What Went Wrong?
Lessons Learned from Lighting Professionals

Moderated by:
Armando Berdiel, LC, Meng.

Panelists:
Shaun Darragh, LC, MIES
Daniel Salinas, LC, IES
Armando Berdiel, LC, Meng.
Before we begin...

During the Webinar

- Attendees will be muted
- Please use the chat feature in the control panel to submit questions to LDL staff
- The presenter will pause to address questions every ~10 minutes
- Please participate in the online polls.

Following the Webinar

- Please take the short survey
- A recording and the slide deck will be posted on LDL’s webpage
- Reach out to LightingDesignLab@seattle.gov with comments or questions.
Click the logo to check them out!

We'd like to thank today's event sponsor
Who We Work With

It takes a village…
Today’s Panelists

Shaun Darragh, LC, MIES  
Daniel Salinas, LC, IES  
Armando Berdiel, M.Eng., LC
Shaun.Darragh@seattle.gov

- More than 30 years in the lighting industry as an architectural lighting designer, instructor, daylighting and sustainability specialist, lighting control system consultant, and theatrical designer.
- Has taught and consulted on sustainability issues, lighting, and daylighting for the Lighting Design Lab and University of Washington Architecture Department.

Selected Projects
- King Abdullah University of Science and Technology
- Masdar Headquarters
- Pearl River Tower
- Canyon Ranch Spa Club
- Amgen Helix Campus
- Reebok World Headquarters
- Reno Sparks Convention Center
- Pacific Place Retail Center
- Ala Moana Retail Center
- REI Denver Flagship Store
- Boeing Commercial Airplanes Offices
- Real Networks Headquarters
- Tommy Bahama Headquarters
- Microsoft B16/17
- San Francisco PUC Headquarters

Selected Awards
- Amgen Helix Campus
- Amgen Helix Pedestrian Bridge
- Canyon Ranch Spa Club
- Harvard University 60 Oxford
- King Street Station
- Lighting Design Lab
- Methodist Hospital Research Institute
- Microsoft B16/17
- One Cambridge Center
- Pacific Place Retail Center
- Reebok World Headquarters
- Reno Sparks Convention Center
- Real Networks Headquarters
- SFPUC Headquarters
- Tommy Bahama Headquarters

AIA COTE Top 10
- REI Flagship Store Denver
- King Abdullah University of Science and Technology
- San Francisco PUC Headquarters
- Manitoba Hydro Place
Time for a Quick Poll…

Enough about me…

Let’s talk about you…
Common Obstacles in Lighting Project

THE BITTERNESS OF POOR QUALITY REMAINS LONG AFTER THE SWEETNESS OF LOW PRICE IS FORGOTTEN.
Construction Phases

- Programming Phase
- Schematic Design Phase
- Design Development Phase
- Contract Documents & Bid Phase
- Construction Phase
- Post-Occupancy Phase
Common Pain Points for Lighting Retrofit Projects

- Constructability
- Cost
- Maintenance
- Not adding Controls
- Design Expectations
- Stakeholder Engagement
Class Number and Title

Presented by
Daniel Salinas
President, Lighting System Design: Salinas Lighting Consult
September 22, 2020
Today’s Learning Outcomes

- To understand the needs of a project and why long term maintenance should be part of the design process

- Ensuring there is full understanding of an owner and users requirements during the design process

- How design concepts not fully resolved in advance, can become a long term issue if not dealt with at the time of construction.
Bellevue Arts Museum

- Founded in 1975
- Moved to Bel-Square in 1982
- New Museum opened in 2001
- Closed in 2003
- Reopened in 2005
Bellevue Arts Museum

Photo courtesy Arcspace.com

Photo courtesy Pinterest
Taste Café at Seattle Art Museum

- Constructed in 2007
- Café remodeled approximately 2010

Photo courtesy Taste Café at SAM
Taste Café at SAM

- Clear cased glass v/s art glass
- Lighting controls
- Design collaboration
Makah Cultural and Research Center

- Constructed in 1978
- Lighting and controls renovation in 2017

Photo courtesy Makah Cultural and Research Center
Makah Cultural and Research Center

Photo courtesy Taste Café at SAM
Up Next: Shaun Darragh

View from Palatine Hill, Rome, IT
Photo by Daniel Salinas
Controls & Stakeholder Engagement
Why use networked lighting controls?

