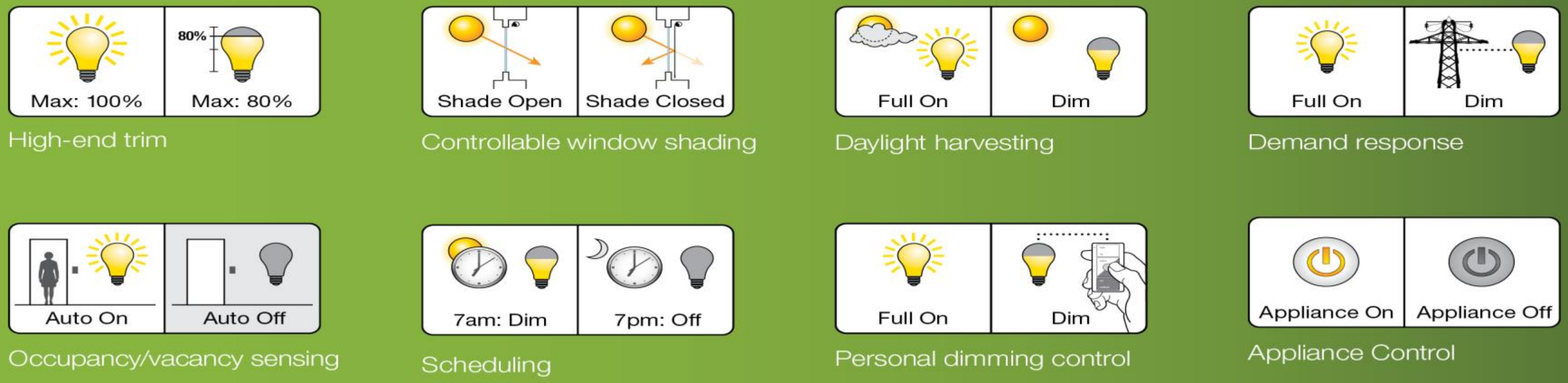
Maximizing Energy Savings with New Technologies in Lighting and Lighting Controls

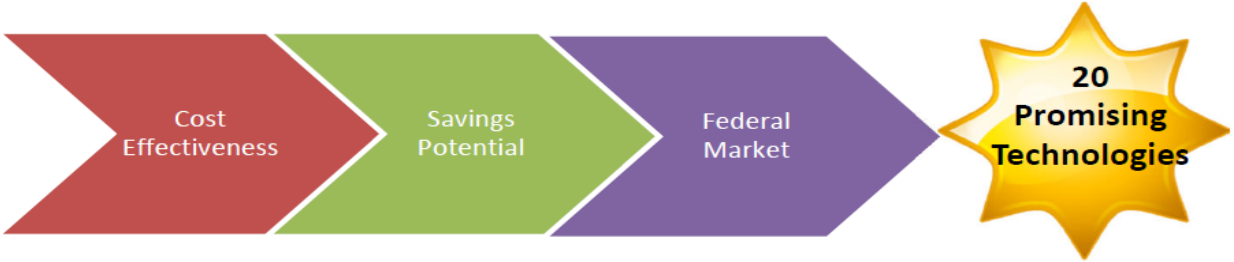


Mike Matour, National Sales Manager - Energy
Lutron Electronics

Agenda

- FEMP Promising Technologies
- Today’s Lighting Controls
- Why Controls?
- New Technologies - Wireless Solutions
- New Technologies - Advanced Controls
- LEDs – How to control?

Promising Technologies List



The Federal Energy Management Program's (FEMP) Promising Technologies List provides information about promising new and underutilized energy-saving technologies available for Federal and commercial building sector deployment. To identify promising technologies, FEMP performed a rigorous analysis with the Prioritization Tool, an analytical tool developed by the Building Technologies Office (BTO). The BTO Prioritization Tool evaluates the energy savings potential of energy efficiency measures, and takes into account cost-effectiveness. FEMP has used the Prioritization Tool to identify 20 technologies with the largest potential for cost-effective energy savings if deployed throughout the Federal Sector.

For More information about the BTO Prioritization Tool, visit
http://energy.gov/eere/buildings/prioritization-tool

Promising Technologies

Lighting
- Wireless Lighting Occupancy Sensors
- Parabolic Aluminized Reflector (PAR) Light-Emitting Diodes (LEDs)
- Parking Lot LEDs with Controls
- High Bay LEDs
- Retrofit Lights to LEDs in Refrigerators

Heating & Cooling
- Ground Source Heat Pumps
- High Efficiency Rooftop Units (RTUs)
- Magnetic Bearing Variable Speed Centrifugal Chillers
- Condensing Gas Boilers

Ventilation
- Demand Control Ventilation (DCV)
- Constant Air Volume (CAV) to Variable Air Volume (VAV) Ventilation
- Energy Recovery Ventilation (ERV)

Water Heating
- Condensing Gas Water Heaters
- Heat Pump Water Heaters
- Tankless Gas Water Heater s

Windows and Envelope
- R-5 Window Replacements
- Cool Roofs (.75 Solar Reflectance)
- Cool Paints for Exterior Walls

Other
- Ozone Laundry Systems for Multi-Clothes Washers
- Auto Sash Fume Hoods

#1

ENERGY.GOV
Office of Energy Efficiency & Renewable Energy

SERVICES | EFFICIENCY | RENEWABLES | TRANSPORTATION | ABOUT US | OFFICES

Wireless Lighting Occupancy Sensors

Occupancy sensors and controls detect human presence, and modulate light settings accordingly. When there is no human presence detected, the system can dim or turn off lights. This technology ensures that lights are not used when there are no occupants present, which can lead to significant energy savings.

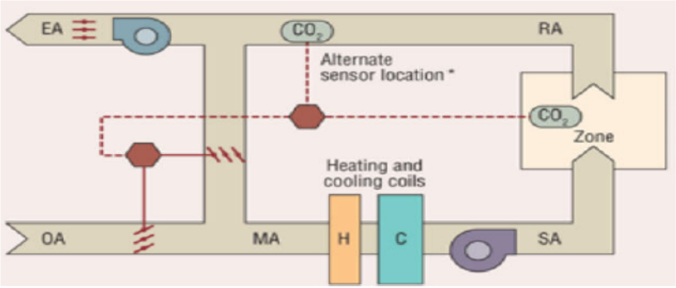
• Site Energy Savings Potential for the Federal Sector (Trillion-BTUs)	6.9
• Avoided Carbon Dioxide Emissions Potential (Million-Tons)	1.2

Implementation of this measure across the Federal Sector would provide energy savings ***equivalent to the site energy consumption of 5,000 average sized office buildings****.*

Technology Considerations

- There are multiple suppliers
- Optimal for buildings with long operating hours
- Applicable to any building type and location
- Has been shown to reduce lighting energy consumption 27% to 63%

Demand Control Ventilation (DCV)



DCV measures carbon dioxide concentrations in return air or other strategies to measure occupancy, and accurately matches the ventilation requirement. This system reduces ventilation when spaces are vacant or at lower than peak occupancy. When ventilation is reduced, energy savings are accrued because it is not necessary to heat, cool, or dehumidify as much outside air.

• Site Energy Savings Potential for the Federal Sector (Trillion-BTUs)	14.4
• Avoided Carbon Dioxide Emissions Potential (Million-Tons)	1.4

Implementation of this measure across the Federal Sector would provide energy savings ***equivalent to the site energy consumption of 10,400 average sized office buildings****.*

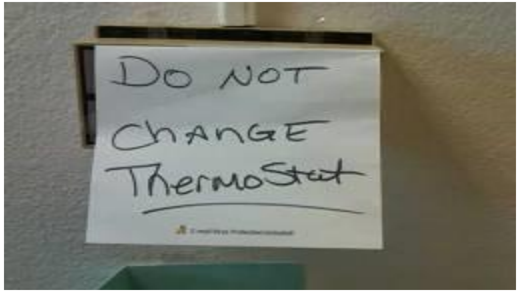
Technology Considerations

- There are multiple suppliers
- Applicable to all building types and locations, though savings will vary according to building characteristics and climate
- Has been shown to reduce energy costs 38% in an office building

Single Zone Lighting Controls

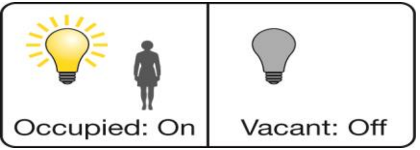
Multi-Zone Lighting Controls

Advanced Lighting & HVAC Control Systems

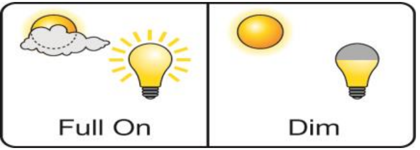


Total Light Management

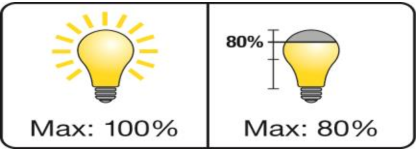
8 Simple Light Control Strategies / ECMs



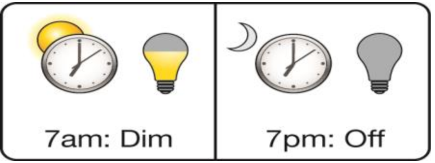
Occupancy/Vacancy Sensing: Automatically turn lights off or dim down when space is vacant. Integrate HVAC locally/digitally.



Daylight Harvesting: Automatically adjust light levels based on the amount of daylight in the space.

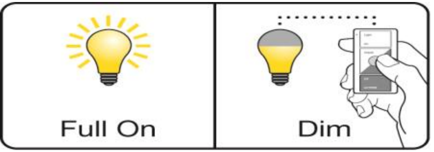


High end trim/Tuning: Set target light level based on occupant requirements in the space.

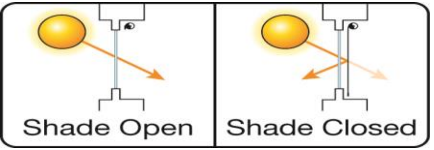


Scheduling: Lights automatically turn off or are dimmed at certain times of the day or based on sunrise or sunset.

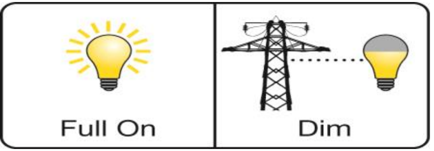
8 Simple Light Control Strategies / ECMs (cont)



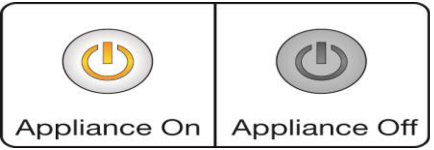
Personal Light Control: Allow users in the space to select the correct light levels for the desired task.



Controllable Window Shades: Allows users to control daylight for reduced solar heat gain and glare.



Demand Response: Reducing lighting load at times of peak electricity pricing. Reduce HVAC load at Peak Times.



Plug-load Control: Automatically turning task lighting and other plug loads off when they are not needed.

Why Lighting Controls?

Quantifiable

- Tuning / Dimming
- Occupant Sensing
- Day-lighting
- Personal Control
- HVAC Savings
- Window Shading
- Demand Response
- Plug Load Control

Other Benefits

- Productivity
- Maintenance
- Sustainability/LEED
- Property Value
- Flexibility

Total Light Management - Case Study

New York Times

•Measured LPD, Lighting Power Density

– Designed at 1.28 W/ft2

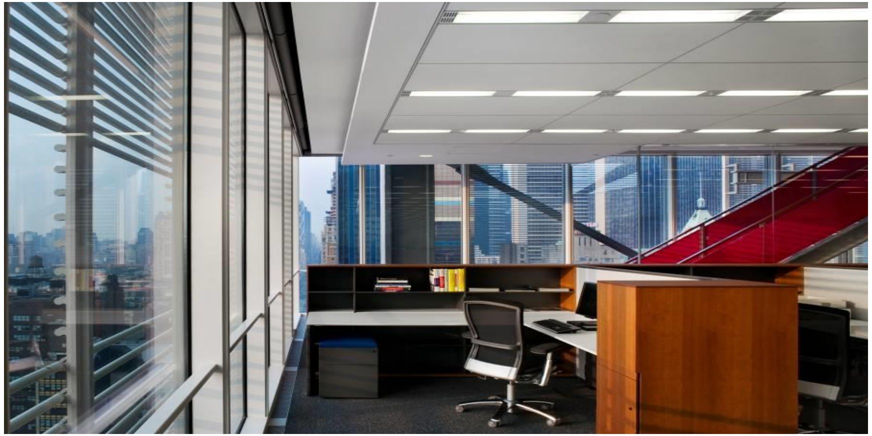
– Operating at 0.36 W/ft2

•Seasonal data reflects yearly lighting energy savings of <u>72%</u>

•Annual Energy Savings:

5,220 MWh

10.7 kWh/ft^2



"We designed our building to use 1.28 watts per square foot of lighting power," Hughes said. "With Quantum, The New York Times Company is using only 0.36"

"Glenn Hughes, Director of Construction for the New York Times Building"

Data from the U.S. Environmental Protection Agency

What data exists to support 15%-70% savings?

Occupancy Area	Energy Savings
Private Office	13-50%
Classroom	40-46%
Conference Room	22-65%
Restrooms	30-90%
Corridors	30-80%
Storage Areas	45-80%

Daylight Harvesting

What data exists to support 20%-40% savings?

