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Light Space Design
Looking at our environment in a whole new light
P.O. Box 4064
Burlington, VT 05406

Conference theme:
NET ZERO by 2030

Total Light Management

Making the Most of Cost Effective Lighting Control Systems

February 5, 2014

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Efficiency Vermont
BBD
BETTER BUILDINGS BY DESIGN
Conference theme:
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Agenda

- ***Opportunities with Light Management Systems***
  - ***Overview- Importance for Net Zero Commercial Buildings***
  - ***What's New – Digital Ballasts / Drivers & Wireless Technologies***
  - ***How it all works together***
  - ***Light Control Strategies***
  - ***Single Space Solution / Examples, Costs & Savings***
  - ***Small Area Solutions / Examples, Costs & Savings***
  - ***Large Area Solution / Examples, Costs & Savings***
  - ***Whole Building Solutions / Examples, Costs & Savings***
  - ***Integrating Operable Shades***
  - ***Integrating Other Systems***

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Benefits of light control

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Your Customer

- Provide comfort and control for users
- Save energy and protect the environment
- Decrease maintenance costs
- Provide feedback on building operations
- Increase the value of building assets and rental income

Your Business

- Design: Be a resource and a design partner
- Energy Management: System optimization

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Benefits of light control

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Light control solutions for any space:

- Healthcare, Hospitality, Education, Government & Military Facilities, Office Buildings, Industrial / Warehouse
- Controlling the light in spaces can improve productivity and save up to 60% of lighting energy
- Reduce operating costs
- Many solutions are expandable—from a single room to hundreds of rooms in a building system.





Single zone and room controls

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- *Single zone controls operate a single zone, or lighting scene at a time.*
- *In contrast, room controls operate several zones and are designed to allow for multiple lighting scenes.*
- *Room controls allow for lighting scenes composed of multiple zones, including the control of electric light with daylighting.*
- *Added benefit when thermal zone can be controlled with the same system.*

Whole building controls

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- *Whole building controls offer a variety of benefits, including reduced energy usage, added convenience, and security.*
- *Programmed dimming controls add ambience with minimal intervention.*

Natural light controls

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- ***Blending the control of natural and electric light can further enhance both the aesthetics and functionality of a given space.***
- ***The sun should be viewed as another primary light source and has a role in most every lighting control scheme.***
- ***Automated shade controls allows for consistent operation of daylighting energy saving controls.***

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What's New?
What does the Future hold?

Why invest in Building Automation?

Wireless solutions for retrofits and renovations

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- *The applications for wireless control technologies are endless*
- *Wireless technologies provide solutions that can be applied to the full range of residential & commercial applications*
- *They save energy, add convenience, and can easily be installed as a retrofit solution*

Digital ballasts and digital LED drivers

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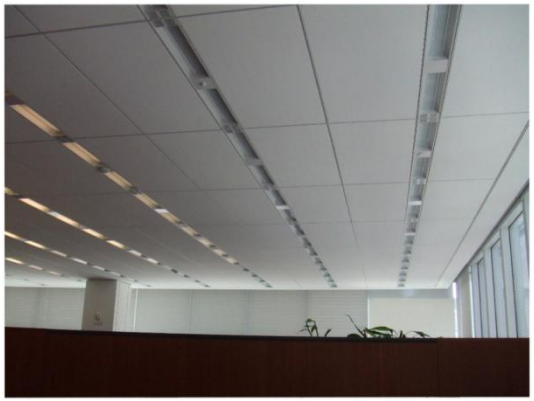
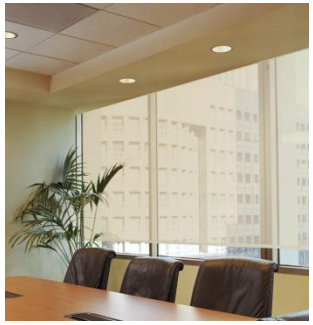
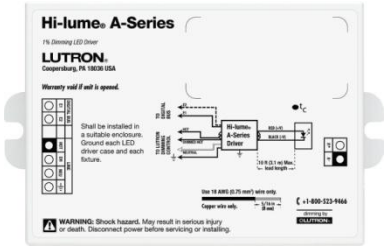
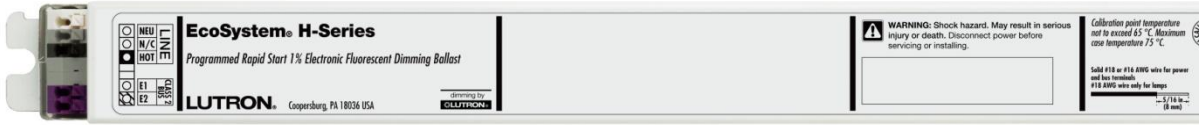
- *Infinite flexibility of lighting*
- *No class 1 rewiring - ever*
- *No power packs or interface boxes to replace or "chase" around the building*
- *Simplified maintenance through reporting*
- *Reduced installation cost provides better return on investment*
- *Dramatic Energy Savings through proper lighting levels and occupancy-based control*









Digital dimming ballasts

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Digital 0-10v Ballasts

- Dimming to 1% or 10%
- Proprietary vs Standard
- Sensor Connections to Controller or directly to the ballast

Wireless Ballasts

- No wires between sensors and fixtures
- Sensor signal relayed wirelessly to fixtures
- Configurations can be easily changed

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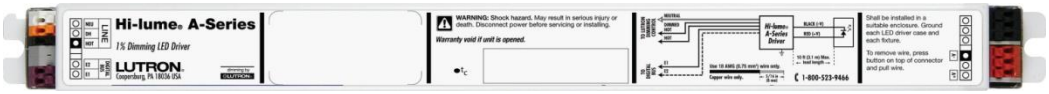
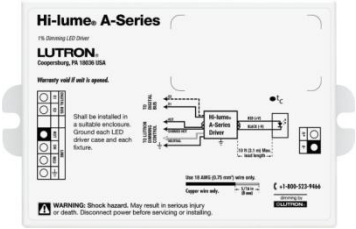
Digital drivers

- Dimming LED driver- some to 1%
- Multiple control options
  - Digital controls
  - 3-wire fluorescent controls
  - Forward Phase Controls (neutral wire required)
- Multitude of current and voltage outputs (to the LEDs)
- Universal Voltage [120V / 277V]
- Compatibility & Performance – critical for all LED dimming
- UL Recognition





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Digital system example

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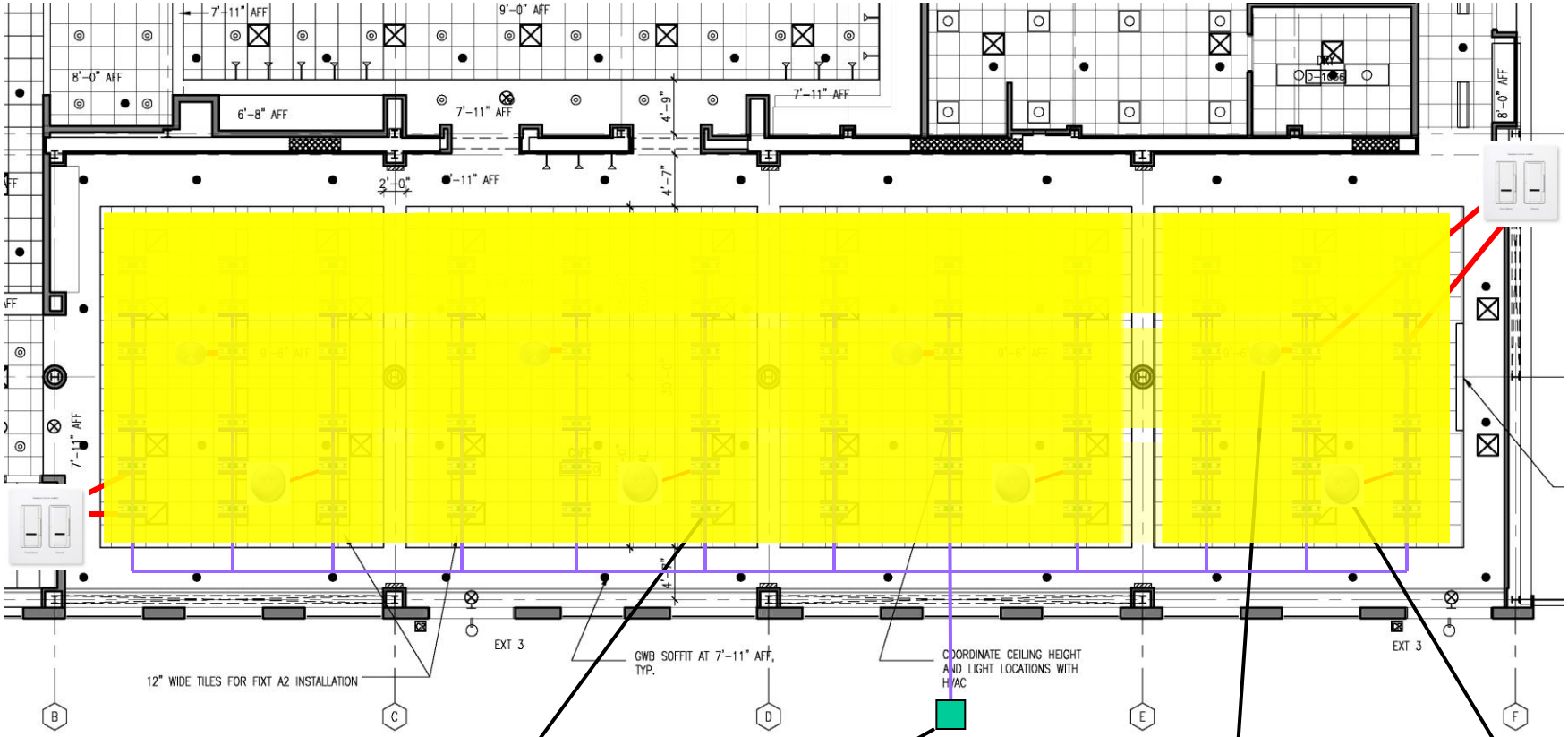
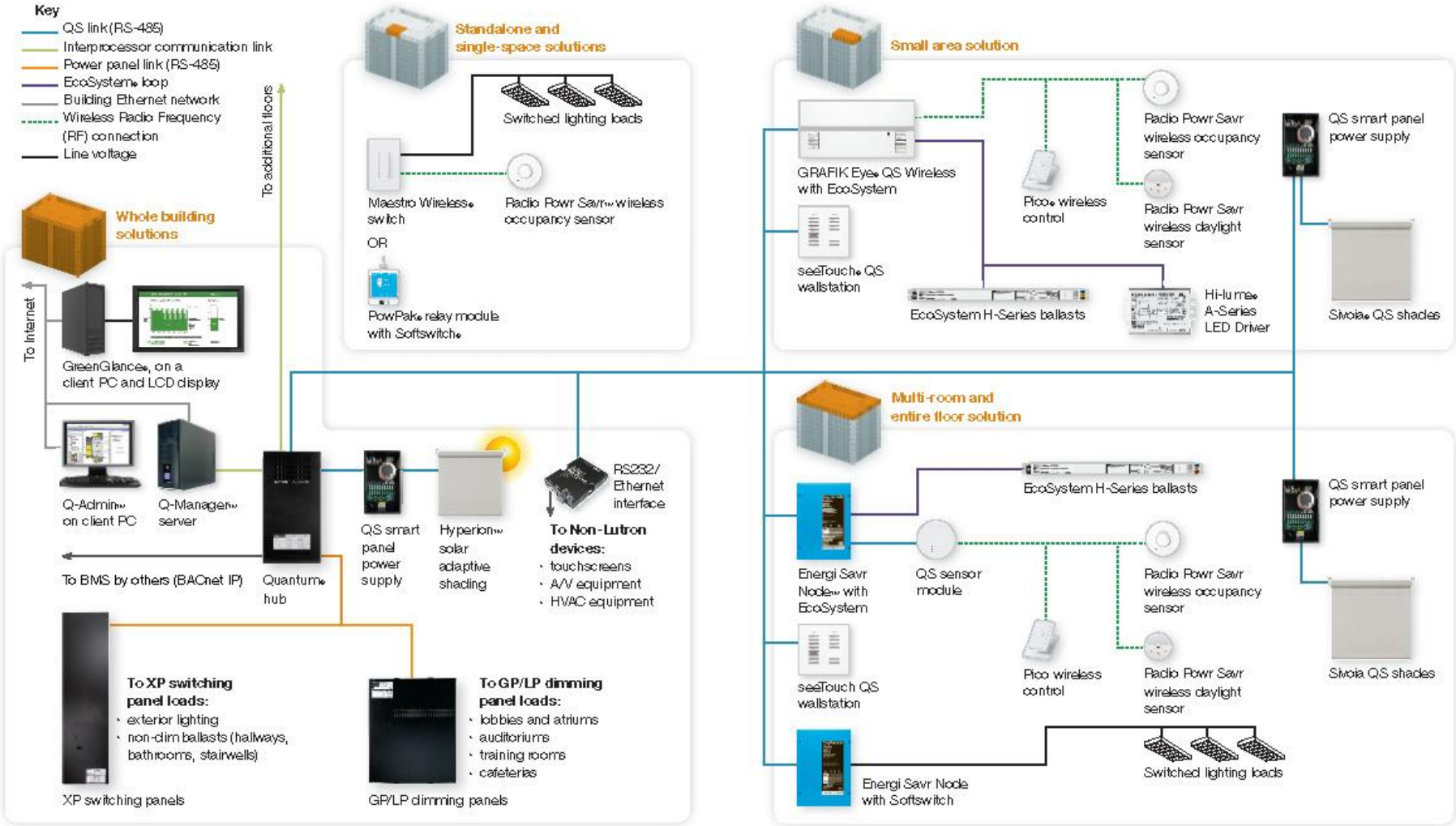


