Lessons Learned from Connected Lighting Installations

Ruth Taylor
Pacific Northwest National Laboratory
LIGHTFAIR 2018
NGLS Steering Committee

Melanie Taylor, IALD, LEED AP
Vice President
Lighting Design
WSP

Craig Bernecker, Ph.D., FIES, LC
Founder and Director
The Lighting Education Institute

Charles Thompson, AIA
IALD, LC, LEED AP, IESNA
ARCHILLUME LIGHTING DESIGN, INC.

Avi Mor, LEED AP, IESNA,
Lighting Designer
LIGHTSWITCH ARCHITECTURAL CHICAGO, LLC

Aram Ebben, IALD, LEED AP BD+C
Principal | Director of Lighting Design
exp, U.S. Services Inc.

Mary Matteson Bryan, P.E.
Energy Engineering

Chris Wolgamott
Northwest Energy Efficiency Alliance (NEEA)

Jeff Brown, IALD
Lighting Specialist
Power Design Engineering

Nancy Clanton, PE, FIES, IALD, LC, LEED AP
President
Clanton & Associates, Inc.

Ron Gibbons, Ph.D, FIES
Virginia Tech Transportation Institute (VTTI)

Chip Israel, FIALD, MIES, LEED® AP, LC
CEO & FOUNDER
Lighting Design Alliance

Mike Lambert, IES, LC
Senior Lighting Designer
KCL Engineering

Nathan Mitten
Senior Manager of Property Standards & Improvements
Kimco Realty Corporation

Dan Blitzer, FIES
Practical Lighting Workshop
Connected Lighting Advisory Group

- Gabe Arnold - DLC, NLC
- Dave Bisbee - SMUD
- Peter Jacobson - Con Edison
- Levin Nock - DLC, NLC
- Michael Poplawski - PNNL/DOE
- Chris Wolgamott - NEEA
What We’ll Cover Today

- NGLS Background
- Evaluation Framework
- Lessons Learned
  - System Architecture
  - Operational Complexity
  - Configuration Tools
  - Wall Controls
  - Communication
- Next Steps
NGL Background

• First competition in 2008
• 14 Steering Committee members, majority involved for 10 years
• Weekly Steering Committee calls (indoor and outdoor)
• 15 separate judging/evaluation events
• 64 different lighting professionals involved as judges
• Over 1300 products submitted by over 300 manufacturers
From NGL to NGLS

• 2008: Focus on LED luminaires of different types
• 2012: Split into separate Indoor and Outdoor Competitions
• 2015: Focus on controllability and serviceability
• 2016: Focus on specific applications and connected systems
• From Next Generation Luminaires to Next Generation Lighting Systems
• 2017: Exclusively Indoor Connected Lighting Systems
  • Build on 2016 experience
  • Separate into levels of system complexity
  • Permanent installations
  • Ongoing evaluations
Leveraging What We Know

NGL Luminaire Competitions
• Subjective designer viewpoint
• Specifier manufacturer communication
• ‘Staged’ environments
• Difficult controls evaluations

Connected Lighting Systems Program
• Configuration Complexity
• CLTB

GATEWAY Demonstrations
• Real sites and users
• Harsh realities become apparent
• Lessons apply to a more limited audience with similar conditions

The Sweet Spot
Configuration Complexity

- Complicated systems have historically under performed.
- More energy will be saved if control systems are working correctly.
- For systems to be broadly deployed, configuration complexity must be reduced.
Subjective Evaluations

- To find the real ‘pressure points’, people need to observe and evaluate the people installing and configuring the system in real time, without assistance - it just can’t be done in a demonstration, mock-up, or testing lab.
Design & Installation Process

• Model the process to learn and share

Identify challenges faced in design, installation, and configuration.

Provide feedback to manufacturers to influence product innovation – what worked, what didn’t?

Identify documentation and communication challenges

Identify key elements to include in a specification.

NGLS/Specifier
• Performance specifications
• Lighting layout

Manufacturer(s)
• Submits proposed system

NGLS/Specifier
• Review/approve system

Contractor
• Install and configure system

NGLS/Specifier
• Performance specifications
• Lighting layout
Living Lab
NGLS Initial Focus

• Luminaire and control systems that are:
  • Marketed as “easy” to install and configure
  • Intended for contractor setup and configuration without prior training
  • Configurable without manufacturer assistance
  • No lighting designer involved

We had to start with the most basic systems to develop our evaluation protocols and procedures and come away with results and recommendations that are tangible and actionable.
## System Requirements

<table>
<thead>
<tr>
<th>Function</th>
<th>Evaluation 1</th>
<th>Evaluation 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupancy Sensing</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Vacancy Sensing</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Local on/off</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Daylight Harvesting</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Manual Continuous Dimming</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>High-End Trim/Task Tuning</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Zoning</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Luminaire Integrated Sensor and Control</td>
<td>preferred</td>
<td>Y</td>
</tr>
<tr>
<td>Field-adjustable Control Settings</td>
<td>preferred</td>
<td>Y</td>
</tr>
</tbody>
</table>
1. **Vacancy control** (manual on/auto off) of two zones with a time out period of 5 minutes.

2. **Manual continuous dimming** of the same two zones indicated in item 1. Minimum dimming level of each zone shall be ≤ 10% of lumen output.

3. **Daylight harvesting** to maintain task plane illumination at the current level provided by the electric lighting (whether full output, task-tuned, or manual dimmed).

4. **Field-adjustable high-end trim** to lower maximum system light output. System shall be delivered with high-end trim set at 100%.

