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Energy Code Basics and Lighting Controls

Energy Code Basics and Lighting Controls

Presented By: Legrand HQ
60 Woodlawn Street
West Hartford, CT 06110

Description: Provides an overview of the lighting requirements and provisions of the ASHRAE Standard 90.1-2010 and the 2012 International Energy Conservation Code®, and identifies light control strategies for energy efficiency.

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Energy Code Basics and Lighting Controls

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Learning Objectives

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

- summarize why energy codes are important, what they cover, and what factors are driving the development of future energy codes
- differentiate code compliance methods, and identify primary codes adopted at the national, state, and city level
- discuss lighting control requirements as stated in ASHRAE 90.1-2010 and the 2012 IECC
- discuss lighting control provisions in terms of energy savings, reduced costs, and the design of energy-efficient buildings, and
- describe several light control strategies for particular building spaces to improve building efficiency and meet energy code requirements.

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Energy Codes: Objectives and Benefits

Energy Codes: Why Bother?

Why should we bother to address energy usage in buildings? Our uncertain energy supply (the bulk of the country's energy comes from petroleum-based products) and capacity constraints (the cost and environmental impact to build new power plants) are just a couple of the reasons why it is important to address energy consumption in buildings.

Building energy codes address cost-effective, energy-efficient strategies to reduce energy usage and demand, eliminate inefficient construction practices, and improve our environment and the air we breathe.

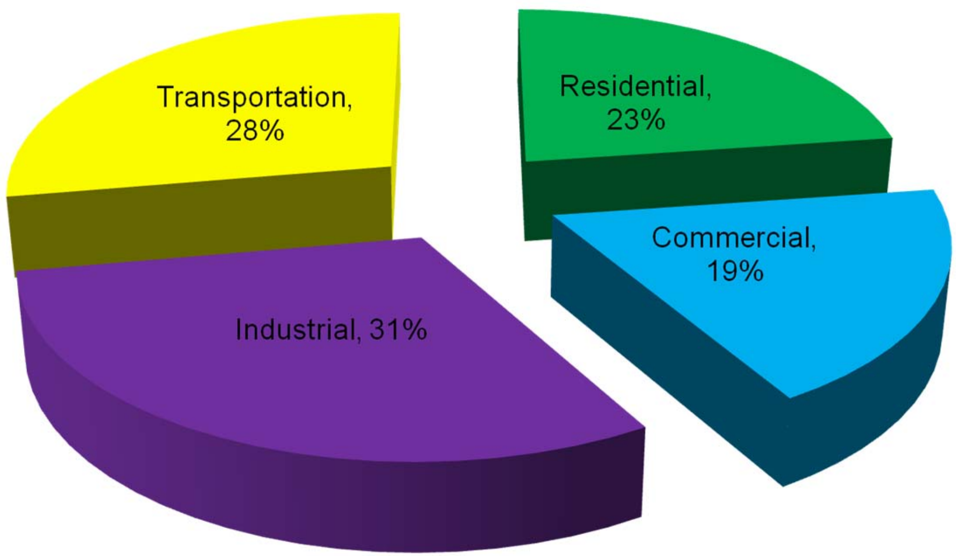
Additionally, various organizations have cropped up over the past several years to tackle the need for sustainable building practices. Examples include the U.S. Green Building Council's (USGBC, www.usgbc.org) LEED® (Leadership in Energy and Environmental Design) green building certification program which focuses on implementing practical and measurable green building design, construction, operations, and maintenance solutions, and the International Dark-Sky Association (IDA, www.darksky.org) which attempts to curb the hazards of light pollution.

United States Energy Use

This chart provides an overview of the breakdown of energy consumption by sector.

Some important energy consumption statistics include:

- nearly 5 million commercial buildings and 115 million residential households in the U.S. consume over 40% of the national energy usage, and
- buildings consume 70% of electricity in the U.S.



Source: U.S. Energy Information Administration. *Annual Energy Review 2010*. U.S. Dept. of Energy.
http://large.stanford.edu/courses/2012/ph241/druzgalski2/docs/aer.pdf

Energy Codes: An Overview

What are building energy codes?

- Energy codes are a subset of building codes.

- Energy codes can vary edition to edition of codes developed by the same authority. The majority of the primary energy codes are on three-year code cycles. This means that as soon as the latest version is approved and published, work begins on the next version.

- Energy codes do not exist to protect building occupants. Building energy codes are minimum requirements for energy-efficient design and construction for new and renovated residential and commercial buildings. Using them does not necessarily equal (what some refer to as) green building.

- Building energy codes are a solid baseline of requirements, and they set the standard by which “above-code” efforts are defined. An example of an above-code effort is the LEED green building certification program.

What Do Building Energy Codes Cover?

What specific parts of buildings do energy codes cover?

They apply to a building's envelope (the materials that make up its outer shell) as well as its systems and built-in equipment.

- Building Envelope
- Mechanical
- Service Water Heating
- Lighting
- Electrical Power

The life cycle of a building is typically decades and can even be centuries long. As minimum energy-use requirements in these vital areas are improved, future generations will benefit from more efficient and less costly living and working environments.

Source: U.S. Department of Energy. Building Energy Codes Program (BECP), www.energycodes.gov

Energy Codes: Individual State Acceptance Levels

There are several different methods used to implement energy codes in various states and jurisdictions.

1. Most states adopt, in entirety, one of the national energy codes.

2. Some states, such as California, develop their own energy codes.

3. Some states adopt one of the national energy codes and then add state-specific amendments to the national codes.

Primary Energy Codes

Here are examples of some major energy codes at the national, state, and city level.

National Energy Codes

- American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE, www.ashrae.org)
    - ASHRAE Standard 90.1 1999, 2001, 2004, 2007, 2010
- International Energy Conservation Code® (IECC®), developed by the International Code Council® (ICC®, www.iccsafe.org)
    - IECC 2003, 2004s, 2006, 2009, 2012

State Codes

- Building Energy Efficiency Standards, California Energy Commission
- Washington State Energy Code (WSEC)

City Codes

- Seattle Energy Code, City of Seattle
- Albuquerque Energy Conservation Code, City of Albuquerque

Energy Code Adoption

Energy code adoption can occur at state or local level in two ways:

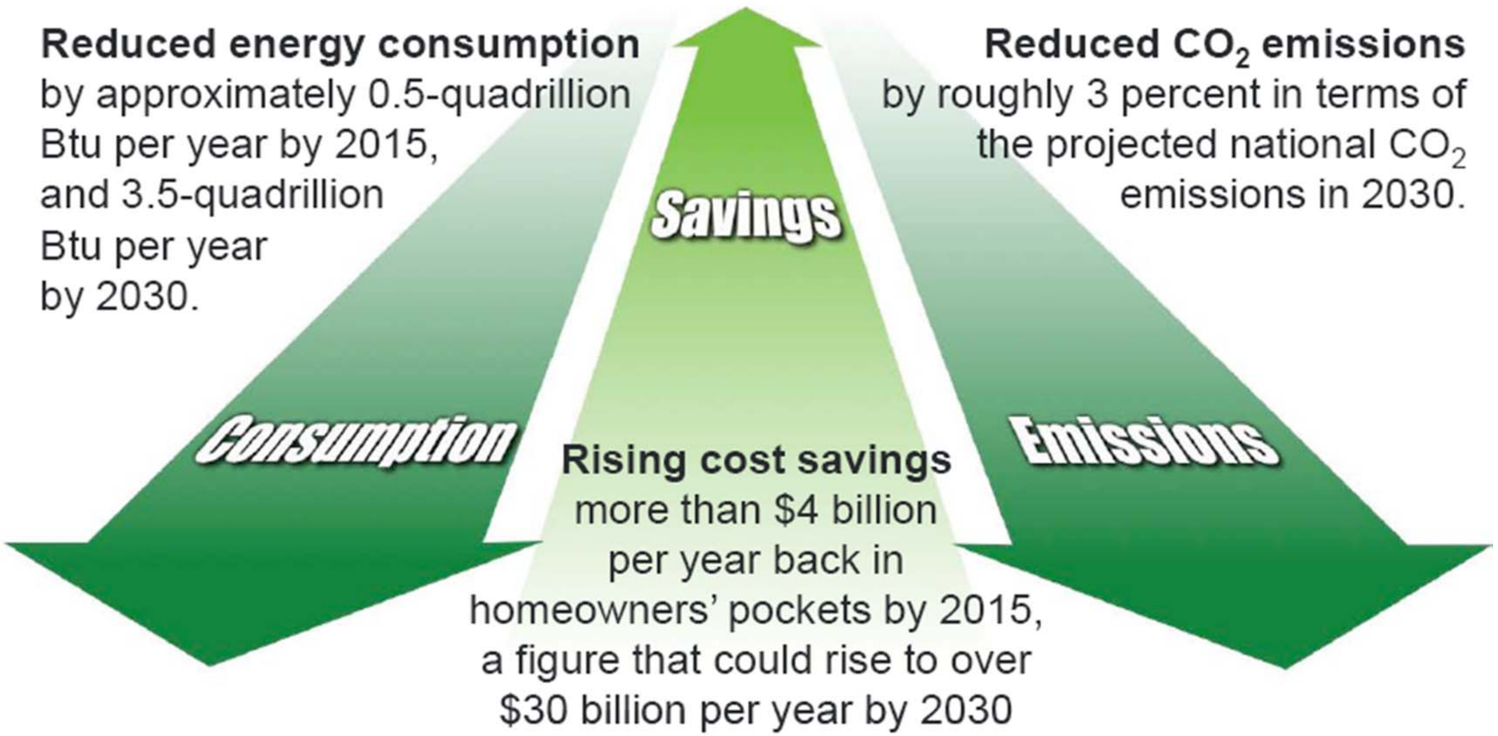
- directly through legislative action (state level), or
- by regulatory action through state or local agencies.

Although there are some variations, generally speaking when a code is adopted through either of the above mentioned methods, the following process is used:

- An advisory board is composed of representatives of the design, building construction and enforcement communities.
- The proposed changes that are put forth by the advisory board undergo a public review process.
- Results of the public review process are incorporated into the code.
- The approving authority (state, local, etc.) reviews the new code, and
- After approval is granted, the code is put into effect usually on a specified future date allowing those affected by the new code to become familiar with the new requirements.

Energy Code Benefits

Building energy codes set minimum efficiency boundaries that bring about vital, tangible benefits. In order to realize the benefits that energy codes offer, it is important that states adopt the latest versions of the code and effectively implement them.

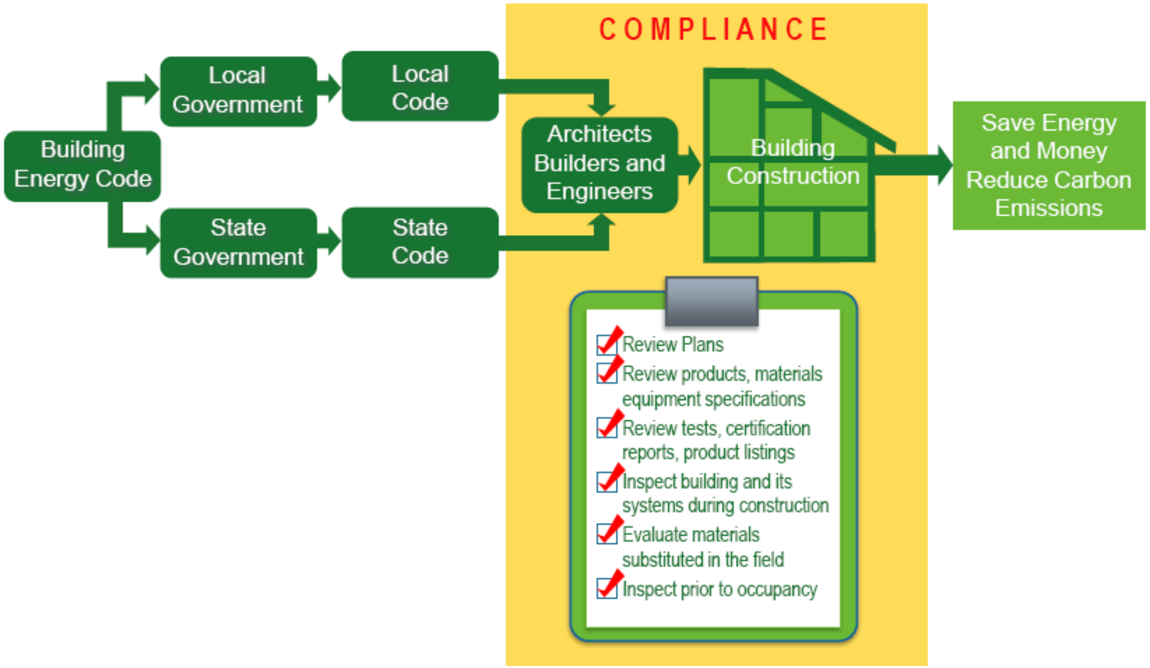


Source: U.S. Department of Energy. Building Energy Codes Program (BECP), www.energycodes.gov

Energy Codes and the Building Process

Enforcement strategies vary according to a state or local government's regulatory authority, resources, and manpower. Commonly they include all or some of the following activities:

- Review of plans
- Review of products, materials, and equipment specifications
- Review of tests, certification reports, and product listings
- Review of supporting calculations
- Inspection of the building and its systems during construction
- Evaluation of materials substituted in the field
- Inspection immediately prior to occupancy



Where Do Energy Codes Come From?

