Introduction to Lighting Systems and Controls

Course No. ENRG 54

Outline

A. Introduction to fundamentals of lighting

- Lighting terminology
- Physics and principles of lighting
- Units of measurement
- Vision and colors
- Ambient, directional and task lighting
- Over- and under-illuminance

B. Lighting systems

- Components
- Types of lamps
- Ballasts
- Lamp comparison matrix
- Types of lighting luminaires and intensities
- Energy efficiency measures (EEMs)

C. Lighting controls

- Basic concepts of effectiveness of lighting control
- Types and appropriate applications of lighting controls
- Lighting control equations
- Energy efficiency measures (EEMs)

D. Additional EEMs

- De-lamping
- Scotopic lighting
- Task and ambient light levels
- Circadian rhythms

E. Lighting measurements

- Tools
- Data loggers and applications

F. Lighting calculations

- Equation and method of calculating lumens (zonal cavity formula)
- Equation and method of calculating energy savings
- Method of calculating skylight energy savings

G. Lighting standards, codes and regulations

- Underwriters' Laboratory (UL)
- Uniform Building Code (UBC)
- Americans with Disabilities Act (ADA)
- Title 24 applications

H. O&M measures to assure optimal performance

C. Lighting controls

1. Basic concepts of effectiveness of lighting control
2. Types and appropriate applications of lighting controls
3. Lighting control equations
4. Energy efficiency measures (EEMs)

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Effectiveness of Control

- Design properly
- Select control component(s) properly
- Install the selected components or system properly
- Commission and maintain properly
- End users operate properly

C. Lighting controls

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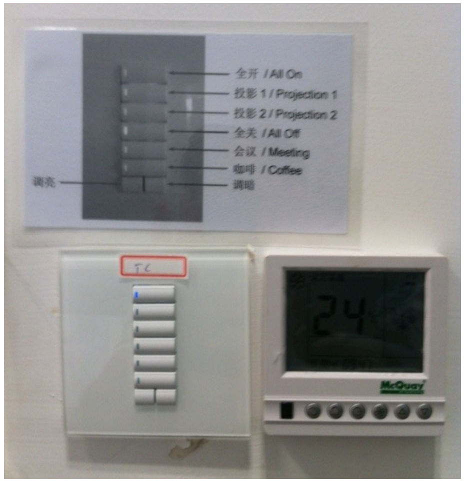
4. Energy efficiency measures (EEMs)

2. Types and appropriate applications of lighting controls

a. Manual Switches
b. Schedule controls or sweeps (building automation systems)
c. Timers and time clocks
d. Infrared and ultrasonic occupancy sensors
e. Manual dimmers
f. Daylight controls or Photosensors
g. Bi-level switching

Manual controls

Most everyone knows that you can save energy by TURNING OFF LIGHTS when they're not needed. But sometimes we forget or don't notice that we've left lights on.



Applications: discuss w/students

Control tech.	kW	time	application
Manual controls		↓	

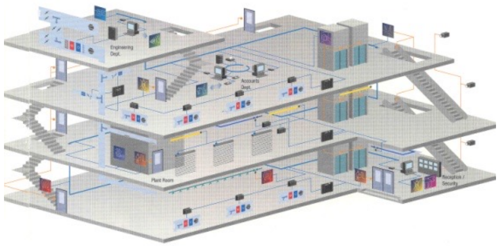
Building management system (BMS)

•Computer-based control system consists of software and hardware

•Monitors mechanical and electrical equipment such as ventilation, lighting, power systems, fire systems, and security systems.

•Most common in a large building, ideal for spaces with regular use

• Combines all sorts of control strategy



Applications: discuss w/students

Control tech.	kW	time	application
Manual controls		↓	
BMS	↓	↓	

Timers

- Used to turn on and off outdoor/indoor lights at specific times.
- For outdoor lighting, timer may have to be reset often with the seasonal variation.
- For indoor lighting, timers are an ineffective control for an occupied space.
- Applications:

electronic

Mechanical

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Applications: discuss w/students

Control tech.	kW	time	application
Manual controls		↓	
BMS	↓	↓	
Timers		↓	

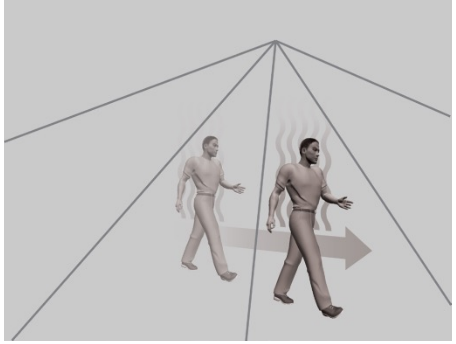
Occupancy sensors   Qualify for PG&E Incentive

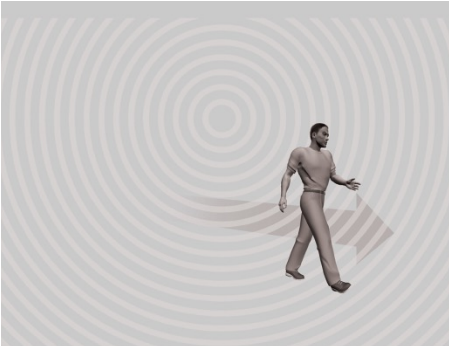
- Types:

  - Passive infrared (PIR): a line of sight beam that reacts to heated motion across a field of view

  - Ultrasonic (US): a reflective wave form that reacts to disturbances in return wave form.

  - Dual Tech (DT): combines both PIR and US sensing technologies in one device.