- *Digital Ballasts*
- *LV Wired Controller*
- *Occupancy Sensor*
- *Daylight Sensor*
- *iPOD Programmer*

How it all works together



scalable . . . and interoperable

Light control strategies

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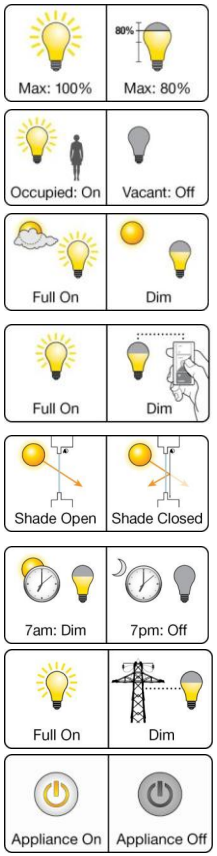

Energy-saving light control strategy	Potential energy savings
High-end trim / tuning	20% Lighting
Occupancy or vacancy sensing	15% Lighting
Daylight harvesting	15% Lighting
Dimming / Personal light control	10% Lighting
Controllable window shades	10% AC
Timeclock / Scheduling	Variable
Demand response	Variable
Appliance Control	Variable

expandable light control solutions

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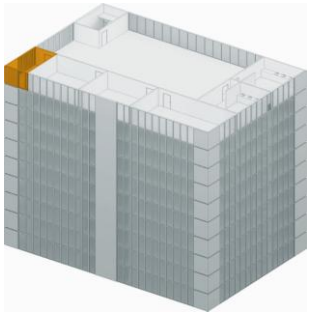
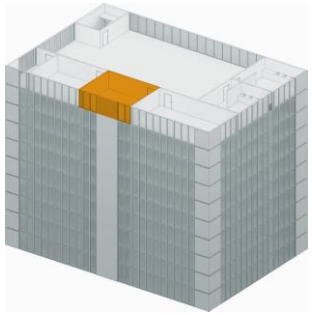
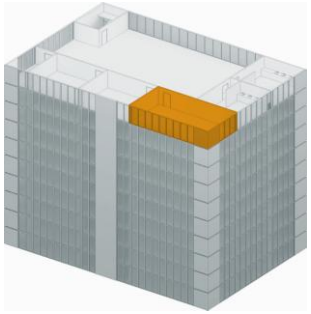


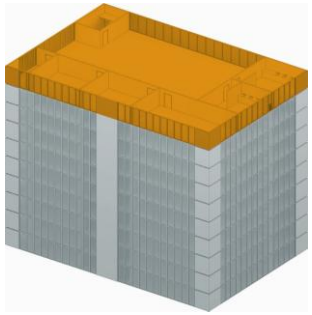
Basic Standalone Solutions



Single-Space Solutions

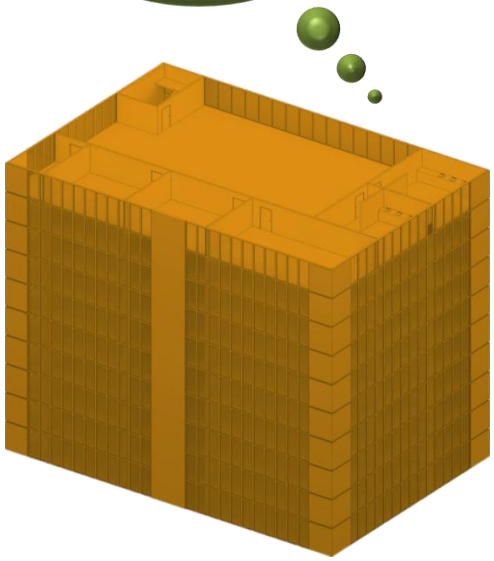


Small Area Solutions



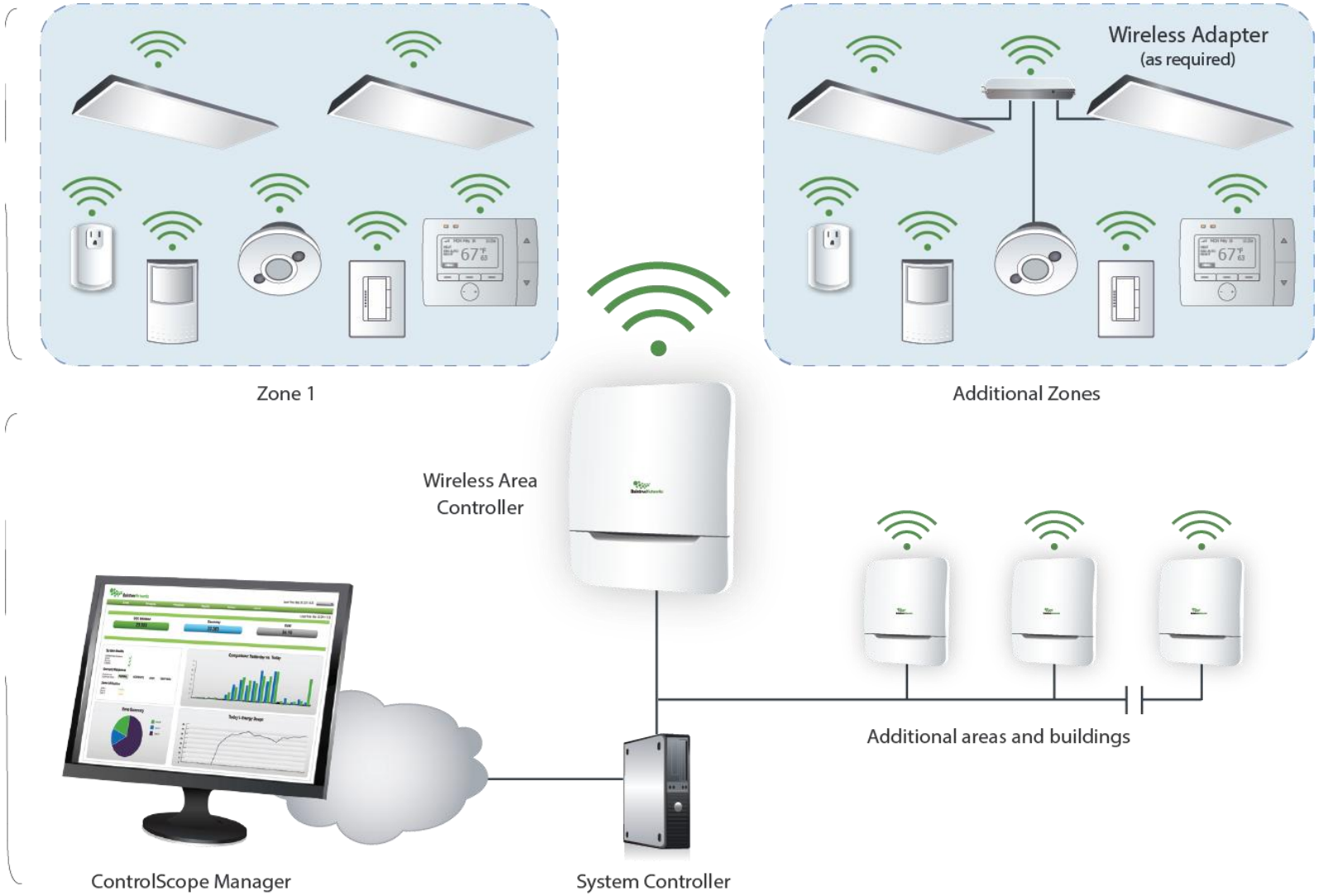
Large Area Solutions

Plan according to your budget . . . and evolve your system towards your building goals over time



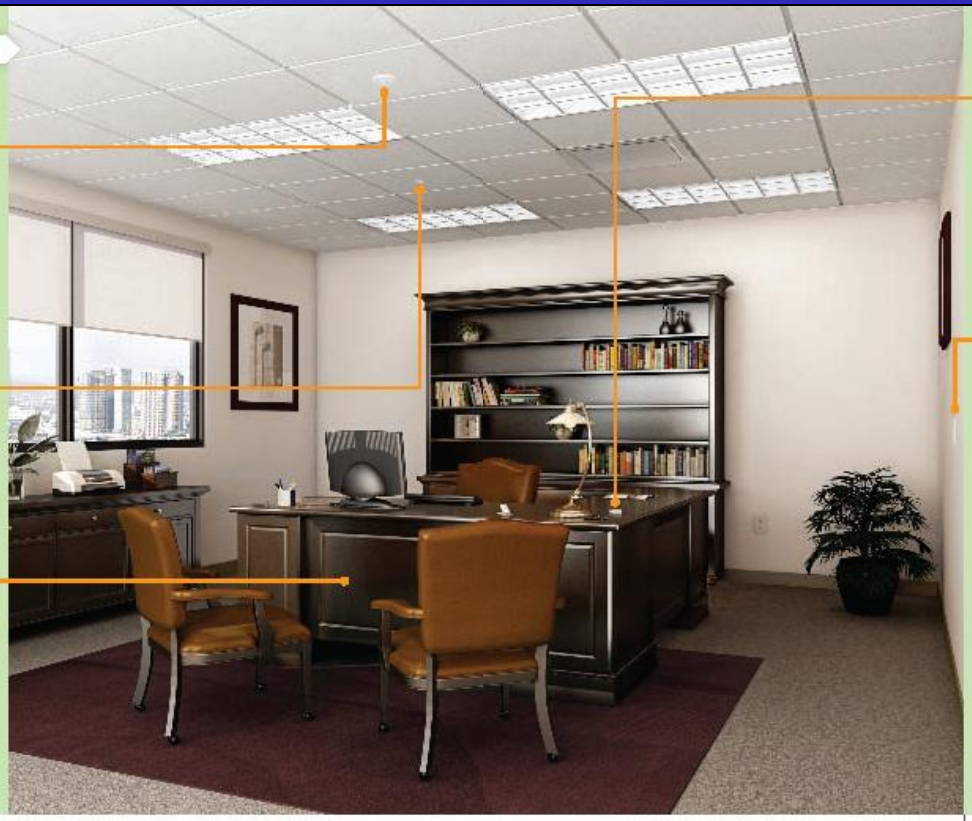
Whole-Building Solutions

Wireless Mesh Network System



Single Space Solutions

switches + sensors + modules



Radio Powr Savr™ wireless occupancy/vacancy sensor
provides energy savings by ensuring lights are off when rooms are unoccupied

Radio Powr Savr wireless daylight sensor
increases energy savings by automatically turning off electric light when daylight is sufficient

PowPak® plug-in appliance module
receives commands from sensors or wireless controls to conveniently save energy by turning off phantom loads (devices that draw power even when turned off or idling); device located on the floor under the desk

Maestro Wireless® lamp dimmer
provides manual control and dims table lamps in response to wireless sensors and controls

Maestro Wireless switch
(120/277V, no neutral wire)
links multiple dimmers or switches to Radio Powr Savr sensors (10 devices total) to control additional zones of light in a space

Alternate solution:

NEW PowPak dimming module with EcoSystem®
can incorporate digital ballasts and LED drivers to add dimming control to a single space (mounted above ceiling)

Energi TriPak® solutions are another simple and cost-effective way to start saving energy today. The Radio Powr Savr wireless occupancy sensor and Maestro Wireless switch combination offers an energy-saving solution that installs in minutes and saves money. Add a daylight sensor to reduce electric light usage when daylight is available. Add PowPak appliance modules to control appliance loads or desk lamps.

