US Department of Energy’s
Commercial Lighting Solutions
National Market Transformation Symposium

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Pacific Northwest National Laboratory
Buildings represents a key market for many EERE technologies.

The Commercial Lighting Solutions are created in support of DOE’s Commercial Buildings Energy Alliances:

- Retailer Energy Alliance
- Real Estate Energy Alliance
- Institutional Energy Alliance
- Commercial Buildings Industry Alliance
The Next Frontier

Cost, Complexity, Energy Savings

T12 to T8 electronic retrofits
HPT8 systems require low/normal/high ballast tuning
Task-Ambient redesign
“Intelligent Lighting” & advanced controls
Solid State Lighting

Power Density → kWh

1995
Low Hanging Fruit

2005
Design Required

2015

2025
Program Elements

Planning & Stakeholder Input

- Performance Metrics - Market Characterization, Baseline & Impacts Assessment
- Partnership-building: Technical & Deployment

Lighting Solutions

- Advanced Lighting Guidelines (NBI)

Series of sector-specific “Solutions” for retail, office, healthcare, and schools- 30% savings

Deployment of integrated lighting systems into utility and EE programs has never been done before

Deployment into

- Manufacturers
- NGOs/Associations
- Technical Experts
- Local Regional EE Programs
- Utility Programs
- National Accounts

Outreach & Visibility
## DOE/CLI Commercial Lighting Solutions

| **Goals** | 30% reduction in lighting energy consumption below 90.1-2004  
*in support of the new construction whole building goal of 50% savings by 2015, and the existing buildings goal of 30% better than CBECS 2003 by 2025* |
|---|---|
| **Baseline** | ASHRAE-IESNA Standard 90.1-2004  
*Future updates: ASHRAE-IESNA Standard 90.1-2001, Title 24, Savings by Design, CBECS, audit/actual* |
| **Design Team** | PNNL, Lighting Designers*, Architects, Manufacturers**  
*working with: *International Association of Lighting Designers and **National Electrical Manufacturers Association based on IESNA Design Criteria* |
| **Stakeholders** | End users, Utilities, EEPS, Lighting Industry, NGO's |
| **Metrics** | kW and kWh |
Why are the Commercial Lighting Solutions valuable?

- **Cutting Edge.** Next big opportunity set in lighting efficiency is integrated quality design using progressive technology, daylighting, and controls.

- **Focus on the End-Users.** Created by nationally known expert lighting designers who understand the needs of the various retail brands, owners, and tenants.

- **Deployment Partnerships.** Strong deployment and outreach program elements are working closely with stakeholders and partners to support their goals.

- **Energy Savings Decision Tool.** *Lighting Solutions* will be delivered via an interactive webtool and tied to an energy and economic analysis to support the decision process.

- **W/SF ⇒ kWh.** Energy savings quantified using kWh, will show savings against a series of common baselines (90.1-2004, 90.1-2001, Title 24, CBECS, etc.), and represents a way for utilities and EEPS to provide incentives for integrated systems using energy consumption rather than connected load.

- **Actionable Solutions.** *Lighting Solutions* include detailed technical information in performance specification language, geared toward the A&E audience.

- **This is the “How-To.”** Amidst a growing set of goals and mandates, the *Lighting Solutions* provide badly needed technical guidance on HOW to achieve these goals.
Provides the missing link: “How-To” meet your goals

<table>
<thead>
<tr>
<th>USDOE Commercial Lighting Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>USGBC LEED EB &amp; CI</td>
</tr>
<tr>
<td>Energy Star Buildings</td>
</tr>
<tr>
<td>ASHRAE Advanced Energy Design Guides</td>
</tr>
<tr>
<td>US GSA PBS-100</td>
</tr>
<tr>
<td>Advanced Buildings Core Performance</td>
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<tr>
<td>Architecture 2030</td>
</tr>
<tr>
<td>Office of the Future</td>
</tr>
<tr>
<td>Energy Policy Act of 2005</td>
</tr>
<tr>
<td>Energy Codes, State &amp; utility EE programs</td>
</tr>
</tbody>
</table>
What is a Lighting Solution?

