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Daylighting Controls for Commercial Buildings

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U.S. Department of Energy Building Energy Codes Program
Energy Codes Commentator Webinar Series
AIA Provider #: I014 AIA Course #: BECPWS916
ICC Provider Course #9273

September 8, 2016 PNNL-SA-120788

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Course Description

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Daylighting controls reduce artificial lighting in response to sunlight coming in through windows and skylights. They were first introduced in ASHRAE Standard 90.1-2010 for commercial buildings and are now part of 90.1-2013 and the 2015 IECC. In this session, we will review the fundamentals of daylighting, describe how daylighting controls work and save energy, and review daylighting control requirements in the latest codes and standards. We will look at how these controls should be implemented and commissioned.

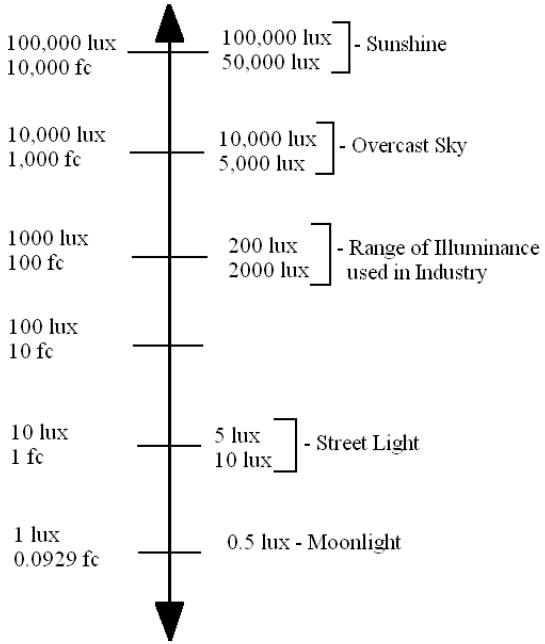
CONTINUING EDUCATION AIA

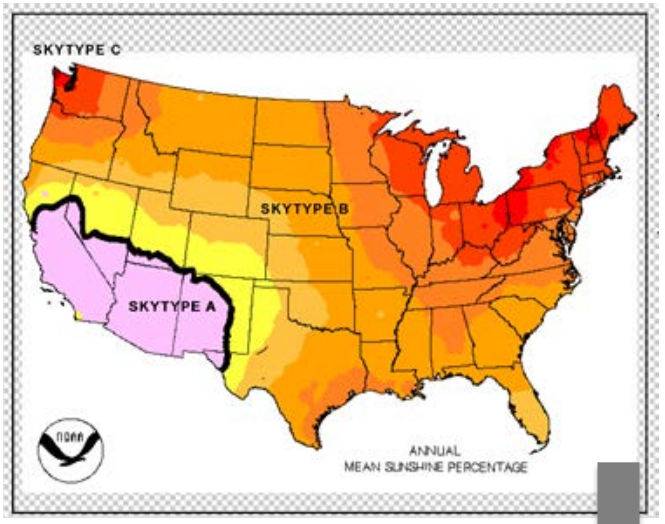
Learning Objectives

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

- Describe how daylighting and controls work
- Understand the benefits of daylighting controls and their energy savings potential
- Describe daylighting requirements in various codes and standards

Daylighting Controls Overview





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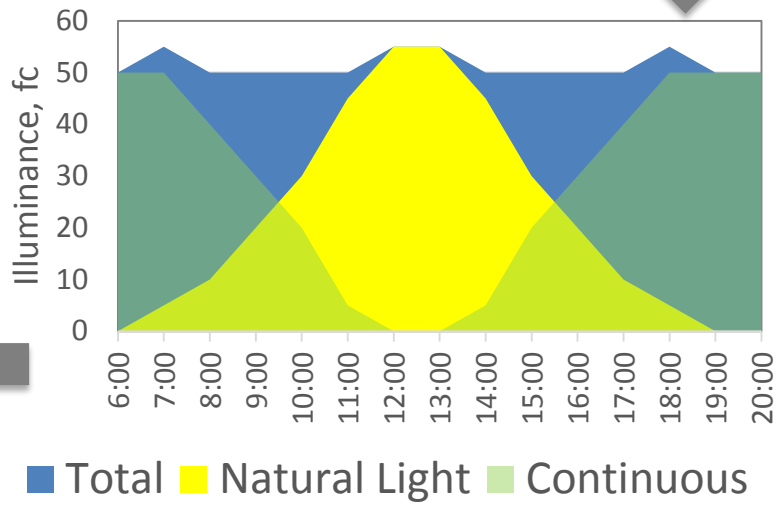

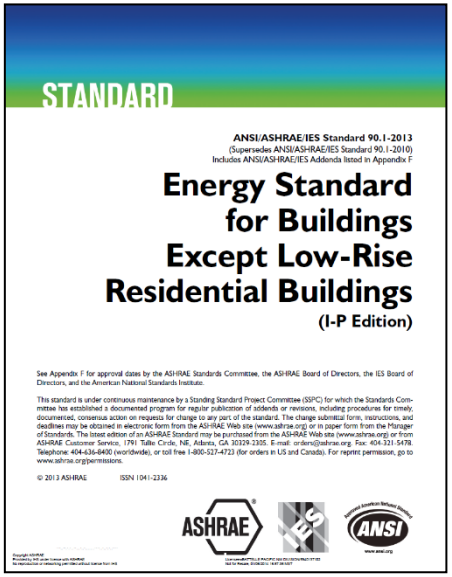

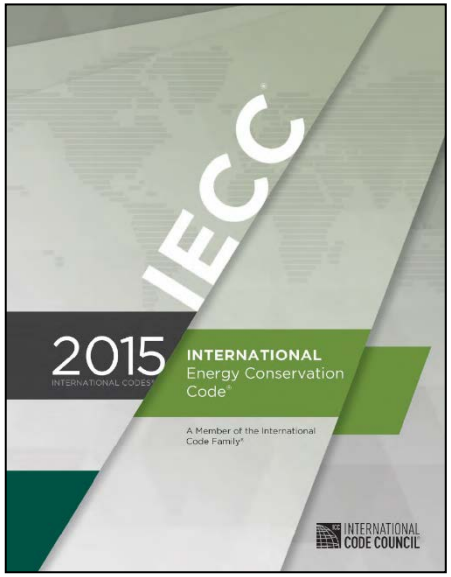

Daylighting 101

Two ways by which natural light generally enters a space: from the side and from the top