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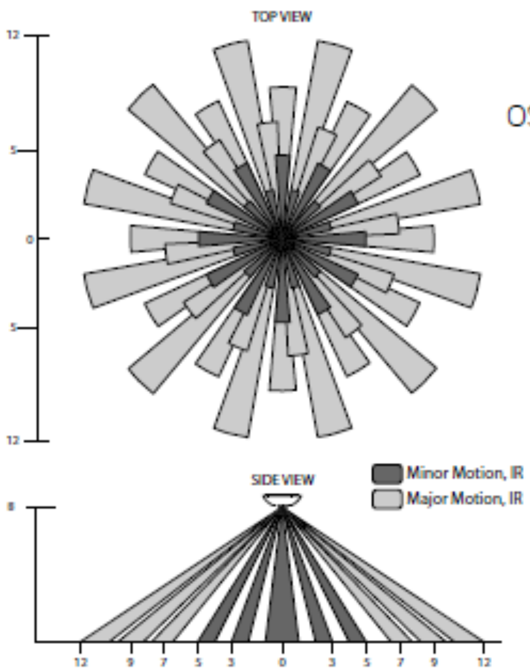
Occupancy sensors: PIR

Ceiling mount

Wall mount



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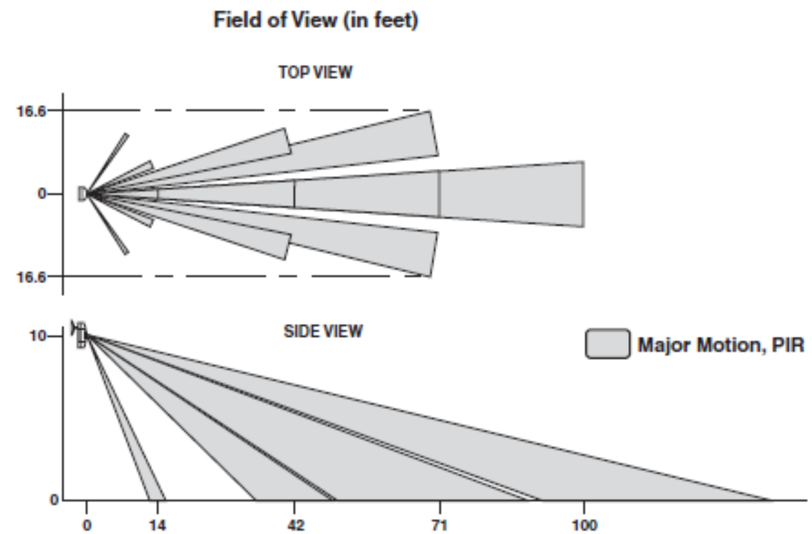
FIELD-OF-VIEW



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Occupancy sensors: Ultrasonic

360 degree

180 degree

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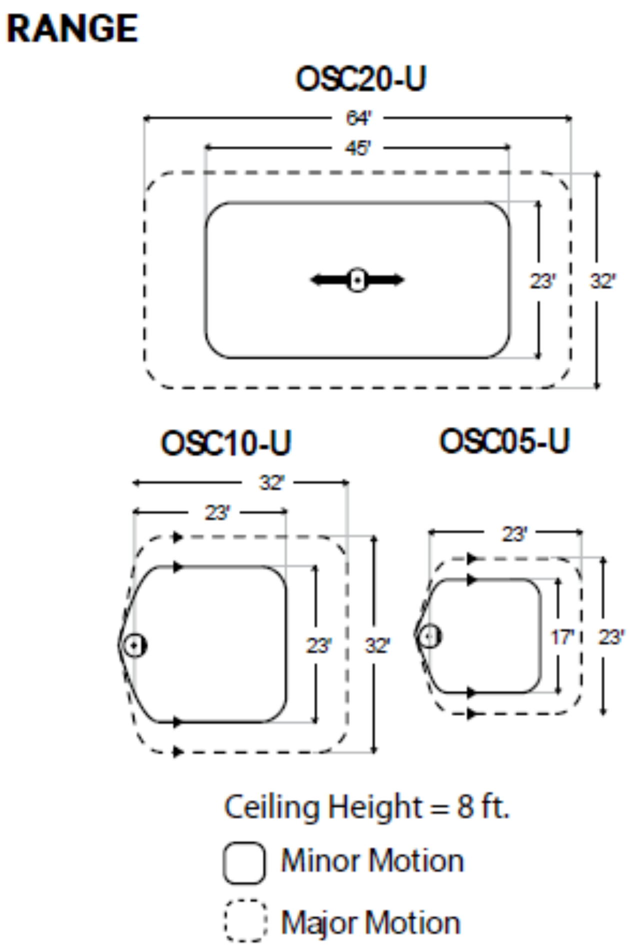
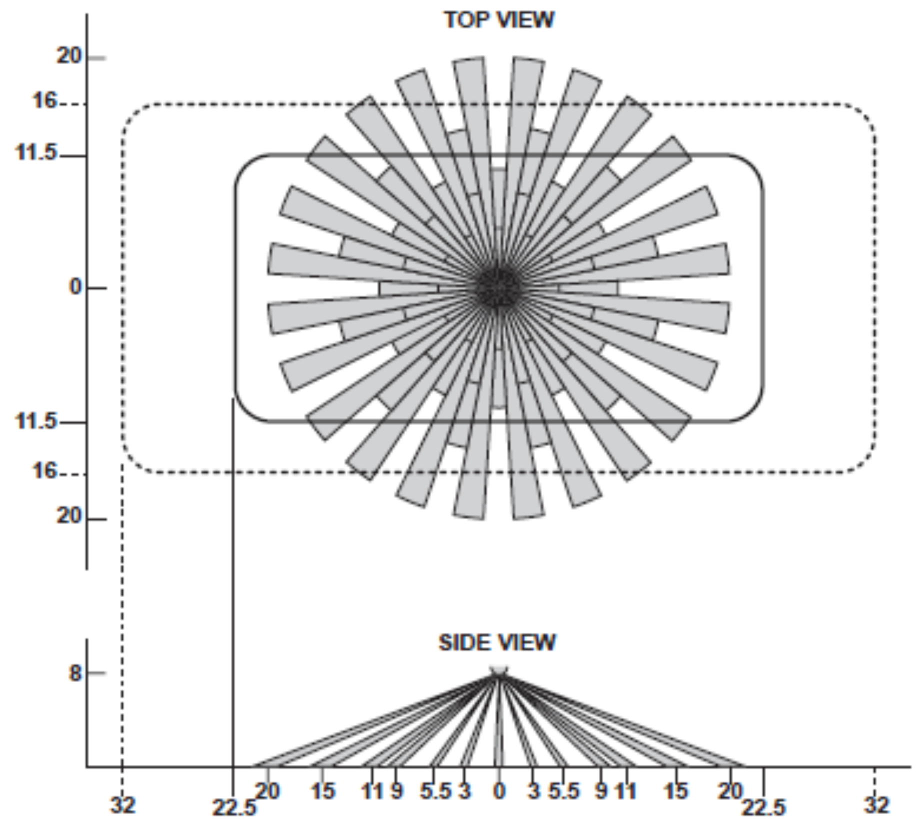


