

Daylighting Controls for Commercial Buildings

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U.S. Department of Energy Building Energy Codes Program
Energy Codes Commentator Webinar Series

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ICC Provider Course #9273

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Course Description

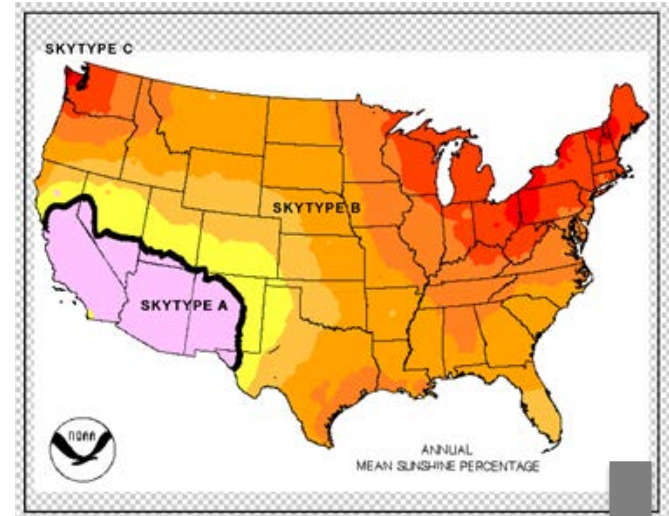
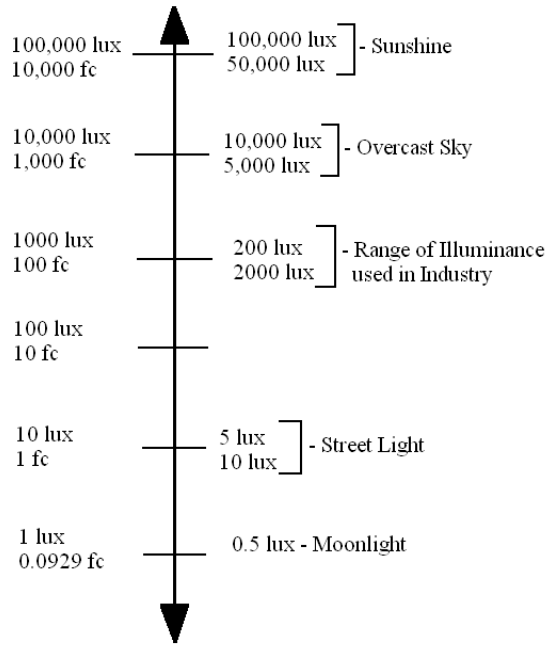
Daylighting controls reduce artificial lighting in response to sunlight coming in through windows and skylights. They were first introduced in ASHRAE Standard 90.1-2010 for commercial buildings and are now part of 90.1-2013 and the 2015 IECC. In this session, we will review the fundamentals of daylighting, 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.

Learning Objectives

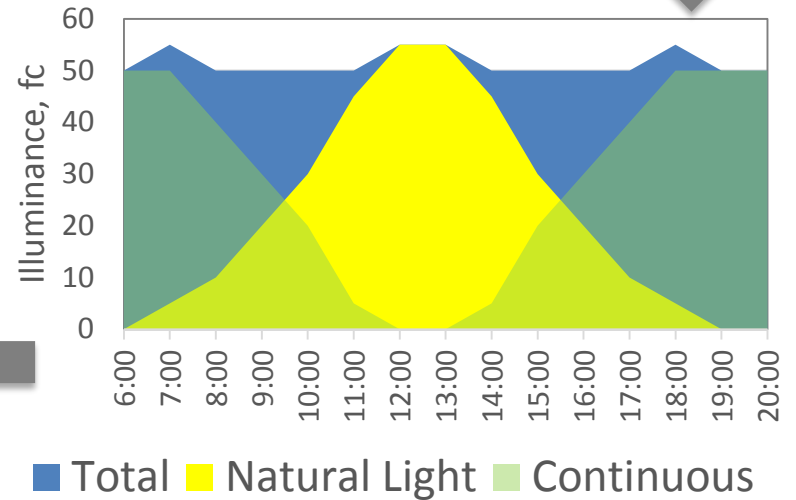
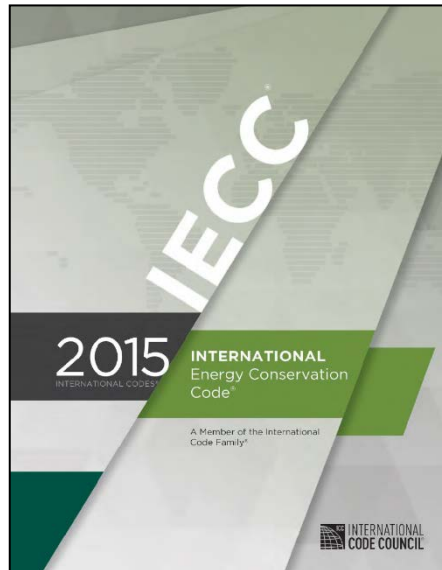
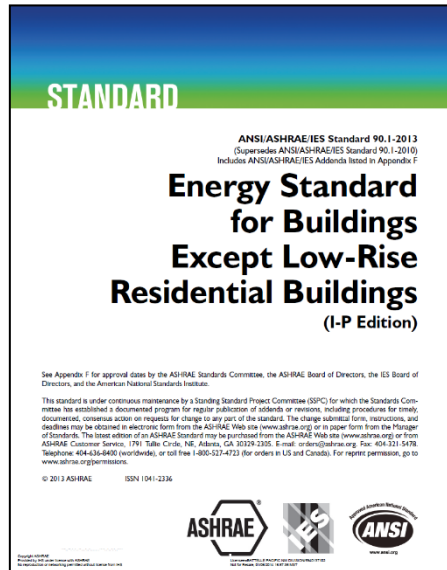
At the end of the this course, participants will be able to:

- ▶ 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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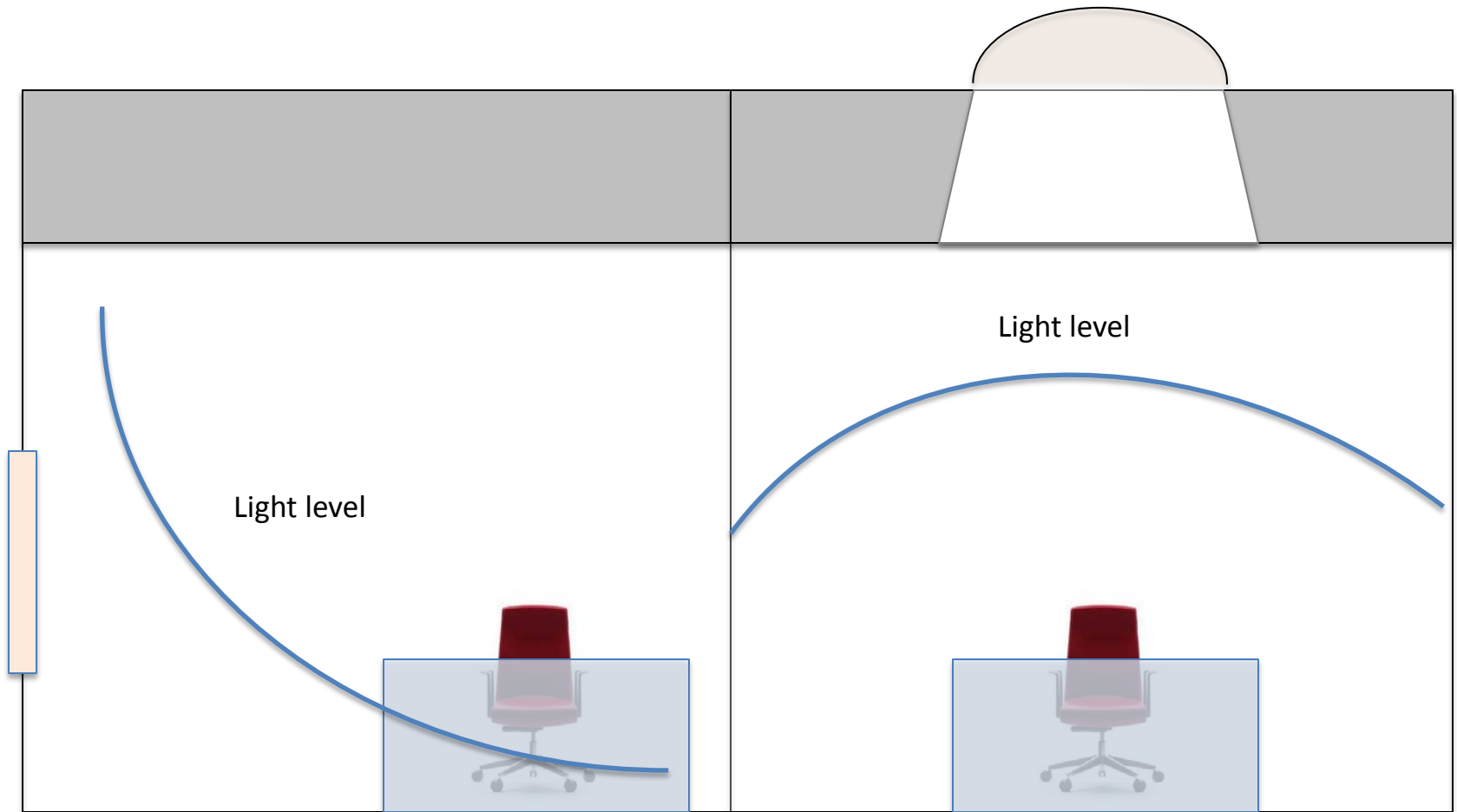


