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Daylighting Controls for Commercial Buildings

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Daylighting Controls for Commercial Buildings

Course Number: EC15-W03

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Rahul Athalye

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Course Description

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Daylighting control requirements were first introduced in ASHRAE Standard 90.1-2010 and have now been expanded in Standard 90.1-2010 and IECC 2015. These controls reduce the general lighting in response to sunlight coming in through windows and skylights. In this session, how daylighting controls work and how they can save energy will be explained, together with a review of daylight control requirements in the various codes and standards. We will look at how these controls could be implemented and how to ensure that they are working correctly.

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Learning Objectives

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

- Clarify the daylighting control requirements in 90.1-2013 and the 2015 IECC.
- Describe how daylighting controls work.
- State the benefits of daylighting controls and their energy savings potential.
- Describe the methods to implement daylighting controls.

Daylighting 101

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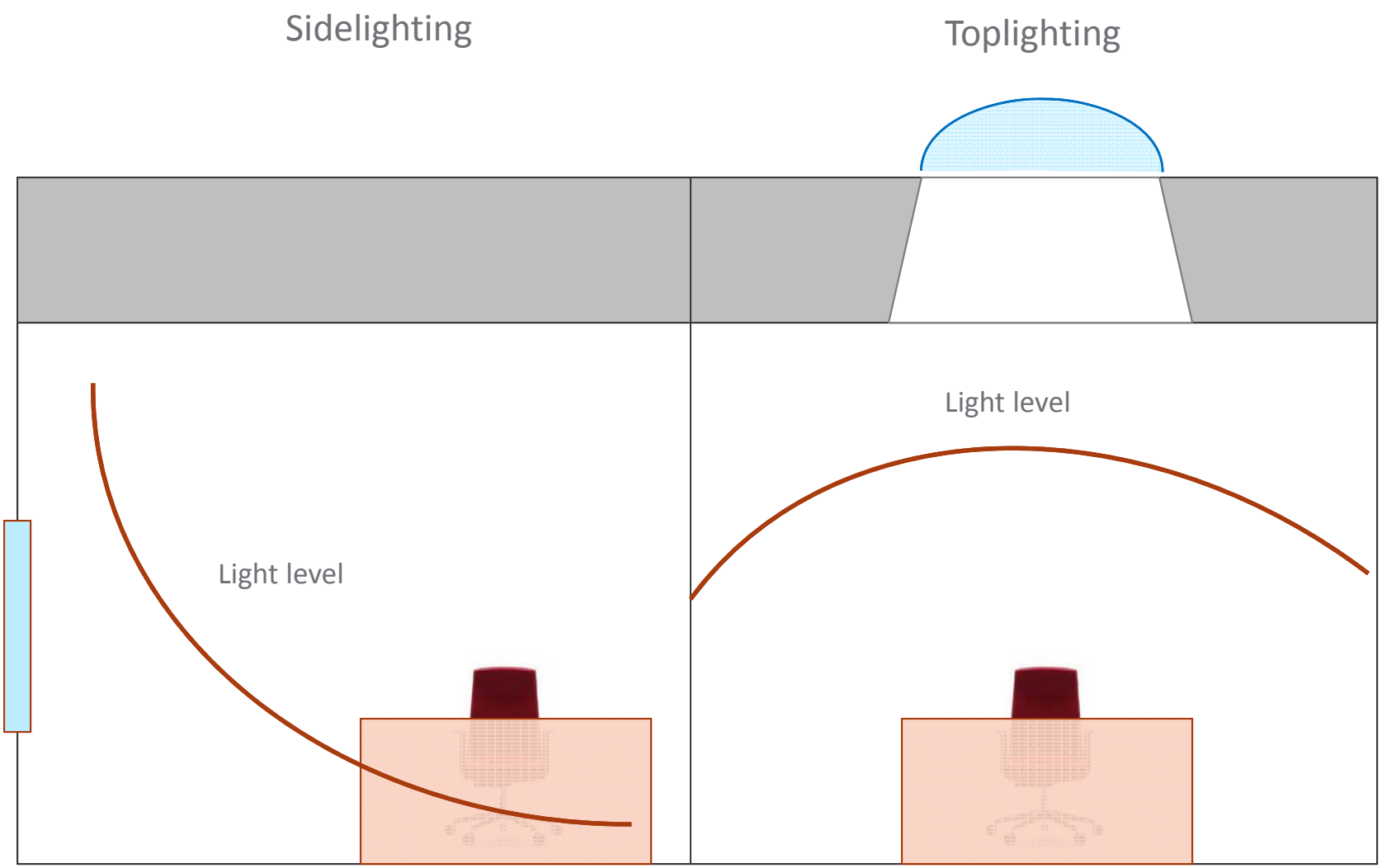
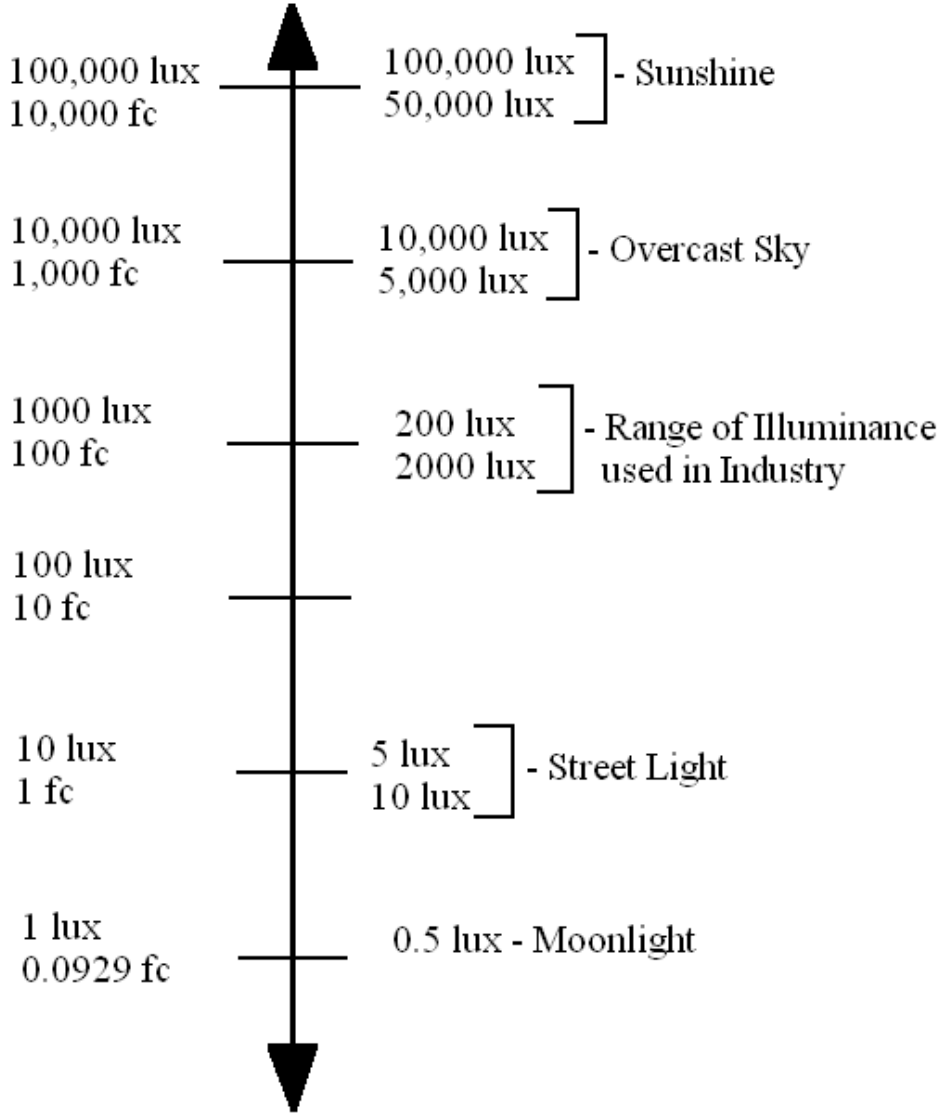


