Nuckolls Fund for Lighting Education
Edison Price Fellowship Grant
Lighting Controls – Tools for Teaching
Instructor notes

Lighting Controls – Tools for Teaching was developed as a module for use by instructors of interior design lighting classes. The module provides a foundation in lighting controls including strategies with explanations and examples, and current energy codes. The intent is for this information to round-out lighting design classes and make students more aware of integrating lighting and lighting controls earlier in the design process. This is critical, especially now with office interiors providing flexible use spaces which requires lighting to be equally adaptable. This module could also be presented and used in a Commercial Studio class where adaptability of space and adherence to energy codes was incorporated into the program.
With energy codes evolving and lamp technology rapidly advancing, interior design students should be current with this information so their projects and vocabulary reflect that awareness. Also with sustainability at the forefront and LEED being the standard, it is imperative that students understand the impact lighting controls have on LEED Credits.

The complete module; instructor lecture notes, PowerPoint slides (categories include; benefits, energy facts, and terminology, commercial energy codes and strategies, and design process, lighting control zones), and lighting control by spaces assignment/test/quiz or in-class discussion, is designed for a 2½ hour lecture time. The module could be broken into two 60-90 minute lectures by covering Benefits, Energy facts, and Terminology, Slides #1 – 10, and Commercial energy codes and strategies, Slides #12-13 on the first day, and Lighting Control Zones for a typical office building, Slides # 19 – 25, and Lighting Control Strategies for a typical office building, Slides # 26 – 42 on the second day followed by either the test, quiz, or group discussion. If the entire module is presented in a 2 ½ hour class, the home work assignment would be strongly recommended following the class.

The following lecture notes will loosely follow the slide format. Information from sources has been cited.

Benefits, Energy facts, and Terminology, Slides #1 - 10
"A good lighting design includes a good controls design. The goal of an effective control system is to support the lighting application goals, which often translates to eliminating energy waste while providing a productive visual environment." *Lighting Controls Handbook, Craig DiLouie, 2008*

How do Lighting Controls save energy?
- Dimming - reduces the number of watts used when the lights are on
- Occupancy sensors - reduce the number of hours that lights are on
- Maintenance – reduce maintenance costs due to re-lamping
- Cooling loads – are reduced when lighting loads are reduced
- Shading – reduces heat build-up

Lighting Controls have both direct and indirect benefits.
Direct benefits include;
- meeting Energy Code requirements, which is required
- energy savings from reduced lighting loads
- economic savings in operating costs and lamp and ballast maintenance
- achieving LEED credits
- energy monitoring
- simplifying human responsibility (occupants do not have to remember to turn lights off!) .

Indirect benefits include;
- removing distractions which allows occupant to focus on their task-at-hand (switching lights on or off can be distracting to users particularly in the offices where occupants spend a great deal of time, whereas controlled dimming or personal controls allows for increased user satisfaction)

- ❑ excessive light due to interior finishes with high reflectances can be reduced with the use of lighting controls
- ❑ lighting controls can be integrated with the total building for monitoring energy use
- ❑ increase in building value (http://costar.com, and http://cascadiagbc.org/news/cascadia-releases-study-on-the-value-of-green-building)
- ❑ spaces needing to be turned around quickly for change in use or for a new configuration can be accomplished most easily and efficiently with lighting controls
- ❑ personal satisfaction of occupants of the interior environment.

The LEED green building rating system is not a standard or code, it is required for some new government buildings. Many LEED requirements go beyond minimum energy code requirements.
Following is a list of LEED credits that could contribute toward achieving credits.