- Flexibility
- Productivity
- User Satisfaction
- Aesthetics
- Maintenance
- LEED / WELL / LBC
- Energy Savings
- Energy Codes
What went wrong?
What went wrong?

More on that later...
Pacific Place

- Design Mid 1990s
- Opened December 1998
- NBBJ
- Koetter Kim
- JMA
- Bouillon
Pacific Place

- Design included lighting controls
- Daylight threshold switching
- Neon Dimming
- CFL Dimming
- Linear FL Dimming
- Zoned Area Switching
Pacific Place
Pacific Place
525 Golden Gate – SFPUC Headquarters

- Design Begun 2006
- Opened 2012
- Designed to be among the most energy effective urban office buildings in the US
- AIA COTE Top 10

- KMD Architects
- JMA
Typical Control Strategies

- Manual Switching
- Manual Dimming
- Scene / Preset Control
- Occupancy Sensing
- Vacancy Sensing
- Daylight Harvesting
- Task Tuning
- Time Scheduling
- Astronomic Scheduling
Office Lighting

Option 2: Integrated Architectural Cove

Lighting system is comprised of high performance cove lighting integrated into architectural elements equipped with one (1) 38 watt T5 fluorescent lamp in cross section. Within the cove lighting an indirect fluorescent luminaire will be recessed on the interior ceiling.

Each workstation will be equipped with energy efficient task lighting. Fluorescent is preferable. Task lighting will provide approximately 10.40fc at the task. Energy efficiency for the office lighting is achieved by a three part hybrid system. The three parts are: natural light, electric ambient and electric task lighting. This type of system will provide an excellent and balanced light quality throughout the office environment.

Lighting the ceiling plane provides a perception of brightness within the office environment, and balances the brightness of the natural light.

Lighting controls are an important key to the conservation of energy and maintenance of a comfortably balanced light space. An intelligent addressable control system is recommended for the integration of shading devices, daylight and occupancy sensors, and scheduling software.

The control system will modify shade positions and electric light levels to complement the transient natural light (daylight harvesting). Dimmers and switches coordinated with occupancy sensors in interior zones (see energy and users' personal preferences for workspace lighting).

Electronic Ambient Lighting
- Sample Area: 3,900 sq. ft.
- Average Illuminance: 18.6 footcandies
- Number of Lamps: 60 T5 standard output lamps
- Proposed LFD: 8.4 watts / sq. ft. (connected load)
- LPF allowed by Title 24: 1.1 watts / sq. ft.
- 5% below Title 24

Task Lighting
- Target Illuminance: 50-60 footcandles
- Lighting: Fluorescent 15W
- Proposed LFD: 8.18 watts / sq. ft. (connected load)
- LPF estimated by Title 24: 9.2 watts / sq. ft.

SFPUC Administration Office Building at 525 Golden Gate Avenue
May 21, 2007

KMD | STEVENS
A Joint Venture
Office Lighting
Sequence of Operations

Ok….so now we have all of this great hardware….now what?

- Who is going to tell us what it’s really supposed to do?
  - Lighting Designer?
  - Electrical Engineer?
  - Architect?
  - Owner?
  - Factory Tech?
  - Contractor?
Sequence of Operations

Whoever winds up doing it…a sequence of operations is required to tell the contractor, startup technician, and commissioning agent how the system is supposed to function.

- What are the time and astronomic schedules
- Which sensors are vacancy and which are occupancy?
- What is the vacancy timeout?
- What are the target light levels for task tuning?
- What switches or dimmers are tied to which zones?
- What zones are included in each preset and at what levels?
- What are the daylight zone dimming thresholds?
- Are there any specialty programming tasks like partition controls?
Sequence of Operations

There are lots of ways that SOO information may be conveyed.

- Basic Matrix
- Narrative
- Detailed Matrix
- Panel Schedule
- Dimming Schedule
- Most manufacturers have their own system
Sequence of Operations

J. Typical private office

1. All general lighting will be programmed to automatically turn "ON" as the user enters the room through the Occupancy Sensor. Initial light level will be 50% of light output.