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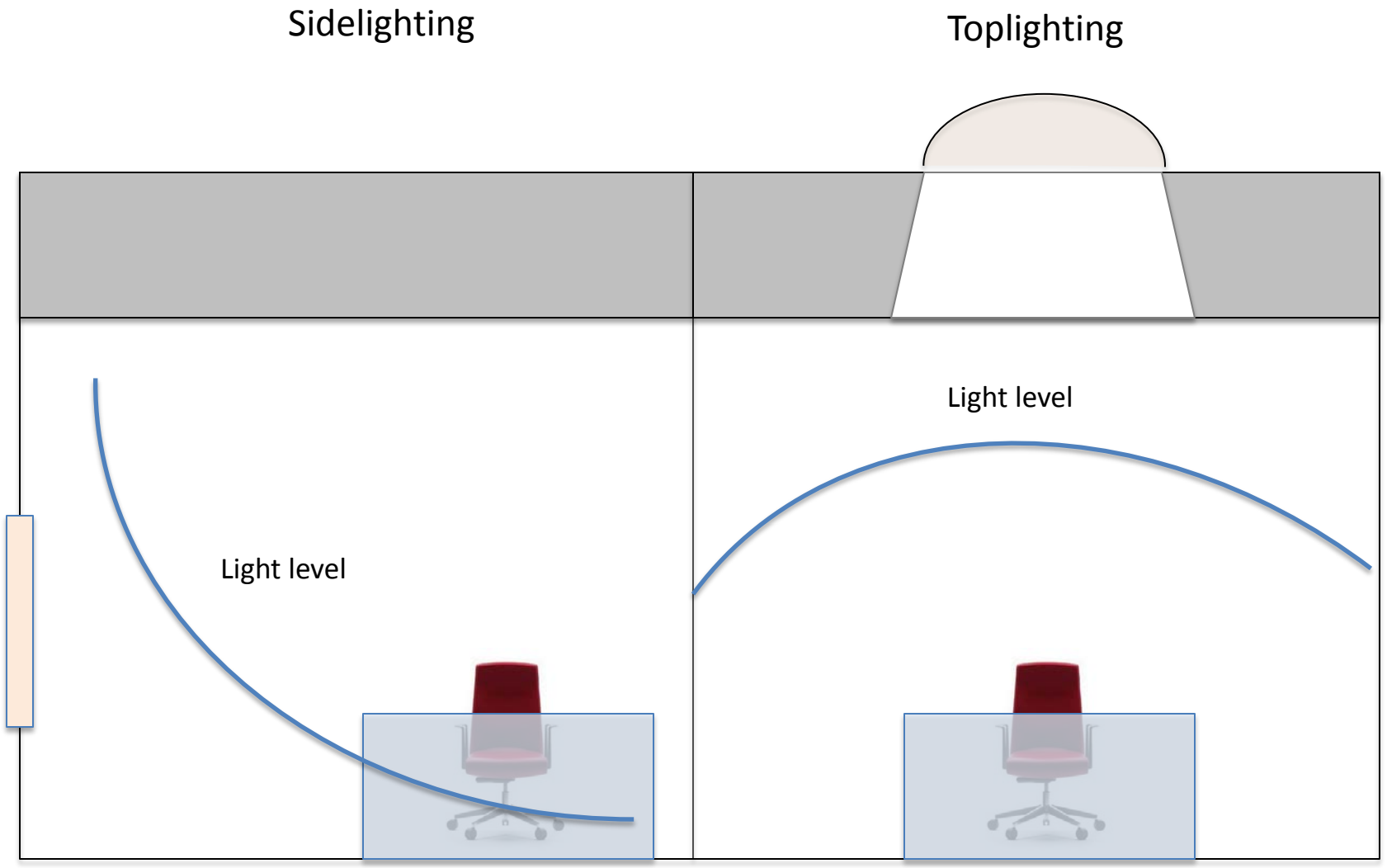
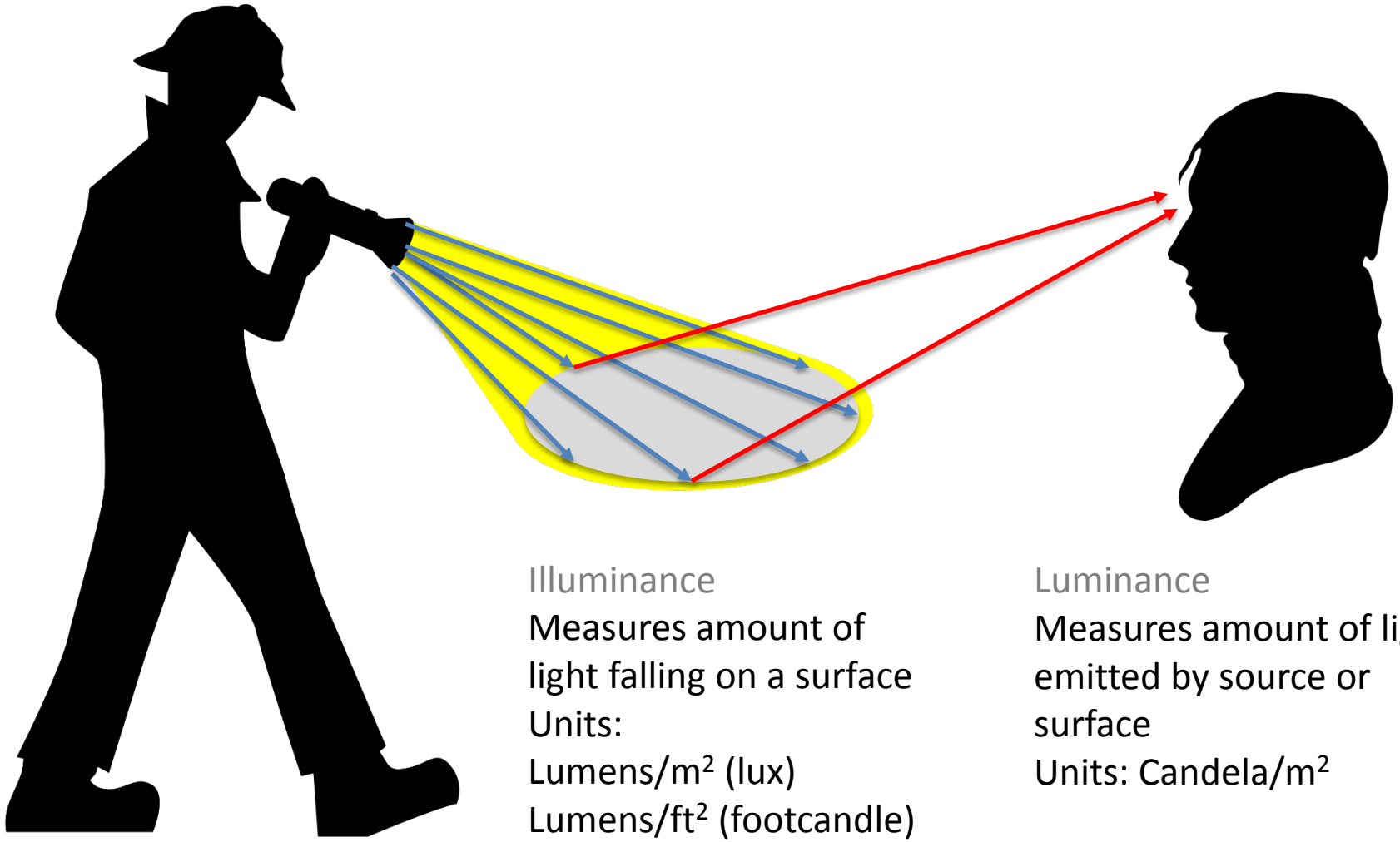


Footcandle and Lux: units of illuminance



Illuminance

Measures amount of light falling on a surface

Units:

Lumens/m^2 (lux)

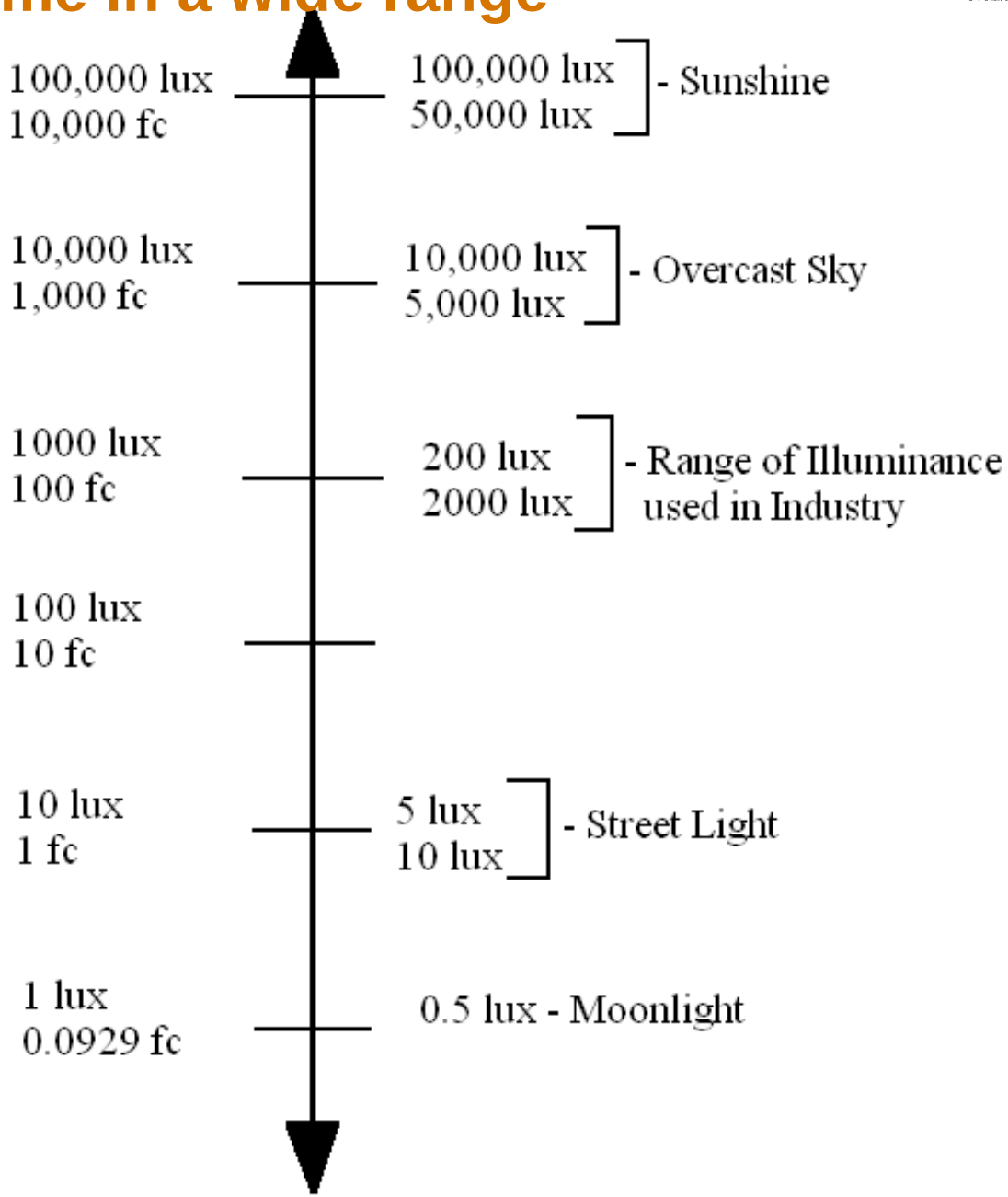
Lumens/ft^2 (footcandle)