In the United States, national model energy codes were created in response to the energy and economic crises of the 1970s. In 1978, the United States Congress passed legislation requiring states to initiate energy efficiency standards for new buildings. Since then, energy codes have undergone significant improvements.

The Energy Policy Act (EPAct) of 1992 mandated that all states must review and consider adopting the national model energy standard. EPAct of 2005 specified IECC 2004 and ASHRAE 90.1-2004, the most current model energy codes at the time of its passage. Today, ASHRAE Standard 90.1-2010 and the 2012 IECC are the national model energy codes, and each is updated on a three-year cycle.

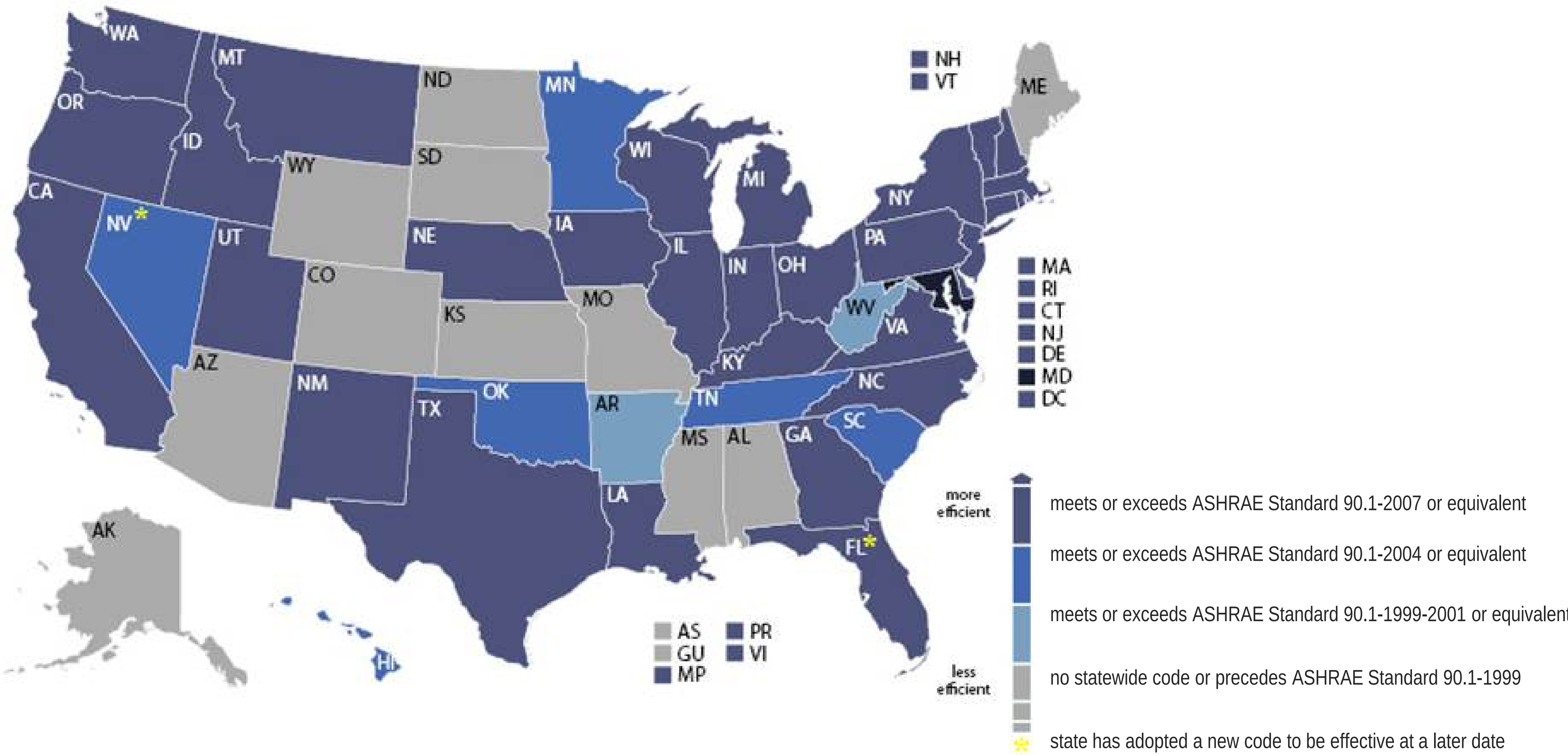
Source: “Energy Codes 101.” *Building Codes Assistance Project.* Online Code Environment & Advocacy Network.
http://bcap-ocean.org/energycodes101

ASHRAE Energy Code Status (Commercial)

Codes are not effective nor enforceable unless adopted by a state or other jurisdiction. On the next slide is a map which shows (as of Feb. 3, 2012) the current ASHRAE (2010) adoption status by each state.

- So far, Maryland is the only state that has adopted the latest version of AHSRAE.
- Most states use 90.1-2007 or equivalent.
- Over 70% of the states have adopted 90.1-1999 or better.
- Many code/standard versions are available, and those currently adopted vary by state.
- Some states have no code or no statewide code but may have a code for a specific jurisdiction within the state.

ASHRAE Energy Code Status (Commercial)



Status as of Feb. 3, 2012
Source: “Code Status: Commercial.” *Building Codes Assistance Project*. Online Code Environment & Advocacy Network.
http://bcap-ocean.org/code-status-commercial

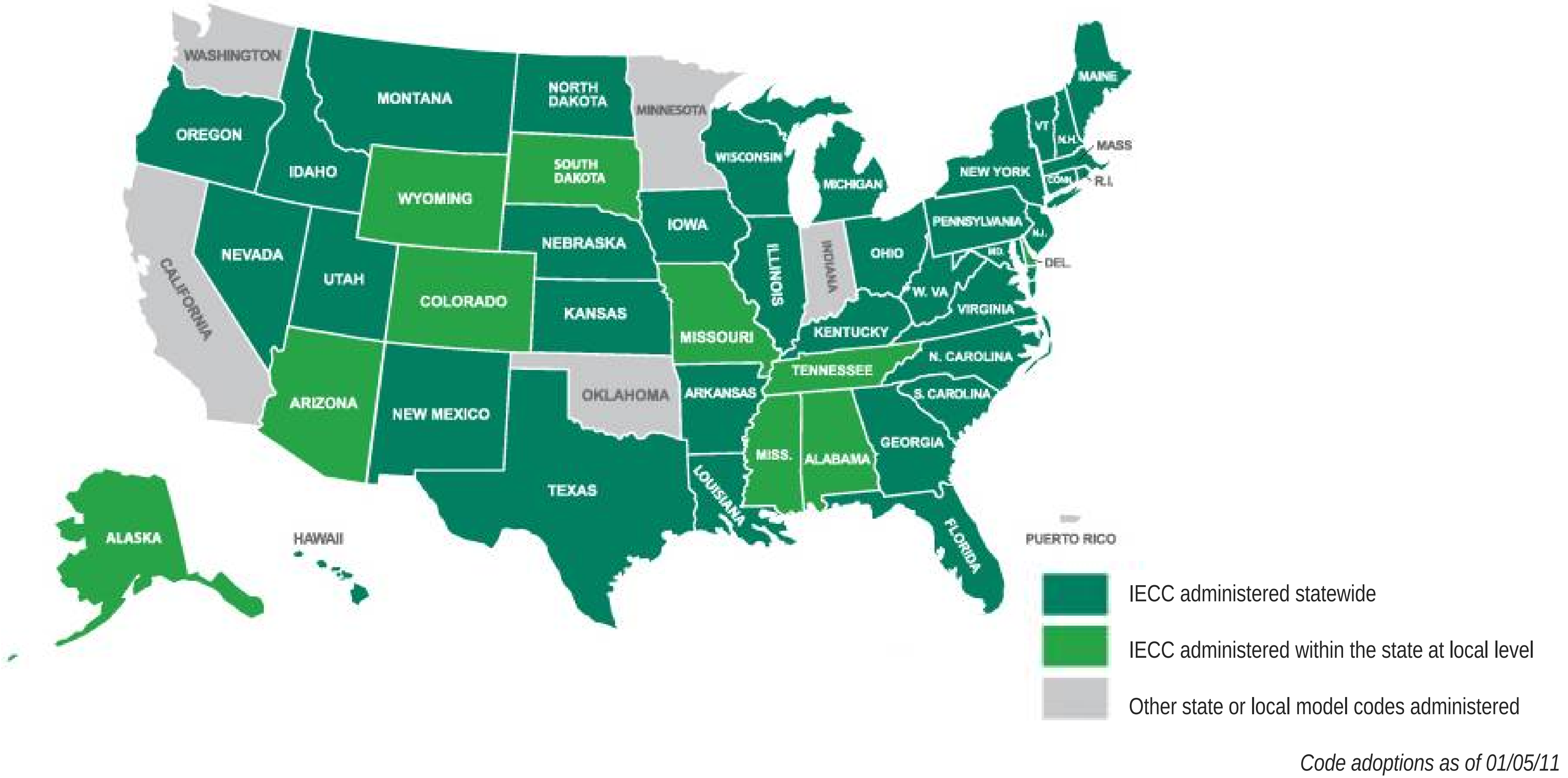
DOE and ASHRAE 90.1-2010

Following compliance with the rulings from the U.S. Department of Energy (DOE) listed below, states are updating their building energy codes. This means that there will be a lot of new mandatory lighting control requirements in place for new construction and major renovations of commercial buildings.

- July 2011 – DOE issued a determination that the ASHRAE 90.1-2007 version saves more energy than 2004 version (3.7%).
    - States have until July 2013 to file certification that their energy code meets or exceeds the 2007 version.
- October 2011 – DOE issued a determination that the 2010 version saves more energy than 2007 version (18.2%).
    - States have until October 2013 to file certification that they have updated their commercial building energy code to meet or exceed ASHRAE 90.1- 2010 by October 18, 2013.
- States can file one certification to address both determinations.

IECC Status

This map shows (as of January 2011) the IECC adoption status by each state.



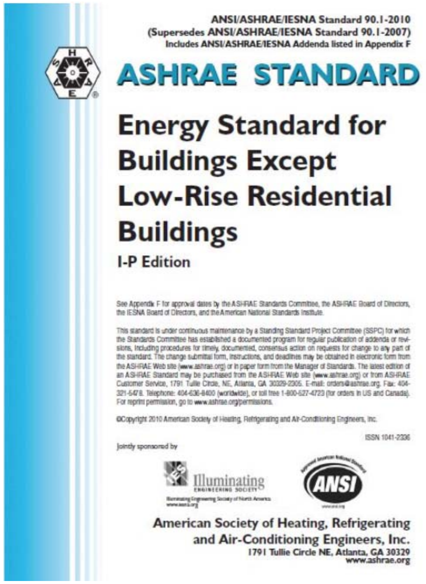
Source: International Code Council®, I-Code Adoptions, www.iccsafe.org/gr/pages/adoptions.aspx

Revisions to Energy Codes

Energy codes are not static documents. They are constantly under revision to improve energy efficiency (savings) in buildings.

The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) partners with the Illuminating Engineering Society of North America (IESNA, www.iesna.org) to produce the 90.1 Standard, which provides the minimum requirements for the energy-efficient design of buildings, excluding low-rise residential buildings.

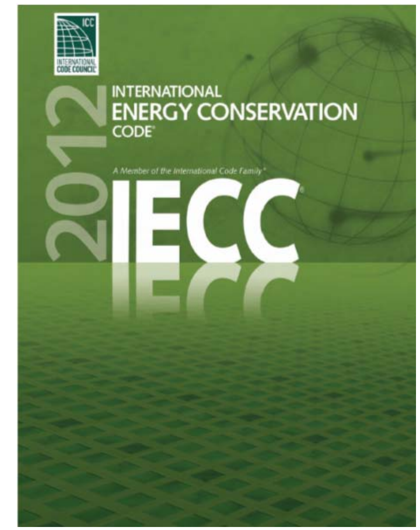
Sometimes referred to as America's primary commercial energy code, ASHRAE Standard 90.1 is published every three years. The 2010 version was released in late 2010. The goal of Standard 90.1-2010 is to use 30% less energy compared to the 2004 edition.



Revisions to Energy Codes

The International Code Council (ICC) released the 2009 version of the IECC early the same year. This energy building code is part of the international "family" of codes produced by the ICC, and was developed through a public hearing process by national experts under the direction of the ICC as a "model" code that can be directly adopted by a state or other jurisdiction.

Like earlier versions, the 2012 version covers lighting in addition to other energy-using systems, and provides minimum energy-efficiency provisions for both residential and commercial buildings. (Note: The IECC references ASHRAE Standard 90.1 as an alternative path of compliance.)



