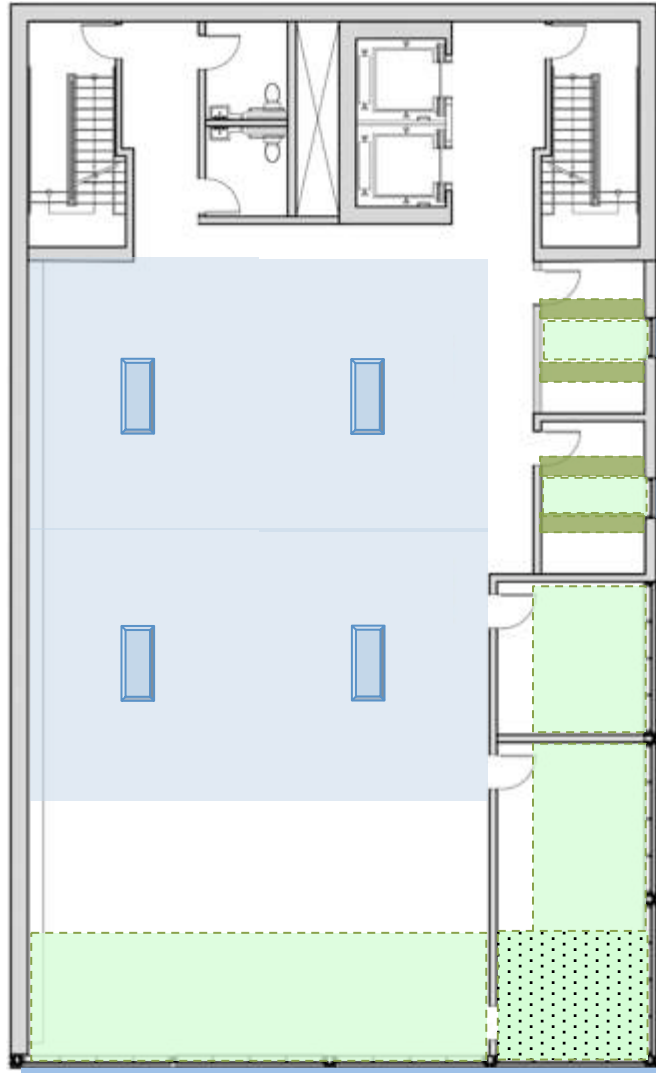
KEY: Same ASHRAE ONLY IECC ONLY



DRAFT 2018-01-28

NYCECC/IECC

Daylight area under skylight = Size of skylight + smaller of :
 0.70 x CH in each direction,
 or
 to an Obstruction that is 0.70 CH or greater

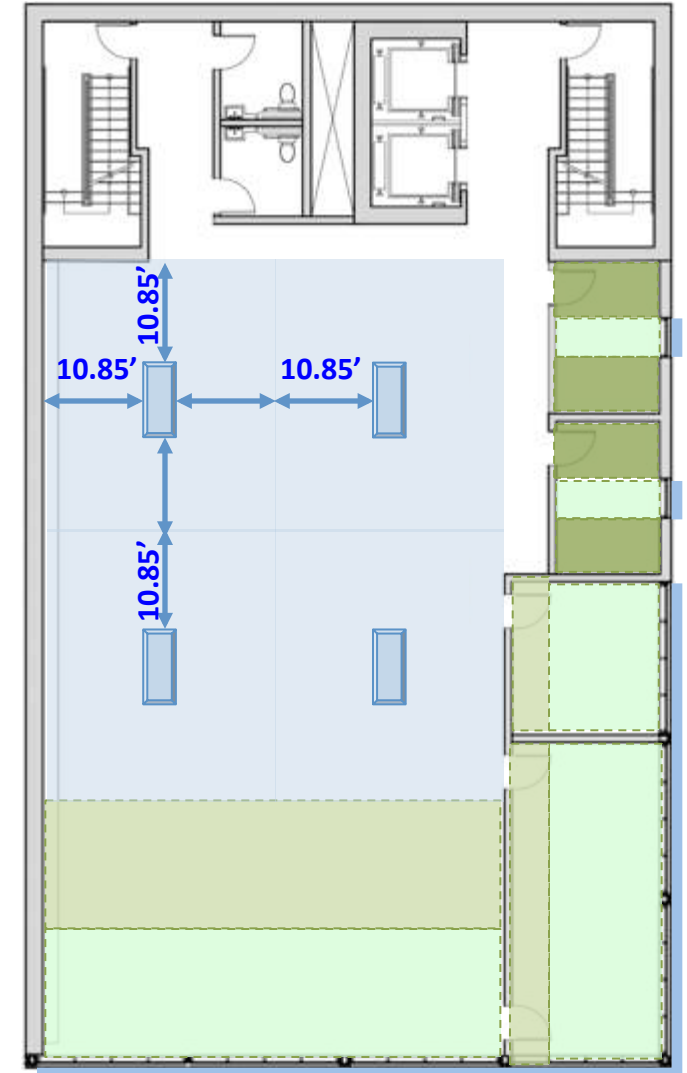


15.5' Ceiling Height: $0.70 \times 15.5 = 10.85'$

ASHRAE

Daylight area under skylight = Size of skylight + smaller of
 0.70 x CH in each direction,
 or
 the distance to an **OPAQUE** Obstruction that is farther away than 0.70 the distance between the top of the obstruction and the CH.
 $0.7 \times [CH-OH]$

Daylight – Toplight Zones



15.5' Ceiling Height: $0.70 \times 15.5 = 10.85'$



NYCECC/IECC

C405.2.3 Daylight-responsive controls. Daylight-responsive controls complying with Section C405.2.3.1 shall be provided to control the electric lights within daylight zones in the following spaces:

1. Spaces with a total of more than 150 watts of general lighting within sidelight daylight zones complying with Section C405.2.3.2. General lighting does not include lighting that is required to have specific application control in accordance with Section C405.2.4.
2. Spaces with a total of more than 150 watts of general lighting within toplight daylight zones complying with Section C405.2.3.3.

Exceptions: Daylight responsive controls are not required for the following:

1. Spaces in health care facilities where patient care is directly provided.
2. Dwelling units and sleeping units.
3. Lighting that is required to have specific application control in accordance with Section C405.2.4.
4. Sidelight daylight zones on the first floor above grade in Group A-2 and Group M occupancies.

Lighting Controls – Daylighting Exceptions

ASHRAE

e. Automatic daylight responsive controls for sidelighting: In any space where the combined input power of all general lighting completely or partially within the primary sidelighted areas is 150 W or greater, the general lighting in the primary sidelighted areas shall be controlled by photocontrols.

	Automatic Daylight Responsive Controls for Sidelighting [See Section 9.4.1.1(e) ⁶]	Automatic Daylight Responsive Controls for Toplighting [See Section 9.4.1.1(f) ⁶]
	e	f
Healthcare Facility		
... in an exam/treatment room	REQ	REQ
... in an imaging room	REQ	—
... in a nursery	REQ	REQ
... in a patient room	REQ	REQ
... in a physical therapy room	REQ	REQ
... in a recovery room	REQ	REQ



NYCECC/IECC

C405.2.3 Daylight-responsive controls. Daylight-responsive controls complying with Section C405.2.3.1 shall be provided to control the electric lights within daylight zones in the following spaces:

1. Spaces with a total of more than 150 watts of general lighting within sidelight daylight zones complying with Section C405.2.3.2. General lighting does not include lighting that is required to have specific application control in accordance with Section C405.2.4.
2. Spaces with a total of more than 150 watts of general lighting within toplight daylight zones complying with Section C405.2.3.3.

Exceptions: Daylight responsive controls are not required for the following:

1. Spaces in health care facilities where patient care is directly provided.
2. Dwelling units and sleeping units.
3. Lighting that is required to have specific application control in accordance with Section C405.2.4.
4. Sidelight daylight zones on the first floor above grade in Group A-2 and Group M occupancies.

ASHRAE

- e. Automatic daylight responsive controls for sidelighting: In any space where the combined input power of all general lighting completely or partially within the primary sidelighted areas is 150 W or greater, the general lighting in the primary sidelighted areas shall be controlled by photocontrols.

9.1.1 Scope

Exceptions

2. Dwelling Units – efficacy only requirement in NYC. Not in scope outside NYC

9.4.1.3 Special Applications

- b. Guestrooms...



NYCECC/IECC

C405.2.3 Daylight-responsive controls. Daylight-responsive controls complying with Section C405.2.3.1 shall be provided to control the electric lights within daylight zones in the following spaces:

1. Spaces with a total of more than 150 watts of general lighting within sidelight daylight zones complying with Section C405.2.3.2. General lighting does not include lighting that is required to have specific application control in accordance with Section C405.2.4.

Exceptions: Daylight responsive controls are not required for the following:

1. Spaces in health care facilities where patient care is directly provided.
2. Dwelling units and sleeping units.
3. Lighting that is required to have specific application control in accordance with Section C405.2.4.
4. Sidelight daylight zones on the first floor above grade in Group A-2 and Group M occupancies.

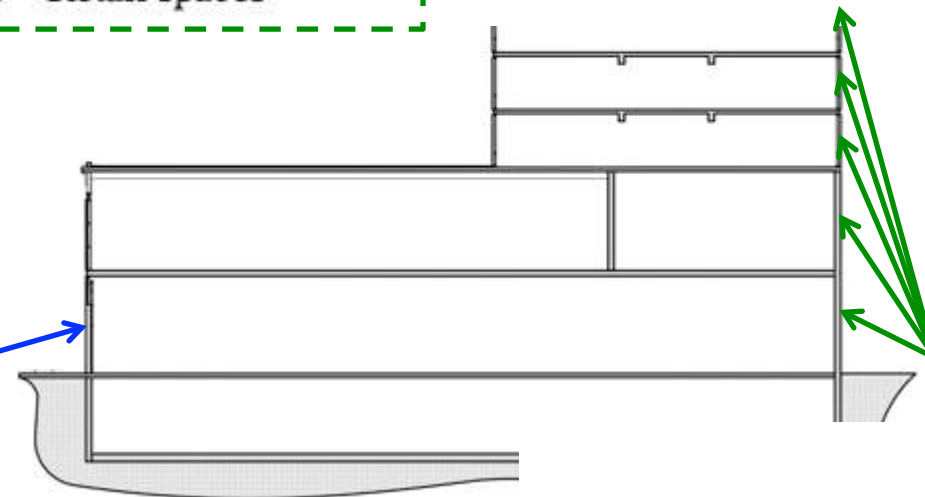
ASHRAE

- e. *Automatic daylight responsive controls for sidelighting:* In any space where the combined input power of all general lighting completely or partially within the primary sidelighted areas is 150 W or greater, the general lighting in the primary sidelighted areas shall be controlled by photocontrols.

Exceptions: The following areas are exempted from Section 9.4.1.1(e):

3. Retail spaces

IECC
A-2 & M



ASHRAE
M ONLY

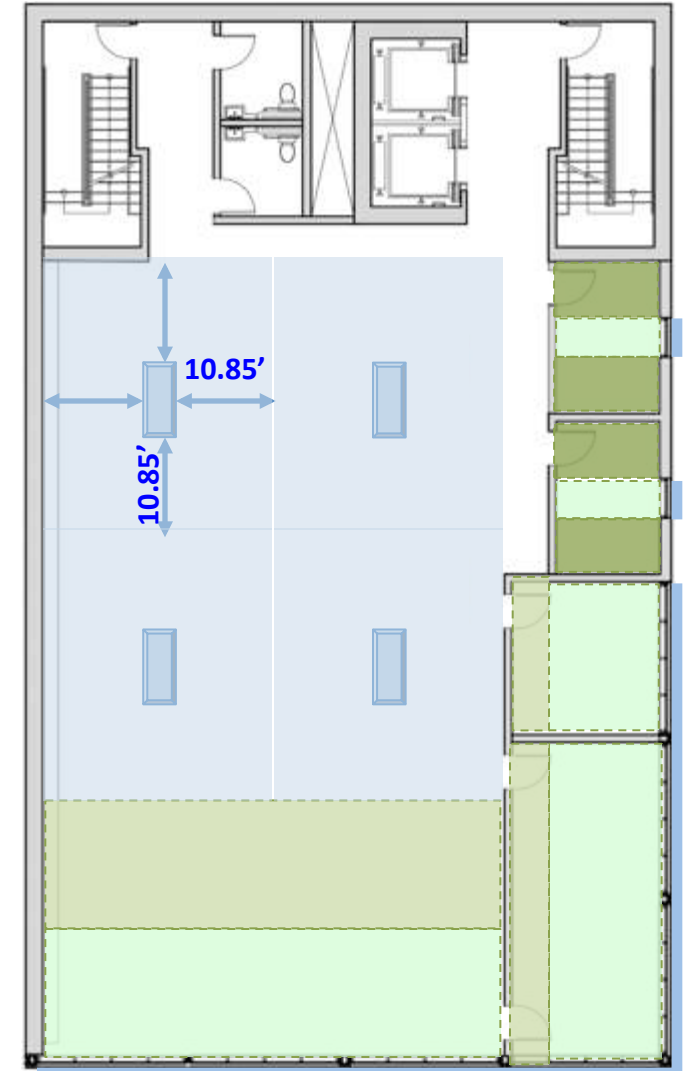


Lighting Controls – Daylight – Toplight Zones

ASHRAE Exempt ONLY

Common Space Types ¹	Automatic Daylight Responsive Controls for Sidelighting (See Section 9.4.1.1(e) ⁶)	Automatic Daylight Responsive Controls for Toplighting (See Section 9.4.1.1(f) ⁶)
	e	f
...open plan	REQ	REQ
Parking Area, Interior		
Pharmacy Area	REQ	REQ
Restroom		
...in a facility for the visually impaired		
...all other restrooms		
Sales Area⁴		
Seating Area, General		

ASHRAE



15.5' Ceiling Height: $0.70 \times 15.5 = 10.85'$



NYCECC/IECC

C405.2.3 Daylight-responsive controls. Daylight-responsive controls complying with Section C405.2.3.1 shall be provided to control the electric lights within daylight zones in the following spaces:

1. Spaces with a total of more than 150 watts of general lighting within sidelight daylight zones complying with Section C405.2.3.2. General lighting does not include lighting that is required to have specific application control in accordance with Section C405.2.4.
2. Spaces with a total of more than 150 watts of general lighting within toplight daylight zones complying with Section C405.2.3.3.