- **51% lighting energy savings**

Sidelighting Photocontrols Field Study. Heschong Mahone, 2003

- **24% savings in open and private offices**

The Potential Simplified Concepts for Daylight Harvesting. Lighting Research Center; http://www.lrc.rpi.edu/programs/daylighting/pdf/simplifiedConcepts.pdf

- **40% lighting energy savings**

Sidelighting – Daylighting Requirements for Sidelit Areas near Windows. July 2006, PG&E

Dimming

<u>High-end Tuning/Dimming Savings</u>

- High End Trim   (programmed at install)   20%- 40%
- Light Level Tuning (managed by area)   10%- 20%

<u>Plug Loads</u>

Total of All Product Stand-by Loads

•100% during After hours

•% of Occupancy during Normal Hours

Personal Control

Personal Dimming Control: 10%

What data exists to support 10% savings?

- Light Right Consortium and National Research Council of Canada – 15% energy savings with a sample size of over 500 people
- Individual Lighting Control: Task Performance Mood & Illuminance: Lighting Research Center.
- http://www.lrc.rpi.edu/resources/pdf/67-1999.pdf : 35-42% savings

UFC – Energy Savings

UFC 3-530-01
22 August 2006
Including Change 2, 1 September 2012

UNIFIED FACILITIES CRITERIA (UFC)

Design: Interior, Exterior
Lighting and Controls

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

UFC 3-530-01
22 August 2006
Including Change 2, 1 September 2012

Table 2-4. Lighting Control Energy Savings Examples by Application and Control Type[5]

Space Type	Controls Type	Lighting Energy Savings (Demonstrated in Research or Estimated as Potential)	Study Reference
Private Office	Occupancy sensor	38%	*An Analysis of the Energy and Cost Savings Potential of Occupancy Sensors for Commercial Lighting Systems*, Lighting Research Center/EPA, August 2000.
	Multilevel switching	22%	*Lighting Controls Effectiveness Assessment*, ADM Associates for Heschong Mahone Group, May 2002.
	Manual dimming	6-9%	*Occupant Use of Manual Lighting Controls in Private Offices*, IESNA Paper #34, Lighting Research Center.
	Daylight harvesting (sidelighting)	50% (manual blinds) to 70% (optimally used manual blinds or automatic shading system)	"Effect of interior design on the daylight availability in open plan offices", by Reinhart, CF, National Research Council of Canada, Internal Report NRCC-45374, 2002.
Open Office	Occupancy sensors	35%	National Research Council study on integrated lighting controls in open office, 2007.
	Multilevel switching	16%	*Lighting Controls Effectiveness Assessment*, ADM Associates for Heschong Mahone Group, May 2002.
	Daylight harvesting (sidelighting)	40%	"Effect of interior design on the daylight availability in open plan offices", by Reinhart, CF, National Research Council of Canada, Internal Report NRCC-45374, 2002.
	Personal dimming control	11%	National Research Council study on integrated lighting controls in open office, 2007.
Classroom	Occupancy sensor	55%	*An Analysis of the Energy and Cost Savings Potential of Occupancy Sensors for Commercial Lighting Systems*, Lighting Research Center/EPA, August 2000.
	Multilevel switching	8%	*Lighting Controls Effectiveness Assessment*, ADM Associates for Heschong Mahone Group, May 2002.
	Daylight harvesting (sidelighting)	50%	*Sidelighting Photocontrols Field Study*, Heschong Mahone Group, 2003.

GSA PBS-P100

PBS-P100

GSA

PBS-P100

Facilities Standards

for the

Public Buildings Service

General Services Administration

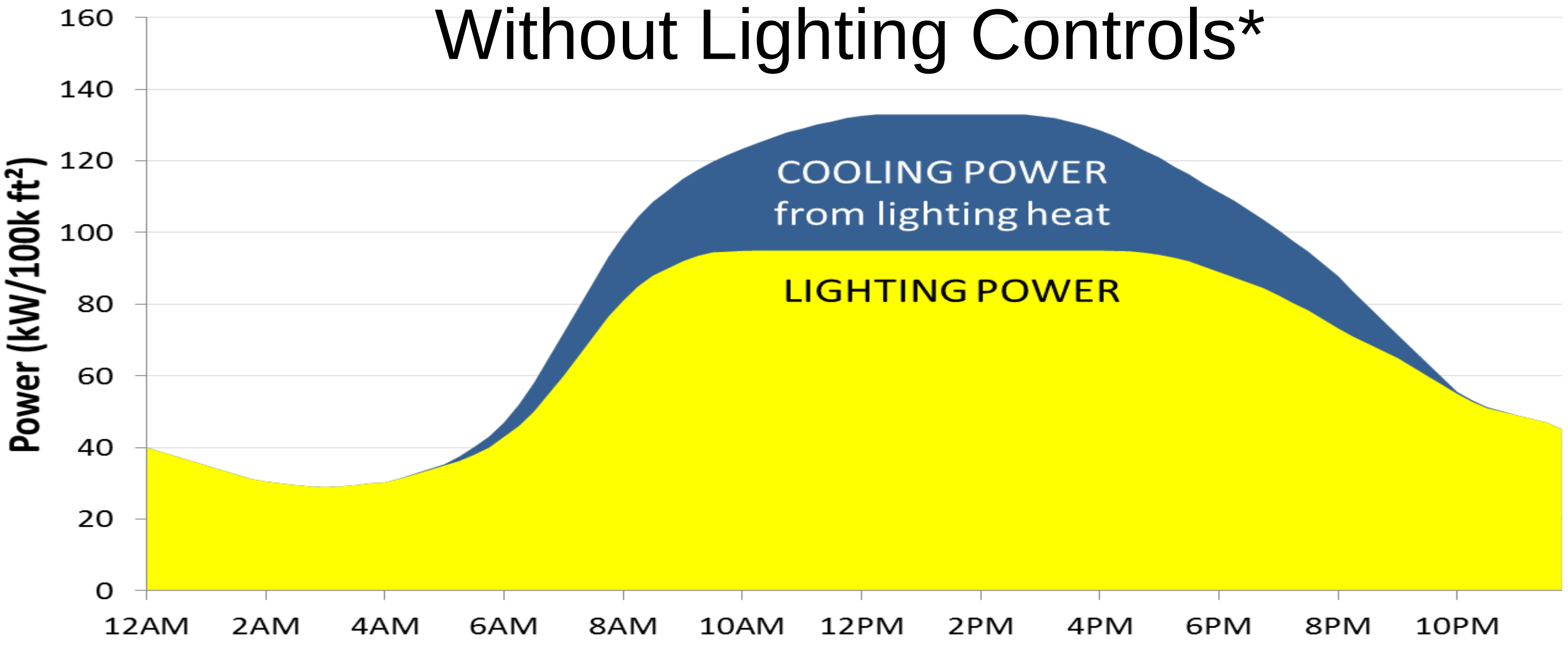
GSA P-100 Version 1.0, issued March 2014 Page 1

6.3.2.5 Lighting Controls

Control systems must be compatible with lamps, light sources, ballasts and lamps.

Lighting controls must use individual luminaire control, such as DALI equivalent. Ambient lighting must be adjusted per daylight availability, occupant/vacancy, and other BAS signals, such as demand response. Task and personalized ambient lighting must be adjusted per occupancy/vacancy and personal dimming.

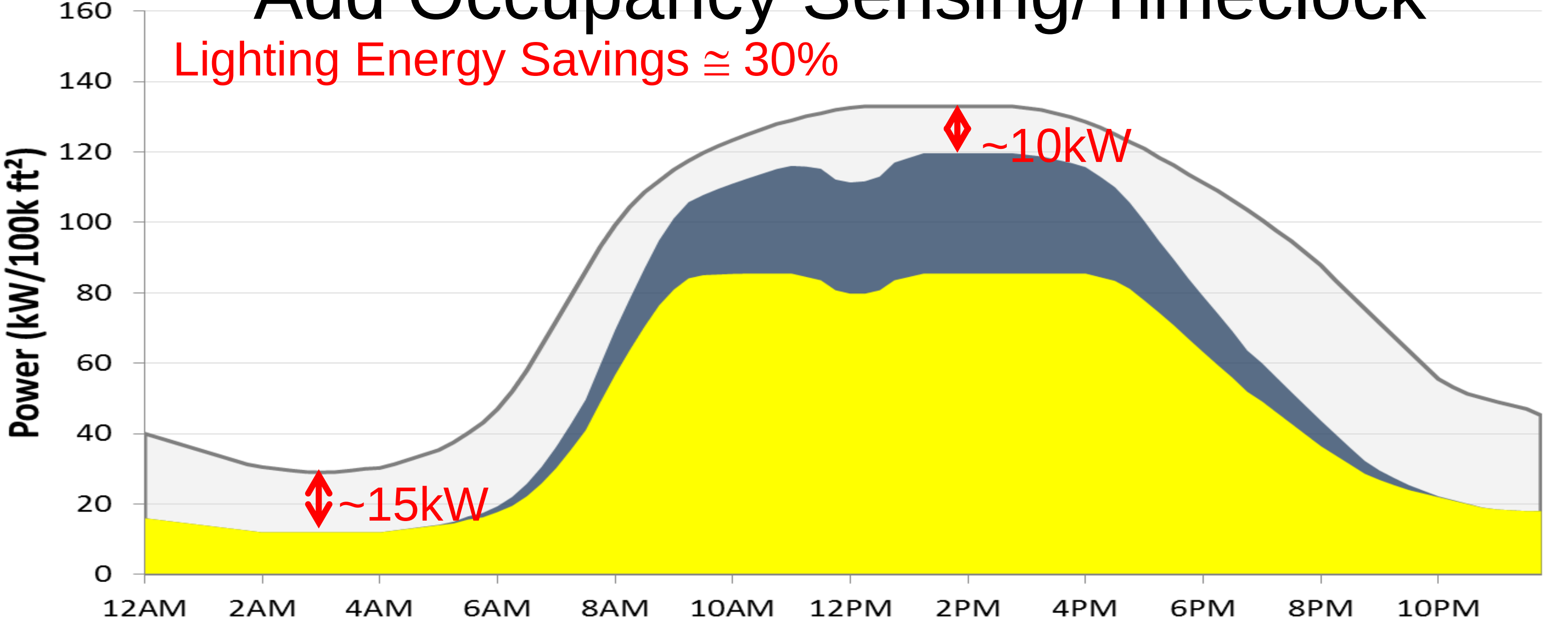
Peak Savings versus Energy Savings



*Lighting power base on typical lighting load profile according to ASHRAE lighting schedules. Cooling power based on a minimum coefficient of performance of 3, which is not reached until mid-day.

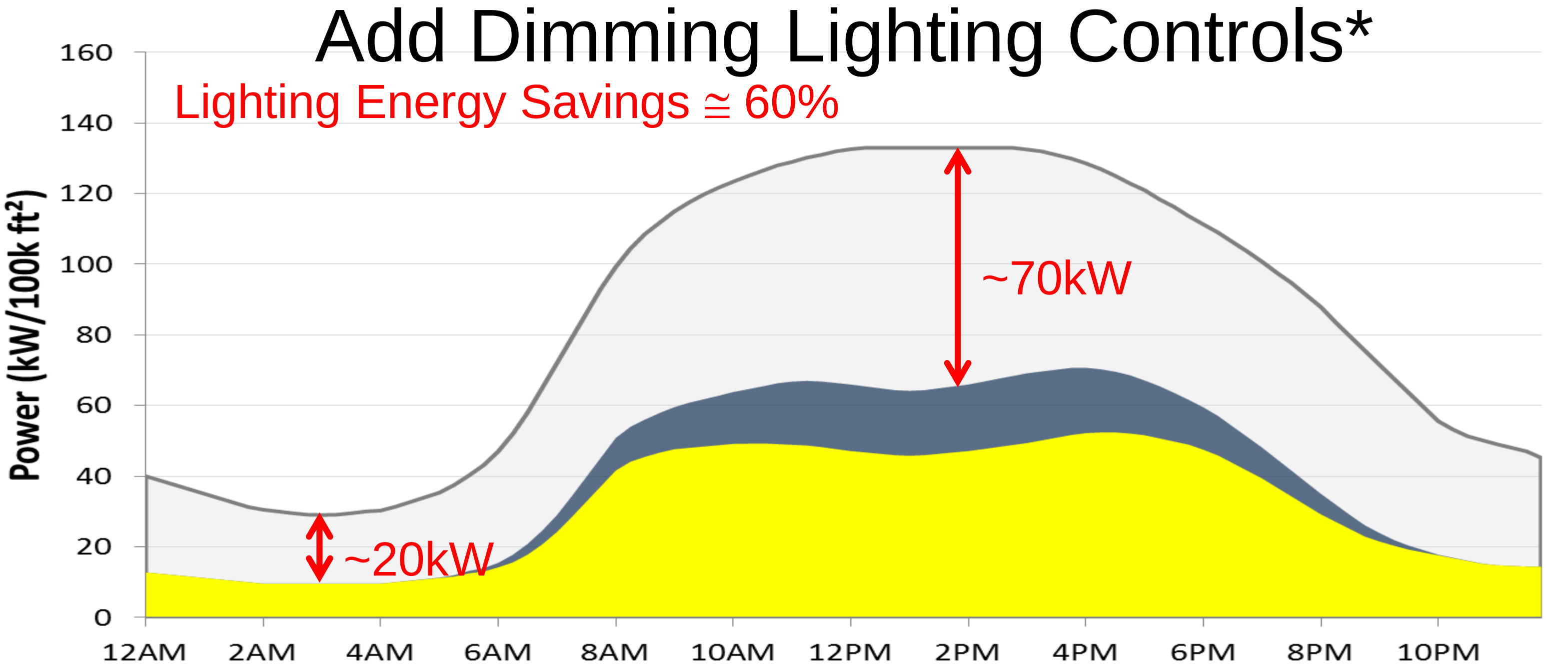
Peak Savings versus Energy Savings

Add Occupancy Sensing/Timeclock*



*Lighting power profile derived from 10 typical Lutron projects ranging in location from New York City, Portland, Boston, and Philadelphia. Cooling power based on a minimum coefficient of performance … reached until mid-day.

