Promoting Energy Efficient Lighting Systems (PEELS)

Presented by
Armando Berdiel Chavez, LC, Meng.
Technology Development Supervisor
Spring 2020
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.
Who We Work With

It takes a village…
LDL’s Four Core Service Areas

EDUCATION & TRAINING

TOOLS & RESOURCES

TECHNOLOGY EVALUATION

INFORMATION AGGREGATION
Instructor Background

- Lehigh University, B.S.
  - Computer Science & Business

- Penn State University, Meng.
  - Engineering Management

- Lutron Electronics (PA)
  - Systems Support
  - Lead Project Coordinator

- Pearl Street LED Systems (NJ, NY)
  - Project Development Engineer
Time for a Quick Poll…

Enough about me…

Let’s talk about you…
Learning Objectives

- Understand key benefits of Connected Lighting
  - Leverage existing resources to simplify the message and promote projects
  - Navigate meaningful financial conversations with stakeholders
    - Present “good, better, best” approaches
What are We PEELing?
<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>NLC / ALC / LC</td>
<td>Networked Lighting Controls</td>
</tr>
<tr>
<td>LLLC</td>
<td>Luminaire Level Lighting Controls</td>
</tr>
<tr>
<td>Connected Lighting</td>
<td>LED + NLC</td>
</tr>
<tr>
<td>NEB</td>
<td>Non-Energy Benefits</td>
</tr>
<tr>
<td>SBE / SB</td>
<td>Smart Building Ecosystem</td>
</tr>
</tbody>
</table>
(Vague) Theory of Lighting Project Evolution

- Incandescent lamps and toggle switches for pennies
- Use HID for exterior!
- Use CFLs and FL Tubes for Interiors!
- Use those sensor switches to save energy and meet code
- LED is too expensive
- Induction Lamps are Coming!!!
- Mindful LED+NLC Design to Maximize Long Term Gains
Let’s Erase the “Saving-Centric” Mentality When Implementing Connected Lighting
What should the Connected Lighting Focus be?

1. Tenant Comfort and Building Purpose
2. Codes & Recommended Practices
3. Revenue Opportunities
The Odds Have Been Stacked Against NLC

<table>
<thead>
<tr>
<th>Desired Timeout (Minutes)</th>
<th>Number of Flashes from Light/Motion Sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Minute</td>
<td>2 Flashes</td>
</tr>
<tr>
<td>5 Minutes</td>
<td>3 Flashes</td>
</tr>
<tr>
<td>15 Minutes</td>
<td>4 Flashes</td>
</tr>
<tr>
<td>30 Minutes</td>
<td>5 Flashes</td>
</tr>
</tbody>
</table>
NLCs Today are Smoother and Leverage NEBs

Even though there is still a long way to go...

The Proliferation of FEATURES...

- Controls
- Persistence
- Energy monitoring
- Color tuning
- Cyber security
- Demand Response

... and so many more
Networked Lighting Controls Today

- Distributed
- Wireless
- More Capable
- More Complex
- Less Complicated
- Less Costly
- Easier to Install / Commission
- Compatible
- Integrated

![Wired vs. Wireless Costs Chart](chart.png)
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
Four Key Control Strategies – Crash Course

High End Trim or Task Tuning

Occupancy & Vacancy

Daylight Harvesting

Scheduling
How These Control Methods Work Together

At the building level

- **Personal Control**
  - Occupancy Sensing: turns lights off when no one is present
  - Daylight Harvesting: adjusts luminaire output to accommodate natural light

- **Demand Response**
  - Graphic showing energy use over time (6:00 am to 6:00 pm)

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**Lighting System Power Use**

- 100%
- 75%
- 50%
- 25%

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**Graphs**

- kW
- 6:00 am to 6:00 pm
Energy Savings Strategies & Benefits Outlook

U.S. Non-Residential Annual Energy Savings Potential
Based on DOE Stock Estimates and Forecasted Adoption & Efficacy

- Networked Lighting Controls with Aggressive Utility Support
- Indoor LED Products
- Outdoor LED Products

- Outdoor LED Products
- Indoor LED Products
- Screw Base LED Products
- NLC - Current Path
- NLC - Aggressive Path

DLC | ENERGY SAVINGS POTENTIAL OF DLC COMMERCIAL LIGHTING AND NETWORKED LIGHTING CONTROLS

Lighting Design Lab
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
2.1: Occupancy, Vacancy, Dimming

2.2: Daylight Harvesting, Dimming

2.3: Networkable

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 LLC 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.