Lighting Solutions are Integrated Systems

- Lighting Solutions = Lighting Vignette + Controls Strategies
  - Lighting Vignette: Lamp + Ballast + Luminaire + Layout/Reflected Ceiling Plan (RCP)
  - Controls Strategies: Controls + Installation & Commissioning guidance

- The Devil’s in the details - we must be specific to get the results we want
- Expert design → Energy savings
- Include daylighting where possible
Power Density → kilowatt hours

✓ The down side of Power Density, aka watts per square foot
✓ The time has come for an energy use metric to be widely used
✓ Annual energy use requires data about usage over time
✓ Solutions will vary by sector and application
✓ Opportunities in Demand Response
Advanced Lighting Guidelines - NBI

✓ Well-established, used, and evaluated tool geared towards designers / A&E’s

✓ History of the document and the players / sponsors

✓ New Buildings Institute (NBI) produces the document

✓ Applications Chapter contains lighting examples, which will be modified and expanded into “modules”

✓ Modules will be synergized with Lighting Solutions; different levels of detail

✓ Update to Applications chapter will happen in context with full document update over the next couple of years
Bridging the Gap, Concept → Implementation

- The audience for *Lighting Solutions* is primarily A&E’s, so they will be written in a form that is usable by them
- *Lighting Solutions* will include generic performance specifications
- Available in electronic format to allow for modification
- Success includes appropriate installation and commissioning
- Pilot projects are being identified now
Parameters for Inclusion in Solutions

✓ 30% savings beyond ASHRAE/IESNA 90.1-2004, which is coincident with 50% below 90.1-2001 and the EPAct 2005 tax credit

✓ Technologies must be commercialized and reliable

✓ Controls must have performance data for use in analysis

✓ Equipment will be at the cutting edge of efficiency, but will still allow for healthy competition between manufacturers

✓ Development will include computer modeled lighting calculations using industry standard software
### Project Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Square Footage (1) Floor</td>
<td>52,300sf</td>
</tr>
<tr>
<td>Ceiling Height</td>
<td>20 Feet</td>
</tr>
<tr>
<td>Gondola Height</td>
<td>8.0 Feet</td>
</tr>
<tr>
<td>Ceiling Type</td>
<td>Open Structure</td>
</tr>
<tr>
<td>Reflectances</td>
<td>75/50/20</td>
</tr>
<tr>
<td>Daylighting</td>
<td>yes –top lighting</td>
</tr>
</tbody>
</table>
Lighting Approach

- Daylighting
  - Toplighting
- Ambient Lighting
  - Linear Fluorescent-Wide
  - Metal Halide Downlight
  - CFL/MH Recessed
- Accent Lighting
  - MH Track Accent
  - MH Monopoint
- Specialty Accent
  - Fiber Optic
  - Perimeter Valence
Translate LPD’s into energy used

✓ Analysis for energy savings will go beyond connected load to include operating hours and will result in an estimate of kilowatt hours per square foot per year.

✓ Controls savings must be based on empirical, measured data and cited data sets.

✓ Optimize the possibilities for demand response strategies where possible.

✓ Analyze the economic impacts of the Lighting Solutions, to the degree that it is possible.

✓ Whole building modeling and analysis in FY09.
True *Lighting Solution* energy savings:

- *Lighting Solutions* need more than LPD comparison
  - Must incorporate some form of lighting time-of-use to apply control savings
  - May involve calculation by individual component (uplight vs. downlight)
  - Can accommodate capacity rate savings and utility demand reduction savings

- A true energy use savings analysis/calculation process can be straightforward ...but....
  
  ...the data to support accurate calculations is a critical element that can be difficult to obtain
Calculated “Best Estimate” method

- Identify discrete lighted areas in buildings for appropriate calculations. Separate by:
  - differing hours of operation
  - specific control/no control
- Apply hours of operation to area LPD
  - Vary by building space, function, etc.
- Apply daylight dimming and other control “factors” to affected area LPD
  - Use appropriate effective solar factor
  - Use specific control effect data – will differ by control type and application
Control effect matrix

- Conservative estimates based on similar research and boundary conditions
- Categorized by activity type