Daylighting 101

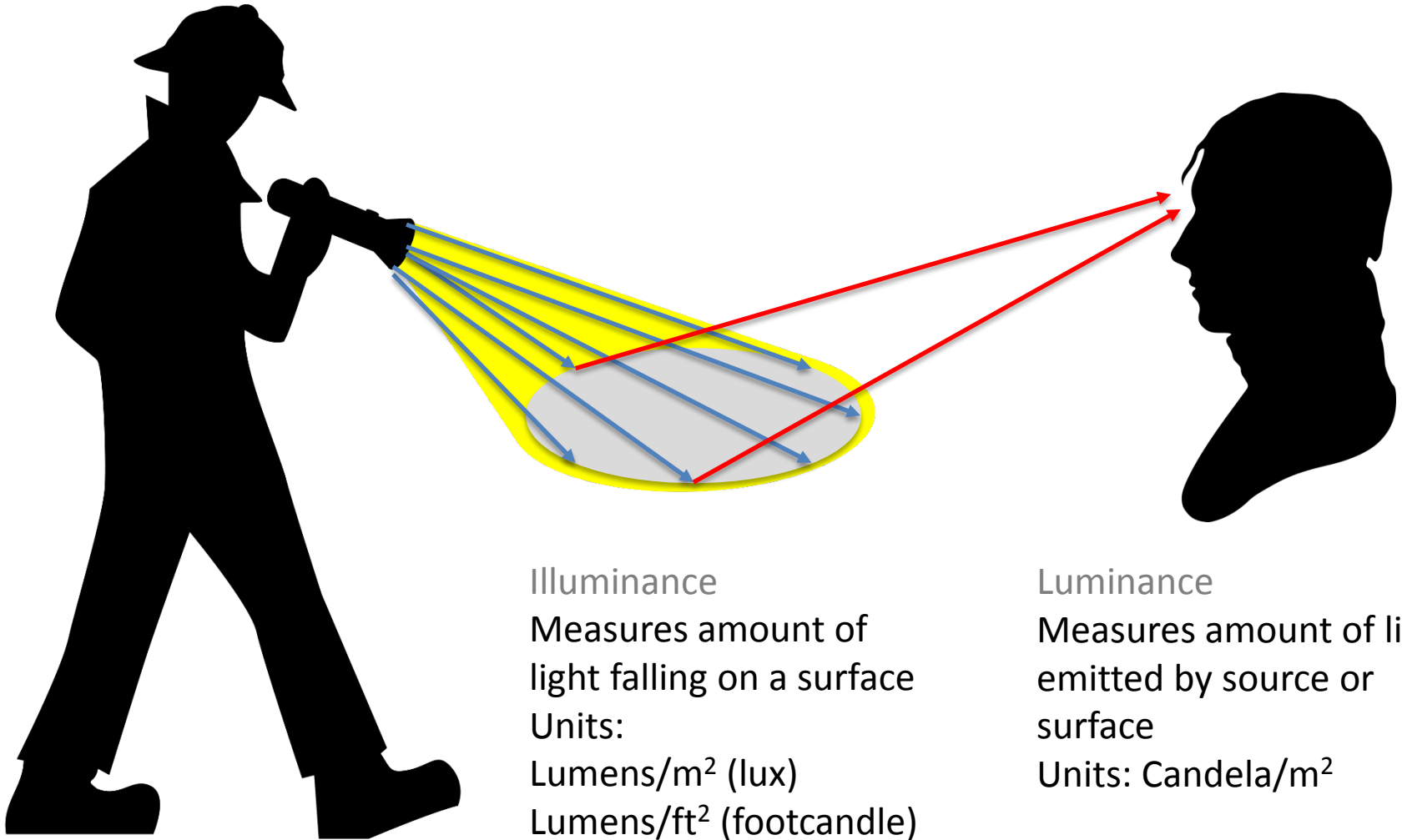
Two ways by which natural light generally enters a space: from the side and from the top

