106-Lighting Retrofits and Audits: and Overview of LLLC Basics.

Presented by
Eric Strandberg LC
Senior Lighting Specialist
Summer 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 ~12 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**
106-Lighting Retrofits and Audits: and Overview of LLLC Basics.

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Since 1995 Eric Strandberg LC, has been one of the lighting specialists at the Lighting Design Lab promoting energy efficiency and quality lighting design. With a passion for “all things lighting”, he has over 30 years in the lighting industry. This work encompasses almost every aspect of lighting design and conservation including; developing and presenting classes, writing articles, technology evaluation and project consultation.

eric@lightingdesignlab.com
What are we doing today?

- Overview of the procedures and issues around doing a lighting audit.
- Look at some of the common retrofit options available and what to be aware of.
- Introduce the advantages of Luminaire Level Lighting Controls
Pop Quiz- How many of you:

- Have done lots of audits and retrofits.
- Do lighting but want to know more about existing buildings.
- Are a contractor and want to know more about lighting.
- Are new to the field and want to know about every aspect.
- Thought this was a cooking class.
Determine project goals and motivations

- Dollar savings- Cut O&M costs
- Energy savings- Be green (LEED-EB)
- Productivity enhancement- Avoid disruption
- Improved lighting- Bad quantity/quality
- Timing- Aging system
- Code triggered- Building remodel
- All of the above?
Is everyone on the same page?

- **What is the priority?**
  - Owner- Low long-term costs
  - Tenant- “Green” status
  - Engineer- Maximize EE
  - Contractor- Lowest first cost
  - Facility operator- Low maintenance
  - Users- Quality lighting
  - Architect- Appearance

- **Hopefully everyone gets what they want.**
Do a preliminary survey

- What are the easy targets
  - What is the percentage of lighting and energy impacted
- What are the challenging areas
  - What is the percentage of lighting and energy impacted
- Is the goal to change all of the lighting regardless.
- Is a detailed audit warranted.

Always ask: How do you like the existing lighting?
Is this building a good candidate for a retrofit?
- Clues to determining feasibility.

- **Cost-Effective:**
  - Facility has long hrs. of operation.
  - Lighting system is more than 20 years old.
  - Electric Utility has high demand and/or energy rates.
  - Utility actively practices DSM, offers rebates.
  - Facility has higher light levels than required.
  - Presence of non-dimmed incandescent lamps.
  - Other energy saving opportunities:
    - Unrealized daylighting
    - Controls deployment

*Sidebar:* How much is the client actually paying for lighting?
Do they know?
Clues to determining feasibility

- **NOT Cost-Effective:**
  - Facility has short hrs. of operation
  - Facility exceeds existing efficiency requirements
    - e.g. ASHRAE 90.1, IECC
  - Facility pays little for energy and/or peak demand
  - Facility is not eligible for rebates or incentives
  - Facility has undergone recent retrofit.

Is it already a Green Building?
Which is likely more cost effective?

- A community center gymnasium or a pro sports stadium
- A theater or a library
- A big box store or a warehouse
- An office building lobby or a hotel lobby
If warranted, a detailed audit may be in order

- Do a plan survey
- Identify similar spaces
- Review electrical circuiting
- Check current recommended light levels and lighting guides
  - Local codes
  - Building standards
  - IES recommendations
Document the existing conditions

- **What you’ll need:**
  - Light meter
  - Measuring tape - Laser *
  - Notebook and/or tablet
  - Tape recorder w/ transcription app
  - Camera w/ zoom and wide angle
  - Binoculars
  - Personal Protection Equipment -
    - Ear plugs, hard hat, goggles, vest
  - Counter
  - Form(s)- (utility)

* Not always useful for exterior day
Document lighting systems

- Illuminance levels – existing.
- Luminaires - types, placement, mounting*.
- Lamps - type, color, wattage.
- Ballasts - type, voltage.
- Daylighting conditions.
- Luminaires already retrofitted, modified, are they consistent w/ as built?
- Lighting controls - occupancy sensors, timer switches, photocells, etc.
- Room reflectances.

*Same fixture different mounting?
Additional Survey tips

- What is the *condition* of the existing lighting.
- Are there any controls in use.
  - Is lighting on during “off” hours.
  - Is lighting off during “on” hours.
- Building conditions
  - Ceiling type
  - Access to plenum
- Daylight opportunities
- Reflectance of interior surfaces.
- What is in the maintenance closet...
Pop Quiz - Which of the following suggest that a retrofit is likely to be cost effective:

- The facility has long hours of operation.
- The measured light levels are higher than recommended practice.
- A community theatre stage has 50+ 500 watt lights.
- A hospital parking garage with 30 year old lights.
- The customer is going for LEED EB certification.
Document existing lighting- Light levels (LL)

- What is proposed
  - What is this based on

- What is Recommended
  - What is that based on

- Are the LL’s consistent throughout the space

- Are users happy with the LL
  - What do you think
Document existing lighting - Luminaires

- A decent zoom can save a lot of time tracking down as-builts or ladders.

Better camera zoomed (top)
Detail enlarged (below)

Phone pictures not useful for detail
A decent zoom can save a lot of time tracking down as-builts or ladders.