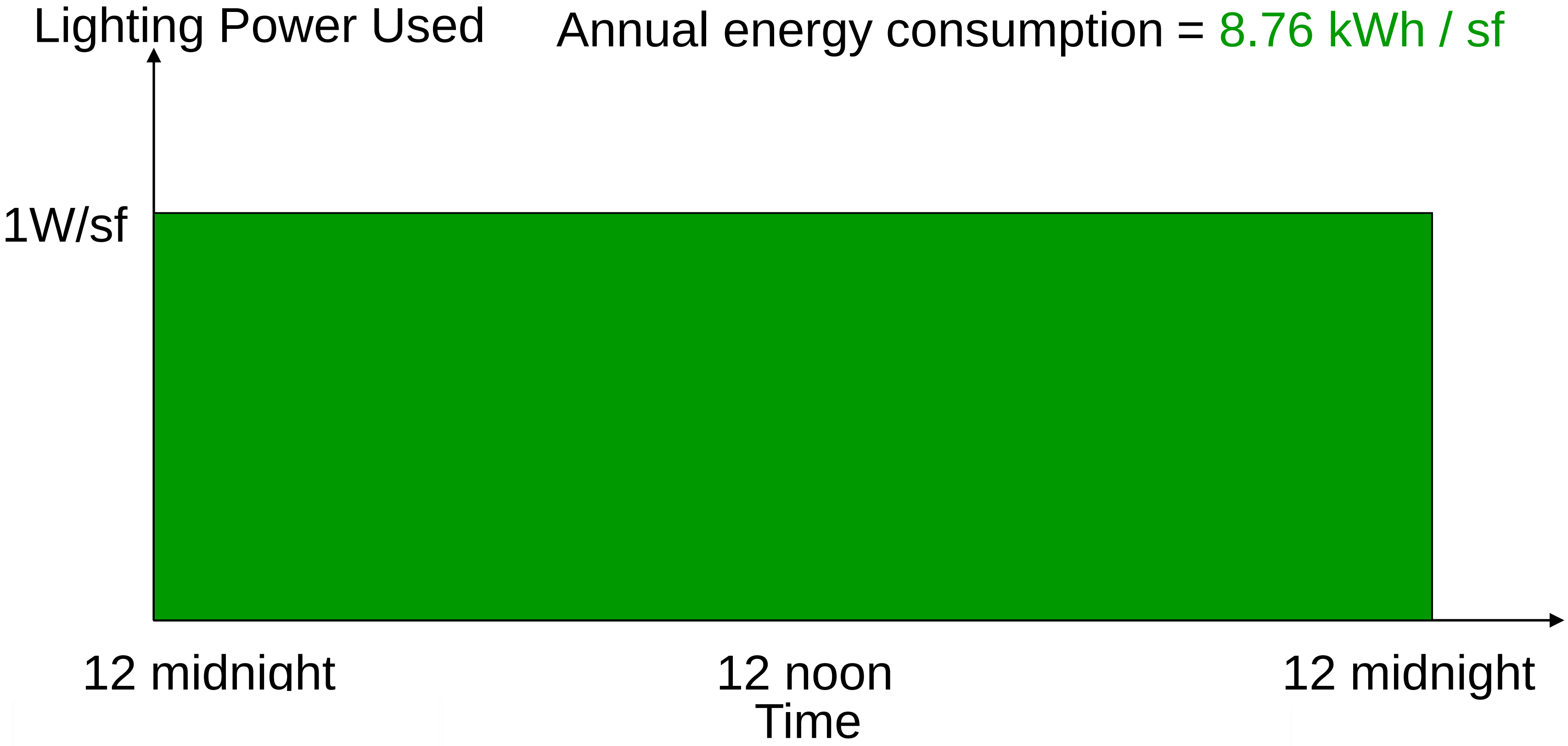
Peak Savings versus Energy Savings



*Lighting power profile derived from 10 typical Lutron projects ranging in location from New York City, Portland, Boston, and Philadelphia. Cooling power based on a minimum coefficient of performance of 3, which is not reached until mid-day.

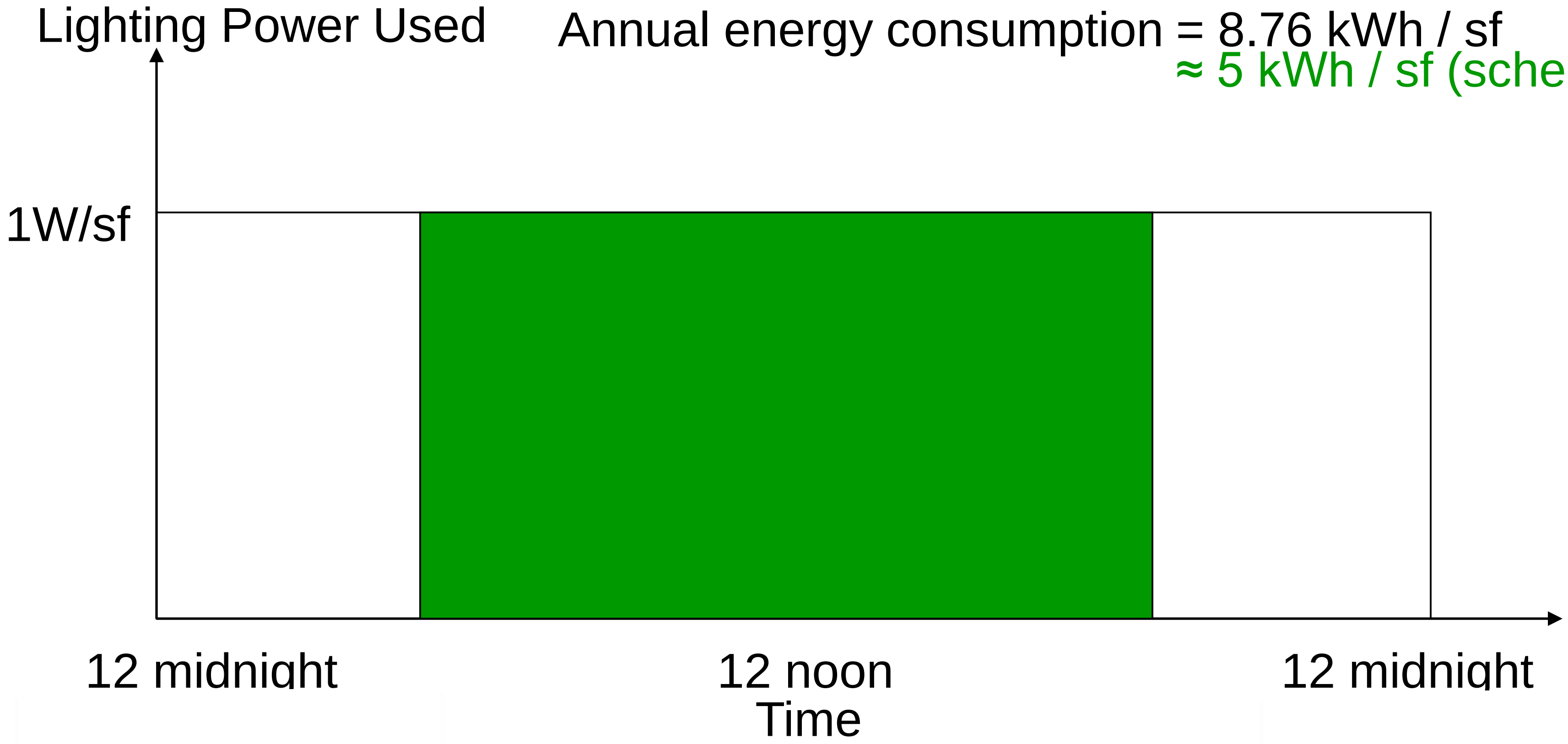
Potential Energy Savings

Annual energy consumption = 8.76 kWh / sf

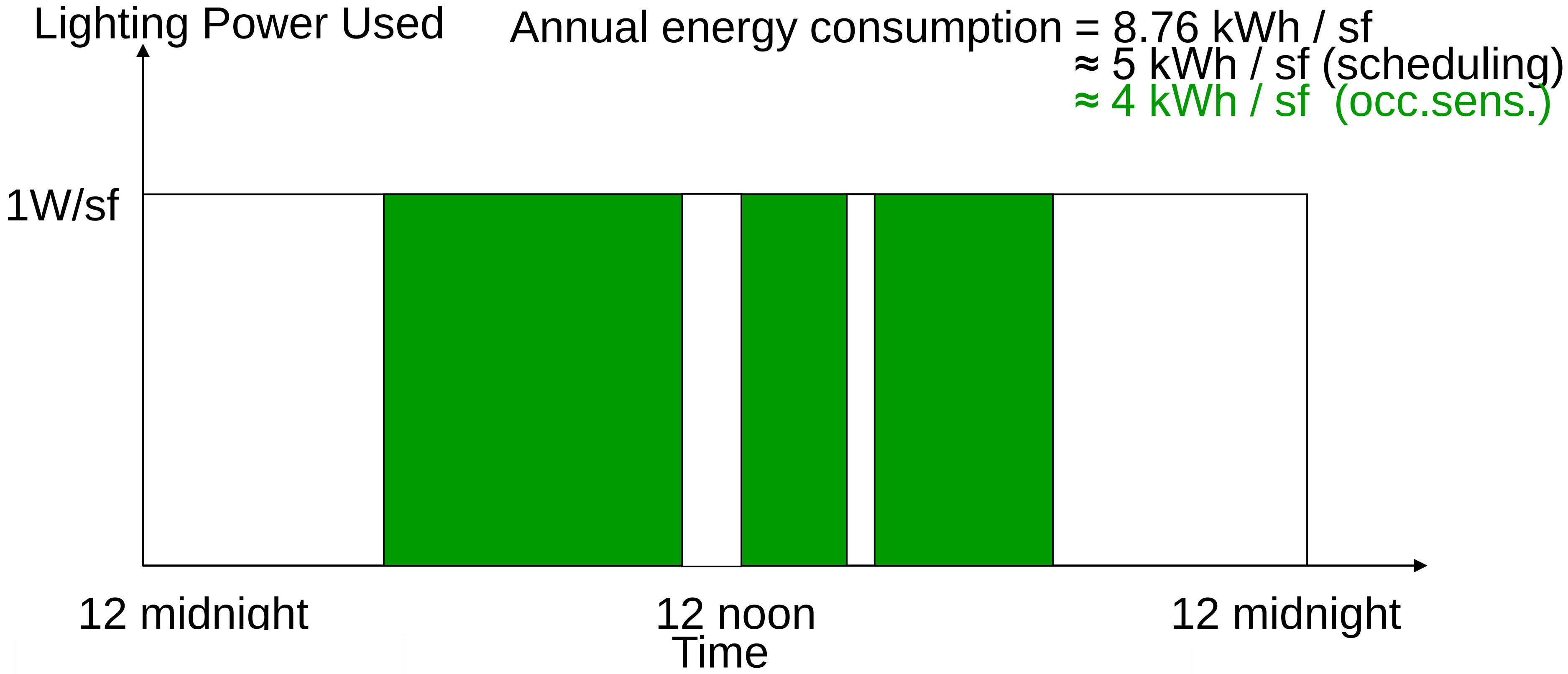


Potential Energy Savings

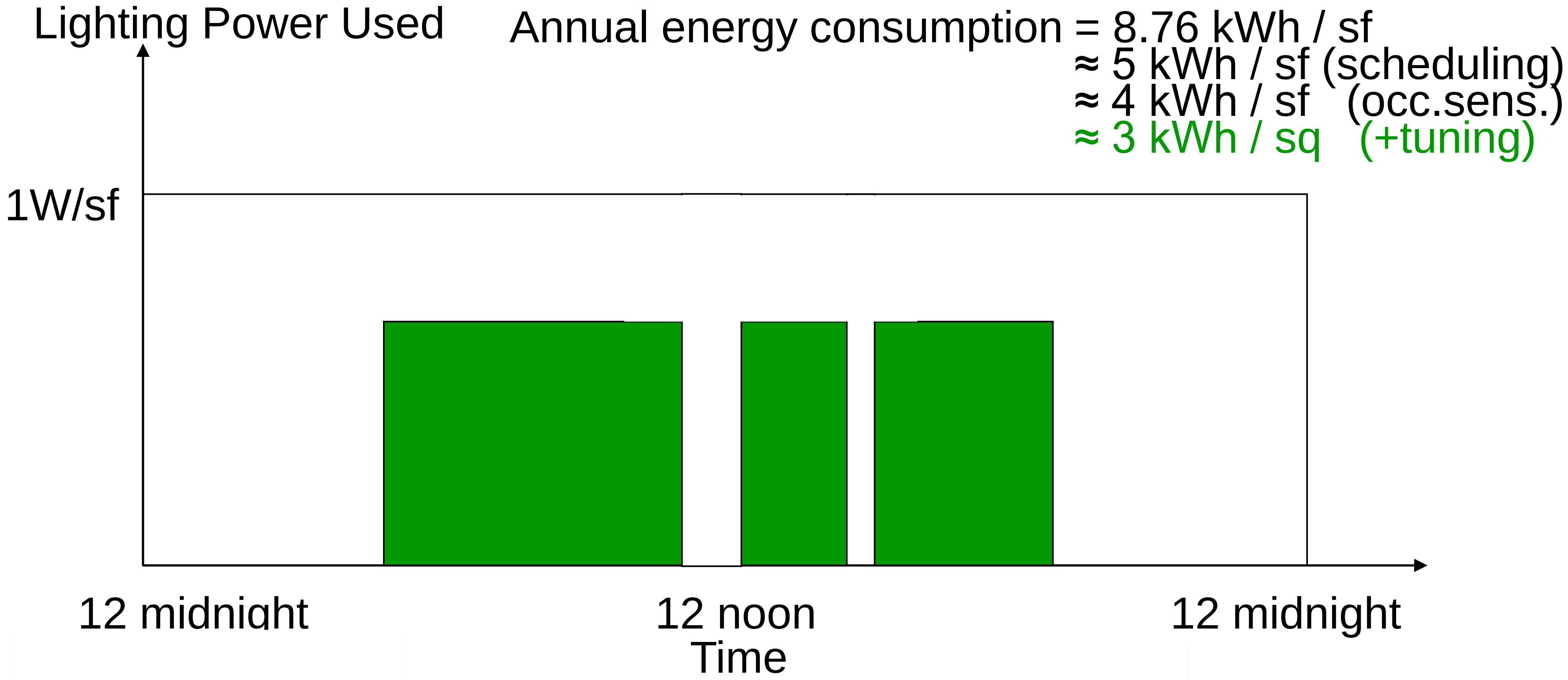
Annual energy consumption = 8.76 kWh / sf
≈ 5 kWh / sf (scheduling)