Sidelighting

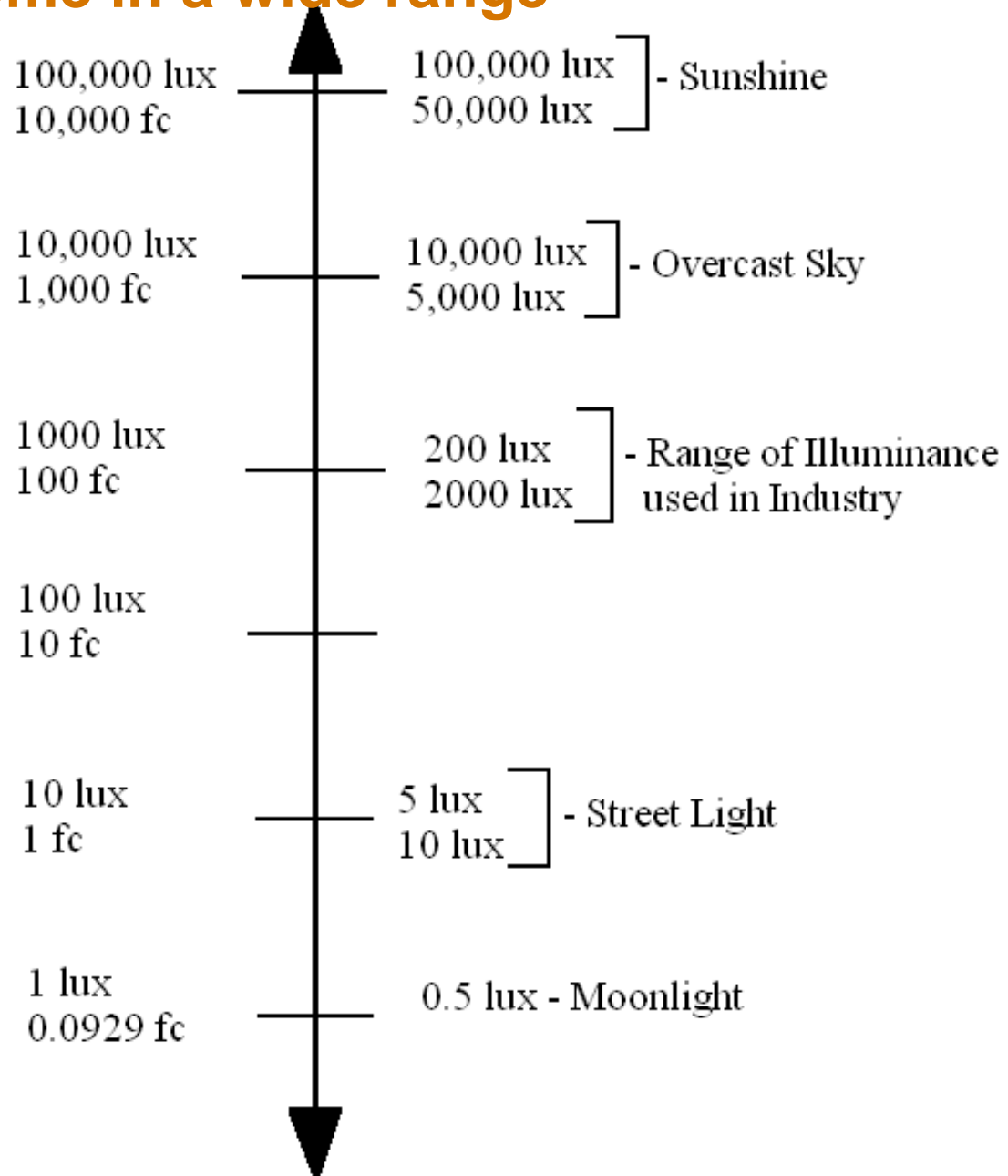
Toplighting



Footcandle and Lux: units of illuminance



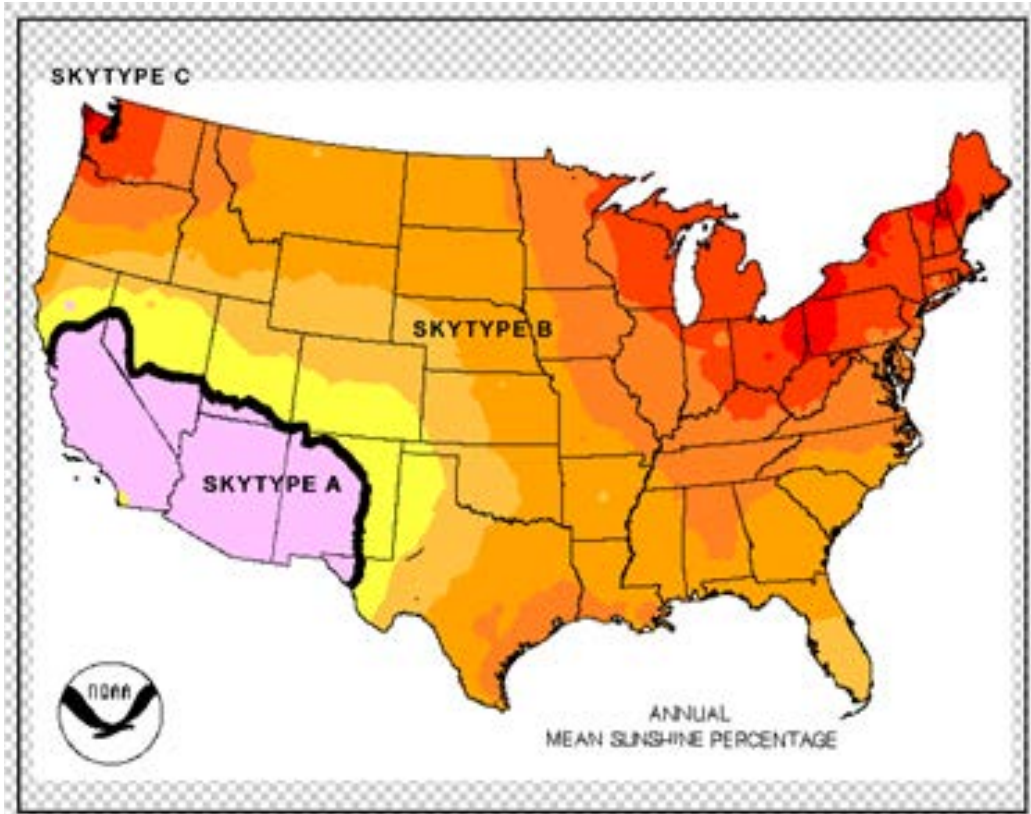
Illuminances come in a wide range



Recommended Illuminance Levels (IES Handbook 1998)

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

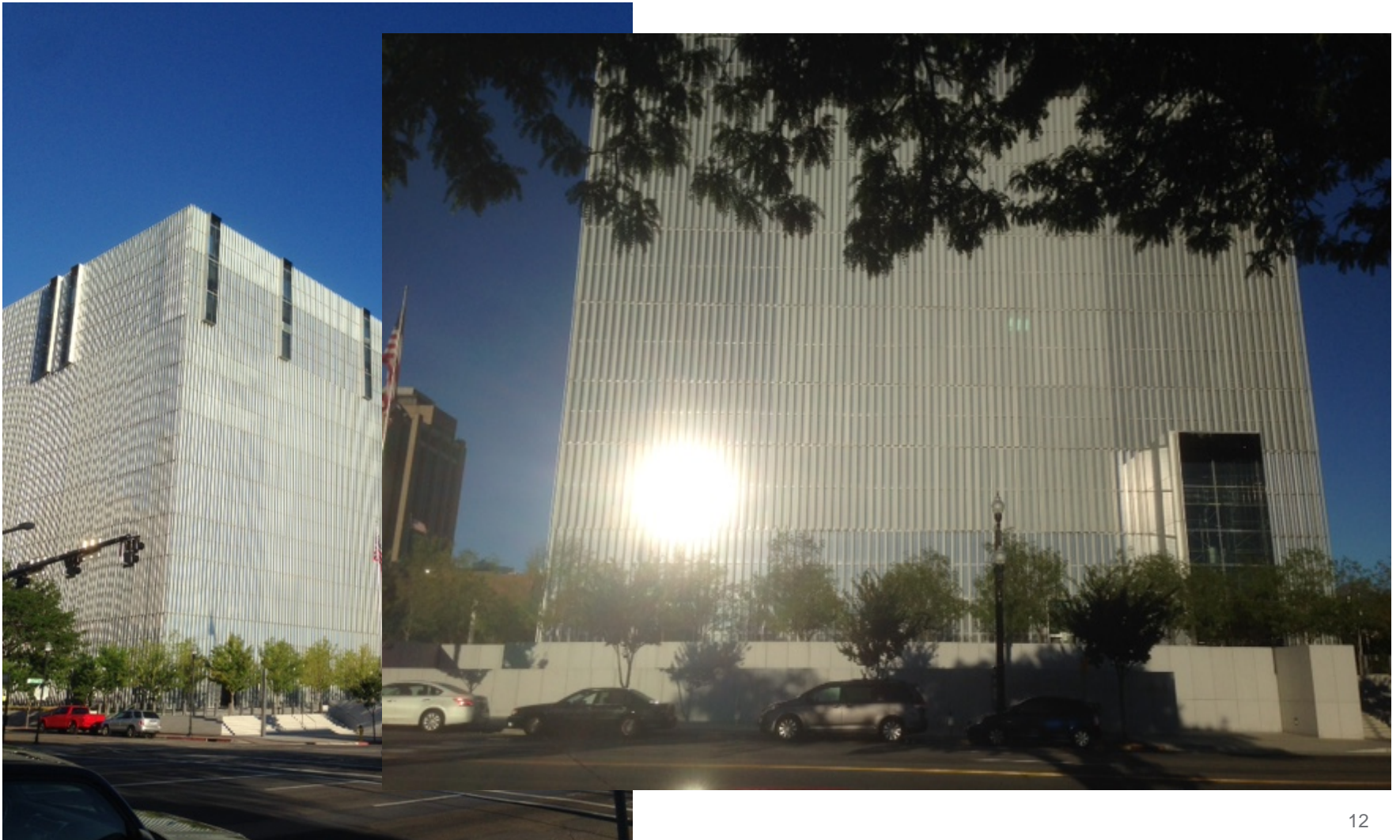
South = variable

East & West = generally bad



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



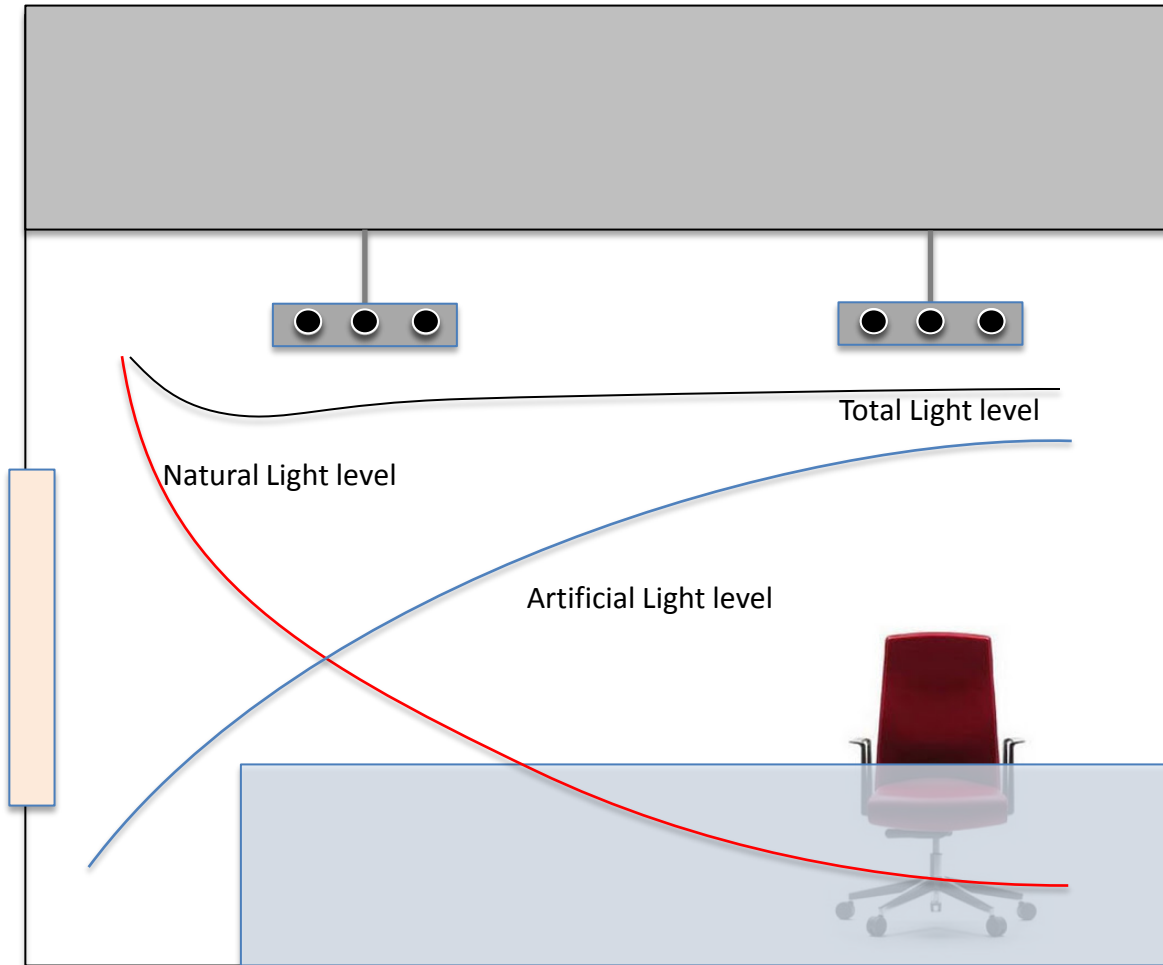
Those pesky humans!