2. Four button switch with off and raise/lower function override switch located at door will override current light setting as long as the override light level isn't above the set point for the daylight sensor during daytime hours.
   a. Pressing Button 1 will turn all fixtures to 50% light output.
   b. Pressing Button 2 will turn all fixtures to 70% light output.
   c. Pressing Button 3 will turn all fixtures to 90% light output.
   d. Pressing Button 4 will turn all fixtures to 100% light output.
   e. Pressing Button 5 will turn all lighting fixtures "OFF".

3. Photo sensor will continuously dim the light fixture up/down depending on the amount of daylight present. Daylight sensor to be calibrated to provide an average of (+/-) 50 footcandles measured at work surface (30" above finished floor).

4. When the user leaves the room, the lights will automatically turn "OFF" after a 15 minute delay (from unoccupied signal).
## Sequence of Operations

### Project X Sequence of Operations Matrix

<table>
<thead>
<tr>
<th>Room Number</th>
<th>Control Zone</th>
<th>Space Type / Use</th>
<th>Lighting Type</th>
<th>Target Light Level</th>
<th>LCS</th>
<th>Manual Switch</th>
<th>Dimmer Switch</th>
<th>Pretzel Station</th>
<th>Astronomic Time Clock</th>
<th>Occupancy Sensor</th>
<th>Vacancy Sensor</th>
<th>Occupancy/Vacancy Time Out</th>
<th>Daylight Dimming</th>
<th>Daylight Threshold</th>
<th>Task Tuning</th>
<th>Site Occupancy Sensor</th>
<th>Site Photo Control</th>
<th>Specialty See Note</th>
<th>Typical Sequence of Operations</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>a</td>
<td>Conference Room</td>
<td>Linear Indirect / Direct</td>
<td>30</td>
<td>1</td>
<td>NA</td>
<td>1</td>
<td>1</td>
<td></td>
<td>30</td>
<td></td>
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<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>b</td>
<td></td>
<td>North Wall Wash</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>c</td>
<td></td>
<td>South Wall Wash</td>
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</tr>
<tr>
<td>2</td>
<td>a</td>
<td>Janitor</td>
<td>Industrial</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10</td>
<td></td>
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<td>3</td>
<td>z1</td>
<td>Private Office</td>
<td>Recessed Troffer</td>
<td>30</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15</td>
<td>200%</td>
<td></td>
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<td></td>
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<td>z2</td>
<td>Art Accent</td>
<td>NA</td>
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<td></td>
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<td></td>
<td></td>
<td>2</td>
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<tr>
<td>4</td>
<td>z2-12</td>
<td>Open Office</td>
<td>Indirect Direct - Daylight</td>
<td>30</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15</td>
<td>200%</td>
<td></td>
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<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>z2-13</td>
<td></td>
<td>Indirect - Direct Inboard</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>200%</td>
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<td>3</td>
</tr>
<tr>
<td></td>
<td>z2-14</td>
<td></td>
<td>Circulation</td>
<td>10</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>150%</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>
Amgen Helix Campus

- Biotech Campus Pier 90
- Labs, Offices, Support Areas

- Koetter Kim
- NBBJ
- Flad
- AEI

- Design began 1999
- Completed 2005
Stakeholder Engagement

IMPROVING THE QUALITY OF OUR VISUAL ENVIRONMENT

A Presentation for

Immunex
March 14-15th, 2001

Agenda

♦ Architectural Lighting
♦ Our Visual System
♦ Lighting Terminology and Metrics
♦ Lighting Quality
♦ Lighting Controls
♦ Conclusion
♦ Questions & Answers

Envision the lighting group of Affiliated Engineers, Inc.

lighting design lab
Proposed Solution

Lamping:

- Linear Fluorescent luminaires are standardized to modern T5 standard and High Output lamps with dimming ballasts.
- Compact Fluorescent luminaires are standardized to Amalgam Triple Tube PLT Style Lamps.
- All Fluorescent lighting shall be controlled by high frequency electronic ballasts to eliminate perceptible strobing.
Immunex....then Amgen...
Public Areas
Stakeholder Engagement

- One of the most often overlooked Commissioning elements….
  Commission the occupants….

- Let them know what to expect from the system and how it operates… and why….