Energy-saving strategies

Occupancy/vacancy sensing[5]	20–60% lighting
Daylight harvesting[6]	25–60% lighting
Plug load control[11]	15–50% of controlled load

Potential lighting energy savings

45%

Sources can be found on page 17.

Example Single Space

Project Example: Classroom 1.3 w/sf fluorescent

- *Excess Light Trim: 20% Dimming reduction*
- *Occupancy Control: Fixture quantity x wattage x 15% reduction*
- *Daylight Dimming Control: Fixture quantity x wattage reduction x 15% reduction*
- *Additional Savings: Ventilation Fan and Computer Monitors*

Estimated Energy Cost Savings

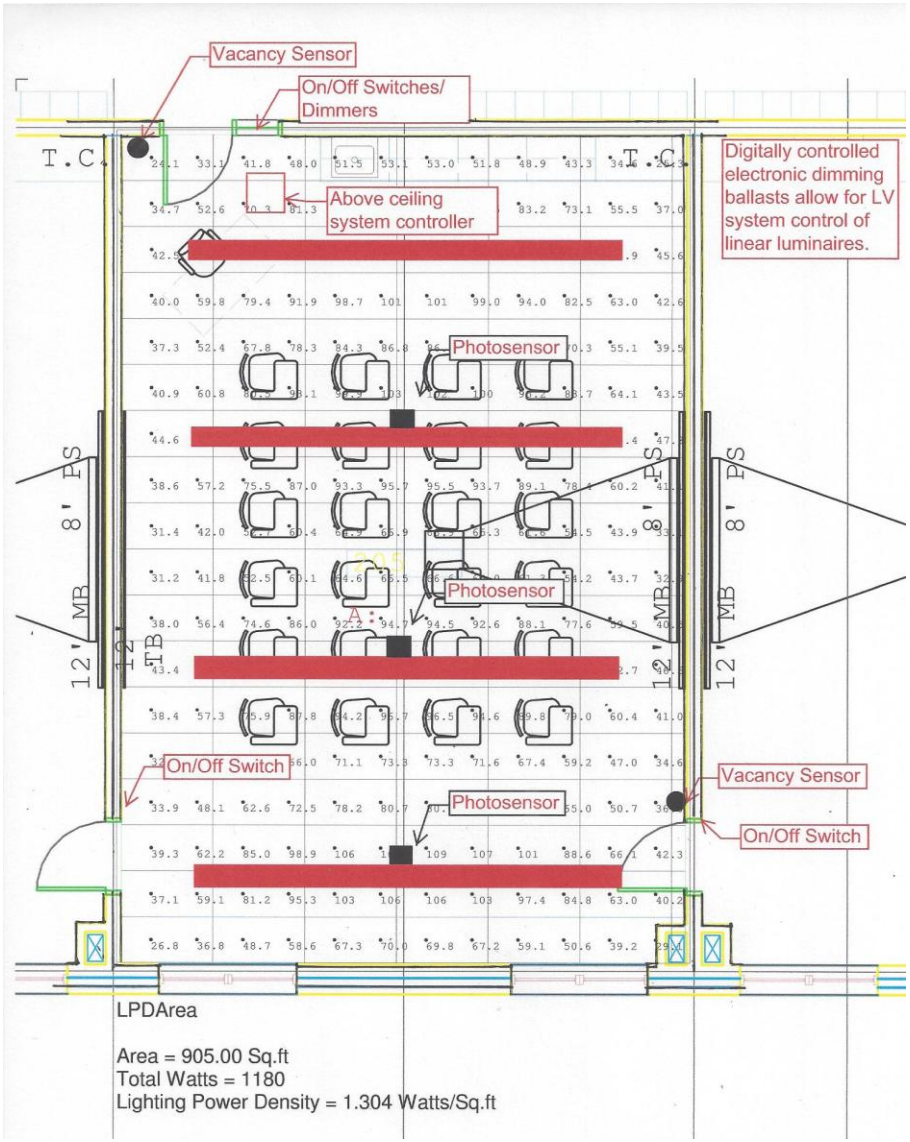
- *63% or $185 @ $0.12/kWh for lighting alone*
- *$222 @ $0.12/kWh adding OS control to ventilation fan, and 2 computer monitors*

Estimated $ for Control Equipment

- *For 0-10v digital controls w/o dimming ballasts = $1020 control equipment cost or $2220 with dimming ballasts*
- *With a 0-10v wireless system w/o dimming ballast = $2300 control equipment cost or $3500 with dimming ballasts*
- *$285 more to control ventilation fan and computer monitors*

Classroom Example 1

- Digital Equipment
  - 20 digital dimming ballasts
  - 2 Occupancy Sensors
  - 3 Photosensors
  - 1 Room Controller
  - 2 Dimmers
  - 3 4-way Switches
- Optional Equipmt
  - Fan OS Control
  - Personal Control OS sensors
  - Drop screen control
- Wireless System provides central control and management



Classroom Example 2

Project Example: Classroom 0.5 w/sf LED with 0-10v dimming driver

- ***Light Trimming: 0% Dimming reduction assumed***
- ***Occupancy Control: Fixture quantity x wattage x 15% reduction***
- ***Daylight Dimming Control: Fixture quantity x reduced wattage x 15% reduction***
- ***Additional Potential: Ventilation Fan and Computer Monitors***

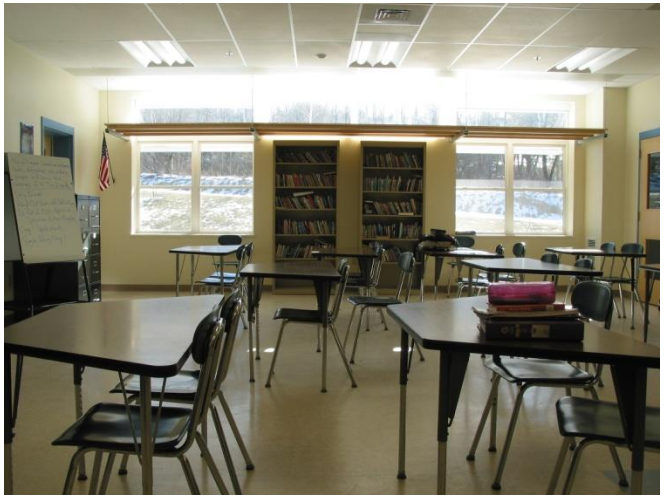


Photo and Design Credit - Banwell Architects

Classroom Example 2

Estimated Energy Cost Savings

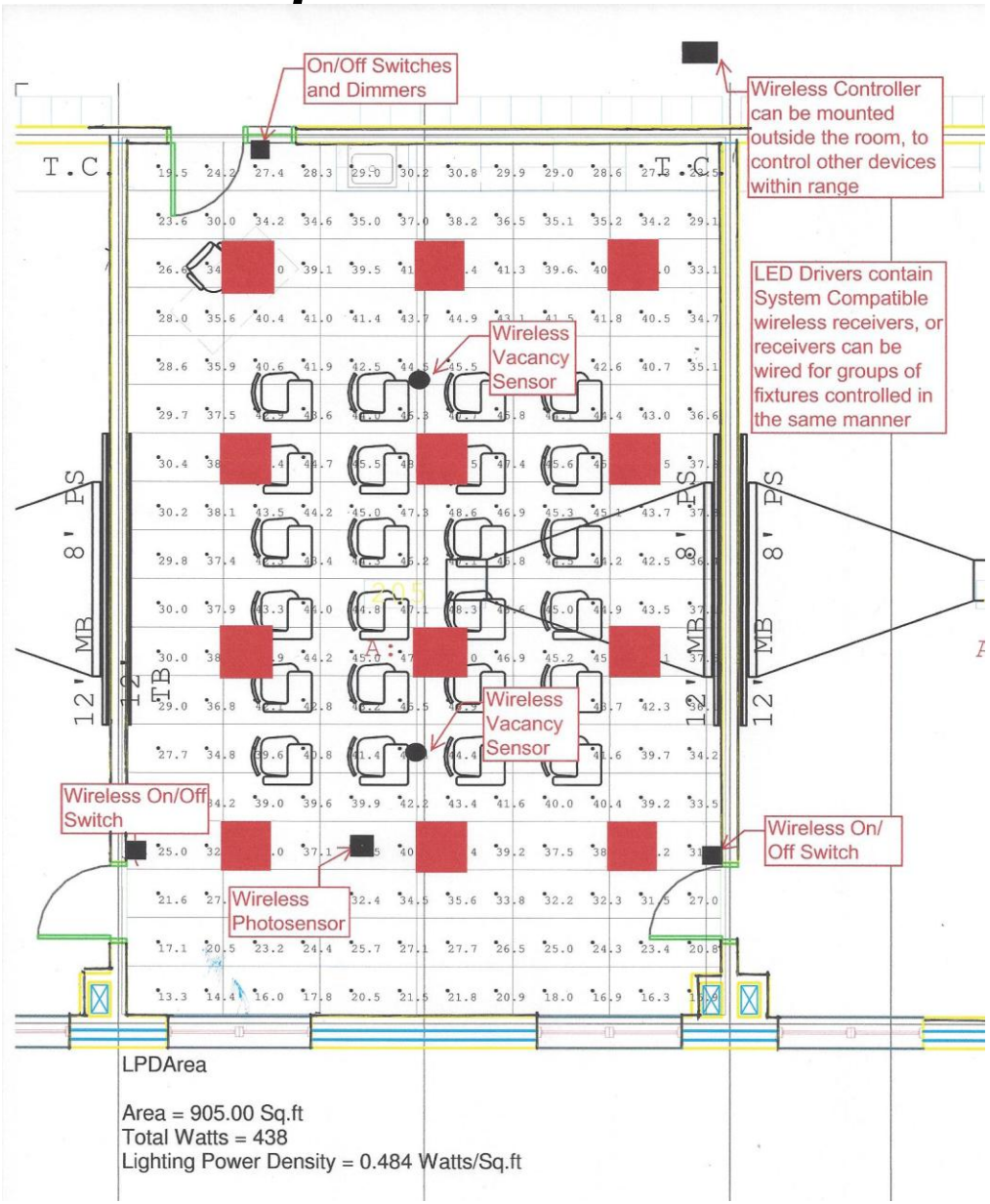
- ***49% or $47 @ $0.12/kWh for OS and daylight control of lighting***
- ***$84 @ $0.12/kWh adding OS control to fan and monitors***

Estimated $ for Control Equipment

- ***For 0-10v digital controls = $1020 equipment cost as stand-alone***
- ***For wireless system = $1020 without building wide control, <$1500 per room with building wide control hub and tracking/monitoring software***

Classroom Example 2

- Wireless Digital Equipment
  - Standard 0-10v drivers
  - 2 Occupancy Sensors
  - 1-3 Photosensors
  - Shared Wireless Controller in hallway
  - 2 Wall Switch Dimmer
  - 4 4-way Switches
- Optional Equipment
  - Fan OS Control
  - Computer Monitor Control Occ sensors
  - Drop screen control