Scale of Illuminances



Recommended Illumination IES Handbook 1998

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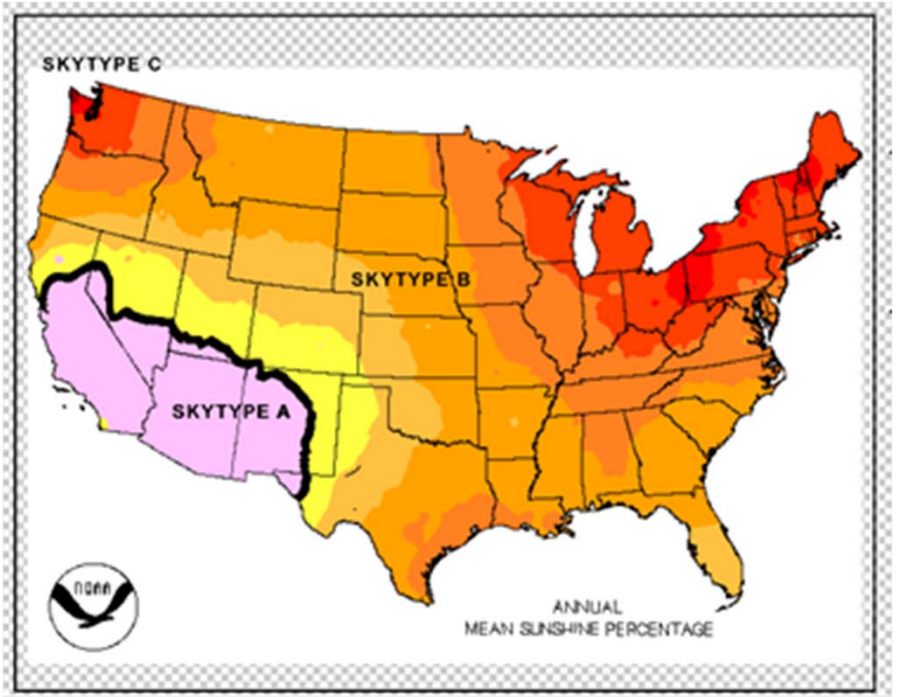
Activity	Illumination *(lux, lumen/m²)*	Illumination *(footcandle, lumen/ft²)*
Public areas with dark surroundings	20 - 50	2-5
Simple orientation for short visits	50 - 100	5-10
Working areas where visual tasks are only occasionally performed	100 - 150	10-14
Warehouses, Homes, Theaters, Archives	150	14
Easy office work, Classes	250	24
Normal office work, PC work, Study library, Groceries, Showrooms, Laboratories	500	47
Supermarkets, Mechanical Workshops, Office Landscapes	750	70
Normal drawing work, Mechanical workshops, Operation theatres	1,000	93
Detailed drawing work, Very detailed mechanical works	1500 - 2000	140-186
Performance of visual tasks of low contrast and very small size for prolonged periods of time	2000 - 5000	186-465
Performance of very prolonged and exacting visual tasks	5000 - 10000	465-930
Performance of very special visual tasks of extremely low contrast and small size	10000 - 20000	930-1859