Occupancy sensors: Dual tech

Ceiling mount

Wall mount

OSC20-M 2000 sq. ft.



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Occupancy sensors: Wall switches

PIR

DT

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Occupancy sensors: wireless

Solar self-powered PIR sensor

- wireless receivers and transmitters are needed.

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Applications: discuss w/students

Control tech.	kW	time	application
Manual controls		↓	
BMS	↓	↓	
Timers		↓	
Occupancy sensors		↓	

Manual dimmers

- Provide variable indoor lighting for incandescent, halogen, fluorescent lamps, and LED etc
- Dimming fluorescents requires special dimming ballasts and lamp holders, but does not reduce their efficiency
- Applications:

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Applications: discuss w/students

Control tech.	kW	time	application
Manual controls		↓	
BMS	↓	↓	
Timers		↓	
Occupancy sensors		↓	
Manual dimmers	↓		

Photosensors – Daylighting control

- Often used for daylighting control combined with dimming.
- Photocell (typically a photodiode) is the light sensitive component within a photosensor
- produce signal in response to the amount of light received.
- The signal can be used to turn on or off, or dim the lights.
- PG&E rebates for exterior photocells

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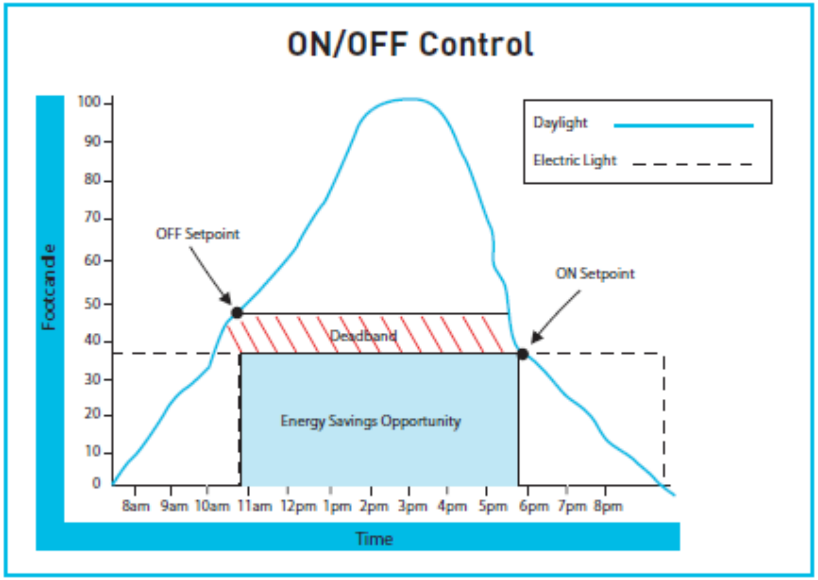
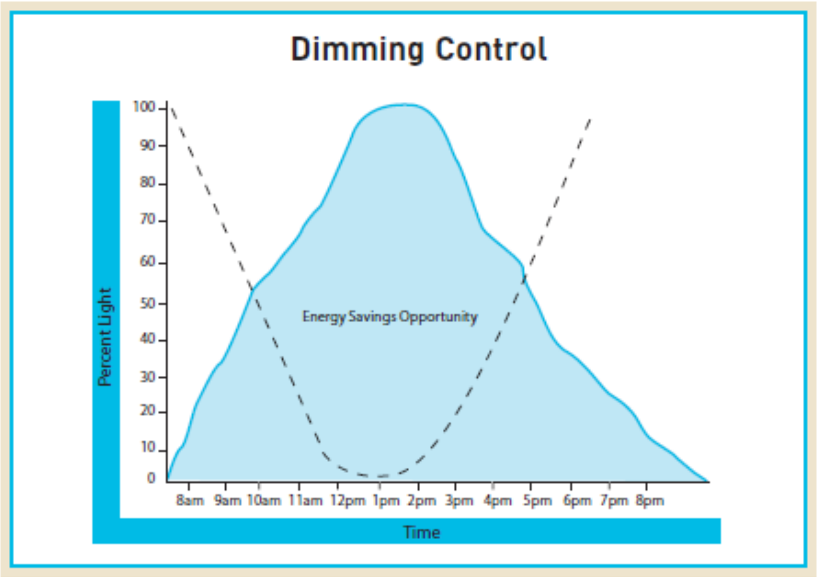
Photosensors – Daylighting control