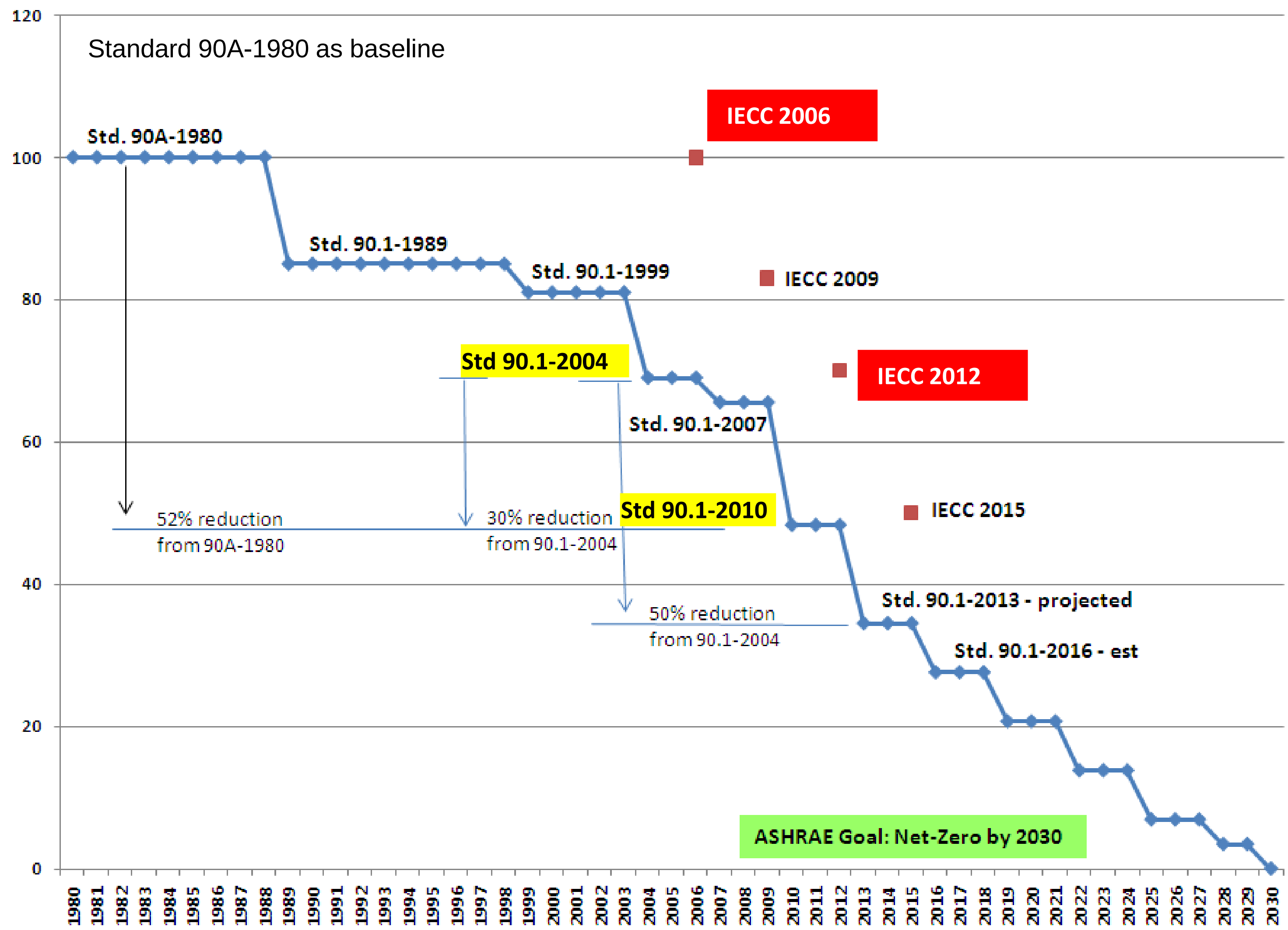
Energy Savings Resulting from Energy Codes

Energy codes existed prior to ASHRAE’s Standard 90.1-1989, but it was not until July 2002 that the DOE ruled that states were required to adopt an energy code at least as “restrictive as ASHRAE standard 90.1-1999.”

According to the DOE, the 2012 IECC will produce approximately 17% in energy-efficiency gains compared to the 2009 edition, and 30% energy savings compared to the 2006 edition.

The graph on the next slide shows the projected energy savings as new energy codes are adopted, moving from one version of the code to the next.

Energy Savings Resulting from Energy Codes



Energy Code Compliance Methods

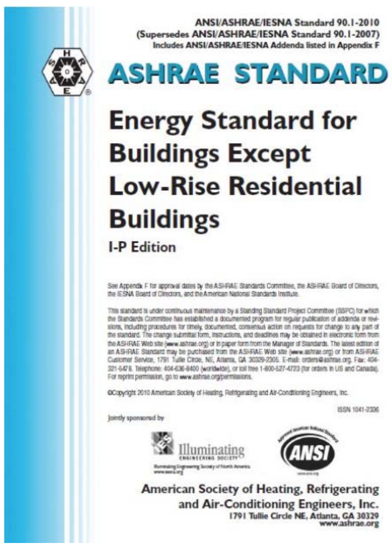
Two different approaches to energy code compliance are a prescriptive method and a performance method. Although the prescriptive method is the most common, in recent years more building projects have been using the performance approach.

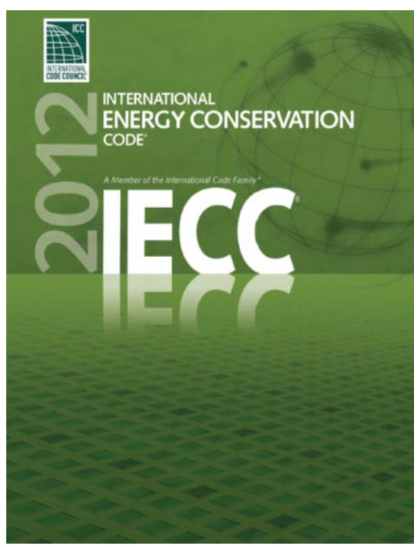
- The prescriptive method requires that a building and its components be built to the prescribed values in the code.
- The performance-based method requires that the building meet a certain energy performance as a whole, rather than assessing the building space by space. The overall energy performance of the structure, and not the individual components, is what matters. A structure is allocated an energy budget, or total allowable energy use, and then uses different combinations of values and efficiencies to meet this budget.

Energy Codes and Lighting Control

Energy Codes and Lighting Control

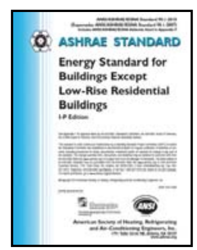
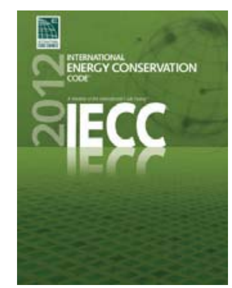
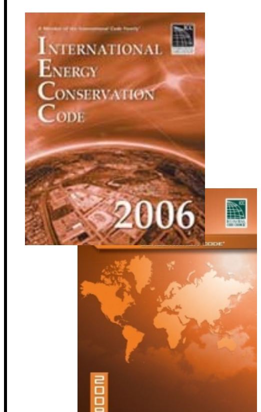
This section of the presentation takes a look at the specific requirements for lighting controls that are contained within ASHRAE 90.1-2010 and the 2012 IECC. Specific details about where and what type of lighting controls are required to meet the code provisions are discussed.





Overview: ASHRAE 90.1 and IECC

This chart references the sections in each of the energy codes that have provisions specific to lighting and plug load control. It is important to note that IECC references ASHRAE as an alternate compliance path, meaning that as long as the building meets the requirements contained within ASHRAE 90.1, it would be considered to be in compliance with IECC, too.

	ASHRAE 90.1		IECC	
	2010	2004/2007	2012	2006/2009
Energy Code				
Power	Section 8			
Lighting	Section 9	Section 9		
Electrical Power & Lighting Systems			Section C405	Section 505

Threshold for Triggering Code Compliance

In the latest version of ASHRAE, a relatively modest lighting upgrade can now trigger code compliance. If a lighting alteration replaces 10% or more of the connected lighting power in a space, then the new lighting systems must comply with the LPD (lighting power density or watts per square feet) and automatic lighting shutoff sections. Previous versions of the code only triggered code compliance on lighting alterations if 50% or more of the connected lighting power was changed.

	ASHRAE 90.1		IECC	
	2010 Section 9.1.2	2004/2007 Section 9.1.2	2012 Section C101.4.3	2006/2009 Section 505.1
New Construction	X	X	X	X
Alterations ≥ 10% of connected lighting load	X			
Alterations ≥ 50% of connected lighting load		X	X	X (2009)

Automatic Lighting Shutoff

Automatic lighting shutoff control is required by both ASHRAE and IECC. The intent of this provision is to eliminate after-hours lighting waste. In ASHRAE, there are three different control methods that can be used to accomplish automatic lighting shutoff, including: control lights on a scheduled basis, occupancy sensors, and signal from another control or alarm system (e.g. BAS).

Requirements

Automatic lighting shutoff control is now required in all interior spaces. Previous versions of the code only required automatic lighting shutoff if the space was greater than 5,000 sq. ft. Override of automatic shutoff is required for no more than two hours. Previous versions of the ASHRAE allowed an override of up to four hours.
Exceptions:

- Lighting for 24-hour operation
- Patient care spaces
- Areas where it would endanger safety or security

Note: The 2012 IECC removed the section devoted to “Automatic Lighting Shutoff” and included it in other sections of the code, requiring either an automatic time switch control device or an occupancy sensor to automatically shut off lighting

Automatic Lighting Shutoff

	ASHRAE 90.1		IECC	
	2010 Section 9.4.1.1	2004/2007 Section 9.4.1.1	2012 Section C405.2.2.1	2006/2009 Section C505.2.2.2
Required in all spaces	X		X	
Required in buildings > 5,000 sq ft		X		X
Scheduled shutoff (time of day)	X	X	X (automatic time switch control device)	X
Occupancy Sensors	X	X	X	X
Signal from another control or alarm system (such as BAS)	X	X		X
Exceptions				
Lighting used for 24 hr operation	X	X	X	
Automatic shutoff endangers safety/security	X	X	X	X
Spaces providing patient care	X	X		X
Sleeping unit				X

Additional Control

New requirements in ASHRAE 90.1 and IECC require lighting in enclosed spaces to be manual-on or auto-on to 50% or less. This is the first time that codes are now specifying the sequence of operation for lighting controls.

In 2005, the CLTC (California Lighting Technology Center) conducted a study comparing three different control strategies in private offices.

- Strategy 1: 100% on while the space was occupied (established the baseline)
- Strategy 2: Manual-on of all lights (user was required to turn on light switch), automatic-off
- Strategy 3: Automatic-on to 50% of the lights (if user wanted additional light, was required to go to the switch to turn on the lights), automatic-off

The study found that Strategy 2 (Manual-on) saved 46% energy when compared to Strategy 1. Strategy 3 (Auto-on 50%) saved 52% energy when compared to Strategy 1. Based on these findings, it is obvious that either a manual-on strategy or auto-on to 50% will save more energy than auto-on to 100%. This helps to demonstrate why the codes are now specifying a particular sequence of operation.

Additional Control

	ASHRAE 90.1		IECC	
	2010 Section 9.4.1	2004/ 2007	2012 Section C405.2.2	2006/ 2009
Controls installed to meet space control, automatic lighting shutoff, and sidelighted daylighting control requirements	Manual-on or auto-on to ≤ 50%		Space Controls = manual device + automatic time switch or occ sensor + daylighting zone control (some enclosed spaces require manual-on or auto-on to ≤ 50%)	
Exceptions				
Public areas (corridors, stairwells, restrooms, primary building entrances, lobbies)	X			
Areas where manual-on operation would endanger the safety/security of the room or building occupants	X			
Sleeping units			X	
Spaces where patient care provided			X	
Spaces where automatic shutoff would endanger occupant safety/security			X	
Lighting intended for continuous operation			X	

Space Control

ASHRAE Section 9.4.1.2 Space Control reads, “Each space enclosed by ceiling height partitions shall have at least one control device to independently control the general lighting within the space. Each manual device shall be readily accessible and located so the occupants can see the controlled lighting.”

ASHRAE allows a switch (dimmer or scene switch) or an occupancy sensor to meet this requirement, whereas to meet IECC’s requirement only a switch is acceptable.

One important item to point out is that if you are using a timeclock for automatic lighting shutoff, the space controls must be connected to the timeclock to allow for an override of no more than two hours. In other words, a stand-alone wall control like an on/off toggle switch will not comply. The switch must be tied to the timeclock to allow for a maximum two-hour automatic lighting shutoff override.

