Emerging Technologies Showcase  December 7, 2017

Residential Lighting: Controls

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Rosenfeld Chair in Energy Efficiency
Professor, University of California, Davis

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GoToWebinar Logistics

- Please use question pane to ask questions at any time, or if you have any technical issues.
- TAG members – Audio will be unmuted after 1:00 PM for our discussion.

Today’s presentation is being recorded and will be available at [http://e3tnw.org/Webinars](http://e3tnw.org/Webinars)
Residential Lighting: Controls

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Adaptive Lighting in Residential Exterior Applications

- Building exteriors
- Pathways and parking areas

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Professor
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WHAT’S NEW IN THE 2016 CODE?

RESIDENTIAL LIGHTING

Changes to mandatory lighting requirements in California’s 2016 Building Energy Efficiency Standards
Lighting for single family homes and lighting mounted to any building on the lot must be controlled by:

Manual On/Off switch and paired with one of the following combinations:

1. **Photocell and motion sensor**
2. **Photocell and automatic time switch control**
3. **Astronomical time clock**
4. **EMCS with features:**
   1. Astronomical time clock,
   2. Does not allow the luminaire to be ON during the day, and
   3. May be programmed to automatically turn lighting OFF at night
Multi-Family Outdoor Control Requirements

Low-rise, multifamily residential buildings, outdoor for private patios, balconies, entrances, and porches must meet these requirements:

Manual On/Off switch paired with one of the following combinations:

1. Photocell and motion sensor
2. Photocell and time switch
3. Astronomical time clock
4. EMCS with features of astronomical time clock, does not allow the luminaire to be ON during the day, and may be programmed to automatically turn lighting OFF at night

Carports, parking garages and parking lots with eight or more spaces must comply with nonresidential standards.

In the 2016 code: see 150(k) 3C
Suivel arms allow directional light
Les bras pivotants brindan luz direccional
Le bras articulé fournit l'éclairage directionnel

All-metal housing for rugged durability
Carcasa toda de metal para fortaleza y durabilidad
Boitier entièrement métallique pour durabilité robuste

Adjustment arm for aiming motion sensor
Ajustable para apuntar al sensor de movimiento
Réglable pour diriger le détecteur de mouvement

Bulbs not included: Use two 732136 Halogen bulbs (120W max, each) or two PAR36 CFL bulbs (30W max, each).
Ampli ne incluye: Utilice dos bombillas PAR36 halógenas (120W max, cada una) o dos bombillas PAR36 CFL (30W max, cada una).

L.E.D. light confirms motion is detected
Luz L.E.D. que confirma que se ha detectado movimiento
La lumière L.E.D. confirme qu'un mouvement est détecté

Selectable motion timer (1.5, or 10 minutes)
Temporizador de movimiento seleccionable (1.5 o 10 minutos)
Minuterie du mouvement réglable (1.5 ou 10 minutes)

Motion detection up to 70 ft.
Detección de movimiento hasta 70 pies (21 m)
Détection du mouvement jusqu'à 21 m (70 pi)

Detects natural lighting to control on/off, Dusk-to-Dawn lighting
Detecta la iluminación natural para controlar el Encendido/Apagado de la iluminación anochecer-aranecer
Détecte la lumière naturelle pour commander l'éclairage Manche/Arrêt, crépuscule à sube

UL

Motion Security
Luz de seguridad
Éclairage de sécurité

150°
Detección de movimiento a 150°
Détection de mouvement à 150°
• Sensor-based
• Full cut-off
• Amber LED
• <2700K
Integrated on-board controls
Bi-level maybe an option

- Safety security
- Aesthetics

- However economics is difficult
  - 10 watt bi-level porch light =~$5 per year based on 10 hours a night
  - New microwave sensors ~25$

- The proposal (previous roundtable) for porch lights with just a photo sensor and security fixtures with photo and motion sensors also makes sense (wattage limit)
Why is this Emerging technology?

- Well developed/developing in the non residential
- We need to develop and apply in residential

- Focus on Integrated product
  
  - Vacancy occupancy
  - Bi-level
  - Color
  - Distribution optics/low glare
  - Dark sky friendly
Adaptive Bi-level parking *(non-res but applies to multi-family)*

- Inclusion in Title 24 2014/16/19
- Utility partners
- Broad application at UC/CSU
- Primary path for ARRA ETAP/CEC funding
- NEMA support
- ASHRAE
Adaptive Bi-level parking safety security

- People are reluctant to “automatically” turn off lamps at night
- Generally police and security people like bi-level
- Sensor based auto on provides sense of security
- Students also have reported positively
- Engage in thoughtful demonstrations