Exceptions: Daylight responsive controls are not required for the following:

1. Spaces in health care facilities where patient care is directly provided.
2. Dwelling units and sleeping units.
3. Lighting that is required to have specific application control in accordance with Section C405.2.4.
4. Sidelight daylight zones on the first floor above grade in Group A-2 and Group M occupancies.

ASHRAE

- e. *Automatic daylight responsive controls for sidelighting:* In any space where the combined input power of all general lighting completely or partially within the primary sidelighted areas is 150 W or greater, the general lighting in the primary sidelighted areas shall be controlled by photocontrols.
- f. *Automatic daylight responsive controls for toplighting:* In any space where the combined input power for all general lighting completely or partially within daylight areas under skylights and daylight areas under roof monitors is 150 W or greater, general lighting in the daylight area shall be controlled by photocontrols having the following characteristics:



NYCECC/IECC

C405.2.3 Daylight-responsive controls. Daylight-responsive controls complying with Section C405.2.3.1 shall be provided to control the electric lights within daylight zones in the following spaces:

1. Spaces with a total of more than 150 watts of general lighting within sidelight daylight zones complying with Section C405.2.3.2. General lighting does not include lighting that is required to have specific application control in accordance with Section C405.2.4.
2. Spaces with a total of more than 150 watts of general lighting within toplight daylight zones complying with Section C405.2.3.3.

Exceptions: Daylight responsive controls are not required for the following:

1. Spaces in health care facilities where patient care is directly provided.
2. Dwelling units and sleeping units.
3. Lighting that is required to have specific application control in accordance with Section C405.2.4.
4. Sidelight daylight zones on the first floor above grade in Group A-2 and Group M occupancies.

ASHRAE

- e. *Automatic daylight responsive controls for sidelighting:* In any space where the combined input power of all general lighting completely or partially within the primary sidelighted areas is 150 W or greater, the general lighting in the primary sidelighted areas shall be controlled by photocontrols.
- f. *Automatic daylight responsive controls for toplighting:* In any space where the combined input power for all general lighting completely or partially within daylight areas under skylights and daylight areas under roof monitors is 150 W or greater, general lighting in the daylight area shall be controlled by photocontrols having the following characteristics:



NYCECC/IECC

C405.2.3 Daylight-responsive controls. Daylight-responsive controls complying with Section C405.2.3.1 shall be provided to control the electric lights within daylight zones in the following spaces:

1. Spaces with a total of more than 150 watts of general lighting within sidelight daylight zones complying with Section C405.2.3.2. General lighting does not include lighting that is required to have specific application control in accordance with Section C405.2.4.
2. Spaces with a total of more than 150 watts of general lighting within toplight daylight zones complying with Section C405.2.3.3.

Exceptions: Daylight responsive controls are not required for the following:

1. Spaces in health care facilities where patient care is directly provided.
2. Dwelling units and sleeping units.
3. Lighting that is required to have specific application control in accordance with Section C405.2.4.
4. Sidelight daylight zones on the first floor above grade in Group A-2 and Group M occupancies.

C405.2.4 Specific application controls

1. Display and accent light
2. Lighting in cases used for display case purposes
3. Hotel and motel sleeping units and guest suites
4. Supplemental task lighting
5. Lighting for nonvisual applications
6. Lighting for sale or demonstration in lighting education.



NYCECC/IECC

C405.2.3 Daylight-responsive controls. Daylight-responsive controls complying with Section C405.2.3.1 shall be provided to control the electric lights within daylight zones in the following spaces:

Exceptions: Daylight responsive controls are not required for the following:

1. Spaces in health care facilities where patient care is directly provided.
2. Dwelling units and sleeping units.
3. Lighting that is required to have specific application control in accordance with Section C405.2.4.
4. Sidelight daylight zones on the first floor above grade in Group A-2 and Group M occupancies.

C405.4.2.2.1 Additional interior lighting power

2. ...lighting specified to be installed in addition to general lighting for the purpose of decorative appearance...

C405.4.1 Total connected interior lighting power

Exceptions:

1. The connected power associated with the following lighting equipment is not included in calculating total connected lighting power.
 - 1.1. Professional sports arena playing field lighting.
 - 1.4. Lighting in spaces specifically designed for use by occupants with special lighting needs, including those with visual impairment and other medical and age-related issues.
 - 1.5. Lighting in interior spaces that have been specifically designated as a registered interior historic landmark.
 - 1.6. Casino gaming areas.
 - 1.7. Mirror lighting in dressing rooms.
3. Lighting for theatrical purposes, including performance, stage, film production and video production.
4. Lighting for photographic processes.
5. Lighting integral to equipment or instrumentation and installed by the manufacturer.
7. Advertising signage or directional signage.
8. In restaurant buildings and areas, lighting for food warming or integral to food preparation equipment.
12. Lighting integral to both open and glass-enclosed refrigerator and freezer cases.



NYCECC/IECC



Casino gaming area



Advertising & directional signage



Refrigerated cases



Historic Interiors



Photographic processes



Professional sports



Theatrical purposes



Special Ltg. needs



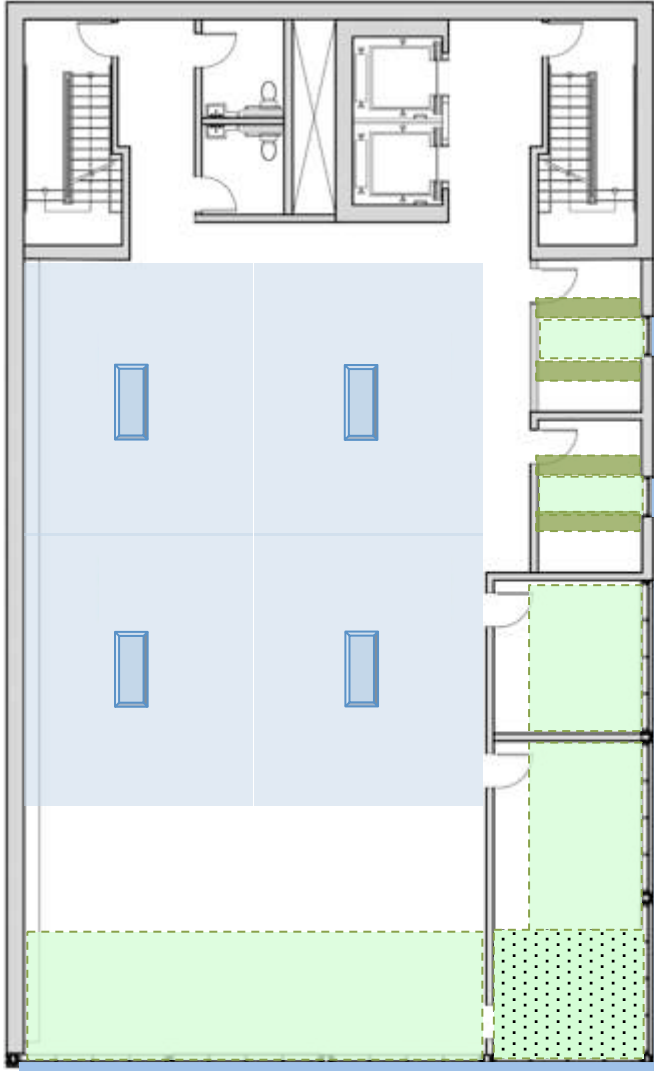
Mirror Lights



Lighting Controls – Daylight – Toplight Zones

IECC ONLY – New Construction

NYCECC/IECC



C402.4.2 Minimum skylight fenestration area

Exception:

2. No skylights required when designed LPD is < 0.50 w/sf.

C402.4.2.1 Lighting controls in daylight zones under skylights. Daylight responsive controls complying with Section C405.2.3.1 shall be provided to control all electric lights within daylight zones under skylights.

Countermands

C405.2.3 Daylight-responsive controls.



NYCECC/IECC

C405.2.3 Daylight-responsive controls. Daylight-responsive controls complying with Section C405.2.3.1 shall be provided to control the electric lights within daylight zones in the following spaces:

2. Spaces with a total of more than 150 watts of general lighting within daylight zones complying with Section C405.2.3.3.

Exceptions: Daylight responsive controls are not required for the following:

1. Spaces in health care facilities where patient care is directly provided.
2. Dwelling units and sleeping units.
3. Lighting that is required to have specific application control in accordance with Section C405.2.4.
4. Sidelight daylight zones on the first floor above grade in Group A-2 and Group M occupancies.

C402.4.2.1 Lighting controls in daylight zones under skylights. Daylight responsive controls complying with Section C405.2.3.1 shall be provided to control all electric lights within daylight zones under skylights.

NYC



Lighting Controls – Daylighting

IECC ONLY – New Construction

NYCECC/IECC

C405.2.3 Daylight-responsive controls. Daylight-responsive controls complying with Section C405.2.3.1 shall be provided to control the electric lights within daylight zones in the following spaces:

No 150 watt Threshold

No Exceptions

C402.4.2.1 Lighting controls in daylight zones under skylights. Daylight responsive controls complying with Section C405.2.3.1 shall be provided to control all electric lights within daylight zones under skylights.