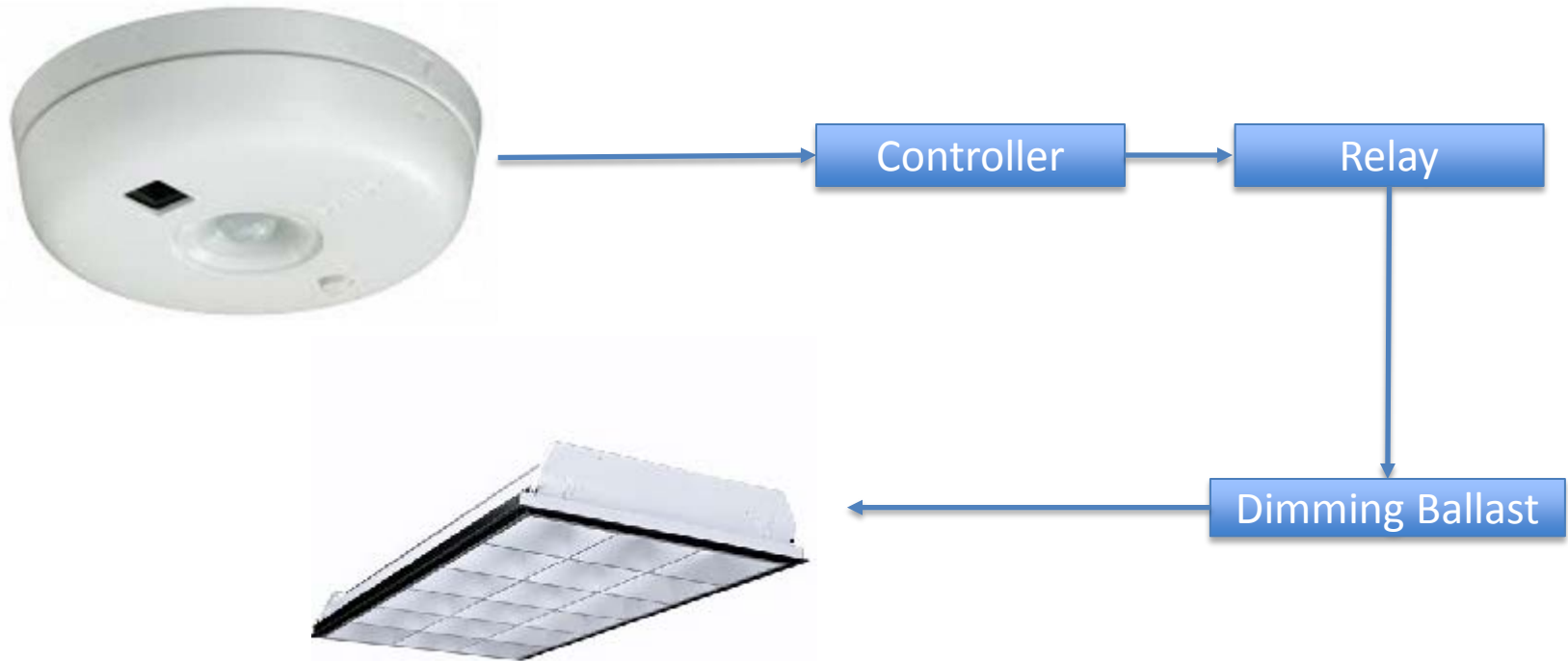


Daylighting Controls

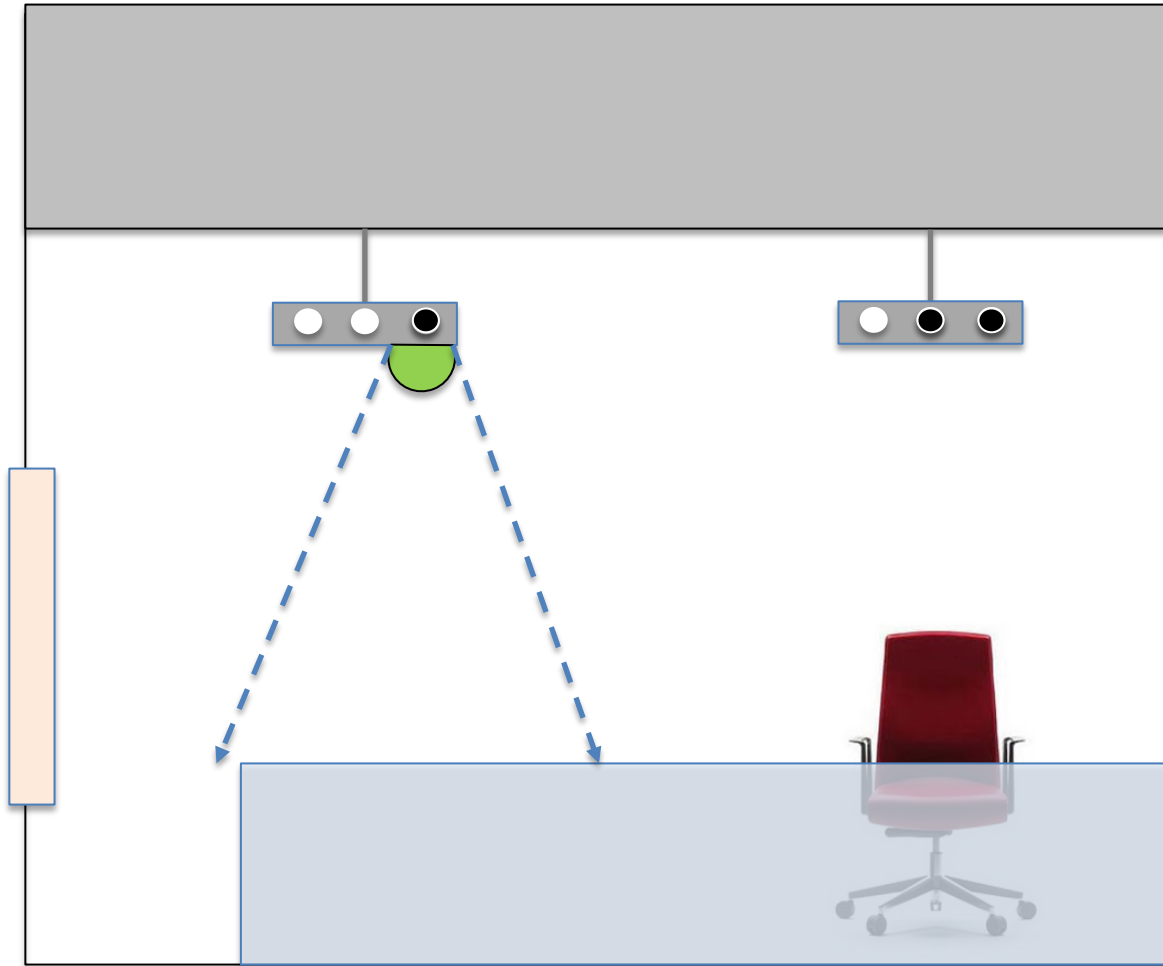
Daylighting controls turn off artificial lighting to save energy