Potential Energy Savings

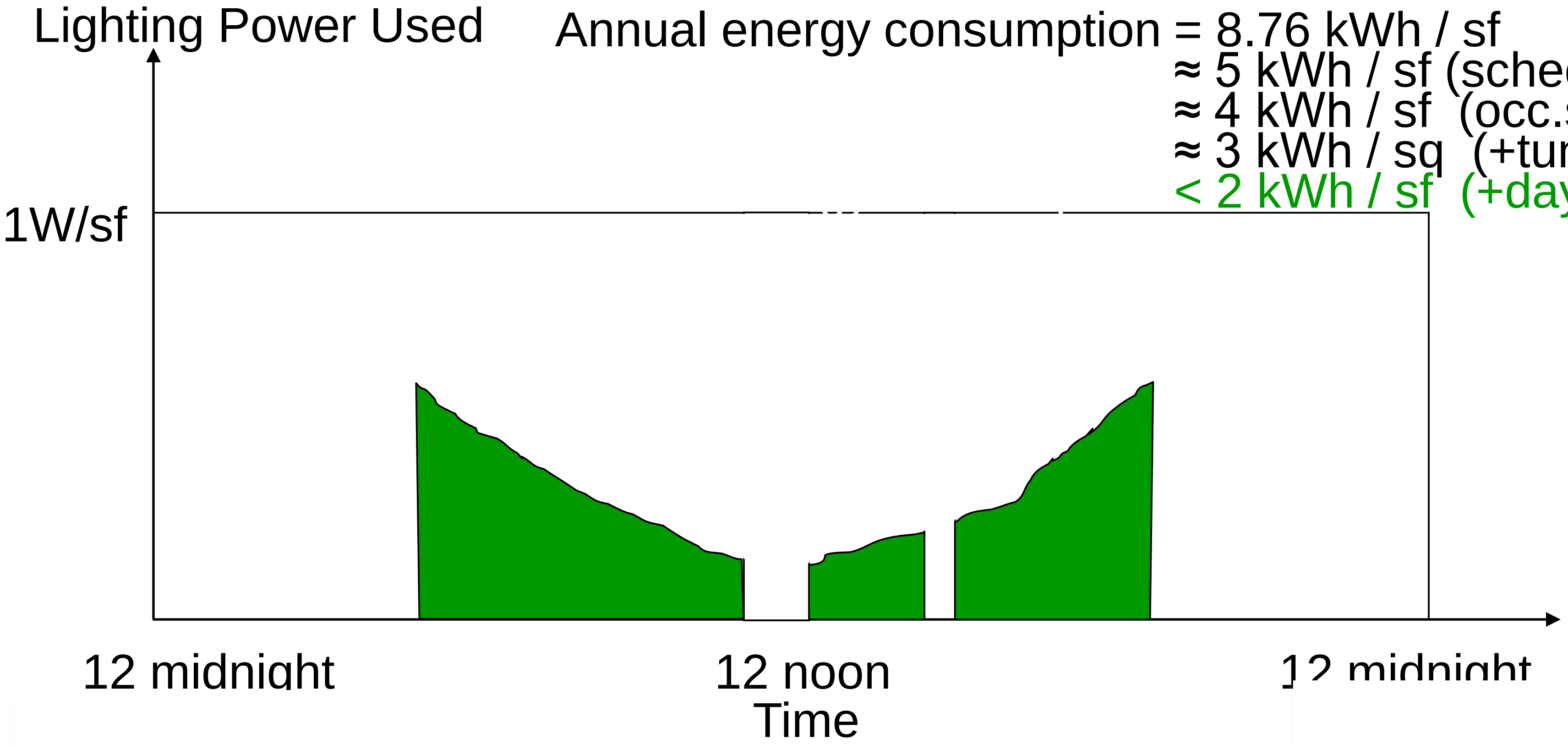


Potential Energy Savings

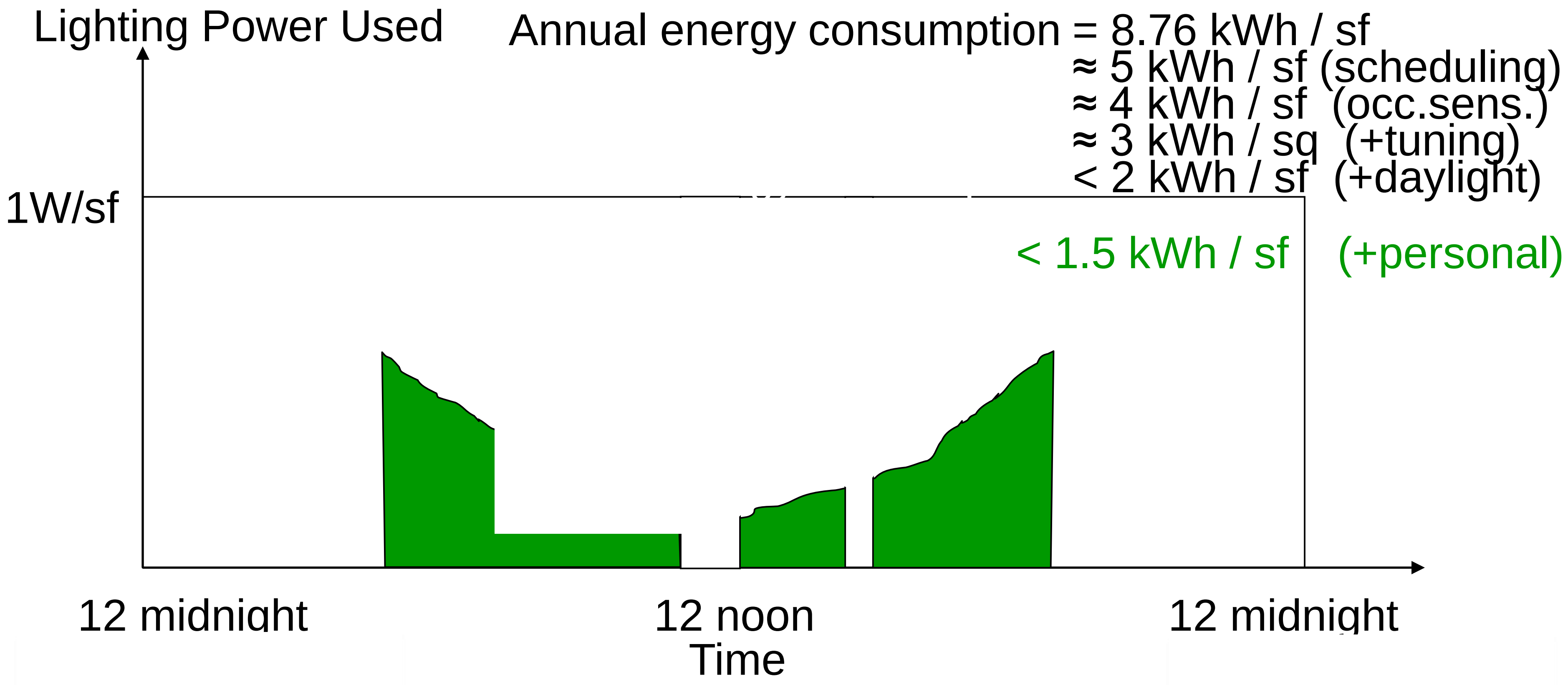


Potential Energy Savings

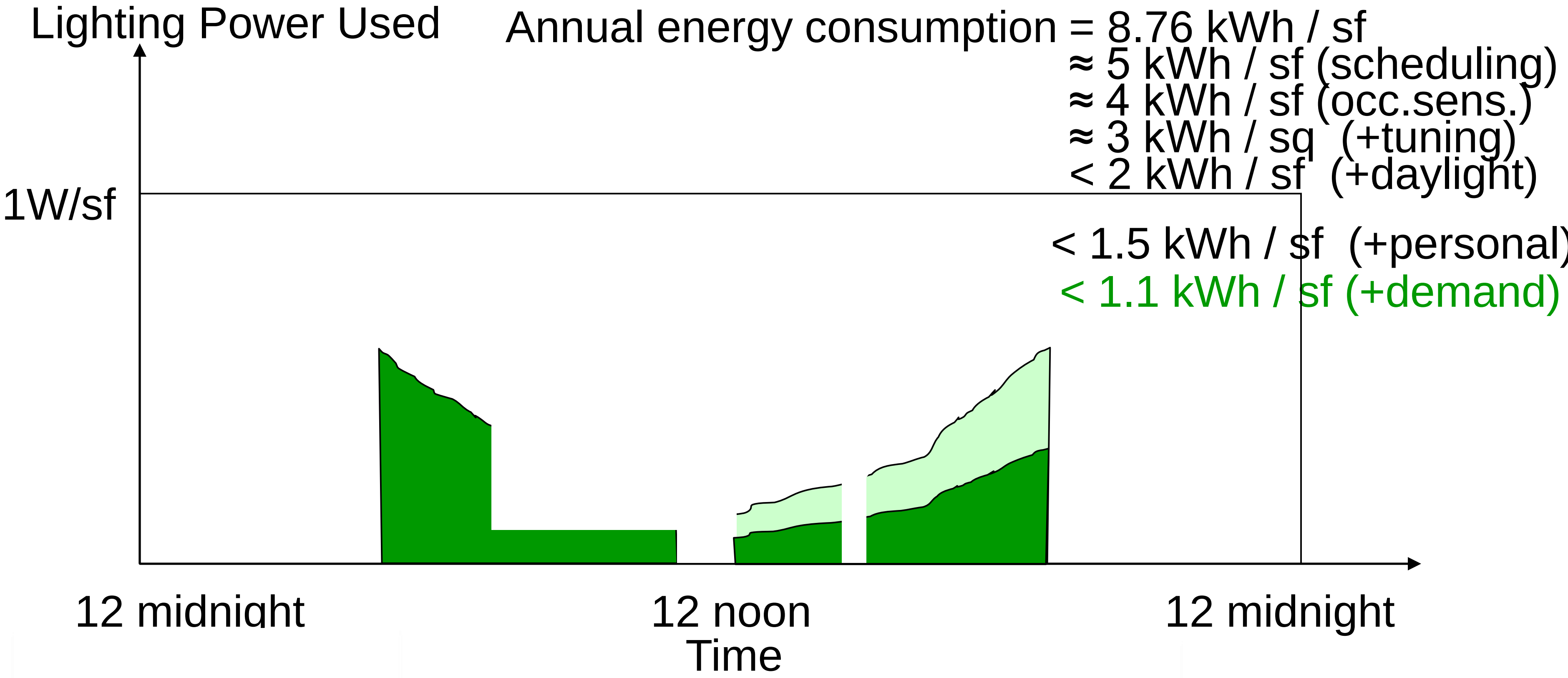
Annual energy consumption = 8.76 kWh / sf
≈ 5 kWh / sf (scheduling)
≈ 4 kWh / sf (occ.sens.)
≈ 3 kWh / sq (+tuning)
< 2 kWh / sf (+daylight)



Potential Energy Savings



Potential Energy Savings



Application – Private Office

For an executive office application, personal control of light levels is of utmost importance. Independent research indicates that occupants are up to 15% more productive when they can tailor the lighting to their needs.*

* Light Consortium. Research Study on the Effects of Lighting on Office Workers. http://www.lightright.org.research/index.htm

Solution components

- Maestro Wireless® Switch
- Radio Powr Savr™ wireless occupancy sensor, ceiling-mount
- Pico® wireless control, 2-button

Return on Investment:

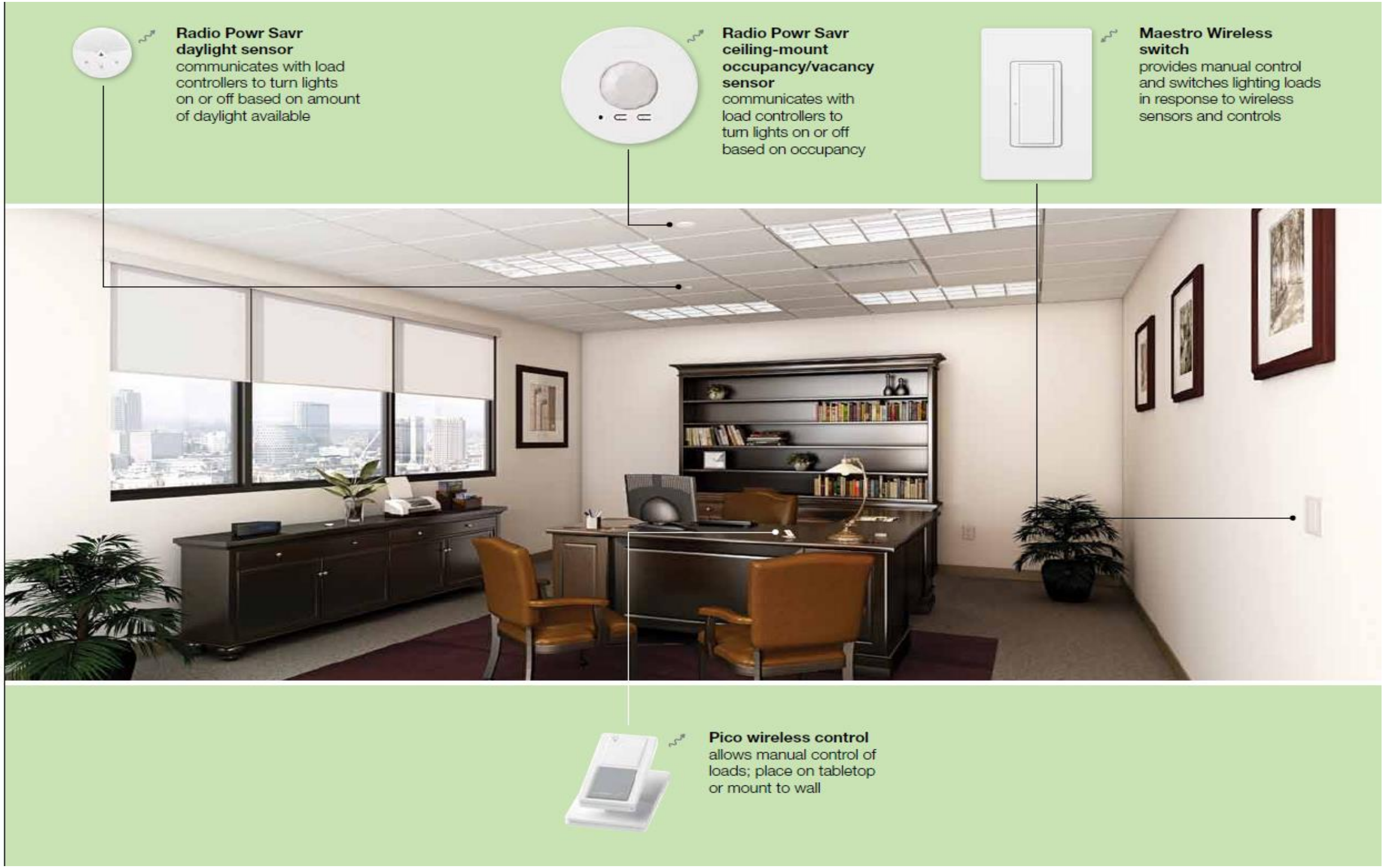
2.9 years*

* ROI based upon $0.13/kWh; ROI = 2.1 years for $0.18/kWh; ROI = 4.7 years for $0.08/kWh See BOM, page 12

Energy savings up to: **50%**

Lutron® Clear Connect™ Wireless Signal **Sent**

Lutron® Clear Connect™ Wireless Signal **Received**



Application - Classroom

A best-practice classroom combines energy efficiency with a high quality learning environment. Classroom lighting plays a particularly critical role because of the direct relationship between good lighting and student performance.*

* Phillips, R. W. (1997). Educational Facility Age and the Academic Achievement of Upper Elementary School Students. Unpublished Doctoral Dissertation. University of Georgia.

Solution components

- PowPak™ Dimming Module with EcoSystem
- Radio Powr Savr™ wireless occupancy sensor, corner-mount
- Radio Powr Savr wireless daylight sensor
- Pico® wireless controls, 5-button
- EcoSystem® H-Series Ballasts

Return on Investment:

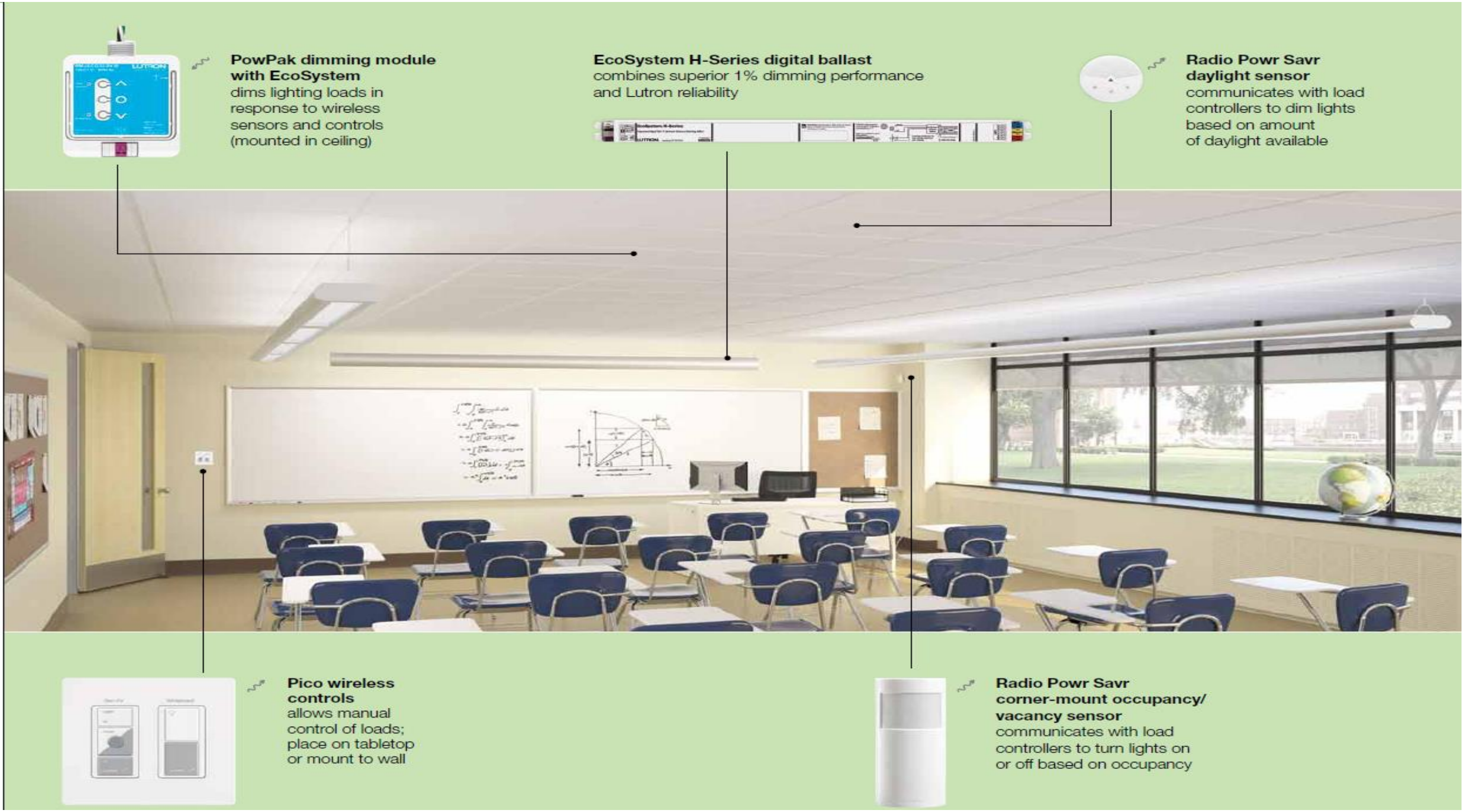
2.2 years*

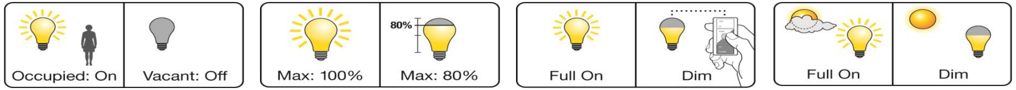
* ROI based upon $0.13/kWh; ROI = 1.6 years for $0.18/kWh; ROI = 3.6 years for $0.08/kWh
See BOM, page 12

Energy savings up to: 77%

Lutron® Clear Connect™ Wireless Signal **Sent**

Lutron® Clear Connect™ Wireless Signal **Received**





Application – Conference Room

Small area solutions

controls + sensors + ballasts + shades + modules

Radio Powr Savr™ wireless daylight sensor
communicates with module to increase energy savings by automatically turning off or reducing electric light when daylight is sufficient

EcoSystem® H-Series digital ballasts
provides cost-effective, digitally addressable 1% dimming ballasts that work with wired and wireless sensors and controls—ideal for any application, both retrofit and new construction

Pico® wireless controls
provides tabletop, handheld, or wall-mount controls that adjust lights or shades from anywhere in the room

Radio Powr Savr™ wireless occupancy sensor
provides energy savings by ensuring light levels are reduced when rooms are unoccupied

Sivoia® QS Wireless shades
adjust quietly to eliminate glare and reduce heating and cooling costs

GRAFIK Eye® QS Wireless with EcoSystem
provides customizable preset light control with built-in timeclock that allows users to adjust the lights and shades for any task and save energy at the touch of a button

Other applications

- Open office, Classrooms

New

CREE Eco chip. EcoSystem enabled 3rd party fixture. Leg CREE Series.

Energy-saving strategies

- High-end trim
- Occupancy/vacancy sensing
- Daylight harvesting
- Personal dimming control
- Controllable window shades
- Timeclock scheduling

Sources on back cover

Potential lighting energy savings

60% [1]

Adaptive Corridors – University Study

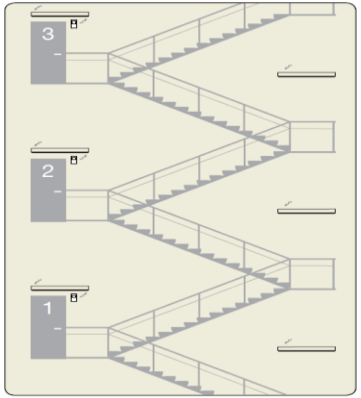
"A wireless lighting control system reduced lighting energy use 68%..."

A wireless lighting control system reduced lighting energy use 68%
in the fourth-floor corridor of UCSF's Mount Zion Medical Center.

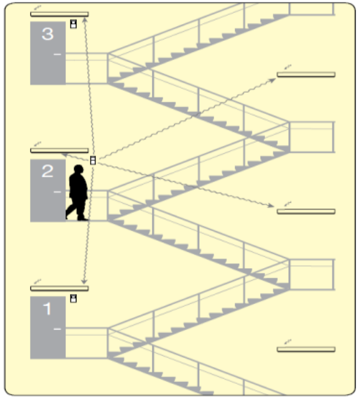
LED Stairwell

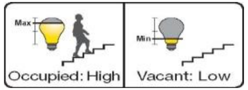
How does it work?