- Dashboard it for them if you can
Continued Stakeholder Engagement

- 2012 Controls Hardware Upgrade
- Mockups
- Occupant Surveys
- User Group Meetings
- Engaged Occupant Scheduling

- Needs change
- Spaces Change
- Our Understanding Changes
Cost & [IT] Infrastructure
Interview: Healthcare Energy Manager

- Lighting Audit helped start conversation, decision
  - T12 in BOH!
  - Feedback from auditor
  - Help Decision Makers Prioritize
- SME familiar handling special space types
- Financials
  - Simple Payback > ROI, IRR
  - $Labor > $Hardware
  - Rebates!
- NEB
  - Ease of Maintenance, feedback
  - Facilities could reprogram
  - No need for software contract
Lunera Smart TLEDs Pilot at NYU

- 2017 Pilot at NYU
- Free gear from Lunera
  - Happy decision makers
- Each T8 needed IP address on Client’s Network

**IT Dept:**

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It's a no from me
```

Lunera Lighting
Not “Value” and not “Engineering”

- Removes hardware / features last minute to reduce cost
- Other Building contractors up-sell
  - EC typically down-sell
- True value engineering “adds” to up-front cost to reduce lifecycle cost
**Program Design Considerations: Savings & Incentives**

**Example of prescriptive savings in City Light’s lighting program**

<table>
<thead>
<tr>
<th>Space Use Type</th>
<th>Networked Lighting Controls</th>
<th>Luminaire Level Lighting Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Break Room</td>
<td>40%</td>
<td>50%</td>
</tr>
<tr>
<td>Classroom</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>Hallway</td>
<td>40%</td>
<td>50%</td>
</tr>
<tr>
<td>Lobby</td>
<td>40%</td>
<td>50%</td>
</tr>
<tr>
<td>The Loo</td>
<td>40%</td>
<td>50%</td>
</tr>
<tr>
<td>Warehouse</td>
<td>40%</td>
<td>50%</td>
</tr>
</tbody>
</table>

And so on and so forth...

**Regional Technical Forums: Non-Residential Lighting Retrofits protocol**

1. Arranged or existing for the present, possible to be changed later

**Simplify Approach:**
- prescriptive savings
- prescriptive incentives

**Right-Sized Incentive**
- $50-75 incentive bonus – In addition to performance savings!
Tunnel Mindset on Margins and Value

Can You Recognize The Tunnel Mindset?

Narrow product portfolio
Competing solely on price
Simple and cheap = best
The Disconnect…

Cost-Focused Stakeholder OR Implementer

Up front cost

Too complicated

Customer doesn’t need it

Too time consuming

Design Ally:
I can’t remember the last time I didn’t spec an NLC product...

End-Use Customer:
I need integrated solutions...

We block out the voices trying to give us new information
Where do Savings Come From?

- Converting to LEDs
  - Reduces Wattage
  - About 50%-75% reduction
- Adding NLC/LLLC Systems
  - Reduces Operating Hours
  - 8760 hours in a year
  - About 50%-75% reduction

**What is a Kilowatt-Hour?**

\[ \text{Energy} = \text{Power} \times \text{Time} \]

\[ 1 \text{ kWh} = 1 \text{ kW} \times 1 \text{ hr} \]

\[ 1 \text{ kW} = 1000 \text{ W} \]

\[ 1 \text{ hr} = 3600 \text{ s} \]

---

**Medium General Service Downtown Network (MDD)**

<table>
<thead>
<tr>
<th></th>
<th>Jan 2019</th>
<th>Nov 2019</th>
<th>Jan 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per kWh</td>
<td>$ 0.0925</td>
<td>$ 0.0919</td>
<td>$ 0.0937</td>
</tr>
</tbody>
</table>
Discuss The Cost of Waiting

- Cost of Waiting - Urgency
  - Utility funding
  - Continue overspending on energy