The client was “pretty sure” they had 100-watt lamps. This difference will be a factor in project viability.
Direct Luminaires

The direct luminaire is a light fixture in which 90 to 100% of the light is directed down to the task surface.
**Indirect Luminaires**

The Indirect luminaire or "uplight" is a light fixture in which 90 to 100% of the light is directed upward away from the task surface.
Document existing lighting - Luminaires - Distribution

**Direct-Indirect / Indirect-Direct**

This type of luminaire is a light fixture in which a high % of light goes up, and a high % goes down.
Document existing lighting - Luminaires

- What type
- What condition are they in
- What is the mounting
- What is the light distribution
- **What is being proposed**
Audit of fixtures- Overall condition of components

- Sockets
- Fasteners
- Wiring
- Lens
- Ballast age

Is there superficial dirt, or is it damage (rust, breakage, ruined gaskets, etc.)
Document existing lighting - Ballasts

- What type
- Condition
- Consistency
- Location
- Disposal issues

A typical pre-1979 PCB-containing fluorescent light ballast (FLB).

A typical Non-PCB containing fluorescent light ballast. The ballast has a "No PCBs" marking on the top of the ballast and the text "electronic ballast". Only magnetic fluorescent light ballasts contained PCBs.
Sometimes you just have to open a lot of fixtures.

All in one part of one building!

- 2Lamp NBF
- 2Lamp LBF
- Battery backup
- 277 Volt 2Lamp LBF
- 3Lamp NBF

Document existing lighting system- Ballasts
Document existing lighting system- Controls

What kinds of controls?

- On/Off switches
- Manual dimmers
- Occupancy sensors
- Daylight sensors
- Time clocks
- No local controls!
Document existing lighting system- Daylight

- Look for opportunities for an easy win.
Mitigate brightness ratio of luminaires, control contrast of tasks and background and, add to higher light levels.
An important part of a lighting design should be existing or proposed surface conditions.

Same lighting on each floor, but with a different surface reflectance.
Effect of surface reflectance on light delivered in the space

<table>
<thead>
<tr>
<th>Surface Reflectance</th>
<th>Average FC</th>
<th>Maximum</th>
<th>Minimum</th>
<th>Max to Min Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>85/75/56 High</td>
<td>51.2</td>
<td>82.7</td>
<td>11.5</td>
<td>7 : 1</td>
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<tr>
<td>70/50/20 Med</td>
<td>35.0</td>
<td>61.1</td>
<td>5.4</td>
<td>11 : 1</td>
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<tr>
<td>35/25/11 Low</td>
<td>23.4</td>
<td>43.7</td>
<td>2.1</td>
<td>21 : 1</td>
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</tbody>
</table>

This isn’t just “Interior Design” stuff!
Note the dark surfaces
Light surfaces compound benefits

- Better visual performance
- More light for less energy
- Lower contrast ratios
Light surfaces compound benefits

For any kind of space
Estimating room reflectance - how to do it.

- Take light level reading **on** the wall.
- Hold meter about a foot out from the wall and meter **toward** the wall.
- The % difference is the amount of light absorbed.
- Example: 80 fc incident, **on** wall 20 fc reflected **off** wall
  - \((20-80=60)/80=0.75\)
  - \(0.75 \times 100 = 75\% \text{ absorbed}\)

Or you can look it up if you know which paint.
When is the best time to audit exterior lighting

During the night?

During the day?
When is the best time to audit exterior lighting

During the night?

During the day?
When is the best time to audit exterior lighting

During the night?

During the day?
More advanced site analysis tools

- Luminance meter
- Data loggers
- Spectrometer
- Flicker checker
- Thermal imager
- UV meter
- GoPro?

If people are complaining about the lighting, Why?
Light Quantity: How much light do we need?

OCT 1939-Nela Park

200 footcandles of “diffused light” – twenty-five to fifty times as much illumination as many office people attempt to see by* -- aided this group when it met recently in the "round table room" of General Electric Institute at Nela Park, Cleveland.

Making possible indoors this newest challenge to seeing conditions as found outdoors is the experimental fluorescent fixture shown here on the ceiling.

* 8 to 4 fc?
### Levels of Illumination (Interior)

<table>
<thead>
<tr>
<th>Area</th>
<th>Footcandles on Tasks*</th>
<th>Dekalux# on Tasks</th>
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<tbody>
<tr>
<td><strong>Offices</strong></td>
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<tr>
<td>Drafting rooms</td>
<td>200†</td>
<td>220†</td>
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<td>Detailed drafting and designing, cartography</td>
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<td>Rough layout drafting</td>
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<td>160†</td>
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<td>Accounting offices</td>
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<td>Auditing, tabulating, bookkeeping, business machine</td>
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<td>160†</td>
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<td>operation, computer operation</td>
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<td>General offices</td>
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<td>Reading poor reproductions, business machine</td>
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<td>operation, computer operation</td>
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<td>Reading handwriting in hard pencil or on poor paper,</td>
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<td>reading fair reproductions, active filing, mail</td>
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<td>Reading high contrast or well-printed materials</td>
<td>30†</td>
<td>33†</td>
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<tr>
<td>Conference rooms</td>
<td>30</td>
<td>33</td>
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</table>

*Minimum on the task at any time for young adults with normal and better than 20/30 corrected vision. For general notes see beginning of tabulation.