Small Area Solutions

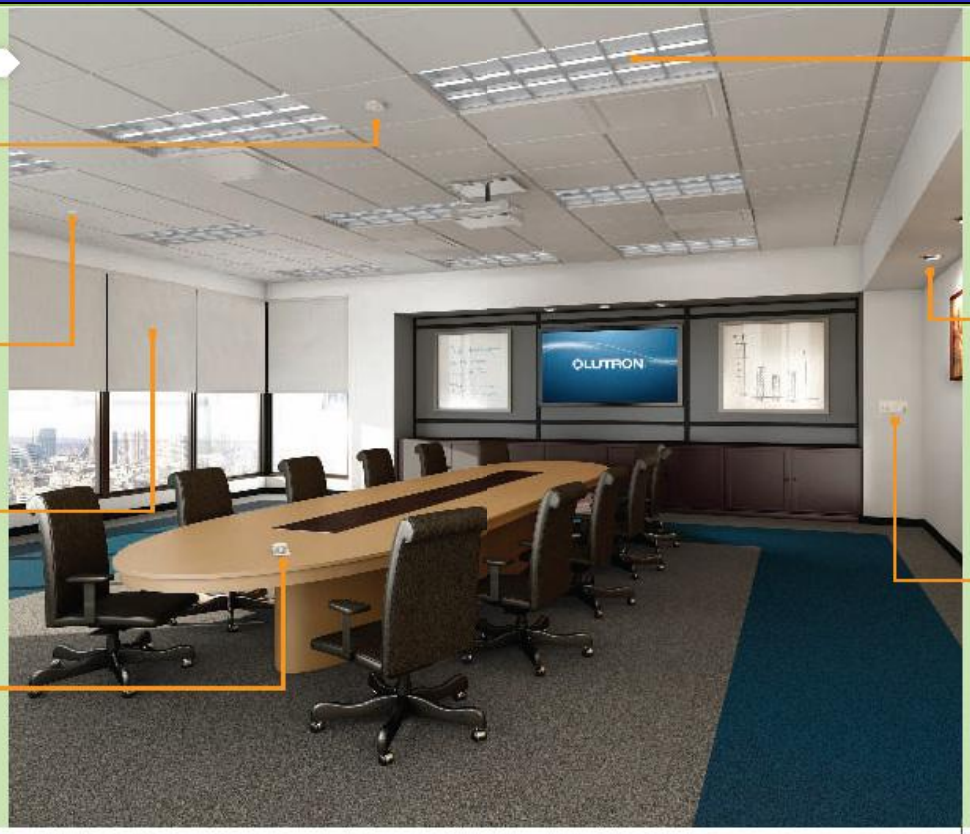
controls + sensors + ballasts + shades

Radio Powr Savr™ wireless occupancy/vacancy sensor
provides energy savings by ensuring lights are off when rooms are unoccupied

Radio Powr Savr wireless daylight sensor
gradually dims lights in response to the amount of available daylight

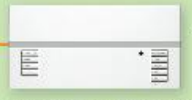
Sivoia® QS Wireless shades
move quietly to eliminate glare and reduce heating and cooling costs

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



EcoSystem® H-Series digital dimming 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

Hi-lume® A-Series LED driver
allows LED driver to offer smooth, continuous 1% dimming for virtually any LED fixture, whether it requires constant current or constant voltage



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

Combine light and shade control to build wireless mini-systems that improve the usability of a multi-purpose space and save more energy. These mini-systems can be easily expanded at any time to control multiple rooms or larger spaces and are suitable for both new construction and retrofit solutions.

Energy-saving strategies

High-end trim[4]	10–30% lighting
Occupancy/vacancy sensing[5]	20–60% lighting
Daylight harvesting[6]	25–60% lighting
Personal dimming control[7]	10–20% lighting
Controllable window shades[8]	10–20% cooling
Timeclock scheduling[9]	10–20% lighting

Potential lighting energy savings

60%

Sources can be found on page 17.

Example Small Area Solution

Project Example: Engineering Office Space (3200 sf)

- ***Room level manual dimming control for all fixtures***
- ***Occupancy Control for downlights - off when zone unoccupied***
- ***Daylight dimming to 20% for fixtures within 15' of window while occupied***
- ***Plug Load control of computer monitors***

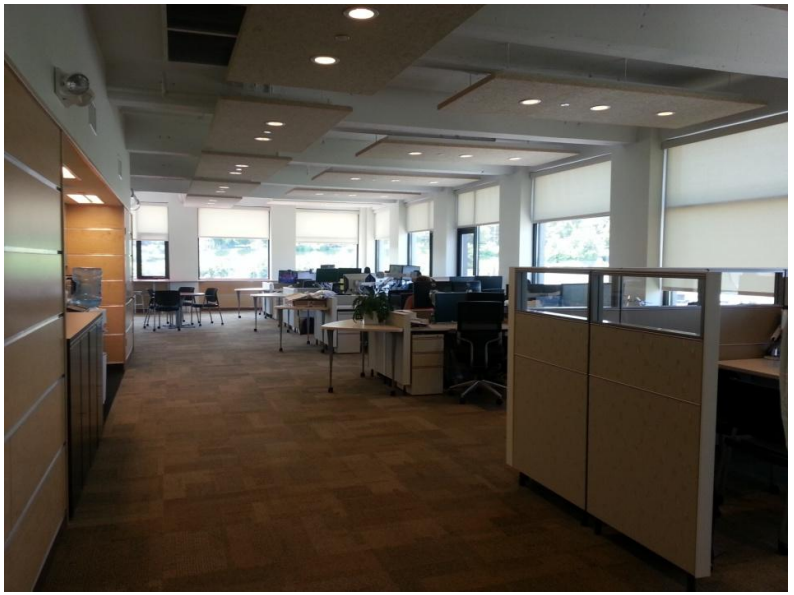


Photo and design credit: Daniel Johnson, Watershed Studios

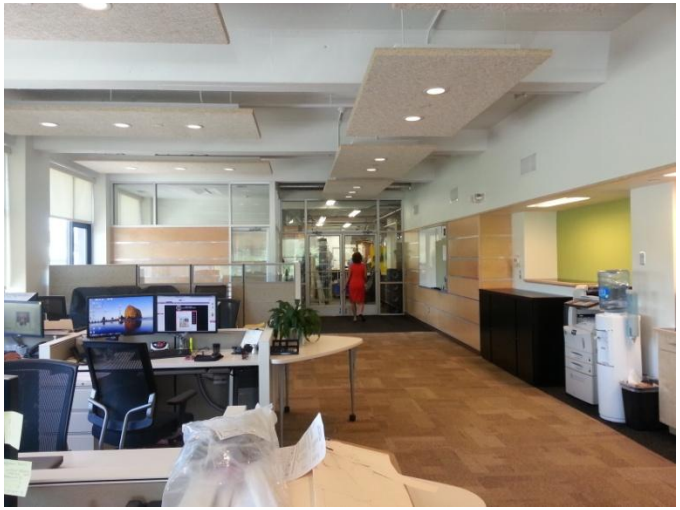
Example Small Area Solution

Estimated Annual Energy Cost Savings

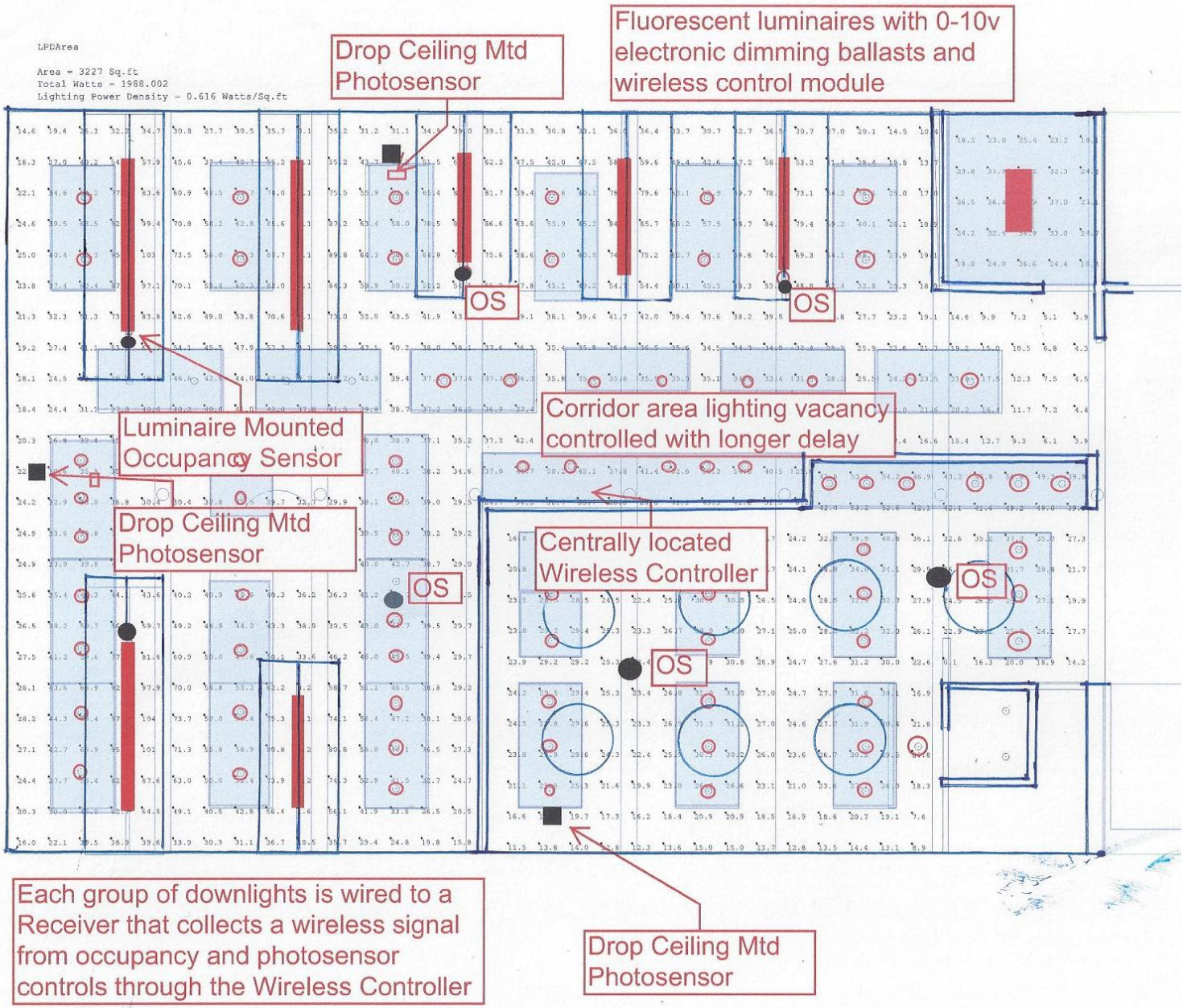
- ***47% or $638 for a 1.3 w/sf office space (3T8 FL + 35w HAL MR16)***
- ***35% or $241 For example new office space at 0.6 w/sf***

Estimated Equipment Cost for Controls

- ***Low Voltage digital control = $1860 ($0.58/sf) for new construction***
- ***Wireless digital control = $1805 ($0.56/sf) for new construction***
- ***Assumes fixtures have compatible dimming driver module built in***



Small Area Solution



Added occupancy-based energy savings

Project Example: Engineering Office Space with Daylighting

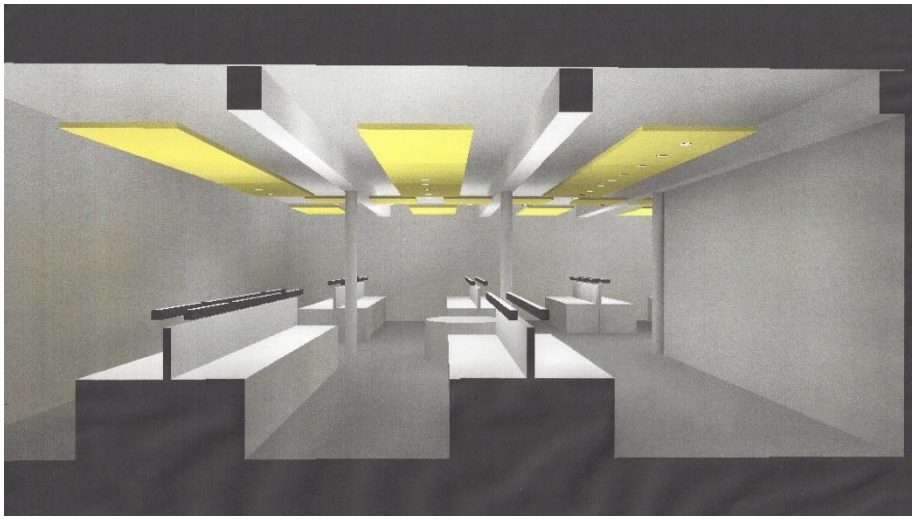
- ***Plug load control for small printers, copy machine and computer monitors***
- ***Ventilation fans***
- ***Automated shade controls to reduce summer cooling load***
- ***Integrated wireless control thermostats.***

Estimated Annual Energy Cost of Major Plug Load: $4302

Energy Star Device	Annual Consumption	Total Consumption
Lazer Color Copier	1027 kWh or $123 ea	(2) 2054 kWh or $246
Desktop Monitor	898 kWh or $108 ea	(14) 12,572 kWh/ $1512
Desktop Computer	1748 kWh or $210 ea	(12) 20,976 kWh/ $2520
Inkjet Printer/Scanner	50 kWh or $6 ea	(4) 200 kWh / $24

Additional Control Savings Opps

- Lighting control systems can be very useful as a Building Management System for:
  - Buildings with significant controllable plug load
  - Room controllable unit ventilator and/or thermostat
  - Buildings without or in addition to DDC



A 20% reduction in plug load at the engineering office example would save $860/yr.