Space Control

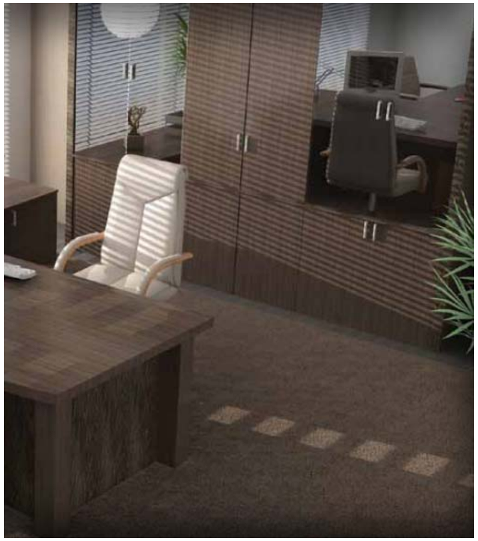
	ASHRAE 90.1		IECC	
	2010 Section 9.4.1.2	2004/2007 Section 9.4.1.2	2012 Section C405.2.1.1	2006/2009 Section 505.2.1
At least one control device needs to independently control the general lighting in enclosed spaces	X (switch or occ sensor)	X (switch or occ sensor)	X (switch)	X (switch)
Exceptions				
Areas designated as security or emergency areas required to be continuously lighted			X	
Egress lighting in stairways or corridors			X	

Space Control

The spaces identified on the next slide require a certain type of control to meet the space control provision.

ASHRAE exceptions include: spaces with multi-scene control systems, shop and laboratory classrooms, spaces where automatic shutoff would endanger the safety or security of occupants, and spaces where lighting is required for 24-hour operation.

Keep in mind that both ASHRAE and IECC specify that when using an occupancy sensor in these spaces, it must be configured to manual-on or auto-on to 50% or less.



Space Control

	ASHRAE 90.1		IECC	
	2010 Section 9.4.1.2	2004/2007 Section 9.4.1.2	2012 Section C405.2.2.2	2006/2009
Must turn lighting off automatically within 30 minutes after last occupant leaves in the following spaces:	X (time switch or occ sensor)	X	X (occ sensor manual-on or auto-on to ≤ 50%)	
Classrooms	X	X	X	
Lecture halls	X			
Conference and meeting rooms	X	X	X	
Training rooms	X			
Employee lunch and break rooms	X	X	X	
Storage and supply rooms	X (between 50-1000 sq ft)		X	
Janitorial closet			X	
All spaces ≤ 300 sq ft enclosed by ceiling height partitions			X	
Rooms used for document copying and printing	X		X	
Offices	X (≤ 250 sq ft)		X	
Restrooms	X		X (100% auto-on allowed)	
Dressing, locker, and fitting rooms	X			

Occupancy Sensors: Energy Savings

Previous slides identified where occupancy sensors are required by code. The following slides take a look at the financial benefits of installing occupancy sensors.

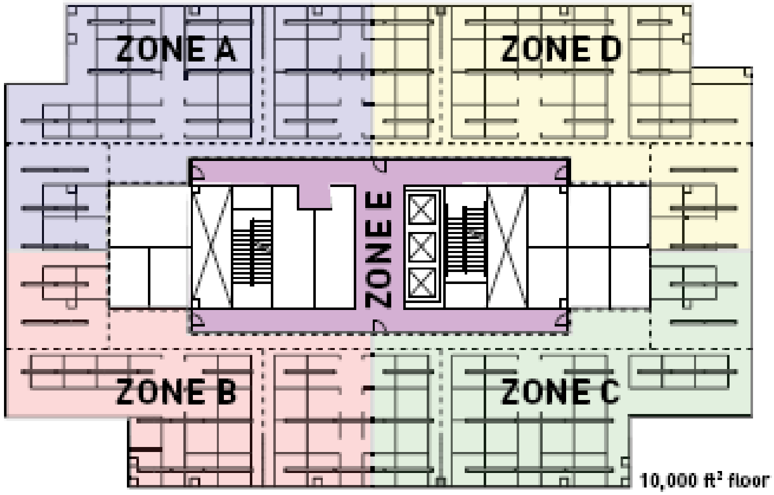
Occupancy sensor solutions are cost effective and have an attractive return on investment (ROI). These examples provide an indication of the type of costs and returns that investors should expect from occupancy sensors. Note that each application may use different technologies and will therefore have different energy savings, as documented by independent research from organizations such as the Lighting Research Center (see below).

Application	Cost/sq. ft.	Energy Savings	Annual ROI
Break room	$0.34	17%	32%
Classroom	$0.34	52%	323%
Conference room	$0.51	39%	44%
Private office	$0.42	28%	112%
Restroom	$0.45	47%	55%

Source: Maniccia, D., A. Bierman, A. Tweed, B. Von Neida, JIES 2001. Von Neida, B., D. Maniccia, A. Tweed, JIES 2001.
* For complete reference see slide 79

Occupancy Sensors: Maximum Control Zones

Both of the energy codes have certain requirements for the maximum size of the control zone. In addition to the requirements listed below, IECC extends the maximum control zone to 20,000 sq. ft. for single tenant retail spaces, industrial facilities, arenas, malls, arcades, and auditoriums. The override time can exceed two hours for these same spaces. ASHRAE 90.1-2010 reduced the allowed override time from four hours to two hours in the latest version.



	ASHRAE 90.1		IECC	
	2010 Section 9.4.1.2	2004/2007 Section 9.4.1.2	2012 Section C405.2.2.1	2006/2009 Section 505.2.2.2.1
Max control zone	2500 sq ft for spaces 10,000 sq ft or less OR 10,000 sq ft for spaces greater than 10,000 sq ft	2500 sq ft for spaces 10,000 sq ft or less OR 10,000 sq ft for spaces greater than 10,000 sq ft	5,000 sq ft	5,000 sq ft
Max override time	2 hrs (time-of-day schedule)	4 hrs (time-of-day schedule)	2 hrs	2 hrs

Occupancy Sensors: Best Applications

Occupancy sensors are typically implemented in high usage areas with irregular schedules. For example, in private offices where the occupant is going to and from meetings, an occupancy sensor will ensure that the lights are on while the space is occupied, and off while the space is unoccupied. With a variety of different options including corner, ceiling, and wall-mounted sensors, occupancy sensors are a cost-effective method for implementing lighting controls that will ensure code compliance.

Occupancy sensors are ideal for high usage areas with irregular schedules.

- Private offices
- Classrooms
- Conference rooms
- Lunch/break rooms
- Restrooms

Benefits

- Increased energy savings above scheduling strategies
- Simple to set up
- Cost effective

Time Switches: Best Applications

Time switches are beneficial for areas where an occupancy sensor will not have a very good view of the entire space. They are ideal for applications such as storage and supply closets since these spaces usually have shelving or other obstructions that block the sensor's view.

With a time switch, users can set the time for how long they need the lights to be on and have the lights turn off automatically when they are finished. Time switches are an inexpensive, easy to install, code-compliant solution.

Time switches are ideal for limited usage areas.

- Supply/storage closets
- Outdoor sports facilities

Benefits

- Inexpensive
- Manual activation with automatic-off

Light Level Reduction

Light level reduction allows building occupants to moderate light levels to save energy.

There are several different control strategies that meet this requirement, including: continuous dimming of all luminaires; dual switching in a uniform patter across the ceiling grid; or, for three-lamp fixtures, switching the middle lamps independently from the outer lamps. It is also possible to control each luminaire or each lamp.

IECC Key Exception:

- In areas with lighting controlled by an occupancy sensor, it is not necessary to meet the light level reduction requirement.

Light Level Reduction

	ASHRAE 90.1		IECC	
	2010 Section 9.4.1.2	2004/2007	2012 Section C405.2.1.2	2006/2009 Section 505.2.2.1
Enclosed spaces have uniform light level reduction of connected lighting load	X (30-70%)		X (50%)	X (50%)
Exceptions				
Spaces with only one luminaire	X (<100W)		X (<100W)	X
Areas controlled by occupancy sensor			X	X
Corridors, storerooms, restrooms, & public libraries	X		X	X
Equipment rooms, electrical & mechanical rooms	X (electrical/ mechanical)		X	
Sleeping units			X	X
Space with LPD	<0.6W/sq ft		<0.6W/sq ft	<0.6W/sq ft
Daylit spaces with automatic daylighting control			X	

Lighting Control in Daylit Zones

In the 2010 version, ASHRAE incorporates daylighting control for the first time. The daylighting provision in ASHRAE is more stringent than that of IECC.

ASHRAE requires automatic daylighting controls in skylit and sidelit spaces of a certain size. These daylighting controls must be multi-level, meaning that there is one control step between 50–70% of the design lighting power, and a second control step that is less than or equal to 35% of the design lighting power.

The previous version of IECC (2009) had some daylighting control requirements. The latest version of the code (2012) extends these requirements. IECC allows for manual daylighting control. Essentially this means that a manual switch that controls the lighting in the daylit zone separately from the general lighting would comply with the daylighting provisions. However, once the fenestration area and skylight area reach a certain size, then IECC also requires automatic daylighting controls. Just like ASHRAE, these controls must be multi-level (continuous dimming is also allowed).

Lighting Control in Daylit Zones

	ASHRAE 90.1		IECC	
	2010 Section 9.4.1.4 & 9.4.1.5	2004/ 2007	2012 Section C405.2.2.3 & C402.3	2006/2009 Section 505.2.2.3
Threshold for triggering daylit zone requirements (lighting in daylit zones in enclosed spaces must be controlled separately from general lighting in the space)	Sidelit: ≥ 250 sq ft; skylit: > 900 sq ft		Sidelit & skylit w/ > 2 fixtures	Sidelit & skylit w/ > 2 fixtures (2009)
Exception				
Retail spaces	X			
Manual daylighting requirements			Triggered based on fenestration and skylight area	
Threshold for triggering automatic daylight control requirements	Same as above		Triggered based on **increased** fenestration and skylight area	
Automatic daylighting controls must be multi-level	X (one control step b/w 50-70% design power and second control step ≤ 35%)		X (continuous dimming to < 35% or stepped dimming with one control step b/w 50-70% design power and second control step ≤ 35%	
Separate switching of sidelit and skylit daylit zones			When skylight is > 15' from the perimeter	When skylight is > 15' from the perimeter (2009)

Lighting Control in Daylit Zones

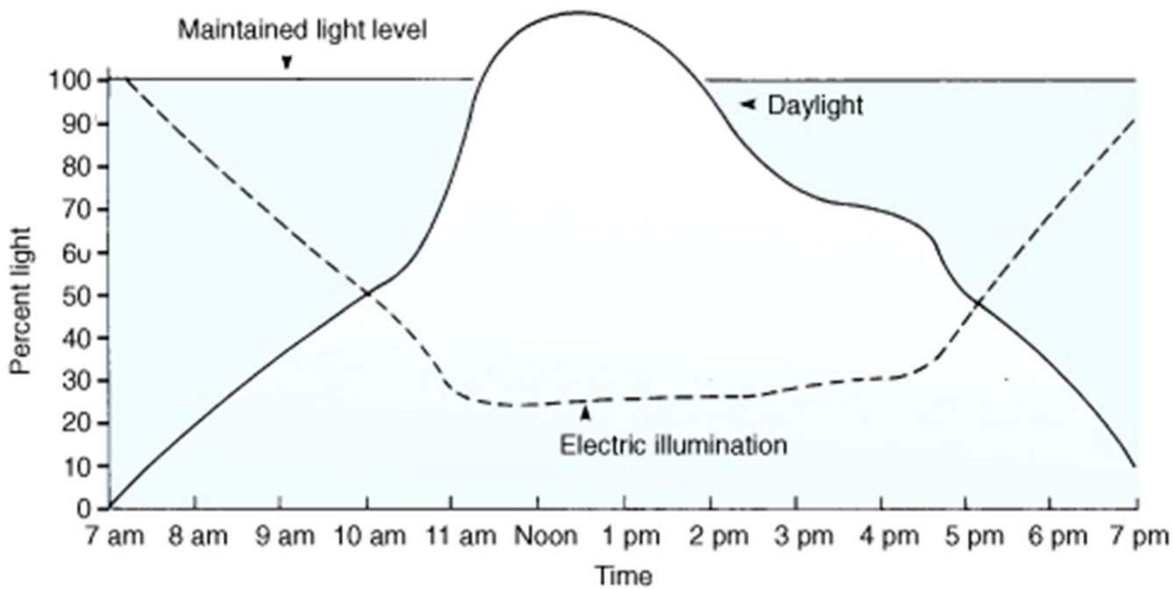
This chart lists some of the additional requirements specific to daylighting controls.