  - Continue overspending on human capital
  - Equipment nearing EOL
- Listen to Stakeholder Objections
- Buy in from stakeholders
Simple Payback

- Not a complex measure
- Initial financial talking point
- TLED projects usually have lower paybacks
- Real story is more complex

Investment or Outlay = $100

Savings (Cash flow in) = $40

Savings (Cash flow in) = $40

Savings (Cash flow in) = $40

Savings (Cash flow in) = $40

Payback = Investment / Return

100 / $40 = 2.5 (years)

LED

Annual kWh Reduction: 19,783

% Reduction (of existing lighting): 78%

Electric Savings: $2,461

Maintenance Savings: $2,619

Upgrade Cost: $20,000

Net Project Cost: $5,000

Return: Simple Payback (years): 2.91
Simple Payback vs. Life Cycle Cost

Life Cycle Cost Analysis

- **Initial Costs**
  - Materials, IT
  - Service Contracts

- **Delivery**
  - Installation
  - Commissioning

- **Savings**
  - Energy & Maintenance
  - NEB

- **Operational Costs**
  - Energy Usage
  - Maintenance

- **Disposal**
  - Decommissioning
  - Removal

To be expressed factoring Time Value of Money

System Life (i.e. 10 years)
Lighting as a Service = Netflix and Lit?

- No up-front capital costs
  - Equipment, Commissioning, Maintenance by Provider
  - Monthly Payment from Savings
- Energy Metering
- Contract with Provider and Implementer
Seattle City Light is piloting America’s first Energy Efficiency-as-a-Service program

By Jennifer Runyon | 6.19.20

Figure 1. Example of Tenant Bill Neutrality

Figure 3. Basis of EaaS Seattle City Light Charges
A Novel Solution – Luminaire Level Lighting Controls
Did You Know… NLC & LLLC

- Luminaire Level Lighting Control
  - Individually Addressable
  - Integrated occupancy and daylight sensors
  - Continuous dimming
  - Networkable

- Benefits
  - Less Components
  - Labor Savings
  - Simple Configuration
  - Future Expandability
  - Reconfigurable

BONUS: Automatically Meets Code
C405.2 Lighting controls. Lighting systems shall be provided with controls that comply with one of the following:

1. Lighting controls as specified in Sections C405.2.1 through C405.2.7.
2. Luminaire level lighting controls (LLLC) and lighting controls as specified in Sections C405.2.1, C405.2.3 and C405.2.5. The LLLC luminaire shall be independently configured to:
   2.1. Monitor occupant activity to brighten or dim lighting when occupied or unoccupied, respectively.
   2.2. Monitor ambient light, both electric and daylight, and brighten or dim artificial light to maintain desired light level.
   2.3. For each control strategy, configuration and re-configuration of performance parameters including: bright and dim set points, timeouts, dimming fade rates, sensor sensitivity adjustments, and wireless zoning configuration.

2: Individually Addressable
   2.1: Occupancy, Vacancy, Dimming
   2.2: Daylight Harvesting, Dimming
   2.3: Networkable

*As per Gov. Inslee – To be Applied Nov 1st, 2020
LLLC Functionality Example

1) 7:00am Initial walk-in
    Lights on to background or daylight level

2) 9:00am Half Occupied
    Lights brighter on occupied desks, not on vacant spaces

3) 5:00pm Leaving
    Lights go to background level as people leave, brighter if occupied

4) 7:00pm Vacant Space
    Lights go off
Assumption:
Labor Rate:
$100/hour
# NLC & LLLC Case Study Cost Comparison

## NLC (non-LLLC) Bill of Materials

<table>
<thead>
<tr>
<th>#</th>
<th>Part Number</th>
<th>Description</th>