NREL Documented Electrical Load in a College Facility, Lewis Hall (NE Ohio) with 59% PV electrical production

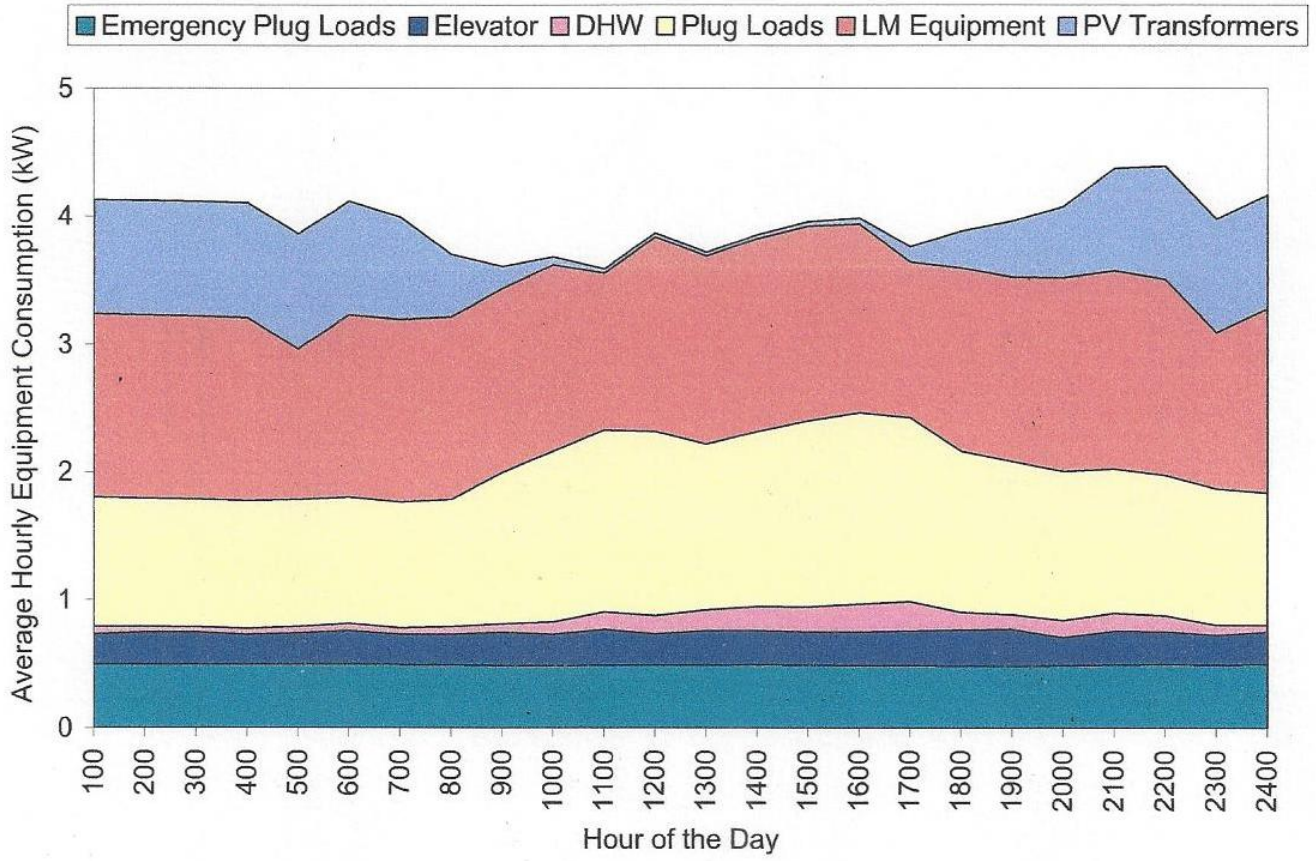


Figure 5-14 Annual equipment consumption load shape

NREL Documented Load Comparison at Lewis Hall with 59% PV electrical production. This is a building with well-designed lighting and daylighting controls, but didn't achieve net-Zero.

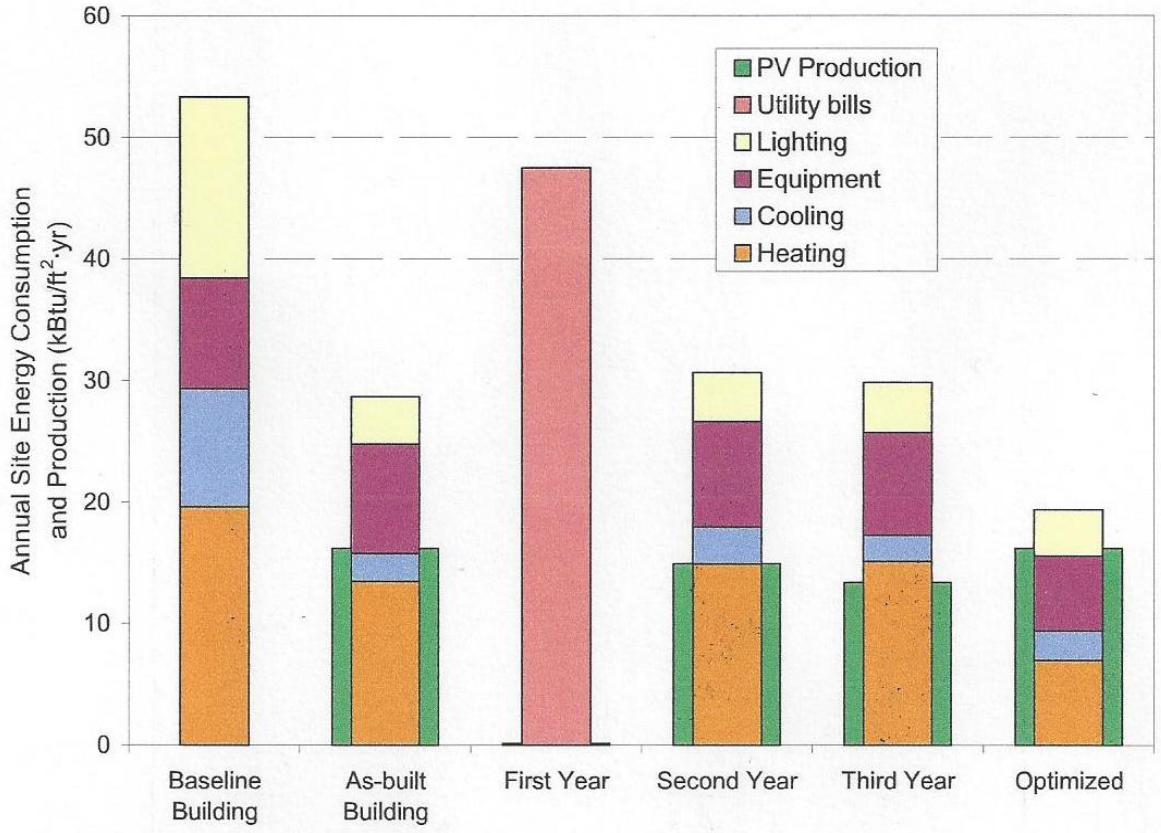


Figure ES-1 Annual site energy performance of building models and measured data

Expandable Area Lighting Control Solution

Project Example: 4350 sf Assisted Living Dining Facility with dimmable fixtures

- ***Manual Dimming of Downlights (halogen or LED)***
- ***Occupancy Control for all fixtures other than egress/emergency***
- ***Dimming of fixtures based on daylight control and time-of-day***
- ***Ventilation Control based on occupancy (not incl in $ savings)***

Expandable Area Lighting Control Solution

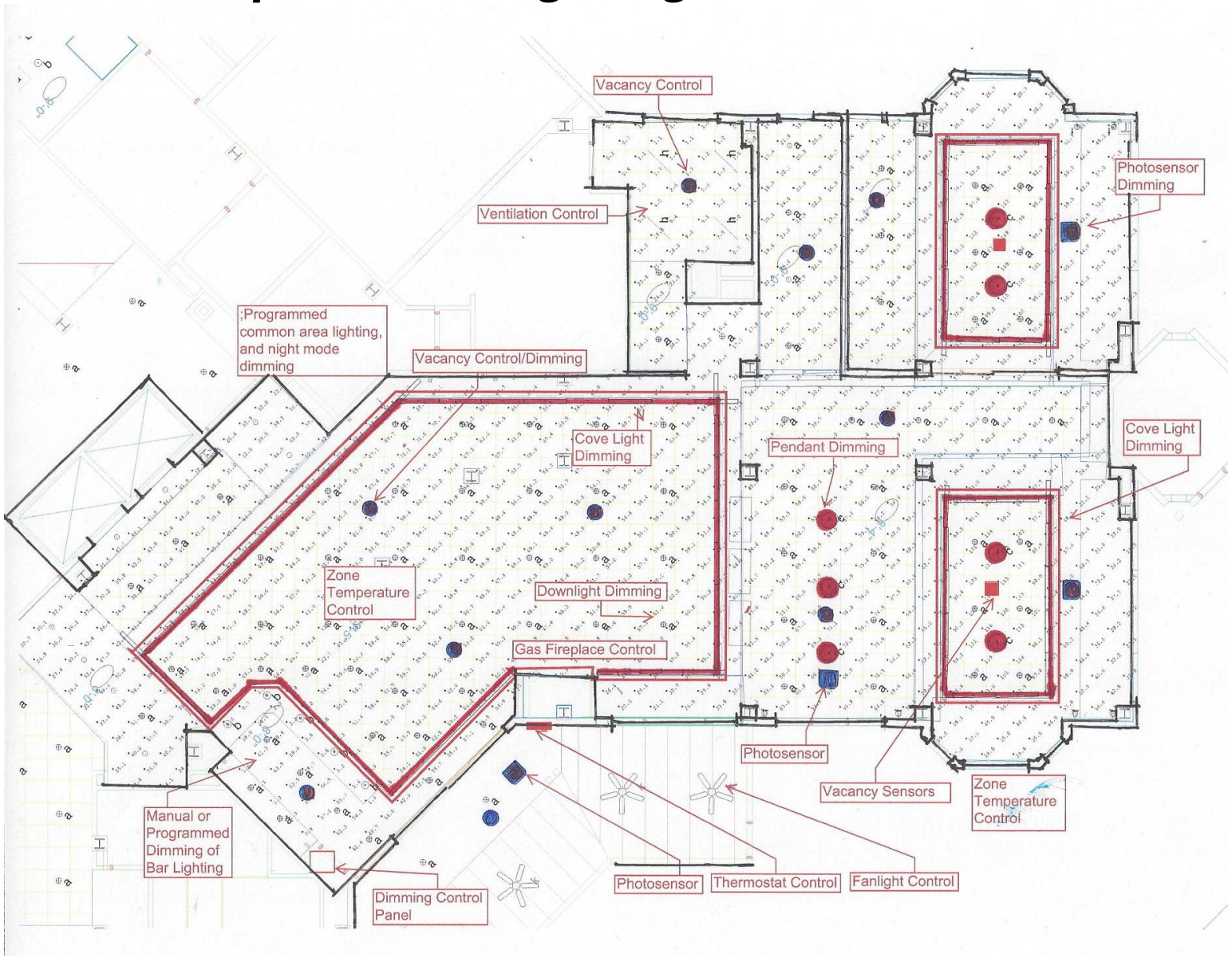
Estimated Energy Cost Savings

- *52% or $2,915 @ $0.12 for an existing 2.4 w/sf dining room (60w halogen downlts)*
- *47% or $1,366 @ $0.12 for a new or relighted dining room at 1.0 w/sf (LED downlts)*