- Multi-level – continuous dimming or control step b/w 50–70% and second step < 35%
- IECC – daylit zone can not exceed 2500 sq. ft.
- Light sensor must be remote from where calibration adjustments are made

	ASHRAE 90.1		IECC	
	2010	2004/ 2007	2012 Section C405.2.2.3	2006/ 2009
Daylight control zone cannot exceed 2500 sq ft			X	
One control device can control contiguous daylight zones adjacent to vertical fenestration when the zone includes ≤ 2 adjacent orientations (north, south, east, west)			X	X (2009)
Skylit areas require at least one multi-level lighting control that controls the lighting in the daylit zone separately from general lighting and reduces the lighting power in the daylit zone in response to available daylight			X	
When areas with multi-level lighting controls are receiving daylight illuminance levels greater than the illuminance from the controlled lighting when no daylight is available the controlled power consumption must be < 35% of the rated power of the controlled lighting			X	
Light sensor must be remote from where the calibration adjustments are made and calibration adjustments must be readily accessible	X (automatic daylighting control)		X (multi-level lighting control)	

Timing Is Right for Daylighting

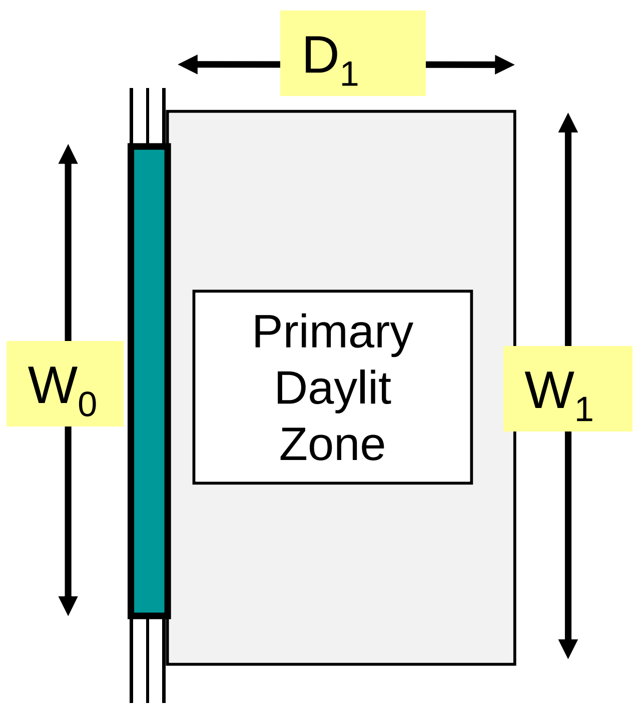
This slide graphically illustrates how daylighting works. As the amount of natural daylight increases in a space, the amount of electric light required to adequately light that same space decreases, thereby reducing the amount of energy consumed. A photosensor automatically measures the amount of light (both daylight and electric light) that is in the space and automatically adjusts the electric light level to ensure that the intended design light level is achieved at all times throughout the day.



Dimming electric light using a photosensor to maintain a constant illuminance level.
Source: Figure 27–1. *The IESNA Lighting Handbook.* Mark Rea, ed. IESNA: 2000.

Primary Sidelit Area

This is the code definition for a primary sidelit area. In order to comply with code requirements, the lighting that is within the primary daylit zone must be controlled separately from the other lighting that is in the space.



Control luminaires in the primary sidelit area

ASHRAE 90.1-2010

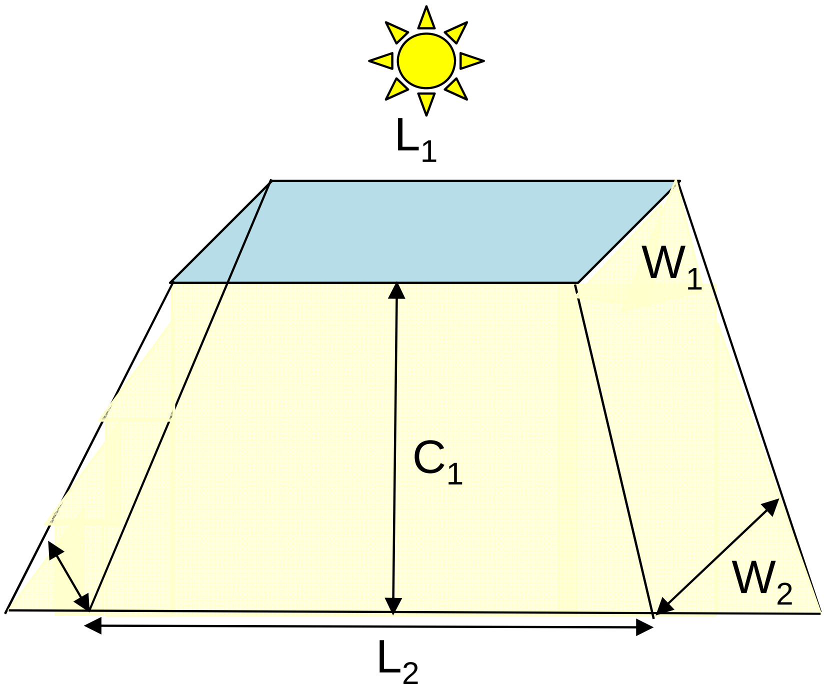
- **D_1** = distance from floor to top of the window (unless it reaches an obstruction 5’ or more)
- **W_1** = Window width (W_0) + 2’ on each side
- Primary Sidelit area = $D_1 * W_1$

IECC 2012

- **D_1** = 15’ (unless it reaches a ceiling height opaque partition)
- **W_1** = Window width (W_0) +
  - 2’ on each side, or
  - the distance to closest ceiling height opaque obstruction, or
  - ½ distance to a Skylight or Window
- Primary Sidelit area = $D_1 * W_1$

Primary Skylit Area (ASHRAE)

Here is the ASHRAE code definition for a primary skylit area. Just like the primary sidelit area, the lighting that is within the primary skylit area must be controlled separately from the rest of the lighting that is in the space.



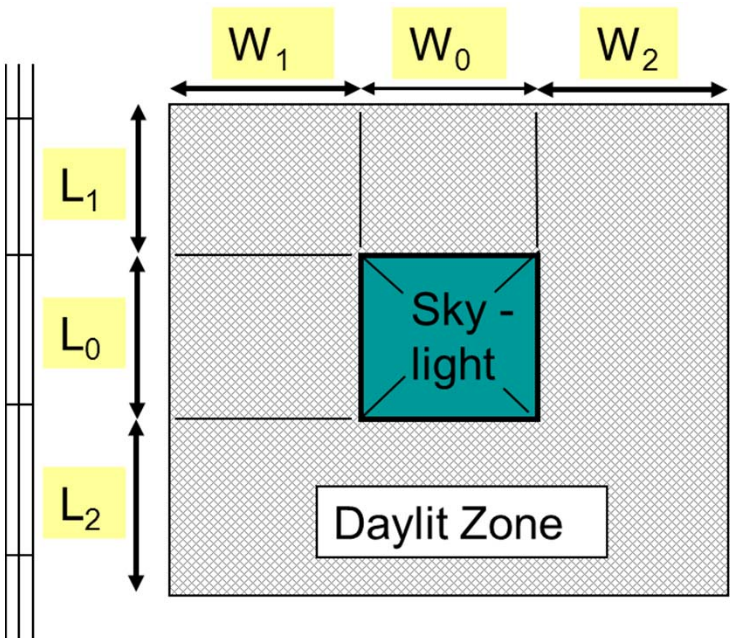
Control luminaires in the primary skylit area

ASHRAE 90.1-2010

- **C_1** = ceiling height
- **L_1** = length of skylight
- **W_1** = width of skylight
- **W_2** = $W_1 + 2(0.7C_1)$
- **L_2** = $L_1 + (2 * 0.7C_1)$
- Primary Skylit area = $W_2 * L_2$

Primary Skylit Area (IECC)

This is the IECC code definition for the primary skylit area. The lighting that is within the primary skylit area must be controlled separately from the rest of the lighting in the space. In addition, IECC has a requirement for areas that have both skylit and sidelit areas. In these spaces, when the skylight is more than 15' from the perimeter of the space, then the lighting in the skylit and sidelit spaces must be switched separately.



Control luminaires in the primary skylit area

IECC 2012

L_1, L_2, W_1, W_2 = smallest of the following values:

- Ceiling height, or
- ½ distance to a Skylight or Window Daylight zone

Parking Garage Lighting Control

For the first time, ASHRAE 2010 has a section dedicated to lighting controls in parking garages. It includes elements of the automatic lighting shutoff, light level reduction, and daylighting provisions and incorporates all of them in parking garage lighting control.

There are several different lighting control strategies that can be combined to meet this requirement including:

- light control solutions
- multi-level occupancy sensor (allows for light level reduction and automatic lighting shutoff)
- pre-programmed dimming ballasts (allows for light level reduction)
- daylight sensors (allows for daylighting control), and
- astronomical timeclocks (allows for automatic lighting shutoff).

Parking Garage Lighting Control

	ASHRAE 90.1		IECC	
	2010 Section 9.4.1.3	2004/ 2007	2012	2006/ 2009
Automatic shutoff using scheduled basis control device, occupancy sensor that turns lighting off within 30 minutes or a signal from another control or alarm system	X			
Automatically reduce lighting power of each luminaire by at least 30% when there is no activity in a lighting zone (3,600 sq ft or less) for $\leq$ 30 minutes	X			
Daylight transition zone lighting separately controlled to automatically turn lighting on during daylight hours and off at sunset	X			
Automatically reduce luminaires in response to daylight within 20 ft of any perimeter wall structure	X			
Exceptions				
Daylight transition zones and ramps without parking are exempt from 30% reduction and wall ratio requirements	X			
Applications using HID of 150 watts or less or Induction lamps are exempt from 30% reduction requirements	X			

Exterior Lighting Control

Previous versions of ASHRAE essentially required lighting to be off during the day (or when sufficient sunlight was available) and on at night.

ASHRAE 2010 is much more stringent. Now exterior lighting must still be off during the day in addition to meeting certain requirements at night. Building façade and landscape lighting must be turned off at night, and all other exterior lighting must be reduced either at night or when motion is not detected for 15 minutes.

Exterior Lighting Control

	ASHRAE 90.1		IECC	
	2010 Section 9.4.1.7	2004/2007 Section 9.4.1.3 & 9.4.4	2012 Section C405.6.1	2006/ 2009 Section 505.2.4& 505.6
Exterior lighting automatically turned off when sufficient daylight available or when not required during nighttime hours	X (when sufficient daylight available)	X		X (2006)
Building façade and landscape lighting	Automatically shutoff between midnight or business closing (whichever is later) and 6am or business opening (whichever is earlier)			
All other exterior lighting, including advertising signage	Automatically reduce by 30% b/w midnight or within 1 hour of business closing and 6am or business opening **OR** during any period when no activity has been detected for $\leq$ 15 min			
All building grounds lighting that operate at 100W must have lamps with minimum efficacy of 60 lumens/W unless controlled by a motion sensor		X	X	X

Exterior Lighting Control

The 2012 IECC exterior lighting control requirements remain the same as the 2009 requirements. IECC essentially requires that lighting be off during the day, but can be on at night.

	ASHRAE 90.1		IECC	
	2010	2004/2007	2012 Section C405.2.4	2006/2009
Lighting not designated for dusk-to-dawn operation controlled by either:				
Photosensor and time switch or		X (2007)	X	X (2009)
Astronomical time switch		X	X	X
Dusk-to-dawn lighting controlled by either:				
Astronomical time switch or		X	X	X
Photosensor		X	X	X

Guest Room Lighting

Lighting and switched receptacles are required to be controlled in guest rooms.

	ASHRAE 90.1		IECC	
	2010 Section 9.4.1.6	2004/2007 Section 9.4.1.4	2012 Section C405.2.3	2006/2009 Section 505.2.3
Rooms in hotels and motels must have one or more control devices at the entry door that collectively controls all permanently installed luminaires and switched receptacles	X	X	X	X
Exception				
bathrooms	X			X
Suites must have controls at the entry to each room or at the primary entry to the suite	X			X
Bathrooms must have a control device to automatically turn off bathroom lighting except for nightlighting not exceeding 5W within 60 minutes of the occupant leaving the space	X			

Task Lighting

Both ASHRAE and IECC have requirements to control task lighting. In both codes, task lighting must be controlled by an integral control device or by a readily accessible wall-mounted device. Furniture-mounted task lighting controlled by automatic shutoff may be excludable from the space LPA (lighting power allowance) calculation if it is in addition to general area lighting.

	ASHRAE 90.1		IECC	
	2010 Section 9.4.1.6 & 9.2.2.3	2004/2007 Section 9.4.1.4 & 9.2.2.3	2012 Section C405.2.3 & C405.5.1	2006/2009 Section 505.5.1
Integral control device or readily accessible wall-mounted device	X	X	X	
Furniture mounted task lighting controlled by automatic shutoff device may be excludable from space LPA calculation if it is in addition to general area lighting	X	X	X	X (2009)

Stairwell Lighting

Stairwell lighting must be automatically reduced by at least 50% when no motion is detected for 30 minutes. The intent of this provision is to eliminate wasted lighting in stairwells. Different light control solutions to meet this requirement include multi-level occupancy sensors and pre-programmed dimming ballasts. For example, using these types of controls will automatically turn stairwell lights on to 75% full light output when occupied and automatically down to 15% full light output when unoccupied. Studies from CLTC (California Lighting Technology Center) show a 40% to 80% energy savings from a stairwell lighting control system like this.