Other Factors



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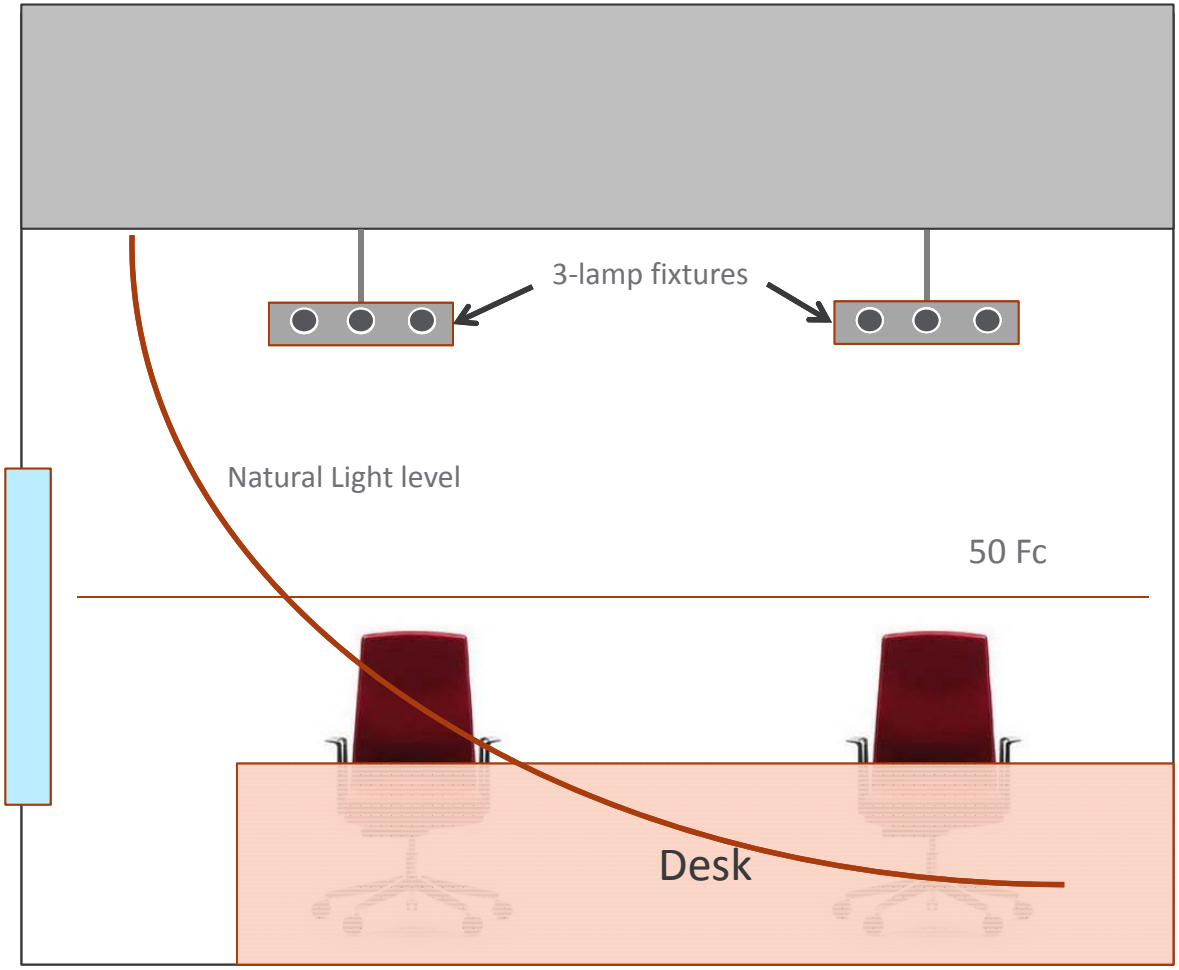
More Factors

- Works best in offices, schools, warehouses, and so on
- Does not work in
  - Residential spaces
  - Spaces which may need to be darkened
  - Sidelighting in some retail spaces

- How much can you save? Depends on
  - window size
  - visible light transmittance
  - Controls
  - Space type (or illumination setpoint)

Where do energy savings come from?