*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
NLC & LLLC Cost Analysis Case Study

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>
</tr>
<tr>
<td>3</td>
<td>LRF2-OCR2B-P-WH</td>
<td>Occupancy Sensor</td>
<td>4</td>
<td>$89.00</td>
<td>30</td>
<td>$200.00</td>
<td>$356.00</td>
</tr>
<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>
</tr>
<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>
<td>$600.00</td>
<td>$912.00</td>
</tr>
<tr>
<td>6</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>7</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>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>
</tr>
</tbody>
</table>

$(1,950.00) $(6,429.00)

## 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>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>
</tr>
<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>

$(1,100.00) $(6,156.00)
## NLC & LLLC Case Study Cost Comparison

<table>
<thead>
<tr>
<th>NLC (non-LLLC) Net Project Costs</th>
<th>LLLC Net Project Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NLC Materials Cost</strong> $ $ (6,429.00)</td>
<td><strong>LLLC Materials Cost</strong> $ $ (6,156.00)</td>
</tr>
<tr>
<td><strong>Labor</strong> $ $ (1,950.00)</td>
<td><strong>Labor</strong> $ $ (1,100.00)</td>
</tr>
<tr>
<td><strong>Room Commissioning</strong> $ $ (200.00)</td>
<td><strong>Room Commissioning</strong> $ $ (150.00)</td>
</tr>
<tr>
<td><strong>Utility LLLC Incentive</strong> $ -</td>
<td><strong>Utility LLLC Incentive</strong> $ 800.00</td>
</tr>
<tr>
<td><strong>Utility Performance Incentive</strong> $ 500.00</td>
<td><strong>Utility Performance Incentive</strong> $ 600.00</td>
</tr>
<tr>
<td><strong>Net Project Cost</strong> $ (8,079.00)</td>
<td><strong>Net Project Cost</strong> $ (6,006.00)</td>
</tr>
</tbody>
</table>
What does the FIRST ‘1’ in 1:1 or 1:Many stand for?

- Load Controllers
- Hubs/Gateways
- Wall Stations
- Day/Occ Sensors
Pause for Questions

HOW'D THE NEW STRATEGY ROLLOUT GO?

THEY RUINED IT WITH QUESTIONS.
Energy Savings … And?
Connected Lighting Prospectus for Buildings

The 1-9-90 Rule

1% Energy & Resources

9%: Space & Layout

90%: Wellness & Productivity

+100%: Revenue & Opportunities

NLC NEBs as Secondary Business Opportunity

- Very likely (41.03%)
- Somewhat likely (30.77%)
- Somewhat unlikely (23.08%)
- Very unlikely, net responses 0%

LEDs Magazine SSL “State of the Industry” 2020 Survey
Leverage Non-Energy Benefits When Discussing Value
Current Market Trends & Dynamics

**Market Proliferation**

- **48** systems currently on DLC NLC QPL
- **23** systems are LLLC

**Just a Few System Features**

- Controls Persistence (66%)
- Energy Monitoring (87%)
- Cyber Security (10%)
- Color Tuning (37%)
- Demand Response (64%)

*Total system count and features pulled from DLC’s Networked Lighting Controls QPL 5/27/20*
Smart Building Platforms are Increasing and Evolving
Space Utilization

- Cost of Empty Space?
- Cost of Space Analysis
NLC/LLLC Energy Monitoring, Control, & Diagnostics

Lutron Vive

RAB Lightcloud

Lutron Vive
Asset Tracking

VA Pittsburg Healthcare Case

Inventory management inefficiencies at hospitals

- 25% of fleet lost per year
- 1 Million USD of wages lost per year
- 70,000 USD spent for new assets
each year for 200 new wheelchairs.

According to the Northern Illinois Hospital, 4,000 USD are lost per day looking for assets.