Luminance

Measures amount of light emitted by source or surface

Units: Candela/m^2

Illuminances come in a wide range



Recommended Illuminance Levels (IES Handbook 1998)

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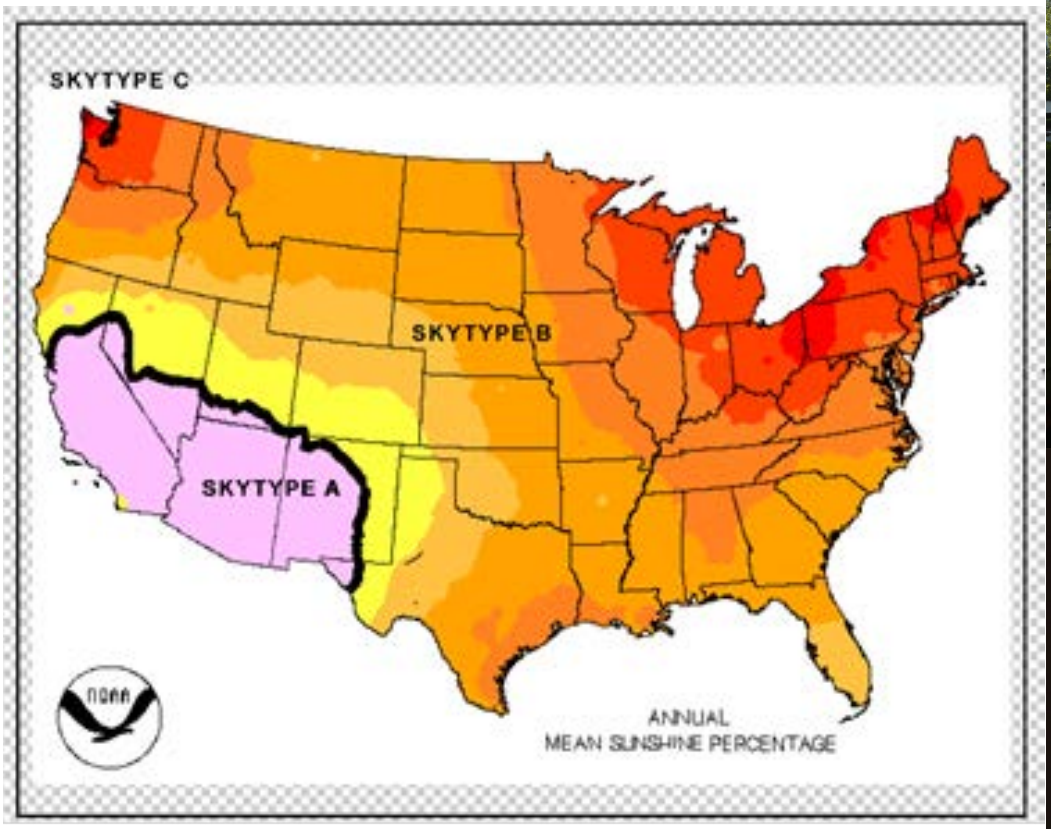
Activity	Lux	Footcandle
Public areas with dark surroundings	20 - 50	2-5
Simple orientation for short visits	50 - 100	5-10
Working areas where visual tasks are only occasionally performed	100 - 150	10-14
Warehouses, Homes, Theaters, Archives	150	14
Easy office work, Classes	250	24
Normal office work, 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

Factors that affect daylighting design: Sunlight Availability



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Orientation is a key variable

North = diffuse
South = variable
East & West = generally bad

Surface finishes have a large influence on the perceived brightness of a room

Those pesky humans!

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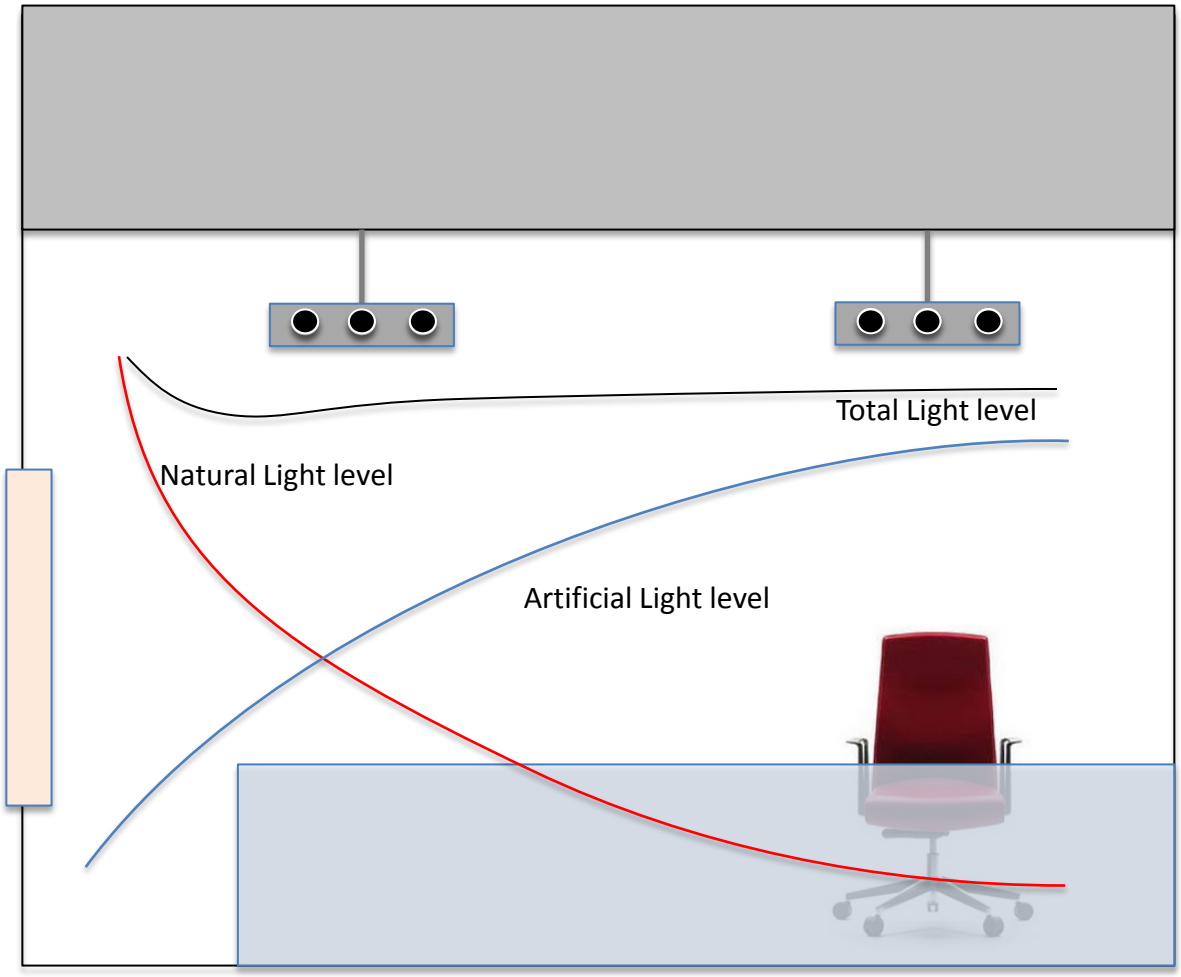
Daylighting Controls