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Photosensors selection

- Stand-alone vs. system controls
- Single vs. multiple control zones
- Open loop vs. closed loop technology

	On/Off Switching	Dimming
Single Zone	LS-102 (closed loop)	LS-301 (closed loop)
Multi Zone	LCO-203 system (open loop)	LCD-203 system (open loop)

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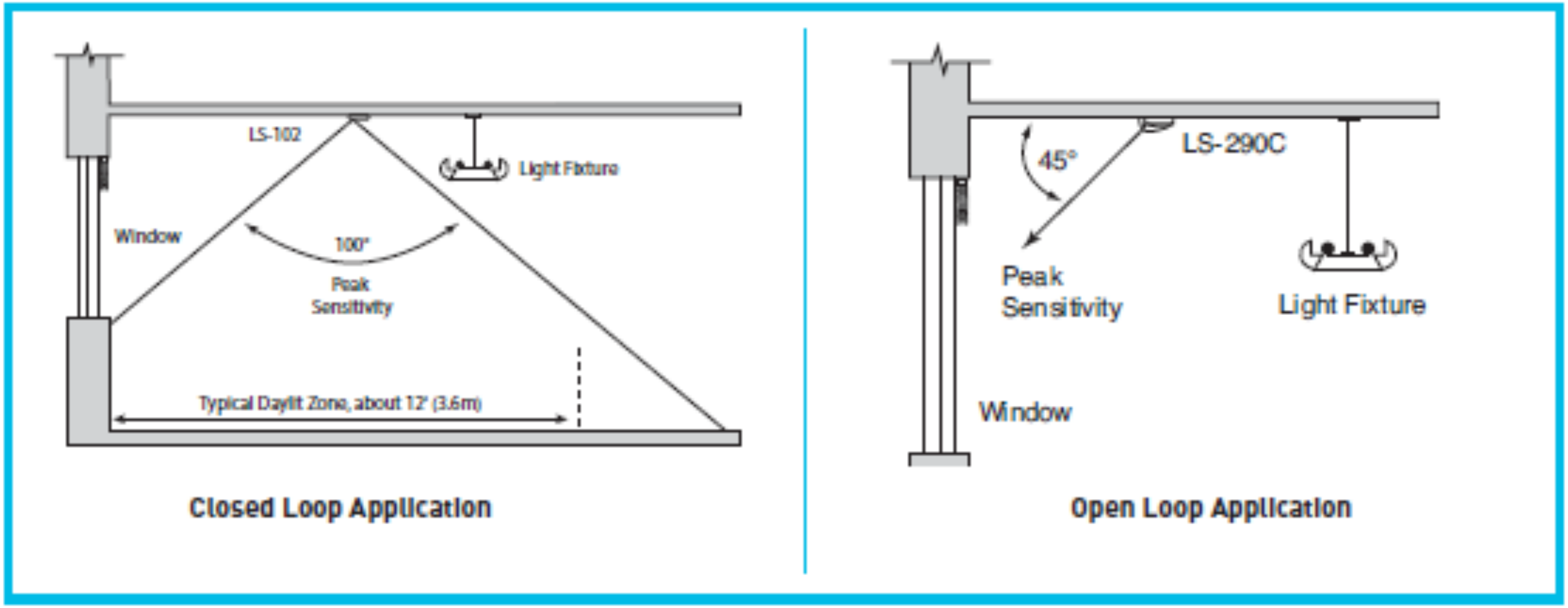
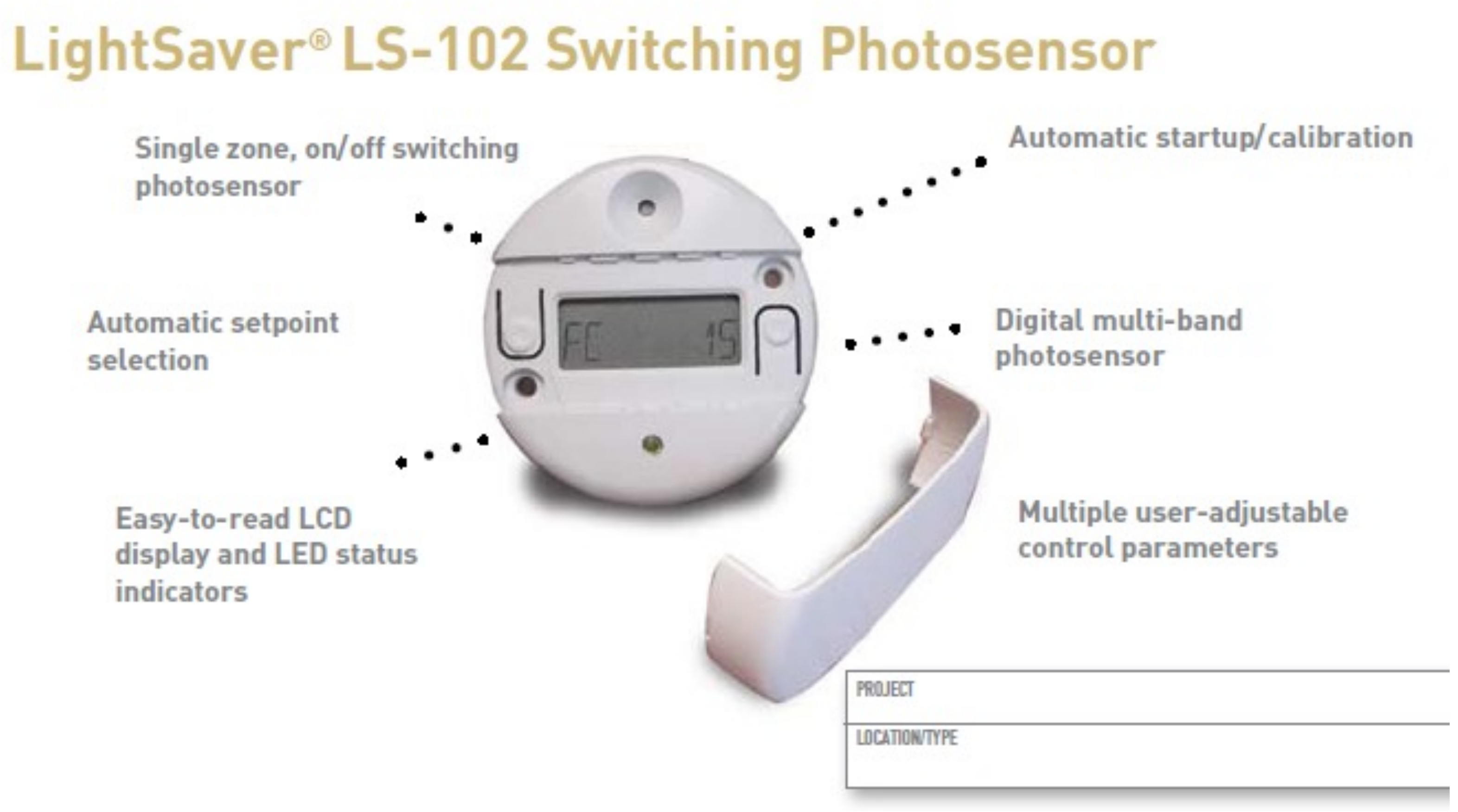