EINSTONE Track & Trace – Process Optimization and Efficiency Enhancements

1. The Asset Beacon is attached on a movable object and sends signal.
2. An EINSTONE Beacon, integrated in the lighting infrastructure, receives the signal from the Asset Beacon.
3. Data is transmitted via a Bluetooth Low Energy mesh to a gateway.
4. The gateway sends data to the secured cloud.
5. The data is displayed for easy review in a dashboard, e.g., current location, temperature, state, heat maps, statistics and analytics of utilization.

OSRAM EINSTONE Beacon Included
Indoor Positioning & Wayfinding

Target gives the go-ahead on IoT lights at half its stores
Demand Response (Traditional Operation: Sneaker-net)
NLC/LLLC Automatic Demand Response

Lutron Vive

RAB LightCloud

Leviton Sector Distributed Lighting
Tunable White Lighting

- Specific color tuning adjusting the correlated color temperature / SPD
- Meant to affect mood or alertness.
- Circadian lighting.
- Simple preference?
Study Conclusions

- Dimming was a primary benefit, CCT tunability was secondary
- Observed 26% to 57% Energy Savings
- Effective cues for scholastic activities and positive behavior impact
- Improved working conditions and learning environment for teachers and students
Infrastructure for the Technologies of Tomorrow

Courtesy of DLC: Interoperability for Networked Lighting Controls (May 19 2020)
Pause for Questions

ARE THERE ANY QUESTIONS?

DO YOU EVER FEEL ALONE WHEN YOU'RE WITH PEOPLE?
I TRY TO
What strategy[ies] should be most successful in promoting efficient lighting systems?

- Energy Savings
- Infrastructure for Connected Technologies
- Directly solving stakeholder problems
- Utility Dollar Injections
Barely Acceptable, Better, Best Approaches
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…

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

End-Use Customer: I need integrated solutions…

Cost-Focused Stakeholder OR Implementer:

- **Up front cost**
- **Too complicated**
- **Customer doesn’t need it**
- **Too time consuming**

We block out the voices trying to give us new information.
## “Good, Better, Best” Pathways

<table>
<thead>
<tr>
<th>COMFORT</th>
<th>New Retrofit LED Lamp without Controls</th>
<th>New LED Fixture or Retrofit Kit without Controls</th>
<th>New LED Fixture or Retrofit Kit with Integrated Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality of Light</td>
<td>Good</td>
<td>Better</td>
<td>Best</td>
</tr>
<tr>
<td>Smart Capabilities</td>
<td>On/Off</td>
<td>On/Off</td>
<td>On/Off, Dim, Occupancy, Daylight, Color Tuning</td>
</tr>
<tr>
<td>Life</td>
<td><img src="lamp_type.png" alt="Life Icon" /> / <img src="lamp_type.png" alt="Life Icon" /></td>
<td><img src="lamp_type.png" alt="Life Icon" /></td>
<td><img src="lamp_type.png" alt="Life Icon" /> / <img src="lamp_type.png" alt="Life Icon" /> / <img src="lamp_type.png" alt="Life Icon" /></td>
</tr>
<tr>
<td><em>varies by lamp type</em></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## “Good, Better, Best” Pathways

### INCENTIVES AND SAVINGS

<table>
<thead>
<tr>
<th></th>
<th>Limited</th>
<th>Better</th>
<th>Best</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utility Incentives</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(contact your utility</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>for more information)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy Savings</td>
<td>Good</td>
<td>Better</td>
<td>Best</td>
</tr>
<tr>
<td>Total Cost of Ownership</td>
<td>Good</td>
<td>Better</td>
<td>Best</td>
</tr>
</tbody>
</table>
**“Good, Better, Best” Pathways**

<table>
<thead>
<tr>
<th>COST</th>
<th>New Retrofit LED Lamp without Controls</th>
<th>New LED Fixture or Retrofit Kit without Controls</th>
<th>New LED Fixture or Retrofit Kit with Integrated Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment Cost</td>
<td>$ / $$$</td>
<td>$$$</td>
<td>$$$</td>
</tr>
<tr>
<td></td>
<td><em>varies by lamp type</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installation Cost</td>
<td>$</td>
<td>$$$</td>
<td>$$$</td>
</tr>
<tr>
<td>Maintenance Cost</td>
<td>$ / $$$</td>
<td>$</td>
<td>$</td>
</tr>
<tr>
<td></td>
<td><em>varies by lamp type</em></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Luminaire Level Lighting Controls Replacement vs Redesign Comparison Study