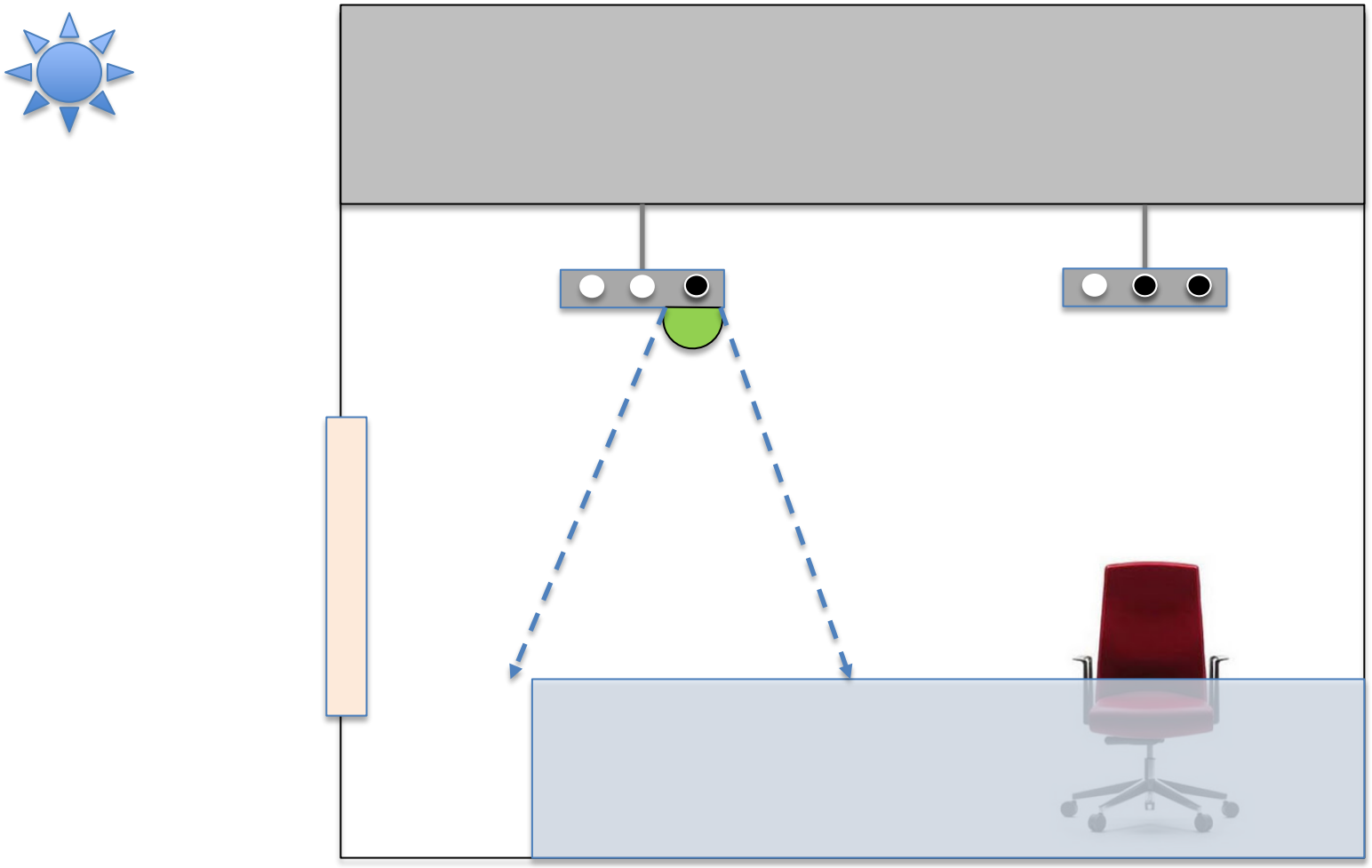
Daylighting controls turn off artificial lighting to save energy



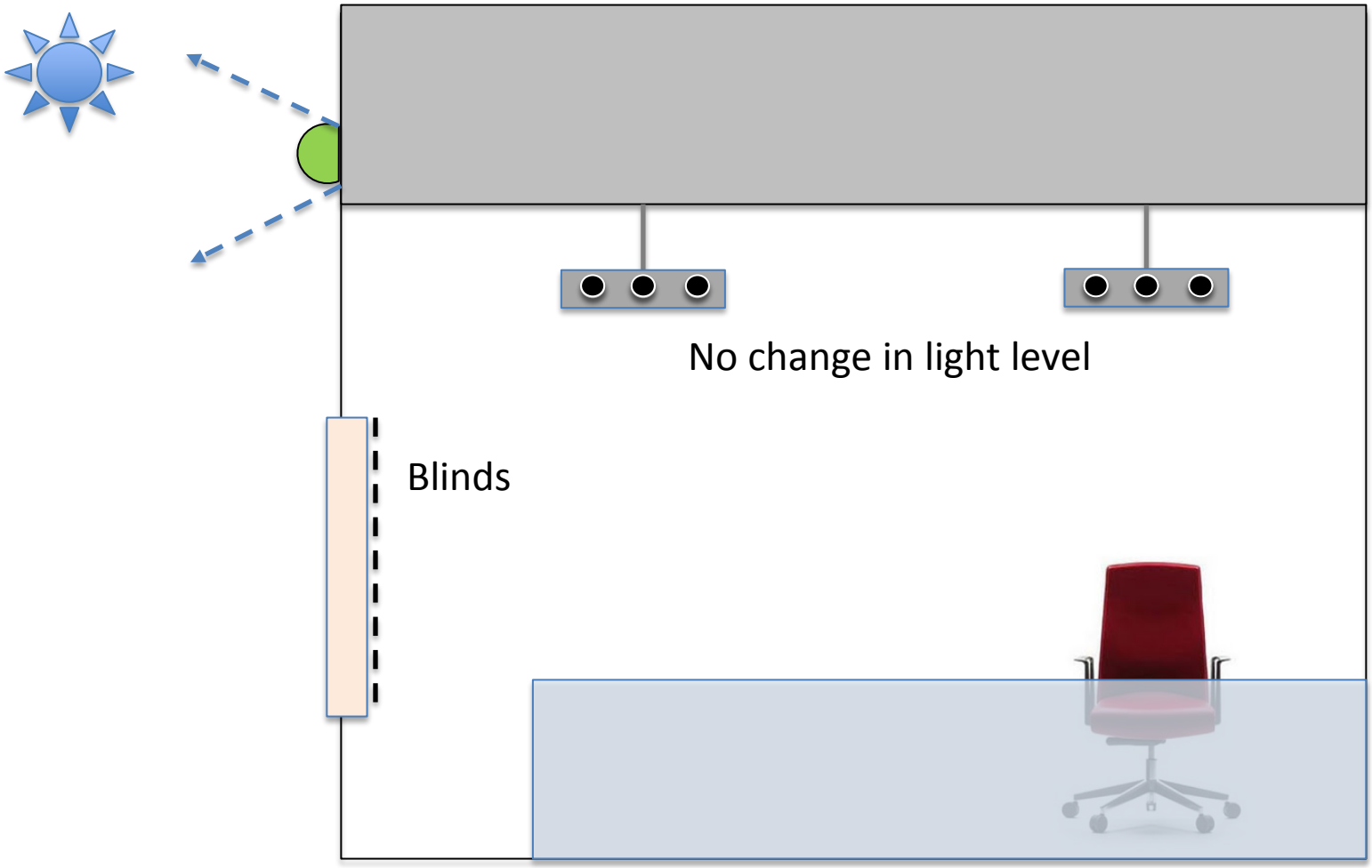
Anatomy of daylighting controls

Controller → Relay → Dimming Ballast

Closed loop controls attempt to keep the illuminance at the sensor constant



Open loop controls adjust artificial lights in proportion to daylight only



Lights can be dimmed in steps

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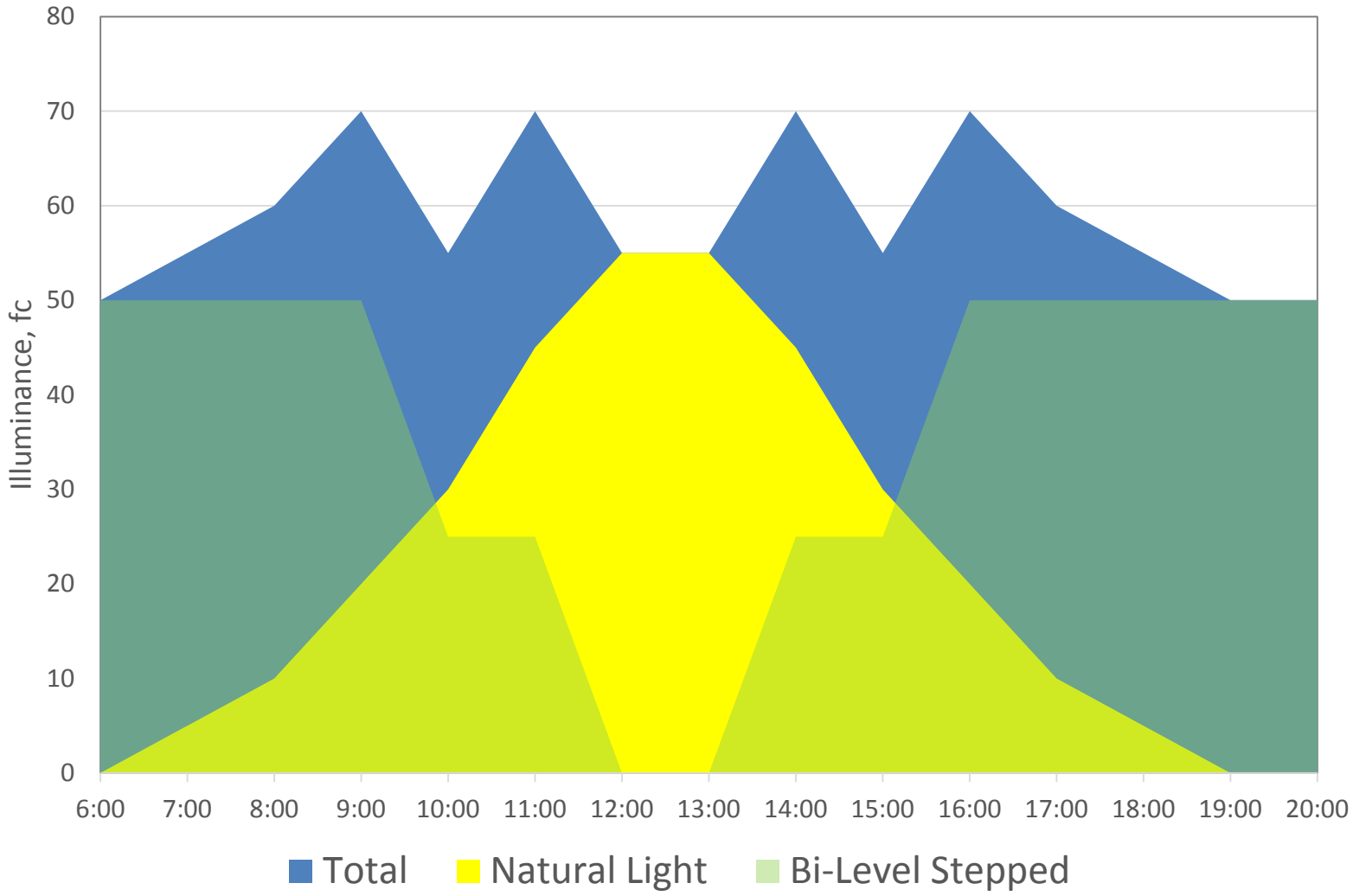