NYC





Lighting Controls – Required Control

Private Office and Small Conference Room

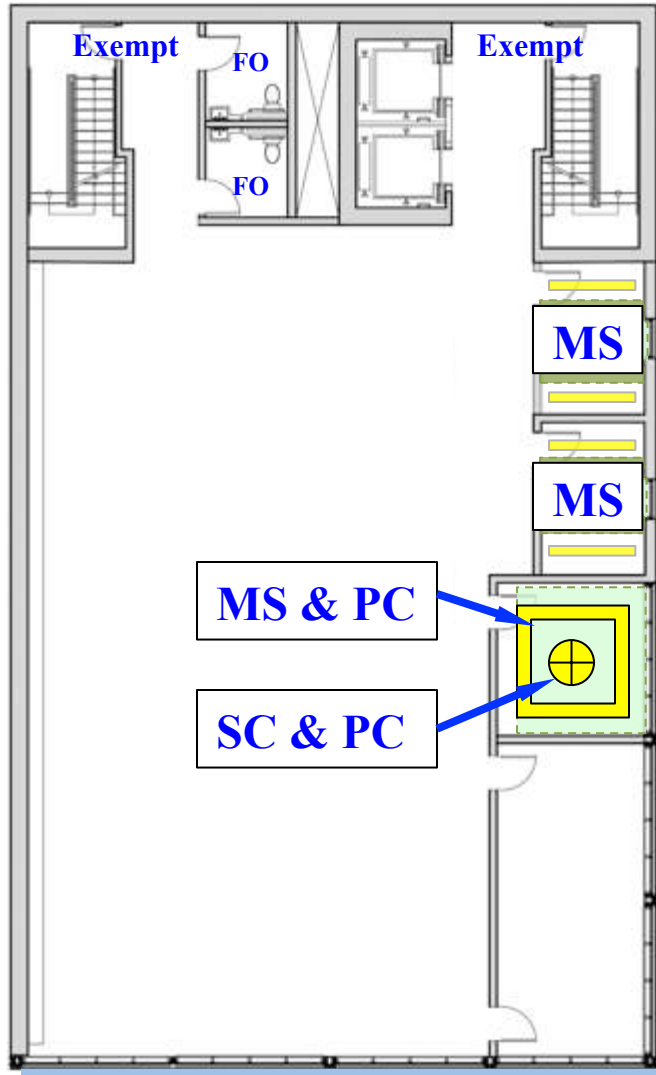
NYCECC/IECC –

Private Offices –
if < 150w –
Manual ON OS

Small Conf. Room –

Manual ON OS
- Daylight control
for General
illumination

Separate
Scheduled Control
of Decorative
fixture with
Daylight Control



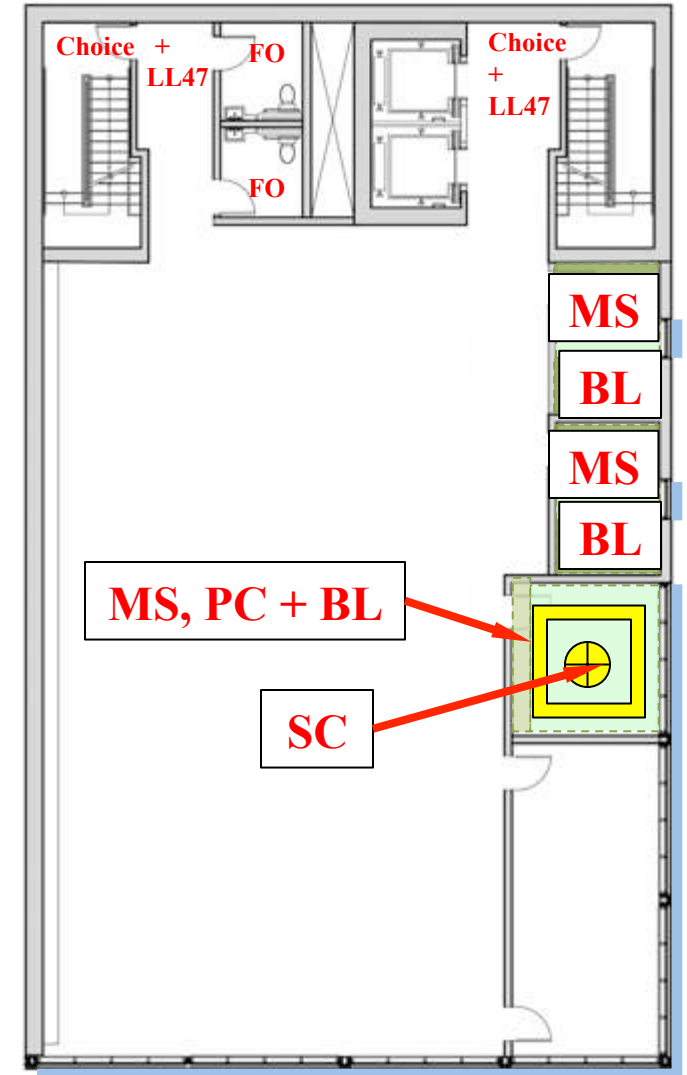
ASHRAE

Private Offices –
if < 150w –
Manual ON OS
- Bilevel

Small Conf. Room –

Manual ON OS
- Daylight control
for General
illumination
- Bilevel for
General Illum.

Separate Scheduled
Control of
Decorative fixture



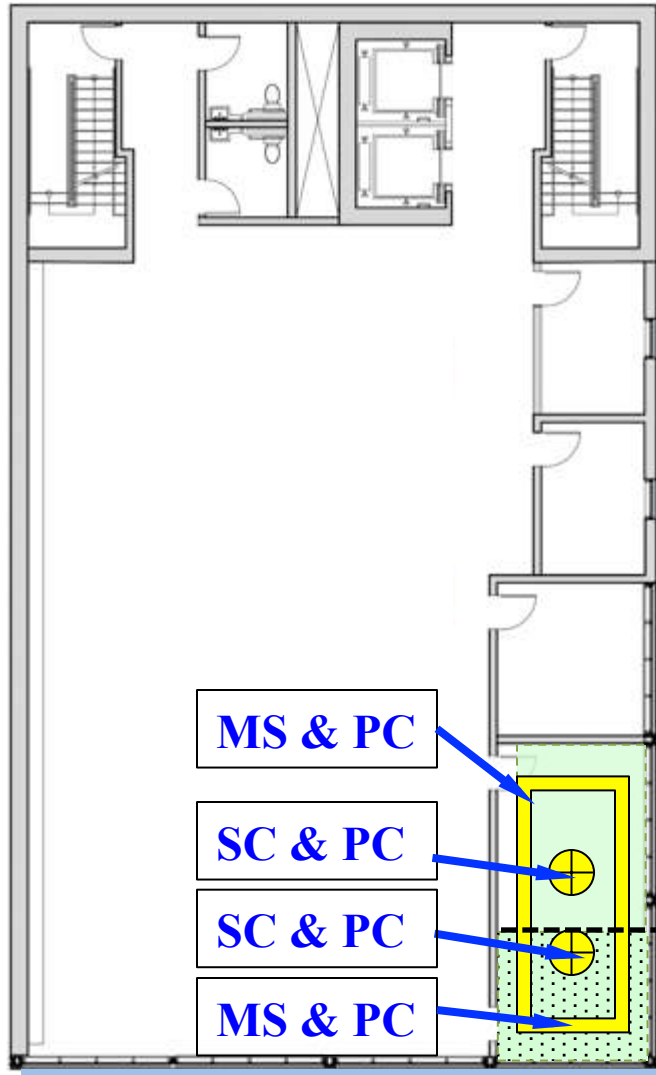


Lighting Controls – Required Controls

Large Conference Room

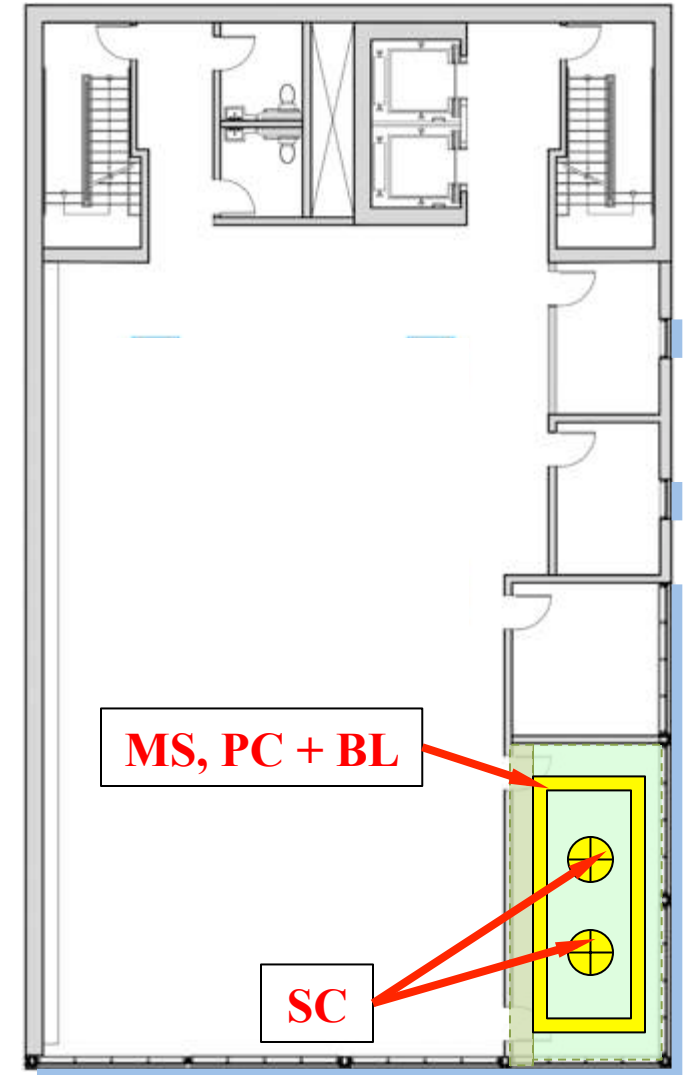
NYCECC/IECC –

- Large Conf. Room - Two (2) Manual ON OS
- Two (2) Daylight zones for General illumination
- Two Separate Scheduled Control zones for Decorative fixtures
- Two (2) Daylight zones



ASHRAE

- Large Conf. Room - One (1) Manual ON OS
- One (1) Daylight zone for General illumination
- Bilevel for General Illumination
- One (1) Separate Scheduled Control for Decorative fixtures



MS = Manual ON Sensor, PC = Photocell for Daylight, SC = Scheduled Control, L = Local, Sensor, BL = Bilevel



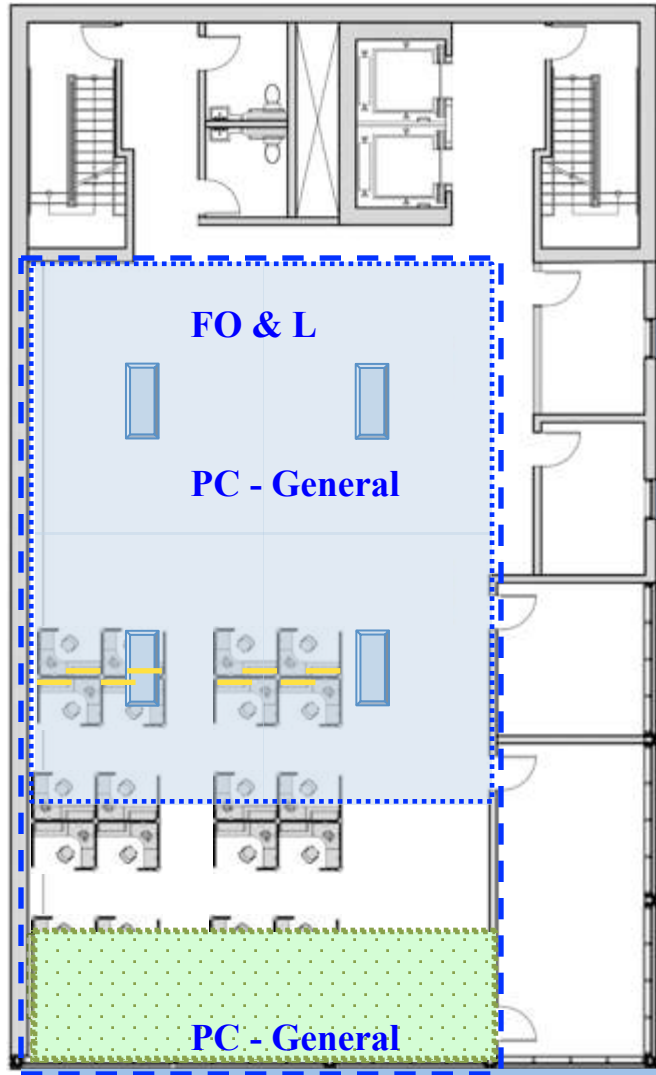
Lighting Controls – Daylight – Control Zones

Open Office

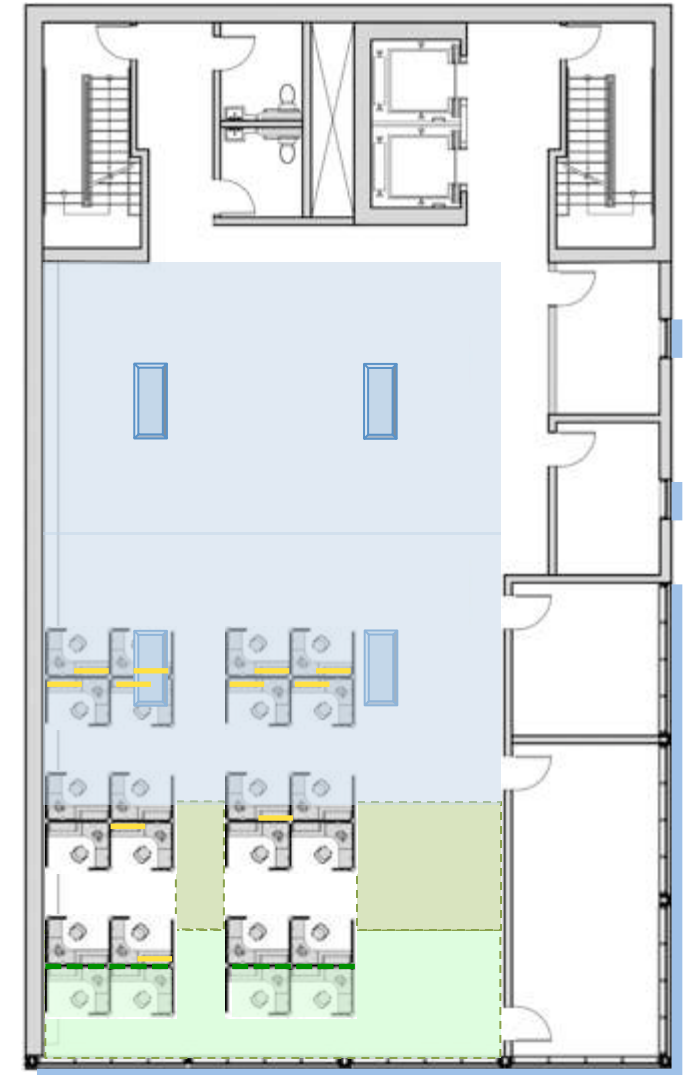
NYCECC/IECC –

Open Office – As req. by NYC

- One (1) Full ON OS for entire space
- One Local Control to turn lights off manually
- Two (2) Daylight zones for General illumination, one for Sidelighting and one for Toplighting, continuous dimming required 100% to 15%