September 3, 2020

REPORT #E20-315
Table 12. Total Cost Comparison of All Retrofit Solutions

<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>Baseline</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
### Annual Estimated Savings & by Major Strategies

<table>
<thead>
<tr>
<th>System</th>
<th>Fixture Zone</th>
<th>Annual estimated lighting energy savings</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>based on pre-tuning maximum energy consumption</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Savings due to all controls measures</td>
<td>Savings due to daylight and occupancy</td>
</tr>
<tr>
<td>LLLC System #1</td>
<td>Perimeter 74%</td>
<td>74%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Middle 49%</td>
<td>37%</td>
<td>12%</td>
</tr>
<tr>
<td></td>
<td>Core 32%</td>
<td>25%</td>
<td>7%</td>
</tr>
<tr>
<td>LLLC System #2</td>
<td>Perimeter 85%</td>
<td>75%</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>Middle 74%</td>
<td>23%</td>
<td>51%</td>
</tr>
<tr>
<td></td>
<td>Core 71%</td>
<td>31%</td>
<td>40%</td>
</tr>
<tr>
<td>LLLC System #3</td>
<td>Perimeter 80%</td>
<td>80%</td>
<td>0%</td>
</tr>
<tr>
<td></td>
<td>Middle 45%</td>
<td>31%</td>
<td>13%</td>
</tr>
<tr>
<td></td>
<td>Core 25%</td>
<td>15%</td>
<td>10%</td>
</tr>
<tr>
<td>LLLC System #4</td>
<td>Perimeter 86%</td>
<td>71%</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>Middle 58%</td>
<td>35%</td>
<td>23%</td>
</tr>
<tr>
<td></td>
<td>Core 47%</td>
<td>26%</td>
<td>21%</td>
</tr>
<tr>
<td>Redesign System #5</td>
<td>Perimeter 86%</td>
<td>71%</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>Middle 73%</td>
<td>23%</td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>Core 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.
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></th>
<th>Total # subjects</th>
<th>Female/male</th>
<th>Age</th>
<th>Vision correction</th>
<th>Total # 2-hr session</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>18-30</td>
<td>31-45</td>
<td>46-55</td>
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<tr>
<td>Baseline</td>
<td>8</td>
<td>4/4</td>
<td>7</td>
<td>0</td>
<td>1</td>
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<tr>
<td>LLLC System #1</td>
<td>16</td>
<td>8/8</td>
<td>13</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>LLLC System #2</td>
<td>12</td>
<td>7/5</td>
<td>8</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>LLLC System #3</td>
<td>10</td>
<td>7/3</td>
<td>7</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>LLLC System #4</td>
<td>15</td>
<td>8/7</td>
<td>11</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Redesign System #5</td>
<td>15</td>
<td>9/6</td>
<td>14</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>76</td>
<td>43/33</td>
<td>60</td>
<td>13</td>
<td>3</td>
</tr>
</tbody>
</table>
Pause for Questions

ARE THERE ANY QUESTIONS? FEEL FREE TO ASK ANYTHING AT ALL.

WHY DO GHOSTS HAVE CLOTHES?

IF SOMEONE GIVES YOU A WEDGIE AT THE MOMENT YOU DIE, WILL YOU HAVE IT FOR ETERNITY?
Which is NOT a TLED Limitation, Constraint, or Concern

- Ballast/Driver compatibility concerns
- Light quality concerns
- Daylight zoning circuit concerns
- Wall Station confusion concerns
- System lifetime cost concerns
Delivering the **RIGHT** Project… Barriers… and Solutions
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 life-cycle cost
It’s about the STAKEHOLDERS – not just the decision maker.