* Dekalux is an SI unit equal to 1/006 footcandles. 1 dekalux = 10 lux.
### Office Facilities Illuminance Recommendations

**Table 32.2 | Office Facilities Illuminance Recommendations continued from previous page**

<table>
<thead>
<tr>
<th>Applications and Tasks</th>
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**Recommended Maintained Illuminance Targets (lx)**

- **Horizontal ($E_h$) Targets**
  - Visual Ages of Observers (years) where at least half are
  - \(<25 \quad 25-65 \quad >85\)

- **Vertical ($E_v$) Targets**
  - Visual Ages of Observers (years) where at least half are
  - \(<25 \quad 25-65 \quad >85\)

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<tr>
<td>* Specular paper and ink</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>* B- and 10-p.t Font</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>* Matte paper and ink</td>
<td></td>
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<tr>
<td>* Specular paper and ink</td>
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<tr>
<td>* 12-p.t Font</td>
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<td>* Specular paper and ink</td>
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<tr>
<td>* VDT Screen and Keyboard</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
How much light will I get?
What is the efficacy?
So many options so many variables

<table>
<thead>
<tr>
<th>Wattage</th>
<th>Lumens</th>
<th>Reflector</th>
<th>Optics</th>
<th>Lens</th>
<th>CCT</th>
<th>CRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>4K, 70CRI</td>
<td>3K, 90CRI</td>
<td>30,000 nominal lumens.</td>
<td>236 watts.</td>
<td>125 l/w</td>
<td>80 l/w</td>
<td></td>
</tr>
</tbody>
</table>

<table>
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<td>236 watts.</td>
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<td>80 l/w</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Operational Data</th>
<th>Wattage</th>
<th>Lumens</th>
<th>Reflector</th>
<th>Optics</th>
<th>Lens</th>
<th>CCT</th>
<th>CRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>236</td>
<td>125 l/w</td>
<td>80 l/w</td>
<td>30,000 nominal lumens.</td>
<td>236 watts.</td>
<td>125 l/w</td>
<td>80 l/w</td>
<td></td>
</tr>
</tbody>
</table>
Question on CRI and CCT?
How many of you:

- Know all about CRI and CCT.
- Have been doing lighting a while but could use a refresher.
- Heard about them but always get confused.
- Am new to lighting and would like to find out about CRI and CCT.
- I thought we were going to learn how to make pizza in this class.
Photometric reports for just **one fixture** - ...

Someone said not long ago, “Isn’t lighting getting easier? It’s just LEDs now.”
Pop Quiz - What are the benefits of light interior surfaces?

- Potential to save energy.
- Hybrid radial outcomes.
- Improve visual comfort.
- Lower contrast ratios.
- Potential higher light levels.
- ...Isn’t this just Interior Design? *(Not my area!)*
- All of the above
Common retrofit applications

Fluorescent troffers
Recessed cans
Decorative surface
High-bay
Parking
LED Tubes (TLEDs) - different formats

- No diffuser
- Wide ends
- Narrow ends
- Glass tube
- Metal heat sink
Tube cross section distribution

- **LED Narrow (13-03)**: 105° aperture
- **LED Medium (13-27)**: 133° aperture
- **LED Wide (13-20)**: 160° aperture
- **Fluorescent (BK13-30)**: 360° aperture

Yellow = 180° aperture, Yellow = 180° aperture, Yellow = 240° aperture, Yellow = 360° aperture
Directionality of TLEDs

Sometimes the directionality of TLEDs can be an advantage.
Directionality of TLEDs

Sometimes the directionality of TLEDs can be a disadvantage.
TLED- wiring

Tubes- at least 3 variations

No rewiring- Ballast Compatible (BC TLED) product operates through existing ballast (has an integral driver) – **UL Type A**

Rewiring- (TLED) disconnect ballast, and rewire sockets for line voltage (product has an integral driver) – **UL Type B**

Rewiring- remote driver product operates off of a driver external to the tube and may use the sockets.* - **UL Type C**

* *When does a “tube” become a “kit”?*
Ballast Compatible-TLED – Read the fine print

Compatible with >90% of electronic T8 ballasts, including instant start, programmed start, rapid start and dimmable fluorescent ballasts
Efficacy: 85-105 LPW at system level
Lamp Delivered Light Output: 1700-2100 lumens per LED lamp*
System Power: 20 watts**
Lamp Watts: 18.5**

Application Information
Application Notes
1. Due to numerous ballast designs and topologies, this lamp should be tested on existing ballasts before mass quantities are installed.
2. Not intended for use with older dedicated voltage (120V or 277V) instant start ballasts. These ballasts have electronic components that degrade over time and may become unsuitable for the new LED T8 lamp.
Rewire TLEDs

“...most include an integral driver and are powered directly by mains voltage (120V or even 277V). In addition, LED lamps may require power to be connected at one end or both ends—sometimes with an additional wire between opposite pins. Improper wiring can result in product failure and/or dangerous conditions, such as sparking, smoking, or tripping circuit breakers. 

Further, each lamp type may require either shunted or unshunted lamp holders..."
"Do not use this retrofit kit in luminaires employing shunted bi-pin lamp holders."

"Shunted lamp holders are found only in luminaires w/ instant-start ballasts."

**WARNING:** To avoid potential fire or shock hazard, do not use this retrofit kit in luminaires employing shunted bi-pin lampholders. Note: Shunted lamp holders are found only in fluorescent luminaires with Instant-Start ballasts. Instant-start ballasts can be identified by the words "Instant Start" or "I.S." marked on the ballast. This designation may be in the form of a statement pertaining to the ballast itself, or may be combined with the marking for the lamps with which the ballast is intended to be used, for example F40T12/IS. For more information, contact the LED luminaire retrofit kit manufacturer.
Remote driver tubes. *Still using the sockets*

Each LED tube is operated by a GE Lightech™ driver. See reverse for LED tubes and Lightech driver product details.