Ways to Implement Daylighting Controls

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- Two major approaches
  - Stepped
    - Ballast dimming
    - Circuit control
  - Continuous
- Circuit control may be cheaper in some cases
- Open loop versus closed loop
- Advanced systems
  - Wireless systems
  - Sensor embedded in fixture

Daylighting and Codes

Daylighting and Codes: Watt's new?

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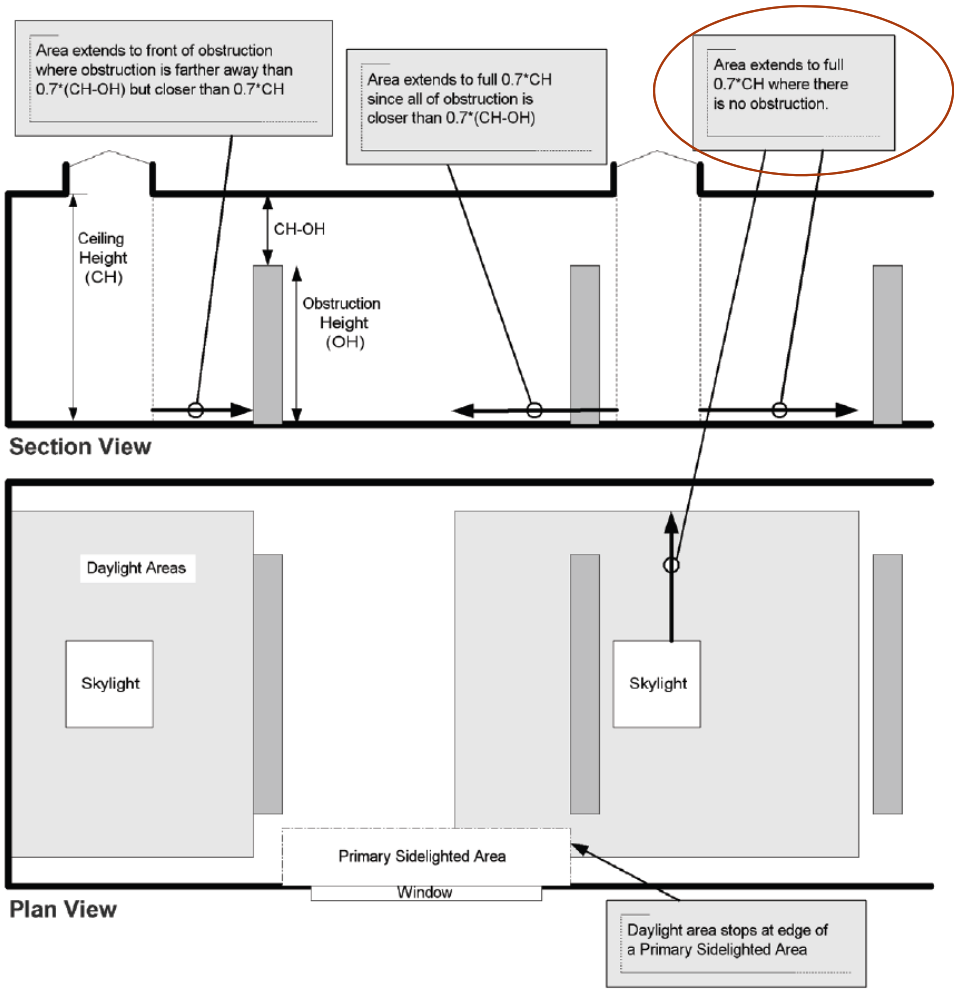
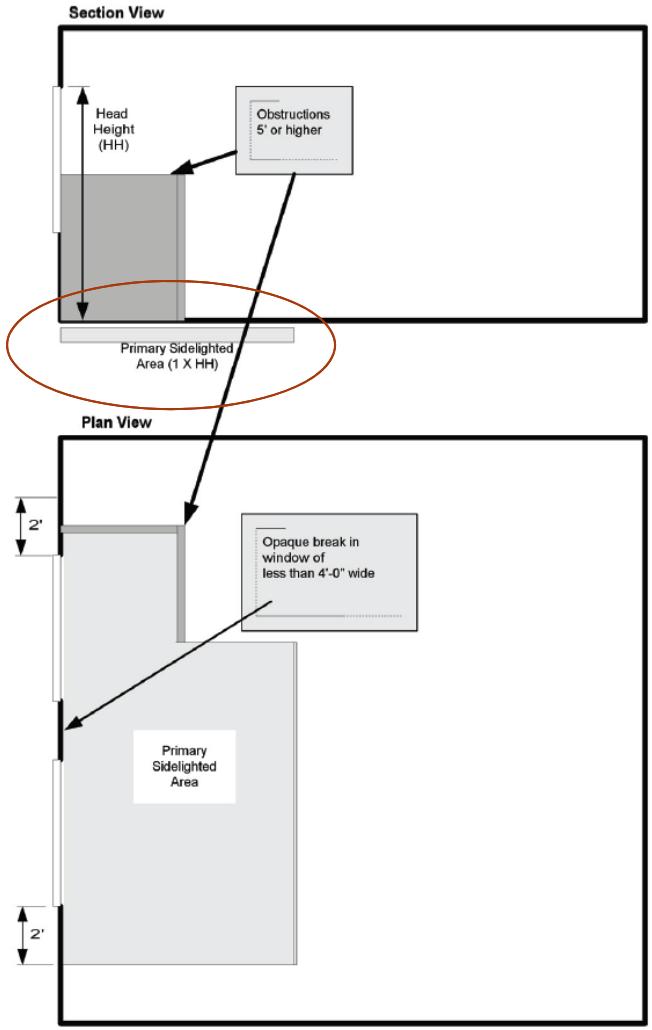
Code/ Standard	Sidelighting Controls	Toplighting Controls	Minimum Toplighted Area	Daylighting Control Credits	Functional Testing
90.1-2007	None	None	No	None	None
2009 IECC	None	None	No	None	None
90.1-2010	++	++	++	++	+
2012 IECC	+	+	+	No	+
90.1-2013	+++	+++	+++	+	+++
2015 IECC	++	++	++	No	+++