- Tenants: Living with the system
- Facility Professionals: Leveraging the system
- Implementers: Implementing the system
- Owners: Invested in the system
Decision Makers vs. Stakeholders

- Recommenders, Influencers, Gatekeepers
- They send key info upstream
- Understand level of involvement
- Get Buy In **EARLY**
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:**

*It's a no from me*

![Lunera Lighting](https://via.placeholder.com/150)
Map Out Decision Makers and Tiered Stakeholders

- Appropriate Topics to the Appropriate Stakeholder

- Create map of tasks and influencers.
Don’t Force the Horse

- A Solution Looking for a Problem?
- What are the most pressing problems/opportunities for your [Insert Building Type Here]?
Tie-in with Stakeholder’s Purpose & Goals

Foster Relationships Through Education, Awareness, and Continuous Improvement
Pause for Questions

NEVER ASK A QUESTION IF YOU DON'T WANT TO HEAR THE ANSWER.

THAT'S WHY I NEVER SAY "HOW ARE YOU?"
Lighting Project Financials 101
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

Payback = \frac{\text{Investment or Outlay}}{\text{Savings (Cash flow in)}}

$100 = \frac{\$40}{\$40}$

Return

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

Life Cycle Cost Analysis

To be expressed factoring Time Value of Money

System Life (i.e. 10 years)
$100 now = $100 next year? … Time Value of Money

### Compounding
- Sum + Interest is reinvested
- **Rate:** 10%

<table>
<thead>
<tr>
<th>Year</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$100.00</td>
<td>$110.00</td>
<td>$121.00</td>
<td>$133.10</td>
</tr>
</tbody>
</table>

- add 10% of $100
- add 10% of $110
- add 10% of $121

### Discounting
- Interest used in cash flow analysis
- Set by companies. Fluctuate
- Weighted Average Cost of Capital (WACC)

### Focus:
- Returns on Investment measures
- Present Value
- Net Present Value
Return on Investment

- **Investment or Outlay**: $100
- **Savings (Cash flow in)**: $40

**ROI**:

\[
\text{ROI} = \frac{\text{Savings}}{\text{Investment}} = \frac{40}{100} = 40\%
\]

Cumulative ROI:

\[
\text{Cumulative ROI} = \frac{160}{100} = 160\%
\]
Tips on Thinking Present Value

- Present Value = today’s equivalent of a future payment
- Discount Rate adjusts a future payment to its present value
- “Future payments are discounted to their Present Value”
- The higher the discount rate, the lower the present value
- The further the payment is in the future, the lower is present value

$69 Today

20% Discount Rate

$100 in 2 years

$48 Today

20% Discount Rate

$100 in 4 years
Net Present Value

- **Net Present value**: Present value of a cash flow, minus the initial investment or outlay
  - Commonly used to compare investments. Even if they don’t have the same lifetime.

<table>
<thead>
<tr>
<th>Investment or Outlay</th>
<th>Present Value</th>
<th>Savings (Cash flow in)</th>
<th>Savings (Cash flow in)</th>
<th>Savings (Cash flow in)</th>
<th>Savings (Cash flow in)</th>
<th>Interest Rate: 15%</th>
</tr>
</thead>
<tbody>
<tr>
<td>$100</td>
<td>$134</td>
<td>$40</td>
<td>$40</td>
<td>$40</td>
<td>$40</td>
<td>$40</td>
</tr>
</tbody>
</table>