<th>Quantity</th>
<th>Price</th>
<th>Install (Minutes)</th>
<th>Install $</th>
<th>Material $</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PJ2-3BRL-GWH-L01</td>
<td>Wall Station</td>
<td>4</td>
<td>$21.00</td>
<td>30</td>
<td>$200.00</td>
<td>$84.00</td>
</tr>
<tr>
<td>2</td>
<td>LRF2-DCRB-WH</td>
<td>Daylight Sensor</td>
<td>1</td>
<td>$125.00</td>
<td>30</td>
<td>$50.00</td>
<td>$125.00</td>
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<td>3</td>
<td>LRF2-OCR2B-P-WH</td>
<td>Occupancy Sensor</td>
<td>4</td>
<td>$89.00</td>
<td>30</td>
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<tr>
<td>4</td>
<td>HJS-2-FM</td>
<td>Gateway/Hub</td>
<td>1</td>
<td>$1,700.00</td>
<td>60</td>
<td>$100.00</td>
<td>$1,700.00</td>
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<tr>
<td>5</td>
<td>RMJS-8T-DV-B</td>
<td>0-10V Load Controller</td>
<td>6</td>
<td>$152.00</td>
<td>60</td>
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<td>$912.00</td>
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<td>6</td>
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<td>Claro Wallplate</td>
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<td>7</td>
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<td>Wallbox Adapter</td>
<td>4</td>
<td>$8.00</td>
<td>0</td>
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<td>$32.00</td>
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<td>8</td>
<td>FIXTURES</td>
<td>Placeholder for Fixtures</td>
<td>16</td>
<td>$200.00</td>
<td>30</td>
<td>$800.00</td>
<td>$3,200.00</td>
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\[ \text{Total Cost: } \$1,950.00 - \$6,429.00 \]

## LLLC Bill of Materials

<table>
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<th>#</th>
<th>Part Number</th>
<th>Description</th>
<th>Quantity</th>
<th>Price</th>
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<td>1</td>
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<td>Gateway/Hub</td>
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<td>$1,700.00</td>
<td>60</td>
<td>$100.00</td>
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<tr>
<td>3</td>
<td>CW-1-WH</td>
<td>Claro Wallplate</td>
<td>4</td>
<td>$5.00</td>
<td>0</td>
<td>$-</td>
<td>$20.00</td>
</tr>
<tr>
<td>4</td>
<td>PICO-WBX-ADAPT</td>
<td>Wallbox Adapter</td>
<td>4</td>
<td>$8.00</td>
<td>0</td>
<td>$-</td>
<td>$32.00</td>
</tr>
<tr>
<td>5</td>
<td>LLLC FIXTURES</td>
<td>Placeholder for LLLC Fixtures</td>
<td>16</td>
<td>$270.00</td>
<td>30</td>
<td>$800.00</td>
<td>$4,320.00</td>
</tr>
</tbody>
</table>

\[ \text{Total Cost: } \$1,100.00 - \$6,156.00 \]

[Lighting Design Lab]
# NLC & LLLC Case Study Cost Comparison

<table>
<thead>
<tr>
<th>NLC (non-LLL) Net Project Costs</th>
<th>LLLC Net Project Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>NLC Materials Cost</td>
<td>$ (6,429.00)</td>
</tr>
<tr>
<td>Labor</td>
<td>$ (1,950.00)</td>
</tr>
<tr>
<td>Room Commissioning</td>
<td>$ (200.00)</td>
</tr>
<tr>
<td>Utility LLL Incentive</td>
<td>$ -</td>
</tr>
<tr>
<td>Utility Performance Incentive</td>
<td>$ 500.00</td>
</tr>
<tr>
<td><strong>Net Project Cost</strong></td>
<td><strong>$ (8,079.00)</strong></td>
</tr>
</tbody>
</table>
Infrastructure for the Technologies of Tomorrow

Courtey of DLC: Interoperability for Networked Lighting Controls (May 19 2020)
Luminaire Level Lighting Controls Replacement vs Redesign Comparison Study