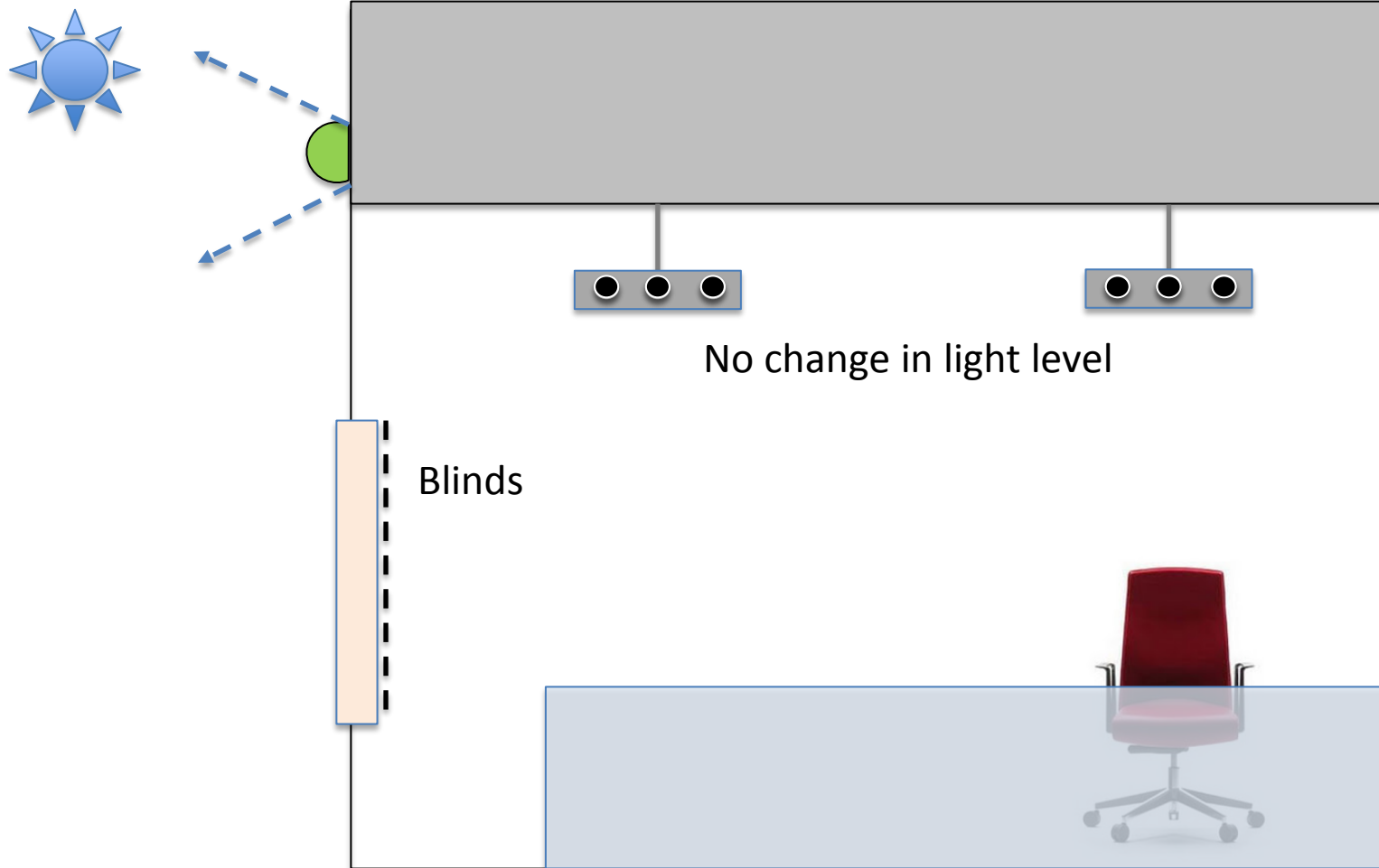
Anatomy of daylighting controls



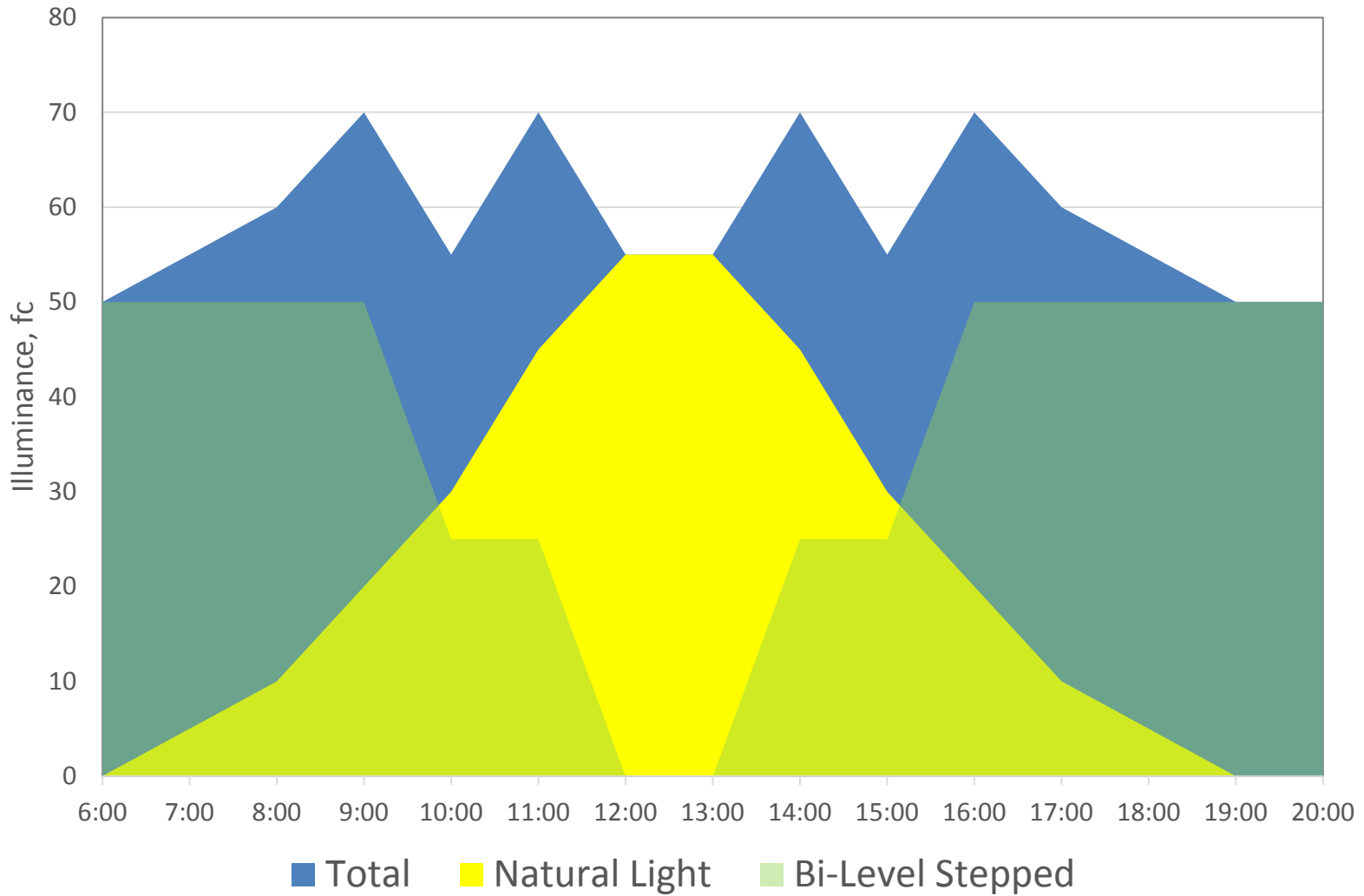
Closed loop controls attempt to keep the illuminance at the sensor constant



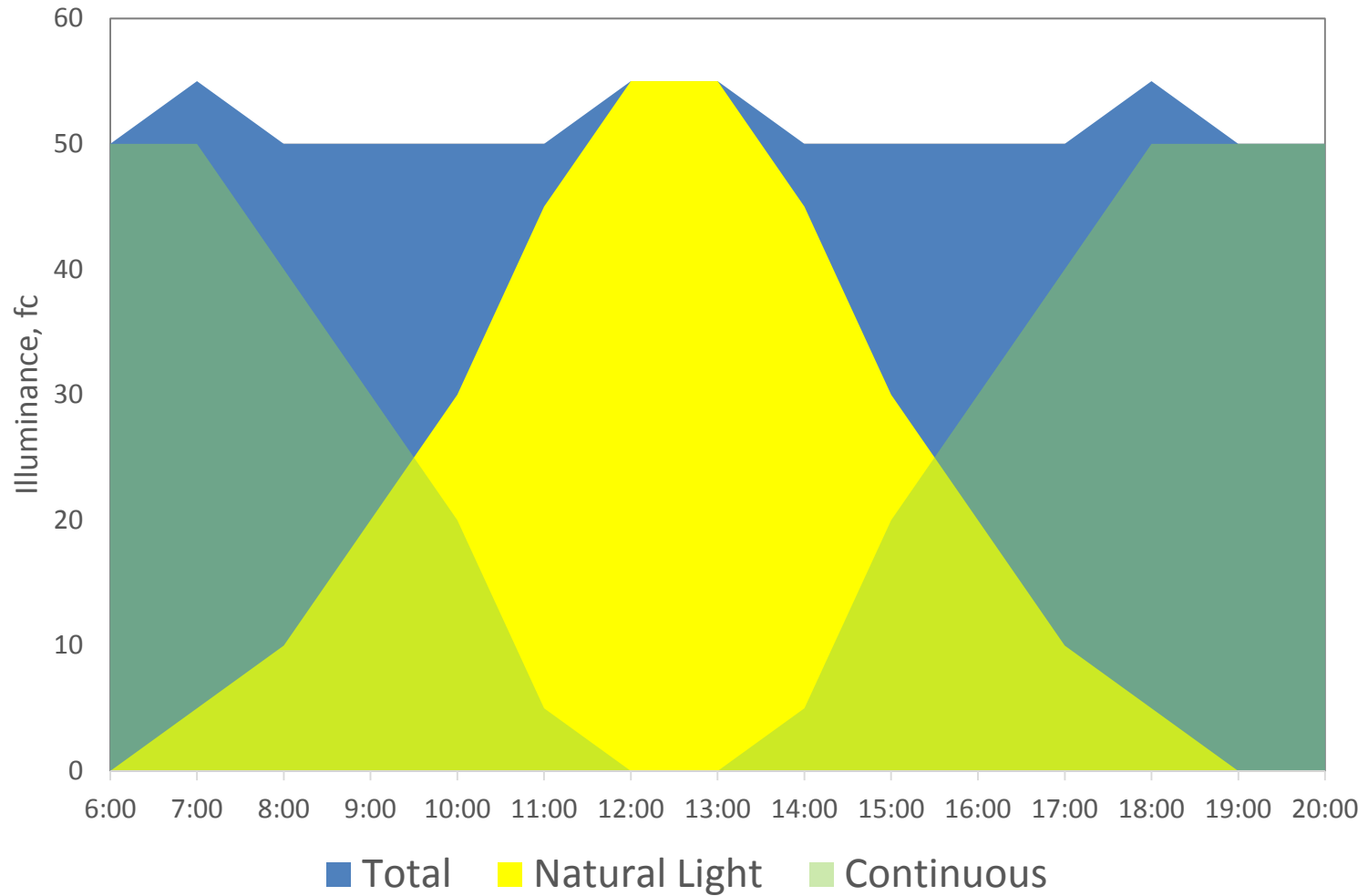
Open loop controls adjust artificial lights in proportion to daylight only