Estimated Cost for Controls

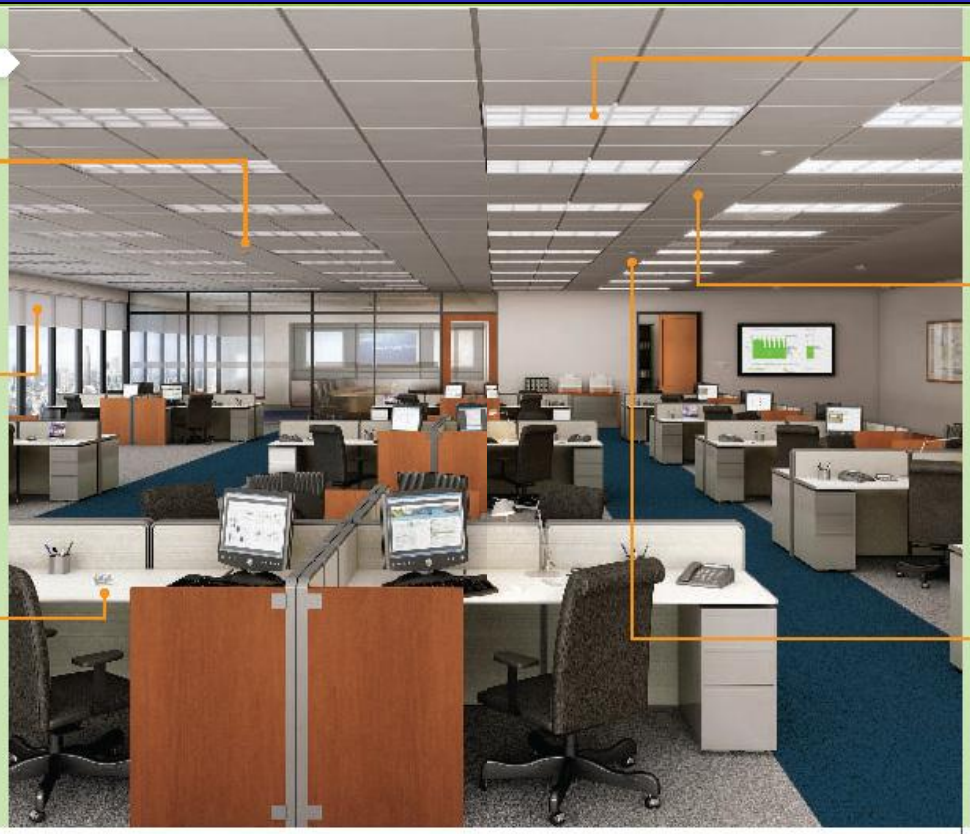
- *For Low Voltage digital controls w/ dimming CFL ballasts = $6140 equipment cost with preset room control*
- *For Wireless controls w/ dimmable LED downlights = $ 3380 including wireless hub and admin software*

Expandable Lighting Control Solution



Large Area Solutions

controls + sensors + ballasts + shades



Radio Powr Savr™ wireless daylight sensor
gradually dims lights in response to the amount of available daylight

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

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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

Energi Savr Node™ with EcoSystem
allows for easy integration of sensors and EcoSystem digital ballasts. Energi Savr Node with EcoSystem communicates with wireless devices through the QS sensor module (above right) to minimize wiring for easy installation

Energi Savr Node for 0–10 V dimming and switching applications are also available

Radio Powr Savr wireless occupancy and vacancy sensor
provides energy savings by ensuring lights are off when rooms are unoccupied

Tie multiple rooms together, up to an entire floor, with these flexible solutions. Integrate daylight and occupancy sensors for significant energy savings. Easily design, install, and reconfigure to meet the changing needs of any space.

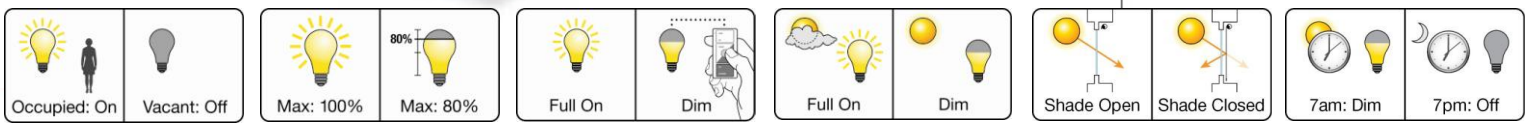
Energy-saving strategies

High-end trim[4]	10–30% lighting
Occupancy/vacancy sensing[5]	20–60% lighting
Daylight harvesting[6]	25–60% lighting
Personal dimming control[7]	10–20% lighting
Controllable window shades[8]	10–20% cooling
Timeclock scheduling[9]	10–20% lighting

Potential lighting energy savings

60%

Sources can be found on page 17.



Large Area Solution for Partition Mounted Lighting

Project Example: Wireless Partition Mounted Lighting System for Large Open Office Daylit Space

- ***Occupancy Control : 1 underdesk per workstation controls lighting and dual computer monitors***
- ***Daylight Dimming of fixtures within 20' perimeter zone***
- ***The system works best with a dense workstation layout and at least 8' (1 lamp T5) of lighting per workstation***
- ***Computer monitors plug into OS controlled hub***

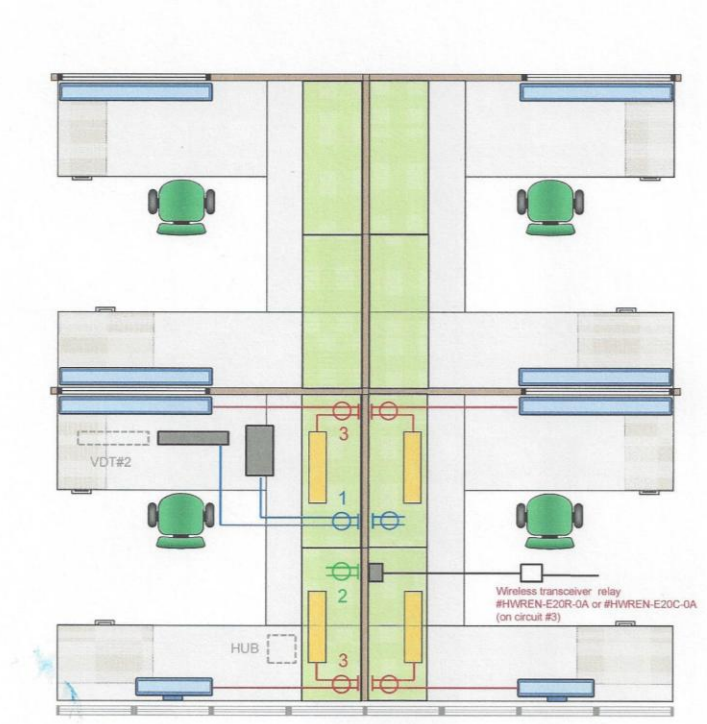
Estimated Annual Energy Cost Savings (228 workstations)

- ***36% or $1441 lighting savings at 0.6 w/sf***
- ***15% or $2667 computer monitor savings from vacancy control***

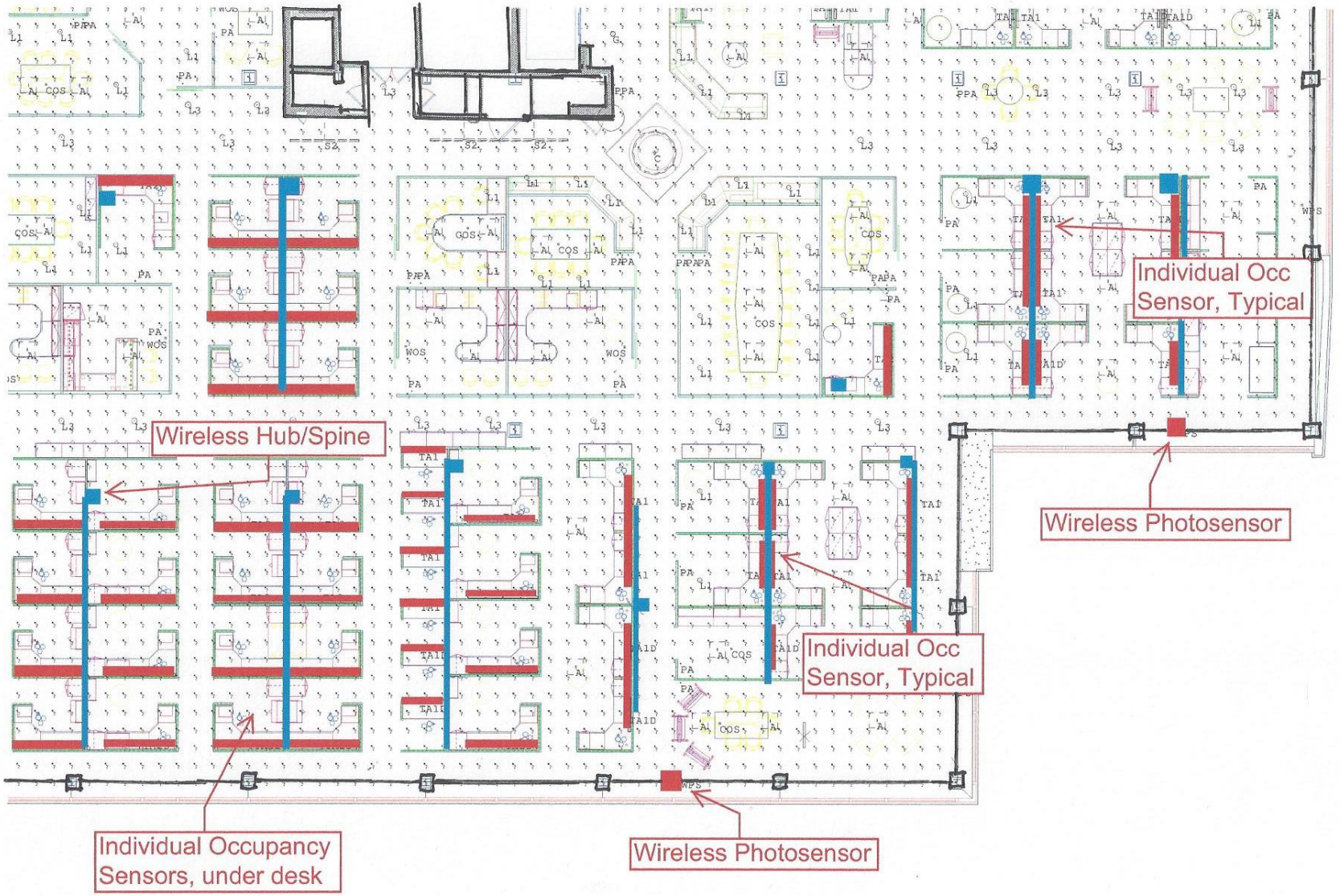
Estimated Cost for controls

Control costs not separately identified

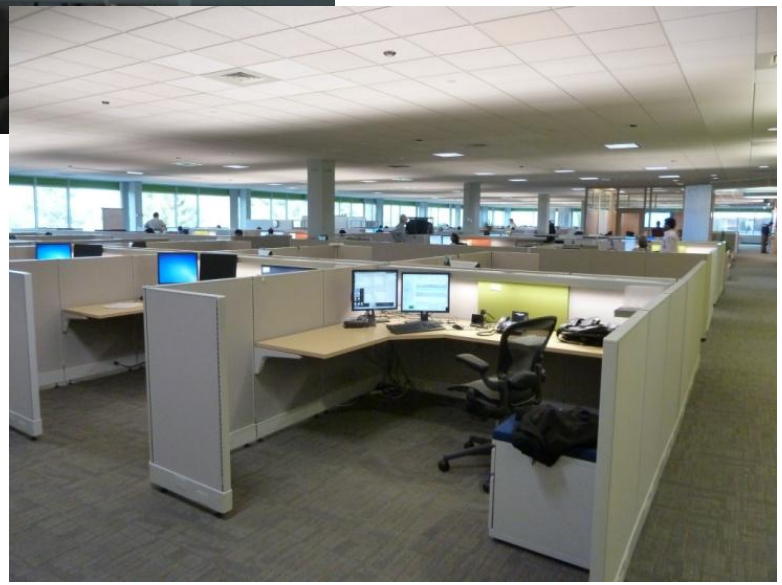
Partition Mounted Lighting & Control System