Usually a manufacturer supplied proprietary driver.
Remote driver tubes Using sockets, but *no power to them*

- **Quick Connect**: QC system removes the step of wiring the DC outputs to the tombstones.
- **Driver**: Driver comes standard with 3M double sided tape to place driver before installing self-tapping screws. The external driver removes unwanted heat source from inside the lamp.
- **DC Power Feed to Tube**: 24 inch power wire allows for an easy connection to the driver and enables the tombstones to simply be place holders for the lamp.
- **AC Input Lines**: Leave your wire cutters at the shop for this job as the QC drivers are precut saving even more time on installation.
- **Heat Sink**: Military grade extruded aluminum heat sink ensures an even and effective heat transfer from the LM80 tested LEDs.
- **LED Diodes**: The QC tubes utilize LED sources that have passed the IESNA LM80-08 test procedure and have gone through IESNA LM79-08 and TM-21 independent testing.
Kits - Basic

Kits
Variations of kits, all have rewired fixtures, and remote drivers

Basic Kit - Replacing just the electrical assembly
Uses existing luminaire optics

UR Series
Kits - Complete have new optics

**Complete Kit** – New electrical assembly and new optical assembly
What about a different kind of lighting?

A new fixture gives the opportunity for a fresh modern look.
What are some other advantages to a new fixture?

Direct lighting system with recessed luminaires
Indirect lighting system with pendant luminaires
What is the LED equivalent in delivered lumens?

CFL fixture: 83 watt w/ 4-1800 lumen lamps = 7,200

LED-A: 24 watt w/ 2558 lumens

LED-B: 22 watt w/ 1898 lumens
CFL fixture efficiency – 37%

After the luminaire efficiency is applied to the 7200 lamp lumens then the luminaire lumens = 2660
LED A lists “source lumens”

We don’t know what the luminaire efficiency is.

LED PERFORMANCE - 3500K STANDARD
120-277V - 3500K, 82 CRI - L80 rating - 60,000 hrs - L70 rating (projected) - 100,000 hrs
Amperage rated @ 110V input
Operating ambient temperature: -20°C / -4°F - 40°C / 104°F

Standard 3500K source lumens noted. Consult Brownlee.com for performance of all CCTs.
B6LED - 6W nominal, .05 A input - 698 lm - 114 lm/W
B12LED - 12W nominal, .10 A input - 1422 lm - 120 lm/W
C9LED - 9W nominal, .10 A input - 1072 lm - 122 lm/W
C17LED - 17W nominal, .15 A input - 1829 lm - 111 lm/W
C24LED - 24W nominal, .20 A input - 2558 lm - 107 lm/W
C37LED - 37W nominal, .30 A input - 3837 lm - 104 lm/W
C49LED - 49W nominal, .40 A input - 5116 lm - 107 lm/W
LED B lists “delivered lumens”

<table>
<thead>
<tr>
<th>Performance</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Wattage</td>
<td>21.8</td>
</tr>
<tr>
<td>Input Voltage Range (V)</td>
<td>120</td>
</tr>
<tr>
<td><strong>Delivered Lumens (lm)</strong></td>
<td><strong>1898</strong></td>
</tr>
<tr>
<td>Efficacy (lm/W)</td>
<td>87.0</td>
</tr>
<tr>
<td>Color Rendering Index (CRI)</td>
<td>80</td>
</tr>
<tr>
<td>Color Temperature (CCT)</td>
<td>3000</td>
</tr>
<tr>
<td>Equivalent Wattage</td>
<td>100W Inc.</td>
</tr>
<tr>
<td>Beam Angle</td>
<td>0</td>
</tr>
<tr>
<td>Power Factor</td>
<td>0.00</td>
</tr>
<tr>
<td>MAX THD (%)</td>
<td>0</td>
</tr>
<tr>
<td>Min. Ambient Temp (°F)</td>
<td>0</td>
</tr>
<tr>
<td>Max. Ambient Temp (°F)</td>
<td>104</td>
</tr>
</tbody>
</table>
Luminaire lumens or Delivered lumens are derived from absolute photometry.

Model Number: ML2LA17SABNIP827

Light Output (Lumens) 1100
Watts 17.6
Lumens per Watt (Efficacy) 62.5

Color Accuracy
Color Rendering Index (CRI) 80

Light Color
Correlated Color Temperature (CCT) 2700 (Warm White)


Registration Number: ULP-U4KLLE/11/E (5/2015)
Model Number: ML2LA17SABNIP827
Type: Luminaire - LED
Know your light source.- LED- Integral Lamp
Not just Lumens or Lumens per watt

~ 75+ Lumens per watt

~ 95+ Lumens per watt

*CBCP and Beam Angle can be the most relevant quantities
**Beam Angle** - The angle at which the light drops 50% from the CBCP

**Field Angle** - The angle at which the light drops to 10% (not used much)
**Omni-directional** lamps in recessed cans.
Some recessed cans are designed for omni-directional lamps. In this case it is the trim that shapes the light and contributes greatly to the optical properties and luminaire efficiency.

It may not have been such a good idea anyway...