5. Control settings shall be adjustable by the user **without factory assistance**.
Installation Evaluation Process

- Three evaluation phases
  - Install luminaires
  - Install and start up controls
  - Adjust control settings
- After each phase, contractor and NGLS judges independently evaluate:
  - Manufacturer’s documents
  - Ease/difficulty
  - Strengths and weaknesses
- Conclude with videotaped contractor interviews
Performance Evaluation Process

- Lighting Performance
  - Lighting effects, luminaire construction and appearance
  - Measured performance (illuminance, CCT, luminance, etc.)
- Control System Performance
  - Ease of use
  - Measured performance
Evaluation Two – Retrofit Kits
## Participating Manufacturers

### Competition One

<table>
<thead>
<tr>
<th>Company</th>
<th>Control System</th>
<th>Luminaire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lumenwerx</td>
<td>Magnum</td>
<td>Reven SIB</td>
</tr>
<tr>
<td>Selux</td>
<td>Easy Sense</td>
<td>M36 D-1</td>
</tr>
<tr>
<td>Crestron</td>
<td>Zum</td>
<td>Starfire Versalux D-I</td>
</tr>
<tr>
<td>Philips Lighting</td>
<td>SpaceWise DT</td>
<td>Sona</td>
</tr>
<tr>
<td>RAB Lighting</td>
<td>RAB LightCloud</td>
<td>Swish 2x2</td>
</tr>
<tr>
<td>Cree</td>
<td>SmartCast</td>
<td>CR22</td>
</tr>
<tr>
<td>Nextek Power Systems</td>
<td>Sky Control</td>
<td>Independence iLED R Series</td>
</tr>
</tbody>
</table>

### Competition Two

<table>
<thead>
<tr>
<th>Company</th>
<th>Control System</th>
<th>Retrofit Kit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Philips Lighting</td>
<td>SpaceWise DT</td>
<td>EvoKit Troffer Retrofit Kit</td>
</tr>
<tr>
<td>Lutron Electronics</td>
<td>Vive</td>
<td>Orion Ison Retrofit Modular</td>
</tr>
<tr>
<td>Acuity Brands</td>
<td>nLIGHT AIR</td>
<td>BLT Relight Series Kit</td>
</tr>
<tr>
<td>Eaton</td>
<td>WaveLinx</td>
<td>Metalux Cruze LED Retrofit Kit</td>
</tr>
<tr>
<td>LG Electronics</td>
<td>Sensor Connect</td>
<td>Simple Choice Retrofit Kit</td>
</tr>
</tbody>
</table>
Onsite Manufacturer Participation
SYSTEM ARCHITECTURE
## System Architecture

<table>
<thead>
<tr>
<th>Components</th>
<th>Least Complex (7)</th>
<th>Moderately Complex (2)</th>
<th>Most Complex (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Luminaire-integrated sensor and control</td>
<td>✓</td>
<td>✓ Luminaire-integrated sensor and control</td>
<td>✓ Remote mounted sensor and control</td>
</tr>
<tr>
<td>Wall switch</td>
<td>✓</td>
<td>✓ Wall switch</td>
<td>✓ Wall switch</td>
</tr>
<tr>
<td>Local area network device</td>
<td></td>
<td>✓ Local area network device</td>
<td></td>
</tr>
<tr>
<td>Wall switch</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Connection</td>
<td>✓ Wireless</td>
<td>✓ Wireless</td>
<td>✓ Wired</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>✓ Wireless</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>✓ PoE</td>
</tr>
</tbody>
</table>

The table above lists the components and connections for different levels of system complexity. The least complex system includes luminaire-integrated sensor and control and wall switch, while the most complex system includes remote mounted sensor and control and wall switch. The connection options vary from wireless, wired, and PoE.
OPERATIONAL COMPLEXITY
### Initial Startup Approach

- **Pre-configured out-of-the box operation**
- **Onsite pairing of luminaires to wall switches**
  - Factory-set default operational settings
- **Onsite pairing of luminaires to wall switches**
  - Various additional steps
  - Factory-set default operational settings
- **Onsite pairing of luminaires to wall switches**
  - Onsite configuration of external daylighting and occupancy sensors

<p>| | | | |</p>
<table>
<thead>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(2)</td>
<td>(5)</td>
<td>(3)</td>
<td>(2)</td>
</tr>
</tbody>
</table>
Operational Complexity

- Clear relationship between system capabilities and ease of operation;

Need appropriate balance between simplicity and functionality for each application!
Configuration Tool Categories

Handheld Tool (1)

Phone App (8)

Computer Front-end (3)
Wall Control Categories

- Pre-configured Rocker Switch (4)
- Pre-configured Multi Button Switch (3)
- Site Configurable Rocker Switch (2)
- Site Configurable Multi Button Switch (2)
The single biggest problem in communication is the illusion that it has taken place.

George Bernard Shaw
Vocabulary

• We all speak a different language

• Designers
• Product & IT Engineers
• Contractors
Documentation
How We Plan to Release Findings

- Conference presentations
- Feature articles in target publications
- NGLS website
- One pagers by topic and audience
Next Steps

- If there is consensus that things should be done the same way – work on standards
- If there are multiple ways to do things – work on templates or models
- If there is no consensus – conduct more studies to figure it out
2018 Outdoor Evaluations

• Virginia Tech Transportation Institute
• VTOLL – Virginia Tech Outdoor Living Lab - collaboration with other VT activities
• Parking garage/lot connected lighting focus – informs other applications
• Coordination with DOE Connected Lighting Test Bed in Portland
Thanks!
Questions?