ASHRAE



FO = Full ON Sensor, PC = Photocell for Daylight, SC = Scheduled Control, L = Local, PO = Partial ON Sensor



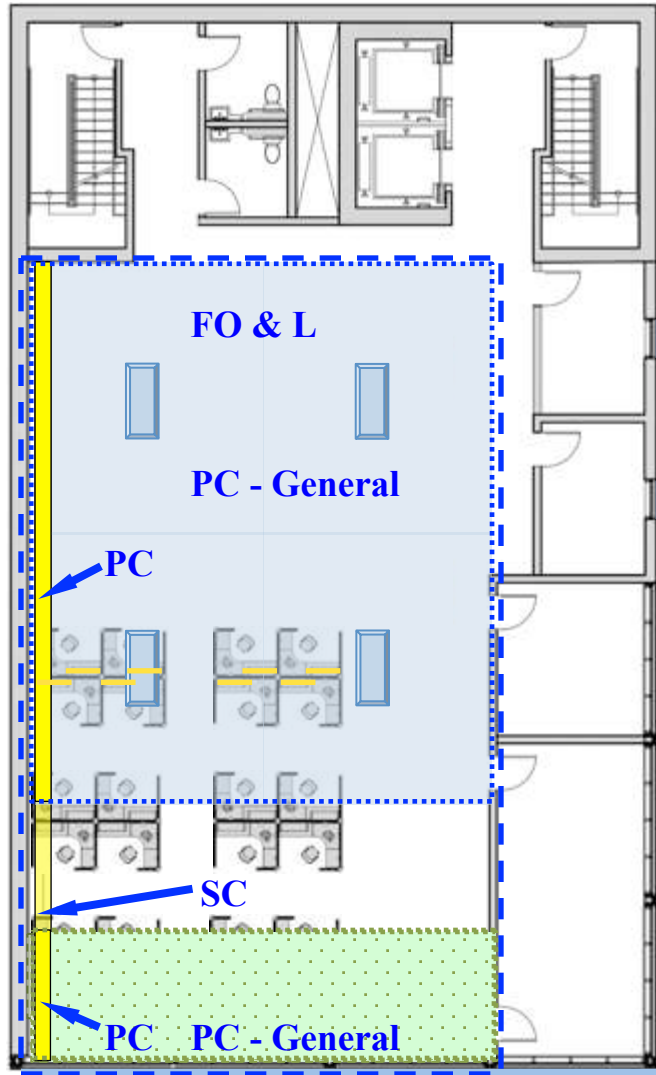
Lighting Controls – Daylight – Control Zones

Open Office

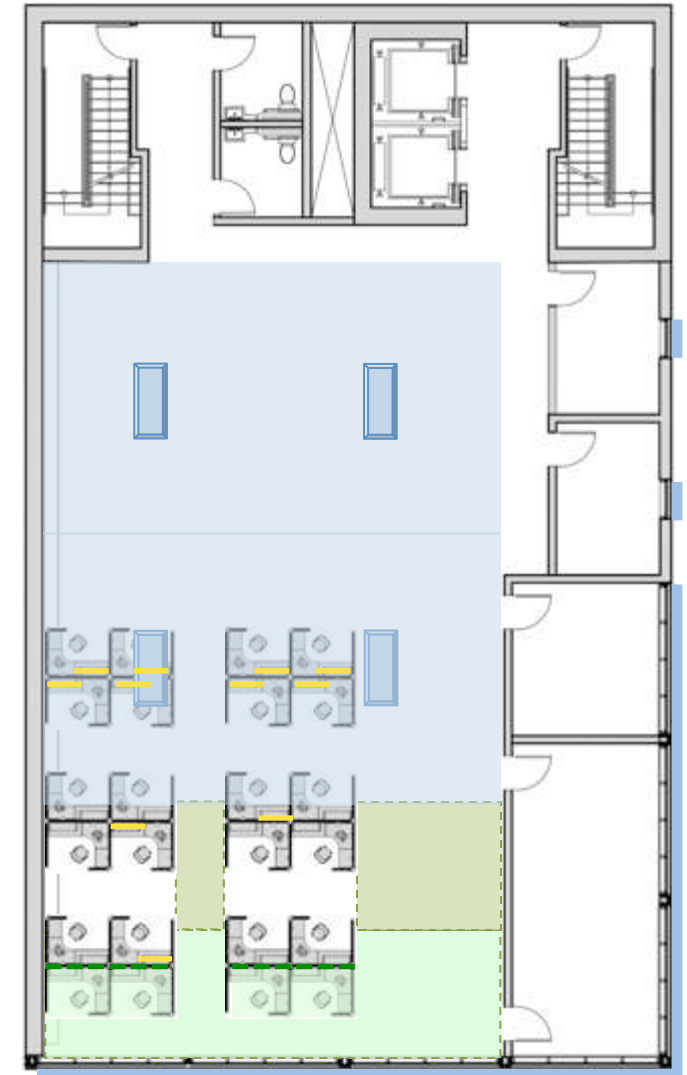
NYCECC/IECC –

Open Office – As req. by NYC

- One (1) Full ON OS for entire space
- One Local Control to turn lights off manually
- Two (2) Daylight zones for General illumination, one for Sidelighting and one for Toplighting, continuous dimming required 100% to 15%
- One (1) Separate Scheduled Control of Decorative linear wall grazer
- Two (2) Daylight zones for Decorative fixture, for portions located in sidelighting and toplighting zones, continuous dimming
- Separate zone for portion not in daylight zone



ASHRAE



FO = Full ON Sensor, PC = Photocell for Daylight, SC = Scheduled Control, L = Local, PO = Partial ON Sensor



Lighting Controls – Daylight – Control Zones

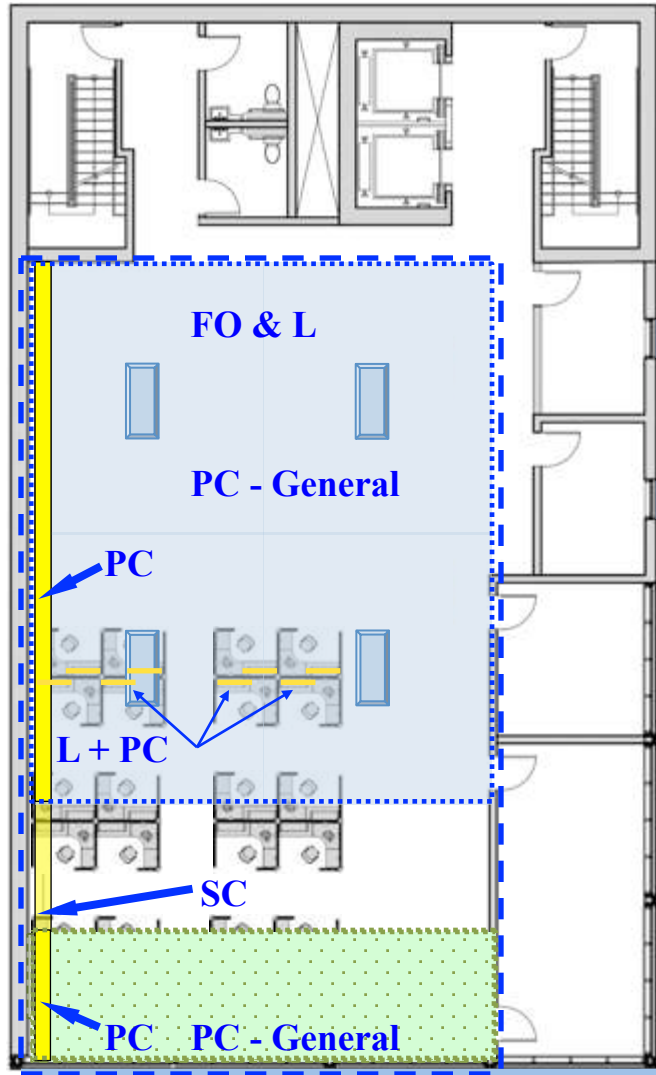
Open Office

NYCECC/IECC –

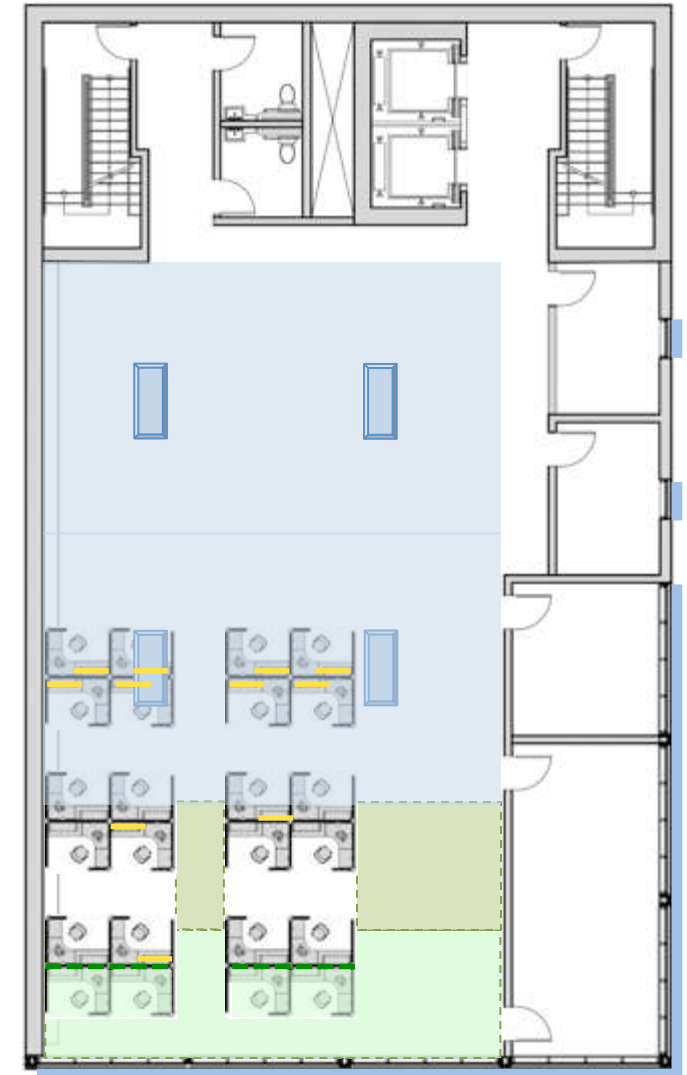
Open Office – As req. by NYC

- One (1) Full ON OS for entire space
- One Local Control to turn lights off manually
- Two (2) Daylight zones for General illumination, one for Sidelighting and one for Toplighting, continuous dimming required 100% to 15%
- One (1) Separate Scheduled Control of Decorative linear wall grazer
- Two (2) Daylight zones for Decorative fixture, for portions located in sidelighting and toplighting zones, continuous dimming
- Separate zone for portion not in daylight zone

Local control for each task light, automatic control to exempt from LPD. – Requires daylight responsive controls if permanently installed under skylights.