Unoccupied: 10% light level



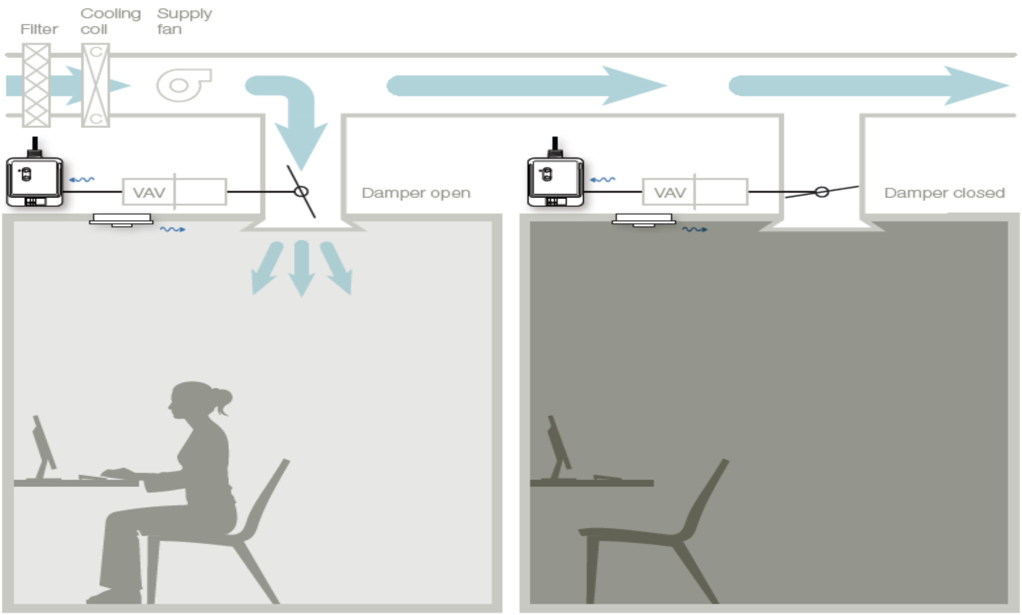
Occupied: 50% light level





Stairwell Fixture Solutions

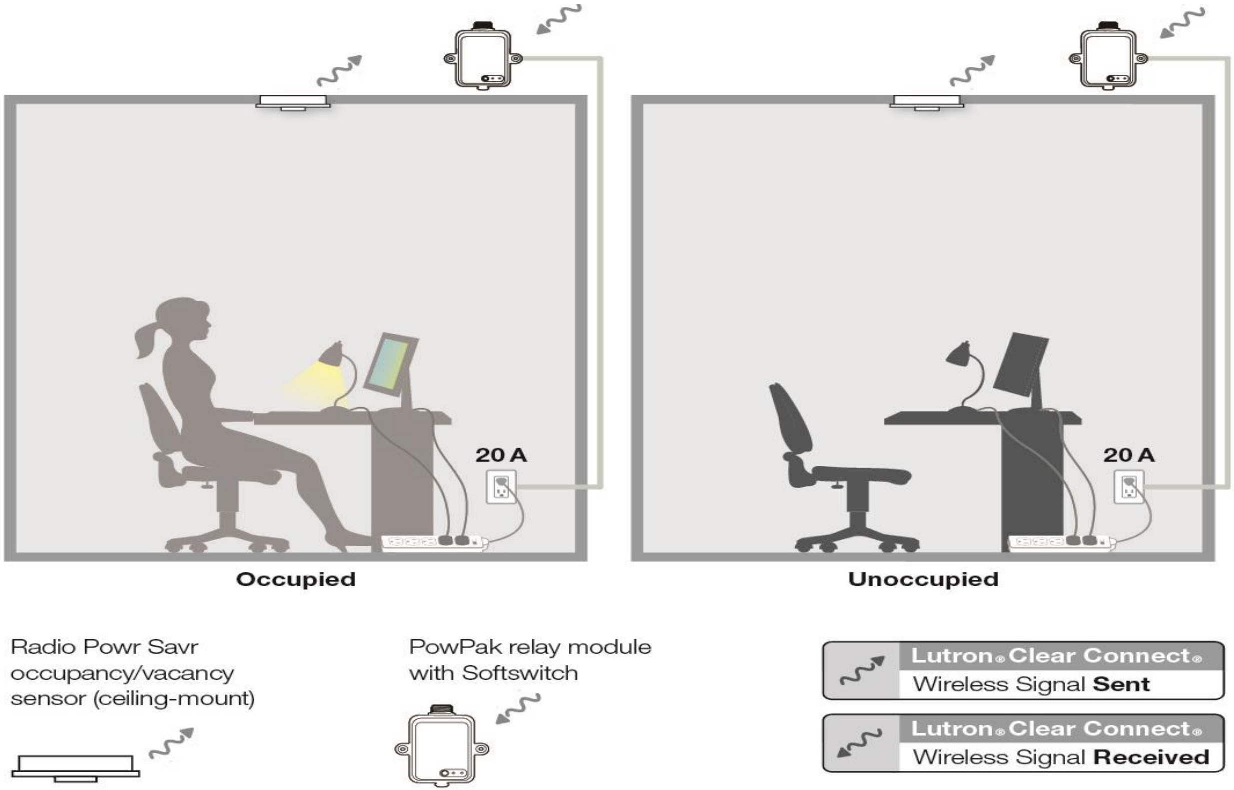
Application: HVAC Integration



- Occ sensor indicates room occupancy to VAV terminal unit to connect/disconnect room from HVAC system
- CCO on the PowPak relay can also be used in this way