- ❑ Energy and Atmosphere: Minimum Energy Performance
- ❑ Energy and Atmosphere: Optimized Energy Performance
- ❑ Energy and Atmosphere: Demand Response
- ❑ Indoor Environmental Quality: Daylight and Views - Daylight
- ❑ Indoor Environmental Quality: Daylight and Views - Views
- ❑ Indoor Environmental Quality: Controllability of Systems – Lighting
- ❑ Indoor Environmental Quality: Low-emitting Materials (LEED for schools only)
- ❑ Materials and Resources: Recycled Content
- ❑ Sustainable Sites: Light Pollution Reduction

When considering a typical commercial office building, lighting is the largest user of electricity. Statistics vary on this and constantly change over time. Further sources; *Energy Information Administration, 2003 Commercial Buildings Energy Consumption Survey, released September 2008, the Department of Energy, http://www.energy.gov*

Lighting Controls play a significant role in energy savings. Each strategy produces their own potential energy savings. Combining strategies will place the individual strategy at the low end of the potential energy savings range.

- ❑ High-end trim – sets the light level at a lower level based on customer requirements.
  Potential lighting energy savings of 10% - 20%
- ❑ Occupancy/vacancy sensors – turns lights on or off based on occupants
  Potential lighting energy savings of 20% - 60%
- ❑ Daylight harvesting – lights are dimmed when daylight is entering the space
  Potential lighting energy savings of 25% - 60%
- ❑ Personal Dimming control – occupants set the desired light level
  Potential lighting energy savings of 10% - 20%
- ❑ Controllable window shading – moves shades to reduce glare and solar heat gain
  Information is not available
- ❑ Scheduling – scheduled light level changes based on time
  Variable savings
- ❑ Demand response – reduces light loads during peak electrical usage
  Variable savings
- ❑ Appliance Control – automatically turns loads off after occupants leave
  Variable savings

As a point of comparison to the Lutron energy-saving strategies, PowerPoint slide #8, the following is a range of energy savings found in *Craig DiLouie's Lighting Redesign for Existing Building, Fairmont Press, 2011, page 176-180*

- *Automatic shutoff/Time clock – "an intelligent relay panel is a low-voltage control system that turns the lights off at a preset time of day producing 5-15% total building energy savings"*

- *Occupancy sensor – "turn lights on and off based on whether the monitored area is occupied, producing 35-45% energy savings"*

- *Daylight Harvesting – " can produce 35-60% energy savings"*

- *Personal controls – "increase occupant satisfaction and generates 10% + energy savings"*

Slide #8 titled, Lighting Controls and HVAC Reduction provides a nation-wide view of HVAC savings achieved; for every 3 Watt reduction from lighting there is a 1 Watt reduction of HVAC. The image clearly indicates that the greatest HVAC savings are in Florida; the least are in the north. In the south air conditioning is frequently used creating a demand on electricity. In the north heating offers more fuel options which impacts electrical energy usage.

Lighting control terminology, Slides #9 - 10

- Daylight harvesting – best for areas with windows, skylights, or clerestories. Electric light levels are increased or decreased based on the amount of light in the space. There are two daylight harvesting systems, closed-loop and open-loop. A closed-loop system evaluates light levels from both daylight and electric light and adjusts the light output to maintain a desired level. They are not recommended for controlling multiple zones. An open-loop system evaluates daylight only. When the determined level of light is reached it sends a signal to either dim or turn off the lights depending on whether it is a switching or dimming system.

- Daylight sensor - a photo sensor that responds to available light.

- Demand response – during times of excessive energy use or grid emergency, utility companies request a reduction in electrical consumption from building owners. A large percentage of potential energy savings comes from lighting. Newer lighting control systems can initiate a load shed for each space based on user satisfaction. All fixtures in a space can be pre-programmed in a building so that the load shed can be initiated with the push of a button. There can be significant monetary incentives for participating.

- Dimmer – decrease light output by reducing power.

- High end Trim - limits the maximum light output of fixtures

- Occupancy sensor – automatically turns lights on and automatically turns lights off. They are best suited to spaces that are intermittently occupied, private offices, classrooms, conference rooms, and break rooms. Source, Lighting Controls Association, http://lightingcontrolsassociation.org/

- Occupancy dependency - permits areas that are adjacent to the working space, slide #41 shows a private office, to maintain a reduced light level while a space is occupied. A goal is to avoid walking into a dark space. This is also a good option for bathrooms and the hallway connecting them.