September 3, 2020

REPORT #E20-315
<table>
<thead>
<tr>
<th>System</th>
<th>Hardware total</th>
<th>Luminaire per unit</th>
<th>Labor</th>
<th>Design/ Specification</th>
<th>Total cost</th>
<th>Total cost/ft²</th>
</tr>
</thead>
<tbody>
<tr>
<td>LLLC System #1</td>
<td>$4,181.00</td>
<td>$380.00</td>
<td>$1,045.00</td>
<td>$252.76</td>
<td>$5,383.76</td>
<td>$6.04</td>
</tr>
<tr>
<td>LLLC System #2</td>
<td>$4,204.77</td>
<td>$410.00</td>
<td>$1,536.15</td>
<td>$379.14</td>
<td>$6,120.06</td>
<td>$6.87</td>
</tr>
<tr>
<td>LLLC System #3</td>
<td>$4,455.43</td>
<td>$490.00</td>
<td>$1,163.75</td>
<td>$1,011.04</td>
<td>$6,630.22</td>
<td>$7.44</td>
</tr>
<tr>
<td>LLLC System #4</td>
<td>$4,015.96</td>
<td>$403.00</td>
<td>$760.00</td>
<td>$631.90</td>
<td>$5,407.86</td>
<td>$6.07</td>
</tr>
<tr>
<td>Redesign System #5</td>
<td>$8,347.07</td>
<td>$389.00</td>
<td>$1,654.90</td>
<td>$5,655.80</td>
<td>$15,657.77</td>
<td>$17.57</td>
</tr>
</tbody>
</table>
### LLLC/NLC Retrofit Systems Implementation Times

#### Table 3. Time Required for Install, Programming, and Commissioning

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LLLC System #1</td>
<td>05:15</td>
<td>00:45</td>
<td>03:00</td>
<td>09:00</td>
</tr>
<tr>
<td>LLLC System #2</td>
<td>05:50</td>
<td>02:45</td>
<td>04:30</td>
<td>13:05</td>
</tr>
<tr>
<td>LLLC System #3</td>
<td>05:40</td>
<td>00:35</td>
<td>04:30</td>
<td>10:45</td>
</tr>
<tr>
<td>LLLC System #4</td>
<td>03:30</td>
<td>00:30</td>
<td>02:30</td>
<td>06:30</td>
</tr>
<tr>
<td>Redesign System #5</td>
<td>07:05</td>
<td>02:35</td>
<td>06:00</td>
<td>15:40</td>
</tr>
</tbody>
</table>
### Table 5. Average Energy Consumption

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Lum. 1</th>
<th>Lum. 2</th>
<th>Lum. 3</th>
<th>Lum. 4</th>
<th>Lum. 5</th>
<th>Lum. 6</th>
<th>Lum. 7</th>
<th>Lum. 8</th>
<th>Lum. 9</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline</strong></td>
<td>5.11</td>
<td>0.57</td>
<td>0.58</td>
<td>0.57</td>
<td>0.45(1)</td>
<td>0.59</td>
<td>0.58</td>
<td>0.59</td>
<td>0.59</td>
<td>0.59</td>
</tr>
<tr>
<td>LLLC System #1</td>
<td>1.54</td>
<td>0.23</td>
<td>0.18</td>
<td>0.08</td>
<td>0.25</td>
<td>0.15</td>
<td>0.12</td>
<td>0.25</td>
<td>0.23</td>
<td>0.05</td>
</tr>
<tr>
<td>LLLC System #2</td>
<td>1.18</td>
<td>0.15</td>
<td>0.24</td>
<td>0.07</td>
<td>0.26</td>
<td>0.19</td>
<td>0.04</td>
<td>0.07</td>
<td>0.10</td>
<td>0.04</td>
</tr>
<tr>
<td>LLLC System #3</td>
<td>1.25</td>
<td>0.22</td>
<td>0.19</td>
<td>0.06</td>
<td>0.18</td>
<td>0.13</td>
<td>0.04</td>
<td>0.24</td>
<td>0.14</td>
<td>0.05</td>
</tr>
<tr>
<td>LLLC System #4</td>
<td>1.55</td>
<td>0.43(2)</td>
<td>0.22</td>
<td>0.05</td>
<td>0.21</td>
<td>0.16</td>
<td>0.05</td>
<td>0.17</td>
<td>0.19</td>
<td>0.03</td>
</tr>
<tr>
<td>Redesign System #5</td>
<td>1.90</td>
<td>0.41</td>
<td>0.16</td>
<td>0.06</td>
<td>0.40</td>
<td>0.21</td>
<td>0.02</td>
<td>0.40</td>
<td>0.18</td>
<td>0.02</td>
</tr>
</tbody>
</table>

**Figure 8. Average Daily Energy Consumption**

![Average Daily Wh/ft²](image)
## Annual Estimated Savings & by Major Strategies

<table>
<thead>
<tr>
<th>System</th>
<th>Fixture Zone</th>
<th>Savings due to all controls measures</th>
<th>Savings due to daylight and occupancy</th>
<th>Savings due to high-end trim</th>
</tr>
</thead>
<tbody>
<tr>
<td>LLLC System #1</td>
<td>Perimeter</td>
<td>74%</td>