<table>
<thead>
<tr>
<th>Control System % savings per Activity</th>
<th>Pre-Open stocking</th>
<th>Store Open W/Daylight</th>
<th>Store Open W/O Daylight</th>
<th>Post-Close Stocking</th>
<th>Cleaning</th>
<th>No Control Period</th>
<th>Unoccupied</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 Top Lighting 4% SFR</td>
<td>24%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C2 Top Lighting 3% SFR</td>
<td></td>
<td>30%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C3 Dimming - Night Operation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C4 50% reduction (stocking)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C5 Occ Sens (cleaning)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C6 Unoccupied - all off</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C7 No control</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Demand Response

- Based on data
- Estimated
- Hard wired by choice
- Required by 90.1 standard
Calculated “Best Estimate” Formula:

\[
\text{LPD-1} \times \text{operating hours-1} \times \text{Control Factor-1}^* \\
+ \\
\text{LPD-2} \times \text{operating hours-2} \times \text{Control Factor-2}^* \\
... + \\
\text{LPD-n} \times \text{operating hours-n} \times \text{Control Factor-n}
\]

= “Total kWh/year”

Where:
1. “Control Factor” depends on control specifics and can be complicated. Must be based on best available data.
2. “Operating Hours” needs to follow varying controls and real operating differences.
### Grocery 1 Control System A

<table>
<thead>
<tr>
<th>Control System Design:</th>
<th>Activity</th>
<th>Time of Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 Top Lighting 4% SFR</td>
<td>Store Open W/Daylight</td>
<td>6AM-7PM</td>
</tr>
<tr>
<td>C7 no control</td>
<td>No Control Period</td>
<td>7PM-10PM</td>
</tr>
<tr>
<td>C4 50% reduction (stocking)</td>
<td>Pre-Open stocking</td>
<td>10PM-6AM</td>
</tr>
</tbody>
</table>

### Grocery 1 Control System B

<table>
<thead>
<tr>
<th>Control System Design:</th>
<th>Activity</th>
<th>Time of Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>C7 no control</td>
<td>No Control Period</td>
<td>6AM-8AM</td>
</tr>
<tr>
<td>C1 Top Lighting 4% SFR</td>
<td>Store Open W/Daylight</td>
<td>8AM-6PM</td>
</tr>
<tr>
<td>C7 no control</td>
<td>No Control Period</td>
<td>6PM-10PM</td>
</tr>
<tr>
<td>C4 50% reduction (stocking)</td>
<td>Pre-Open stocking</td>
<td>10PM-6AM</td>
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### Grocery 3 Control System A

<table>
<thead>
<tr>
<th>Control System Design:</th>
<th>Activity</th>
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</thead>
<tbody>
<tr>
<td>C1 Top Lighting 4% SFR</td>
<td>Store Open W/Daylight</td>
<td>6AM-7PM</td>
</tr>
<tr>
<td>C7 no control</td>
<td>No Control Period</td>
<td>7PM-10PM</td>
</tr>
<tr>
<td>C4 50% reduction (stocking)</td>
<td>Pre-Open stocking</td>
<td>10PM-6AM</td>
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</table>

### Grocery 3 Control System B

<table>
<thead>
<tr>
<th>Control System Design:</th>
<th>Activity</th>
<th>Time of Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>C7 no control</td>
<td>No Control Period</td>
<td>6AM-8AM</td>
</tr>
<tr>
<td>C1 Top Lighting 4% SFR</td>
<td>Store Open W/Daylight</td>
<td>8AM-6PM</td>
</tr>
<tr>
<td>C7 no control</td>
<td>No Control Period</td>
<td>6PM-10PM</td>
</tr>
<tr>
<td>C4 50% reduction (stocking)</td>
<td>Pre-Open stocking</td>
<td>10PM-6AM</td>
</tr>
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</table>
# Grocery Energy Analysis

<table>
<thead>
<tr>
<th>Design and Control System</th>
<th>Base LPD</th>
<th>Design LPD</th>
<th>Energy Savings (kWh)</th>
<th>% Savings</th>
<th>Cost Savings ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design #1 Control System A</td>
<td>1.7</td>
<td>1.03</td>
<td>445,874</td>
<td>57.4%</td>
<td>$35,670</td>
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<tr>
<td>Design #1 Control System B</td>
<td>1.7</td>
<td>1.03</td>
<td>431,752</td>
<td>55.6%</td>
<td>$34,540</td>
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<tr>
<td>Design #3 Control System A</td>
<td>1.7</td>
<td>1.30</td>
<td>359,082</td>
<td>46.2%</td>
<td>$28,727</td>
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<tr>
<td>Design #3 Control System B</td>
<td>1.7</td>
<td>1.30</td>
<td>341,258</td>
<td>43.9%</td>
<td>$27,301</td>
</tr>
</tbody>
</table>