- Personal control – any device that allows changing light levels in a space; any device that controls light.

- Set point – the target total light level in a space. This applies to dimming scenarios.

- Threshold – when a determined level of light is reached the daylight sensor will turn lights off.

- ❑ Time clock – a feature that enables scheduling of lights based on usage. Time-of-day and astronomic time clocks produce energy savings. Good for areas with predictable schedules.

- ❑ Vacancy sensor – lights must be manually turned on but the lights automatically turn off after a preset period of time. Vacancy sensing has a larger energy savings than occupancy sensing due to the fact that lights must manually be turned on and in some cases they may not need to be on. Examples, if the occupant of a private office is out at a meeting and a letter needs to be dropped off at their desk, someone entering to do so may not turn the lights on. With an occupancy sensor the lights would detect the person and turn the lights on, then after a preset time turn the lights off. The preset times should not be set so short that they create "false on or off" which can be disturbing to occupants.

Types of sensors Source, Lighting Controls Association, http://lightingcontrolsassociation.org/

- ❑ PIR, passive infrared – "reacts to the movement of heat … within a field of view."

- ❑ Ultrasonic – "emit(s) a high-frequency signal and monitor(s) that signal for changes." These sensors can be recognized by their cut-outs for the microphones. Source, Lighting Controls Association, http://lightingcontrolsassociation.org/

- ❑ Dual technologies - uses PIR and Ultrasonic technologies.

- ❑ Passive acoustics - sound activated sensor

- ❑ Combined PIR and Acoustic sensor

Commercial energy codes and strategies, Slides #12-13
"All states must have a commercial energy code at least as stringent as this (ASHRAE and IESNA 90.1)."
Lighting Controls Handbook, Craig DiLouie, page 207

The map of the US is showing each state and the adopted Energy Code(s) for that state. States without a listing have either developed their codes or adopted a model code.
The energy Codes set lighting power density (LPD) limits for a building.
In 1992 the Department of Energy was requested by the Energy Policy Act to establish a national energy standard. ASHRAE and IESNA jointly developed Standard 90.1-1999 as the national energy standard in 2004. Each state must have a code that at least meets this Standard. Some states, Washington, California, Florida, and Oregon have their own Codes which they developed. The ASHRAE/IESNA 90.1 Standard is for commercial buildings and residences over four stories above grade.
For state Code updates and adoptions refer to *Commercial State Energy Code, http://www.energycodes.gov/states/maps/commercialStatus.stm*

Following is a list of the minimum energy code requirements in ASHRAE 90.1-2010, IECC 2012, and Title 24 2008. They are listed by control type with the requirements.
Source: *Codes and Controls, Commercial Building and Energy Code Requirements for Light Control*
http://www.lutron.com/TechnicalDocumentLibrary/3672234a_codesandcontrolswhitepaper_sg.pdf

- ❑ Area control - Each area enclosed by ceiling-height partitions must have an accessible, independent switching or control device (such as an occupancy sensor, manual switch, or dimmer) to control the general lighting.

- ❑ Automatic shut-off - All indoor lighting systems must include a separate automatic shut-off control, such as an occupancy sensor or time switch.

- ❑ Automatic receptacle control - 50% of power outlets in certain spaces, such as private and open offices, must be controlled with an occupancy sensor or time clock.

- ❑ Daylight zone control - Areas in daylight zones* shall have a separate control for the general lighting**. Typically, a daylight sensor and dimming ballasts that control at least 50% of the general lighting power, meets this requirement. Switched daylight control also complies with code, but is more disruptive to occupants.

- ❑ Functional testing – Prior to inspection, lighting controls must be tested to ensure that they are working properly.