Photosensors – Daylighting control



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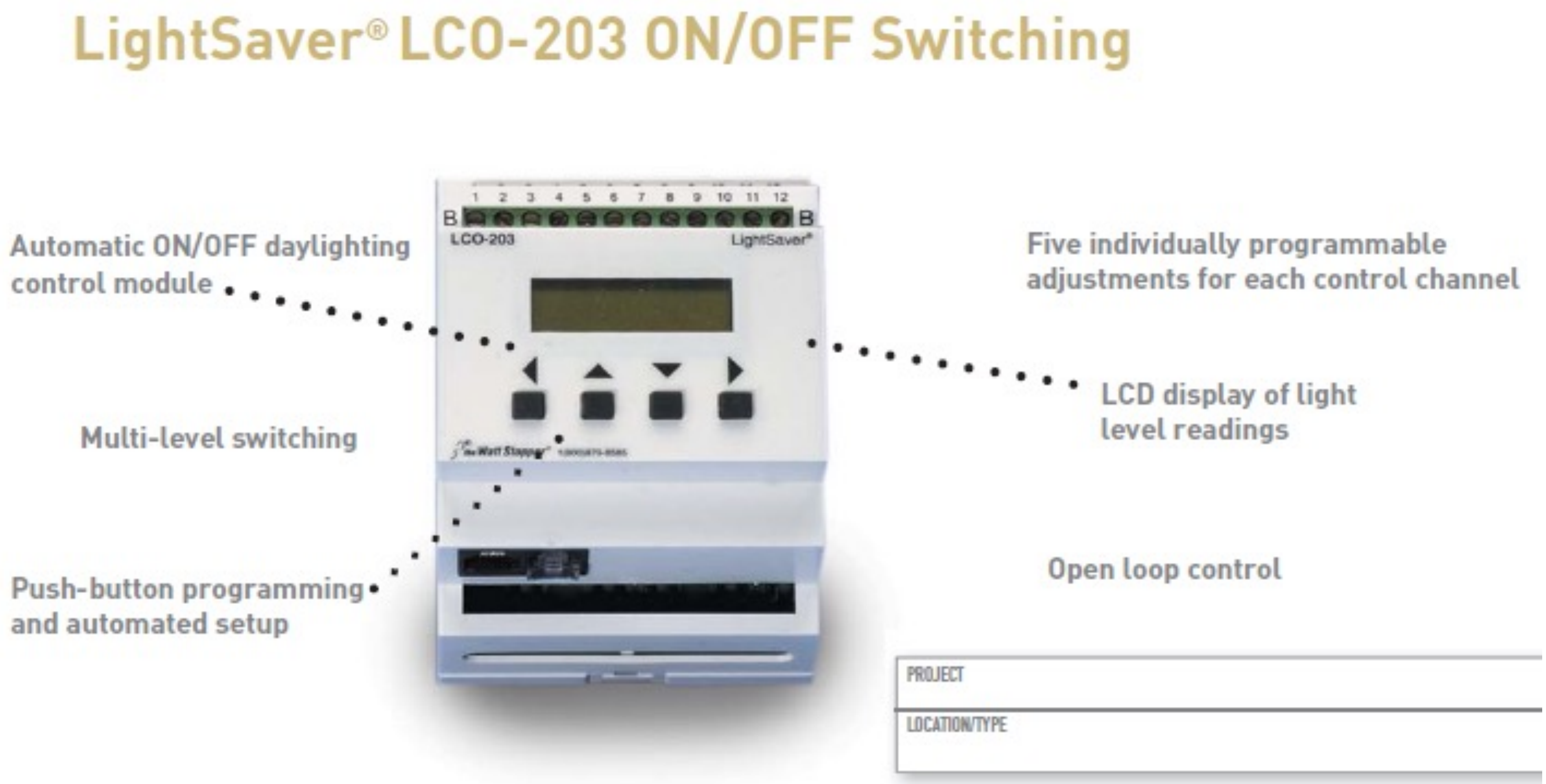
Photosensors – Daylighting control