ASHRAE



FO = Full ON Sensor, PC = Photocell for Daylight, SC = Scheduled Control, L = Local, PO = Partial ON Sensor



Lighting Controls – Daylight – Control Zones

Open Office

NYCECC/IECC –

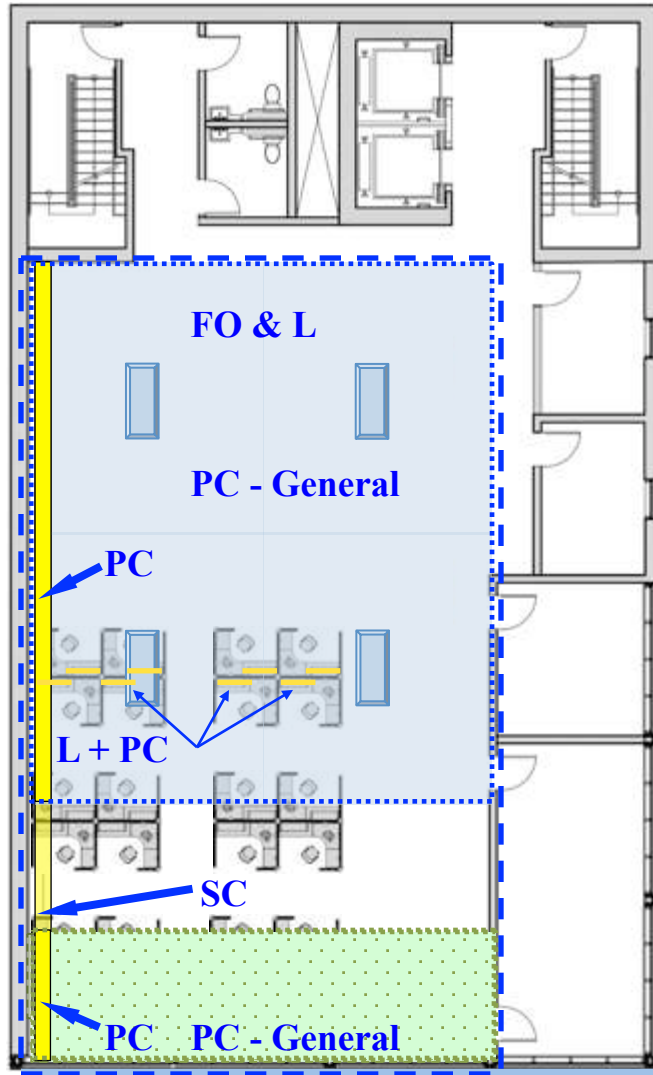
Open Office – As req. by NYC

- One (1) Full ON OS for entire space
- One Local Control to turn lights off manually
- Two (2) Daylight zones for General illumination, one for Sidelighting and one for Toplighting, continuous dimming required 100% to 15%

One (1) Separate Scheduled Control of Decorative linear wall grazer

- Two (2) Daylight zones for Decorative fixture, for portions located in sidelighting and toplighting zones, continuous dimming
- Separate zone for portion not in daylight zone

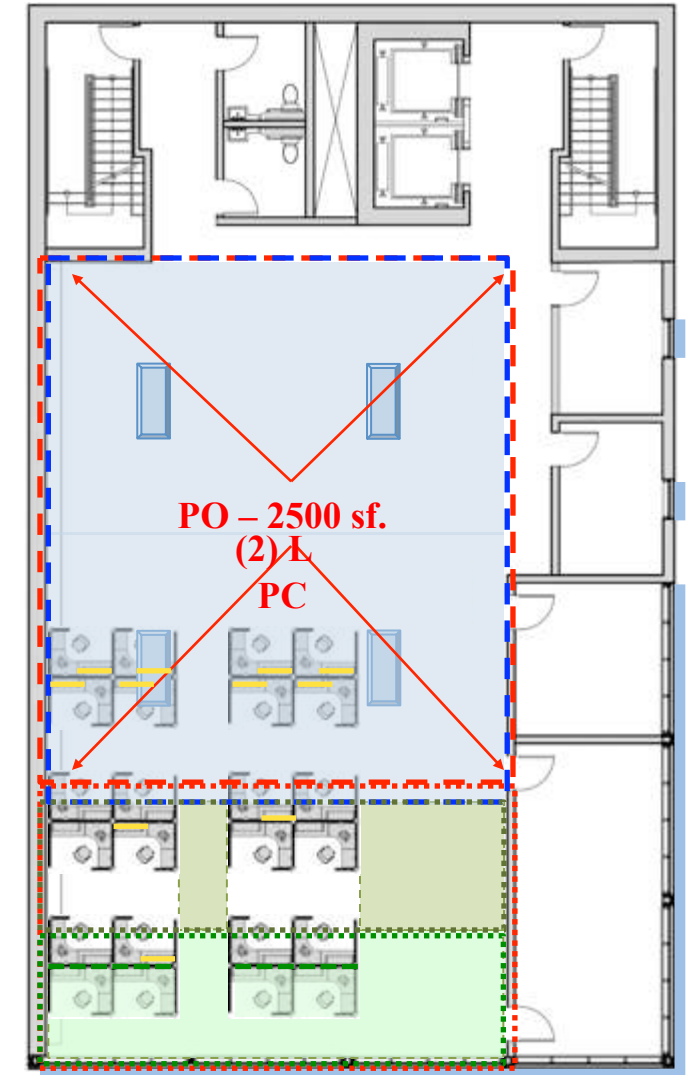
Local control for each task light, automatic control to exempt from LPD. – Requires daylight responsive controls if permanently installed under skylights.



ASHRAE

Open Office – As req. by NYC

- One (1) Partial On OS for 2500 sf (approx. skylight zone)
- One Local Control for those lights
- One Local Control to turn ON/OFF other 50% of lts. in zone
- One daylight control for general illumination under skylight zone, at least 2 setpoints + Off required



FO = Full ON Sensor, PC = Photocell for Daylight, SC = Scheduled Control, L = Local, PO = Partial ON Sensor



Lighting Controls – Daylight – Control Zones

Open Office

NYCECC/IECC –

Open Office – As req. by NYC

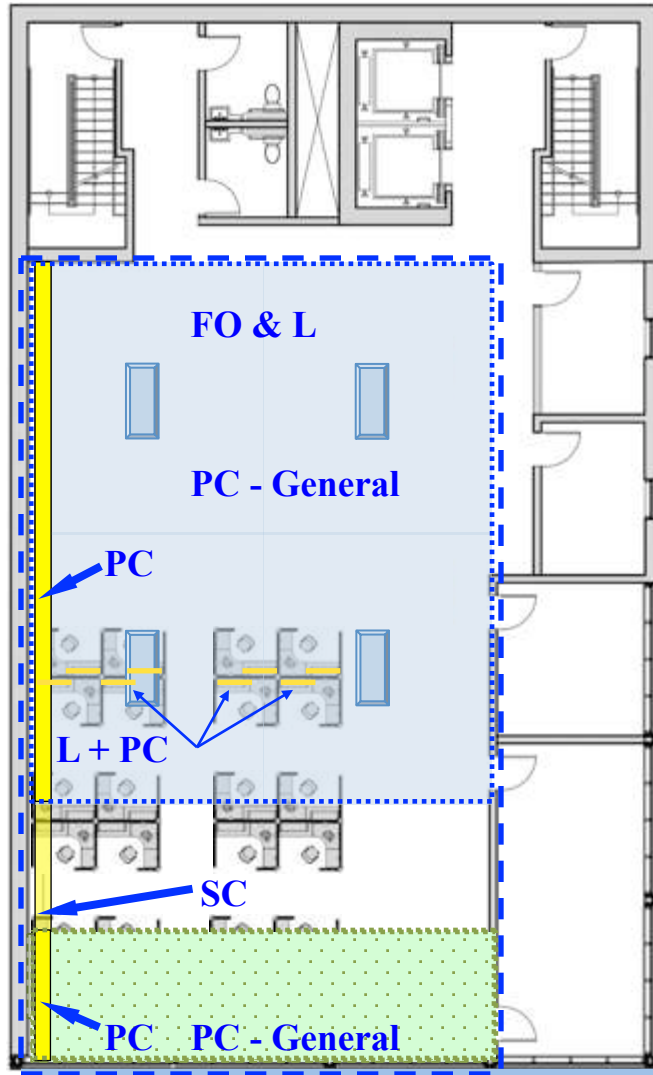
One (1) Full ON OS for entire space
 - One Local Control to turn lights off manually

- Two (2) Daylight zones for General illumination, one for Sidelighting and one for Toplighting, continuous dimming required 100% to 15%

One (1) Separate Scheduled Control of Decorative linear wall grazer

- Two (2) Daylight zones for Decorative fixture, for portions located in sidelighting and toplighting zones, continuous dimming
 - Separate zone for portion not in daylight zone

Local control for each task light, automatic control to exempt from LPD. – Requires daylight responsive controls if permanently installed under skylights.



ASHRAE

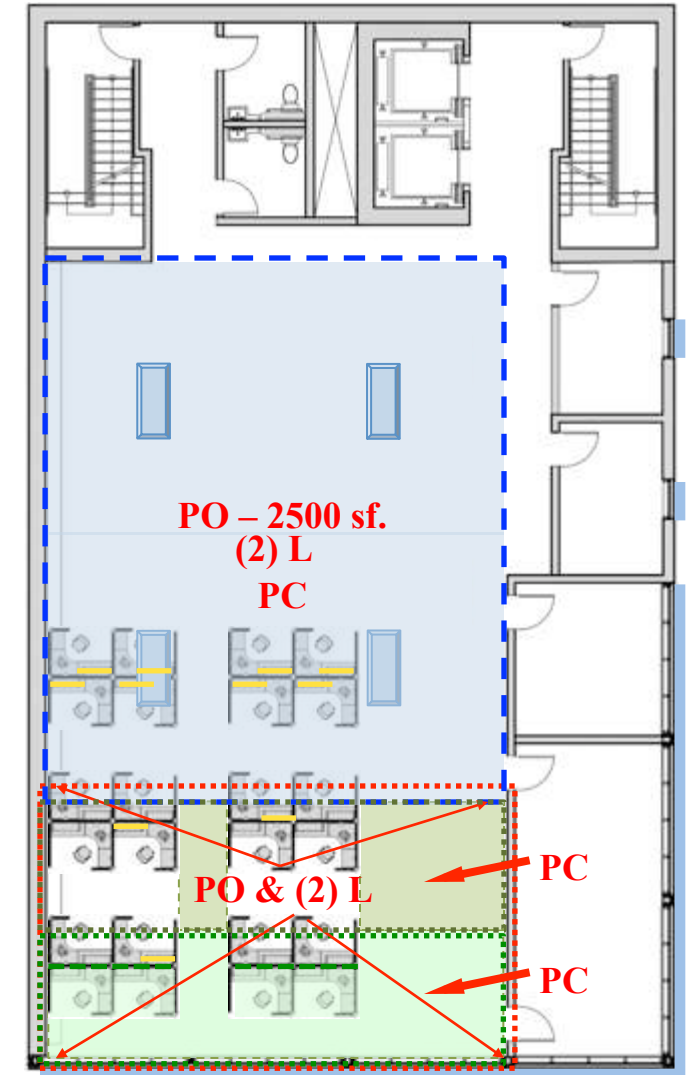
Open Office – As req. by NYC

One (1) Partial On OS for 2500 sf (approx. skylight zone)

- One Local Control for those lights
 - One Local Control to turn ON/OFF other 50% of lts. in zone
 - One daylight control for general illumination under skylight zone, at least 2 setpoints + Off required

One (1) Partial On OS for balance of space

- One Local Control for those lights
 - One Local Control to turn ON/OFF other 50% of lts. in zone
 - Two (2) Daylight zones for General illumination- Primary and Secondary, at least 2 setpoints + Off required



FO = Full ON Sensor, PC = Photocell for Daylight, SC = Scheduled Control, L = Local, PO = Partial ON Sensor



Lighting Controls – Daylight – Control Zones

Open Office

NYCECC/IECC –

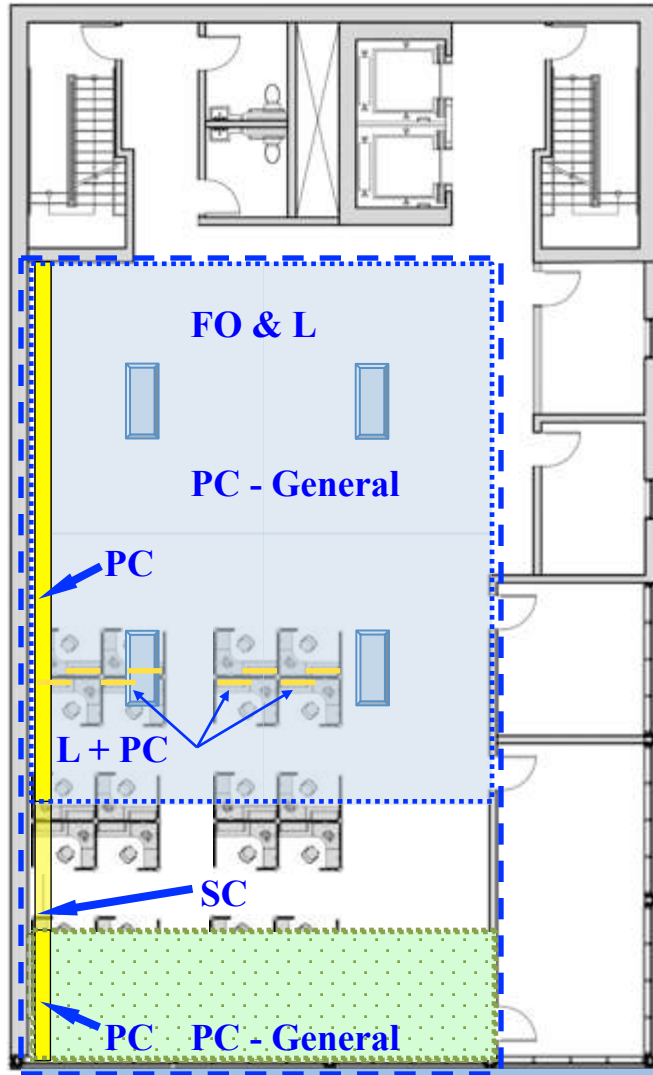
Open Office – As req. by NYC

- One (1) Full ON OS for entire space
- One Local Control to turn lights off manually
- Two (2) Daylight zones for General illumination, one for Sidelighting and one for Toplighting, continuous dimming required 100% to 15%

One (1) Separate Scheduled Control of Decorative linear wall grazer

- Two (2) Daylight zones for Decorative fixture, for portions located in sidelighting and toplighting zones, continuous dimming
- Separate zone for portion not in daylight zone

Local control for each task light, automatic control to exempt from LPD. – Requires daylight responsive controls if permanently installed under skylights.