- ❑ Hotel/motel guest room lighting control (manual) - All guestrooms must have a control at the entry which controls all the permanently installed lighting except those in the bathroom. Bathrooms must use an automatic lighting shut-off control (i.e. occupancy sensor) to turn lights off within 60 minutes of vacancy.

- ❑ Manual-on or partial-on occupancy control - For most spaces, occupancy sensors shall not automatically turn the lighting to full-on. This effectively requires manual-on/automatic-off controls or a 50% maximum light level for auto-on. These controls are referred to as “vacancy sensors” or “multi-level” occupancy sensors. Spaces that allow auto-on include: public corridors and stairwells, restrooms, primary building entrance areas and lobbies, and areas where manual-on operation would endanger safety or security.

- ❑ Multi-level lighting controls - Most areas must have the ability to reduce lighting power by either continuous dimming, stepped dimming (dimming lights to certain, pre-defined, light levels), or stepped switching (separately switching alternate lamps in a fixture or alternate luminaires in a space) while maintaining a reasonably uniform level of illuminance throughout the controlled area.

- ❑ Occupancy sensor or timer switch controls - Occupancy sensors (as well as timer switches in 90.1-2010) that turn off lighting within 30 minutes of vacancy are required in spaces such as, but not limited to:
  1. classrooms and lecture halls
  2. conference, meeting, and training rooms
  3. employee lunch and break rooms
  4. storage and supply rooms

- ❑ Stairwell controls
  Lighting in enclosed stairwells shall have one or more control devices to automatically reduce lighting power by at least 50% within 30 minutes of vacancy.

A comparison chart of Codes and Controls - Commercial Building Energy Code Requirements for Light Control, is at the end of this document.

<u>Design process, lighting control zones, and lighting control by spaces</u>, Slides #15-40

A day in the life of an office graphically represents time of day with both light energy saved and level energy used as well as a mock-up, by hours, of a classic day in an office with routine events indicated at their typical times. Each “hour” of the graphic states the events that are happening at that time along with the lighting control strategies in use. Emphasis on changes in light control strategies over the course of the day are explained along with the human element; light control changes are so subtle that their impact on the interior environment is barely noticeable to occupants, resulting in few lighting-related distractions. This graphic is also a good tool to demonstrate how a space needs to be thought out and analyzed when considering lighting controls.

Lighting controls should be considered concurrently with the lighting design process to achieve compatibility between lamps, fixtures, ballasts/drivers, and lighting control strategies. The design process; programming, schematic design, design development, contract documents, contract administration, replaces post-occupancy evaluation with commissioning. The steps for each stage of the process are;

- ❑ Programming – The requirements of all spaces within the building are the building itself are considered. Required illuminance levels, daylighting, time-based use patterns, time clock and manual controls should all be addressed. Life safety and energy codes must be considered along with the functions of the space and occupant interaction with the lighting controls and/or lighting control system.
- ❑ Schematic design - Solutions are developed to meet space and building needs in line with the budget. The lighting controls procedure is run through with the projected lighting plan.
- ❑ Design development - Selection and layout of lighting control equipment and lighting control system. Zones for the control of groups of fixtures are determined. Finalization of the lighting control equipment and layout is completed.
- ❑ Contract documents – Drawing lighting and power plans, lighting control drawings and the writing of specifications for the lighting control equipment occurs in this stage. The sequencing of lighting control operations is included.
- ❑ Contract administration – The services which make sure that installation of lighting controls is in accordance with the drawings and specifications.
- ❑ Commissioning - This occurs once all lighting controls are installed. Testing of the equipment is done to verify that sensors, scene controls and other lighting controls are set for correct operation.

<u>Occupancy Sensor mounting placement</u>

There is not a specific PowerPoint slide to demonstrate these rules but they can be integrated into the discussions on the Typical Office by Space.