- Bi-level allows for large distribution flexibility (large tolerance)
- Sensors need improvement
- Quality specification
- Bi-level in PV canopy parking lots
- One of the first applications (all UC’s)
- Common for multi-family
Sensor control technology
Parking (surface lots)

All installed outdoor lighting, where the bottom of the luminaire is mounted between 12 and 24 feet above the ground, shall be controlled with motion sensors. The motion sensor shall be capable of automatically reducing the lighting power by at least 40 percent but not exceeding 80 percent, or provide continuous dimming through a range that includes 40 percent through 80 percent, and shall employ auto-on functionality.
LED BI-LEVEL SMART GARAGE VS. BASELINE HID TECHNOLOGY

68% SAVINGS
Pathways

1. passive IR motion sensors controlling bi-level lighting
2. can be layered with radio frequency controls for remote control and monitoring.
Bi-level Residential Pathway/walkway

- Sensor based
- Full cut-off
- 2700K
Pathway luminaires, April 24, 2012:
Preliminary data gathered from the pathway leading to the University’s new Aggie Stadium reports an average energy savings of 60% as compared to a static installation of the same fixture.
Emerging technology: adaptive lighting at all points

- Vacancy / occupancy
- Scheduling / communication
- Maintenance needs
- Accurate energy use monitoring
- Emergency response
- Demand response
Scoring Criteria SF photo/motion

• Energy Savings – large potential savings ~50%

• Non-Energy Benefits—Potential maintenance/safety benefits, dark sky, and enhanced security,

• Ease of Adoption – easy can be integrated into existing product lines

• Value – high value

• Market/Commercial —California is driving this market, should be large scale availability soon
Scoring Criteria MF parking area photo/motion control (bi-level):

- Energy Savings – large potential savings ~50%
- Non-Energy Benefits – Potential maintenance/safety benefits, dark sky, and enhanced security,
- Ease of Adoption – easy can be integrated into existing product lines
- Value – high value
- Market/Commercial – California is driving this market, should be large scale availability soon
Product performance

- Concept not yet validated
- Concept validated
- Limited assessment
- Extensive assessment (for parking and area)
- Comprehensive Analysis
utility program readiness

• Highly cost effective
  • Parking
  • Wall packs
  • Sensor based LED

• Lots of programs pre-code in California

• Bi-level
• Sensor based
Stair-wells multi-family (sensor-based)

Bi-level

- Safety and aesthetic issues
- Cannot egress into dark stairwell
- Addressed with bi-level

- Originally ultra-sonic
- Research shows PIR works well
Average Daily Energy Use

- Full output: 616 W; Low mode: 313 W (3:00 am)
Residential Connected Lighting TAG Presentation

Chris Wolgamott
Senior Product Manager
The Alliance

[Logos of various organizations]
Presentation Overview

1) What is Residential Connected Lighting?
2) Available Products
3) Communication Protocols
4) Energy Savings
5) Demand Control Possibilities
6) Non-Energy Benefits
7) Energy Code
8) Performance/Adoption
What is Residential Connected Lighting?

Combines several different features in lamp and/or fixture, which could include:
- Daylighting (Dimming)
- Occupancy sensing
- Color tuning
- Smart Phone controls (phone apps)
- Emergency lighting (battery back-up)
- Energy Reporting
- Dimming (self or controlled)
What’s on the Market Today?
What’s on the Market Today?
Home
Automation/Communication Protocols

How important is this for residential use?
- Might not be a huge issue – homeowners are more brand loyal
  - People tend to stick with one brand: Apple vs. Google vs. Amazon
  - What’s out there now?
  - May follow the same course as Cell phones

[Logos for ZigBee, Amazon Alexa, and Google Home]
How Much Energy Can It Save?