…or lights can be dimmed continuously

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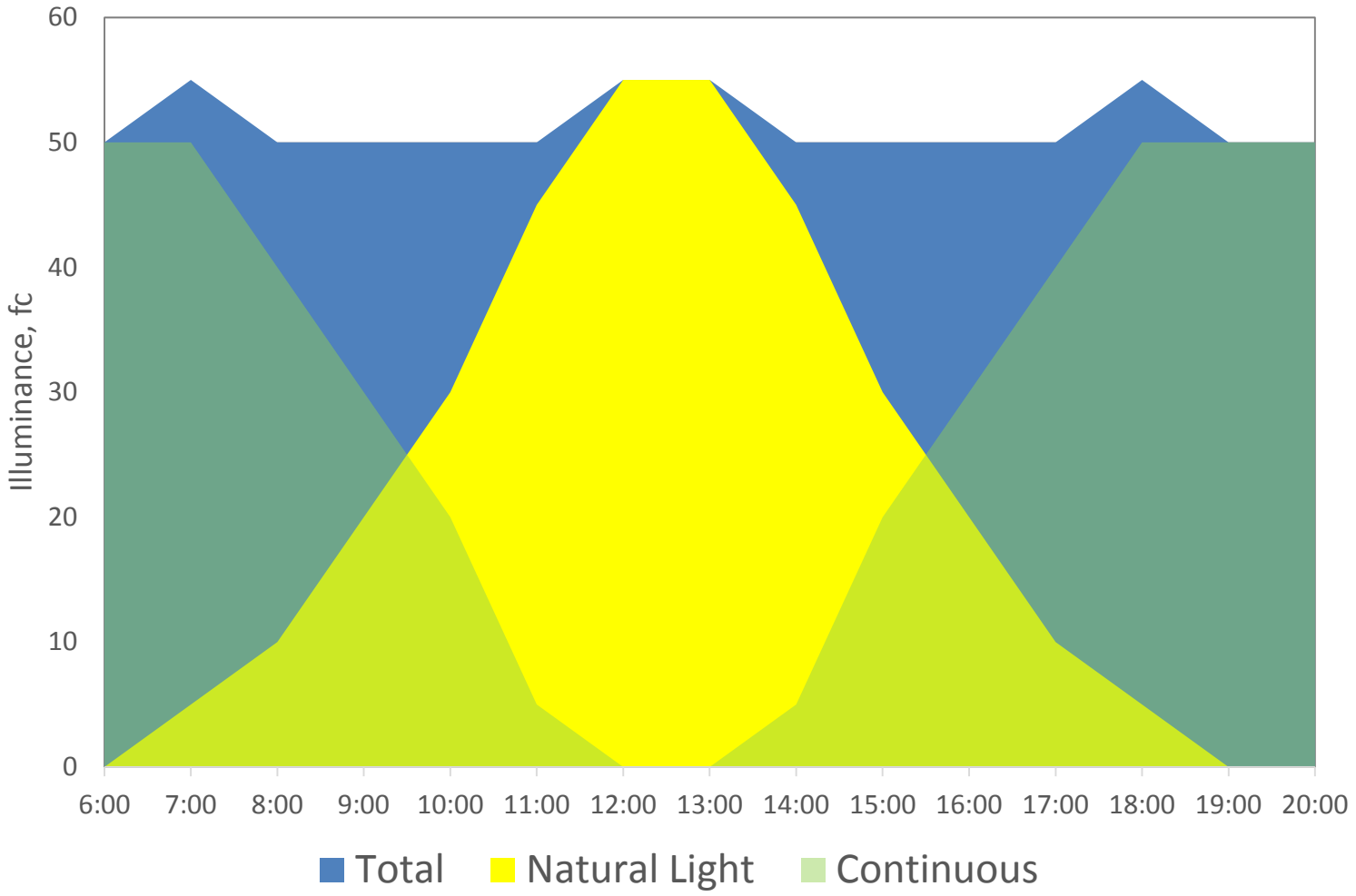

Factors affecting daylight control savings

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- Works best in offices, schools, warehouses, and so on
- Daylighting does not work well in
  - Residential spaces
  - Spaces which may need to be darkened
  - Retail spaces, etc.

- Savings depend on
  - window size
  - Window visible light transmittance
  - Control type
  - Space type (or illumination setpoint)

Daylighting controls require

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- Calibration, commissioning, and testing
- Appropriate sensor location
- Correct configuration with occupancy sensors
- Training of owner/maintenance staff and occupants

Daylighting in Codes and Standards

Daylighting and Codes: Watt's new?