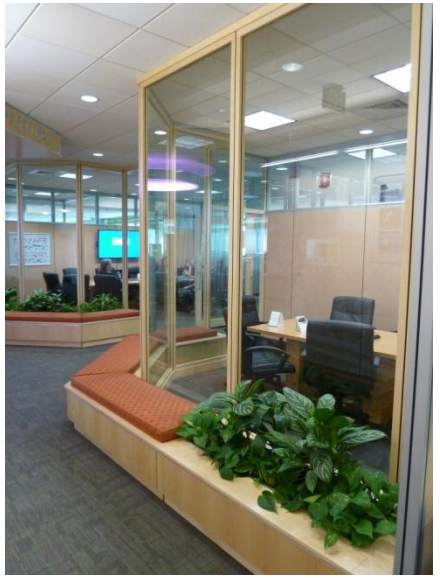


Partition Mounted Lighting Solution



Large Area Lighting Solutions at National Life of VT



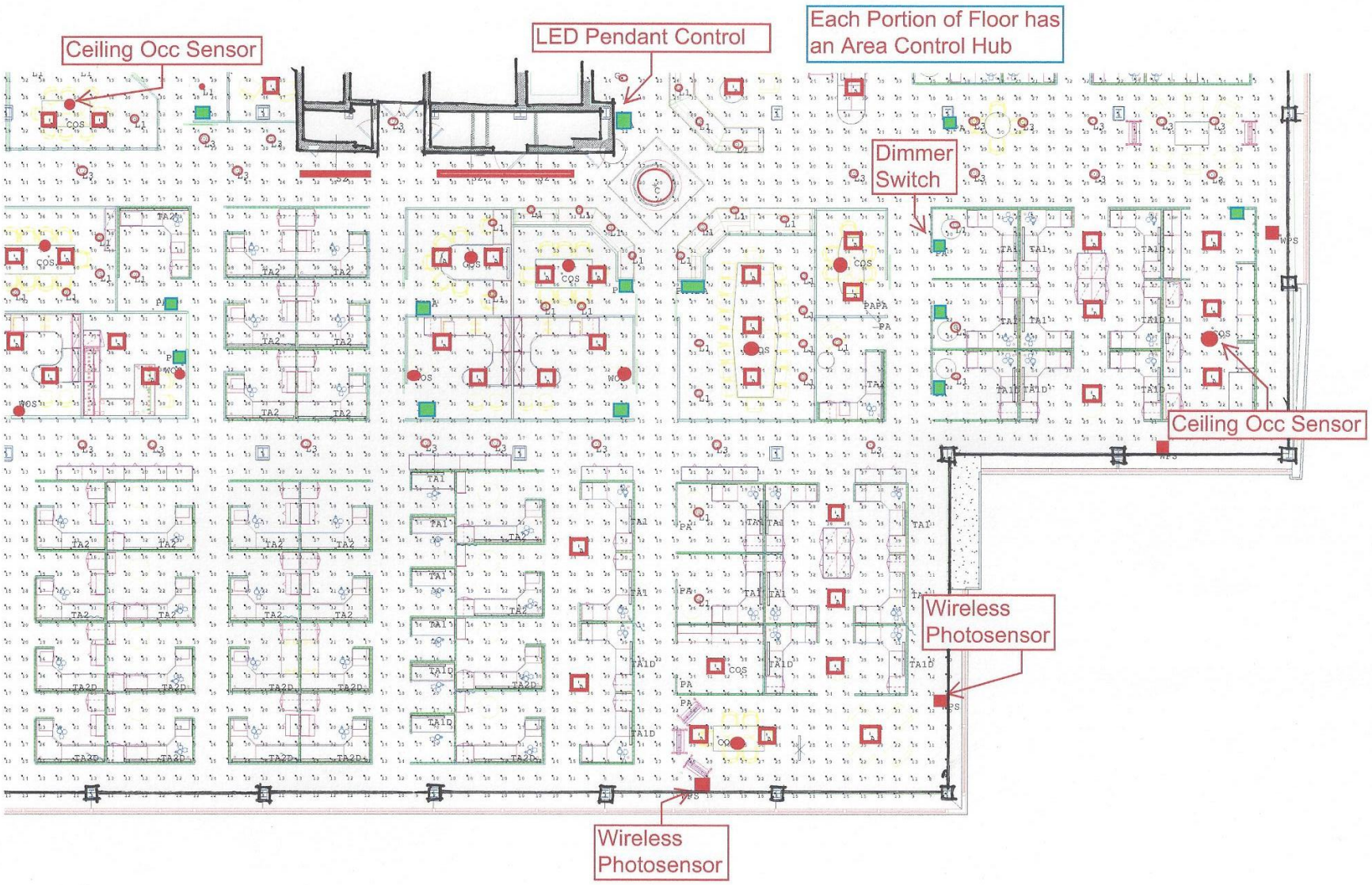


Large Area Lighting Control

Project Example: Large Open Office Space with Daylighting

- ***Wireless Occupancy Control : For private offices, conference rooms, and common areas***
- ***Daylight Dimming of fixtures within 20’ of windows using Wireless Photosensors***
- ***Manual dimming of private office spaces and conference rooms***
- ***Light trimming using wireless dimmable fluorescent ballasts***
- ***Programmed time control for hallways and common areas***
- ***Equipment Cost was roughly $0.85/sf***

Large Area Lighting Control



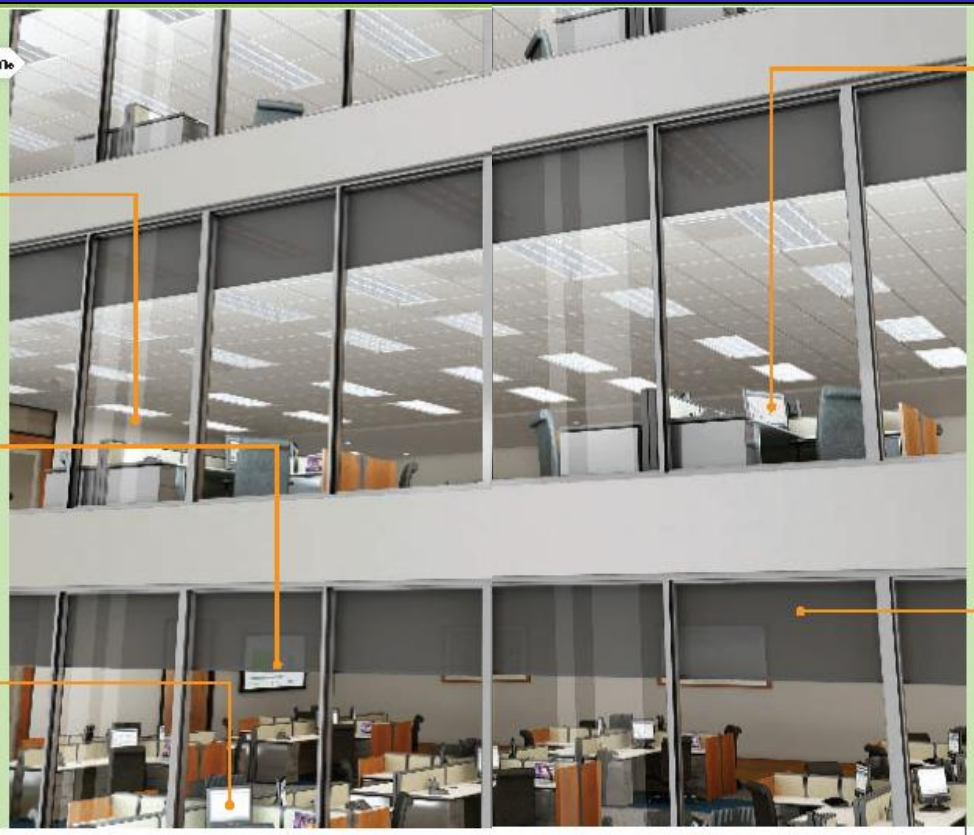
Whole Building Solutions

controls + sensors + ballasts + shades + Quantum

Quantum hub
connects all system components for Total Light Management™ of an entire building or campus

GreenGlance®
energy-saving display software exhibits a real-time snapshot and historic view of the energy savings delivered by Quantum solutions

Personna® PC
gives occupants control of their lighting fixtures and automated window treatment from any device that can run a web browser



Q-Admin™ software
allows facility managers to control lights and shades, set timeclocks, and configure, monitor, analyze, and report on the light in an entire building

IntelliDemand™ loadshed
IntelliDemand loadshed allows facility managers to shed a percentage of the system lighting output to reduce peak demand charges and comply with demand response programs.

Q-Control+ app
Provides a simple user interface for end-users, facility managers, and lighting designers to control and monitor the lights and shades from anywhere in the building using a mobile iPad® platform

Hyperion™ solar-adaptive shading with Sivoia® QS shades
creates a shade adjustment schedule based on the angle of the sun to effectively manage daylight entering each façade. Shades maximize daylight harvesting and prevent heat glare from entering a space.

Easily expand systems by adding Quantum functionality to control multiple floors, a whole building, or an entire campus.
Facility managers can configure, control, manage, monitor, and report on all the lighting in a building from a central location. By maximizing the use of daylight and minimizing waste, a Quantum system allows you to save significant amounts of energy and money.

Energy-saving strategies

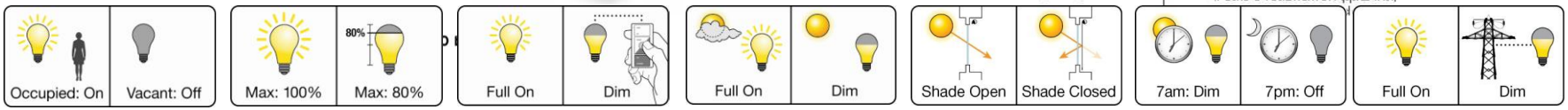
High-end trim[4]	10–30% lighting
Occupancy/vacancy sensing[5]	20–60% lighting
Daylight harvesting[6]	25–60% lighting
Personal dimming control[7]	10–20% lighting
Controllable window shades[8]	10–20% cooling
Timeclock scheduling[9]	10–20% lighting
Demand response[10]	30–50% during peak period

Potential lighting energy savings

60% +

Sources can be found on page 17.

iPad is a trademark of Apple® Inc.,



Whole Building Solutions

Project Example: 15,000 sf College Library with Luminous Ceiling

- ***Light Tuning: Reduce lumen output to meet requirements***
- ***Occupancy Control : For stack areas, reading rooms, study carrels, conference and classroom space, private offices***
- ***Daylight Dimming or on/off control of fixtures in daylight reading areas and perimeter offices***
- ***Manual dimming of private office spaces and conference rooms***