<table>
<thead>
<tr>
<th>Efficiency</th>
<th>65 lm/W</th>
<th>54%</th>
<th>35 lm/W</th>
</tr>
</thead>
</table>

**Lighting Design Lab**
CFL recessed cans may lose 40% of light or more due to inefficiency.
CFL to LED Retrofit

Potentially a “great fit”
Taking an omnidirectional lamp out of a usually marginal optical system and putting in a directional lamp

Replacing a 12K hr lamp w/a 50K lamp

26 watt ~ = 13 (14.5) watt

But…
But... CFL to LED replacement- Check compatibility

“LED replacement for CFL plug-in. LED plug-in lamps allow you to replace inefficient CFL 4 pin G24q/GX24 without tools or costly upgrades. Simply plug the replacement lamp into the existing ballast.”
Its supposed to work...

### GE LED Plug-In (4-pin) Ballast Compatibility List

**IMPORTANT NOTICE.** This list is based on information provided by the ballast supplier, and testing was done on a stable AC power supply under laboratory, which may not be representative of your particular end-use conditions. While each ballast type listed has undergone testing, some have undergone revisions that may change operating parameters and impact lamp performance. Applications and conditions of use are many and varied, and beyond GE's control, so purchasers and users should make their own determinations as to the suitability of a lamp-ballast combination for their specific application and use. Compatibility may also extend to ballasts beyond this list, so performing an on-site test before installation is recommended.

<table>
<thead>
<tr>
<th>Ballast</th>
<th>One Lamp</th>
<th>Two Lamp</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>120V</td>
<td>277V</td>
</tr>
<tr>
<td>Advance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICF-2526-M1-8S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICF-2526-H1-LD*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICF-2513-H1-LD*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICF-2518-H1-LD*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICF-2510-M1-9S*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICF-2526-M1-9G-QS*</td>
<td></td>
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<tr>
<td>GE Proline</td>
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<tr>
<td>GEC226-MPS-BES</td>
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</tr>
<tr>
<td>GEC226-MPS-3W</td>
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<td></td>
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<tr>
<td>GEC226-MPS-5E</td>
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<tr>
<td>GE</td>
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<td></td>
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<tr>
<td>GEC218-MPS-5EW</td>
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<tr>
<td>GEC</td>
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<td></td>
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<tr>
<td>GEC213-MPS-3W</td>
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<tr>
<td>Hatch</td>
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<td></td>
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<tr>
<td>HC213P5-UVD</td>
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<tr>
<td>Hatch</td>
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<tr>
<td>HC226P1-UVD</td>
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<tr>
<td>Howard</td>
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<td></td>
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<tr>
<td>EP2/13CF/MV2</td>
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<td></td>
</tr>
<tr>
<td>Howard</td>
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<tr>
<td>EP2/25CF/MV2</td>
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<tr>
<td>Lumapro</td>
<td></td>
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<tr>
<td>4K6J7</td>
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<tr>
<td>Lumapro</td>
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<td>Lumapro</td>
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<td>16X959</td>
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<tr>
<td>Lumapro</td>
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<tr>
<td>4K6U8</td>
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<tr>
<td>Robertson PS2126CQ/MW/AC</td>
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<tr>
<td>Syvania</td>
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<tr>
<td>OTP 2x10CF/UVN S PEM</td>
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<tr>
<td>Syvania</td>
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<td></td>
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<tr>
<td>OTP 2x10CF/UVN DIM</td>
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<tr>
<td>Syvania</td>
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<tr>
<td>OTP 1x18CF/UVN DIM*</td>
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<tr>
<td>Tridol</td>
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<tr>
<td>C2642UNVSE</td>
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<tr>
<td>Tridol</td>
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<tr>
<td>C2642UNVME</td>
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</tr>
<tr>
<td>Tridol</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C218UNVME</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[Compatible](#) [Not compatible](#)

*compatibility may vary per revision*

Information is subject to change without notice
Humm...

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<td>120V</td>
<td>277V</td>
</tr>
<tr>
<td>Advance ICF-2S26-M1-BS</td>
<td>Green</td>
<td>Green</td>
</tr>
<tr>
<td>Advance ICF-2S26-H1-LD*</td>
<td>Green</td>
<td>Red</td>
</tr>
<tr>
<td>Advance ICF-2S13-H1-LD*</td>
<td>Green</td>
<td>Green</td>
</tr>
<tr>
<td>Advance ICF-2S18-H1-LD*</td>
<td>Green</td>
<td>Green</td>
</tr>
<tr>
<td>Advance ICF-2S18-M1-BS*</td>
<td>Green</td>
<td>Green</td>
</tr>
<tr>
<td>Advance IZT-2S26-M5-LD*</td>
<td>Green</td>
<td>Green</td>
</tr>
<tr>
<td>Advance ICF-2S26-M1-BS-QS*</td>
<td>Green</td>
<td>Green</td>
</tr>
</tbody>
</table>
There is always some fine print.

**For maintenance and energy savings reasons ESL Vision recommends bypassing all ballasts for permanent operation.**
What about a retrofit “kit”? What has changed?*

*Note the lens
CFL replacement products.
Wire in, recessed light source.

Improved optics, LED advantages
The HID Opportunity - 2% of the sockets, 26% of the lighting energy in US

Mogul based HID lamps are used in a mere 2% of lamp sockets in the US, but in 2010 HID lamps used 26% of the lighting energy in the United States and are second only to linear fluorescent lamps for lighting consumption.*

*Mogul based LED replacement lamp study
Conducted by the Lighting Research Center, Rensselaer Polytechnic Institute
Prepared for Bonneville Power Administration and Washington State University Energy Program
**Optics** - built around a point source

- **Glare control**
  - High degree possible
  - High degree *needed*

- **Distribution**
  - High precision possible

- **Infrastructure investment**

- **Luminaire efficiency**
  - Influences system lumens and delivered light

---

Point source = Metal halide
Brightness and size

This is not strictly the case with LEDs. But there is a relationship, so higher lumen needs, usually result in a larger size.