Application Outlet Control

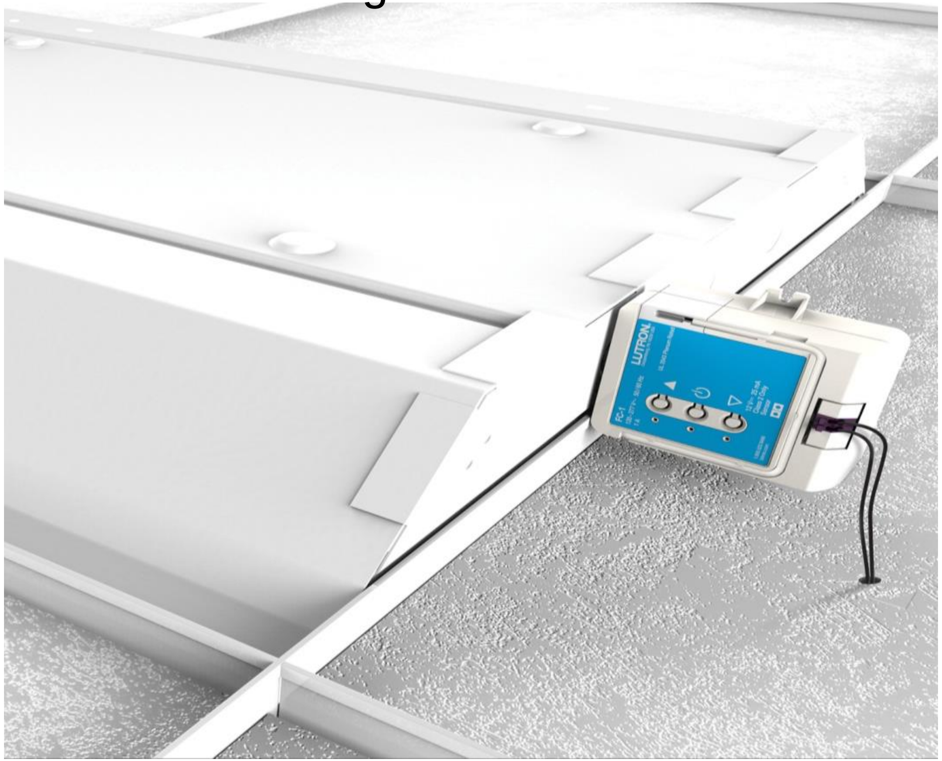
Application



Individual Wireless Fixture Controller

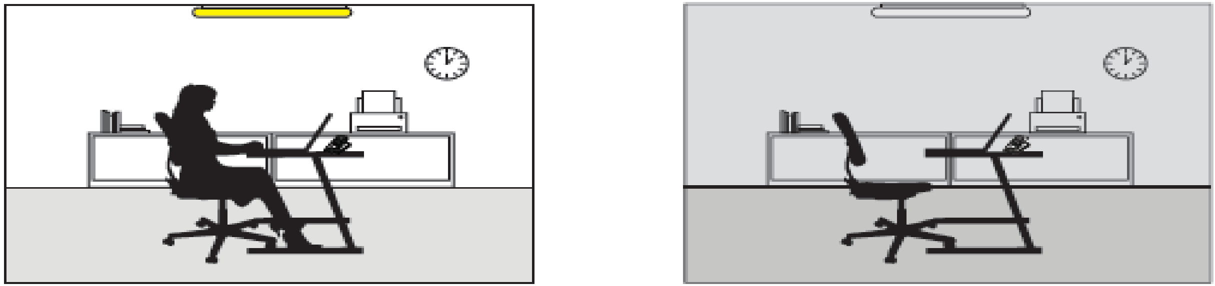
Below the Ceiling

Above the Ceiling



Wireless Fixtures

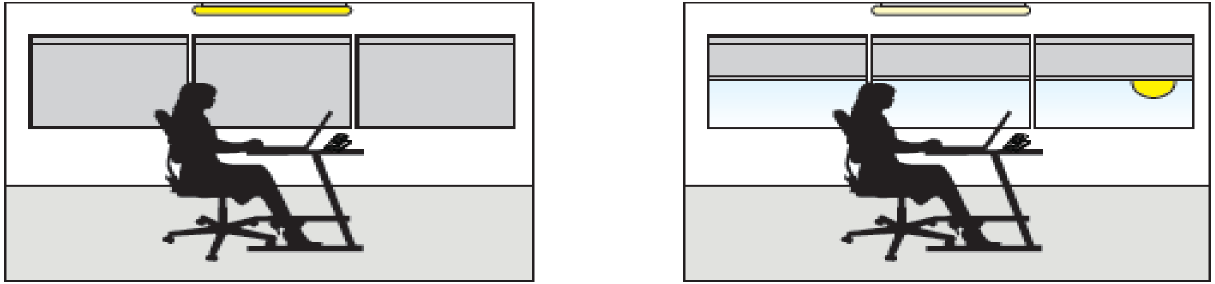
Occupancy sensing



Turns individual fixtures on when people occupy the area

Turns individual fixtures off when people vacate the area

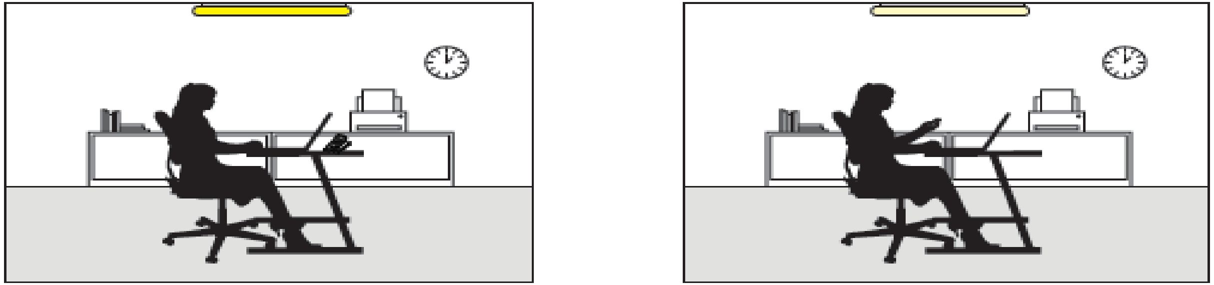
Daylight harvesting



Dims/brightens the fixture to take advantage of daylight

Wireless Fixtures

Personal wireless control



Adjusts light level based on wireless remote button presses

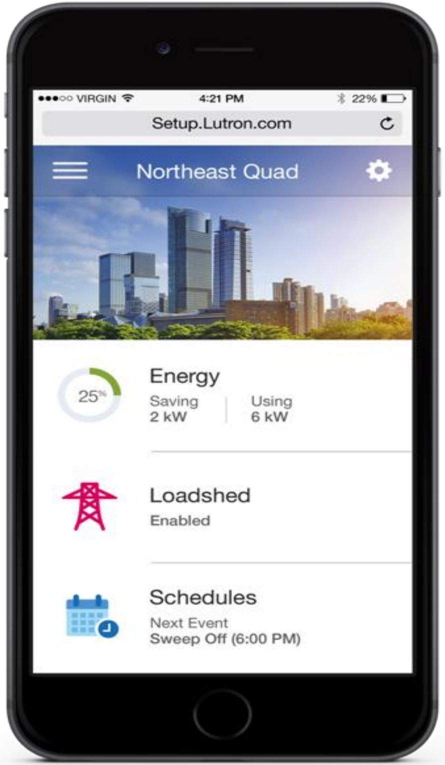
Central and Area Networking

Central timeclock

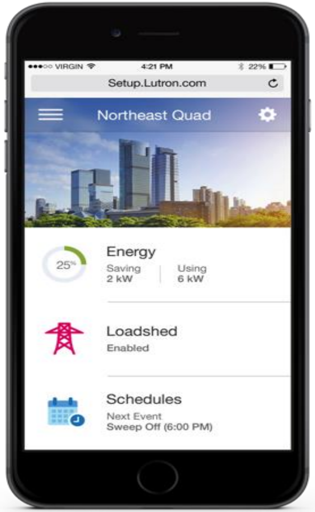
BACnet integration

Energy reporting

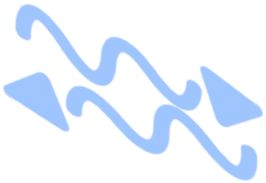
Automatic demand response

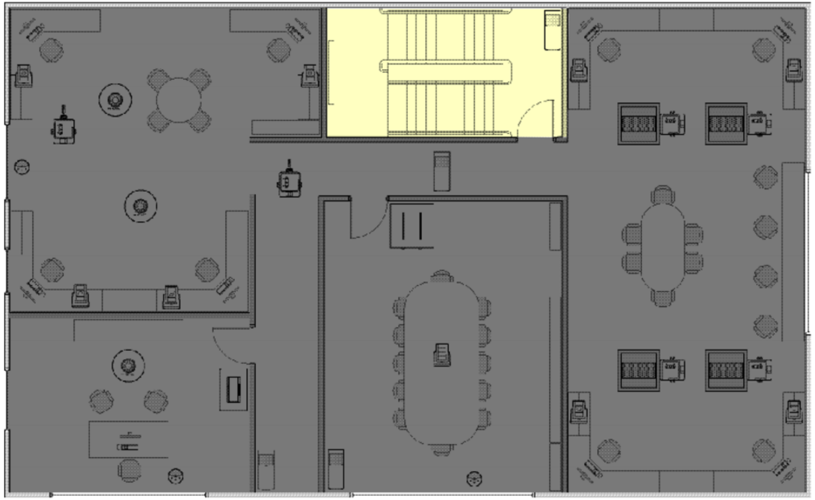


Connect your wireless Controls

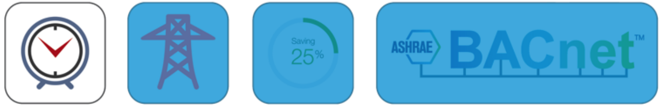


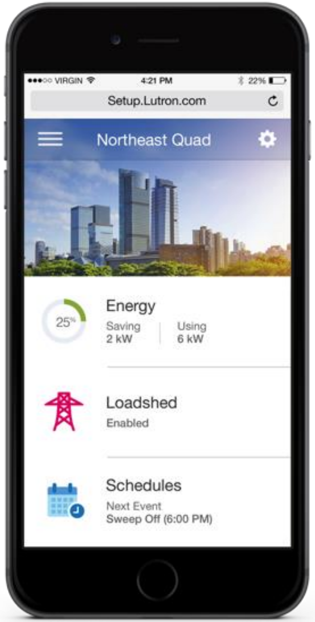
Wireless Router



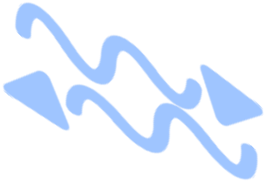


Connect your wireless Controls

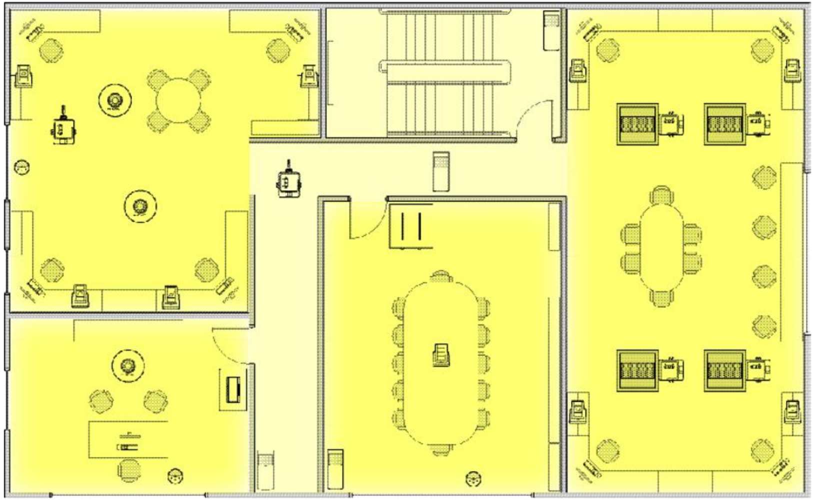




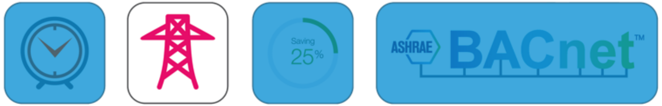
Wireless Router



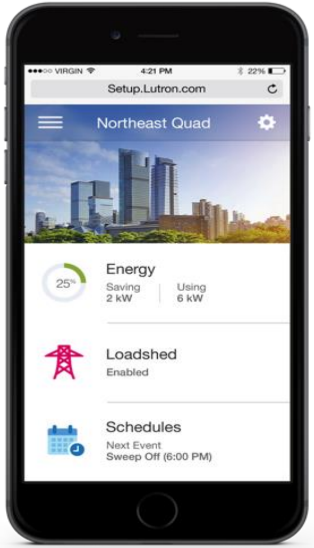
Time Clock: Sweep on – 7 a.m.

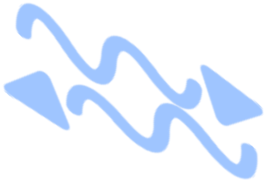


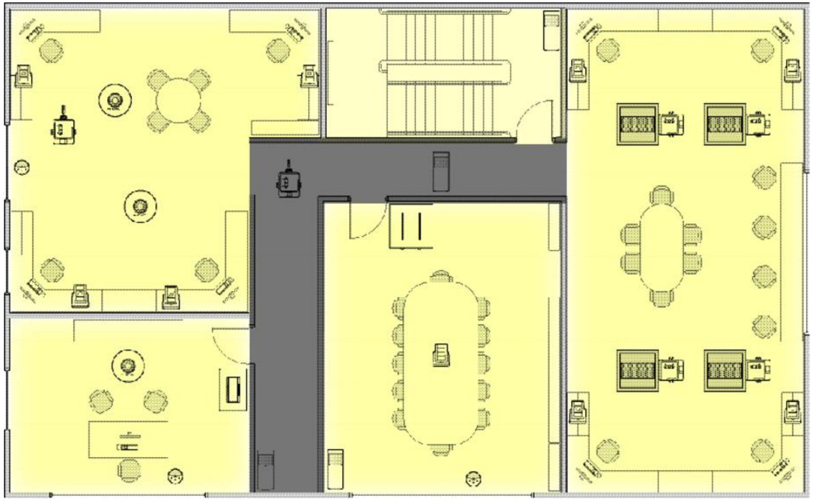
Connect your wireless Controls



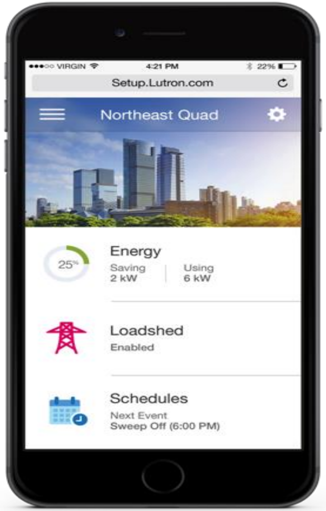
Automatic demand response:
Lights dim



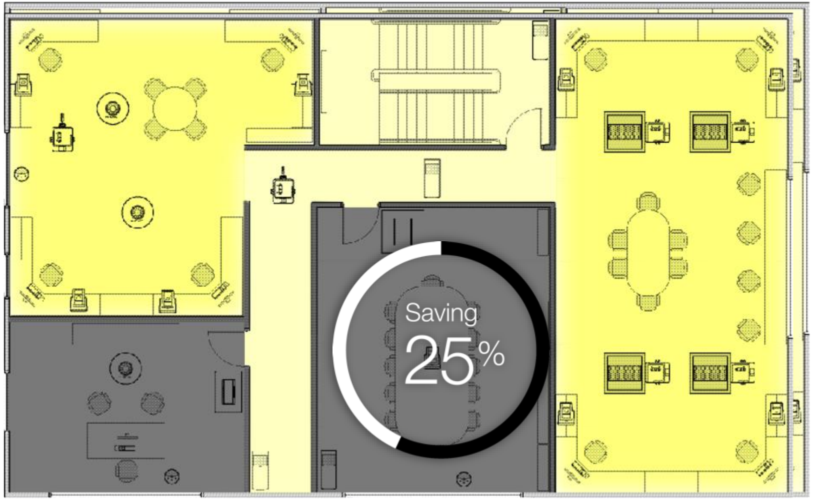




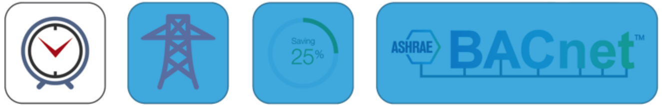
Connect your Wireless Controls



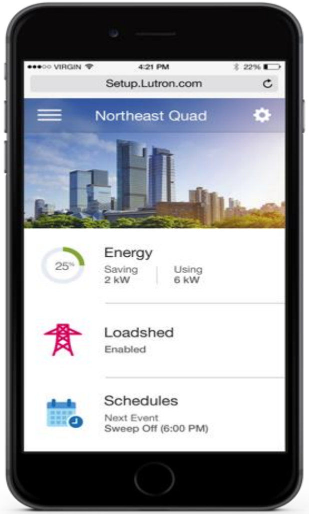
Monitor energy savings

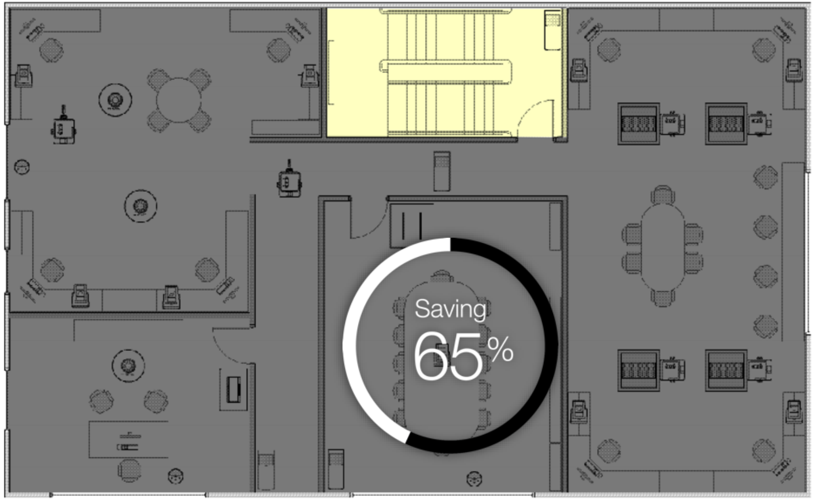


Connect your Wireless Controls

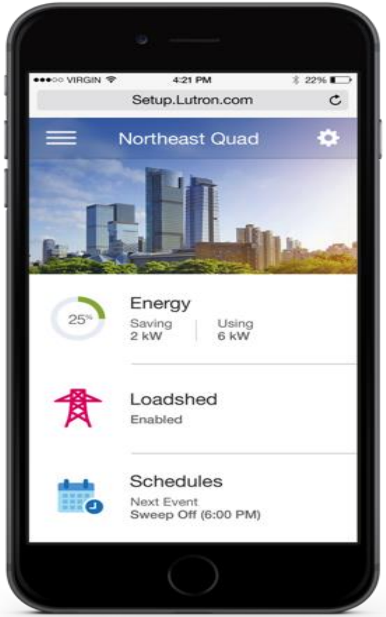


Time Clock: Sweep off – 8 p.m.





Central Control BMS Integration



- Building/energy management systems (BMS/EMS)
- Energy dashboards & analytics packages
- Maintenance & work order management systems
- HVAC
- Fire & safety
- Access & security
- Audio & video
- Metering
- IT

Mobile Access

Access from any PC or mobile device

- Optimized for mobile platforms
- Receive notifications and address building performance needs from anywhere
- Real-time trouble-shooting while in space

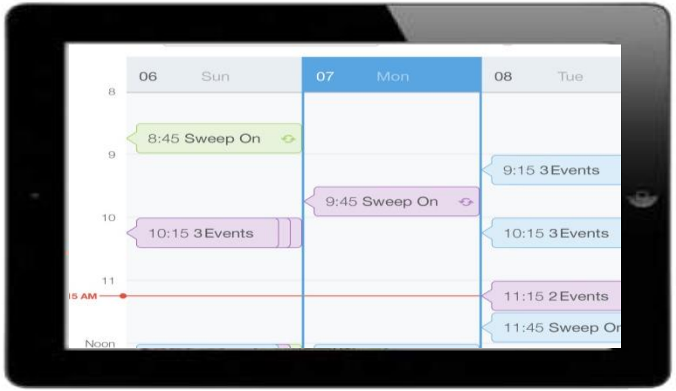
PC　　Android tablet™　　iPad® mini　　iPhone® or Android

Automated Scheduling and Alerts

Provides actionable information to ensure building performance

Plan

Visual calendar for easy scheduling



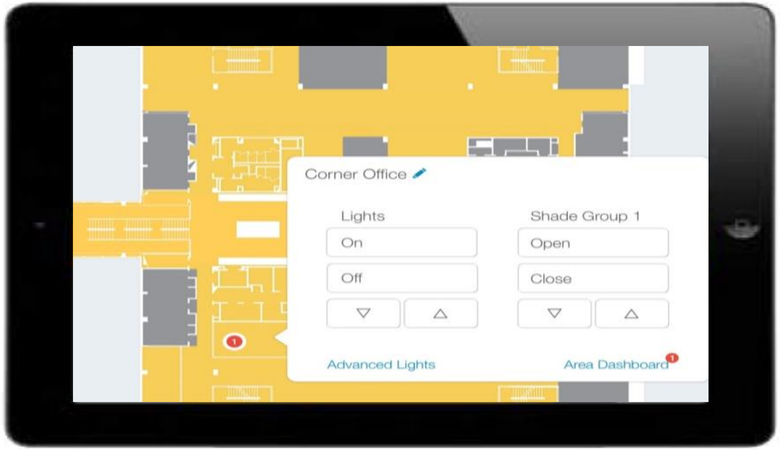
Alert

Instant notification of a lamp or driver outage

Predict Success with Management Reports

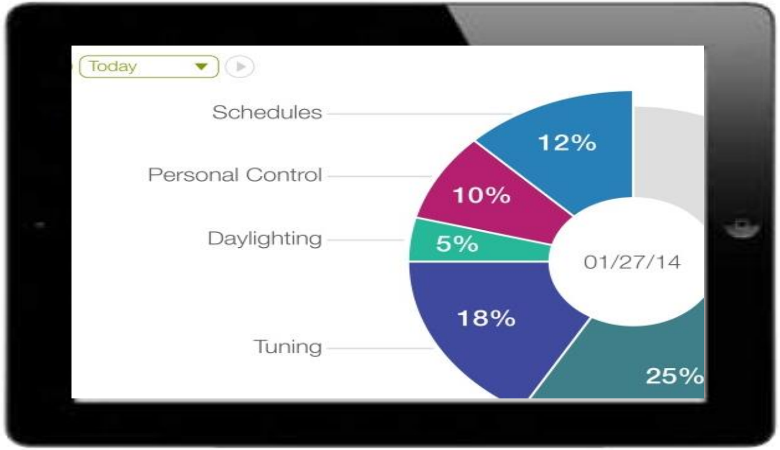
Manage

Operate your spaces remotely using the graphical floorplan



Report

Quickly view and export data that drives decision-making



Thank You

Questions?