	ASHRAE 90.1		IECC	
	2010 Section 9.4.1.6	2004/2007 Section 9.4.1.4	2012	2006/2009
Automatically reduce lighting power in any one controlled zone by at least 50% within 30 minutes of all occupants leaving that zone	X			

Automatic Receptacle Control

For the first time, ASHRAE 2010 requires automatic shutoff of receptacles in computer classrooms, and both private and open offices. This must be done using the same methods as that of the automatic shutoff of lighting requirements.

Typically, half of each duplex outlet is switched and the other half is powered continuously. However, other configurations may also be acceptable, i.e. every other duplex outlet is switched. Note, the automatic control devices cannot be plugged into the receptacle (i.e. a power strip that talks to an occupancy sensor and is plugged into a receptacle does not comply).

Automatic Receptacle Control

	ASHRAE 90.1		IECC	
	2010 Section 8.4.2	2004/ 2007	2012	2006/ 2009
Automatic shutoff of 50% of all receptacles in private offices, open offices, and classrooms via:	X			
Scheduled shutoff	X			
Occupancy sensor that receptacles off within 30 minutes following non-occupancy of space	X			
Signal from another control system	X			
Exceptions				
Receptacles dedicated to equipment with 24-hour operation	X			
Spaces where automatic shutoff would endanger the safety/security of occupants	X			

Additional Efficiency Requirement

In addition to all of the provisions outlined on the previous slides, the 2012 IECC also requires compliance with one additional efficiency option.

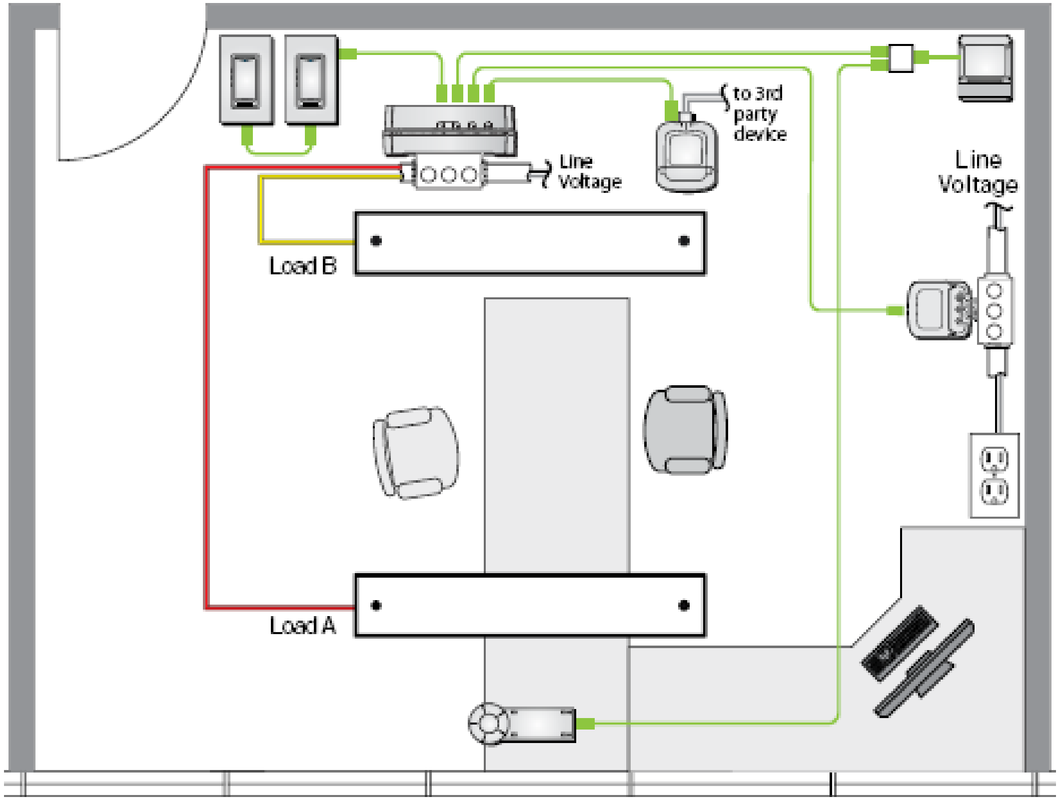
The option specific to lighting controls requires that the total interior lighting power density (watts/sq. ft.) of the building is reduced, in addition to including automatic daylighting controls in certain spaces such as warehouses.

	ASHRAE 90.1		IECC	
	2010	2004/ 2007	2012 Section C406	2006/ 2009
Must comply with one of the following:			X	
Efficient HVAC performance			X	
Efficient lighting system requiring a reduced lighting power density + automatic daylighting control in specific space types			X	
On-site supply of renewable energy			X	

System Commissioning

ASHRAE and IECC now require that a lighting control system be properly commissioned and signed off on (approved formally). The intent of this is to ensure that controls are calibrated, adjusted, programmed, and in proper working condition. Note, the party responsible for functional testing cannot be part of the design or construction team. The light control manufacturer can provide the functional testing.

	ASHRAE 90.1		IECC	
	2010 Section 9.4.4	2004/ 2007	2012 Section C408.3	2006/ 2009
Perform functional testing	X		X	
Confirm acceptable performance of the placement, sensitivity, and time-out adjustments for occupancy sensors	X		X	
Confirm time switches and programmable schedule controls are programmed to turn the lights off	X		X	
Confirm placement and sensitivity adjustments of photosensors reduce electric light in the space as specified	X		X	
Submit documentation certifying performance	X		X	



Best Practices and Control Strategies

Best Applications: Scheduling

Using some of the lighting control provisions detailed on previous slides, this section of the presentation looks at lighting control strategies for a variety of applications.

Generally speaking, controlling lights on a scheduled basis works best in high usage areas with regular schedules—for example, open offices, retail, outdoor lighting, hallways, and common areas. Lighting is set to turn on at a certain time and off at a certain time. In instances where someone might be working outside of the set time limits, an override (up to two hours to be code compliant) can be used so that the lights do not turn off while the person is still in the space.

Lighting control panels also make it easy to program holiday schedules. Day-of-week programming is very beneficial if the weekend hours vary from the weekday hours.

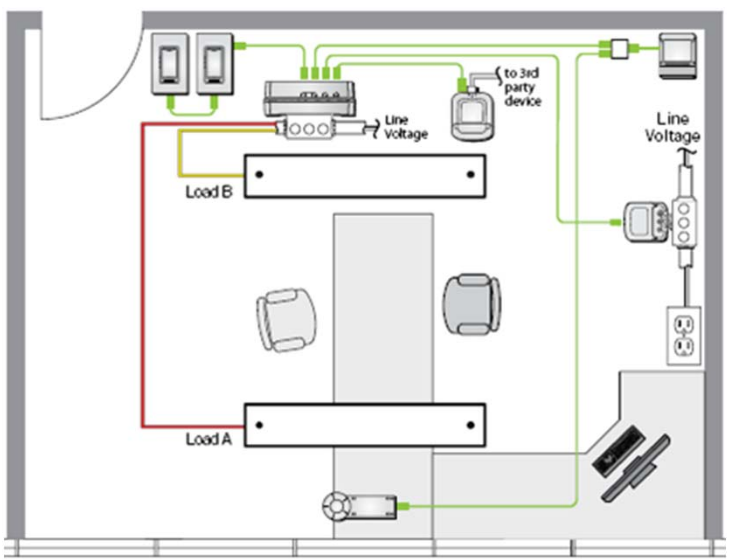
Best Practices: Examples

The next few slides look at the recommended lighting controls that will allow for code compliance in addition to meeting the needs of the occupants in each of the following applications:

- private office
- small conference room
- classroom
- open office
- gymnasium
- parking garage, and
- exterior lighting.

Private Office

In a private office, the occupancy sensor is configured to manual-on and automatic-off, ensuring that the sequence of operation is code compliant as well as meeting the automatic shutoff provision. A switch in the space allows for manual control which is required to meet the space control provision. For the purpose of this example, assume that the sidelit area is greater than 250 sq. ft. and that daylighting controls are required. Continuous dimming of the fixtures meets the ASHRAE light level reduction requirement. ASHRAE requires automatic daylighting controls and that 50% of the receptacles in the space be automatically shut off. IECC requires daylighting control; however, since the space is controlled by an occupancy sensor, light level reduction is not a requirement.



ASHRAE 90.1-2010

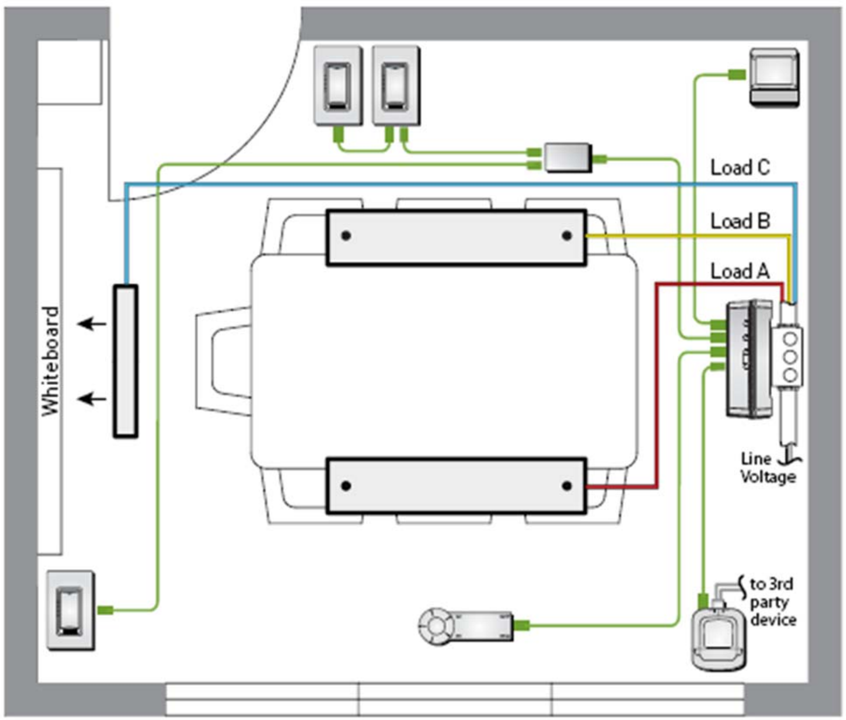
- Manual-on/Automatic-off with occupancy sensor
- Manual control
- Multi-zone daylight dimming
- Automatic shutoff of receptacles

IECC 2012

- Manual-on/Automatic-off with occupancy sensor
- Manual control
- Multi-zone daylight dimming

Small Conference Room

This small conference room is very similar to the private office. Essentially, the lighting control strategy is the same. The only difference in this space is that there is an extra light over the whiteboard. This fixture is controlled by a separate switch from the general lighting in the space and is turned off automatically by the occupancy sensor. Automatic control of receptacles is not required in conference rooms.



ASHRAE 90.1-2010

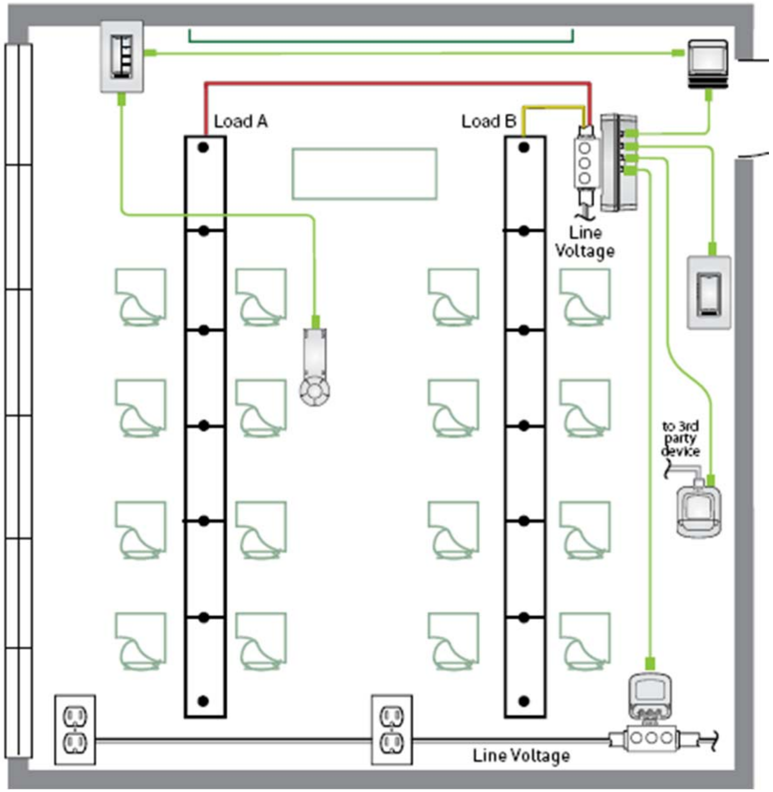
- Manual-on/Automatic-off with occupancy sensor
- Manual control
- Multi-zone daylight dimming

IECC 2012

- Manual-on/Automatic-off with occupancy sensor
- Manual control
- Multi-zone daylight dimming

Classroom

The classroom lighting control strategy is similar to that of the private office and conference room. If we assume this example is a computer classroom, to be compliant with ASHRAE, 50% of the receptacles must be automatically controlled. As discussed earlier, occupancy sensors are a good choice for high usage areas with irregular schedules.