- Controls continue to become cheaper, hence their proliferation into codes

90.1-2010 – Daylight Zone Definitions





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IECC 2012 – Daylight Zones Definitions

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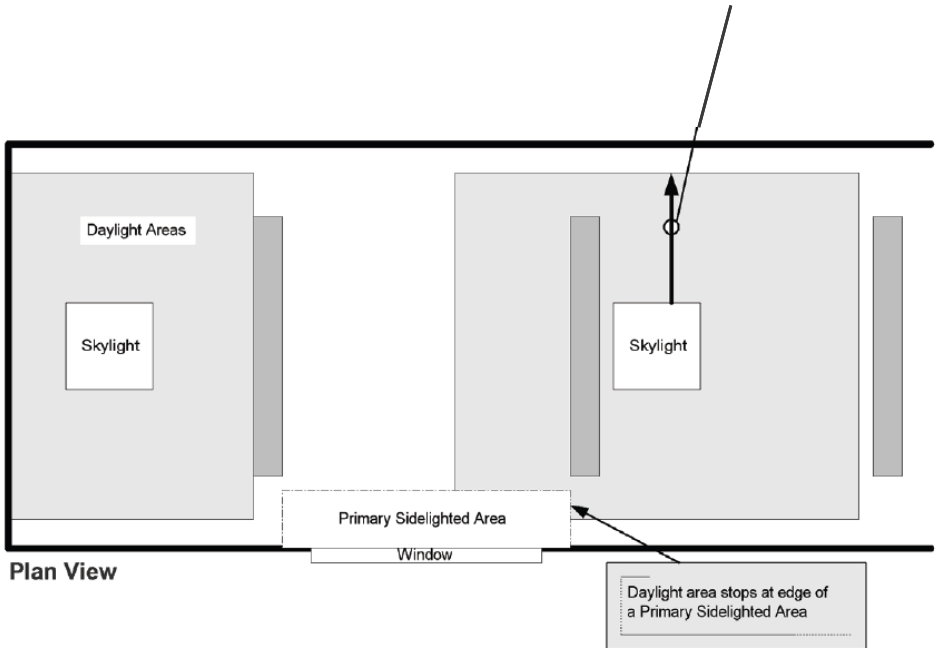
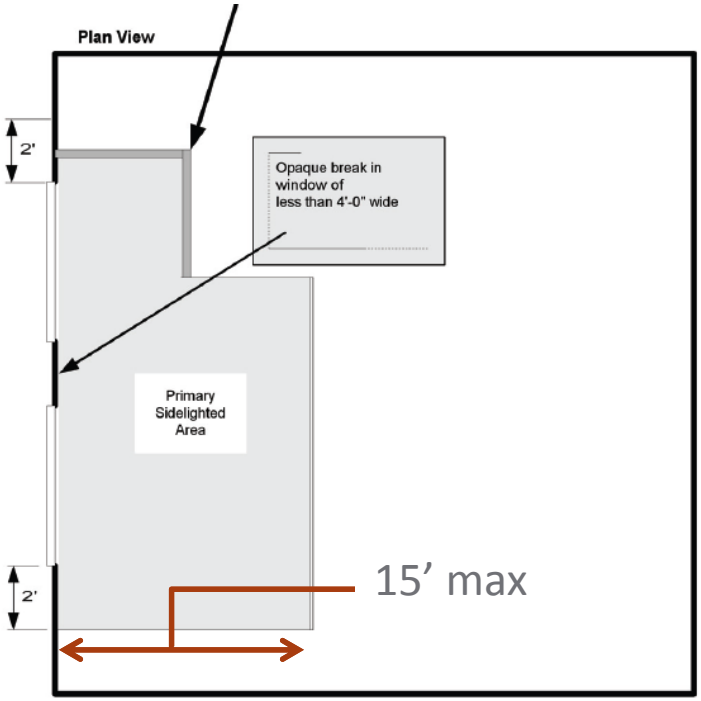
Floor to ceiling height