Thank you,

Michael Matour
mmatour@lutron.com
610 597 8942

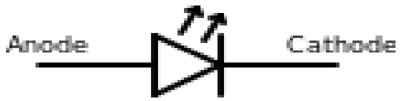
save energy with Lutron™ ®

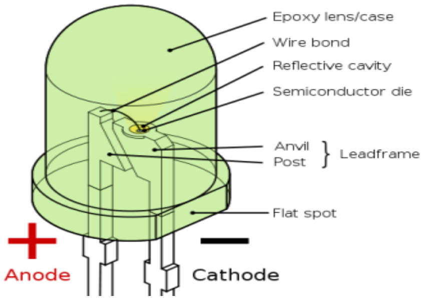
LED Controls and Drivers

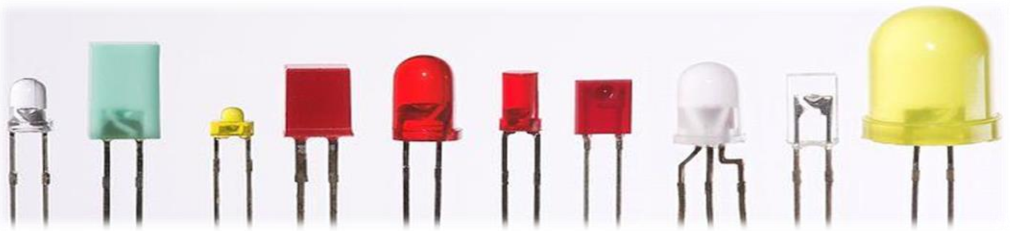
- LED Advantages / Limitations
- LED Technologies
- LED Control Types – Drivers
- Dimming Technologies

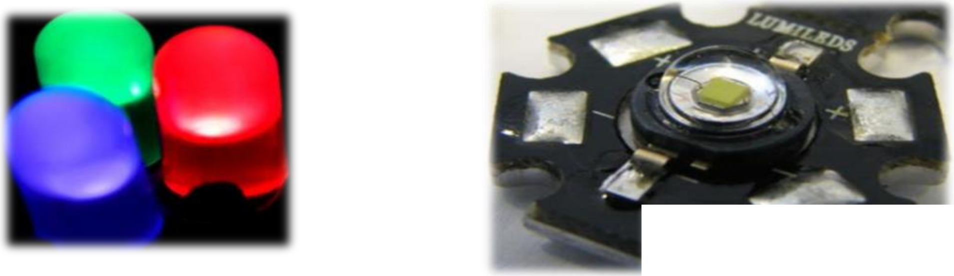
What is an LED?

- LED – Light Emitting Diode – Solid State Lighting
- First practical use in the 1960’s
  - Indicators, panel displays, 7 segment displays
- Widely used for general lighting today









LED Advantages

- Longevity
  - Useful life (L70) of 25,000 to >50,000 hours
    - Reduced maintenance costs
    - <1,000 for incandescent or 3-6,000 for Halogen
    - Requires a driver of equally long life!
- Environmentally friendly
  - No hazardous materials
    - Mercury vapor in CFL lamps
    - Lead-free
- Immediate light output
  - No delay or warm up
- Excellent cold-weather performance

LED Advantages

- Color temperature
  - Available 2,700K to 4,500K

- Color rendition
  - Greater than 90 CRI available
  - Some spec sheets now state R9 values (>0 = good)

- Color stability over time and temperature
  - Depends on quality of LED module and phosphor application

LED Limitations

- Higher first cost
  - LEDs for general illumination are (still) expensive
  - LEDs require a driver to convert AC to discrete DC (similar to need for ballasts for fluorescent or transformers for low voltage)

- Thermal Management
  - Heat must be conducted away from LEDs effectively by the fixture or lamp design

- Confusing/inconsistent literature and specs
  - Information about dimming varies widely and is sometimes missing completely!

LED Limitations

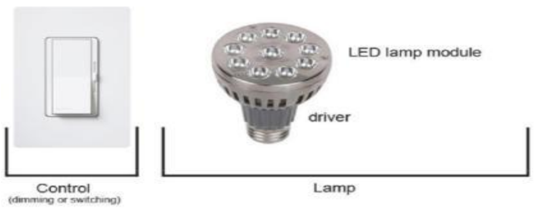
- Controls compatibility
  - Dimmable fixtures may have unknown or poor performance
  - Not all LEDs are dimmable

- Application-specific challenges
  - No one style is universally accepted
  - High amount of product variation
  - Inexperienced manufacturers / exaggerated claims

- Color consistency

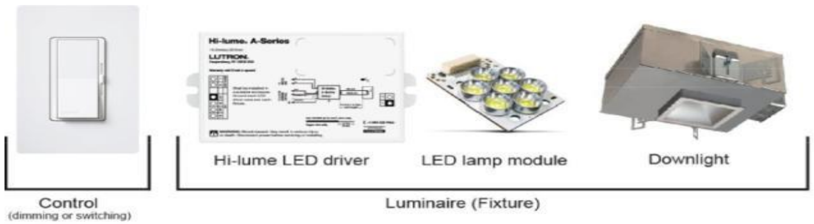
What type of LED product am I using?

LED Bulbs/T8 LED



- Designed to replace standard incandescent, screw-in CFL bulbs, or linear T8s
- Integral drivers determine dimming performance (if dimmable)

LED Fixtures

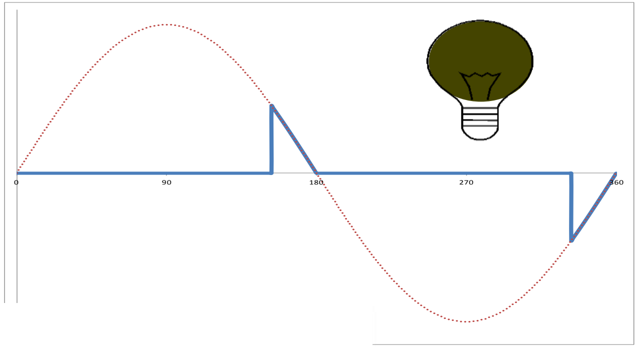


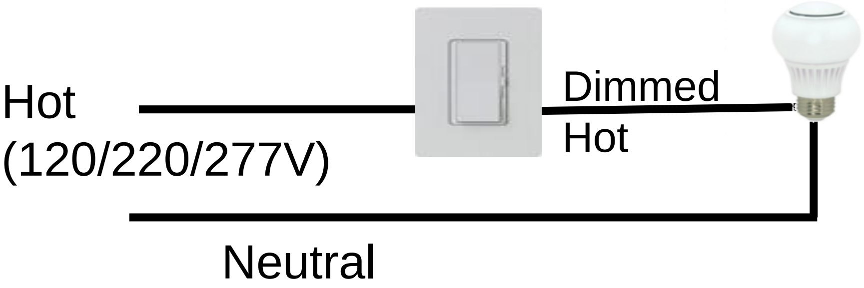
- Variable in purpose (cove lights, down lights, 2x2, etc.)
- Usually have an external driver, selected by the OEM mounted as part of the fixture housing
- OEMs offer multiple driver options to support different control technologies and applications (dim vs. non-dim, 0-10V vs. DALI)

What control type do I need?

Line Voltage Dimming - Forward Phase analog

- Most common dimming method (150 million dimmers in use)
  - Designed for resistive (incandescent, halogen) or magnetic low-voltage (MLV) loads
  - Installed base not intended for LEDs, performance issues and compatibility problems likely

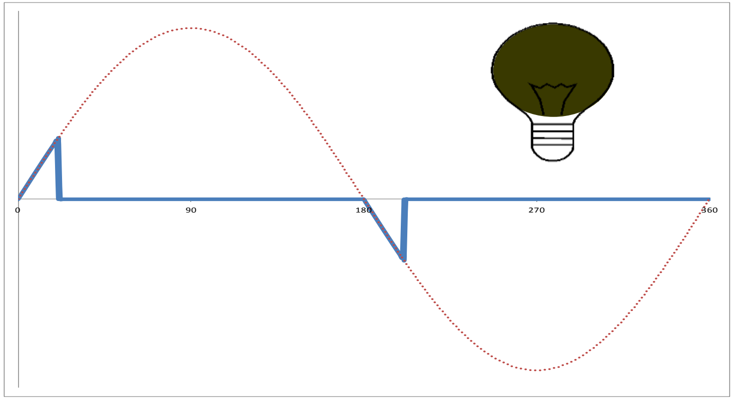


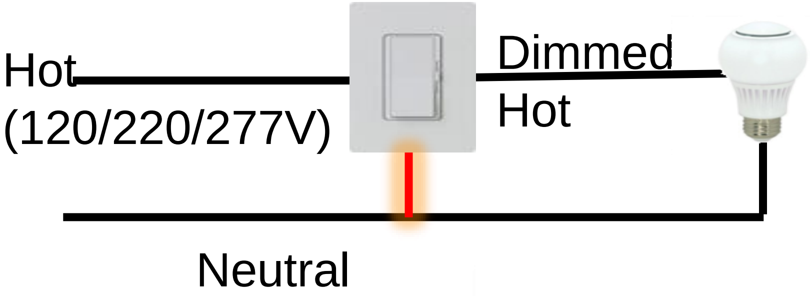


What control type do I need?

Line Voltage Dimming - Reverse Phase Analog

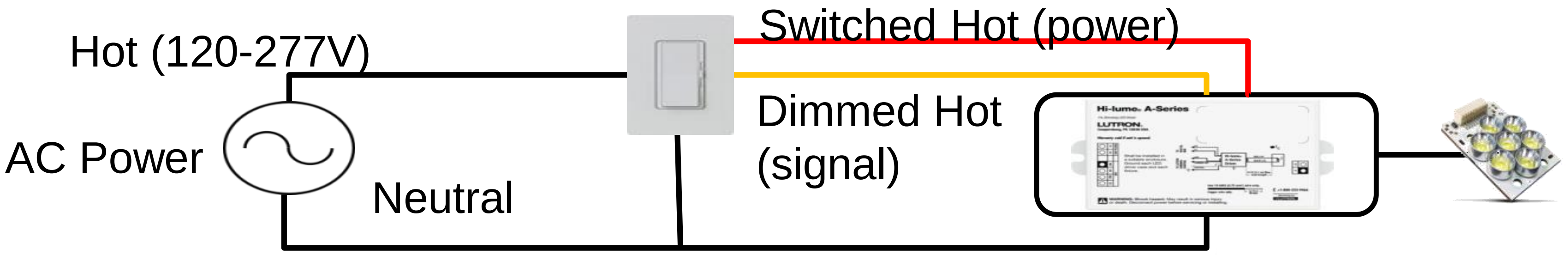
- Typically used for ELV loads, sometimes perform better with LEDs
- Less likelihood of acoustic noise due to no repetitive peak current
- Smaller installed base, usually require a neutral wire





What control type do I need?

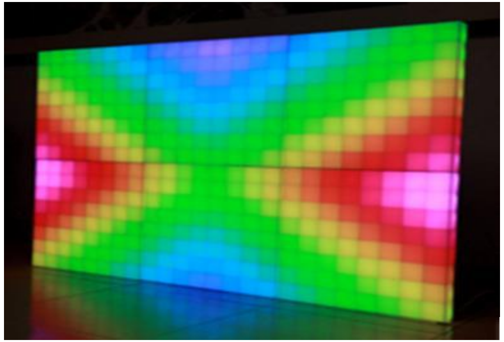
- **Line Voltage Dimming** - 3-Wire analog
  - Fluorescent standard, control signal carried separate from power
  - Precise, less prone to noise, but requires a third line voltage wire
  - Universal voltage, high power factor, multiple control types available



What control type do I need?

DMX-512 digital

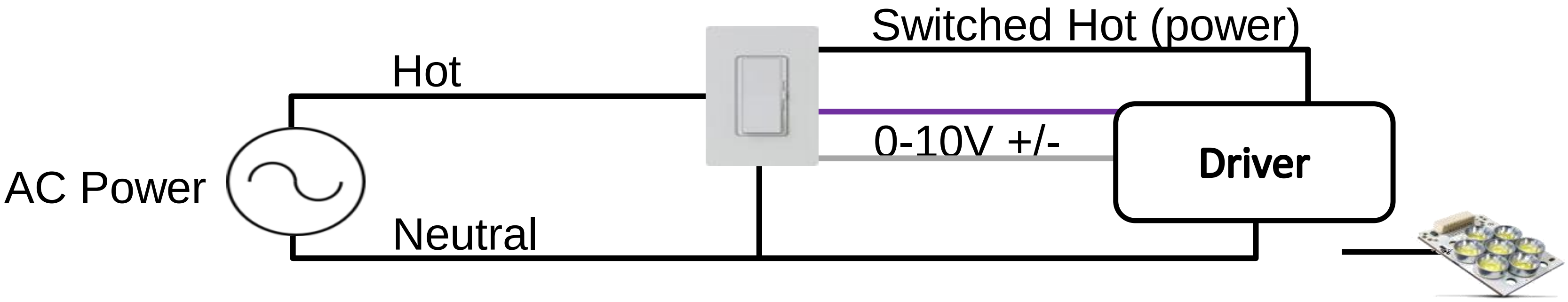
- Popular in theater applications & RGB (Red Green Blue) LED control
- Multiple channels for individual color control
- Possible to use for single color general applications
- Complicated wiring for general illumination
- Often requires an interface and more complex programming and installation



What control type do I need?

Low Voltage Control - 0-10V Analog Dimming

- Analog control standard, low voltage wiring to each fixture in lighting control zone
- Requires 0-10V low voltage control output AND line voltage switching



What control type do I need?

Low Voltage Digital Control - DALI / EcoSystem

- DALI (Digital Addressable Lighting Interface) allows digital addressing of individual ballasts/drivers in fixtures & status feedback
- EcoSystem (Digital Low Voltage Data System) allows assignment to daylight sensors, occupancy/vacancy sensors, timeclocks and multiple controls for one or many fixtures without added wiring
- Control wires are independent of power, no need to rewire line voltage