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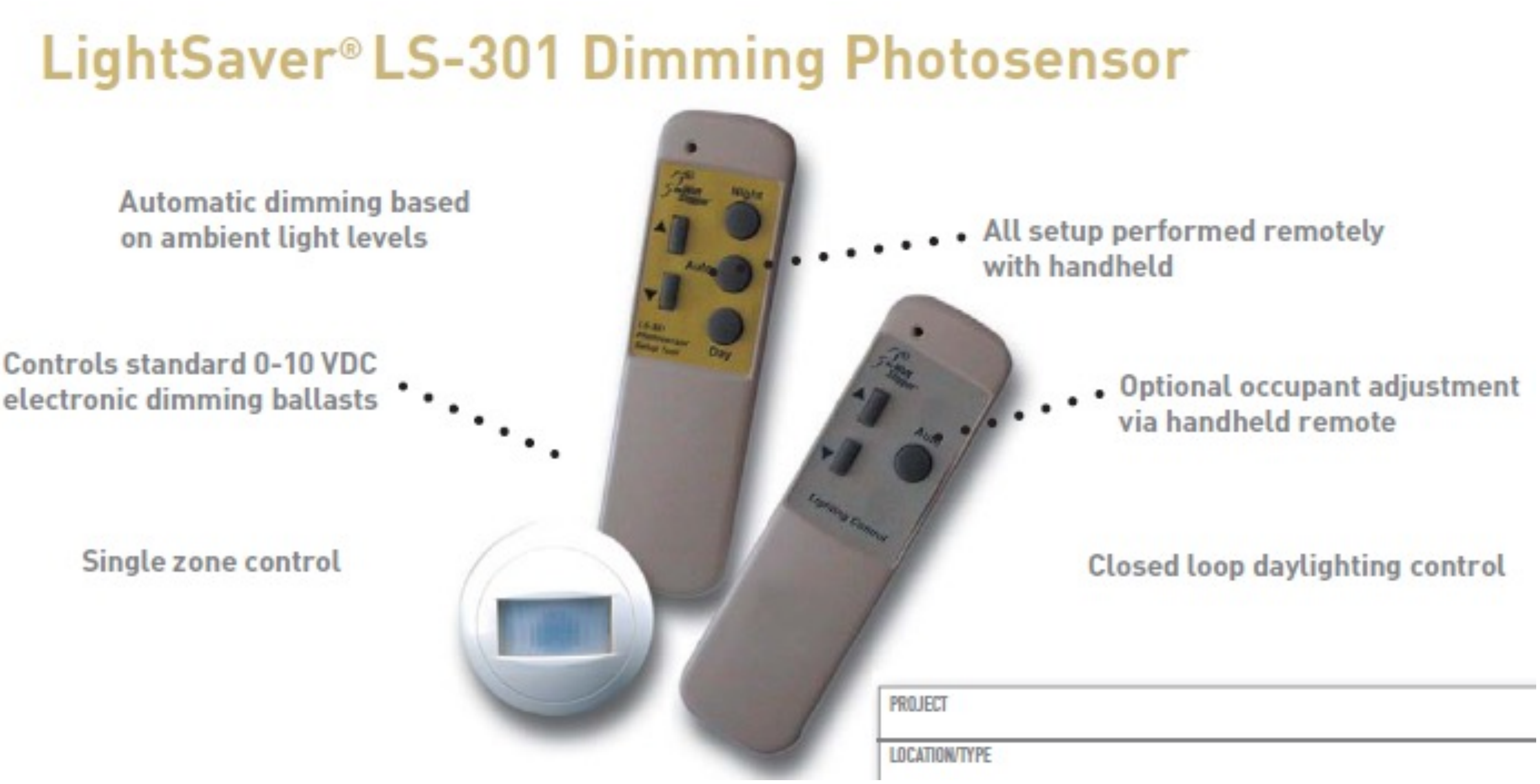
Photosensors – Daylighting control