- ❑ Ceiling mounting – good for large areas with partitions, corridors, and warehouse aisles
- ❑ High-wall/corner mounting – directional detectors, usually placed over the door viewing into the space
- ❑ Wall switch – good for smaller enclosed spaces, private office, break rooms
- ❑ Luminaire mounting – typically used for medium/high bay applications

The written example of programming for a private office shows how lighting control requirements for each space must be considered individually, not a “typical” that is repeated throughout the building. Windows, clerestories, skylights, interior finishes, solar orientation (north/south/east/west), and time of year impact each space differently as do the occupants of the space with their specific light requirements. Designing lighting to meet IES recommended levels is the beginning but it is ultimately the occupant of the space that will determine their light levels.

<u>Lighting Control Zones for a typical office building</u>, Slides # 18 - 24

A typical office plan of approximately 6440 sq. ft will be used as the example to explore lighting control zones. The office plan, slide # 19, has spaces identified by name. This same plan will be used to explore lighting control strategies per space.
The plan has two perimeter walls with window exposure, west and south.

- ❑ Daylighting is demonstrated with colour to show the greatest area of impact, yellow for the zone windows to 15' interior, and orange for the less directly impacted area between 15' and 30' interior.
  As stated in the minimum energy code requirements in ASHRAE 90.1-2010, IECC 2012, and Title 24 2008, "areas in daylight zones shall have a separate control for the general lighting." It is worth noting that switching is not preferred since it is more disruptive to occupants particularly in office and locations where occupants spend large amounts of time. Hallways with windows, break rooms, atriums, and similar places would be fine with switched daylight harvesting.
  Source *http://www.lutron.com/TechnicalDocumentLibrary/3672234a_codesandcontrolswhitepaper_sg.pdf*

- ❑ Occupancy sensing detects the presence or absence of people in a space and automatically turns lights on or automatically turns light off. This can be convenient when hands are full and it reduces human responsibility.

- ❑ Vacancy sensing requires lights to manually be turned on but automatically turns lights off a period of time after the space is vacated. Vacancy sensing has the potential for larger energy savings than occupancy sensing due to the fact that lights must manually be turned on and in some cases they may not need to be on. Example, the occupant of a private office returns from lunch. There may be adequate light in the room and they do not think to turn on the lights until later in the afternoon when the additional light is needed.

- ❑ Manual controls are required for general lighting in enclosed spaces which have ceiling height partitions. *Source, ASHRAE/IESNA 90.1-2010, ASHRAE 189.1-2011*

- ❑ A time clock enables scheduling lights based on use.

Lighting Control Strategies for a typical office building, Slides # 25 - 39

Occupancy Sensor mounting placement

There is not a specific PowerPoint slide to demonstrate these rules but they can be integrated into discussions on the lighting control strategies, Typical Office by Space.

- ❑ Ceiling mounting – good for large areas with partitions, corridors, and warehouse aisles

- ❑ High-wall/corner mounting – directional detectors, usually placed over the door viewing into the space

- ❑ Wall switch – good for smaller enclosed spaces, private office, break rooms

- ❑ Luminaire mounting – typically used for medium/high bay applications

The same office plan used for Lighting Control Zones is used as the example to apply lighting control strategies by space. The office plan, slide # 26, has spaces identified by name and are colour coded. Each space type can benefit from lighting controls. The strategies recommended for each space consider occupant comfort and performance along with energy savings of the control strategy.

- ❑ Open office - the office plan has a large area dedicated to systems furniture with windows on two sides, west and south.
  The primary goal of the open office space is to have the lights on when people are at work and then have lights off when they are not working. This is typically accomplished using a time based control. A time clock for this space would be programmed to turn lights on at 7 AM before occupants arrive and then sweep lights off at 8 PM, once workers have left for the day.
  In addition a manual override control would be needed for early arrivers and late workers who need lights on when the time clock believes lights should be off.