Lights can be dimmed in steps



...or lights can be dimmed continuously



Factors affecting daylight control savings

- ▶ 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

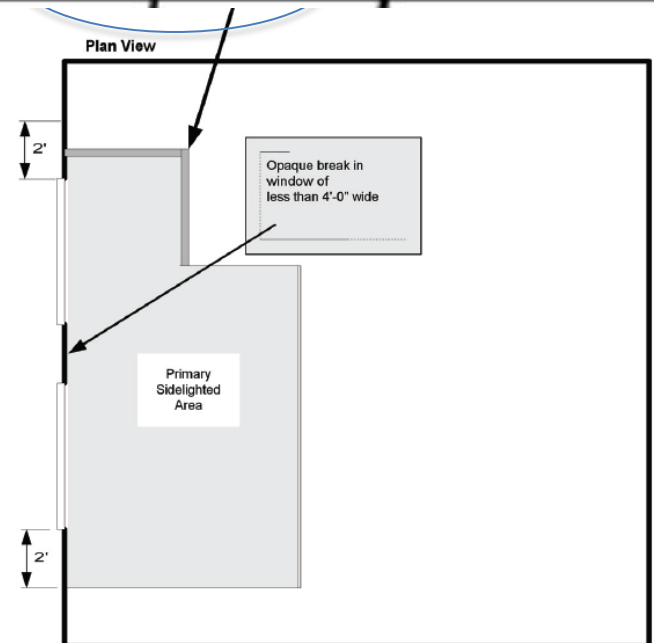
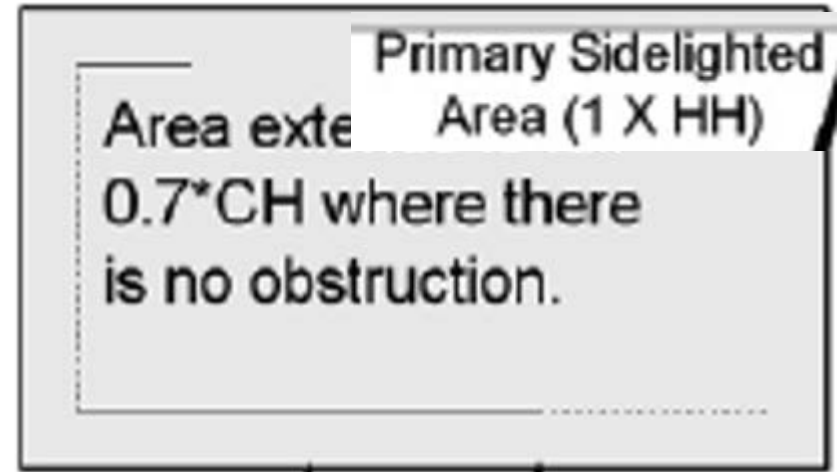
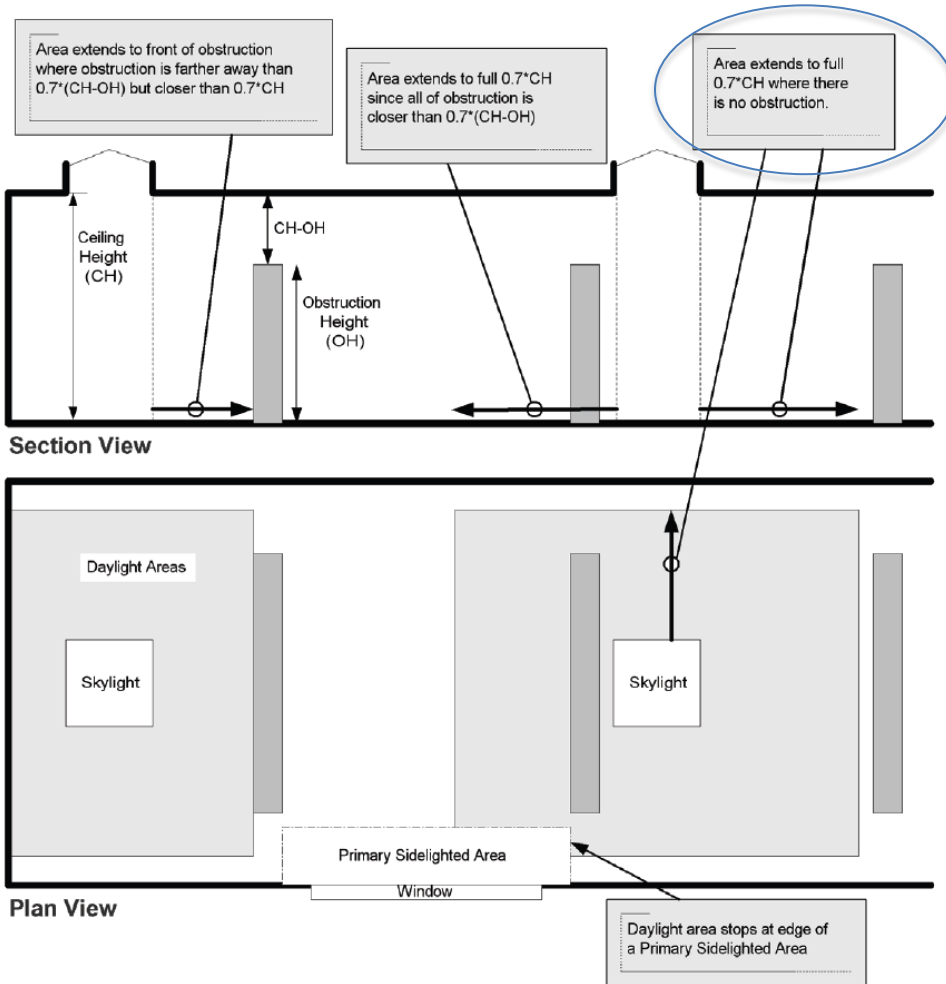
- ▶ Calibration, commissioning, and testing
- ▶ Appropriate sensor location
- ▶ Correct configuration with occupancy sensors
- ▶ Training of owner/maintenance staff and occupants

Daylighting in Codes and Standards

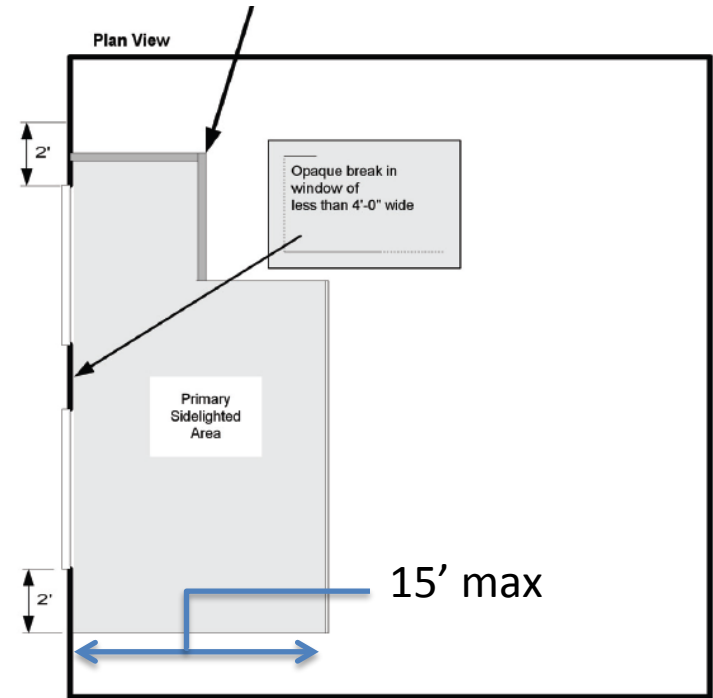
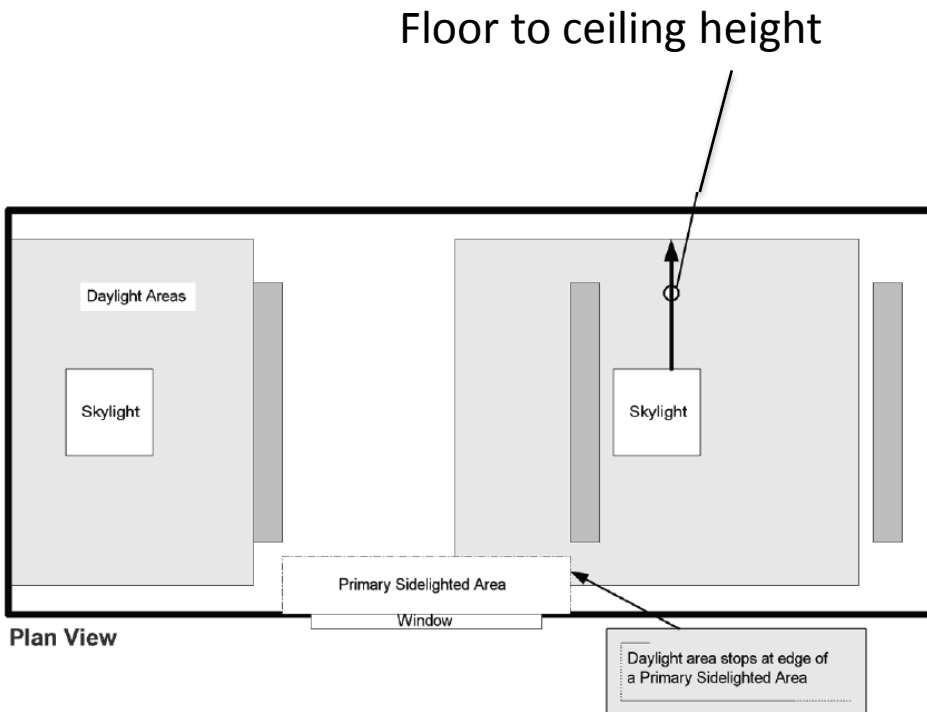
Daylighting and Codes: Watt's new?