ASHRAE

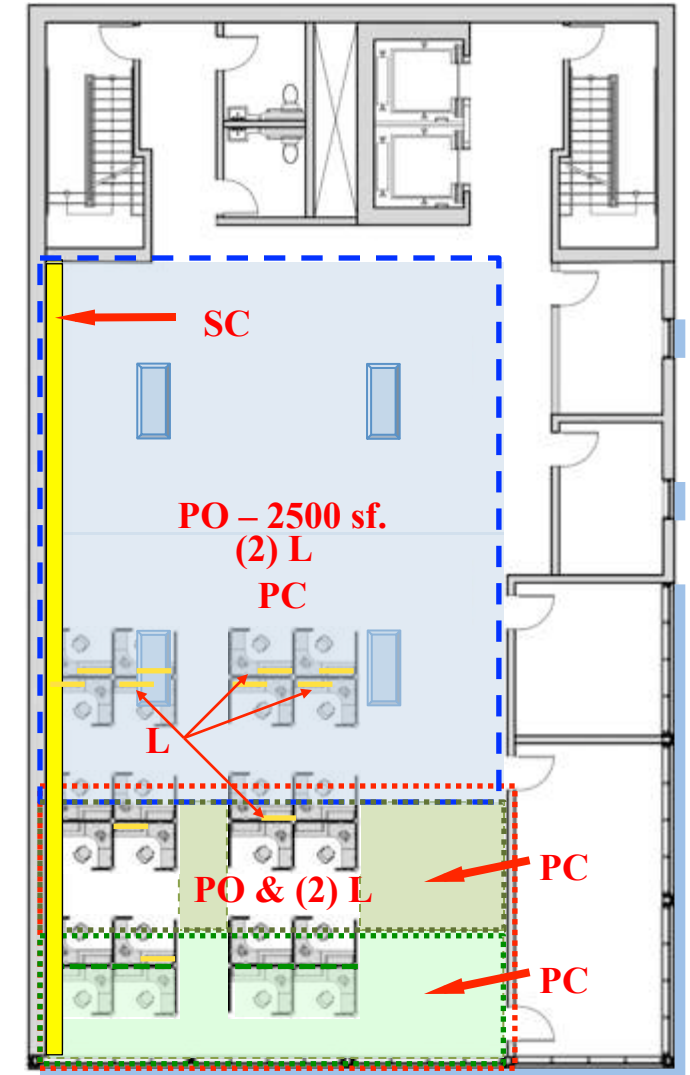
Open Office – As req. by NYC

- One (1) Partial On OS for 2500 sf (approx. skylight zone)
- One Local Control for those lights
- One Local Control to turn ON/OFF other 50% of lts. in zone
- One daylight control for general illumination under skylight zone, at least 2 setpoints + Off required

- One (1) Partial On OS for balance of space
- One Local Control for those lights
- One Local Control to turn ON/OFF other 50% of lts. in zone
- Two (2) Daylight zones for General illumination- Primary and Secondary, at least 2 setpoints + Off required

One (1) Separate scheduled control of Decorative linear wall grazer

Local control for each task light, automatic control to exempt from LPD



FO = Full ON Sensor, PC = Photocell for Daylight, SC = Scheduled Control, L = Local, PO = Partial ON Sensor

Additional Efficiency Options vs. Automatic Receptacle Controls

NYCECC/IECC



SECTION ECC C406

NYC

ADDITIONAL EFFICIENCY PACKAGE OPTIONS

C406.1 Requirements. Buildings shall comply with at least one of the following:

1. More efficient HVAC performance in accordance with Section C406.2.
2. Reduced lighting power density system in accordance with Section C406.3.
3. Enhanced lighting controls in accordance with Section C406.4.
4. On-site supply of renewable energy in accordance with Section C406.5.
5. Provision of a dedicated outdoor air system for certain HVAC equipment in accordance with Section C406.6.
6. High-efficiency service water heating in accordance with Section C406.7.

C406.1.1 Tenant spaces. Tenant spaces shall comply with Section C406.2, C406.3, C406.4, C406.6 or C406.7. Alternatively, tenant spaces shall comply with Section C406.5 where the entire building is in compliance.

ASHRAE



8.4.2 Automatic Receptacle Control





NYCECC/IECC

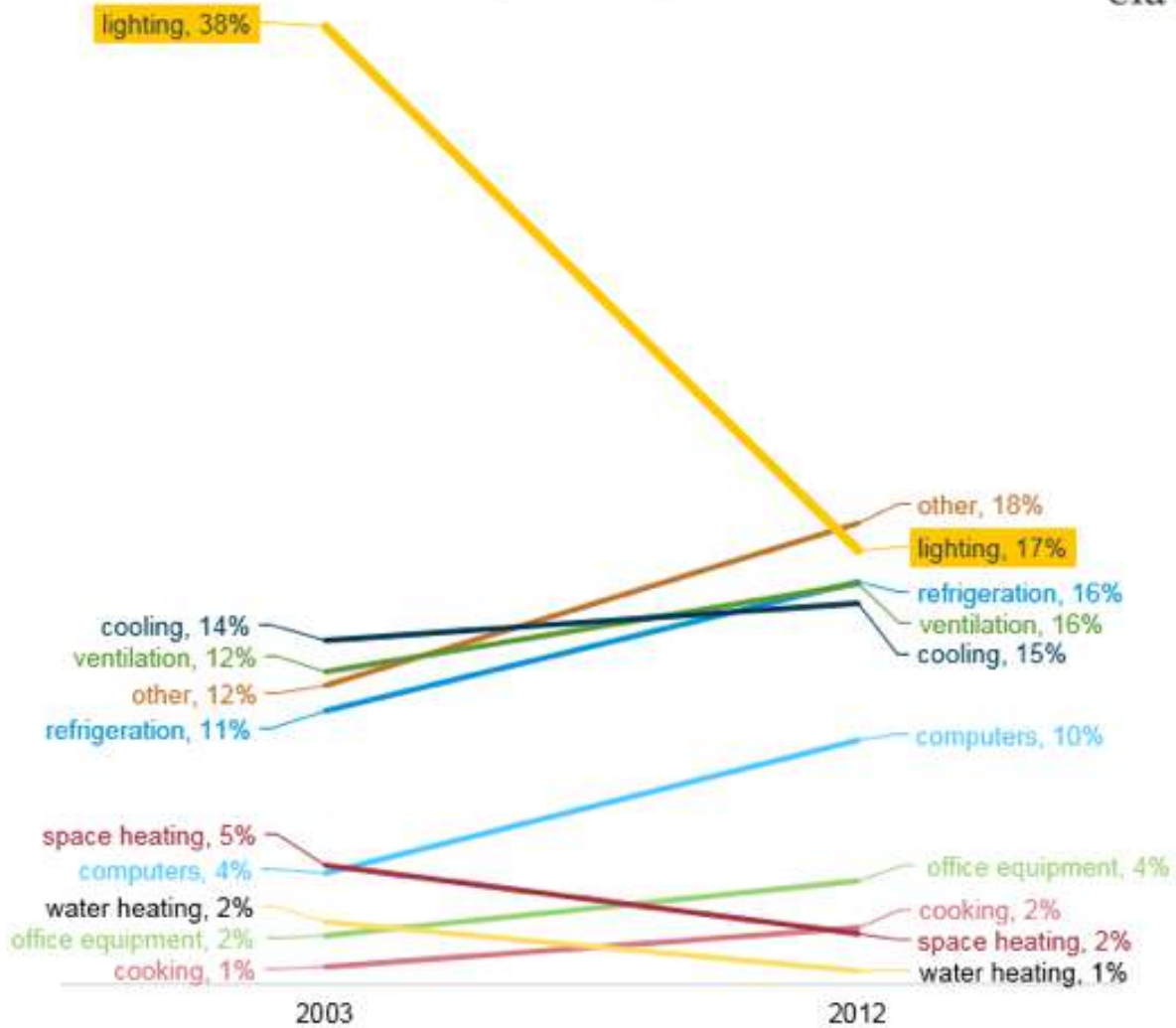
C406.3 Reduced lighting power density. The total interior lighting power (watts) of the building shall be determined by using 90 percent of the lighting power values specified in Table C405.4.2(1) times the floor area for the building types, or by using 90 percent of the interior lighting power allowance calculated by the Space-by-Space Method in Section C405.4.2.

C406.4 Enhanced digital lighting controls. Interior lighting in the building shall have the following enhanced lighting controls that shall be located, scheduled and operated in accordance with Section C405.2.2.

1. Luminaires shall be capable of continuous dimming.
2. Luminaires shall be capable of being addressed individually. Where individual addressability is not available for the luminaire class type, a controlled group of not more than four luminaries shall be allowed.
3. Not more than eight luminaires shall be controlled together in a daylight zone.

4. Fixtures shall be controlled through a digital control system that includes the following function:
 - 4.1. Control reconfiguration based on digital addressability.
 - 4.2. Load shedding.
 - 4.3. Individual user control of overhead general illumination in open offices.
 - 4.4. Occupancy sensors shall be capable of being reconfigured through the digital control system.
5. Construction documents shall include submittal of a Sequence of Operations, including a specification outlining each of the functions in Item 4 of this section.
6. Functional testing of lighting controls shall comply with Section C408.

Figure 4: In the commercial sector, lighting is no longer the largest end use as a share of total electricity consumption



Automatic Receptacle Controls

ASHRAE ONLY

Why?