\[ \text{NPV} = 134 - 100 = 34 \]
## Simplified 10-Year Example

<table>
<thead>
<tr>
<th>Cash Outflows</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Lighting System:</td>
<td>$(65,400.00)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rebate Incentives:</td>
<td>$ 15,400.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Outflow:</td>
<td>$(50,000.00)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cash Inflows</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Savings:</td>
<td>$10,000.00</td>
<td>$10,300.00</td>
<td>$10,609.00</td>
<td>$10,927.00</td>
<td>$11,255.00</td>
<td>$11,593.00</td>
<td>$11,941.00</td>
<td>$12,299.00</td>
<td>$12,668.00</td>
<td>$13,048.00</td>
</tr>
<tr>
<td>Maintenance Savings:</td>
<td>$ 5,000.00</td>
<td>$ 5,150.00</td>
<td>$ 5,305.00</td>
<td>$ 5,464.00</td>
<td>$ 5,628.00</td>
<td>$ 5,796.00</td>
<td>$ 5,970.00</td>
<td>$ 6,149.00</td>
<td>$ 6,334.00</td>
<td>$ 6,524.00</td>
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<tr>
<td>Inflows:</td>
<td>$15,000.00</td>
<td>$15,450.00</td>
<td>$15,914.00</td>
<td>$16,391.00</td>
<td>$16,883.00</td>
<td>$17,389.00</td>
<td>$17,911.00</td>
<td>$18,448.00</td>
<td>$19,002.00</td>
<td>$19,572.00</td>
</tr>
<tr>
<td>Annual Cash Flows:</td>
<td>$(50,000.00)</td>
<td>$15,000.00</td>
<td>$15,450.00</td>
<td>$15,914.00</td>
<td>$16,391.00</td>
<td>$16,883.00</td>
<td>$17,389.00</td>
<td>$17,911.00</td>
<td>$18,448.00</td>
<td>$19,002.00</td>
</tr>
<tr>
<td>PV of Cash Flows:</td>
<td>($50,000.00)</td>
<td>$13,636.36</td>
<td>$12,768.60</td>
<td>$11,956.42</td>
<td>$11,195.27</td>
<td>$10,483.01</td>
<td>$ 9,815.64</td>
<td>$ 9,191.18</td>
<td>$ 8,606.13</td>
<td>$ 8,058.70</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>10-Year</th>
<th>Year-1</th>
<th>Year-2</th>
<th>Year-3</th>
<th>Year-4</th>
<th>Year-5</th>
<th>Year-6</th>
<th>Year-7</th>
<th>Year-8</th>
<th>Year-9</th>
<th>Year-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPV:</td>
<td>$53,257.17</td>
<td>$(36,363.64)</td>
<td>$(23,595.04)</td>
<td>$(11,638.62)</td>
<td>$( 443.34)</td>
<td>$10,039.67</td>
<td>$19,855.31</td>
<td>$29,046.48</td>
<td>$37,652.61</td>
<td>$45,711.31</td>
</tr>
<tr>
<td>Simple Payback:</td>
<td>3.19</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ROI:</td>
<td>34%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
One Page Proposal

- Components
  - Title and Subtitle
  - Target
  - Problem statement
  - Financial Summary
  - Payment Terms
  - Status
  - Action -> PO
  - Appendix
20% more Light with 40% Lower Energy Cost for the Parking Garage at 123 Project St.

*Improving security, saving energy, lowering operating costs, and boosting the Energy Star score*

**Target:** TO IMPROVE PARKING-AREA LIGHTING WITH ENERGY EFFICIENT, LONG-LASTING LED TECHNOLOGY

- To address tenant safety concerns by increasing average lighting levels by 20% and moving to "whiter" light, enhancing visibility for both occupants and security camera.
- To reduce operating and maintenance costs for parking-area lighting by $15,000 the first year (10-year NPV of over $53,000).
- To capture $15,400 in Energy Trust incentives, covering 24% of project costs.
- To avoid a quarter-million pounds of CO2 emissions annually, boosting ENERGY STAR score to 70 from 68.

**Financial:** Project first cost is estimated at $50,000 after a utility incentive of $15,400. A 10-year analysis yields a net present value of $53,256 and a simple payback of 3.3 years.

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple Payback</td>
<td>3.2 years</td>
</tr>
<tr>
<td>Net Present Value*</td>
<td>$53,256</td>
</tr>
<tr>
<td>Return on Investment</td>
<td>34%</td>
</tr>
</tbody>
</table>

* NPV Assumes 10-year analysis term, 10% discount rate
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
Stakeholder Objection
Counter Suggestion

- "I don't have any budget for an upgrade"
  - Consider existing cost for system and equipment maintenance
  - Discuss the cost of waiting
  - Demonstrate lifetime economics
  - Highlight NEBs to different stakeholders
  - Divide project into smaller phases
  - Project will set both an economic and technical infrastructure for additional value-add building projects

- "I Just want the cheapest option"
  - Provide at least 2 options: A cost-based option and a value-added benefit option for the building
When should the Simple Payback calculation be Used over the Lifetime Calculation

- When you want the complete picture
- When you want to plan for the life of the system
- To get a quick snapshot of a project's financials
- Included in the project proposal
Pause for Questions