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	+++

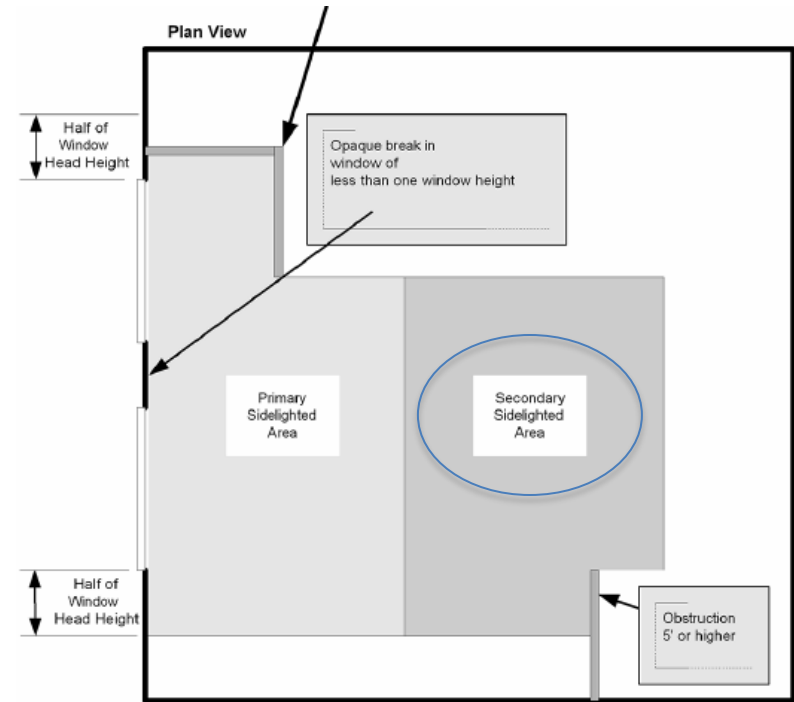
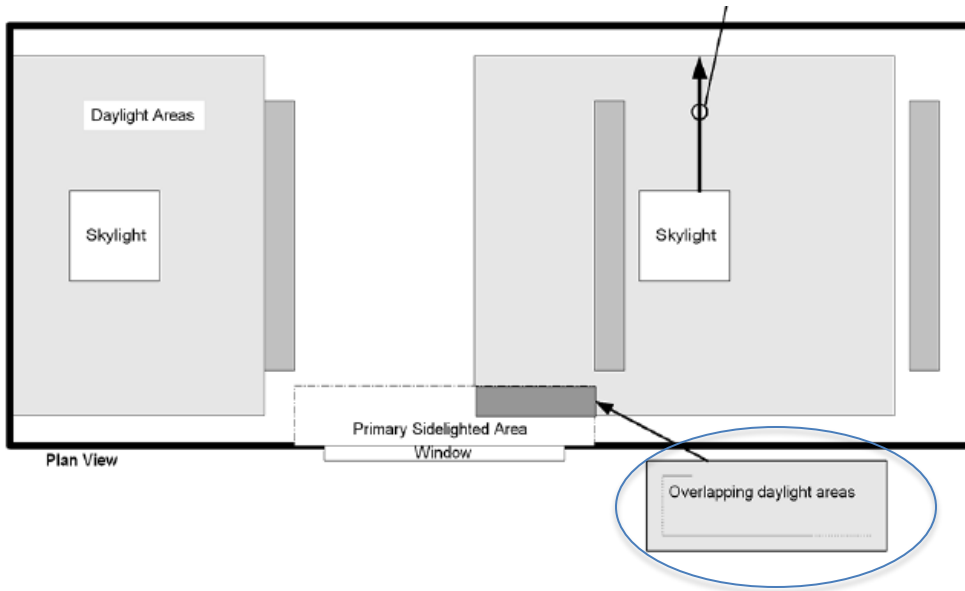
90.1-2010 – Daylight Zone Definitions



IECC 2012 – Daylight Zones Definitions



90.1-2013 Daylight Area Definitions



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Cropped and annotated for this presentation.

Sidelighting Controls

	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 <i>(not required to be controlled)</i>	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 <i>off-step</i>	Stepped, continuous in offices and classrooms

Sidelighting Controls – Exceptions

	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

	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

	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

	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 $\geq 3\%$, $VT \geq 0.40$ OR skylight effective aperture $\geq 1\%$			
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 <i>enclosed space</i> 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

	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

	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 ft² and with effective aperture >0.15, then

$$\text{Additional lighting power allowance} = \text{general lighting power controlled with automatic continuous dimming} \times 0.2 \text{ (control factor from Table 9.6.2)}$$

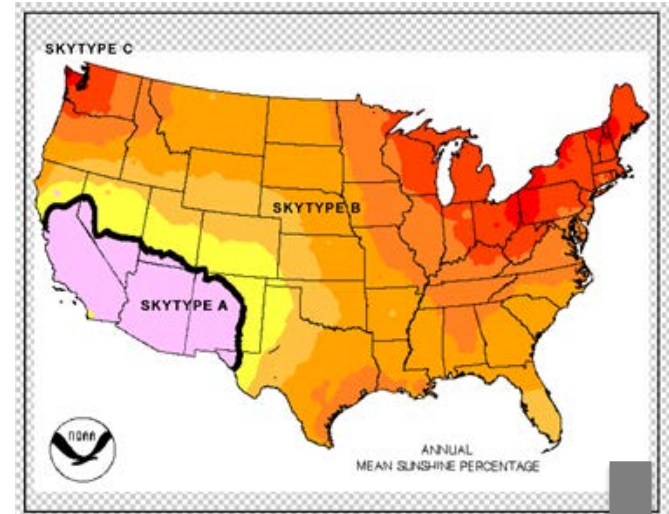
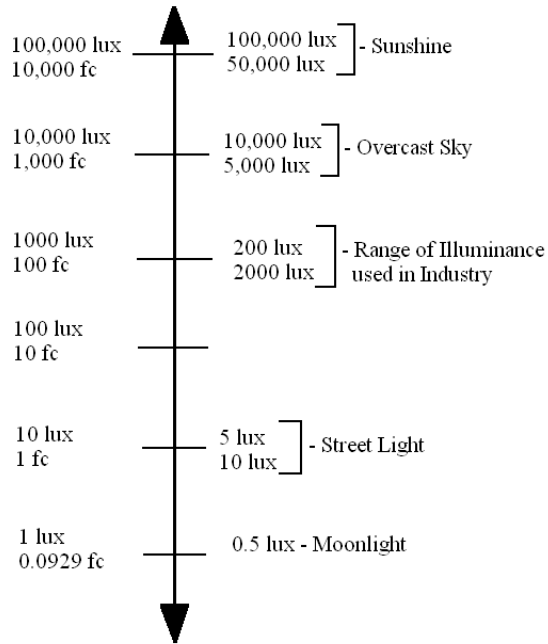
- ▶ 90.1-2013 has only one credit when continuous dimming controls are installed in secondary daylight zones