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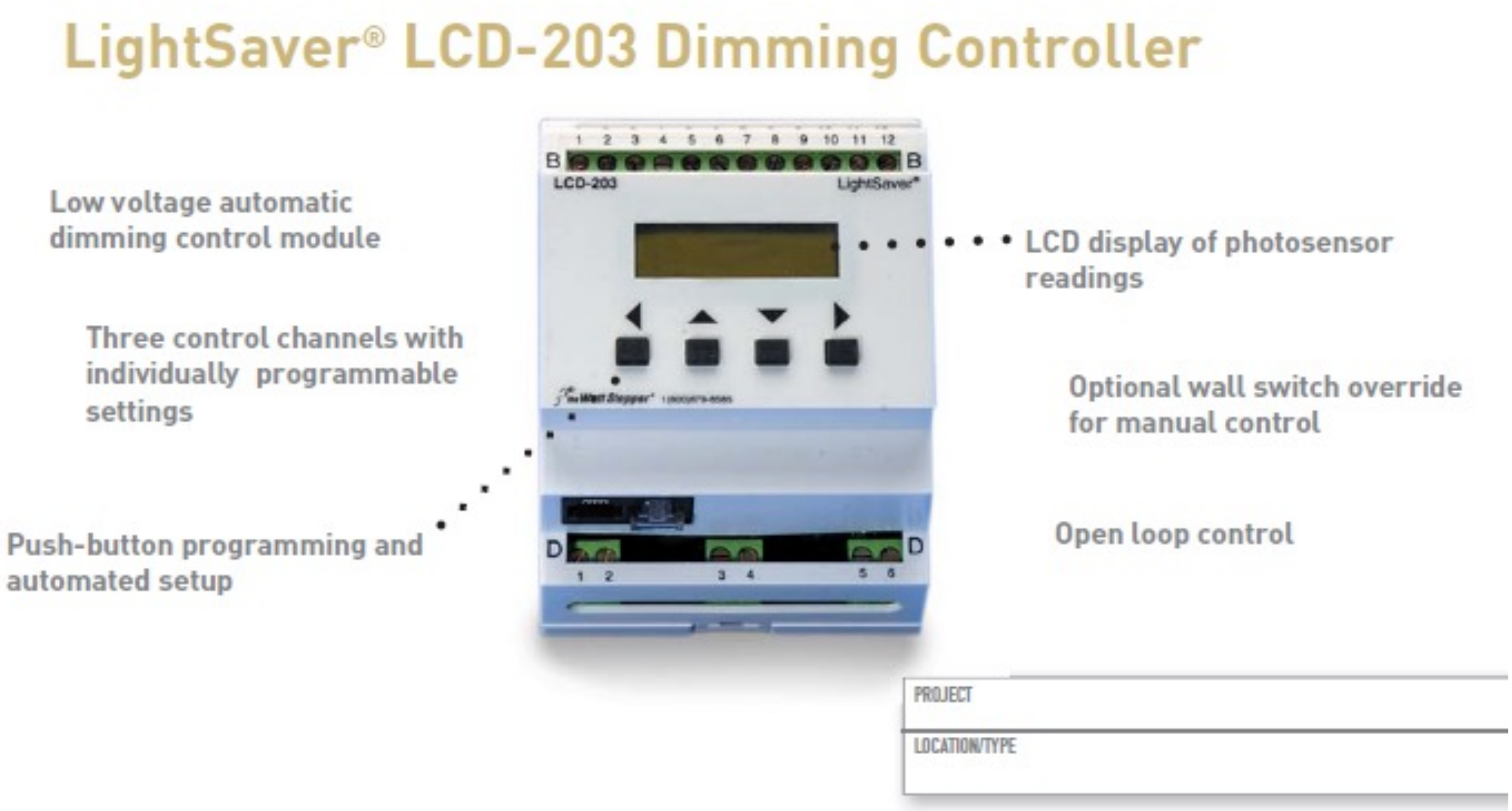
Photosensors – Daylighting control



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Applications: discuss w/students

Control tech.	kW	time	application
Manual controls		↓	
BMS	↓	↓	
Timers		↓	
Occupancy sensors		↓	
Manual dimmers	↓		
Photosensors	↓	↓	

Bi-level switching

- Controlling all lamps or fixtures
- Dual switching alternate rows, fixtures or lamps
- Switching middle lamp independent of outer lamps (3-lamp fixtures)
- Switching each fixture or each lamp

Applications: discuss w/students

Control tech.	kW	time	application
Manual controls		↓	
BMS	↓	↓	
Timers		↓	
Occupancy sensors		↓	
Manual dimmers	↓		
Photosensors	↓	↓	
Bi-level switching	↓		
Combinations	↓	↓	

Labs: Strongly suggested free hands-on lighting control workshop at SMUD or PEC

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Classes and Seminars

Hands-on Lighting Control Workshop

Pre-registration required.
Class space is limited.

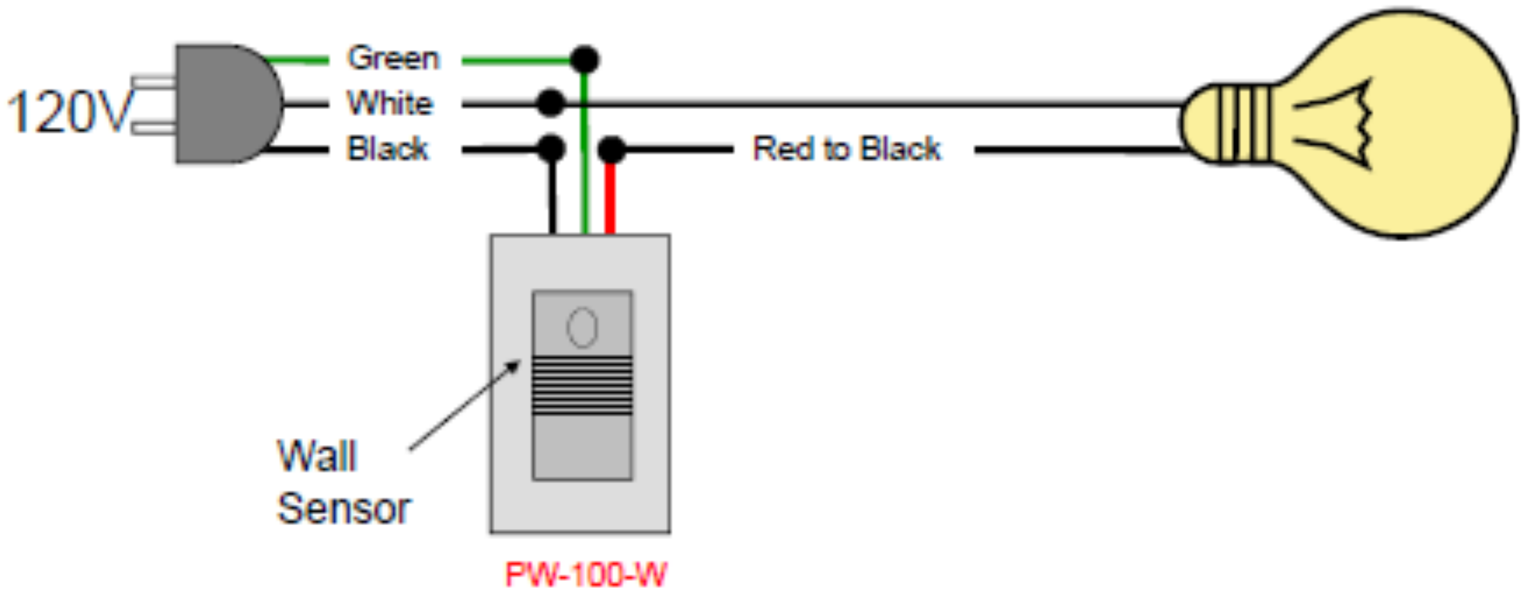
Date:	TBD
Time:	**8:30 a.m. - 4:00 p.m.**
Fee:	**$ 0.00**
Presenter:	
Location:	**CSC 6301 S Street** (Map) **Rubicon Meeting Room** Sacramento, CA
Questions:	Contact: **Connie Samla** Connie Samla