Notes:
1) Energy Savings include LPD and control savings.
2) Cost savings are based on $0.08/kWh and do not include any time-of-use demand or response program savings.
3) Numbers are subject to change pending results of peer review input.
Elements of the Webtool

✓ front page information and orientation

✓ user and project registration

✓ input screens to provide project info about building type, square footage, operations, baseline, and more

✓ a decision tree process to guide user selections using key plans, design vignettes, controls strategies, lighting equipment specifications, calculation examples, and implementation guidance

✓ energy calculations to show savings in kW and kWh

✓ economic calculator

✓ linkage to utility and energy efficiency programs for rebates and incentives
Welcome to Commercial Lighting Solutions

The Commercial Lighting Solutions provide actionable "how to" guidance on ways to improve your building interior lighting efficiency and reduce your energy consumption, without compromising quality design criteria. Strategies include the use of high performance commercially available products, daylighting, and lighting controls, all within the context of integrated designs supported by performance specifications.
Hello Ryan Scott!

You can begin a new project or load an existing one.

START A NEW PROJECT

Load Project

LOAD AN EXISTING PROJECT

Select project...
Demo Grocery Store Project

Building Type: Grocery Store

Zip Code: 99352

Energy Code: 90.1-2004

Project Description:

Next!
Design Vignettes

Select the spaces your store will include, then enter the floor space and select a lighting vignette.
Design Vignettes

Select the spaces your store will include, then enter the floor space and select a lighting vignette.
Webtool Progress

General Sales Vignettes

Vignette 1
Description: Suspended linear fluorescent pendants, running perpendicular to aisles, allow aisle configuration flexibility. Reflectors redirect light to product display shelves.
LPD: 1.4W/ft²

Vignette 2
Description: Suspended linear fluorescent pendants run parallel to aisles. Less light is wasted on top of gondolas. Reflectors redirect light to product display shelves.
LPD: 1.29W/ft²

Vignette 3
Description: Luminaire cantilevered directly to gondola reduces glare and effectively washes vertical face of shelves.
LPD: 1.5W/ft²

Area: 15000 ft² x 1.29W/ft² = 19350 watts

OK or Cancel
NOTE: Three dimensional sketch courtesy of Unified Facilities Criteria.
Control Strategies

Select the control strategies you intend to implement in your building.

- **Daylighting**
  Dimming ballasts and photo sensors dim luminaires near skylights when sufficient daylight is available. Demand reduction can be accommodated.

- **Nighttime dimming**
  Dimming ballasts dim luminaires during nighttime hours when less light is needed. Demand reduction can be accommodated.

- **Switching during stocking**
  During stocking hours, when less light is needed, half of the luminaires are switched off.

PROJECT DESCRIPTION

Grocery Store

DESIGN VIGNETTES

- General Sales - Vignette 2
- Produce - Vignette 1
- Point-of-Sale - Vignette 1
- Pharmacy - Vignette 2
- Freezer Cases - Vignette 2
- Specialty - Vignette 1

CONTROL STRATEGIES

- Daylighting
- Nighttime dimming

DOWNLOADS

90.1-2004
Baseline: 297,840 kWh
Proposed: 208,497 kWh
30%
Your documentation is ready. The link below contains detailed information on the design vignettes and control strategies you selected to implement in your building.

Download Documentation

The energy efficiency calculations included in this documentation are generalized and may not match the final numbers for your building.

Once you have adjusted your plans for the building please return and enter the final square footage and wattage values below. With the actual numbers we can generate a certificate which documents your energy savings for you to take to your power utility.

\[ \text{Square Footage} \times \text{Wattage} = \text{Power Density} \]
Mission success requires more than just better technology, it requires scalable and integrated design solutions. Let’s make it happen.