Whole Library Building Solutions

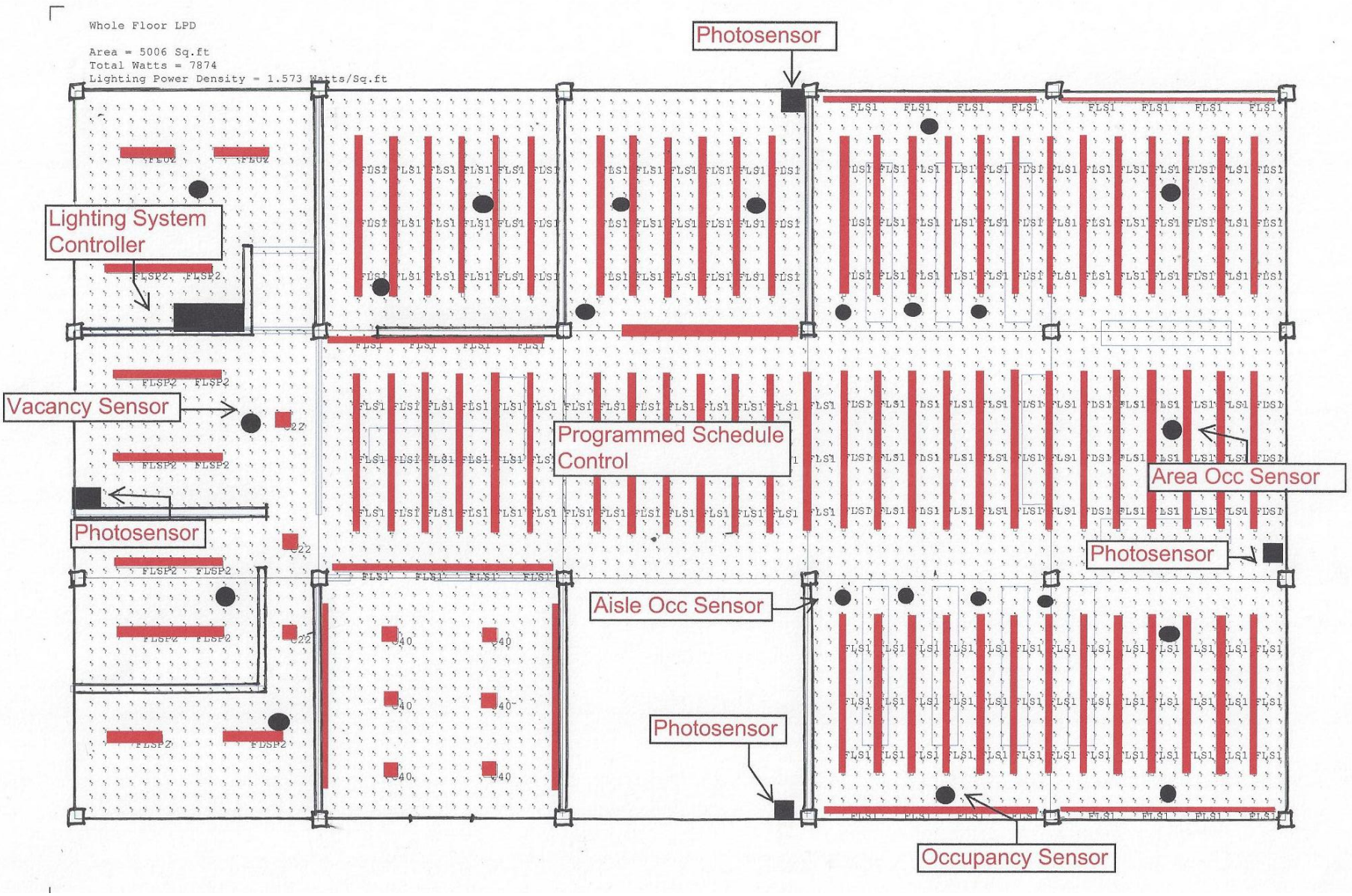
Estimated Annual Control Savings (based on ReLight)

- ***50% or $7,312 for the existing 1.6 w/sf library with dimming T8 fluorescent***
- ***59% or $8,378 with a mostly LED system at 1.0 w/sf***

Estimated Cost for Controls (for 15,000 sf building)

- ***For Low Voltage controls with dimming ballasts = $41,600***
- ***For Wireless dimming with new LED dimmable fixtures (fixtures not included) = $32,500***

Whole Building Solutions



Whole Building Solutions

Project Example: 58,000 sf , 5-level College Library

- ***Occupancy Control : For stack areas, reading rooms, study carrels, conference and classroom space, private offices***
- ***On/off control of fixtures in daylight reading areas***
- ***Manual dimming of private office spaces and conference rooms***
- ***Vacancy control for workshops and storage areas***
- ***Remote Management Capability***

Whole Building Solutions

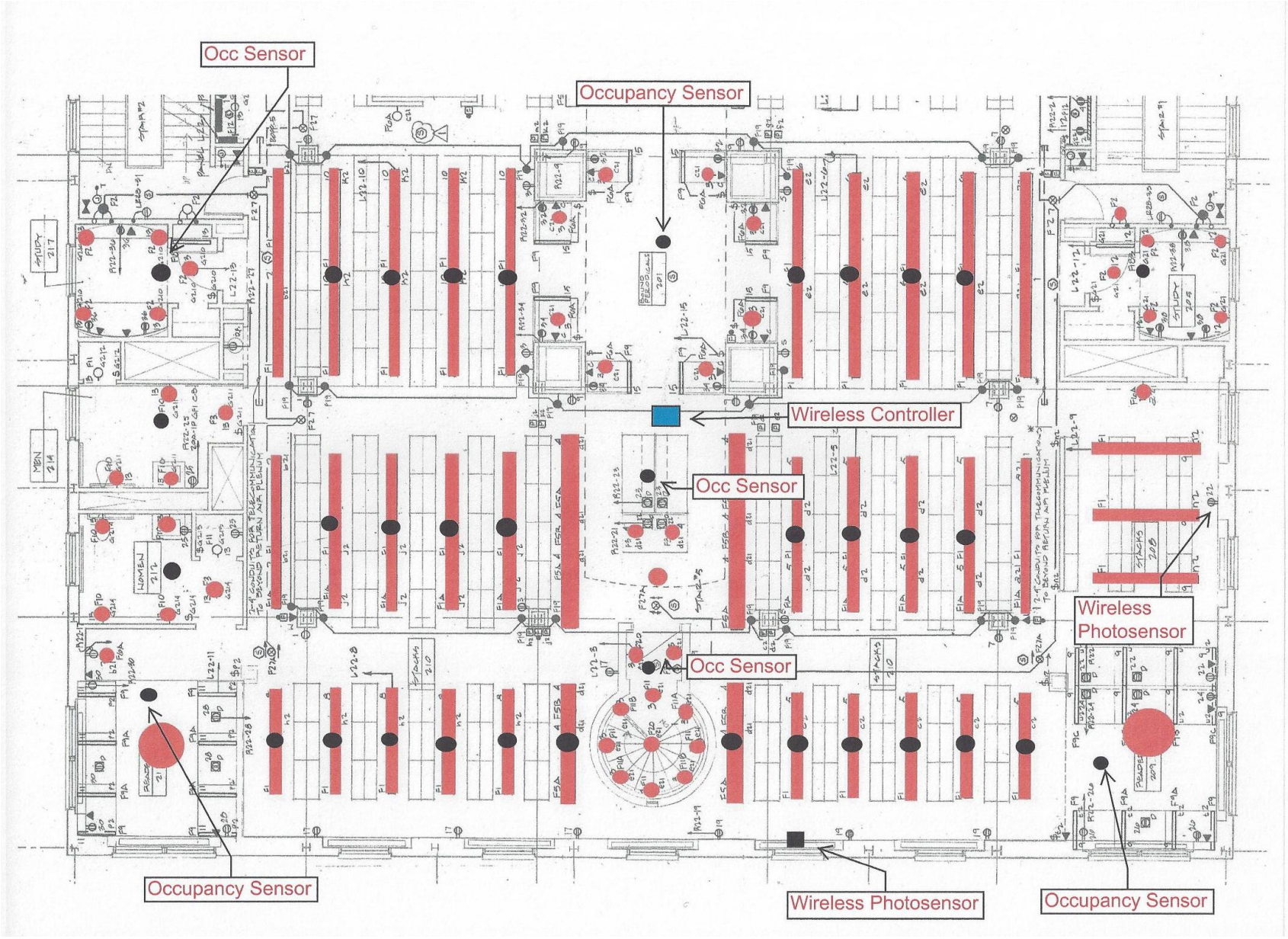
Estimated Annual Energy Cost Savings

- ***With most cost effective retrofit of non-dimming linear T8 FL = $10,060 or 45%***
- ***With replacement of T8 and CFL to LED = $11,600 or 52%***
- ***LED advantage for frequent cycling***

Estimated Cost for Controls

- ***For Wireless control equipment = $63,600. This is without dimming, but with LED retrofit kits to CFL fixtures. (ReLight estimate)***

Whole Building Solutions



Demand Response Savings with Smart Metering

C%I Demand Rate	kWh Rate	kWh/ Mo.	Charge
Monthly Charge	$34.96		
kWh on Peak	$0.21	10500	$ 2,197.13
kWh off Peak	$0.09	10200	$ 948.50
			$ 3,180.58
Monthly Charge	$34.96		
kWh on Peak	$0.21	9450	$ 1,977.41
kWh off Peak	$0.09	10200	$ 948.50
			$ 2,960.87

Time of Use Rates are Coming

- On Peak Use Reduction has the most savings
- Coincides with Best Opportunity for Lighting Energy Savings

Integrating with Shades

Light Space Design
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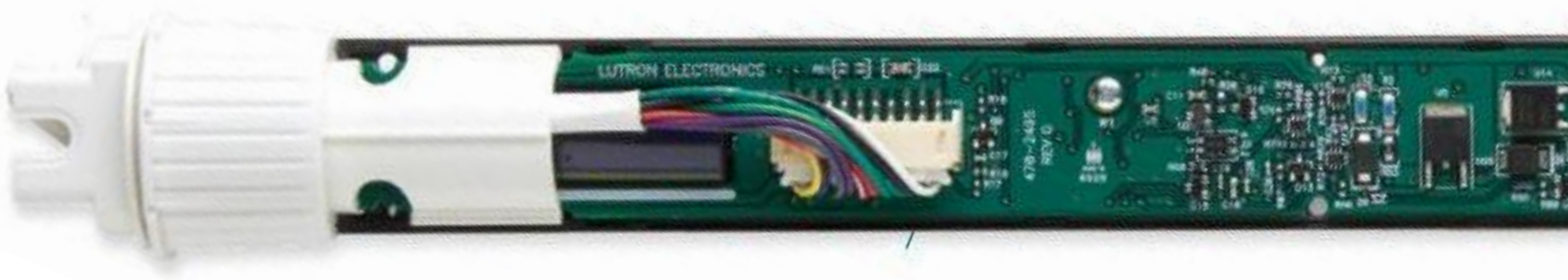
- ***Shading controls are one of the next generation of lighting controls.***



- ***Controlling shades is important to ensuring electric light savings, particularly where large window areas and glare are a consideration.***
- ***When shades are drawn, they are not opened again.***

Integrating Controls with Shades

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- *Simple operation, great aesthetics*
  - *Preset buttons recalls shade position*
- *Quiet operation*
- *Integrated software can adjust shades based on sun position*
- *Maximize use of available daylight while minimizing heat penetration.*

- *User Selects*
  - *Desired sunlight penetration*
  - *Number of shade preset positions*
  - *Manual override of shades*

Other Control System Integration benefits

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Additional Benefits

- *Security and surveillance – lights turn on based on occupancy, making it easier to know when intruders are present.*
- *Room scheduling*
- *Occ Sensing for Ventilation*
- *Heating and/or Cooling Setback*

Savings

- *Reduced losses from theft*
- *Reduces staff time for scheduling and monitor ing conference space*
- *Roughly 3 to 4 times the savings from occupancy based on/off lighting controls for temperature setback*

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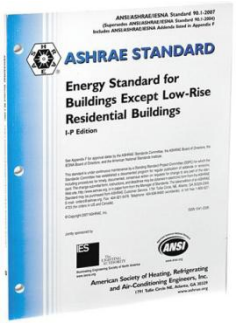
BACnet Integration

- Connection on any processor in the Quantum or other large system network over a standard IP based network
- Control and monitor areas or groups
- No gateway required, BACnet/IP is resident in each processor
- Integrators can work with proper names automatically generated by the processor

BACnet

Energy codes, utility incentives EPAct, and LEED

- *All lighting controls help meet the requirements for EPAct tax deductions*
- *A lighting control system may help to contribute to up to 20 LEED points for new construction, as well as help ensure compliance with a broad variety of energy codes.*



LEED & Lighting Control

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- ***Lutron total light management solutions contribute toward earning points in the following LEED credits/prerequisites:***
  - ***Light Pollution Reduction SS 8***
  - ***Fundamental commissioning E&A prereq 1***
  - ***Minimum Energy Performance E&A prereq 2***
  - ***Optimize Energy Performance E&A 1***
  - ***Enhanced Commissioning E&A 3***
  - ***Measurement & Verification E&A 5***
  - ***Controllability of Systems IEQ 6.1***
  - ***Daylight and Views EQ 8.1 and EQ 8.2***
  - ***Innovation & Design ID 1***

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Questions???