~760 lumens
7 watt

~7800 lumens
75 watts

10X
Different HID optical systems
Reflector and lens type

Translucent

Solid
Directional lamp vs omni directional.
In some cases it may not matter.
Directional retrofit for an omnidirectional decorative fixture

Sometimes appearance does matter.
Industrial retrofit case study

Model is 226’ x 65’ with 72’ ceiling (est. from plans)
Fixtures mounted at 61’ (est.) in 4 rows of 16 per plans
### Model summary

#### Mercury Vapor

<table>
<thead>
<tr>
<th>Fixture</th>
<th>Wattage</th>
<th>Avg FC*</th>
<th>Max/Min</th>
<th>LPD</th>
<th>Fixture quantity</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merc. Vapor</td>
<td>400 / 465</td>
<td>30</td>
<td>2.1 : 1</td>
<td>2.0</td>
<td>64</td>
<td>Luminaire= 84% efficient</td>
</tr>
<tr>
<td>Light Efficient Dsgn.</td>
<td>160</td>
<td>35</td>
<td>2.1 : 1</td>
<td>0.7</td>
<td>64</td>
<td>Retrofit existing. Luminaire= 84% efficient</td>
</tr>
<tr>
<td>DEG-LED</td>
<td>220</td>
<td>40</td>
<td>2.0 : 1</td>
<td>0.96</td>
<td>64</td>
<td>Retrofit existing. Luminaire= 100% efficient</td>
</tr>
<tr>
<td>Cree- CXB</td>
<td>227</td>
<td>80</td>
<td>2.3 : 1</td>
<td>1.0</td>
<td>64</td>
<td>New fixture Replace 1 for 1</td>
</tr>
<tr>
<td>Cree- CXB</td>
<td>227</td>
<td>42</td>
<td>2.2 : 1</td>
<td>0.53</td>
<td>34</td>
<td>New fixture Eliminate ~ 50% of existing fixtures</td>
</tr>
</tbody>
</table>
### Model summary

**Light Efficient Design - Fixture retrofit**

<table>
<thead>
<tr>
<th>Fixture</th>
<th>Wattage</th>
<th>Avg FC*</th>
<th>Max/Min</th>
<th>LP D</th>
<th>Fixture quantity</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Merc. Vapor</td>
<td>400 / 465</td>
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</tr>
<tr>
<td>DEG-LED</td>
<td>220</td>
<td>40</td>
<td>2.0 : 1</td>
<td>0.9</td>
<td>64</td>
<td>Retrofit existing. Luminaire= 100% efficient</td>
</tr>
<tr>
<td>Cree- CXB</td>
<td>227</td>
<td>80</td>
<td>2.3 : 1</td>
<td>1.0</td>
<td>64</td>
<td>New fixture. Replace 1 for 1</td>
</tr>
<tr>
<td>Cree- CXB</td>
<td>227</td>
<td>42</td>
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<td>New fixture. Eliminate ~ 50% of existing fixtures</td>
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<td>Fixture</td>
<td>Wattage</td>
<td>Avg FC*</td>
<td>Max/Min LP</td>
<td>Fixture quantity</td>
<td>Notes</td>
<td></td>
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<td>Merc. Vapor</td>
<td>400 / 465</td>
<td>30</td>
<td>2.1 : 1</td>
<td>2.0</td>
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<td>Light Efficient Dsgn.</td>
<td>160</td>
<td>35</td>
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<tr>
<td>DEG-LED</td>
<td>220</td>
<td>40</td>
<td>2.3 : 1</td>
<td>0.9</td>
<td>64 Retrofit existing. Luminaire= 84% efficient</td>
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<tr>
<td>Cree- CXB</td>
<td>227</td>
<td>80</td>
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Model summary: Cree CXB- New fixtures 1 for 1 = 64 fixtures
## Model summary - Industrial retrofit case study

<table>
<thead>
<tr>
<th>Fixture</th>
<th>Wattage</th>
<th>Avg FC*</th>
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\[
64 \times 300 = 19,200 \\
34 \times 550 = 18,700
\]
Pop Quiz- Before doing a LED lamp only retrofit, always check to see which of the following?

- That the fixture is in good shape.
- That the lamp is compatible with the electronics (ballasts and existing controls).
- That the optics are appropriate.
- That the utility is agreeable.
- That the customer has enough money...
Luminaire Level Lighting Control (LLLC) and Networked Lighting Control (NLC)

Presented by Eric Strandberg LC
Summer, 2020

Courtesy; Acuity, Enlighted
Why use lighting controls at all?

Save energy costs
Save on maintenance cost
Which lights to control and how?

It shouldn’t be all or nothing.
Is this space “occupied”

- Lights on when occupied.
- What is wrong with this picture?
Is this space lit?

Productivity and security are important factors.
Varying tasks and a variety of lighting conditions.

Intensity
Occupancy
Daylight
Preference
Tasks
What kinds of control?