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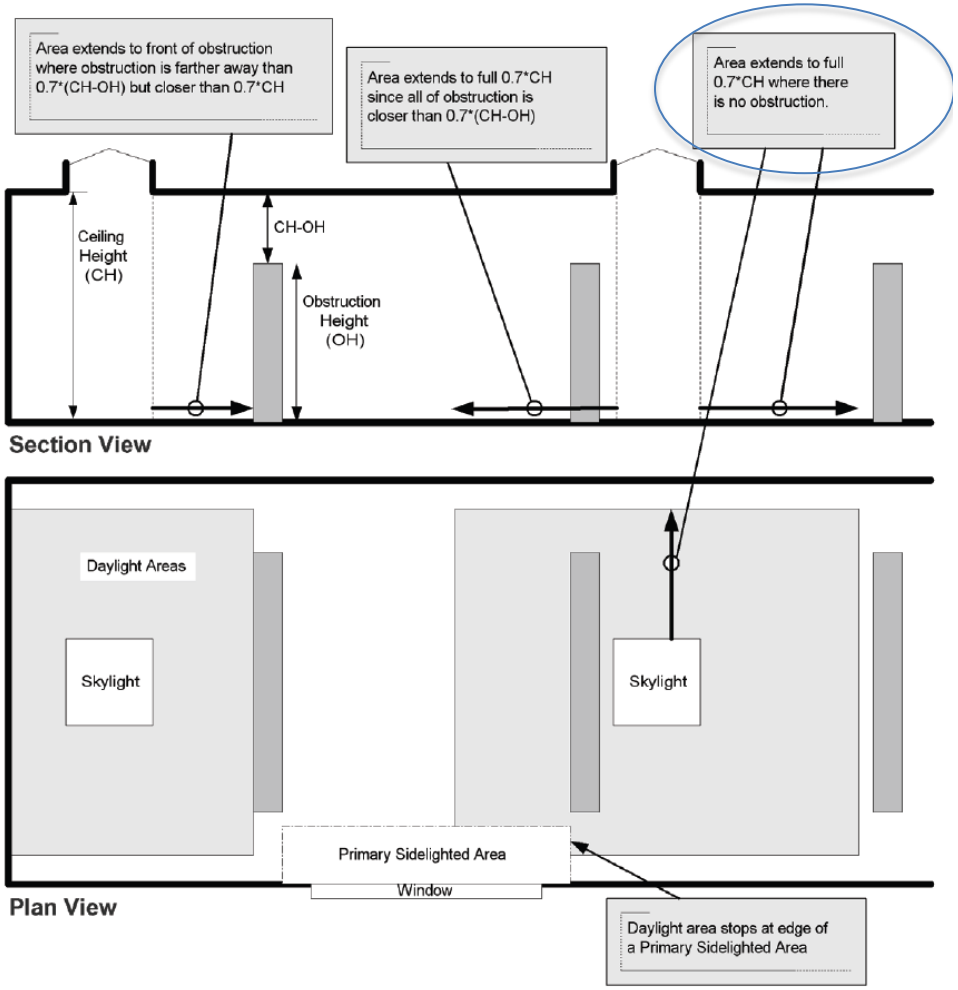
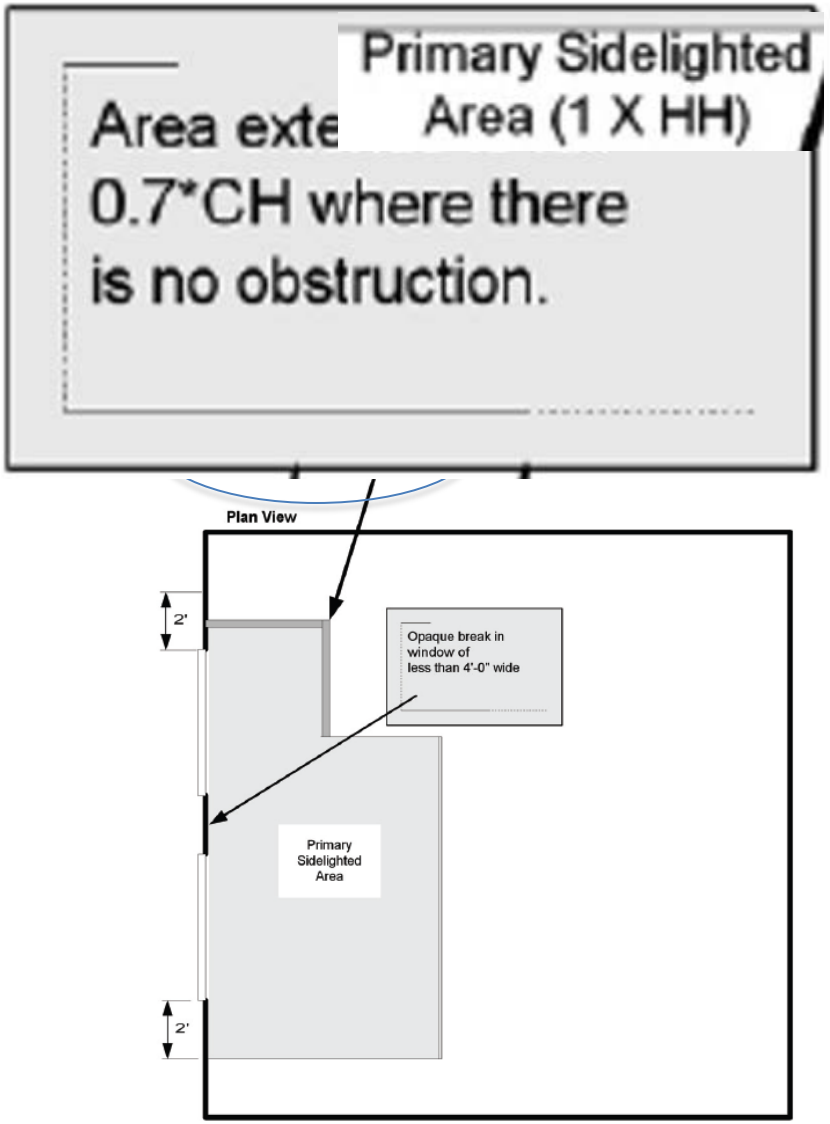
Code/ Standard	Sidelighting Controls	Toplighting Controls	Minimum Toplighted Area	Daylighting Control Credits	Functional Testing
90.1-2007	None	None	No	None	None
2009 IECC	None	None	No	None	None
90.1-2010	++	++	++	++	+
2012 IECC	+	+	+	No	+
90.1-2013	+++	+++	+++	+++	+++
2015 IECC	++	++	++	No	+++

90.1-2010 – Daylight Zone Definitions





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IECC 2012 – Daylight Zones Definitions

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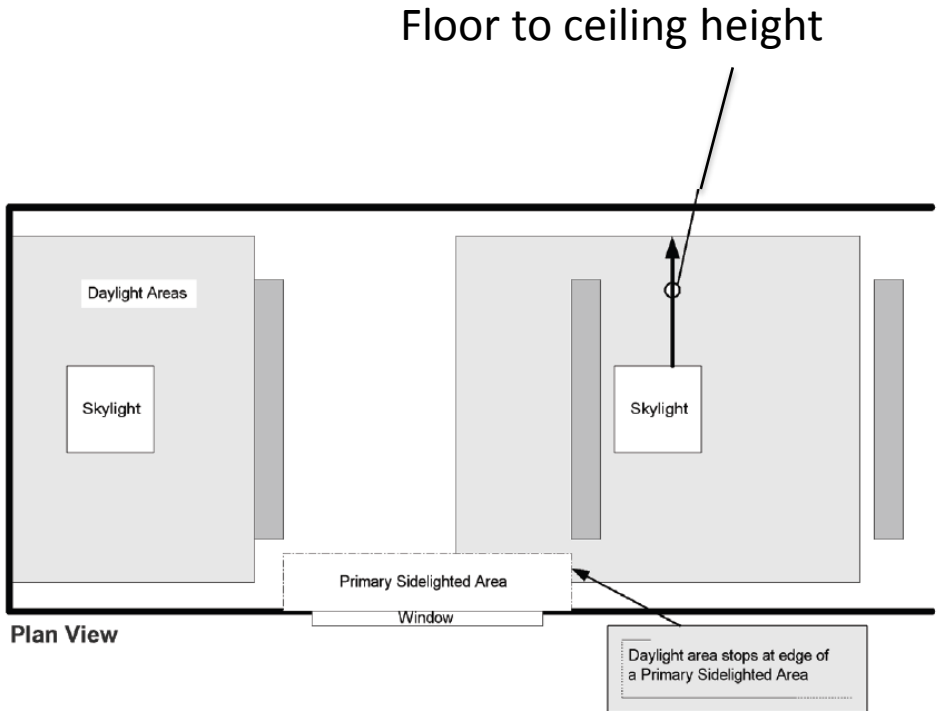