Table 4.2 U.S. LED Forecast Energy Savings Scenario Comparison

<table>
<thead>
<tr>
<th>Source Annual Energy Savings (tBTU)</th>
<th>2015¹</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial</td>
<td>280</td>
<td>998</td>
<td>2,110</td>
<td>2,990</td>
<td>3,720</td>
</tr>
<tr>
<td>Residential</td>
<td>183</td>
<td>461</td>
<td>970</td>
<td>1,440</td>
<td>1,850</td>
</tr>
<tr>
<td>Industrial</td>
<td>35</td>
<td>287</td>
<td>643</td>
<td>875</td>
<td>1,020</td>
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<tr>
<td>Outdoor</td>
<td>22</td>
<td>49</td>
<td>100</td>
<td>131</td>
<td>155</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>200</td>
<td>397</td>
<td>546</td>
<td>693</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source Annual Energy Savings (tBTU)</th>
<th>2015¹</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current SSL Path</td>
<td>280</td>
<td>1,510</td>
<td>3,260</td>
<td>4,420</td>
<td>5,070</td>
</tr>
<tr>
<td>Residential</td>
<td>183</td>
<td>731</td>
<td>1,670</td>
<td>2,310</td>
<td>2,650</td>
</tr>
<tr>
<td>Industrial</td>
<td>35</td>
<td>324</td>
<td>717</td>
<td>972</td>
<td>1,140</td>
</tr>
<tr>
<td>Outdoor</td>
<td>22</td>
<td>76</td>
<td>158</td>
<td>195</td>
<td>209</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>380</td>
<td>716</td>
<td>938</td>
<td>1,070</td>
</tr>
</tbody>
</table>

DOE SSL Program Goals

Answer: We don’t know for sure, but DOE has estimated what they think connected lighting will save by 2035.

- Savings per lamp is going to be really small (low wattage and few hours) but like most residential lighting, quantity is important

More Savings

The difference between these two numbers is mostly connected lighting.

Table 4.6 Annual Energy Savings from Lighting Controls by Sector for Each Scenario

<table>
<thead>
<tr>
<th>Sector</th>
<th>2015</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source Annual Energy Savings (tBTU)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial</td>
<td>658</td>
<td>695</td>
<td>700</td>
<td>807</td>
<td>1,050</td>
</tr>
<tr>
<td>Industrial</td>
<td>543</td>
<td>581</td>
<td>584</td>
<td>661</td>
<td>829</td>
</tr>
<tr>
<td>Residential</td>
<td>18</td>
<td>16</td>
<td>13</td>
<td>15</td>
<td>22</td>
</tr>
<tr>
<td>Outdoor</td>
<td>92</td>
<td>90</td>
<td>89</td>
<td>111</td>
<td>170</td>
</tr>
</tbody>
</table>

Source Annual Energy Savings (tBTU)

<table>
<thead>
<tr>
<th>Sector</th>
<th>2015</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial</td>
<td>658</td>
<td>1,400</td>
<td>1,610</td>
<td>1,910</td>
<td>2,280</td>
</tr>
<tr>
<td>Industrial</td>
<td>543</td>
<td>1,180</td>
<td>1,330</td>
<td>1,530</td>
<td>1,760</td>
</tr>
<tr>
<td>Residential</td>
<td>18</td>
<td>31</td>
<td>26</td>
<td>31</td>
<td>53</td>
</tr>
<tr>
<td>Outdoor</td>
<td>92</td>
<td>172</td>
<td>212</td>
<td>291</td>
<td>388</td>
</tr>
</tbody>
</table>

1. The energy savings presented in this Table 4.6 are not additive to those provided in Table 4.2 and represent the portion attributed to lighting control use.

Demand Response Possibility

These products can’t work in a Demand Response program yet, but the potential is there. How?

- Batteries in the lamp or fixture
- Sensors in the lamp or fixture
- Connectivity
- Dimming (most people can’t tell the difference between 100% and 80% light output)
Non-Energy Benefits

Not much information on these yet. It stands to reason that NEB’s could be more significant in the decision to purchase than EE.

- Voice Control
- Energy Reporting
- Circadian rhythm
- Security
- Maintenance
Can Energy Code help adoption?

— Limited residential lighting energy code (excluding CA) that includes controls

— If the code changes to require controls or connected lighting, can we increase the adoption rate?

### Table 4.5 Installed Penetration of Connected-LED Lamps (Relative to Non-Connected)

<table>
<thead>
<tr>
<th>Sector</th>
<th>2015</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connected LED Lamps (%)</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
<td>2%</td>
<td>4%</td>
</tr>
<tr>
<td>Commercial</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
<td>3%</td>
<td>9%</td>
</tr>
<tr>
<td>Residential</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
<td>2%</td>
<td>4%</td>
</tr>
<tr>
<td>Industrial</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
<td>2%</td>
<td>8%</td>
</tr>
<tr>
<td>Outdoor</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
<td>1%</td>
<td>5%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sector</th>
<th>2015</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connected LED Lamps (%)</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
<td>1%</td>
<td>5%</td>
<td>16%</td>
</tr>
<tr>
<td>Commercial</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
<td>1%</td>
<td>6%</td>
<td>18%</td>
</tr>
<tr>
<td>Residential</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
<td>1%</td>
<td>5%</td>
<td>16%</td>
</tr>
<tr>
<td>Industrial</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
<td>1%</td>
<td>5%</td>
<td>15%</td>
</tr>
<tr>
<td>Outdoor</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
<td>1%</td>
<td>3%</td>
<td>10%</td>
</tr>
</tbody>
</table>