On/Off switches
Manual dimmers
Occupancy sensors
Daylight sensors
Time clocks
Setting a wall box device
So simple, just one button

OPERATIONAL SETTINGS

NOTE: (+) Indicates factory default (unless otherwise marked)

2 = Occupancy Time Delay
Time sensor keeps lights on after last occupancy detection.
1 30 sec 4 7.5 min 7 15.0 min 10 30.0 min
2 2.5 min 5 10.0 min* 8 17.5 min
3 5.0 min 6 12.5 min 9 20.0 min
For additional time settings, contact technical support at 1.800.PASSIVE.

3 = On Mode
Automatic On turns lights on when occupancy is detected. Manual On requires a button press to turn the lights on. Reduced Turn-On directs the sensor to only detect large motions, such as a person entering a room. Weak signals, such as reflections from glass, are ignored. Once lights are on, the sensor returns to maximum sensitivity.
1 Automatic On* 2 Manual On** 3 Reduced Turn-On
* Standard Factory Default
** Factory Default for -SA and -NL versions

4 = Switch Modes
These modes dictate switch functionality. Pressing the button in Override Off mode (setting 1) turns off and keeps lights off until pressed again. Disabling the Switch (setting 2) prevents the button from turning the lights on.

5 = Photocell Set-Point
The ambient light level at which the sensor prevents the lights from initially turning on. Once on, the lights will remain on until the occupancy time delay expires and turns them off.
1 Disabled* 6 4 fc
2 Auto Setpoint 7 8 fc
3 0.5 fc 8 16 fc
4 1 fc 9 32 fc
5 2 fc 10 64 fc
Note: Sensor will be changed to Automatic On mode if photocell is enabled. Photocell not present in -NL versions. LED flashes while Auto-Setpoint mode is running.

6 = LED Operation
Indicates behavior of device’s LED.
1 Occupancy Indication* 3 Disabled
2 Relay Indication 4 Override On***
* Standard Factory Default
*** Factory Default for -NL version

9 = Restore Factory Defaults
Returns all functions to original settings.
1 Maintain Current* 2 Restore Defaults
Programing each occupancy sensor

Programing Instructions:
Operational settings can be changed via the push-button sequence outlined below (note the example used is for changing occupancy time delay).

1. Press & hold button until it flashes.
2. Release button.
3. Select function.
   - E.g., press 2x for Occupancy Time Delay.
   - While LED flashes, select current setting 3x.
4. Select new setting.
   - E.g., press 5x to change to 10 min.
5. Press & hold button.
6. LED flashes rapidly.
   - E.g., 4 flashes indicates new 7.5 min time delay setting.
7. Release button.
   - LED flashes twice to save and exit.

There is only one button to do everything...
SmartCast

- Self-programming wireless lighting control
- Integrated sensors
- Daylight harvesting
- Task tuning
- One button set-up

Automated luminaire association and configuration
NLCS can have:

Graphical User Interface (GUI) to make programming easier
Why use controls?.. Energy Codes

WASHINGTON STATE ENERGY CODE, COMMERCIAL PROVISIONS

**C405.2 Lighting controls (Mandatory)** Lighting systems shall be provided with controls as specified in Sections C405.2.1 through C405.2.8.

**C405.2.4 Daylight responsive controls.** *Daylight responsive controls* complying with Section C405.2.4.1 shall be provided to control the lighting within *daylight zones* in the following spaces:

1. Sidelight daylight zones as defined in Section C405.2.4.2 with more than two general lighting fixtures within the primary and secondary sidelight daylight zones.
2. Toplight daylight zones as defined in Section C405.2.4.3 with more than two general lighting fixtures within the daylight zone.
Office plan controls
Office plan controls
Daylight zones
Office plan controls
Daylight zones - Primary and Secondary
**Why use controls - Energy Codes**

**WASHINGTON STATE ENERGY CODE, COMMERCIAL PROVISIONS**

**C405.2 Lighting controls (Mandatory).** Lighting systems shall be provided with controls as specified in Sections C405.2.1 through C405.2.8.

**C405.2.1 Occupancy sensor controls.** Occupancy sensor controls shall be installed to control lights in the following space types:

1. Classrooms/lecture/training rooms.
2. Conference/meeting/multipurpose rooms.
3. Copy/print rooms.
4. Lounges.
5. Employee lunch and break rooms.
6. Private offices.
7. Restrooms.
8. Storage rooms.
10. Locker rooms.
11. Other spaces 300 square feet (28 m²) or less that are enclosed by floor-to-ceiling height partitions.
Office plan controls
Occupancy zones
Office plan controls
Occupancy zones- Open Office too
Office plan controls
Corridor/ Egress path
Office plan controls
Combined - It gets complicated.
Combining Control Strategies

Room empty lights on.
Not good.

Room empty lights off and lots of daylight.
Good, but what happens when room is occupied?
Occupied, daylit, lights off...**success.**
C405.2 Lighting controls (Mandatory). Lighting systems shall be provided with controls as specified in Sections C405.2.1 through C405.2.8.

Exception: Except for specific application controls required by Section C405.2.5:

1. Areas designated as security or emergency areas that are required to be continuously lighted.
2. Interior exit stairways, interior exit ramps and exit passageways.
3. Emergency egress lighting that is normally off.
4. Industrial or manufacturing process areas, as may be required for production and safety.