Another approach for this area is to provide occupancy sensing that looks for people at work. Lights would turn on when an employee enters the space. If the space becomes completely unoccupied a sensor will detect vacancy and turn the lights off.
ASHRAE 90.1-2010, IECC 2012, and Title 24 2008 require an automatic off so a time clock would suffice.
Once the space is occupied and the lights are on, the next lighting control strategy would be personal controls, either via PC, infrared transmitter, or a wall mounted dimmer or scene control. This allows each occupant to raise or lower the lighting above their workspace to a desired level for comfort and improved visibility. Control of lighting above a workstation is dependent on the light fixture layout.

- Private office - the office plan has private offices on the building perimeter as well as the interior. Perimeter offices should respond to sunlight via daylight harvesting. Smooth light transitions are important for employee focus; automatically raising and lowering shades based on light conditions creates the least disturbance for employees.
  For both perimeter and interior offices vacancy sensing will automatically turn lights off if the office is vacant.
  The ability to dim lights from a wall station or desk provides personal control which is part of the idea of a private office; customizing a space to meet occupant needs for optimal performance.

- Conference rooms, meeting spaces, and training rooms - are used in many ways; A/V presentations, team gatherings, and meetings. Lighting controls are well suited to these dynamic environments.
  The lighting system needs to be adjustable and turn off when the room is not in use.
  The lighting controls should be intuitive and allow for dimming during presentations and full bright for meetings and setup and cleanup functions.
  Advanced lighting control options include integration of the lighting control with A/V systems such as projectors and projection screens which makes the space user friendly.

- Corridors and hallways - can account for 15%-20% of the total floor space, requiring a large amount of lighting electricity.
  Occupancy dependency allows lights to be on when any space they join is occupied. In some cases the path between an office, when occupied after hours, to the staircase and/or elevator remains lit even when the main space is off. Leaving an elevator to enter a dark corridor can be avoided by maintaining low light levels afterhours. This provides safety and comfort for building occupants.

- Break rooms, elevator lobbies and restrooms - have unpredictable use patterns. Typically occupancy or vacancy sensors are used which respond to the use patterns. Entering a dark restroom can be avoided by keeping lights on at a low level reducing fear and promoting safety. The same is true for elevator lobbies.

The sequences of operations outlined above helps the end user understand how their light controls will work and assures that design intent is achieved.
The summary reinforces some key points covered in the slides and lecture.

- Lighting is the largest user of electricity in commercial buildings and many spaces are over lit resulting in wasted light
- Lighting controls can produce significant savings in light energy, up to 60% reduction
- Lighting control strategies improve building efficiency and occupant performance through the use of; occupancy sensing, vacancy sensing, daylight harvesting, personal dimming, time clock/scheduling, demand response, high end trim/tuning, shading, and plug load control
- Energy codes and Standards state the results not the strategies to achieve the results