### Table 4.4 Installed Penetration of Connected-LED Luminaires (Relative to Non-Connected)

<table>
<thead>
<tr>
<th>Sector</th>
<th>2015</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connected LED Luminaires (%)</td>
<td>&lt;1%</td>
<td>1%</td>
<td>4%</td>
<td>12%</td>
<td>23%</td>
</tr>
<tr>
<td>Commercial</td>
<td>&lt;1%</td>
<td>2%</td>
<td>7%</td>
<td>17%</td>
<td>34%</td>
</tr>
<tr>
<td>Residential</td>
<td>&lt;1%</td>
<td>1%</td>
<td>3%</td>
<td>6%</td>
<td>12%</td>
</tr>
<tr>
<td>Industrial</td>
<td>&lt;1%</td>
<td>1%</td>
<td>4%</td>
<td>12%</td>
<td>27%</td>
</tr>
<tr>
<td>Outdoor</td>
<td>&lt;1%</td>
<td>&lt;1%</td>
<td>3%</td>
<td>10%</td>
<td>25%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sector</th>
<th>2015</th>
<th>2020</th>
<th>2025</th>
<th>2030</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connected LED Luminaires (%)</td>
<td>&lt;1%</td>
<td>15%</td>
<td>31%</td>
<td>43%</td>
<td>59%</td>
</tr>
<tr>
<td>Commercial</td>
<td>&lt;1%</td>
<td>28%</td>
<td>52%</td>
<td>66%</td>
<td>73%</td>
</tr>
<tr>
<td>Residential</td>
<td>&lt;1%</td>
<td>1%</td>
<td>4%</td>
<td>13%</td>
<td>29%</td>
</tr>
<tr>
<td>Industrial</td>
<td>&lt;1%</td>
<td>16%</td>
<td>42%</td>
<td>60%</td>
<td>66%</td>
</tr>
<tr>
<td>Outdoor</td>
<td>&lt;1%</td>
<td>9%</td>
<td>37%</td>
<td>63%</td>
<td>77%</td>
</tr>
</tbody>
</table>

Adoption

Lots of room for adoption – even the aggressive view only has 15% connected lamps installed by 2035.

By increasing the adoption, we increase the savings possibilities.

Scoring Criteria: Lighting with Controls

- **Energy Savings:** DOE thinks there could be as much as 13 Million Megawatts by 2035 (in residential homes across the US)
- **Non-Energy Benefits:** Today – Good  
  Future – Great
- **Ease of Adoption:** Has to be easy
- **Value:** Okay to good, but energy is not the only factor that will decide value. What else can it do?
Scoring Criteria: Lighting with Controls

- Market/Commercial Readiness:
  - Not commercially available or limited, pre-commercial availability
  - Commercially available outside of NW. Requires special order in NW.
  - Commercially available in NW from 1 manufacturer through standard channels
  - Commercially available in the NW from at least 2 manufacturers. Stocked throughout the region.
  - Commercial available from 2+ manufacturers, well developed supply chain. Widely and easily available

- Product Performance:
  - Concept not yet validated
  - Concept validated
  - Limited assessment
  - Extensive assessment
  - Comprehensive Analysis
  - Approved for Implementation
Scoring Criteria: Lighting with Controls

Utility Program Readiness:

- No program design. No risk assessment
- Not cost effective, but preliminary analyses shows a pathway to CE. Limited program design and risk assessment
- Not cost effective but shows pathway to CE with higher volumes, more competition, improved technology. Small scale pilots.
- Marginally at cost effective levels. Program design complete, larger scale pilots underway. Well developed risk assessment.
- Cost effective. Ready for full-scale programs. Periodic risk assessment process in place.
Scoring Criteria: Home Automation Systems

- **Energy Savings**: Foggy, limited data on energy saving
- **Non-Energy Benefits**: Today – Good  
  Future – Great
- **Ease of Adoption**: Should be easy*
- **Value**: Okay to good, but energy is not the only factor that will decide value. What else can it do?
Scoring Criteria: Home Automation Systems

- **Market/Commercial Readiness:**
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  - Commercially available outside of NW. Requires special order in NW.
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- Cost effective. Ready for full-scale programs. Periodic risk assessment process in place.
Wrap-Up

- Where do we go from here?
- Are the savings enough to align with utility programs?
- Are utility programs going to have to change to account for Demand Response?
- Are the products ready for prime time?
- If so, can we speed up market adoption? Do we want to?
Questions?

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Thank you for attending!