Summary

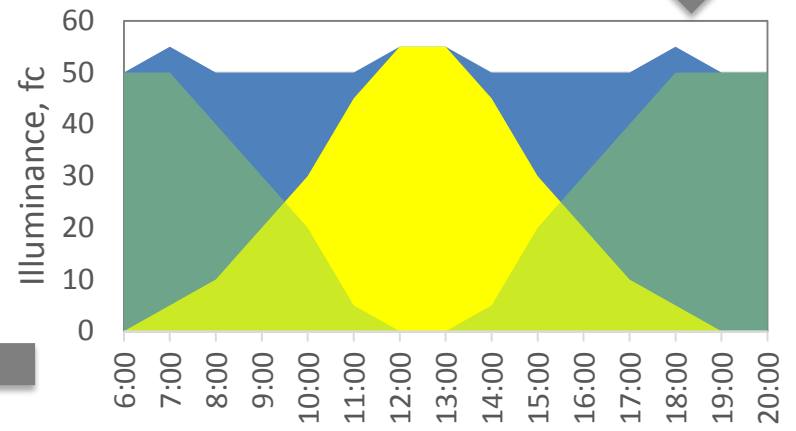


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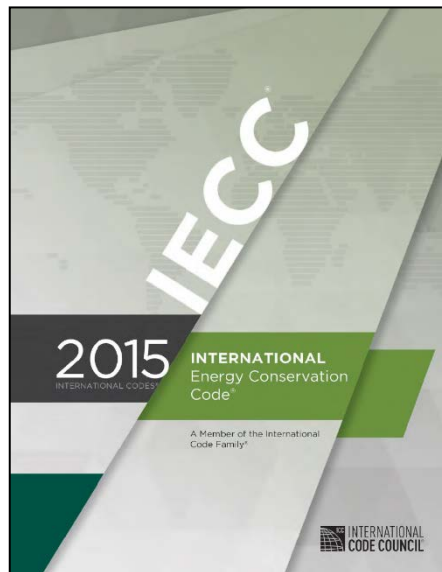
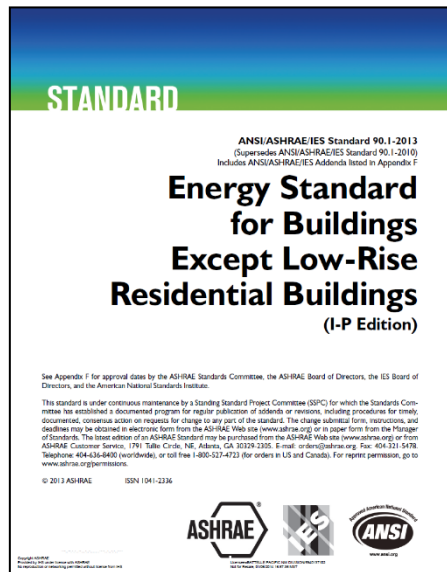
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■ Total ■ Natural Light ■ Continuous



Building Energy Codes Program - Resources



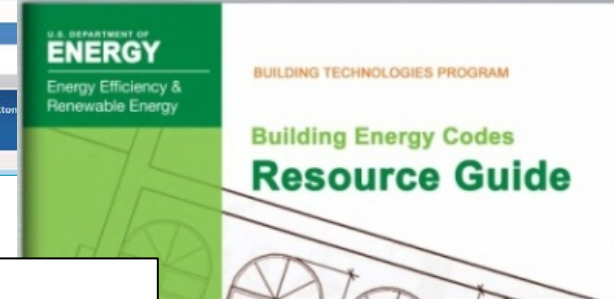
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Row	Component	Assembly	Orientation	Building Area Type	Fenestration Details	Construction Details	Gross Area	Cavity Insulation R-Value	Continuous Insulation R-Value	U-Factor
1	Roof	Insulation Entirely Above Deck		1 - Retail (Nonresidential...			10000 ft ²		38	0.026
2	Ext. Wall	Wood-Framed, 24in. o.c.	North	1 - Retail (Nonresidential...			2600 ft ²	20	10	0.037
3	Window	Vinyl Frame: Fixed								
4	Door	Insulated Metal								



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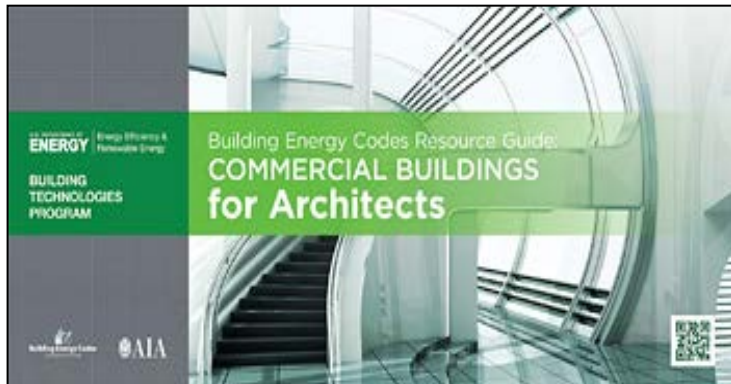
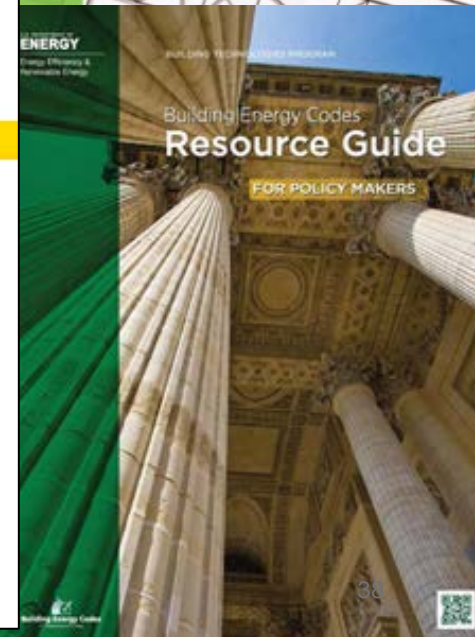
ANSI/ASHRAE/IES Standard 90.1-2010 & 2012 IECC

Insulation Requirements in Commercial Buildings for Mechanical and Service Hot-Water Piping

The intent of the pipe insulation requirements is to reduce temperature changes while fluids are being transported through piping associated with heating, cooling or service hot water (SHW) systems, thereby saving energy and reducing operating costs.

Uninsulated piping systems that transport fluids can create water temperature irregularities, which ultimately requires additional heating or cooling and associated energy costs to bring the water to operating temperature. Any piping that carries heated or cooled water, including piping systems with external heating (e.g., heat trace or impedance heating), should be thermally insulated to reduce heat loss or gain, allowing the fluid to be delivered at the intended temperature.

Any insulated piping in areas exposed to weather is required to be further protected from exposure to sunlight, moisture, and wind—all of which can...



Training Topic Ideas?

► Give us your topic ideas

The screenshot shows the website for the Building Energy Codes Program. The header includes the U.S. Department of Energy logo and navigation links for EERE Home, Programs & Offices, and Consumer Information. The main navigation bar features links for HOME, NEWS, EVENTS, and ABOUT. A search bar is located in the top right corner. The breadcrumb trail reads: DOE » EERE » BTO » BECP » Resource Center. The left sidebar lists various categories: DEVELOPMENT, ADOPTION, COMPLIANCE, REGULATIONS, RESOURCE CENTER (with sub-links for FAQs, TRAINING, PUBLICATIONS, RESOURCE GUIDES, GLOSSARY, and RELATED LINKS), and RELATED LINKS. The main content area is titled "Training" and contains the following text: "The Building Energy Codes Program (BECP) offers a variety of training resources related to the world of energy codes, ranging from overviews to a variety of special topics and tutorials. A list of the most commonly requested materials is included below. Additional resources are also available in the full [Training Catalog](#)." Below this text are three sections: "Topics" with a list of 10 links, "Residential Buildings" with 3 links, and "Commercial Buildings" with 3 links under the heading "ANSI/ASHRAE/IES Standard 90.1:".

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Training

The Building Energy Codes Program (BECP) offers a variety of training resources related to the world of energy codes, ranging from overviews to a variety of special topics and tutorials. A list of the most commonly requested materials is included below. Additional resources are also available in the full [Training Catalog](#).

Topics

- [Codes 101: An Overview of Building Energy Codes](#)
- [Adoption, Compliance & Enforcement \(ACE\) Learning Series](#)
- [Energy Code Compliance Paths: Which is best for you?](#)
- [Achieving and Evaluating Residential Compliance of Tight Envelopes](#)
- [REScheck Basics](#)
- [Lighting Requirements and compliance with the 2015 IECC and ASHRAE 90.1-2013](#)
- [COMcheck Basics](#)
- [2015 IECC – Energy Rating Index \(ERI\) Compliance Alternative](#)
- [Intro to Commercial Building HVAC Systems and Energy Code Requirements](#)
- [Daylighting Controls – New](#)

Residential Buildings

- [2015 International Energy Conservation Code \(IECC\) – New](#)
- [2012 International Energy Conservation Code \(IECC\)](#)
- [2009 International Energy Conservation Code \(IECC\)](#)

Commercial Buildings

ANSI/ASHRAE/IES Standard 90.1:

- [ANSI/ASHRAE/IES Standard 90.1-2013 – New](#)
- [ANSI/ASHRAE/IES Standard 90.1-2010](#)
- [ANSI/ASHRAE/IESNA Standard 90.1-2007](#)

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BECP help desk
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AIA LU's, ICC CEU's and Certificate of Attendance for self-reporting
<https://www.energycodes.gov/Daylighting-credit-request>