Usually, twice the head height

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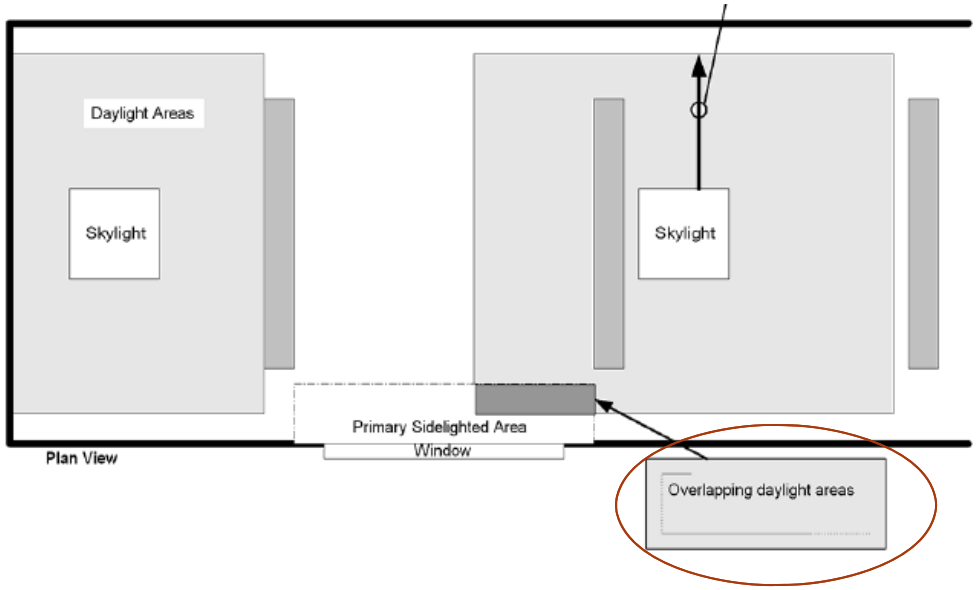
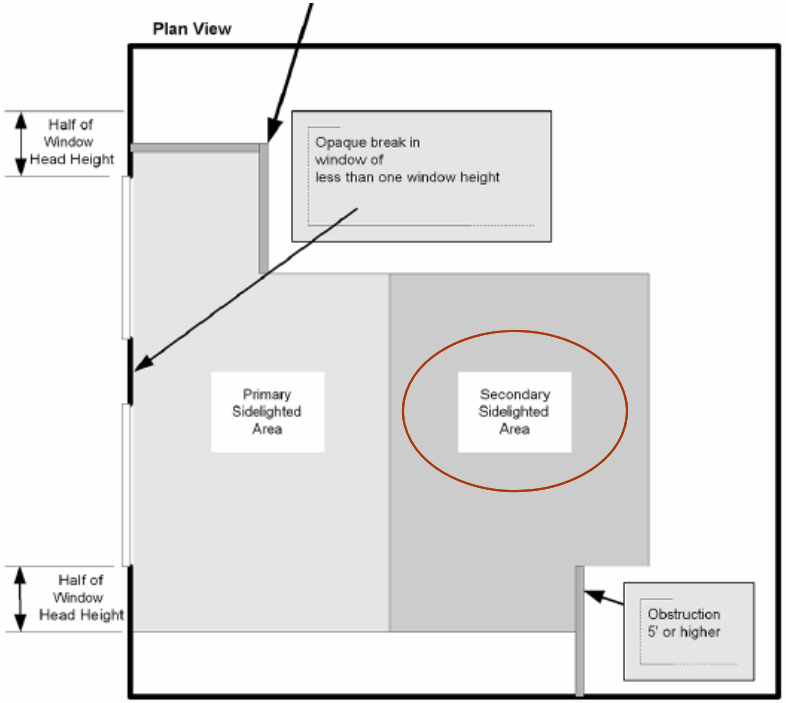
90.1-2013 Daylight Area Definitions





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Sidelighting Controls

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	90.1-2010	2012 IECC	90.1-2013	2015 IECC
Threshold Type	Area	None	Controlled Power	Controlled Power
Threshold	250 ft^2	None	150W	150W
Primary Sidelight Zone Depth	1 x HH	15'-0"	1 x HH	1 x HH
Secondary Sidelight Zone Depth	2 x HH	Not defined	2 x HH	Not defined
Control Type	Stepped	Stepped	Stepped, with off-step	Stepped, continuous in offices and classrooms

Sidelighting Controls – Exceptions

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	90.1-2010	2012 IECC	90.1-2013	2015 IECC
Effective Aperture	> 0.1	NA	NA	NA
Resource Availability	Obstructions twice as high as distance away	None	Obstructions twice as high as distance away	Obstructions twice as high as distance away
Minimum Lighting Power	No	No	No	No
Climate Zone	No	No	No	No
Other	Retail spaces	None	< 20 ft^2 glazing	< 24 ft^2 glazing, VT < 0.2

Sidelighting Effective Aperture

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- 90.1-2010 definition
  - Attempts to link daylighted area with available daylight
  - More daylight area + same available daylight = smaller effective aperture
  - Does not consider orientation
  - Problems with formula

$$EA = \frac{VT \times \text{Window Area}}{\text{Sidelighted area}}$$

- Traditional definition:
  - EA = Window Area x Window VT

- 90.1-2013 and IECC 2015 remove dependence on EA

Toplighting Controls

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	90.1-2010	2012 IECC	90.1-2013	2015 IECC
Threshold Type	Area	None	Controlled Power	Controlled Power
Threshold	900 ft^2	None	150W	150W
Exceptions				
Resource	Sunlight access blocked for > 1500 hours between 8 am and 6 pm			
Effective Aperture	< 0.006	NA	NA	NA
Minimum Lighting Power	0.5 W/ft^2	0.5 W/ft^2	NA	NA
Climate Zone	8 and < 1,500 ft^2	6-8	8 and < 200 W controlled	8 and < 200 W controlled
Other	None	Overlap	VT < 0.4	None