ASHRAE 90.1-2010

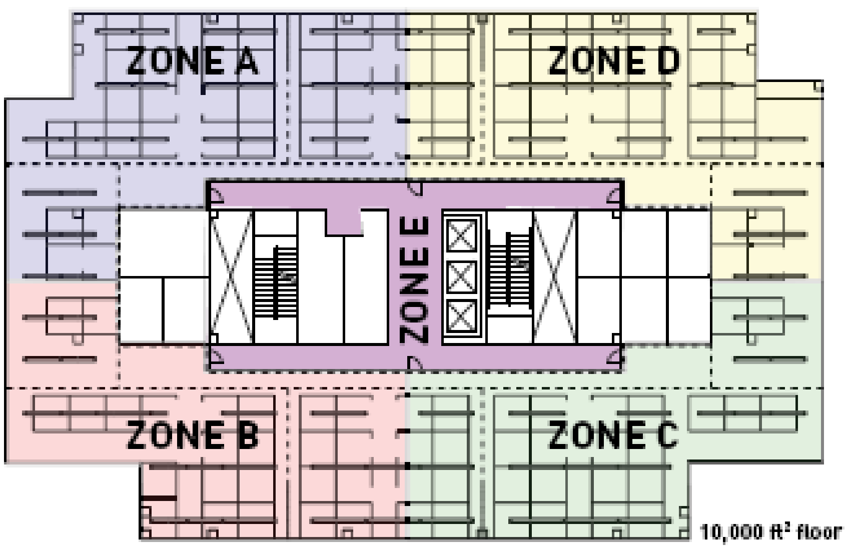
- Manual-on/Automatic-off with occupancy sensor
- Manual control
- Multi-zone dimming
- Daylighting
- Automatic shutoff of receptacles

IECC 2012

- Manual-on/Automatic-off with occupancy sensor
- Manual control
- Multi-zone dimming
- Daylighting

Open Office: Scheduling

This open office space is 10,000 sq. ft., so in order to be compliant with IECC, it needs control zones that are less than 5,000 sq. ft. To be compliant with ASHRAE, it needs control zones that are less than 2,500 sq. ft.. In this example, the space was divided into zones that are 2,500 sq. ft. Scheduling is the recommended strategy to use in open offices which are high usage areas with regular schedules. In addition to schedule-based control, each zone is controlled with a manual switch allowing for the space control provision to be met. The sidelit daylight area in this application is greater than 250 sq. ft., meaning that daylighting controls are required. ASHRAE requires that 50% of the receptacles in open offices are automatically shut off.



ASHRAE 90.1-2010

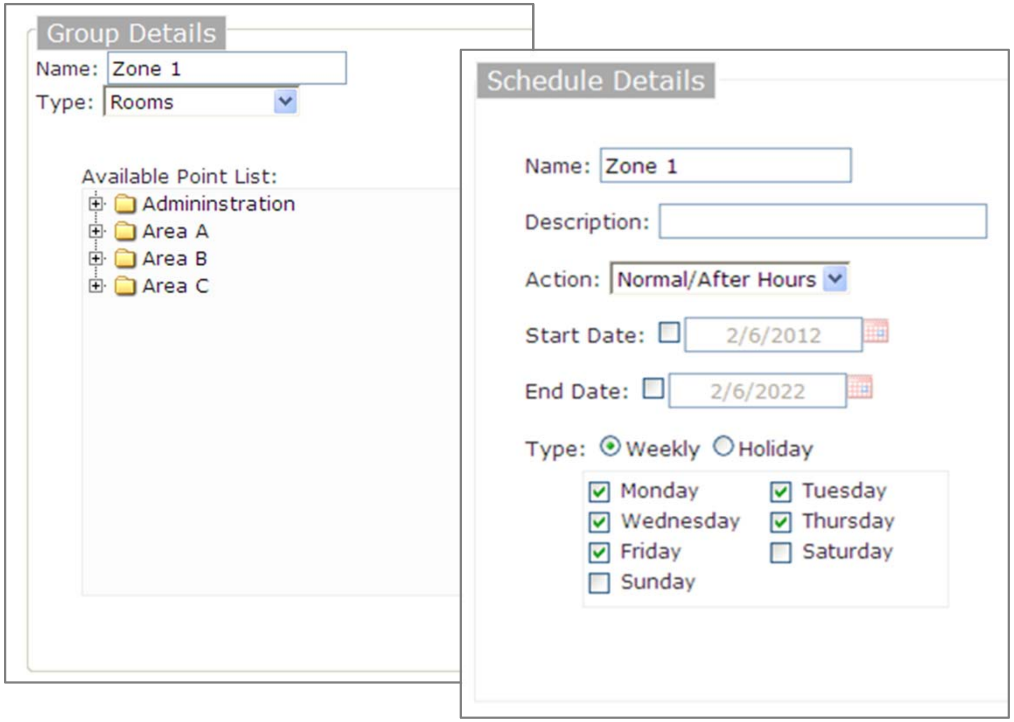
- Automatic-off via scheduling
- Manual override – 2 hours

IECC 2012

- Automatic-off via scheduling
- Manual override – 2 hours
- Bi-level

Open Office: Relay Schedule

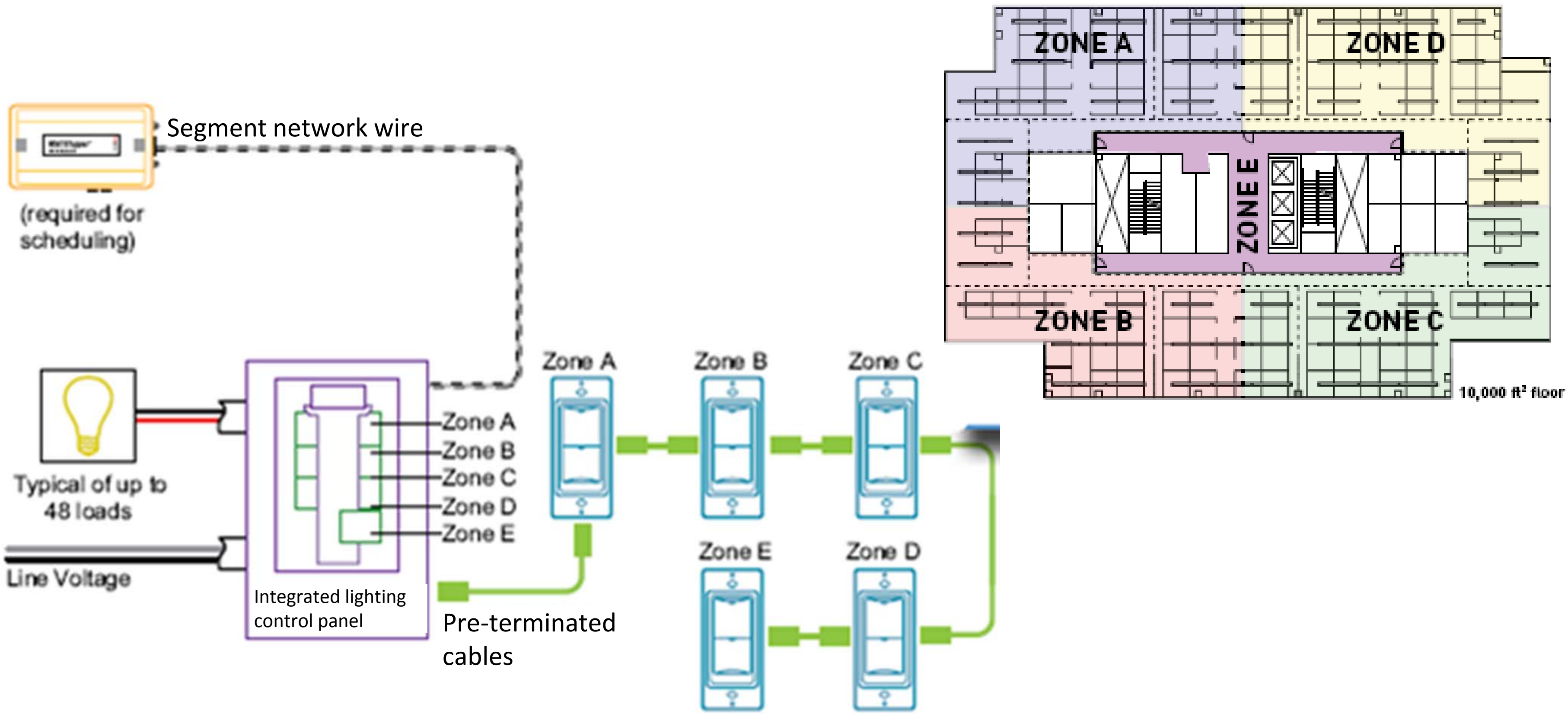
In an open office, it is necessary to set up the correct schedule for each zone. Remember, to be compliant with ASHRAE 90.1, each control zone size must be no larger than 2,500 sq. ft.



Please remember the **exam password OPEN**. You will be required to enter it in order to proceed with the on-line examination.

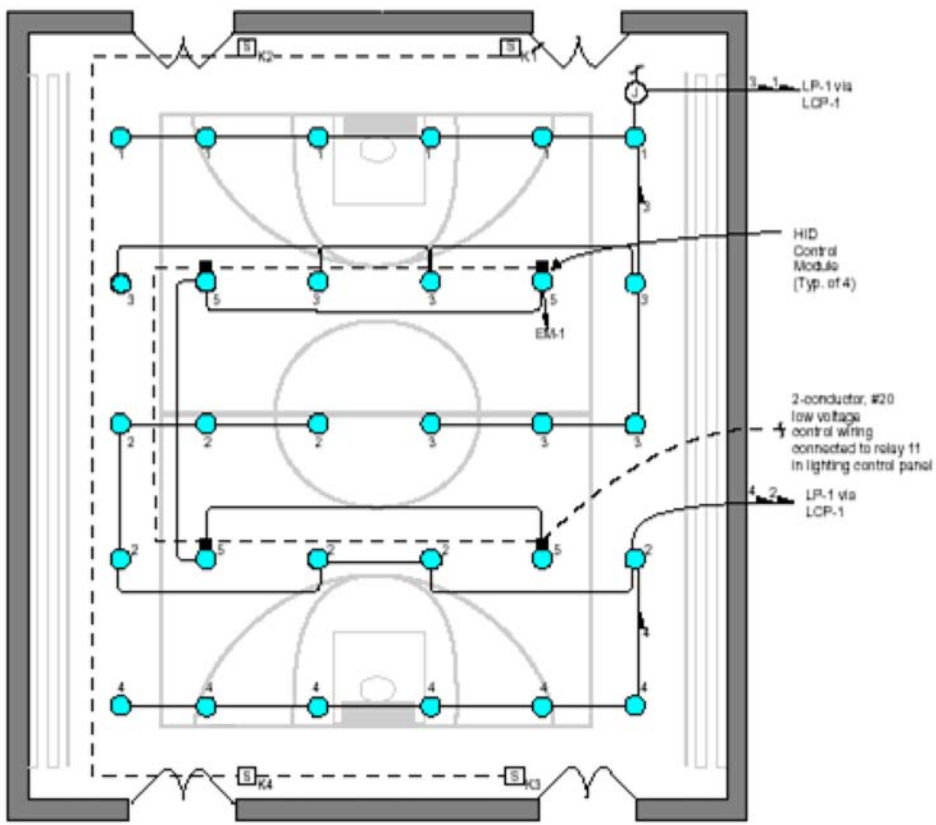
Open Office: Zone Control

A relay panel, combined with manual switches and a device to allow for scheduling, illustrates some of the lighting controls required for the open office application. Each switch provides manual control in each of the different control zones.



Gymnasium

Lighting control in a gymnasium can be code compliant by scheduling for automatic lighting shutoff and providing a two-hour manual override.