Class Description:
If you have ever wondered how a lighting control system really works or what a wiring diagram really means you will enjoy this one-day hands-on workshop. Every participant will wire up several control devices via deciphering wiring diagrams, identifying and locating the equipment, connecting wires with the end result of electrifying the final product and getting the satisfaction of a working device. Lighting controls identified in this workshop include: wall box devices, occupancy sensors, photosensors, low-voltage relay systems, and more. Seating is limited. (AIA HSWs and LC CEUs available.)

Add Course

Labs: Strongly suggested free hands-on lighting control workshop at SMUD

PIR wallbox sensor, single-pole



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Energy saving equation

Power = The Rate of Consumption kilowatts kW

Time = The Duration of Consumption

Energy = Power X Time

= Total Consumption in Kilowatt hours kWh

Control strategy: regulate the rate of consumption (power),

or the duration of consumption (time), or both.

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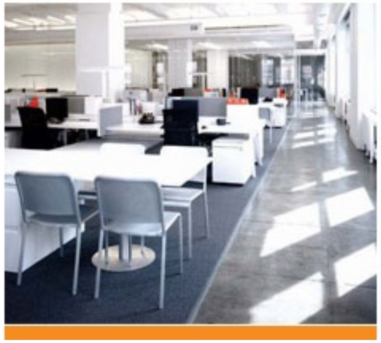
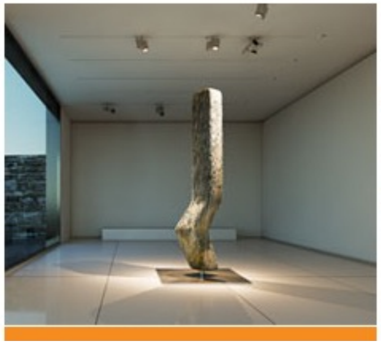
Advanced Lighting guidelines

CONTROL STRATEGY	EXAMPLES	AVERAGE SAVINGS
Institutional Tuning	High-end trim dimming (ballast tuning), task tuning, lumen maintenance, provision of controls for areas/groups of occupants	36%
Personal Tuning	Dimmers, wireless switches, bi-level switches, computer based controls (for personal offices, workstation-specific lighting, classrooms)	31%
Daylighting	Photosensors	28%
Occupancy	Occupancy sensors, time clocks, EMS	24%
Multiple Strategies	Any combination of the above	38%






Case study :

An air compressor room is lit by 9 F32-T8 2-lamp fixtures. According to maintenance, these lights are left on during plant operating hours even though the area is rarely occupied.

Recommendation
Installing an occupancy sensor wall switch at both entrances to the room.

Estimated Savings
According to product description, their F32T8 2-lamp fixture draws about 66 Watts. Maintenance estimates that the lights are currently on for 24 hours per day, 6 days per week and 51 weeks per year, but really only should be on for about 2 hours per day. If so, the electrical energy savings from turning the lights off when not needed would be about:

9 fixtures x 0.066 kW/fixture x 22 hrs/day x 6 days/week x 51 weeks/year = 3,999kWh/year
3,999 kWh/year x $0.10 /kWh = $399.9 /year

Case study :

9 fixtures x 0.066 kW/fixture x 22 hrs/day x 6 days/week x 51 weeks/year = 3,999kWh/year
3,999 kWh/year x $0.10 /kWh = $399.9 /year

An infrared occupancy sensor wall switch costs about $85. Thus, the material cost of two sensors would be about:
$85 /sensor x 2 sensors = $170

Maintenance estimates that it would take about 2 hours to install both sensors. Thus, at a labor rate of about $40 per hour, the labor cost of installing the sensors would be about:
2 hours x $40 /hour = $ 80

Thus, the total implementation cost would be about $250.

Estimated Simple Payback
$250/ $399.9 /year x 12 months/year = 7.5months

Homework 2 and prepare for presentation

Homework:

- Check classroom, hallway, bathrooms, and conference in the building

- Identify lighting control strategies in those spaces

Presentation (at the end of the class):

- Identify problem or improvement to current controls

- EEM possibility, calculate energy savings and financial analysis

Homework project

Design lighting control strategies for a campus space: e.g. conference room, hall way, restroom, classroom, office. Requirement:

• choose the right type(s) of controls, explain why.

• choose the proper physical place to install, explain why.

• each student will have 5-10 minutes to discuss his/her design with the class.

Useful links:

Products and information:

www.wattstopper.com
www.leviton.com

Reading materials:
http://www.wattstopper.com/~/media/54657AD8625A42D480105F9D26B9272F.ashx

http://www.wattstopper.com/~/media/8C20C6401B034957B32099D2AE87642A.ashx

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