Minimum Toplighted Daylight Area From Skylights

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	90.1-2010	2012 IECC	90.1-2013	2015 IECC
Spaces	office, lobby, atrium, concourse, corridor, non-refrigerated warehouse or storage, gymnasium/exercise center, convention center, automotive service, manufacturing, retail, distribution/sorting area, transportation, or workshop		**Same as 90.1-2010 plus new spaces**: playing area, gymnasium seating area, courtroom, fire station engine room, manufacturing corridor/transition and bay areas, library reading and stack areas	Same as 2012 IECC
Threshold	5,000 ft^2	10,000 ft^2	2,500 ft^2	2,500 ft^2
Numbers of Floors	4 stories or less	Any	Any	Any

Minimum Toplighted Daylight Area From Skylights

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	90.1-2010	2012 IECC	90.1-2013	2015 IECC
Ceiling Height	15’-0”			
Requirement 1	Must daylight at least half the floor area of the space			
Requirement 2	Skylight area/Daylight area >= 3%, VT>=0.40 **OR** skylight effective aperture >= 1%			
Exceptions				
Climate Zones	6-8			
Resource	When existing structures or natural objects block direct beam sunlight on at least half of the roof over the *enclosed space* for more than 1,500 daytime hours per year between 8 a.m. and 4 p.m.			
Lighting Power	< 0.5 W/ft^2	< 0.5 W/ft^2	None	< 0.5 W/ft^2
Other	Sidelighting/toplighting			

Functional Testing

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	90.1-2010	2012 IECC	90.1-2013	2015 IECC
Required	Yes	Same as 90.1-2010	Enhanced from 90.1-2010	Same as 90.1-2010

- Photocontrols must be tested to ensure correct operation
- Confirm that daylighting controls reduce electric lighting in response to daylight
- Check placement and sensitivity
- Documentation of testing is required
- Third party must perform the functional testing and produce report certifying all control requirements are met

Daylight Control Credits – 90.1 only

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- For certain spaces, when using the space-by-space method, higher LPD is allowed when above code controls are installed

- For example, if automatic continuous dimming is implemented in primary sidelighted areas < 250 ft^2 and with effective aperture >0.15, then

Additional lighting power allowance	=	general lighting power controlled with automatic continuous dimming	x	0.2 (control factor from Table 9.6.2)

- 90.1-2013 has only one credit when continuous dimming controls are installed in secondary daylight zones

90.1-2010

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ANSI/ASHRAE/IESNA Standard 90.1-2010
(Supersedes ANSI/ASHRAE/IESNA Standard 90.1-2007)
Includes ANSI/ASHRAE/IESNA Addenda listed in Appendix F

ASHRAE STANDARD

Energy Standard for Buildings Except Low-Rise Residential Buildings

I-P Edition

See Appendix F for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, the IESNA Board of Directors, and the American National Standards Institute.

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90.1-2010 – Miscellaneous Items

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- Control Types
  - One control step between 50% and 70% and another no greater than 35% of full power
  - Dimming controls not required, but allowed
  - Off-step not required, but allowed

- Skylight haze value > 90%

IECC 2012

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IECC 2012 – Increased WWR

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- Increased WWR
  - Max allowed 30% WWR
  - Can go up to 40% WWR if
    - Climate zone 1-6
    - 50% of floor area is in daylight zone
    - Daylight area is controlled using automatic controls
    - Fenestration VT is 1.1 times SHGC

IECC 2012 – Daylight Control Types

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- Continuous dimming must be capable of reducing power to 35% of maximum
- Stepped dimming with minimum two steps; one between 70% and 50% of maximum; another less than 35%
- Multi-level control: full on or less than 35% of maximum power
- Daylight zone under skylights shall be controlled by multi-level controls

IECC 2012 – Increased U-factor and SHGC for Skylights

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- When daylight zones under skylights are controlled by automatic daylighting controls
  - Maximum U-factor allowed to be
    - 0.9 Btu/h-ft^2-F in climate zones 1-3
    - 0.75 Btu/h-ft^2-F in climate zones 4-8
  - Maximum SHGC allowed to be
    - 0.6 in climate zones 1-6
    - Climate zones 7 and 8 have no SHGC requirements in main prescriptive table
- These U-factors are higher than in prescriptive tables

IECC 2012 – High-Efficiency Path

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- Must choose at least one high-efficiency package
- One path is lighting
  - Reduced LPD for certain space types
  - For office and retail spaces, two LPD values are provided; higher value can be used if
    - at least 30% of conditioned floor area is in daylight zones, and
    - is controlled using automatic stepped or continuous dimming controls
  - For warehouses, 70% of floor area must be in a daylight zone and be controlled by automatic stepped or continuous dimming controls

