The Application and Costs of Lighting Controls

Efficiency Vermont
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GREEN LIGHT NEW YORK

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www.greenlightny.org
Three Different “Levels” of Control Systems

1. Stand Alone Controls
2. Centralized Panel Controls
3. Fully Integrated Networked, Addressable Controls
Three Different “Levels” of Control Systems

- Stand Alone Controls
- Centralized Panel Controls
- Fully Integrated Networked, Addressable Controls

How do these levels correlate to:
- Costs?
- Savings?
- Complexity?
- Functionality?
- Occupant Satisfaction?
- Marketability / Rents?
Stand-Alone Controls

Line Voltage Wall Switch

Line Voltage Occupancy/Vacancy Sensor

Two Zone or “Bi-Level” Occupancy/Vacancy Sensor

Stand-Alone Photocell w/ Relay/Power Pack

Stand-Alone Occupancy Sensor w/ Relay/Power Pack
Stand-Alone Controls Pros/Cons

Pros:
- May be less expensive
- Familiar wiring methods

Cons:
- Less Flexible
- Complicated to combine multiple control strategies
- Less energy savings
Centralized Panel Controls

- Power Pack
- Low-Voltage Wiring
- Low-Voltage Relay-based Lighting Control Panel
- Line-Voltage Wiring

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Centralized Panel Controls

Pros:
- More flexible
- Programming & monitoring from a centralized location
- Can be integrated into BAS systems (security, HVAC)

Cons:
- Requires low-voltage wiring to be installed
- Less familiar wiring methods may result in higher bid costs
- Limitations on zoning & no. of control strategies
Fully-Integrated Addressable Control System (Wired)

- Ethernet Network
- Dali Gateway/Controller
- 5 Core Electric Cabling
  - Active-Neutral-Earth-D1-D2 (free topology)
  - Switch Plate (via group/scene controller)
- DALI Power Supply
- DALI Ballast
- Fluorescent Lamp
Addressable systems can require up to 60% less wiring.
Fully-Integrated Addressable Control System (Wireless)
**Fully-Integrated Addressable Control System**

**Pros:**
- More flexibility > potential for more energy savings
- Programming and monitoring from a centralized location
- Allows for multiple control strategies
- Can be easily reconfigured, re-zoned, for changes in space layout and tenants without requiring rewiring

**Cons:**
- May have higher initial cost
- Proprietary products, trademarked DALI
- May require low-voltage wiring to be installed (wired)
- Less familiar wiring methods may result in higher bid costs
- May require a computer server
- Commissioning can be more complicated and
Applying different “levels” of controls to an example Office Space
Review of Code Lighting Control Requirements per IECC 2009

- **Automatic Lighting Shutoff**
  - “Buildings… shall be equipped with automatic control device to shut off lighting… based on either:”
    - Scheduled basis using time of day
    - Occupant Sensor
    - Signal from control or alarm system that indicates area is unoccupied

- **Daylight Zone Control**
  - Daylight zones shall be provided with individual controls that control the lights independent of general area lighting
2-Lamp T5 Troffers on 8’x10’ spacing

Four Private Offices

One Open Office

Vertical Glazing on East & North
First Approach
Use Stand-alone Controls to Meet the Code Minimum
Open Office Control Strategies

- Timeclock scheduling (all zones)
Open Office Control Strategies

- Timeclock scheduling (all zones)
- Manual switch for daylight zone luminaires
Open Office Control Strategies

- Timeclock scheduling (all zones)

- Manual switch for daylight zone luminaires

Private Office Control Strategies

- Line Voltage Vacancy Sensors
# Savings Analysis using Stand-Alone Controls

<table>
<thead>
<tr>
<th>Space</th>
<th>Control Strategy</th>
<th>Controlled Fixture(s) %</th>
<th>Total Project % Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open</td>
<td>Timeclock Scheduling Control</td>
<td>15%</td>
<td>14%</td>
</tr>
<tr>
<td>Open</td>
<td>Daylight Zone Luminaires Switch</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Private</td>
<td>Vacancy Sensors</td>
<td>30%</td>
<td>2%</td>
</tr>
</tbody>
</table>

**Total Cumulative Lighting Control Savings:** 16%
What are the Pros & Cons of this approach?

- Functionality
- Cost
- Wiring
- Energy Savings
- Flexibility
- Occupant Satisfaction
- Marketability & Rents
Second Approach
Centralized Relay Panel with Additional Control Strategies
Centralized Panel Controls