ASHRAE 90.1-2010

- Automatic-off via scheduling
- Manual override – 2 hours

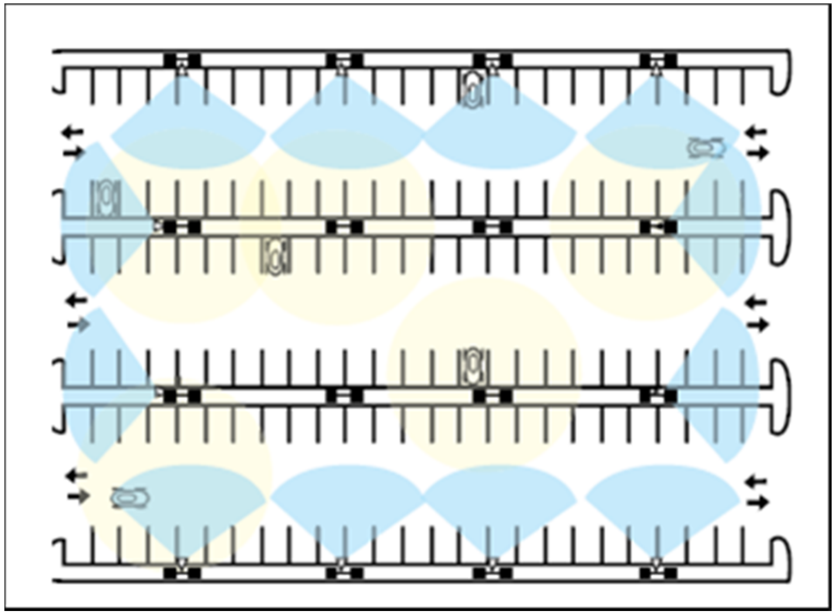
IECC 2012

- Automatic-off via scheduling
- Manual override – 2 hours
- Bi-level

Parking Garage

In order to design a parking garage that is code compliant, several different lighting controls are required:

- an occupancy sensor to meet the automatic-lighting shutoff provision
- daylighting controls for lighting that is around the perimeter of the parking garage structure (as long as there is sufficient daylight entering the space), and
- hi/lo control to meet the light level reduction requirement (lighting must be automatically reduced by at least 30% when there is no activity for 30 minutes or less).

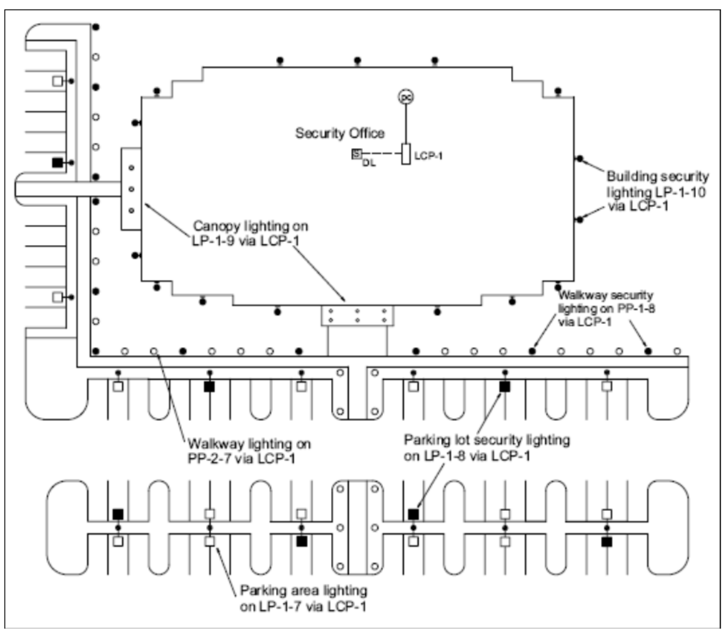


ASHRAE 90.1-2010

- Automatic shut-off with occupancy sensor
- Daylighting
- Hi/Lo control

Exterior Lighting

For exterior lighting applications, in order to be compliant with ASHRAE, it is necessary to have photocell control so that lighting is off during the day when sufficient daylight is available. Schedule-based control will ensure that building façade and landscape lighting is automatically shut off between midnight (or business closing) and 6 a.m. (or business opening). Hi/lo control will ensure that all other exterior lighting can be automatically reduced by 30%. The 2012 IECC requires a photosensor and time switch, or an astronomical time switch, so that lighting is off during the day.



ASHRAE 90.1-2010

- Schedule based control
- Hi/Lo control based on schedule or occupancy
- Photocell control

IECC 2012

- Photocell and time switch or astronomical time switch

Future of Energy Codes

Energy codes and standards are going to continue to become more and more stringent as time goes on. This leads to:

- the movement from prescriptive criteria to "real," outcome-based building performance metrics
- the inclusion of all building energy use including plug and process loads
- an increasing scope to include commissioning and annual verification of compliance with outcome-based metrics
- limitations on peak demand capability, increasing need for more responsive building controls, and
- the alignment of codes.

Source: Conover, D., P. Cole, and J. Henderson. "Status of State Energy Code Adoption and Compliance Measurement." AIA 2010 National Convention and Design Exposition. Miami, FL. June 10, 2010. http://www.aia.org/aiaucmp/groups/aia/documents/pdf/aiab083217.pdf

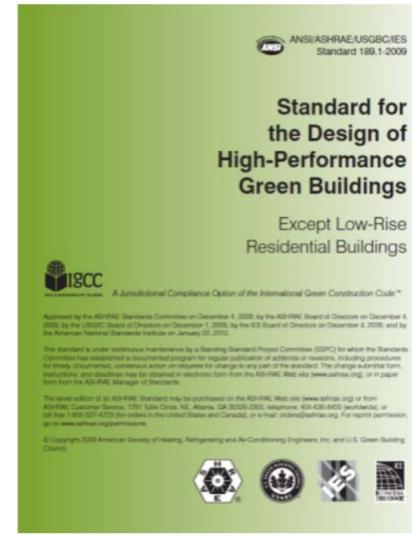
Future of Energy Codes

New green codes are more restrictive of the energy usage in buildings than regular energy codes.

<u>ASHRAE 189.1 High Performance Green Buildings</u>

Similar to LEED, ASHRAE's green building code is a standard that a state or city can adopt into law. It requires compliance with ASHRAE 90.1 2007 as a baseline and additional requirements beyond 90.1 to include:

- a 10% reduction in LPDs from 90.1 2007
- peak load reduction (i.e. demand responsive lighting), and
- multi-level and manual-on occupancy sensor requirements.



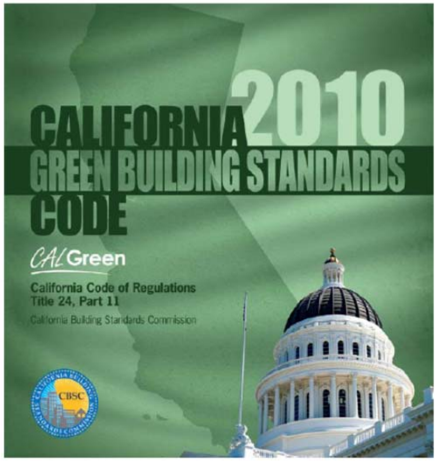
Future of Energy Codes

International Green Construction Code (IgCC)

Released in March 2012, the intent of the IgCC is to provide a broad-reaching set of building codes that include sustainability measures for an entire construction project.

CALGreen

Effective January 1, 2011, California's mandatory statewide green building code comprises stringent codes requiring compliance with sustainability and ecological standards.



Resources

The internet sources citied here and throughout this course were utilized in the gathering of information for this presentation. They were all accessed and verified on October 16, 2012.

- American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE, www.ashrae.org)
- Building Codes Assistance Project (BCAP, http://www.bcap-ocean.org/)
- Illuminating Engineering Society of North America (IESNA, www.iesna.org)
- International Energy Conservation Code® (IECC®), International Code Council® (ICC®, www.iccsafe.org)
- U.S. Department of Energy (DOE, http://energy.gov/)
- Slide 39 - Lighting Research Center www.lrc.rpi.edu/resources/pdf/LRCAuthoredReferenceList.pdf)

Maniccia, D., A. Tweed, A. Bierman, and B. Von Neida. "The effects of changing occupancy sensor time-out setting on energy savings, lamp cycling and maintenance costs." *Journal of the Illuminating Engineering Society* 30.2 (2001): 97-110.

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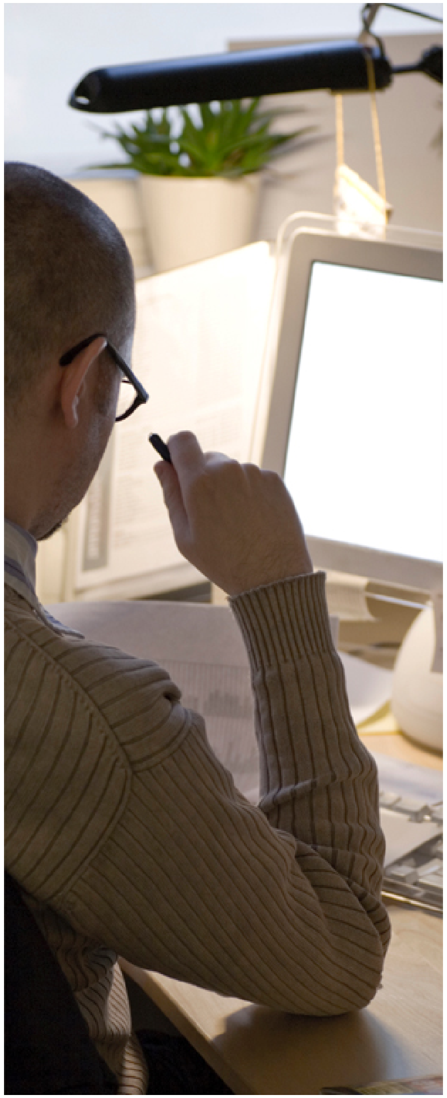

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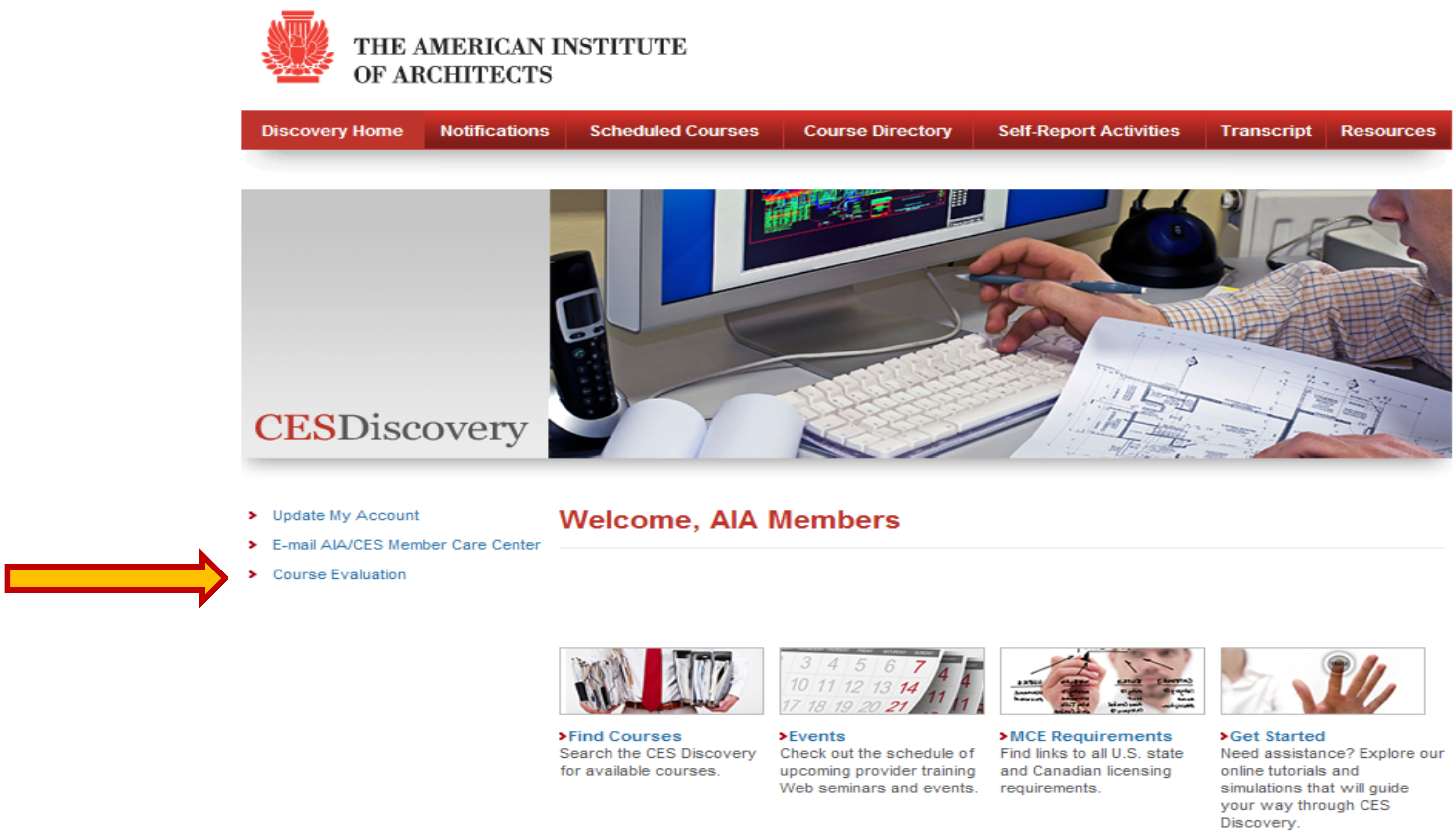

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