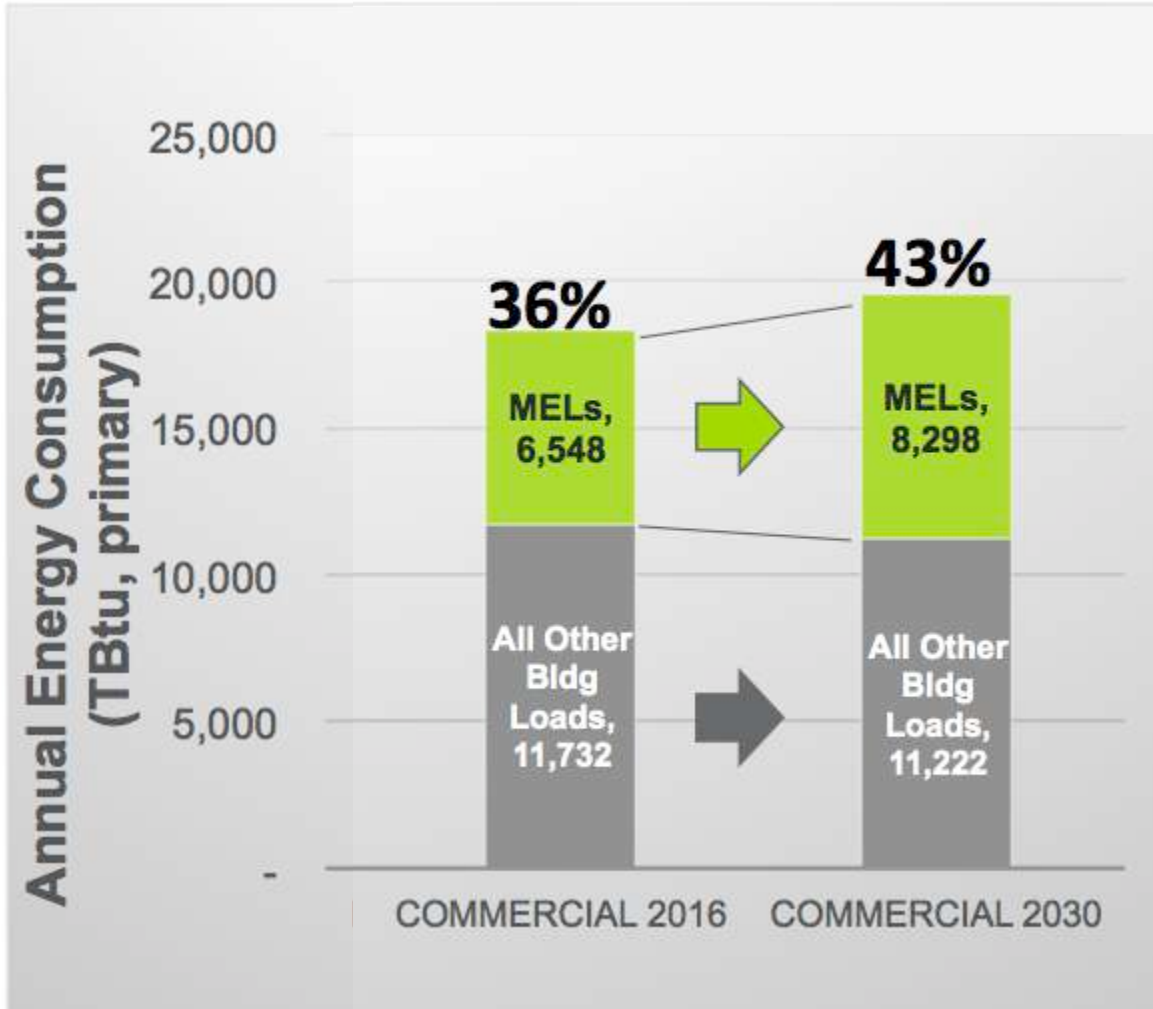
ASHRAE

8.4.2 Automatic Receptacle Control



2012

Miscellaneous Electric Loads vs Total Building Energy Use



Automatic Receptacle Controls

ASHRAE ONLY

Why?



ASHRAE

8.4.2 Automatic Receptacle Control



Additional Efficiency Options vs. Automatic Receptacle Controls

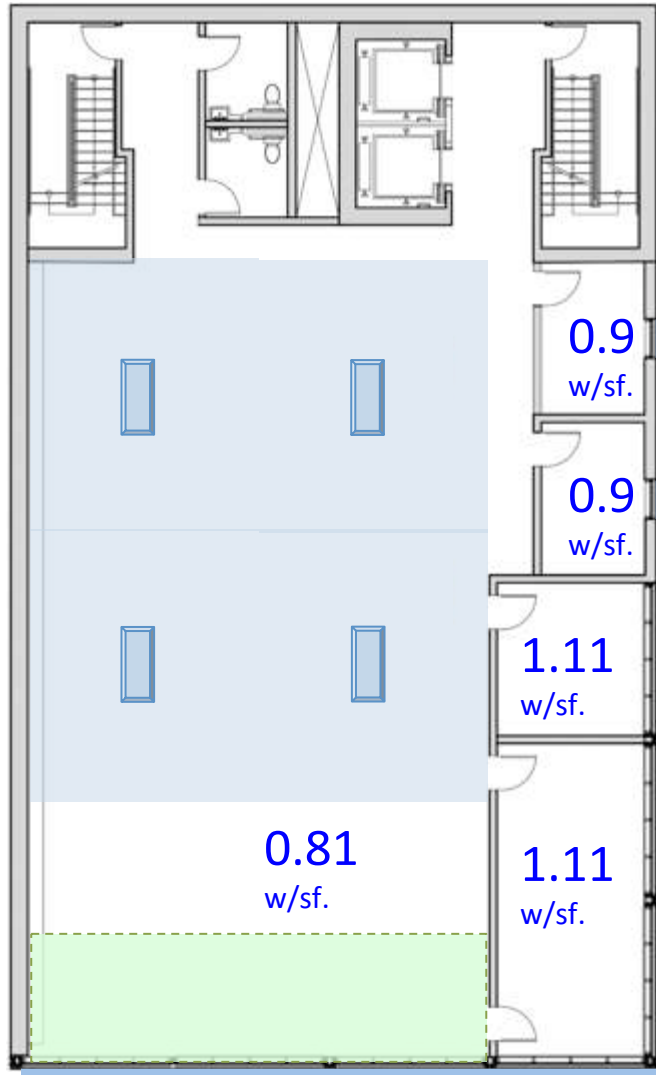
NYCECC/IECC

90% of Each Allowance

or,

All Continuously Dimmable & Individually Addressable

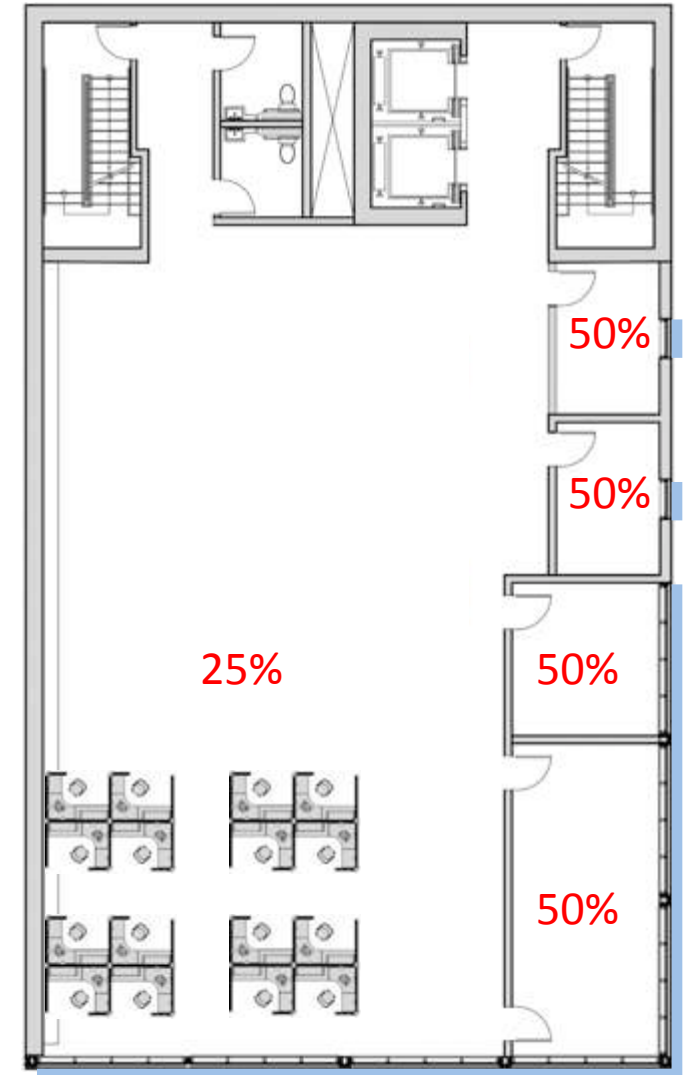
- No more than 8 luminaires controlled together in a daylight zone