90.1-2013

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STANDARD

ANSI/ASHRAE/IES Standard 90.1-2013
(Supersedes ANSI/ASHRAE/IES Standard 90.1-2010)
Includes ANSI/ASHRAE/IES Addenda listed in Appendix F

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(I-P Edition)

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90.1-2013 – Additional Functional Testing Requirements

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- Expanded functional testing requirements
  - More explicitly stated
  - Placement, field calibration, operation, accessibility
- Daylighting documentation
  - Identify daylight areas and luminaires in daylight areas

90.1-2013 – Control Types

- Minimum 3-step control
  - 70%-50%
  - 40%-20%
  - Off-step
- Overlapping sidelighted and toplighted area to be controlled by toplighted area controls

90.1-2013 – Envelope Requirements

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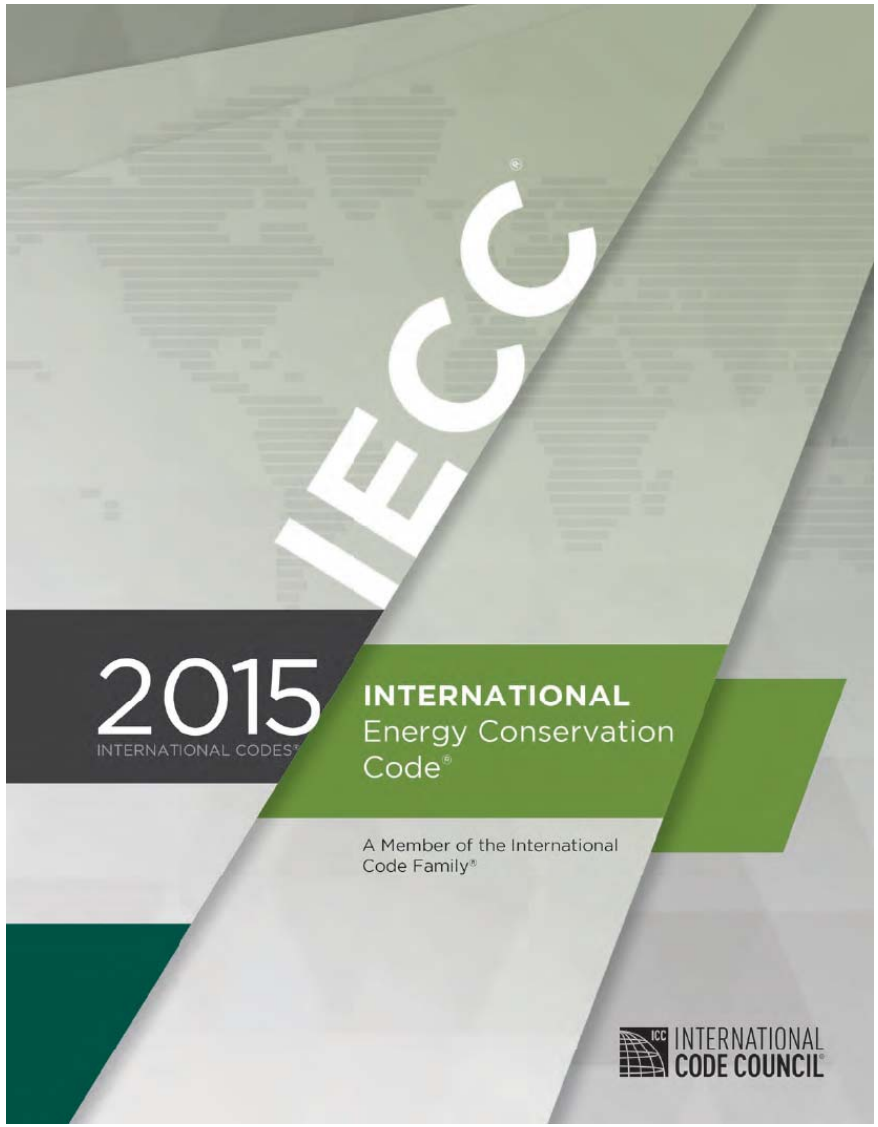
- Skylight SHGC exempted under certain conditions
- Sidelighting
  - Vertical fenestration
    - Minimum VT/SHGC ratio must be maintained when daylighting controls are in place
    - Minimum VT ensures daylight potential is not lost or reduced

IECC 2015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IECC 2015 – Miscellaneous

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- Increased WWR
  - Max allowed 30% WWR
  - Can go up to 40% WWR if
    - Climate zone 1-6
    - 50% of floor area is in daylight zone for buildings 2 stories or less above grade
    - 25% of floor area is in daylight zone for buildings 3 stories or more above grade
    - Daylight area is controlled
    - Fenestration VT is 1.1 times SHGC
- Increased U-factor, SHGC

Alterations

	90.1-2010	2012 IECC	90.1-2013	2015 IECC
Alterations	> 10% of connected lighting load in a space	> 50% luminaires in a space provided LPD is not increased	> 10% of connected lighting load in a space	> 10% luminaires in a space provided LPD is not increased
Daylighting Controls	Not applicable	Not Applicable because controls not required in prescriptive path	Not applicable	Applicable

Thank you!

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Questions?

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