<td>74%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>49%</td>
<td>37%</td>
<td>12%</td>
</tr>
<tr>
<td></td>
<td>Core</td>
<td>32%</td>
<td>25%</td>
<td>7%</td>
</tr>
<tr>
<td>LLLC System #2</td>
<td>Perimeter</td>
<td>85%</td>
<td>75%</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>74%</td>
<td>23%</td>
<td>51%</td>
</tr>
<tr>
<td></td>
<td>Core</td>
<td>71%</td>
<td>31%</td>
<td>40%</td>
</tr>
<tr>
<td>LLLC System #3</td>
<td>Perimeter</td>
<td>80%</td>
<td>80%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>45%</td>
<td>31%</td>
<td>13%</td>
</tr>
<tr>
<td></td>
<td>Core</td>
<td>25%</td>
<td>15%</td>
<td>10%</td>
</tr>
<tr>
<td>LLLC System #4</td>
<td>Perimeter</td>
<td>86%</td>
<td>71%</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>58%</td>
<td>35%</td>
<td>23%</td>
</tr>
<tr>
<td></td>
<td>Core</td>
<td>47%</td>
<td>26%</td>
<td>21%</td>
</tr>
<tr>
<td>Redesign System #5</td>
<td>Perimeter</td>
<td>86%</td>
<td>71%</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>Middle</td>
<td>73%</td>
<td>23%</td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>Core</td>
<td>47%</td>
<td>7%</td>
<td>40%</td>
</tr>
</tbody>
</table>

Notes: Annual estimated lighting energy savings attributed to controls relative to pre-tuning maximum energy consumption of each fixture and system.
Never Forget… The Human Factor

4.5 Human factors comfort responses

- Highest satisfaction: LLLC systems being tuned to IES standards
- Overall brightness was found to be lower than expected (Trim)
- Light was more calming and helped focus than FL baseline
- Brighter task (desk) illuminance
- No major satisfaction difference between LLLC & NLC

Table 8. Study Participant Demographics and Sample Statistics

<table>
<thead>
<tr>
<th>Total # subjects</th>
<th>Female/ Male</th>
<th>Age</th>
<th>Vision correction</th>
<th>Total # 2-hr session</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>8</td>
<td>4/4</td>
<td>7/0/1</td>
<td>5/3</td>
</tr>
<tr>
<td>LLLC System #1</td>
<td>16</td>
<td>8/8</td>
<td>13/3/0</td>
<td>6/10</td>
</tr>
<tr>
<td>LLLC System #2</td>
<td>12</td>
<td>7/5</td>
<td>8/4/0</td>
<td>5/7</td>
</tr>
<tr>
<td>LLLC System #3</td>
<td>10</td>
<td>7/3</td>
<td>7/3/0</td>
<td>4/6</td>
</tr>
<tr>
<td>LLLC System #4</td>
<td>15</td>
<td>8/7</td>
<td>11/3/1</td>
<td>6/9</td>
</tr>
<tr>
<td>Redesign System #5</td>
<td>15</td>
<td>9/6</td>
<td>14/0/1</td>
<td>4/11</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>76</strong></td>
<td><strong>43/33</strong></td>
<td><strong>60/13/3</strong></td>
<td><strong>30/46</strong></td>
</tr>
</tbody>
</table>
And now – a few words from LDL
## Upcoming LDL Online Events

Today’s slide deck and previous online courses can be found on our [website](#).

<table>
<thead>
<tr>
<th>LDL Course</th>
<th>Delivery Date</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intro to PoE</td>
<td>Oct 6</td>
<td>10:00 - Noon</td>
</tr>
<tr>
<td>NLC for Healthcare Environments</td>
<td>Oct 20</td>
<td>10:00 - Noon</td>
</tr>
<tr>
<td>Fundamentals of NLC (Side A – Theory &amp; Technology)</td>
<td>Nov 3</td>
<td>10:00 - Noon</td>
</tr>
<tr>
<td>Fundamentals of NLC (Side B – Practical Application)</td>
<td>Nov 4</td>
<td>10:00 - Noon</td>
</tr>
<tr>
<td>NLC for Warehouses</td>
<td>Nov 17</td>
<td>10:00 – Noon</td>
</tr>
</tbody>
</table>
Please take the online survey once you exit the webinar

We’ll SEE you on the next call… 😊