WRITE UP SOME ANSWERS TO THE QUESTIONS WE COULD NEVER ANTICIPATE.
Tools and Teamwork to Make the Dream Work
Codes & Regulations as Tool to Implement NLCs

LIGHTING POWER ALLOWANCES

- Dining
- School
- Office
- Warehouse

Seattle Department of Construction & Inspections

lighting design lab
Great Tool to Start These Talks: Lighting audit

- Attend LDL Audit & Retrofit Class ;)
- Benchmark Existing Conditions
- Estimate Energy, Labor, Rebate Savings
- Propose Multiple Solutions, Model kWh Savings
- Lead to Life Cycle Analysis and Non-Energy Benefits
- Tell a Story from Audit to Proposal
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
Why Utilities like City Light Care About Connected Lighting?

**Cost Effective Energy Savings**
Ensures optimal project savings for lifetime of EE upgrade

**Elite Customer Service**
Relationship with customers for continuous improvements

**Gateway to Connected Stuff**
Keeps utilities relevant and part of the solution
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...

Simplify Approach:
- prescriptive savings
- prescriptive incentives

Right-Sized Incentive
- $50-75 incentive bonus – In addition to performance savings!

Regional Technical Forums: Non-Residential Lighting Retrofits protocol

1. Arranged or existing for the present, possible to be changed later
City Light NLC $50/Fixture 2020 Requirements

- DLC NLC QPL System
- Programmed HET, Occupancy, Daylight Harvesting
- Min (2) Zones per 300sqft
- Pre-Install
  - SOO
  - Floor Plan
- Post-Install
  - As Builts
  - Site Visit

- TLEDs
- Fixtures under 20W
  - HET under 20W = prorated $50 incentive

Seattle City Light

Commercial and Industrial Retrofit Program
The Sequence of Operations communicates intent

Click to access LDL Sequence of Operations learning guide

### NLC Key Collaboration Tool: **Sequence of Operations**

<table>
<thead>
<tr>
<th>Area</th>
<th>Typical open office</th>
</tr>
</thead>
</table>
| **Lights**            | Zones (a) - (d)  
|                       | Fully dimmable lights controlled in this area                                       |
| **Daylight Zones**    | Zones (a) - (b)  
|                       | Daylight rows 1 and 2 will dim independently. Lights will automatically adjust to daylight maintaining 30FC on task surfaces |
| **Manual Wall Control** | Zones (a), (b), (c), (d)  
|                       | For each independent zone, the user can select scenes on/off, 50%, and can raise/lower the zone |

### CONTROL METHOD

<table>
<thead>
<tr>
<th>SPACE TYPE</th>
<th>HIGH END TRIM</th>
<th>DAYLIGHT SENSOR</th>
<th>MANUAL SWITCH</th>
<th>OCCUPANCY SENSOR</th>
<th>TIME CLOCK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conference</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Equipment</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Office - open</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X X</td>
</tr>
<tr>
<td>Office - private</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Restrooms</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

![Diagram with lighting zones and control methods]
Leverage Partner’s Procedural Efficiency

- Quoting tools
- Project Development tools
- One lines with Packaging
- Room Packaging
- Pre-Pairing
- Pre-Commissioning
Education & Market Development

LDL’s Flagship Workshop

1 & 2 Day NLC Workshops for EVERYBODY...

Hands-On Learning & Practical Application

- Specifics of control methods
- Developing sequence of operations
- Specification writing & interpreting
- System design & set up
- And so much more!!!
Click to access the LDL networked lighting control learning guides
Project Specific Consults and Mockups
Stay Tuned: LDL User Experience Study

Informing and Increasing Acceptance: The NLC User Experience

Ease of Use
Functionality
Operations
Pause for Questions
And now – a few words from LDL
## Upcoming LDL Online Events

<table>
<thead>
<tr>
<th>LDL Course</th>
<th>Delivery Date</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>What Went Wrong?</td>
<td>Sept 22</td>
<td>10:00 - Noon</td>
</tr>
<tr>
<td>Power Over Ethernet</td>
<td>Oct 06</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 03</td>
<td>10:00 - Noon</td>
</tr>
<tr>
<td>Fundamentals of NLC (Side B – Practical Application)</td>
<td>Nov 04</td>
<td>10:00 - Noon</td>
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