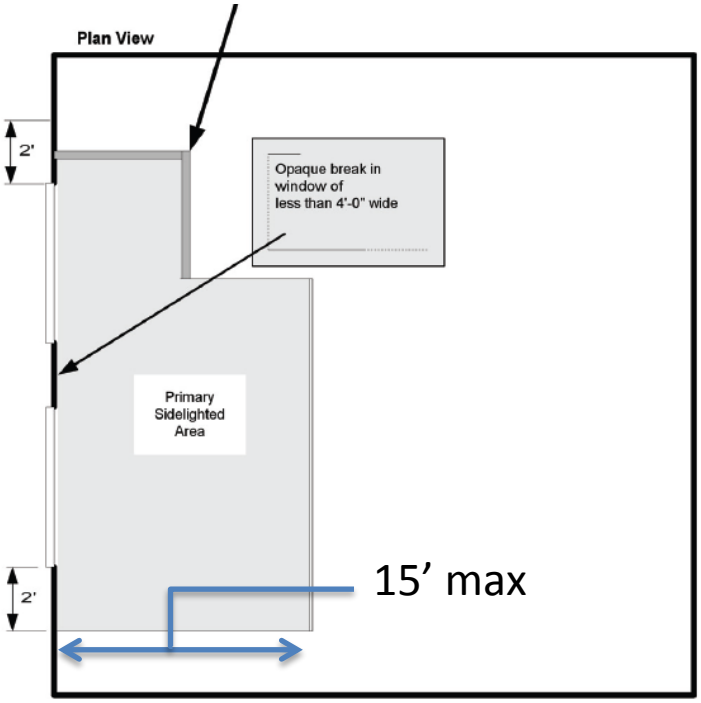

Usually, twice the head height

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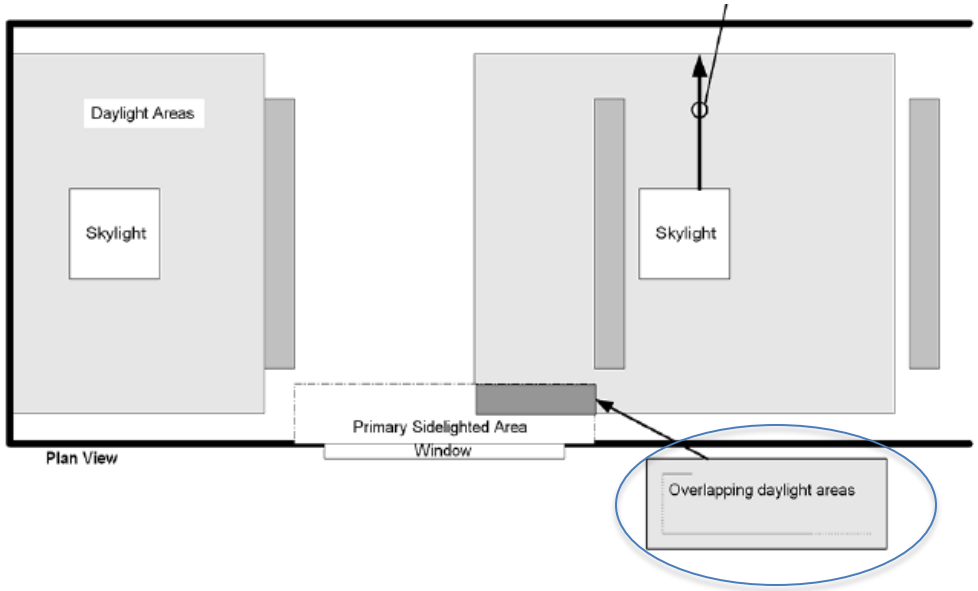
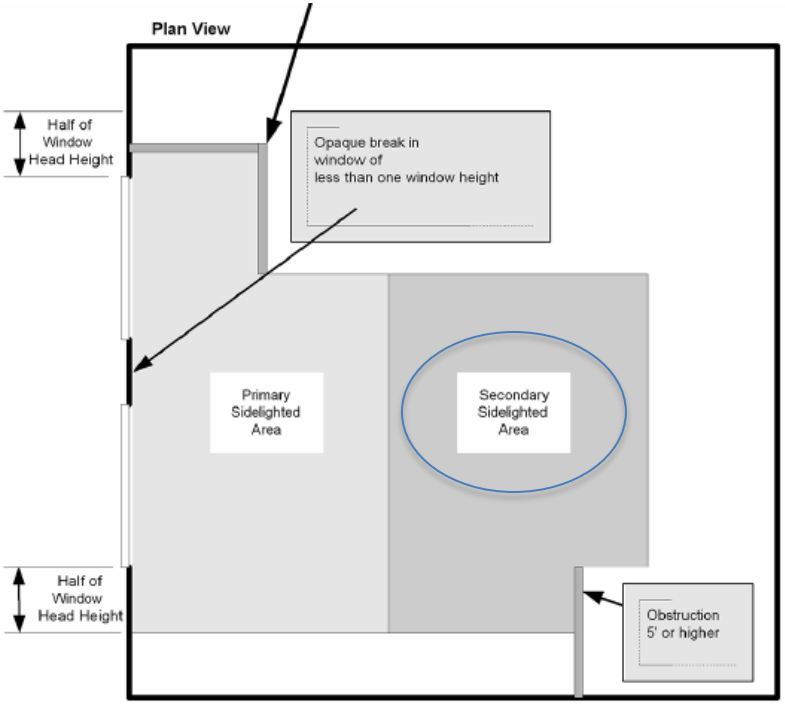
90.1-2013 Daylight Area Definitions





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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 required to be controlled)	Not defined	2 x HH	Not defined
Control Type	Stepped (<35%, 50%-70% of full power)	Continuous (<35%) or stepped (<35%, 50%-70% of full power)	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
Obstructions	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

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			

Alterations

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	90.1-2010	2012 IECC	90.1-2013	2015 IECC
Alterations	> 10% of connected lighting load in a space provided LPD is not increased	> 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

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

- Controls 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

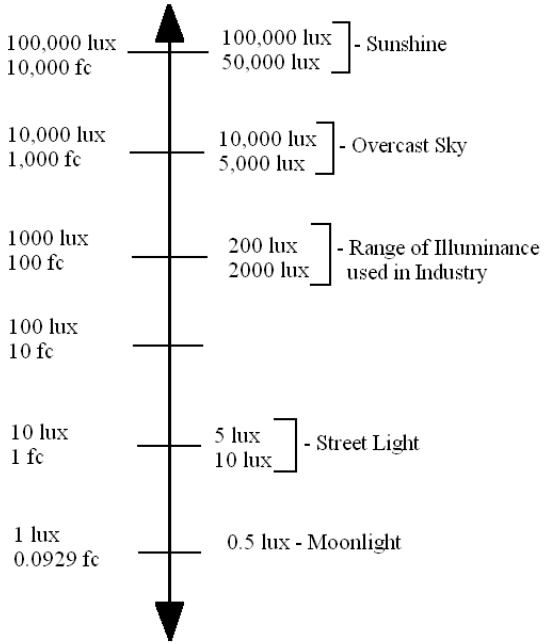
- For certain spaces, when using the space-by-space method, higher LPD is allowed when above code controls are installed

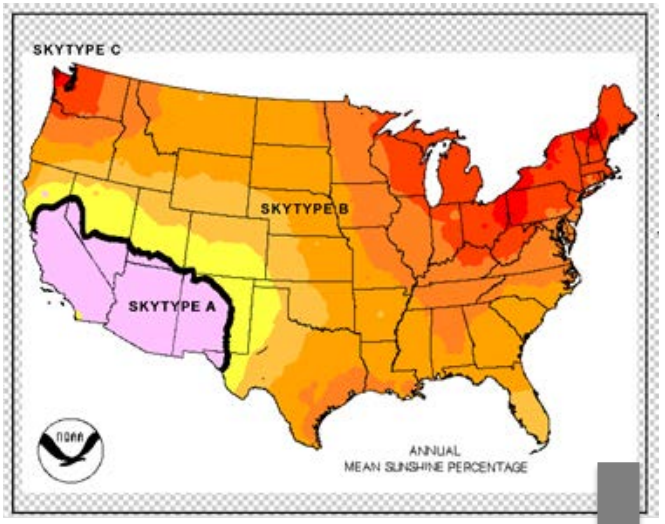
- For example, if automatic continuous dimming is implemented in primary sidelighted areas < 250 ft^2 and with effective aperture >0.15, then

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

Summary





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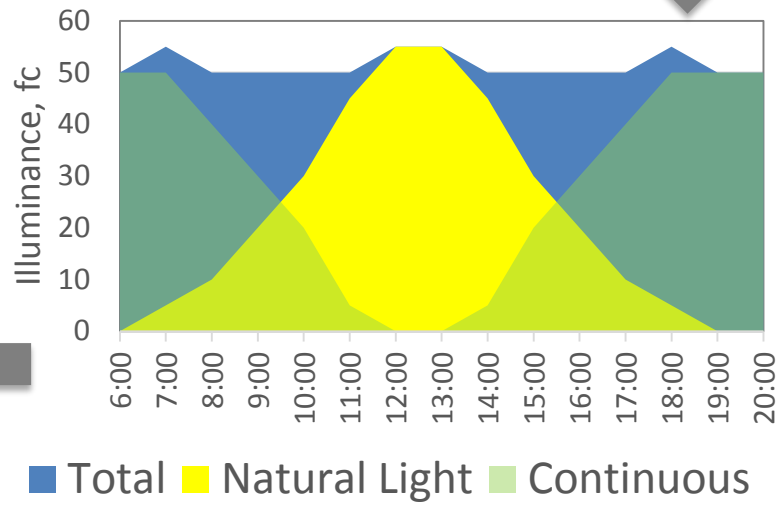
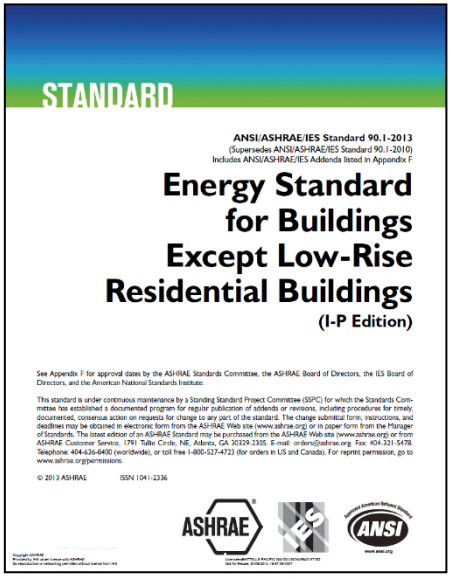
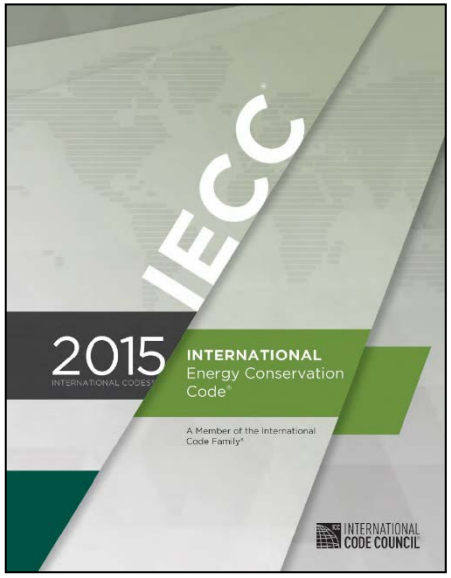