- Power Pack
- Low-Voltage Wiring
- Line-Voltage Wiring
- Low-Voltage Relay-based Lighting Control Panel
Open Office Control Strategies:

- Timeclock scheduling by day
Open Office Control Strategies:

- Timeclock scheduling by day
- Occupancy control at night
Open Office Control Strategies:

- Timeclock scheduling by day
- Occupancy control at night
- Daylight responsive dimming for daylight zone luminaires (2 zones)
Open Office Control Strategies:

- Timeclock scheduling by day
- Occupancy control at night
- Daylight responsive dimming for daylight zone luminaires (2 zones)

Private Office Control Strategies:

- Vacancy Sensors with bi-level switching
## Centralized Panel w Additional Control Strategies Savings Analysis

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<th>Total Project % Savings</th>
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</thead>
<tbody>
<tr>
<td>Open</td>
<td>Timeclock by Day, Occupancy Control at night</td>
<td>21%</td>
<td>19%</td>
</tr>
<tr>
<td>Open</td>
<td>Daylight Responsive Dimming for Daylight Zone Luminaires</td>
<td>23%</td>
<td>8%</td>
</tr>
<tr>
<td>Private</td>
<td>Vacancy Sensors</td>
<td>30%</td>
<td>2%</td>
</tr>
<tr>
<td>Private</td>
<td>Bi-Level Switching</td>
<td>9%</td>
<td>1%</td>
</tr>
</tbody>
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**Total Cumulative Lighting Control Savings:** $30\%$
What are the Pros & Cons of this approach?

- Functionality
- Cost
- Wiring
- Energy Savings
- Flexibility
- Occupant Satisfaction
- Marketability & Rents
Third Approach

Fully Addressable, Wireless with all Cost-effective Control Strategies
Open Office Control Strategies:

- Timeclock scheduling by day
Open Office Control Strategies:

- Timeclock scheduling by day
- Occupancy control at night
Open Office Control Strategies:

- Timeclock scheduling by day
- Occupancy control at night
- Daylight responsive dimming for daylight zone luminaires
Open Office Control Strategies:

- Timeclock scheduling by day
- Occupancy control at night
- Daylight responsive dimming for daylight zone luminaires
- Task Tuning

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Diagram showing wireless area controller, CAT 5 system controller & software, wireless override switches, daylight zone 1, daylight zone 2, wireless photocell, wireless occupancy sensor, and system control.
Private Office Control Strategies:
- Vacancy sensors

System Controller & Software

Wireless Area Controller

CAT 5

Wireless Occupancy Sensor and Photocell

Wireless Occupancy Sensor

Wireless Photocell

Wireless Override Switches

Daylight Zone 2

Daylight Zone 1

Low-Voltage Relay-based Lighting Control Panel

Power Pack

Low-Voltage Controls

Light Fixtures

Low-Voltage Wiring

Line-Voltage Wiring

Wireless Override Switches
Private Office Control Strategies:

- Vacancy sensors
- Personal Dimming
Private Office Control Strategies:

- Vacancy sensors
- Personal Dimming
- Task Tuning

[Diagram with various controls and sensors labeled, including Wireless Dimming, Wireless Occupancy Sensor and Photocell, Wireless Photocell, and Wireless Override Switches.]
<table>
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<th>Control Strategy</th>
<th>Controlled Fixture(s) % Savings</th>
<th>Total Project % Savings</th>
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<tr>
<td>Open Office</td>
<td>High-end trim dimming</td>
<td>10%</td>
<td>9%</td>
</tr>
<tr>
<td>Open Office</td>
<td>Timeclock Scheduling Control during day, Occupancy Control at night</td>
<td>19%</td>
<td>17%</td>
</tr>
<tr>
<td>Open Office</td>
<td>Daylight Responsive Dimming for first two rows of luminaires near glazing</td>
<td>8%</td>
<td>7%</td>
</tr>
<tr>
<td>Private Office</td>
<td>High-end trim dimming</td>
<td>10%</td>
<td>1%</td>
</tr>
<tr>
<td>Private Office</td>
<td>Vacancy Sensors</td>
<td>27%</td>
<td>2%</td>
</tr>
<tr>
<td>Private Office</td>
<td>Personal dimming</td>
<td>10%</td>
<td>1%</td>
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</table>
What are the Pros & Cons of this approach?