5. **Luminaire-level lighting controls (LLLC) that control interior lighting.** The LLC luminaire shall be independently configured to:
   5.1. Monitor occupant activity to brighten or dim its lighting when occupied or unoccupied, respectively.
   5.2. Monitor ambient light (both electric light and daylight) and brighten or dim electric light to maintain desired light level.
   5.3. Configuration and reconfiguration of performance parameters, including bright and dim setpoints, time-outs, dimming, fade rates, sensor sensitivity adjustments, and wireless zoning configurations, for each control strategy.
   5.4. Meet the operational and commissioning requirements of Sections C405.2.1, C405.2.2, C405.2.3, C405.2.4, and C408.
Each fixture has its own controls? That could never happen...
Individual controls is not a new idea

Each fixture has a **Photocell**.
They each do their own thing.
What about interior?
Individual controls
High-bay

Each fixture has an **Occupancy Sensor**
Why couldn’t we do this in the past?
What if each fixture had its own controls in an office?

Offices have a lot higher fixture density per Sq. Ft.
Convergence of Technologies and Timing

Miniaturization of Control Devices

Controllable Light Sources

Higher Data Bandwidth

More demanding Energy Codes

Not the price…
What are the advantages of LLLCs

- More savings due to **higher granularity**
- **No rewiring** needed due to wireless functionality
- Ability to **re-zone** if area use changes
Lighting is a handy place to put these devices

Because it's everywhere, and it has power already
LLLC = High Granularity. Traffic patterns
Traffic patterns-
Night- Minimum lighting for egress at 10%
Traffic patterns-
First entry- ambient to 30%, traffic to 90%
Traffic patterns-
First entry- ambient to 30%, traffic to 90%
Traffic patterns-
Daytime- ambient to 30%, traffic to 90%, daylight zone off if ok

It is summer
Traffic patterns-
Daytime- ambient to 30%, traffic to 90%, daylight zone off if ok

It is summer… and almost everyone is on vacation.

Highly granular control
LLLCs don’t have to be troffers.

What control effects do you see?
Pop Quiz- The most effective retrofit luminaire:

A. Is energy efficient.
B. Has appropriate color qualities.
C. Puts light where it is needed.
D. Has low operating costs.
E. Is controllable.
F. All of the above.
Find a solution that is right for your business.

NW Utility Incentive Programs

Call 206.684.3800
Email SCLEnergyAdvisor@seattle.gov

Connect with an Energy Advisor to help you better understand energy options, navigate your choices, and create a plan that helps your home or business save energy and money. Conservation, energy efficiency and smart energy choices are within reach.
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Our current commercial lighting programs include:

Business Lighting Incentive Program

[VIEW OPTIONS]

Lighting To Go instant discounts

[VIEW OPTIONS]

Host a bulb recycling collection box

[VIEW OPTIONS]

If you need help with your application, call an Energy Advisor at 1-800-562-1482, Monday through Friday from 8 a.m. to 5 p.m.
NW Utility Incentive Programs

For Your Business

Business Energy Advisor
Rebates & Incentives
For Small Businesses
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1-877-783-1000
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SAVE WITH LIGHTING

Bright Rebates Program
BrightRebates@cityoftacoma.org
(253) 502-8619

Updating your lighting is one of the most cost-effective options for saving money and energy - it may also reduce maintenance and operation costs in your business.

With Bright Rebates, you can get a rebate for up to 60% of the project cost. You will also enjoy monthly savings on your electric bill.

Rebate-Eligible Changes Include:
- Incandescent to CFL or LED fixtures and lamp replacements
- T12 to T8 or T5, Hi performance T-8, or LED fixtures or retrofits
- Magnetic HID to electronic ballasted HID, fluorescent or LED
- Incandescent to LED exit signs
- Occupancy sensors/lighting controls

There are several options for updating your lighting. Start exploring the best option for your space by reading our Lighting Guide.

Bright Rebates Application

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**Residential:** (253) 502-8363
- Email: RConservation@CityofTacoma.org

**Multifamily & Condo:** (253) 502-8363
- Email: Multifamily@CityofTacoma.org

**Business:** (253) 502-8619
- Email: BizRebates@CityofTacoma.org
Or you can just go to our web site to find the links and lots of other great stuff! lightingdesignlab.com

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<th>Northwest Utility Programs</th>
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<td>Energy Trust of Oregon - Incentives</td>
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<tr>
<td>View Website</td>
<td>Idaho Power - Savings</td>
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<td>Pacific Power - Washington</td>
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<td>Pacific Power - Washington watsmart Business Vendor network (for trade allies)</td>
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<td>Portland General Electric - Savings</td>
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<td>Puget Sound Energy - Contractor Alliance Network (CAN)</td>
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Thanks
And now – a few words from LDL
Upcoming LDL Online Events

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<th>LDL Course</th>
<th>Delivery Date</th>
<th>Time</th>
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<td>Introduction to Codes and Standards</td>
<td>August 25</td>
<td>10:00 – Noon</td>
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<tr>
<td>Promoting Energy Efficient Lighting Systems</td>
<td>September 8</td>
<td>10:00 - Noon</td>
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<tr>
<td>What Went Wrong?</td>
<td>September 22</td>
<td>10:30 - Noon</td>
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Today’s slide deck and previous online courses can be found on our [website](#).
Click – Call – Connect

- Eric Strandberg
  - 206-817-7142
  - eric.strandberg@seattle.gov

Visit us online

Education
Advance your knowledge of complex lighting systems and energy-efficient strategies. From the science of light to the best practices of design...

Resources
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OR

Email Us
lightingdesignlab@seattle.gov

Today's slide deck will be posted here!
With support from member utilities
Please take the online survey once you exit the webinar

We’ll SEE you on the next call... 😊