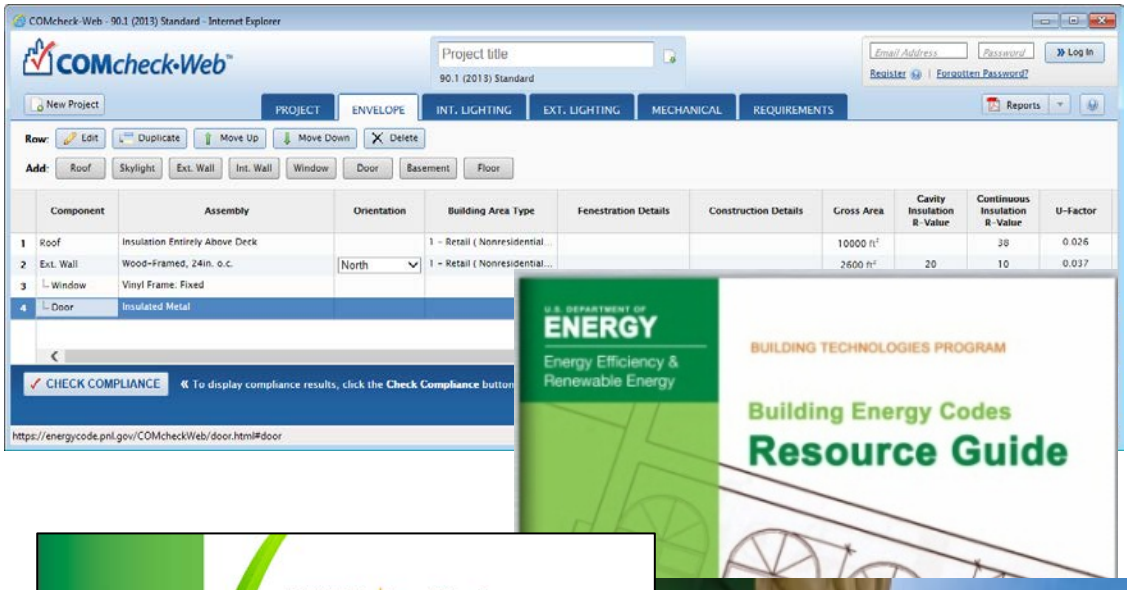


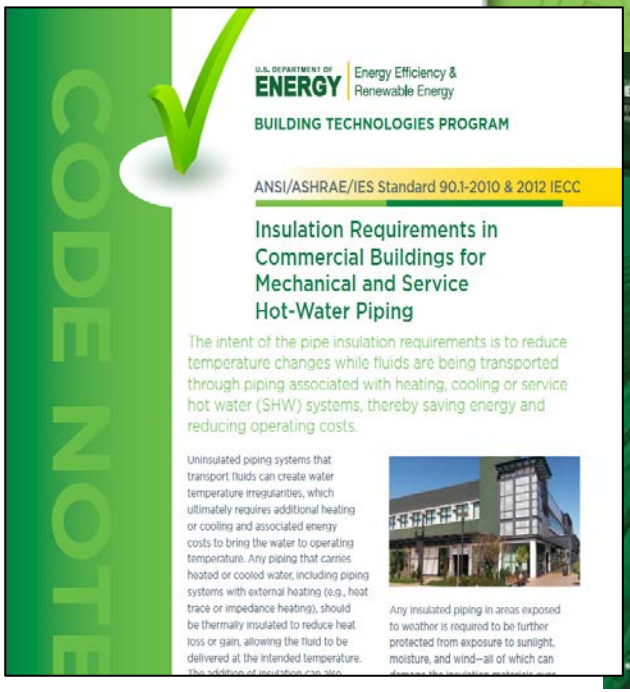


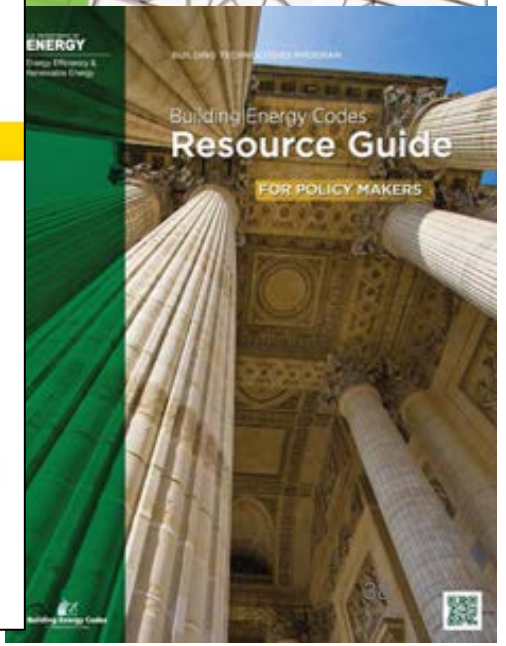
Building Energy Codes Program - Resources

- Compliance software
- Technical support
- Code notes
- Publications
- Resource guides
- Training materials

www.energycodes.gov







Training Topic Ideas?

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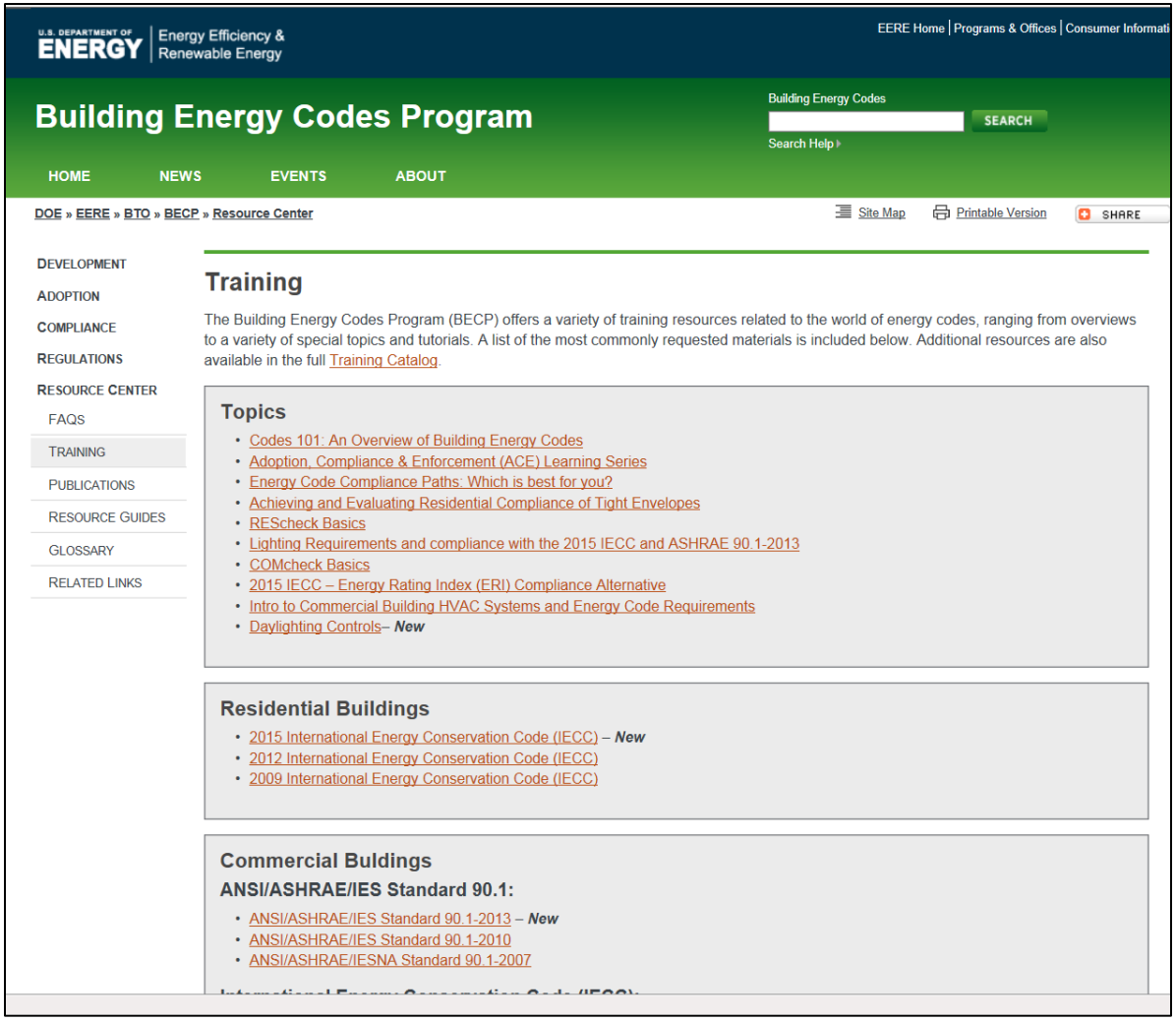
- Give us your topic ideas



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