Commercial Building Energy Code Requirements for Light Control

	area control	automatic lighting shut-off	automatic receptacle control	automatic light reduction control	bi-level lighting control (minimum one light level)	continuous lighting dimming	daylight zone control (sidelighting)	daylight zone control (toplighting)	demand response / max load reduction	emergency lighting control	energy consumption measurement	exterior lighting control	functional testing	guest room lighting and HVAC control (hotels)	guest room lighting control (hotels)	manual-on or partial-on occupancy control	manual projections	occupant sensor or timer switch controls	occupancy sensing	parking garage lighting control	stairwell lighting control
Codes/Standards																					
Previous Generation of Energy Codes (ASHRAE 90.1-2007 or IECC 2009)	All	All			IECC 2009			IECC 2009				All			All			All			
Most Recent Energy Codes (ASHRAE 90.1-2010, IECC 2012, CA Title 24 2008)	All	All	90.1-2010		All		All	All	T24-2008			All	All		All	90.1-2010		All		90.1-2010	90.1-2010
Green Codes (ASHRAE 189.1-2009, ASHRAE 189.1-2011, IgCC)	All	All	IgCC 2012	All	All		All		All			All	All	All		189.1-2009	189.1-2011	189.1-2011	189.1-2011	189.1-2011	189.1-2011
Next Generation of Energy Codes (ASHRAE 90.1-2013, IECC 2015, CA Title 24 2013)			All		All	T24-2013	All	All	T24-2013	All	All	All	All		All	90.1-2013		All		90.1-2013	90.1-2013
Strategy																					
bi-level switching	x				x						x										
continuous window treatments																	x		x		
daylight dimming							x	x				x								x	
daylight switching (multi-step)							x	x				x								x	
daylight switching (ON/OFF only)								x				x								x	
Demand Responsive Lighting									x												
Dimming	x				x	x															
Energy Metering/Measurement											x										
Flex service													x								
High-end trim/tuning																					
Key card control														x							
Load shedding									x												
Multi-level occupancy sensing (auto-on/partial-off)	x			x	x							x						x		x	x
Multi-level occupancy sensing (partial-on/auto-off)	x	x			x							x		x		x		x		x	
occupancy sensing (auto-on/auto-off)	x	x										x		x				x		x	
Personal control	x				x			x													
Plug-load control			x																		
Preset scene control	x				x			x							x						
Scheduling		x										x								x	
Switching (manual)	x							x							x						
Vacancy sensing (manual-on/auto-off)	x	x												x		x		x			

Note: due to its size, this table figure is presented here in its complete form, and then follows in segments scaled for readability

	Area Control	Automatic Lighting Shut-off
Codes/Standards		
Previous Generation of Energy Codes (ASHRAE 90.1-2007 or IECC 2009)	All	All
Most Recent Energy Codes (ASHRAE 90.1-2010, IECC 2012, or CA Title 24 2008)	All	All
Green Codes (ASHRAE 189.1-2009, ASHRAE 189.1-2011, or IgCC)	All	All
Next Generation of Energy Codes (ASHRAE 90.1-2013, IECC 2015, or CA Title 24 2013)		
Strategy		
Bi-level Switching	•	
Controllable Window Treatments		
Daylight Dimming		
Daylight Switching (multi-level)		
Daylight Switching (ON/OFF only)		
Demand Responsive Lighting		
Dimming	•	
Energy Metering/Measurement		
Field Service		
High-end Trim/Tuning		
Key Card Control		
Load Shedding		
Multi-level Occupancy Sensing (Auto-on/Partial-off)	•	
Multi-level Occupancy Sensing (Partial-on/Auto-off)	•	•
Occupancy Sensing (Auto-on/Auto-off)	•	•
Personal Control	•	
Plug-load Control		
Preset Scene Control	•	
Scheduling		•
Switching (on/off)	•	
Vacancy Sensing (Manual-on/Auto-off)	•	•

Automatic Receptacle Control	Automatic Light Reduction Control	Bi-level Lighting Control (minimum of 2 light levels)	Controllable Lighting (more than 2 light levels or dimming)	Daylight Zone Control (Automatic)	Daylight Zone Control (Automatic)	Demand Response/ Peak Load Reduction	Emergency Lighting Control	Energy Consumption Management	Exterior Lighting Control
		IECC 2009			IECC 2009				All
90.1-2010		All		All	All	T24 2008			All
IgCC 2012	All	All		All		All			All
All		All	T24 2013	All	All	T24 2013	All	All	All
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Functional Testing	Guest Room Lighting and HVAC Control (Automatic)	Guest Room Lighting Control (Manual)	Manual-on or Partial-on Occupancy Control	Permanent Projections	Occupant Sensor or Timer Switch Controls	Office Space Shading	Parking Garage Lighting Control	Stairwell Lighting Control
		All			All			
All		All	90.1-2010		All		90.1-2010	90.1-2010
All	All		189.1-2009	189.1-2011	189.1-2011	189.1-2011	189.1-2011	189.1-2011
All		All	90.1-2013		All		90.1-2013	90.1-2013
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