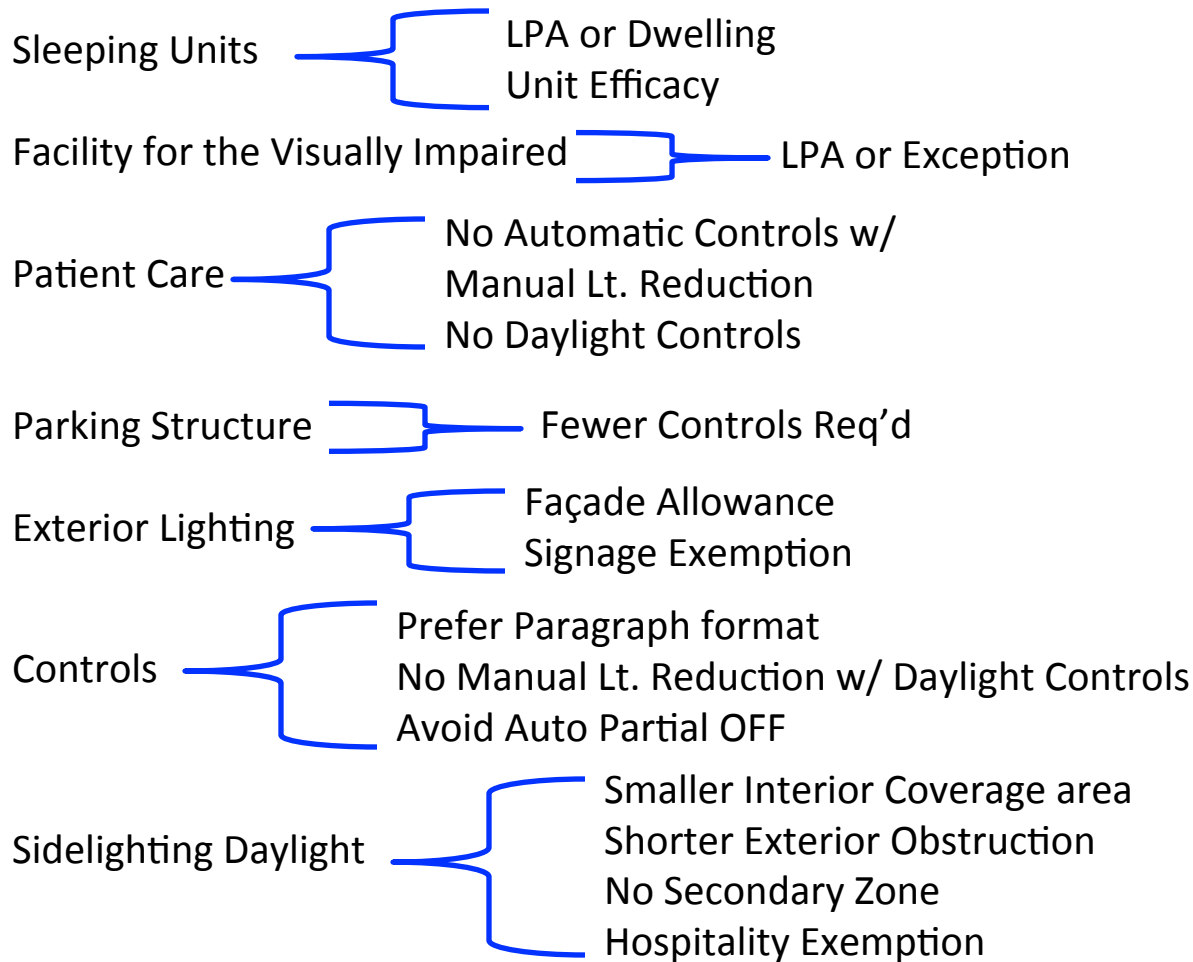
ASHRAE

50% of Receptacles in Private Offices, Conferences Rooms,

25% of Branch Circuit Feeders for Modular Furniture

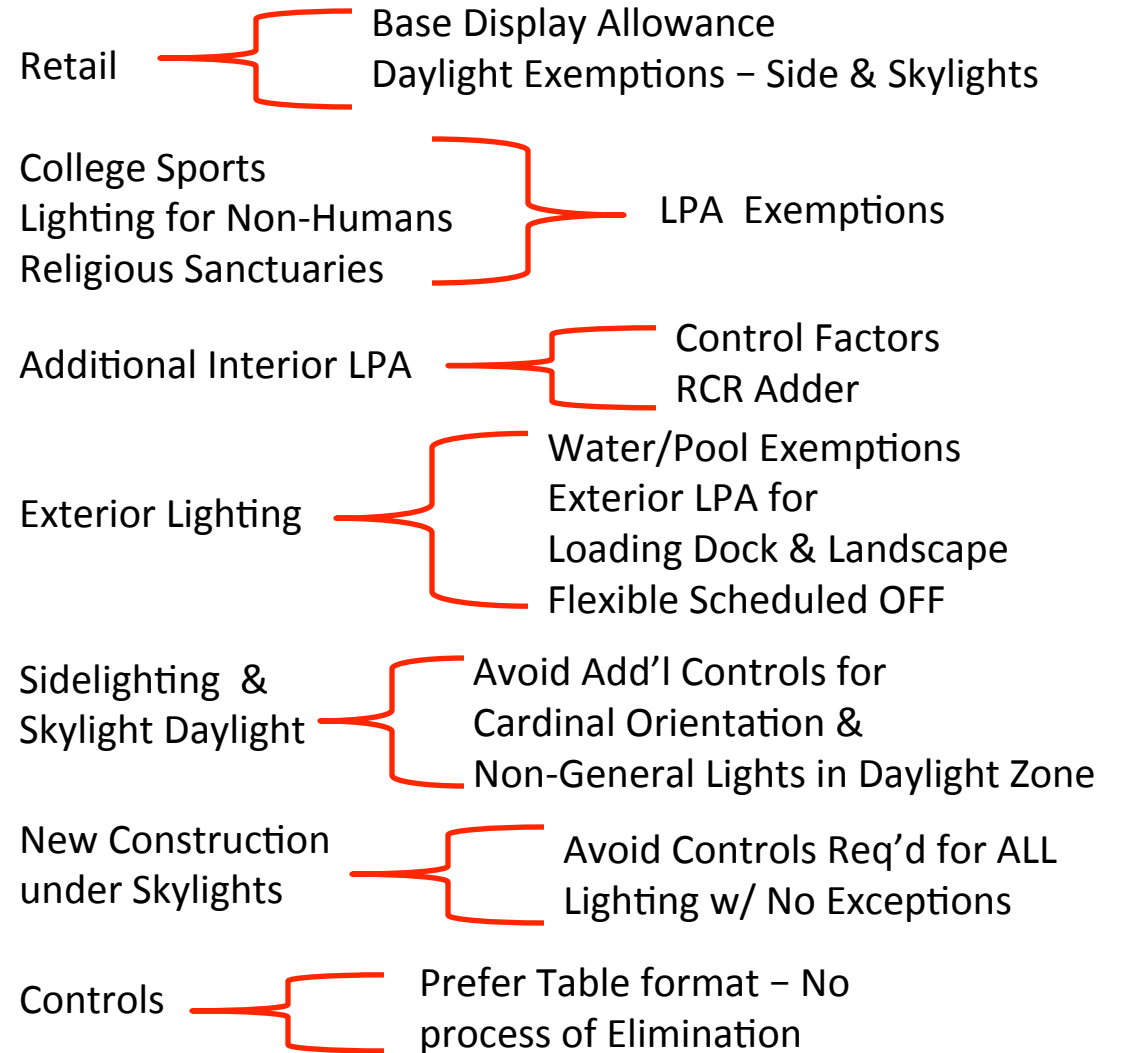


NYCECC/IECC



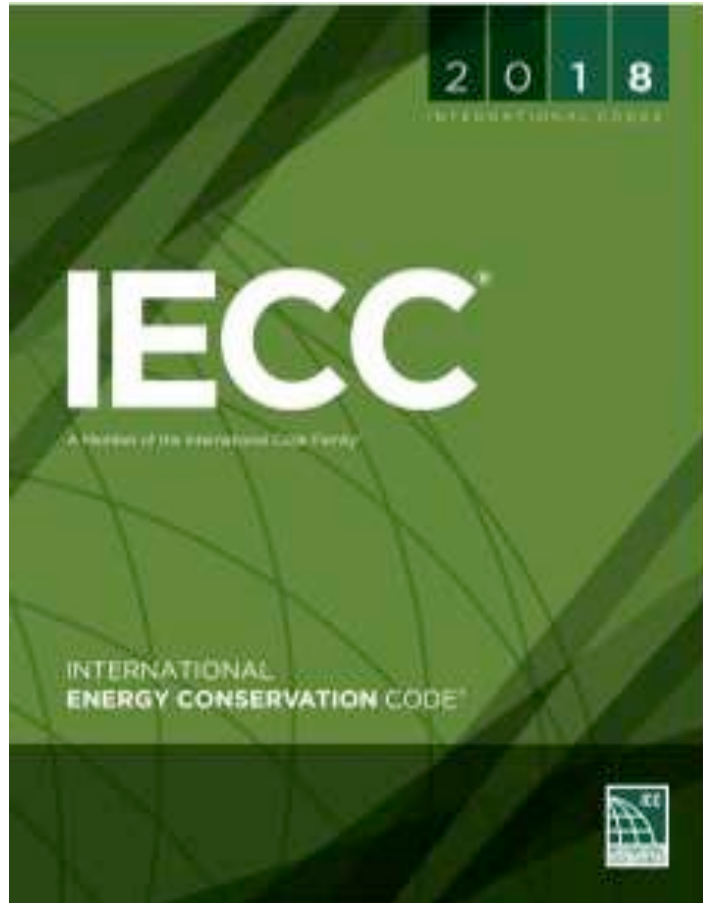
Avoid Receptacle Control in ASHRAE
COMcheck accuracy

ASHRAE



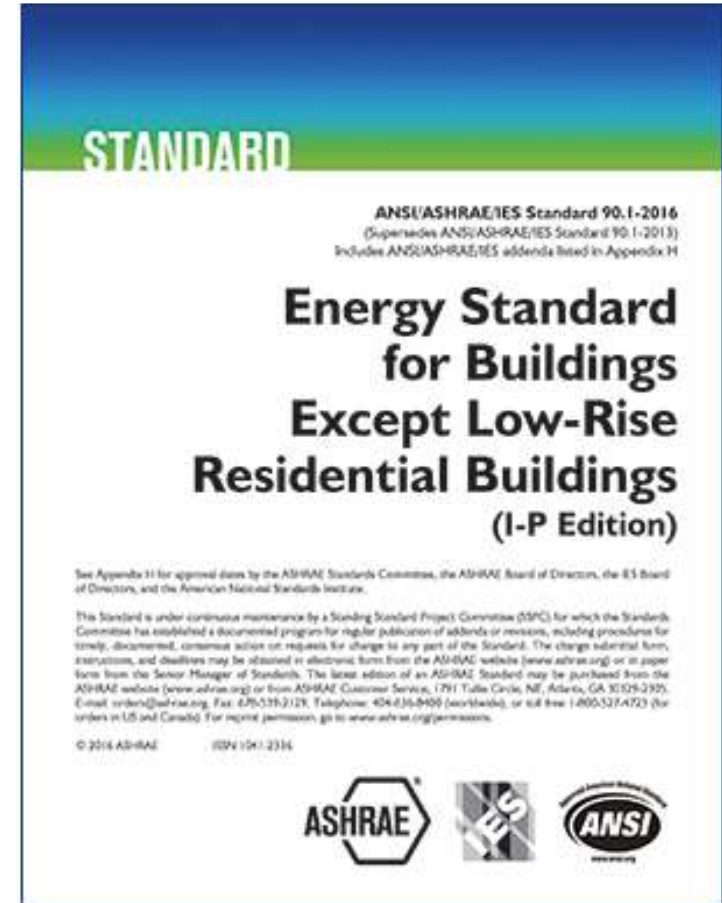
Avoid Additional Efficiency in IECC

NYCECC/IECC 2018



The Energy Code Future in NYC

ASHRAE 90.1-2016



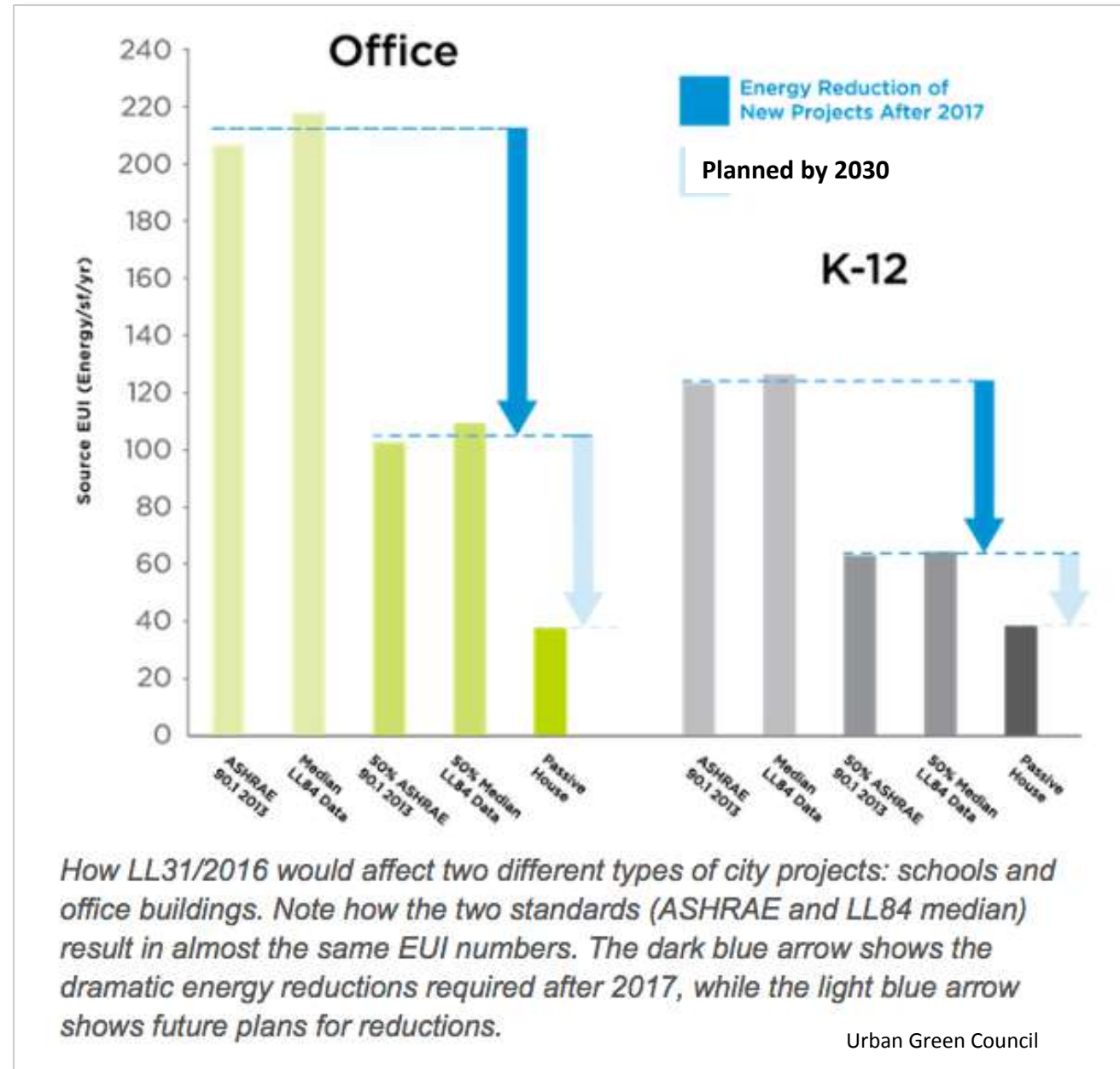
NYCECC Local Law 31 of 2016 – Effective July 2017

NYC capital projects – New Construction, Additions, Substantial Reconstruction of [city owned property](#) – 50% of energy used today

LEED Gold required for many projects

Consider feasibility of at least 10% on-site renewables

By 2030 – move to a limit of kBTU/sf/year for each building type



NYCECC Local Law 32 of 2018



Target: 20% < Current Code

CURRENT NYCECC CODE - Exterior COMPARED TO NEXT PUBLISHED CODES

Exterior Area Zone 3	NYCECC 2016 LPA	IECC 2018/ ASHRAE 90.1-2016
Base Allowance	750 w	500 w
Parking	0.10	0.06
Walkways > 10' wide	0.16	0.11
Entries	30 w/lin.	21 w/lin.

CURRENT NYCECC CODE - Interior COMPARED TO NEXT PUBLISHED CODES

Space Type	NYCECC 2016 LPD	IECC 2018/ ASHRAE 90.1-2016	Reduction in LPD
Classroom/lecture/ training	1.24	0.92	34%
Conference/meeting Multipurpose	1.23	1.07	15%
Family Dining	0.89	0.71	25%
Lounge/Breakroom	0.73	0.62	16%
Office - enclosed	1.00 *	0.93	7%
Office - open	0.90 *	0.81	10%
Sales area	1.30 *	1.22	6%

* As modified
by NYC



This concludes The American Institute of Architects Continuing
Education Systems Course

More Energy Code Questions?
Contact me:
Martysalzberg@verizon.net

Thank you to CBBLD for many of the project images used in this presentation

Thank you to Adam Kroll for graphics from LEDucation 11