- Functionality
- Cost
- Wiring
- Energy Savings
- Flexibility
- Occupant Satisfaction
- Marketability & Rents
Should more advanced controls cost more?
Clanton Lighting Control Study

- Life Cycle Cost Evaluation of Multiple Lighting Control Strategies

- Compares different levels of lighting control upgrades in Boston & Los Angeles

- Do or should Advanced Lighting Controls cost more?

- Do Advanced Lighting Controls save more?
Analyzed 6 different levels of Lighting Control Upgrades

Networked Addressable

- (6) Wireless Full Dimming
- (5) Wireless Partial Dimming
- (4) Addressable Ballasts
  - Central Panel
- (3) Dimming Panel
- (2) Relay Panel
  - Stand-Alone
- (1) Localized control
Baseline Building
How much energy did each system save?

14% Below Baseline
20% Below Baseline
30% Below Baseline
47% Below Baseline
31% Below Baseline
49% Below Baseline

(1) Localized Control
(2) Relay Panel
(3) Dimming Panel
(4) Addressable Ballasts
(5) Wireless Partial Dimming
(6) Wireless Full Dimming

Annual Energy Density [kwh/sf]
Capital Costs

(1) Localized Control
(2) Relay Panel
(3) Dimming Panel
(4) Addressable Ballasts
(5) Wireless Partial Dimming
(6) Wireless Full Dimming

- Highest Cost branch circuit and control wiring
- Lower Cost for Control Equipment
- Low Cost branch circuit and control wiring
- Highest Cost for Lighting System
- Lowest Cost branch circuit and control wiring
- Highest Cost for Control Equipment and Devices

- Branch Circuit Wiring
- Lighting System
- Devices
- Control System
- Commissioning

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Figure 11 – Capital Cost Breakdown for Boston
Key Findings of Clanton Study

- Advanced Lighting Controls can achieve 50% less energy than code-compliant lighting controls
- Wireless Advanced Lighting Controls have lower capital costs than other systems studied in office retrofit applications
- Reduced labor & energy costs of advanced networked lighting control systems can out-weigh increased equipment & commissioning costs

- Will this be true on your project?
Challenges With Pricing

Does uncertainty or lack of familiarity increase bid price?

Will the wiring savings be realized?

What can we do to address these challenges?
Strategies to Reduce the Cost of Advanced Controls

- Hold mandatory pre-bid training for all bidders
  - Highlight issue of controls pricing
  - Communicate that you are looking to realize savings from reduced wiring
  - Controls pricing should not be based on standard $/SF
  - Clearly explain how controls will be wired
  - Clearly identify who is responsible for what
Strategies to Reduce the Cost of Advanced Controls

- Carefully and Fully Specify Controls
  - Provide Design Narrative for all Controls
  - Provide Control Intent and Zoning Diagrams
  - Specify Initial Calibration Settings
  - Identify who is responsible for what
  - Align responsibility with who is most knowledgeable and/or cost-effective for each task
    - Example: Consider putting responsibility on Manufacturer for Commissioning and System Functionality
    - Example: Require the contractor is trained on control system
Strategies to Keep Advanced Controls on Projects

- Reduce the Costs per previous slides
- Play up the benefits beyond energy savings:
Light Level Preferences

A 2004 open office study found that people exhibit a wide range of light level preferences.

Energy Savings

5–20%

Source: LightRight Consortium
Allowing workers to control their light can result in higher productivity and occupant satisfaction.

People costs typically outweigh building costs by 13:1.

Investing in personal controls can lead to desirable financial outcomes beyond energy savings.

Reasons People Control Their Lights

- Computers
- Compensate for daylight
- Reading printed test
- Create atmosphere for work
- Energy
Green Buildings and Property Value / Rents / Lease Rates

Certification on Office Values, Fuerst et al, 2011
* 4-5% Rental Premium, 25% Sales Premium for LEED or ENERGY STAR Buildings

Sustainability and the Dynamics of Green Building, Eichholtz et al, 2010
* 6% Rental Premium, 11-13% Sales Premium for LEED or ENERGY STAR Buildings

Green Design and the Market for Commercial Office Space, Wiley et al, 2010
* 7-17% Rental Premium, 8-18% Sales Premium, 10-11% higher Occupancy Rates for ENERGY STAR Buildings
Thank You

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